

BUILDING RESEARCH WORLD WIDE

Proceedings of the Eighth CIB Triennial Congress, Oslo, June 1980 Volume 1b

Key-note papers, invited papers and submitted papers

Edited by Norwegian Building Research Institute

RECHERCHE MONDIALE DU BÂTIMENT

Actes du 8ème Congrès Triennal du CIB, Oslo, juin 1980 Volume 1b

Edité par Institut Norvégien de Recherche du Bâtiment

BUILDING RESEARCH WORLD WIDE

Proceedings of the Eighth CIB Triennial Congress, Oslo, June 1980

Volume 1b

Key-note papers, invited papers and submitted papers

Edited by Norwegian Building Research Institute

ISBN 82-536-0115-8 (3 vol. set) ISBN 82-536-0117-4 (vol. 1B) OPPLAG: 800 Nikolai Olsens trykkeri a.s, Kolbotn

CONTENTS Volum 1 A

		page
Subject 3A Resources for	or constructions, availability of materials	
focusing on	developing countries. Local materials	15
Albert Kartahardja	Development of locally produced building materials	
	in developing countries	17
Paal Cappelen and	Extending the lifespan of traditional houses	
Knut I. Edvardsen	Examples from Tanzania	22
Thomas Ringsholt	Development of Building Materials and Low-Cost	
	Housing in Indonesia	29
Charles O'Rourke	The quantification of steel and concrete product use,	
	by sector, in the Irish construction industry	35
R. J. S. Spence	The properties and testing of lime-pozzolana mixtures	40
W. J. Allen		
Gu Qihao	The utilization of local materials in the development	
	of block construction	45

Subject 3B Energy conservation: Installations. Heat exchangers, heat pumps, solar panels etc

Installations. Heat exchangers, heat pumps, solar panels etc.		49
J. A. Basson	An integral solar water heater for low income housing	51
G. W. Brundrett	Advanced dehumidifiers for moisture control	57
Derek J. Croome Kenneth J. Parker	Low Energy Building Design	60
D. J. Dickson	The Energy Implications of Ventilation in Houses	67
F. W. Fleming	Design, Construction and Instrumentation of a house incorporating high standards of insulation and a solar/ solid fuel powered air and water heating system	72
Walter Esposti	Performance Evaluation of Solar-integrated Buildings	77
E. G. A. Goodall	Comparison of the performance of air/air heat pumps in small commercial premises	82
M. Johnson	A low energy house for a warm dry climate	88
Sven Mandorff	Balancing of water-heating systems	94
Sven Mandorff	The function of heating systems with thermostatic radiator valves having no pre-set maximum flow	100
G. H. Newton	Testing flat plate solar collectors in conditions of variable insolation	105
Tetsuo Ono Katsumori Miyazaki Akira Takakusagi	Building design and air-conditioning systems for energy saving in NTT	109
Michel Rubinstein Jacques le Quere	Utilisation de l'énergie solaire pour le chauffage des bâtiments	114
Anders Svensson	Thermostatic radiator valves – functions and requirements	118

Helmut Weber	Solar technique in the building construction.	
Anselm Eissenblätter	Aspects in the field of building construction and design	122
Heinz Hullmann		

Subject 3C Housing sociology. Human requirements. Basic needs 127 related to family and national resources. 129 Stefan Dahlgren Sociological Research for planning and Design Odd H. Guntvedt Housing sociology. Human requirements. Basic needs 135 Haktor Helland related to family and national resources Socio-cultural and Economical Factors Effecting The Spatial Nesil Baytin 140 Arrangement of Dwellings in Turkey Gülsün Saglamer Measuring Adaptability Between Activities and 145 Hülya Yürekli Spaces in Dwelling Units Ahsen Özsoy Mine Bindal

Klaus Blach	Standards for low income housing – a new type of standard may make more informed choices possible	151
Aliye Pekin Celik	A Model for the Analysis of Bioclimatic User Requirements	154
Michel H. Conan	Le changement de logement en temps de crise économique	158
Tarja Cronberg Erik B. Jantzen	User Participation in the planning of Residential Areas – an Evaluation of Four Experiments	163
Bernard Delaval	Le logement dans les villes du tiers monde. Les ressources et les besoins.	169
Zafer Ertürk	A Method for Determining Spatial Requirements with Special Emphasis on User Comfort	174
K. A. Finlayson	Community involvement in the identification of housing requirements and community priorities	179
Lars Hjärne	Concerning aims and forms of tenant influence. Some preliminary considerations	184
G. C. Mathur	Social and Economic significance of Housing in Developing Countries	191
G. C. Mathur	Basic concepts for housing the poor in developing countries	198
Joab H. Rektor	Inhabitants' Appreciation of the Environmental Quality in Public Housing Projects	203
B. R. Rubanenko D. G. Tonsky	Improvement of architectural and technical solutions of dwellings in the U.S.S.R.	206
Taneo Sakata R. C. Kumarasuriyar	Modular co-ordination in energy conserving design for living space	212
Ann Schlyter	The Basic Need of Space. An Example from a Squatter Settlement	216
Finn Vedel-Petersen Ole Jensen	Planning of Housing Development and the Social Environment	221
Ulla Westerberg Margareta Lindquist	Dwelling Habits and Dwelling Standards – Results of an Interview Study on 308 Swedish Households	227
David P. Wyon Ingrid Nilsson	Human experience of windowless environments in factories, offices, shops and colleges in Sweden	234

Hans Granum	The Role of the Building Envelope	
K. N. Agarwal	Energy Conservation in multistoreved buildings	
A. Alphan	On The Design of The Use and Discharge of Water in Building	
András Armuth Klára Szöke	Economic evaluations concerned with energy conserving improvements of the building envelope. Some Hungarian examples	
Esher Berköz Gülsün Saglamer	A Dynamic Simulation Model for the Optimization of Solar Energy Flow Through the Building Envelope	
Esher Berköz Zerrin Yilmaz	Building Facade Design From the Standpoint of Solar Radiation and Air Temperature Control	
Ugo M. Montedison E. Brosio Giancarlo Bedotti Walter Esposti Roberto Vinci	Optimisation énergetique des fenêtres	
Klaus Blach	Successful passive energy conservation – a highly insulated, traditional Danish house	
Constantin Bogos	La protection termique des bâtiments et l'economie d'energie	
Erichbernd Brocher Wilfried Zapke	The reduction of energy consumption in the heating	
G. W. Brundrett G. F. Poultney	Field trials in well insulated houses	
Aliye Pekin Celik	Bioclimatic Design of the Building Envelope in Vernacular Architecture	
E. L. Deshko V. G. Tsimbler A. V. Scherbakov E. I. Semenova A. N. Mazalov	The main measures of improvement of enclosing structures in mass construction of the USSR	
E. Deutschmann Horst Rehm	Improvement of the heat insulation of multipane window glazing in residential buildings	
Karl Gertis	Energy savings by means of improved thermal insulation of the building envelope	
Pavol Knaze Karol Szabó	Reduction of heat losses in dwelling buildings by the application of new research knowledge	
Maurice Lebegge	L'expérience belge en matrière d'isolation thermique par injection de mousses isolantes dans les murs creux	
Brian E. Lee .	The natural ventilation of groups of low rise buildings and the implications for energy conservation	
K. M. Letherman F. M. Wai	A hybrid simulation technique for predictions of seasonal energy consumption	
Ib Møller Michael Granit	The geometric form of buildings – qualities and energy consequences. Four office-buildings analyzed.	
J. B. Siviour	Theoretical and Experimental Heat Losses of a Well-Insulated House	

D. C. Spooner	Preliminary measurements of the heat losses from an unoccupied house	333
T. Stathopoulos H. Homma	Natural Wind Effects on the Infiltration of Low-Rise Buildings	337
E. Tammes	The thermal insulation-index of buildings	343

Subject 4B Sanitation problems. Solutions by non-water-borne systems and by infiltration

systems and by	infiltration	347
F. Perrier	Distribution et évacuation des eux, les problèmes des pays en voi de développement	349
Tor Arve Pedersen	Solution by dry and non-water-borne system and by infiltration	252
Hans Bjur Conny Jerkbrant	Does alternative refuse, water and sewage systems offer new possibilities for town planning?	357
Peter Engløv	Infiltration of waste water. Some Swedish experiences	262
Dag Guttormsen	Features of different types of «non-water-borne» toilet systems	366
Rolv Kristiansen	On-site soil disposal of septic tank effluent	370
Paul Liseth	A Norwegian Research Program for Treatment of Waste Water (The PRA Project)	376
G. R. Rabinovich	Optimization of calculation of water treatment facilities with the use of computers	381

CONTENTS Volum 1 B

Subject 4C Timber structures and modern wooden housing		395
J. G. Sunley K. Thomas	Wooden constructions and wooden housing	397
K. V. Kozlov A. Y. Lemke	Timber-based structural elements in panel housebuilding in rural areas	405
Trond Ø. Ramstad Åge Hallquist	Scandinavian timber frame house construction Technical design and future trends	410
F. A. Blakey R. H. Leicester	The use of grouping systems for the structural utilization of timber from multiple species forests	416
Sahap Cakin	Use of the Feed-Back Information in Housing Appraisal	420
A. S. Freidin	The using of decreased energy consumption adhesives for production of laminated timber structures	425
Edwin N. Morris Suresh Gajjar	Moment-rotation relationship for joints in roof trusses with metal plate connectors	429
N. B. Hutcheon	Evolution of the insulated woodframe wall in Canada	434

G. O. Handegord		
Gorozo Iizuka	Effective use of small logs and their products for house construction	439
K. Imaizumi	Recent research and development of wood house construction in Japan	444
L. M. Kovalchuk	Glulam timber strength as affected by variables in manufacturing process	447
I. M. Linkov	Research of strength of wood-board materials	449
S. K. Malhotra S. J. Mazur	Effective utilization of nailed laminated timber construction in buildings	452
E. George Stern	Up-grading of wood structures by use of improved mechanical fasteners	457
John A. Webster	Design Methods for Timber Structures in Seismic Zones	463
V. G. Zenkov	Energy-saving structural designs for wooden panel houses	469

Subject 5A Building docume projects in deve	entation, information and local demonstration cloping countries. Experiences and solutions	473
G. C. Mathur	Management of information needs of human settlements in developing countries	475
Klaus Blach	Roving seminars in developing countries – an efficient way to reach building technicians and administrators with up-to-date information	482
Carin Boalt Vitor Campos Mirina Curutchet C. Hannan-Andersson Ann Schlyter	Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a project	486
Ulker Copur Sevinc Yavuz	Building Documentation, a Case Study in Turkey	488
Richard N. Wright Steven J. Fenves James R. Harris	Modeling of Standards	492
Anna Gáspár Ákos Terebessy	Assistance in organizing building information systems for the developing countries	498
Bjarne Hegdal	Information from Building Research in a Developing Country	502
Ingvar Karlén	Information Exchange on Human Settlements – Needs, Problems and Actions	505
Moses D. Mengu	An appraisal of Ghana's scientific and technological information system	511
Michael Munday	The role of education for information management in the building industries of developing countries	516
Mustafa Pultar	The CEMBIL Information Centre at Middle East Technical University	521
A. Volbeda K. L. de Vries	Building Information in Developing Countries; Inter- national Support of National and Local Activities	423

Subject 5B Advanced metods of documentation		527
Wilhelm Wissmann	Advanced methods of documentation	529
Judith Grad	Management information system in the Hungarian Institute for Building Science	535

539

Subject 5C Management information systems. Construction project management, building sites management and technology, cost management Louis R Shaffer Organization and management of construction (W-65)

Louis R. Shaffer	Organization and management of construction (W-65)	541
S. S. Atayev	Management problems in building	547
N. Lemunge	Management of construction	552
Per L. Berge Ragnar Hansen Bjørn J. Nielsen Thorleif Sagbakken Janusz Ziolko	The new concept of SfB Tables as a tool for the management of civil engineering projects	556
D. W. Cheetham	Management by Objectives – The philosophies and techniques with reference to a case study of its application within a Building Contracting Company	560
A. da Costa Manso L. A. da Cunha	An information system for the building industry – a stepwise approach	566
Tadashi Eguchi	A Microscopic Viewpoint of Work Breakdown Structure in Building Construction	569
Gösta Fredriksson	The implementation of an innovation in building site construction	573
I. L. Freeman	Quality control in construction on site – Some observations of current UK practice	578
Einar Gabrielsen Odd Sjøholt	Improved production planning and control, a cooperation between a Research Institute and 30 Building Contractors	583
Knut Gilboe Janusz Ziolko	Need of education on the project management area on technical colleges and universities	587
A. P. Krotov	The Organizational Forms of Capital Construction Management	590
Peter Manning Myron Chin	Construction project management in the Caribbean: an educational approach	595
Eugene L. Marvin	Construction materials data base	600
M. M. Mbilikira	Management of construction	604
A. I. Mitrofanov	Economic methods of the Construction Management	614
K. M. Nor V. B. Torrance	An Investigation Into The Nature Of And Barriers To Feedback In Communication On Building Sites	620
P. P. Oleynik V. V. Shakhparonov	Production process preparation in construction	625
A. Nagabhushana Rau	The Role of Construction in National Development	628
Calin Popescu	Construction site population: estimating the size and structure	633
A. I. A. Saleh B. Whitehead	The relative importance of men and materials in determining the layout of a building site	636
Eigil Stang	Project Management, an Experiment in Cooperation	640

Gilbert Turner	Education for building development in third world countries	
Abraham Warszawski	Organization of Construction Company	
Janusz Ziolko	The advanced use of Norwegian National Building and Civil Engineering specifications in project management	654
Section 6 General papers		657
E. G. Andrienko M. I. Petrovnin	An air supported pneumatic structure with a heat protection screen	659
V. Angelov A. Klimukhin V. Sukhov	Sound insulation problems in modern residential buildings	663
A. Anis I. C. Ward	An analysis of the net short wave radiative balance of buildings within proposed urban complexes with different building densities, orientations and shapes for Lahore, Pakistan	667
I. L. Aparin	Economic Substantiation of the Main Directions of Scientific and Technical Progress in Construction	673
G. L. M. Augenbroe	A finite element-based computer program for the simulation of the thermal behaviour of complex systems	677
Giancarlo Bedotti Roberto Vinci	Une hypothèse de programmation de la recherche dans le secteur de bâtiment en ce qui concerne le contexte italien	683
Donato Bertola Gianni Caroli Fulvio Naldi Roberto Vinci	Une banque de données sur les dispositions pour le bâtiment. Perspectives de gestion et d'emploi	687
A. A. Bezverkhii V. I. Nikitinskii	Concrete strength as function of time and water/cement ratio in isothermic setting	691
J. Benes W. J. Diepeveen	The balance method for value analysis in the construction industry	694
A. S. Bychkov L. A. Dikarev P. P. Budnikov	On the non-destructive control of the strength of building materials	700
Yu. M. Chumakov G. A. Obyeschhenko S. E. Lensky	Basic Trends in Energy Conservation in Precast Reinforced Concrete Industry in the USSR	703
Galip Coker	A Computerized Method for Data Coordination for the Design Process for Component Approach of Buildings	708
John O. Costello Raymond A. Mulvihill	Some aspects of the design process in Irish towns	713
E. Deutschmann	Application of large-panel structures in public buildings including ground floors of dwelling houses	717
N. A. Dihovichnaya V. I. Lishak	Bearing structures of residential buildings	722
V. A. Drozdov	Major trends in the development of building physics today	725
A. A. Fikry I. C. Ward	An investigation into the use of fixed horizontal shading devices to control the internal environments in low latitude regions	729

Large span membrane suspension roofs for Olympic

L. I. Goldenberg

V. I. Trofimov V. B. Mikulin	sporting facilities in Moscow	
V. Gusev	The Development of the Resort Complexes for Mass Recreation of the Working People	738
Václav Kasalicky	The task of construction in creating a healthy and cultural housing environment	742
Gy. Kunszt L. Molnár	The use of system dynamics in housing supply forecasting	747
L. F. Miriushchenko	International Comparison of Value Data in Construction	752
C. K. Murthy Surinder Singh	Cost Estimation of Reinforced Concrete Framed Structures for High-rise Residential Buildings	755
N. V. Obolensky	Insolation and Sun Protection in Town-Planning	761
N. V. Obolensky A. I. Panurov V. V. Tokarev A. V. Spiridonov	Comprehensive prediction method of environment comfort in application of sun protection means in construction	767
Boris D., Plessein Nicolaï N. Tsaplev	Développement de la préfabrication des maisons en éléments de grande dimension et activité du C. I. B.	770
Gyula Sebestyén	System in construction	773
Dan Segal	Analysis of Manpower Demand in the Israeli Building Sector	777
I. Sh. Sverdlov	Methods of thermal drying and burning of sludge of town sewage	781
V. I. Travoush M. Yu. Zapol	Multiply wooden structures used for roofs of sports facilities	784
Helmuth-Zdenko Wantur	Prefabricated girder box units under unequal loads	787
Section 8 Building resear	ch institutions in developing countries, an example	789
A. L. Mtui	Building research institutions in developing countries BRU an example	791
Gyula Sebestyén	Building research in developing countries	796
Denis Baytin	Building Research Organization in Developing Countries – Turkey Approach	800
Øivind Birkeland	Building research in a developing country	804
M. E. Burt	Research co-operation between the Building Research Establishment and developing countries	807
Thomas L. Webb	Building research for both worlds	812
Author index		818

SUBJECT 4C

Timber structures and modern wooden housing

Constructions en bois. Habitations modernes en bois.

WOODEN CONSTRUCTIONS AND WOODEN HOUSING

by

J. G. Sunley, M.Sc., F. I. Struct, E., F.I.W.Sc. (Director – Timber Research and Development Association, U.K.) and

K. Thomas, M.Sc., F. I. Struct.E., F.I.O.B., A.R.T.C. (Deputy Director – Timber Research and Development Association, U.K.)

Summary

The paper describes the development and growth of timber framed construction in the U.K., and discusses the basic forms of construction in current use. It describes an attempt to re-introduce suspended timber ground floors by suggesting alternatives to concrete ground seals which have become accepted as traditional. Timber bridges are briefly touched upon and the present limited but potential use of glued laminated construction discussed. Work on farm buildings and a new growth industry in timber construction in Germany due to the current vogue for the «holiday on the farm» are included.

Timber framed houses for the Middle East form a section of the paper, also the new headquarters for TRADA which demonstrate the possibilities of hardwoods imported from the Far East, Australia and West Africa.

The final section discusses the problems associated with timber construction in the Third World and the developing countries and the educational and other requirements essential to further development.

Résumé

Cet exposé décrit le développement et l'accroissement de la construction en charpente de bois au Royaume-Uni et discute les méthodes fondamentales courantes de construction. L'exposé dépeint une tentative de faire réintégrer le rez-de-chaussée suspendu en bois, en proposant des alternatives au couvre-sol de béton, ce dernier étant maintenant accepté comme construction traditionnelle. Les ponts en bois ont une brève mention ainsi que la construction lamellé-collé qui a un grand potentiel d'emploi peu realisé actuellement. L'exposé décrit également le développement des bâtiments agricoles et une nouvelle industrie de construction en bois en Allemagne qui s'accroît grâce à la mode «vacances sur la ferme».

Une section de l'exposé traite des habitations en charpente de bois destinées au Moyen-Orient ainsi que les nouveaux bureaux principaux de la TRADA, constructions qui démontrent les possibilités d'emploi des bois feuillus provenant de l'Extrême-Orient, de l'Australie et de l'Afrique de l'Ouest.

La section finale présente une discussion des problèmes associés à la construction en bois au Tiers Monde et aux

pays sous-developpés et des besoins d'enseignement et d'autres exigences qui doivent être satisfaits pour faire avancer cette forme de construction.

Introduction

Different countries have developed their own methods of construction, depending largely on the availability of local raw materials (due to transport problems) and, to a lesser extent, climate.

The originally low populated large forest areas in the northern hemisphere obviously used timber construction, and developed methods and designs to meet the material and the climate. For example, Canada developed a highly insulated method of construction, capable of being built in cold weather, using green material, and hence a stick/ balloon method was developed.

The highly populated regions of western Europe generally have used stone and masonry type constructions, after exhausting most of their timber resources in earlier building. It is only in more recent years that timber frame construction has become more popular and this, of course, has been linked with the easing of transport and other problems.

In view of the evolutionary development of building, this paper draws freely on United Kingdom developments which have generally adopted North American and Scandinavian methods to suit their needs. The requirements of the Third World countries are somewhat different, in that they have a need for improved standards of housing linked to using a wide range of indigenous timbers coupled with considerable transportation difficulties. The Third World can therefore benfit enormously from developments in Europe and elsewhere as long as the appropriate changes are made to meet local conditions.

Timber framed housing in The U.K.

Wooden housing, or timber framed housing as it is known in the U.K., is usually brick clad, sometimes called brick veneer construction. The first large scale use in Britain of this form of construction was carried out at FAZAKER-LEY in 1928 by the Liverpool Corporation. An investigation in the 1950's indicated that these houses provided the occupants with a high degree of thermal comfort. In recent years, the Liverpool Corporation har renovated 229 of the 231 houses that were constructed by lining the inside with plasterboard and updating the toilet and kitchen facilities. The original linings were fibre board and the connection between the stud frames and the brickwork was found to be by large nails driven into the face of the studs and embedded in the mortar joints.

Earlier history in the use of timber framed construction followed a different pattern, using timber or stone cladding or wattle and daub infill to half-timbered houses and, except for the brief introduction of brick by the Romans, very little was used until the 15th century. Timber was the prime constructional material except for fortifications and other large buildings, which were constructed in stone. By the 18th century brick had become the predominant building material and many a half-timbered house was provided with a new facade in brick, a Georgian veneer added to conform to contemporary taste, usually a 225 mm brick wall tied to the timber frame.

The timber framed houses being constructed in the U.K. today have basically evolved as a result of experiences in North America and Scandinavia, although the U.K. method bears the closest resemblance to the construction of North America. However, there are significant differences in the way U.K. houses are actually constructed and the degree of prefabrication which goes into them.

Timber framed housing was re-introduced into the U.K. in the early 1950's and is now extensively regarded as a normal building practice. Traditional construction (o.e. brick/block cavity wall construction) is becoming less popular and the scarcity of bricklayers coupled with the many problems of wet construction is perhaps responsible for the increasing popularity of timber framed construction. Additionally, the higher standards of thermal insulation possible with this form of construction have undoubtedly encouraged its use due to the energy crisis. There are a number of different methods of construction, but the most commonly used is known as platform frame, Fig. 1, so named because the floor decking to the upper floor level is used as a platform for following work.

The other method of construction, but less common in use, is the balloon frame. This method uses longer stud lengths forming panels up to two stories high. This makes erection times even faster than platform frame. There are variations of these two basic methods of construction. Two ways of building in timber frame are (a) using factory made panels, delivered by lorry and erected on prepared bases (this represents over 90% of the U.K. market), and (b) by building in 'stick'. The latter method takes longer on site, and may also be affected by bad weater, but can be economic by using prepared and cut to length timber members to make up the framing on site. For buildings more than two stories high platform frame or a combination of methods may be used.

The structural studs are usually processed from basic sawn sizes of timber of either 100×50 mm or 75×50 mm and spaced at 400 mm or 600 mm centres, usually the latter. They are nailed with simple butt joints to top and bottom plates of the same size. These frames or panels may be either of a continuous wall length containing openings where required or of separate sections such as window or door units nailed and/or bolted together with continuous separate head binders surmounting all the elements. Frame or panel size is dictated by an early decision on whether they are to be craned or manhandled into position. Wind bracing of external walls is designed using a sheating of sheet material, usually plywood of a suitable quality, nailed normally to the external face of the frame, Fig. 2. In design, account is seldom taken of other elements such as wall linings or claddings that provide additional stiffness, although work in this connection has been carried out by TRADA and is described by



Figure 1 The platform frame method of construction

Johnson [1]. Other materials such as certain types of fibreboard and hardboard can be used in place of ply-wood for sheathing.

To prevent interstitial condensation, a vapour barrier typically of 250 gauge polythene is applied on the inside faces of the stud frames beneath linings which are usually of 12.7 mm plasterboard. Within the cavities formed between the studs, a mineral wool fibre or glass wool insulation at least 60 mm thick is secured. The insulation can be increased up to maximum cavity depth.

On the outer face of the framing the plywood sheathing is covered with a moisture barrier in the form of breather paper which is applied prior to cladding. This protects and weatherproofs the building whilst construction of the external cladding continues and also provides a second line of defence against any wind driven rain or moisture that might penetrate the exterior cladding. However, if the sheathing is moisture resistant, the breather paper is sometimes not provided, but the joints between the sheathing should then be taped.

As mentioned earlier, brick cladding is the most used in



the U.K., and is secured across a cavity to the timber frame with flexible metal ties. Other cladding materials are rendered blockwork, rendering on expanded metal/ metal lathing with a plywood backing. Experiments are currently being carried out at TRADA on alternative backgrounds for rendering and one preferred background recommended by the suppliers of ready-mixed rendering is wooden battens. Another popular finish to the upper storey is tiling hung on preservatively treated softwood battens, jointed or lapped boarding usually upon battening, and a wide choice of proprietary weathering materials. A range of such claddings is shown in Figs. 3, 4, 5 and 6.



Figure 4 External wall with feather-edged boarding

Rebated shiplap

Figure 2 Typical external wall construction



Figure 5 External wall with rebated shiplap

ure 2

Typical external wall construction

Figure 3

External wall with brick veneer

Internal walls are usually stud framed lined on both sides with plasterboard. Typically, such a wall could comprise 12.7 mm plasterboard linings on a stud frame of timber graded for structural use and of sufficient dimensions to support the loading against the effects of fire for the appropriate time to satisfy Building Regulations, usually half-an-hour. Openings in loadbearing walls are bridged by timber lintels bearing on cripple studs arranged as shown in Fig. 2.

Separating walls between dwellings are constructed from two stud frameworks as shown in Fig. 7. The linings to the room on either side are typically each of 32 or 38 mm thickness of plasterboard applied in two or more layers with staggered joints. Back to back spacing between the linings are usually 225 mm minimum. Also the frames and linings must extend right up to roof level, and at least one layer of 60 mm insulation quilt applied over the whole inner face of one stud framework, the wall being free of encased electrical wiring or other services. It has been demonstrated by site testing [2] that party walls constructed in this manner give excellent sound insulation, and achieve periods of one hour fire resistance from each side as required under the U.K. Building Regulations.



Figure 7 Typical party wall construction

Trussed rafters (prefabricated timber trusses jointed with metal plates) and floor joists are provided at 400 mm or 600 mm centres (usually the latter) and generally fixed to head binders nailed on top of the wall panels. An additional floor joist is carried around the perimeter of the dwelling to support upper floor panels.

The reaction of U.K. occupants to timber framed housing is quite favourable and a recent survey by Bedding, Hedgecock and Thomson [3] illustrates this. When occupants were asked what they disliked about this form of construction, the answers basically had no relevance and would have been equally applicable to so-called traditional construction, the major worries relating to such items as heating systems, neighbourhood, etc.

In order to demonstrate the construction of timber framed housing, TRADA has recently built a house at their laboratories, the purpose being to show visitors a typical house with cut away sections illustrating the construction, insulation, etc. As little is known about the interaction of the various components and the contribution made to the stiffness by the individual elements, it was decided to carry out racking tests on the building (a) with only the timber studs and plywood sheathing in position (under full roof and floor dead load conditions), (b) with timber studs, plywood sheathing and plasterboard lining, (c) with (b) plus brickwork cladding to first floor level, and (d) with (c) plus timber cladding on battens to the upper storey. At the time of writing (a) and (b) are complete and the results are extremely encouraging. It is hoped to give more information at the time of presentation. In the U.K. it is assumed that the timber frame carries all the vertical and racking loads, hence the frequently used description 'veneer construction'. However, it is well known that cladding and lining make a substantial contribution to the strength and stiffness of the structure, and it is hoped that this exercise will provide much useful information.

It is also intended to produce a site manual relating to this project as part of our education programme which will describe the construction generally with the appropriate visual aid back-up for interested parties.

Suspended timber ground floors without oversite concrete

Immediately after the last war restrictions were imposed on the import of structural timber and where it was possible to substitute other materials in house construction this was done.

This factor paved the way for the concrete ground floor as an alternative to suspended timber ground floors. The second reason was that a «deemed to satisfy» provision was included in the Building Regulations 1976 (for England and Wales) which in effect stated that 100 mm thick concrete slab on a hardcore base would provide a satisfactory ground seal. The Regulation has been grossly misinterpreted and the concrete industry have not been slow to highlight the economics of the integral concrete floor.

Plywood sheathing

Breather paper

Battens

Tiles

Figure 6

External wall with tiling

In an attempt to redress the balance, TRADA has recently issued a Technical Code TC1/79 [4]. This document describes an alternative to the 100 mm concrete site ground cover, recommending 1000 gauge polythene sheeting and describes the method of laying and securing the sheeting to provide a more effective and cheaper moisture barrier which paves the way back to the more acceptable suspended timber ground floor, which incidentally is simpler to insulate than the concrete floor.

Timber bridges

Timber's durability, high strength to weight ratio, and cost effectiveness in comparison with other materials, make it a particularly suitable material for bridge building. A major drawback in the past has been the lack of familiarity in the U.K. with the capability of timber as a structural material for bridges. By contrast, North American railways have erected some 2000 miles of timber bridging and there are almost 220 000 wooden roadbridges in Canada and America. In the U.K. a number of timber railway bridges were built by Brunel for the Great Western Railway during the last century.

Of particular significance are the timber preservation treatments now available plus modern developments in adhesives and laminating techniques which, all combined, present the designer with countless opportunities.

Bridges constructed using glulam members enable optimum strength and stiffness to be achieved by placing the strongest timber where the stresses are highest. Also, scarf or finger joints allow short length timber to be used in the construction of spans that would otherwise exceed even the longest available timber lengths. Theoretically, beams of unlimited size can be produced but transportation and current manufacturing facilities tend to limit spans in the U.K. to approximately 27.5 m. However, there are examples – such as centre hinged arches – where each half reaches 40 m. in length.

Glue laminated members (Glulam)

Glulam is aesthetically one of the most effective ways of producing attractive structural timber members of large cross section and long lengths from small cross section boards in commercial sizes.

In the U.K. as a general guide, straight beams and columns can range from about 75 mm \times 150 mm upwards, although such small sizes would not normally be competive with solid timber.

The U.K. market for glulam is relatively small and is some way behind Canada and certain European countries. From time to time it is suggested that glulam should be imported as standard straight members from Europe or Scandinavia, but investigations into the economics of such practices tend to mitigate against it. One of the reasons for this is that when design loadings have been assessed, a smaller more economical section could be produced by incorporating the appropriate camber.

Education on the fire resistance properties of timber have

resulted in the winning of several contracts where originally steel portal frames were specified, particularly when the architects concerned considered post fabrication treatment, and the more pleasing aesthetics of glulam. One of the problems with long members is that British Standard 4169 [5] recommends that preservative pressure treatment should be carried out after fabrication of the members and this can be difficult if the manufacturer does not have ready access to an appropriate long tank. Glulam begins to be economic compared with solid timber in larger sections, particularly for lengths in excess of 4-5 m.

As mentioned under Bridges, this is a very popular and expanding market for glue laminated members.

Farmbuildings

Timber is a popular material for farm buildings but in recent times the competition from steel and concrete has increased and as a result in 1972 TRADA formed an organisation known as TRADAFARM in order to achieve a more realistic share of the agricultural market for timber structures and, subsequently, a wider acceptance of ancilliary elements made of wood. This is achieved by a programme of development work by TRADA on design, publication of technical aids for members, seminars, conferences, visits to farms of interest, etc. TRADA-FARM enables a large number of small operators to compete with large organisations by carrying out centralised design and promotion.

In the U.K. specialist firms produce the buildings appropriate to their expertise but the bulk of the larger type buildings are of portal frame construction. A limited amount of self building is carried out by farmers and some schools of agriculture give instruction in the building of pole barns, although this is not generally encouraged by manufacturers of timber buildings and the recent introduction of British Standard Code of Practice 5502 [6] will almost certainly bring this practice to an end.

Other countries do not have the same restrictions and in Germany the do-it-yourself factor is more common with the practical minded farmers, and a number of agricultural associations have initiated training courses on building construction. Questions of insurance, correct interpretation of regulations and responsibility for safety have led to certain problems and restrictions. In order to overcome these difficulties professional help is needed for design calculations and site supervision, but the farmer takes over the role of general contractor on his own farm. Here he bears the full responsibility for safety, payment of labour, security and insurance of third persons.

This new development has generated new demands from German industry to produce structures and structural systems which, once delivered to site, can be incorporated into the self help system without major problems.

A growth industry in Germany is the «holiday on the farm» programme. Here families from major cities spend their vacation on the farm and timber buildings and installations are creating a new market. Additionally, riding

stables and indoor riding halls have been constructed to meet this new trend.

Timber framed houses for the Middle East

The Middle East har proved to be a considerable export market, so much that in January 1976 TRADA produced a leaflet [7] «Timber Framed Houses for the Middle East».

The design considerations for this location are quite different from those usually applicable in the Northern Hemisphere, and it is particularly important in this area to obtain as much local information as possible, as conditions and requirements can vary considerably.

Small and medium sized timber framed buildings can withstand heat, high winds and seismic forces well. A general principle is to design the structure as a well insulated rigid box strengthened by well tied-in cross walls and joints bolted together where possible. Walls generally should be symmetrically spaced and large openings avoided, particularly near the corners in external walls. Provided such requirements are satisfied construction can largely follow normal practice.

Assembly needs to be such that as far as possible it can be achieved by simple hand nailing and bolted joints, as local labour is likely to be unskilled.

As moisture content is a function of relative humidity rather than temperature, to ensure timber shrinkage is not excessive, a maximum moisture content of approximately 18 per cent is appropriate for structural timbers and 10–12 per cent for joinery.

Termites are likely to be a problem in this region unless timber is pre-treated by pressure impregnation with copper chrome arsenate or by double vacuum treatment with an organic solvent preservative. Additionally, soil around the foundations should be poisoned.

Because windows are a major source of heat gain from solar radiation, the traditional Middle Eastern building has small window openings set in deep reveals. Larger openings such as doorways are protected from direct sunlight by covered ways, courtyard layout or shade from adjacent buildings.

In the timber framed house, the aim must be for windows to let in adequate levels of light whilst excluding direct sunlight. One method of achieving this is to avoid east and west facing windows which would be extensively exposed to the sun at low angles of incidence. Additionally, external shades of louvered, light coloured materials can be used.

Lightweight construction has the disadvantage of low thermal capacity. Some useful effect in providing thermal inertia for this form of construction can be achieved by using a concrete slab floor/foundation where conditions permit. As a general rule it is advisable to increase the thermal insulation in walls to a maximum, also any cavities should be airtight, thus eliminating convection currents. Alternative methods of giving protection from the sun are (a) to use an independent roof which acts as a sun shade and permits an air space between the dwelling and the roof, or (b) to use an earth roof for insulation.

TRADA's new headquarters

The new buildings at TRADA's headquarters in the U.K. demonstrate the structural possibilities of hardwoods imported from the Far East, Australia and West Africa, which come in much bigger sizes and are much stronger than the normal European and American softwood carcassing timbers. Some of the solid beams are up to 400 mm deep and have a loadbearing capacity and small deflection competitive with steel or larger laminated softwood sections.

Constructional techniques used are similar to those used in softwood frame or panel construction on a domestic scale, but enclosing much larger space. The form of building is not a closed system, rather a «method» and is suitable for schools, community centres and office building, particularly when an economic yet attractive scheme is desired.

The larger spaces in the new building; the lecture theatre and the dining hall; demonstrate the structural possibilities of hardwood with pyramid roof structures of the simplest kind, with four hip beams spanning from an eaves ring-beam to a ridge or, in the case of the square dining hall, to a single steel connector. These are large timber sections 300 mm \times 125 mm, which in other constructions would normally require steel.

In the lecture theatre the hip beams support stressed skin plywood panels filled with insulation, with no intermediate supports. The plywood is simply varnished as a ceiling finish and the panels give the effect of homogeneous sheet materials. This roof is felt covered, but the dining hall has asbestos cement tiles so that it was necessary to use rafters – not hardwood this time but ordinary softwood, left unplaned and stained black.

One of the lessons learned from the construction of the laboratory and office block was that to design the timbers to be handled by four men was unrealistic. A crane had to be used for the first phase of buildings, and subsequently stage two was based on narrower timber sections capable of being lifted by two men, but a crane was used for the largest members in the pitched roofs.

A feature of the design is that the materials should be accepted for what they are – shakes, knots, splinters and all. This is a trend away from traditional building in the U.K. which generally dictates that rough timber should be covered up. Here, structural hardwood was left with a sawn finish except in places where it could be touched.

Structural hardwood was by no means the only application of timber products, and chipboard was used in double and even single skins for partitions which have no accoustic insulation function; perforated hardboard was used untreated for soffits and instead of ventillation grilles; fibreboard for internal linings; stressed skin plywood panels for roof decking; and for the external walls, red meranti faced plywood with butt joints covered in the simplest possible way by means of pinned strips of softwood or hardwood wrot or unwrot, all timber, structural or joinery, was stained or varnished, never painted.

In only one place was a concession made to convention: the front elevation of the dining block, when a rendered finish was used to match the old house around which TRADA is built.

The structure of the main complex is neither a regular gridded frame nor a modular platform. It is a hybrid variant of the two with a central post and beam spine carrying long span joisted floors spanning onto an irregular external wall of stressed skin panels.

Due to a sloping site the conference room has an undercroft of stilted construction, not unlike a building system for Laos designed by TRADA, the difference being that the Laos system uses reinforced concrete posts and floor slabs because of termites, and the need for moment connections at the head of the columns, whereas the TRADA complex uses hardwood timber, sufficient lateral support being available.

Timber construction in the Third World/ under-developed countries

It is not possible in a paper of this nature to make a statement which encompasses the whole of the Third World and therefore discussion is limited to selected areas which may be typical.

South America is a huge area and conditions vary across the continent, but the major problems relate to the quality of the timber available. Distorted harwood trees are abundant, and long straight lengths of timber are consequently rare. The species are legion, making consistency of quality a problem, but perhaps the greatest difficulty which is common to many remote regions in the world is the necessity to transport the timber long distances over difficult or even non-existant road systems.

A problem generally common to the Third World is the lack of skilled tradesmen for general construction – frequently in South America craftsmen highly skilled in joinery are available, whilst carpenters are scarce.

The size of the region, the terrain and respective distances from the equator means that extremes of heat and cold are experienced in one area, whilst another or even the same area might have considerable wet to dry variation, the latter condition being more problematic than the former. Problems associated with the climate and the use of green timber, termites and other factors, make good design that much more essential in under-developed zones, where unfortunately the necessary expertise is not always readily available.

In such parts of the world insulation and an appreciation of environmental problems are not always adequately understood and a vast educational exercise is badly needed. In countries such as Peru, the population tends to be greatest at the opposite side of mountain ranges to the forest regions and, once again, transportation is the major difficulty. Also, facilities for drying timber are not generally available and natural drying tends to be a long process with the added danger of attack by wood boring insects.

The local trade sells timber direct to building sites with a moisture content in the region of 50%. This, of course, results in movement problems in use but on the other hand facilitates nailing, which might be impractical with hard dry timbers and is consequently acceptable to the workforce.

Central America poses certain different problems in addition to some of those mentioned above. Mexico has good pine forests, but problems of distance from the forests to civilization create transportation difficulties – they certainly have some excellent timbers and it is only a matter of time before they can be correctly utilized.

Africa has similar problems to South America, with extremely hard and difficult to work timbers, and little softwood exists. Where available, they are usually fast growing and only suitable for secondary uses such as props, etc.

Southern Africa generally has better transport but lack of knowledge in the remote areas leaves a considerable educational problem. Also, a tradition of using clay for building exists and it is difficult to know to what extent timber framed construction will develop. Perhaps the problem should be studied on the basis of what is happening in South America.

The bulk of Africa tends to be hot and arid, and the sawn hardwood timbers are practically unworkable for construction, but are satisfactory for joinery.

In certain parts of Africa poor quality timber having wavy grain, etc., is unsatisfactory for constructional purposes and TRADA is currently studying how such material can be used for the production of board materials and how such boards could be used in their constructional processes.

The precentage of forest in India is small compared to the size of the country, and what exists is purely tropical forest – this is small in the northern regions with larger quantities in the south. Little industry exists, and is craft based. TRADA has recently carried out an investigation for the Indian Government on export market development, and this will obviously influence their thinking on future developments.

The Middle Eastern contries tend to be importers of our wood products, as they basically have no trees and very little appropriate technology.

The Far East has a well developed timber industry and in certain parts there are considerable forest resources of excellent species.

Courses are currently being arranged on timber design and stress grading in Malaysia and Singapore respectively.

Little is known about China, but this must be a potential growth area, as numerous trade delegations and representatives of the European construction industry have recently made visits.

To sum up this section, the problems can be divided into

two parts; resources and technology. Resources can be further divided into people and materials. The majority of under-developed countries have a large population of unemployed people and therefore the workforce is available but usually in need of training. Materials are either readily available or must be imported and this therefore resolves into the requirement of available materials or finances.

Technology is perhaps less of a problem in that to coin a phrase «technology transfer» is relatively cheap in relation to simple construction, but industrialisation and massive road building programmes are a much more complicated and expensive operation.

In some areas it is also not only a question of education in the use of timber frame construction but also in overcoming traditional building practices which, although cheap, are not appropriate to the requirements and basic needs of the 20th century.

Conclusions

Timber has a lot to offer in the future in meeting the construction needs of the world with a limitless renewable resource. Timber has always been the chief building material in countries with their own supplies, and in recent years designs have been developed to meet the needs of other industrial countries, since it provides many of their requirements with regard to simple construction, pre-fabrication and easy erection.

Some of the techniques could be developed and demonstrated as suitable for many developing countries. However, there are many problems to be solved in the transfer of technology, etc., within these countries if these aims are to be achieved.

References

- Johnson, V. C. «Brick cladding on timber frame construction». 1977 Interbuild Conference. November 1977.
- Sewell, E. C. and Alphey, R. S. «Field measurements of the sound insulation of party walls in timber-framed dwellings». BRE current paper CP 39/77. August 1977.
- Bedding, B., Hedgecock, J. A. and Thomson, A. «Feedback on timber frame housing. Interim report – Occupant Survey». Timber Research and Development Association – to be published shortly.
- 4. Anon. «Specification and recommendations for the use of polythene ground cover beneath suspended timber floors». Timber Research and Development Association, Technical Code TC1/79. December 1979.
- British Standard 4169:1970. «Glue laminated timber structural members». British Standards Institution 1970.
- British Standard Code of Practice 5502 : Part 1: Section 1.2 1978. «Code of practice for the design of buildings and structures for agriculture». British Standards Institution 1978.
- 7. Anon. «Timber-framed houses for the Middle East». Timber Research and Development Association, Wood Information Sheet, Section 0, Sheet 2. January 1976.

TIMBER-BASED STRUCTUR-AL ELEMENTS IN PANEL HOUSEBUILDING IN RURAL AREAS

K. V. Kozlov, Cand. Sc. (Eng.), A. Y. Lemke, architect, TSNIIEPselstroi, Moscow Region, USSR.

Summary

The paper deals with the principal characteristics of panel wooden houses designed for construction in rural areas. It also describes some architectural and layout solutions for houses built in the USSR and discusses some of the design features of different panel applications in these houses. Data are given on research and development activities to improve the designs of panels for houses, based on timber and timber materials.

Résumé

Le rapport présente les caractéristiques principales des maisons d'habitation en panneaux préfabriqués en bois pour les régions rurales. On a décrit des conceptions architecturales en plans pour les maisons bâties en URSS ainsi que des disposition constructives particulières des façades de ces maisons. On a présenté les données des études dans le domaine du perfectionnement des formes constructives des panneaux à la base de la matière en bois et des matériaux ligneux déstinées pour la construction des maisons d'habitation.

At present, our country is engaged in an immense housing construction effort. In the 1976-1980 period alone, a total of about 550 million square meters of housing space was built, in which the construction of small apartment houses in rural areas accounted for 180 million square meters. During this five-year period, construction of wooden houses with the use of industrially manufactured elements will reach the figure of around 30 million square meters of housing space, at the beginning of 1980 the volume of this construction almost doubled over the 1960 level.

Despite the construction of wooden houses being traditional in our country, it did not, for a long time, gain a due level of development. This was partly attributable to the notion of timber as a material hardly fit for capital construction, because in the process of operation and changing humidity it swells and dries, is subject to rot and inflammable, and cannot assure a long time of operation. At present, however, this notion has undergone a substantial change. The development of a number of industries having to do with construction made it possible to apply effective methods of enhancing the durability and reliability of timber.

The timber gluing and saturation techniques have broadened the scope of its utilisation in bearing and enclosing structures, increasing its resistance to rot, inflammation and biological destruction.

All these achievements have made it possible to regard, at present, the building of wooden apartment houses with a limited number of storeys as one of the promising trends in carrying out housing construction programmes in rural areas. The use of timber and timber-based materials as structural elements of buildings permits a transfer to the industrial plant of almost all of the operations involved in the manufacturing and finishing of panels serving as house walls, partitions and ceilings, making it possible to switch over, at the construction site, from «wet» processes to dry, to embark on an assembly-line production and to put the overall construction process on an industrial footing through the use of container transportation, small-scale mechanisation equipment and mobile cranes at the construction site, which speeds up, simplifies and cheapens construction operations.

Wooden houses posses better thermal physical qualities and ensure better conditions for life than houses made of concrete and reinforced concrete elements and parts.

According to the data of TSNIIEP grazhdanselstroi, industrially produced wooden houses are 7% more economical, over 30% less labour intensive (both at the plant and at the construction site) than reinforced- concrete and concrete elements, and consume only one sixth of the steel. Wooden houses weigh only one fifth of reinforcedconcrete panel houses or those made of bricks.

Considering the need to assure an increasing rate of rural housing construction and to raise labour productivity in construction industry, one must recognise as the most promising trend the development of construction of wooden-panel houses, striving to carry out the greatest possible amount of production operations at the industrial plant (using plywood, wood-fibres and woodchips slabs, mineral wool, foam plastic material, etc.).

The total mass of wooden-panel houses is almost 30% less compared to similar houses made of wooden bars. The thermal conductivity resistance of panel walls is 38% higher than of barred walls, and 2.4 times that of brick walls.

The share of capital investment (as per 1 m^2 of total housing space) into the creation of the production base for wooden-panel housebuilding is 10% less than the investment needed to develop the base for producing large reinforced concrete panel houses.

In the USSR, industrialized wooden-panel housebuilding is being developed along several ways of designing and producing wooden houses on an industrial basis.

One of the most widely utilized types is that of standard panel houses, particularly one or two-storey, block or section apartment houses and hostels, produced mainly by enterprises of the Minlesprom (Ministry of timber in-

By the volume of timber procurement, the Soviet Union ranks first in the world. The chief consumer of timber in the country is the building industry whose annual share of commercial timber is 40%.

dustry) of the USSR. The houses are based on the use of the 1.2 layout model with a rigid spatial positioning of the kitchen and the sanitary block which makes it possible to introduce variations in the size and the positioning of the rest of the rooms.

The design layout adopted for the houses includes transversal bearing walls with a standard spacing of 3.6 meters. The outside and internal walls, partitions and ceilings are made of ready-made wooden panels. Groundfloor ceiling panels have the size of $3.6 \times 1.2 \times 0.22$ m. The bearing elements of the panels are wooden beams with the 50×180 mm section. The panels are warmed up with mineral-wool plate. The facing is of wooden boards with a thickness of 22 and 16 mm. A flooring of wood-fibre plate or linoleum is laid over the panels. The length of external wall panels is 3.6 or 1.2 m, and their height is that of one storey. They are mounted on a wooden carcass made of wood bars with a height of 124 mm. The boarding of panels is done of hard wood-fibre plate or plywood. In some cases additional outside facing of wood bars is provided for. The external boarding is fixed to the carcass with nails. Interior walls are made of 1.2 m - long panels fixed to a carcass of bars with a thickness of 94 mm. The panels are boarded on both sides with hard wood-fibre plate. As thermal insulator, one uses mineral-wool plate or other effective materials.

Partitions are made of board panels faced on both side with wood-fibre plate. Panels of inter-storey ceiling are mounted on a carcass of bars with a height of 177 mm, the facing underneath being of wood-fibre plate and, on top, of wood boards with a thickness of 22 mm. A layer of pergamine is used in garret panels as vapor insulator. The socle and eaves sections of a house are given in Figure 1. The double-pitch roof is fixed, over wooden



a) Eaves assembly

b) Socle assembly

The Giprolesprom institute has developed over 60 standard designs of wooden houses made of industrially produced elements. These include farmstead houses with 2, 3 and 4 one-room apartments, two-storey houses with apartments on both levels and four-section houses consisting of 8 and 12 apartments.

An example of an integrated approach to building a wooden-panel house settlement is that of the «Selskaya Nov» settlement of the Kuntsevo poultry factory in Moscow region (Figure 2).



A general view of the «Selskaya Nov» settlement i Moscow region

The Ministry of Rural construction of the USSR has approved, for mass-scale construction, apartment houses and other buildings with a limited number of storeys, produced on an industrial basis. The houses use panel structures, with the module of design of 1.5 m. They are designed for areas with winter temperatures of down to minus 40 degrees centigrade with the snow of 150 kg force per m^2 and the wind load of 45 kg force per m^2 . Stability of the buildings is ensured by the joint work of the bearing wall panels and those of ceilings. The elements and structures are manufactured at industrial plants and supplied to the site as a complete set. All the elements of walls and roofs are made of bearing glued plywood panels with wooden carcass and a heat-insulator made of semi-hard mineral wool plate.

According to the design, the panels have a carcass of wooden bars with a section of 50×130 , 50×150 and 50 \times 180 mm with a twoside boarding of glued plywood. External panels are also provided with a protective screen of asbestos sheets fixed to wooden planks. All the panels have a width of 1.5 m (there also being a panel version of the «room» size). The garret roof is of inclined trusses. It is protected by asbestos sheets of a standard profile.

Horizontal and vertical panel joints are tightly sealed with cold-resistant foampolyurethane and, over it, with an aluminium or wooden lap (Figure 3).

In the Kalinin region, the first pilot projects of this type have been built. The elements for their construction were manufactured and supplied by the enterprises of the Minselstroi (Ministry of Rural construction) of the Russian federation, which supply glued wooden structures. Besides the Kalinin region, the serial construction of houses and elements for them is envisaged in a number of regions of the Non-black-earth area of the Russian federation and Northern Kazakhstan.

Tested and now introduced into production are wooden panel houses for areas with winter temperatures of down to minus 60 degrees centigrade and the snow load of up to 200 kg forces per m^2 . They are supplied by the industrial plants to the contstruction site in complete sets. Foundations are either wooden or reinforced concrete piles with a grating of glued elements on which the ground flooring is laid. The design of all the panels uses a carcass of wooden bars. The external and internal walls are faced with glued plywood; the ceiling panels are faced – on top – with woodchips plate and – beneath – with plywood. The garret roof is made of truss elements; the roof is protected with fibrous asbestos sheets. The wall panels have the width of 1.5 m or the «room» size.





Figure 3.

Design variants for panel joints in houses a) Horizonal and vertical joints b) Angular (corner) panel joint The Baltic areas of the USSR have adopted, for rural settlements, apartment houses with 2, 3, 4 and 5 room flats, the design module being 1.2 meters. The panels for roofs and walls are of a combined design: the carcass consists of wooden bars or wood-fibre plates, and the boarding is of wooden boards or wooden plates. The size of the most widely used panels is 1.2×2.5 m, the weight up to 300 kg. Structural elements are joined together with nails or glue. Brickwork is used for external protection of outside walls. The Latvian Soviet Socialist Republic produces up to 2000 sets of houses a year. The houses have good architectural layout and maintenance qualities. They can be assembled with small-scale mechanisation means.

In 1977 Latvia commissioned a housebuilding factory to produce complete sets of elements of wooden houses. The factory can annually produce 2000 houses or 183 000 m^2 of floor space. It can also manufacture joinery products and built-in furniture.

The houses are produced in a finished state: the elements are finished and painted, electrical and sanitary equipment installed and built-in furniture in place.

External walls of houses are glued panels of woodchips sheets with a thickness of 12 mm and the carcasses are of the same sheets. Mineral wool plate serves as insulator. The panels are shielded with flat asbestos-cement sheets. Internal walls are carcass panels of woodchips sheets with a thickness of 12 mm. Again, mineral wool serves as the heat insulator. The panels are 225 mm thick, up to 9.5 m long and 2.37 m wide.

Roofing is made of woodchips elements and wooden trusses. A house is assembled by five fitters in one workday. Similar houses are now produced by enterprises of «Roskolkhozstroiobjedinenie».

Another example of industrial housebuilding is houses made of arbolite structures. These houses are designed for areas with winter temperatures of down to minus 40 degrees centigrade. The house uses the design module of 0.6 m. The floor area is 102.28 m² and the living area is 56 m². The house has all the necessary facilities.

Foundation is either cyclopean concrete posts or pre-cast concrete blocks. The socle is of bricks. External and internal walls are of arbolite Grade 25 blocks. Arbolite's density in a dry state is 650 kg/m³. The thickness of external blocks is 240 and 280 mm, of internal – 200 mm. Partitions are of board panels faced with gypsum sheets. Garret roofing is beams with bars on which board sheets are laid. From beneath, the roof is boarded with gypsum sheets. Flooring is made of milled wood boards on lags with a 50 \times 100 mm section. The boards are laid over brick posts with wooden rests.

Another type of construction which is an important user of industrially produced wooden elements are farmstead houses with walls made of local building materials. Here, industrially produced wooden structural elements include beams, bars, roofing sheets, boarded trusses, girder lattices and veranda elements.

Dismountable and «footloose» buildings serving different purposes account for an important share of small house building industry. The houses and buildings are being produced by over 80 enterprises of different ministries and departments. Houses of this type are broadly utilized in the development of areas with scarce population and extreme weather conditions. Among others, they are used on a broad scale for building modern settlements in the area of the Baikal-Amur Mainline railway.

According to the conditions of their utilisation and design features, the houses can be divided into three types: transferable, container-type and prefabricated-dismountable.

Transferable houses are, as a rule, mounted on a foundation frame which assures the house's rigidity and links the vehicle with the overground part of the house.

Container-type houses consist of spatial elements – industrially produced panels, and can be transported by different transport vehicles to the place of destination in an assembled form.

To build settlements to serve for two or more years, use is made of prefabricated-dismountable houses. These are supplied in dissembled complete sets of flat and linear elements. As a rule, houses of this type consist of a wooden carcass, heat insulator and boarding of sheet material or wood boards. The panels of transferable houses consist of a wooden carcass, external steel facing, interior plywood boarding, as well as wood-fibre or woodchips board. In container houses, use is made of metal-andwood elements protected by wood boards. Used in all houses as heat insulator is mineral-wool plate or phenol-resol foam plastic with a density of 50–70 kg/m³.

In our country, industrial wood house building relies both on the existing industrial production capacities and on the designs of technological lines and factories to produce structural elements of houses.

In recent years, the USSR Ministry of forest and timberprocessing industry has developed and commissioned three large housebuilding factories, using Soviet-made equipment, with the capacity of 250 000 m² of panel houses a year each, as well as three large factories to produce prefabricated houses with the capacity of 200 000 m² of housing space a year each. These latter use the technology supplied by the Swedish firm «Chers-Machiner».

The Ministry of Rural construction of the USSR is also developing a base for standard wooden housebuilding. In 1979, a production line was commissioned with a capacity of 57 000 m² of housing space, to produce wooden house elements. Four factories are operating at present, producing glued wood structures, which will be reoriented to produce wooden house elements. With this aim in mind, the «TSNIIEPselstroi» is busy working out proposals to provide complementary equipment to these factories.

In 1978, the standard housebuilding enterprises of the Soviet Union produced a total of wooden houses with a housing space of about 4 500 000 m^2 .

In evaluating the national experience in wooden panel housebuilding, it should be pointed out that the most widely applied design was that of the wall and floor panels forming a wooden carcass of solid piece timber with two-side plywood boarding, wood-fibre and woodchips sheets and other plate materials. Such a design largely simplifies the production technology, but leads to a greater waste in saw-timber. Such overexpenditure of timber is not always justified since the thickness of wall and roof panels and, thus, the section of the wooden carcass bars are, in many cases, determined not by the needed strength and rigidity of panels but rather by the thickness of heat insulator.

In the USSR, the research and development as well as designing organisations, together with the manufacturing enterprises and builders, are working to improve the existing design solutions to increase the level of standard wooden house prefabrication, to extend the service period and increase reliability of wooden houses, to reduce their weight and to make the execution more industrialized.

In this respect, one can identify the following areas:

- development of larger facade elements to make them fit the size of a section, a block-flat or even the whole length of the building;
- development and organisation of factory production of spatial (threedimensional) elements and larger assembly elements (sanitary premises, porch parts, built-in stairs, roofs);
- development of effective profile bearing elements for large-size panels for roofs and walls;
- reduction in the number of element sizes and types with account for the possibilities of the existing manufacturing equipment;
- switching over from fir-tree timber to leafbearing tree timber in building elements in order to broaden the range of timber used and thus to offset the shortage in the supply of fir-tree timber for housebuilding;
- development of proposals to replace plywood boarding of panels by boarding them with wood-fibre and woodchips sheets, asbestos-cement and synthetic materials;
- development of more advanced industrial production techniques.

The practice of the development of the national wooden housebuilding has proved the great effectiveness and the promise of this building industry which can well be regarded as one of the viable solutions to the problem of housing construction in rural areas.

In recent years, the Soviet Union has carried out a number of measures of social development and to provide public services and amenities in rural human settlements. However, the attainment of the necessary rates of building apartment houses as well as of cultural and communal buildings, and to meet the need of rural population for houses with all modern conveniences pose the need for a further improvement in the organisation of housing construction in rural areas.

It has been recognized that one of the chief trends in the improvement of the rural housing construction is a further development of industrial production of wooden panel houses as well as a substantial increase in the output of complete sets of wooden elements for houses with walls made of local building materials.

The November 1979 Decision of the Central Committee of the CPSU and the Council of Ministers of the USSR, whose draft was elaborated with the participation of a number of research, designing and public organisations as well as ministries and departments, provides for implementation of a set of measures for a futher development of the production base for industrial housebuilding in rural areas. By 1985, the enterprises of the building industry and the inter-collective-farm associations will be industrially producing wooden houses with a total annual floor area of 7.1 million and, by 1990, up to 11 million m². Production of complete sets of wooden elements for houses with walls made of local materials will increase, respectively to 8.5 and 12.2 million m^2 of housing space a year. The plan for this period includes building new and expansion of the existing 78 housebuilding and timber processing enterprises, 23 machinebuilding and metal-processing plants and 31 enterprices of the building materials industry.

SCANDINAVIAN TIMBER FRAME HOUSE CONSTRUC-TION TECHNICAL DESIGN AND FUTURE TRENDS

Trond Ø. Ramstad and Åge Hallquist, Civil Engineers, Norwegian Building Research Institute, Oslo, Norway

Summary

The paper reviews the present position of timber frame house construction in Scandinavia. The purpose of the paper is to provide knowledge about the technical design principles and the materials currently in use. Some future trends and developments towards new designs for timber frame construction are also discussed.

Résumé

Cet exposé presente la position acutelle de la construction en charpente de bois en Scandinavie. L'intention de l'exposé est de procurer connaissance sur les principes techniques de la construction et les materiaux actuellement en usage aujourd'hui. Certains tendances futures et developpements vers nouvelles constructions en bois sont aussi discutés.

Introduction

Timber frame house construction as presented in this paper is based primarely on Norwegian design solutions. However, timber frame houses in Sweden and Denmark are technically very similar, and the main design concept is also closely linked with the traditional North American construction practice.

In Norway low-rise houses are now accounting for close to 80 % of all residential buildings (house units), and more than 95 % of these are timber frame construction. Also in Sweden are wooden houses dominating residential building to approximately the same extent.

A majority of these houses are financed through the State Housing Bank, being built to a standard and cost reflecting the government's social policy programme. Privately financed housing, also to luxury standards, is also usually timber frame design.

In 1978 over 60 % of all houses were built by the use of standard drawings (catalogue designs). Apart from residential building is timber frame construction also widely used for building low-rise schools and kindergartens, smaller industrial and service buildings etc., in addition to an important market for secondary homes like cottages at the seaside or in the mountains. It is the intention with this paper to provide knowledge about Scandinavian timber frame building and give technical background for comparison with similar constructions in other countries. It is also hoped that the paper shows the flexibilities of timber frame design and its possibility of adapting to local environmental conditions, thus providing background for a consideration of utilizing the wooden house concept also in areas without a tradition with this type of houses.

Design principle

Characteristically for timber frame construction is the use of several materials or products in combination. Each product serves only one or a few functions as part of the total system, and being specialized and refined for these functions particularly.

Wall construction starts with a load-bearing frame of timber studs and plates as shown in *figure 1*. This frame is completed with a number of other materials to form the finished wall, using the design principle indicated in *figure 2*.



Fig. 1. Basic structural timber wall frame. Walls can be build in «stick» on site, or prefabricated. The degree of prefabrication may vary from the basic frame with one layer of sheathing to completely finished wall panels. Wall frames are erected directly on a concrete floor slab, concrete floor elements, or on a timber floor structure as shown here.

Timber floor and roof construction is based on the same design concept, by completing a load-bearing structure of wood beams or trussed rafters with additional materials on both sides and filling the cavities with thermal insulation. An important feature of this design is the very large number of different building products and makes which can be utilized. With the same basic construction technique and design work the choice of materials can be adjusted to local material supplies, product prices at the time of buying, special appearance requirements etc. Timber frame structures are dry construction and light in weight. The same



Fig. 2. Construction of timber frame exterior wall, in principle. Several building products are combined, each product serving only a limited number of functions.

basic design concept is used whether the house is to be built completely on site with a minimum of tools, or being prefabricated in a factory with highly automated machinery. The dissimilarities in how timber framed houses are built, both within Scandinavia and between various other countries, reflects mainly the difference in local availability of building products and materials. But there is also significant differences in a number of construction details, particularly in connection with external appearance. The design principle is nevertheless mainly the same.

Materials and construction details in current use

Traditionally the balloon frame construction has been used, where wall studs and the roof are erected before the subfloor panels or the floor boards are fastened to the floor joists. During the 1970's, however, the platform frame method has become very common. By using water-resistant materials the floor is made to form a working platform before starting the erection of walls and roof, *figure 3*. The advantage are faster erection and increased working safety. On the other hand the method requires more expensive floor materials and often more work on floor finish.

A typical section of a house from the 1970's is shown in *figure 4*, while *figure 5 a, b and c* show the most typical materials currently in use. These different alternatives are combined in almost all possible ways.

Timber frame construction is limited to two-storey houses by fire safety regulations. As foundation are basements widely used, particularly in detached house construction, while alternatives are slab on the ground or suspended timber floors over foundation strips, piles or a crawl-space. Houses are usually designed for snow loads in the range 1.5 kN/m^2 to 3.0 kN/m^2 , and a maximum basic wind load about 0.60 $kN/m^2 - 0.85 kN/m^2$.

Wind bracing is given much attention in many countries. Experience from the timber frame house construction in Scandinavia shows there is few or none problems related to horizontal wind forces on a completed house, and structural calcualations are normally not carried out regardless the size and shape of the house. With a minimum of one layer with any of the ordinary sheet type materials as sheathing or lining on all exterior walls the wind bracing is considered satisfactorily. Let-in corner bracing is used only when there is timber boards both for cladding and lining, breather paper and no sheathing.



Fig. 3. Platform frame construction. All walls are placed upon the subfloor, built in «stick» or as prefabricated panels. Partition walls are usually erected after roof completion when they are built on site.

Preservation by design is given high priority in all detailing. This include good ventilation of the roof structure, ventilation of external cladding, emphasize on water drainage at window and exterior door details and at plates and foundations, entrance-doors covered by roof, etc. Special durable wood species are not used, while utilization of preservative treated timber being pressure impregnated normally is limited to base plates and balcony structures.

In cases where fire safety requires special measures to be taken it is common to find solutions with plasterboards covering the timber structure. In row-houses and other type of dense housing the permissible area (horizontal projection) between non-combustible fire walls usually range from 600 m² to 800 m², depending upon size and design. Acoustic insulation requirements are normally met by the use of double separated framework designs, for walls as well as for floors.



Fig. 4. Typical Scandinavian timber frame design from the 1960's and the 1970's. Alternative materials are shown in figure 5.

Cladding a) Vertical or horizontal timber boards, 19 mm thickness, 95 mm - 170 mm width, stained 110 mm brick veneer Ъ) c) 9 mm - 15 mm plywood d) Corrugated aluminium or steel sheets e) Asbestos-cement boards Ventilation space 0 - 50 mm, usually 19 mm - 23 mm Wind Barrier a) Asphalt impregnated breather paper (600 gr./m²) ъ) 12 mm asphalt impregnated, porous fibreboard with windtight layer c) 9 mm special plasterboard 3 mm asbestos-cement-cellud) lose boards Thermal insulation 100 mm or 150 mm thickness (bats) a) Glasswool, 15 or 21 kg/m³ b) Rockwool, 33 og 45 kg/m3 Studs 4 600 mm spacing, softwood a) 48 mm x 98 mm b) 36 mm x 148 mm c) 48 mm x 98 mm plus 48 mm x 48 mm horizontal ribbons Vapour barrier a) 0.04 mm. 0.06 mm or 0,10 mm polythene film b) Paper covered with polythene film Lining a) 12 mm chipboard

- b) 12 mm medium density fibreboard
- c) 13 mm plasterboard
- d) 15 mm tongue-and groove wooden board with various profiles c) 6 mm - 9 mm plywood

Fig. 5 a. Alternative materials in current use for exterior wall designs.



Roof covering

ing

layers

a) Tiles (mainly concrete)

on battens, usually with asphalt roofing

felt over the sheath-

b) Asphalt shingles

c) Asphalt felt, two

Fig. 5 b. Alternative materials in current use for roof desians.

fibreboard



Fig. 5 c. Alternative materials in current use for timber floor designs.

Competitive position

Wood has always been the traditional building material in large parts of Scandinavia, due to availability from local resources. But a prime reason for today's strong position of timber frame house construction in Scandinavia, as indicated in the introduction, is its adaptability to changes in technology and requirements.

The construction principle allows the designer and builder to select between various materials and construction techniques to provide an optimal performance/cost solution. One result of this process during the last 25 years has been a reduction in wood material used for an ordinary house to about one half, while construction time has been cut to one third. Building timber frame means the use of light materials, which is equally important in transportation as for the handling on site. This allows also small builders with light and inexpensive equipment to operate effeciently. The dry building process allows fast completion as problems with the drying of in situ concrete etc. are minimized. It is also important that timber frame construction can go on continuously through the cold winters.

The quality of framed houses depend on skilled workers who understand why good workmanship is needed in a number of critical details. This may be details related to air-tightness, to avoid excessive moisture content causing rot or paint blister, squeaking floors etc. Lack of skilled workers may sometimes favour other building systems. On the other hand prefer most habitants houses made of wood because they are familiar with this material and are able to carry out maintenance, rebuilding and alterations themselves.

One of the most important competitive features of the timber framed house is the adaptability to increasing thermal insulation requirements. Design work is easier than with other construction systems, especially because the structural components do not form severe thermal bridges.

Total cost figures from Norway, including the running cost of maintenance and heatloss, shows well insulated timber framed walls to be the cheapest external wall construction on the market, along with steel framed systems based on cold-formed steel profiles. Economic considerations indicates that timber frame construction will continue to keep its strong competitive position in Scandinavia.

Future trends and new designs

It is believed that the following factors will be among the most important affecting the further development of timber frame design as far as materials and construction techniques are concerned:

- Energy conservation. New building code requirements with lower U-values are already introduced to save energy on a national level. The effect of heating cost on private economy may even result in the use of better thermal insulation than the minimum code requirements. Better control of air infiltration and ventilation may also affect the design of joints between building elements and the use of materials for barriers against air penetration.

- Skilled work force. A shortage of skilled carpenters and other specialized building workers is foreseen as an increasing problem. This leads to stronger efforts in the development of prefabricated components where fast and simple erection on site is a primary goal. More prefabrication is also required to meet demands related to more stationary jobs and sheltered working places.

- Individual house design. Areas with a large number of houses looking almost totally standardized are now being avoided. There is a need for using systems which offer maximum opportunities in individual design, combined with the economic benefits of using long series of standard building operations and purchasing materials and components in as large quantities as possible. Effective combinations of prefabrication and building on site are required. - *Timber resources*. A shortage of sawn wood with large dimensions and good quality is gradually becoming more significant. At the same time new technology leads to more possibilities in automatic production of composite materials and components, in particular based on gluing techniques combined with automatic handling and quality control.

The effect of new thermal insulation requirements in national building regulations have already had a noticeable effect on Schandinavian timber frame design. The thickness of mineral wool in external walls is now increased to 150 mm or more. This is obtained by switching to wider studs and/or placing horizontal ribbons to one or both sides of the studs as indicated in figure 6.



Fig. 6. Examples of external walls with horizontal ribbons to provide space for increased thermal insulation.

Increased thermal insulation in roofs is now resulting in larger members for the lower chords in trussed rafters as the thickness of mineral wool and not structural calculations are governing the design.

I-shaped profiles made of wood and structural, woodbased sheet material have so far mainly been utilized as plywood beams for more specialized structures. Time seems now more ready for the introduction of I-sections in ordinary timber frame house building. It is now possible to produce this type of members to a competitive cost when thick walls (minimum 200 mm) and high roofbeams or floor joists (minimum 250 mm) are required. An example of commercially available I-sections are shown in figure 7. This type of members combine high strength and stiffness, little shrinkage and accurate dimensions, and they can be produced by using rather small timber dimensions. Another I-section design, from USA, is using a plywood web and flages of «micro-lam» instead of solid wood to ensure a more uniform quality.



Typical cross section of roof with thermal insulation

Fig. 7. Example of I-sections for studs and beams, commercially available for timber frame housing (Masonite of Sweden). The beams will have a longer permissible span than solid wood members, thus providing better opportunities for roof and floor designs.

Laminated timber may be more widely used in ordinary house construction. Laminated members are often used for the architectural effect and the appearance alone, particularly in more expensive house design. However, the effect of high material cost for lamination can partly be offset by fast erection. The use of a simple load-bearing structure of large laminated beams and posts combined with prefabricated elements and components is a concept that already has proved to be economically interesting. New developments in stressed-skin and sandwich panels are expected to appear on the market in increasing numbers. Specialized sealing systems for joints, like polyurethane foams, rubber sealing strips etc., will probably be more widely used in wodden house building.

Solid timber boards are still the most popular external cladding in Scandinavia, particularly in Norway and Sweden, even for the most expensive houses. Brick veneer does also have a strong position, having good appearance and virtually no need for maintenance, which partly make up for a high initial cost. A number of new cladding materials are marketed every year, mainly metal- and woodbased sheet materials. These are often claimed to require very little maintenance. However, it looks like private house owners in particular are ready to do the necessary maintenance themselves on traditional timber claddings, as well as other parts of their wooden houses. The use of grouping systems for the structural utilization of timber from multiple species forests

R.H. Leicester BE MSc PhD, Principal Research Scientist, CSIRO Division of Building Research, Highett, Victoria, Australia.

F.A. Blakey BE PhD, Chief of Division, CSIRO Division of Building Research, Highett, Victoria, Australia.

Summary

Many developing countries are located in tropical regions that are forested with mixtures of numerous species of trees, often numbering several thousand within a single country. If most of these species are to be utilized for structural purposes, it is not feasible to derive or to make use of detailed structural information on each individual species. Rather, the various species of timber must be grouped with respect to their structural properties. In Australia, methods of grouping timber for this purpose have evolved over a period of some 40 years, and these should be useful guidelines for the development of international systems of grouping. Of particular value to developing countries are grouping methods that can be used when there are only limited data available.

Sommaire

Beaucoup des pays en voie de developpement se trouvent aux régions tropicales où poussent les mélanges des espèces d'arbres, peut-être milles d'espèces à l'interieur d'un pays simple. Lorsque la plupart des espèces soient utilisé comme les materiaux de béton, il n'est pas utile à dériver ou utiliser l'information de résistance detaillée sur chaque espèce individuelle. A la place de cette information, il faut qu'on groupe les espèces de bois divers à propos de leurs charactéristiques de résistance. En Australie, des méthodes de groupement des bois ont évolué pendant les derniers 40 ans, et ces méthodes collectives soient les indications utiles pour le developpement des systèmes collectifs internationaux. Les systèmes collectifs, qu'on peut utiliser lorsqu'il y a seulement les données limitées, ont la valeur spéciale aux pays en voie de developpement.

Introduction

Most developing countries are located in tropical regions that are forested by numerous species of trees. For example, Pong Sono (1) has listed approximately 200 species of merchantable timber in Thailand; and Espiloy (2) notes that in the Philippines there are over 2000 species, of which several hundred are presently merchantable. If it is intended to utilize most of the species in a multiple species forest, then it is not feasible to base utilization on the use of detailed structural information provided for each individual species. This would require excessive material testing, excessive numbers of designs by engineers or architects, and excessively complex building regulations. In practice, these difficulties would be compounded further because the timber is often sold in mixtures of species.

It is only really feasible to use multiple species forests if the forest species are grouped with respect to their structural properties. Each of these groups can, in effect, then be regarded as hypothetical new species. In this way, the timber from multiple species forests can be regarded as belonging to a small set of hypothetical species, which may then be handled with the usual Standards and systems that have been developed in countries which utilize only a few species of timber.

The following is a brief discussion on the use of grouping systems for the structural utilization of multiple species forests. Much of this is based on systems that have evolved in Australia over a period of 40 years, and are now used in several developing countries. Although this paper concerns only the use of grouping systems based on structural properties, it will be obvious that similar systems which have been developed for other design properties such as shrinkage and durability, can also be applied with benefit.

Examples of structural grouping systems

Tables 1 and 2 show two examples of grouped design parameters given in the current draft revision of the Australian Timber Engineering Code, Standard AS 1720 (3). In Table 1, the basic design bending strength, tension strength and stiffness are given for stress-graded sawn timber and in Table 2 the basic design strengths are given for laterally loaded nailed joints. Thus it is intended that for structural utilization purposes, every stick of stress-graded sawn timber, regardless of the species and method of grading, must be classified as being in one of the twelve stress grades F2-F34. Similarly, every stick of structural timber must be classified into one of the four joint groups J1-J4 if used green or JD1-JD4 if used seasoned. Consequently, users and building regulatory authorities should specify timber according to these limited sets of stress grades and joint groups, rather than according to species and grading methods.

In order to apply grouping systems it is also necessary for timber producers to specify the strength classifications of marketed structural products from a species or mixtures of species. Tables 3 and 4 give typical examples of the classification systems used in the draft revision of the Standard AS 1720 (3). Table 3 gives classifications for a single species and Table 4 for a mixture of species. In terms of these classifications, the draft revision of the Standard gives design parameters for pole timber, sawn timber, plywood, laminated timber and many types of metal connector joints.

TABLE 1 Design parameters for graded sawn timber

	DESIGN PARAMETERS			
STRESS GRADE	Basic bending strength (MPa)	Basic tension strength (MPa)	Modulus of elasticity) (MPa)	
F34	34.5	20.7	21500	
F27	27.5	16.5	18500	
F22	22.0	13.2	16000	
F17	17.0	10.2	14000	
F14	14.0	8.4	12200	
F11	11.0	6.6	10500	
F8	8.6	5.2	9100	
F7	6.9	4.1	7900	
F5	5.5	3.3	6900	
F4	4.3	2.6	6100	
F3	3.4	2.0	5200	
F2	2.8	1.7	4500	

TABLE 2 Design parameter for nailed joints subjected to lateral loads

TIMBER JOINT GROUP		BASIC LATERAL LOAD CAPACITY (N)			TY (N)
Green timber	Seasoned timber	d=2.5	d=3.15	a=4.5	d=5.6
	JD1	435	650	1220	1780
Jl	JD2	330	490	915	1346
J2	JD3	260	385	720	1060
J3	JD4	185	275	515	755
J4		130	195	365	540
d = nail diameter (mm)					

TABLE 3 Strength classifications for Sydney blue gum (Eucalyptus saligna)

PROPERTY		DESIGN CLASSIFICATION		
		Green timber	Seasoned timber	
Stress grade for pole timber		F27	-	
Stress grades for GF=0.75 sawn timber* GF=0.60 GF=0.48 GF=0.38		F22 F17 F14 F11	F27 F22 F17 F14	
Stress grade for GF=0.60		-	F22	
Strength group		S2	SD3	
Joint group		J2	JD2	
<pre>* GF = grade factor = MOR of graded timber MOR of small clear timber MOR = bending strength</pre>				
Port - Dendring por engon				

A detailed description of Australian grouping systems is given elsewhere by Leicester and Keating (4). In a later section of this paper, a brief discussion will be given on some methods for classifying timber into the appropriate groups.

TABLE 4 Strength classifications for mixed Victorian hardwoods

PROPERTY		DESIGN CLASSIFICATION		
		Green timber	Seasoned timber	
Stress grade for pole timber		F17	-	
Stress grades for sawn timber*	GF=0.75 GF=0.60 GF=0.48 GF=0.38	F14 F11 F8 F7	F22 F17 F14 F11	
Stress grade for plywood*	GF=0.60	-	F17	
Strength group		S4	SD4	
Joint group		J3	JD3	
* GF = grade factor = <u>MOR of graded timber</u> MOR of small clear timber				
MOR = bending strength				

Benefits from the use of grouping systems The essential effect arising from the use of grouping systems in the utilization of timber is to introduce an intermediate step between the measured properties of timber and the rules of building regulations. This is illustrated schematically in Fig. 1.



Figure 1. Schematic illustration of the effect of using grouped design parameters $% \left({{{\left[{{{\left[{{{c}} \right]}} \right]}_{{\rm{c}}}}_{{\rm{c}}}}} \right)$

The most obvious consequences of this is that building regulations need be concerned only with limited sets of design parameters, rather than a great number of real timber properties. For example, in Australia the Standard AS 1684-1979, the SAA Timber Framing Code (5), through a limited set of tables covering only eight stress grades, manages to present timber sizes for domestic construction applicable to all grades of green timber for several hundred species. As another example, the United Nations Industrial Development Organisation has in preparation a set of standard designs for wooden bridges which is based on only eight strength classes; and yet it is applicable to the commonly available timber species of India, South and Central America, West and East Africa, the Pacific Region and South-East Asia (6).

Another benefit of grouping arises from the fact that it enables the marketing of timber to be carried out in terms of structural properties (such as stress grades) rather than in terms of production factors (such as species and grading methods). This obviously simplifies matters for the design engineer or architect, whose acquaintance with timber technology may be very limited. More importantly however, it provides the producer with an increased flexibility in his operations, since now a large number of timber species may be used to meet a given market demand. This is particularly useful in the marketing of the lesser known species.

Finally, a less obvious but important benefit arising from the use of grouping methods is that it can be used to provide an effective separation between problems related to timber properties and those related to building regulations. This means that in making amendments to one area, the other is not affected.

<u>Methods for the classification of timber into group-</u> ing systems

The great range in the availability and market conditions of the numerous species utilized leads to a corresponding range in the expense and type of technology that is most suitable to apply in classifying the various species. For example, in Australia sawn timber is classified into stress grades by the three following methods:

- (i) visual grading combined with mechanical tests on small clear timber specimens;
- (ii) visual grading combined with mechanical tests on structural size timber members;
- (iii) mechanical grading combined with mechanical tests on structural size timber members.

In addition, a fourth method based on proof testing is under consideration.

Experience has shown that it is best to permit the use of any reasonable classification technique, and to write fairly rigorous Standards on methods for checking the structural properties of the classified timber.

Because of the large number of species involved, the effective utilization of multiple species forests requires not just the use of grouping systems, but also the use of classification methods based on low-level technology, particularly for the classification of lesser-used species. One such method is based on strength grouping (4) as described in the SAA Miscellaneous Publication MP 45 (7). To date, timbers grouped according to MP 45 include 630 Australian species (7), 700 African species (8), 362 South-East Asian species (9) and 190 South American species (10).

<u>Timber grouping systems for international standards</u> At a meeting in Ottawa, in September 1979, the International Standards Organisation's Committee ISO/TC 165, concerned with drafting an international timber engineering code, set up a working group to draft methods for grouping timber based on structural properties. The use of internationally accepted grouping systems will lead to obvious benefits with respect to international trade involving structural timber, and also assist in the transfer of technology software, such as for example timber framing codes for housing. These benefits will be considerably enhanced if the use of grouping is associated with a set of preferred structural timber sizes and tolerances. This will simplify the transfer of technology software and is probably an essential prerequisite to constructing grouping systems for timber composites such as glulam and plywood.

In a brief literature survey reported elsewhere (4), it is noted that, apart from Australia, grouping systems are in use or have been proposed for several countries in East and West Africa, Fiji, Indonesia, Laos, Malaysia, Papua New Guinea, Singapore, the Solomon Islands, parts of South America, and the United Kingdom. Of these, it would appear that Fiji, Kenya, Nigeria, Papua New Guinea, Tanzania and the Solomon Islands are using the current Australian grouping systems, and that the classification systems used in many other countries closely resemble earlier Australian systems (11). In addition, the current Australian systems are being used in at least one United Nations development project (6). Because of their widespread usage and extensive development, the current Australian grouping system could form a useful starting point for developing international systems for grouping.

Recommendations

If multiple species forests, a common feature of many developing countries, are to be effectively utilized for structural purposes, then it is essential to use grouping systems for the specification of the structural properties of timber. This makes possible the utilization of numerous species simultaneously, and provides many other benefits to producers, designers and building regulatory authorities.

The use of internationally accepted grouping systems would assist in the trade of timber and the transfer of technology software between countries. Australian grouping systems, which have evolved over several decades and are already applied in several developing countries, should be useful in providing guidelines for the development of international systems of grouping. <u>References</u>

1. Pong Sono. Merchantable Timbers of Thailand. Symposium on Research and Marketing of South East Asian Timbers and Timber Products, organised by the German Foundation for International Development (Berlin) and the Government of the Republic of the Philippines. Manilla and Los Baños, Philippines, 19-23 November 1974, pp. 120-165.

2. Espiloy Jr., E.B. Strength Grouping of Philippine Timbers for Utilisation of Lesser-Known Wood Species. Forest Products Research and Industrial Development Commission, National Science Development Boards, Technical Note No. 187, March 1978.

3. Standards Association of Australia. Australian Standard AS 1720-1975, SAA Timber Engineering Code. Sydney, Australia (Draft revision, 1980).

4. Leicester, R.H. and Keating, W.G. Strength Classifications for Timber Engineering Codes. CSIRO Division of Building Research Technical Paper, Melbourne, Australia (In Press).

5. Standards Association of Australia. Australian Standard AS 1684-1979. SAA Timber Framing Code. Sydney, Australia, 1979.

 United Nations Industrial Development Organisation. Low Cost Modular Prefabricated Wood Bridges.
 Vienna, Austria (In Preparation).

7. Standards Association of Australia. SAA Miscellaneous Publication MP 45-1979. Report on Strength Grouping of Timbers. Sydney, Australia, 1979.

8. Bolza, E. and Keating, W.G. African Timbers -The Properties, Uses and Characteristics of 700 Species. CSIRO Division of Building Research, Melbourne, Australia, 1972.

9. Bolza, E. and Keating, W.G. Characteristics, Properties and Uses of 362 Species and Species Groups from South East Asia, Northern Australia and the Pacific Region. CSIRO Division of Building Research, Melbourne, Australia (In Press).

10. Berni, C., Bolza, E. and Christensen, F.J. Characteristics, Properties and Uses of 190 South American Timbers. CSIRO Division of Building Research, Melbourne, Australia, 1979.

ll. Pearson, R.G., Kloot, N.H. and Boyd, J.D. Timber Engineering Design Handbook, Jacaranda Press, Brisbane, Australia, 1962.
Use of the Feed-Back Information in Housing Appraisal

Şahap Çakın

Dipl.Eng.Arch., M.Arch.,Ph.D.

Assistant Professor of Architecture

Building Research Center, Istanbul Technical University, Turkey.

Summary

The present paper aims at examining the ways of which feed-back information obtained from housing evaluation and user studies are utilized in designing new housing schemes and remodeling old houses. Theoretical issues in relation to the subjective and normative evaluation of housing are reviewed. Various methodologies for housing evaluation are discussed.

A model for housing evaluation and appraisal is introduced. The model is discussed in relation to its output in the form of appraisal kits, programmes and design guides for housing. Relationships between the quantitative aspects of the residential environment that are consisted of the spatial, environmental, functional and economical performance attributes, and the qualitative aspects as determined by user requirements and preferences that are measured by questionnaires and observations, are emphasized. The importance of the feed-back approach for developing countries with very limited resources to design, build and maintain housing, are discussed.

Sommaire

L'objectif de cet proclamation est la recherche des possibilités d'utilisation des connaissances obtenues de l'evaluation des habitations au sujet de design des habitations nouvelles et renouvellement des anciennes. Il s'agit des allures theoriques à propos de l'evaluation subjective et normative des habitations et des divers methodes de l'evaluation.

Un model est presenté pour l'evaluation des habitations. Ce model et ses composants qui sont les paquets d'evaluation, les programmes des habitations, les quides de "design" sont discutês relativement. Les relations entre l'aspect qualitatif qui s'est formé par les preferences et les volontés des employeurs apprecié avec les enquites et observations et l'aspect quantitatif qui s'est formé par performances spatiales, fonctionnelles, economiques et environnementales sont precisés.

L'importances de l'allure feed-back est determiné pour as pays sous developpés qui out les sources insuffisantes a propos de design d'habitation, de production et d'entretion.

Introduction and Theoretical Issues in Housing Appraisal

Research in building design reveal that environmental designers face difficulties in predicting the consequences of decisions they make in the design process. The uncertainity about the strength and direction of those design variables under architect's control and others outside his/her control appears to be one of the major difficulties architects face in housing design. Although some statistical techniques can be used to identify the most important aspects of the residential environment, there still exist uncertainities in the ways of which behavioral, social and cultural factors influence the residential environment [1].

<u>Building appraisal</u> is based on the notion of feedback or the return of information about what happened last time [2]. It is a procedure for providing information about buildings, in our case, houses when they are in use. Environmental design professions are quite familiar with the concepts of housing appraisal and evaluation. A substantial proportion of the architectural literature is devoted to the recordings of drawings, models and photographs of housing schemes to expose the works of architects to others in a process of mutual appraisal. Although the aesthetic judgements on the exterior architectural forms still prevail, there is a growing concern for <u>evaluation based on the sociological and behavioral</u> <u>criteria</u> derived from the users requirements and preferences.

Observations of the housing estates show a number of building defects which are not necessarily caused by inadequate maintenance or construction faults, but the wrong assumptions made in the process of programming and design. Similarly, when users are asked to evaluate their residential environment, their complaints tend to focus on the issues which are originated from the wrong assumptions made by designers [3]. Findings of evaluation research reveal the role of systematic housing appraisal as a learning process and support the argument that it should be regarded as an integral part of the housing procurement process, i.e. programming, design, construction and occupancy.

The primary aim of housing appraisal should be to examine the relationships between human requirements and the housing environment with a view to formulate new guidelines for programming and design, standards and norms for space utilisation [4]. Secondly, it should provide right answers to four major questions; what is to be evaluated; where should the evaluation take place; when should it take place; and for whom should it take place. Research on the investigation of conflicts between the planned and actual use of residential environments, of the open spaces and interiors aim at gaining insight into the behavior/environment interface in the housing context. Some researchers argue that the <u>behavioral ecological</u> <u>approach</u> would form an appropriate basis for subjective evaluation [5]. To some others, appraisal would be the most suitable stage in environmental design process where users can participate in making the vital decisions about their immediate environment [6].

A different approach to provide a theoretical framework for systematic evaluation is offered by Hillier and Leaman [7]. In the Four-Function Model, built environment can be appraised from the climatic, functional, symbolic/cultural and economical aspects. Broadbent suggests a conceptualized system of people, building and environment that seems to form a canprehensive framework for housing appraisal [8]. In his conceptualization, human system consists of user requirements and client objectives. Building system includes building technology and environmental comfort. Environment system has two sub-groups; (a) Physical Context; i.e. physical characteristics of the site and related constraints; (b) Cultural Context, i.e. social, political, economical, scientific, technological, historical, aesthetic and religious influences on the built environment.

A conceptualized <u>system of people and buildings</u> is introduced by the Building Performance Research Unit [9]. The proposed model of people and buildings includes five sub-systems, namely the building, environmental, activity, objectives and the resources sub-systems, which are all open to the influences of the economical, cultural, political, climatic changes and to the factors related to site characteristics. Building appraisal studies based on this particular framework are noted elsewhere [10].

Methodologies in Housing Appraisal

Some of the methods employed in the housing appraisal provide us with the tools to measure effects of the residential environment on behavior subjectively, and others normatively. In situations where post-occupancy evaluations are possible, the side-effects of the experimental setting can be avoided. Campbell discusses the use of <u>behavioral maps, time budgets</u> and <u>activity charts</u> in recording users behavior in residential environments[11]. Depending on the objectives of the housing appraisal study, direct <u>observations</u>, <u>questionnaires</u>, <u>interviews</u> and indirect <u>cognitive techniques</u> can be useful at varying degrees. The main criteria in selecting methods for evaluation should be the savings in time and money, and the methods potential to obtain reliable results.

In the subjective evaluation of a residential area, the lack of norms or standards for human behavior often necessitates a comparison between two or more different situations. Results of a <u>survey</u> on space utilization patterns could be compared with the findings of observations made on the same user group. Alternatively, results of two surveys conducted on two different groups are compared to identify interrelations between behavior related variables and certain features of the built environment. <u>Unobstrusive observations</u>, <u>surveys and inter-</u><u>views</u> are usually conducted on particular representative groups, selected from larger populations. <u>Stratification</u>, <u>multi-stage sampling</u>, <u>time</u>, <u>spatial</u> and <u>event sampling</u> <u>methods</u> are worth mentioning among techniques used in recording users behavior.

The primary purpose of the experimental approach in the field of environment/behavior is testing one or more hypotheses on the relationships between behavior and environment related variables. One of the major difficulties in experimental design lies in controlling the <u>interfering variables</u>. Howeverg the effects of such variables on the variations observed in the dependent variable can be eliminated by distributing them among different experimental conditions. The experimental approach appears to be more effective in revealing causal effects than the observation, as long as the interfering variables are controlled. However, observations carry the advantage of revealing facts in natural settings.

Two types of housing evaluation can be distinguished; summative and normative. Summative evaluation involves in comparing the extent to which buildings, or in our case residential environments are fulfilling their intended goals. This type of evaluation consists of a comparison between what is actually occurring and what should be occurring. In the formative evaluation, the problem would be to understand the nature of the fit between building and the users so that it can be improved by making modifications to the building. The formative evaluation would be most appropriate where a few houses in a housing estate were purposely constructed on a pilot basis with future adjustments in mind. There seems to be a number of problem areas in housing appraisal which should primarily concern the evaluator, client organization and the designer.

The first concern of the housing evaluator should be to determine who needs appraisal and for what purpose. The type of evaluation that will be appropriate, depends very much on the level of organization requesting it and the kind of decision involved.

The second problem lies in defining the goals in such a way as to make them measurable. Goals should be defined before determining whether the goals of the housing programme are being met and when and how to measure them. The evaluator is confronted with a challenging task defining the behavioral objectives.

The third concern presents itself in choosing an appropriate <u>plan for data collection</u>. When the behavior of the users are observed, it might not be possible to tell whether the behavior is caused by certain aspects of the residential environment or by other factors such as the types and personalities of users and the users past experience with other environmental settings. The comparison between users behavior in a particular residential environment with of those in similar environments can aid in determining whether users act as they do because of the design features or because of other reasons. Assuming similar occupant characteristics and similar activities different responses to the buildings are more likely to be related to the physical features of the residential environment.

The fourth type of problem arises in assessing the impact of the remodeling or rehabilitation projects. Data should be collected before and after remodeling to see if changes in the behavior meet what was expected. Alternatively data can be collected on a control group in a similar setting that did not experience remodeling. Temporary changes in users behavior requires continuous assessment of building use over the period of occupancy.

The fifth difficulty exists in <u>choosing the appropri-</u> <u>ate measuring instruments</u> for users behavior. In housing estates where the actual use of buildings is quite different from their planned use, measures of user behavior should be accompanied by measures of the physical features of the housing areas. Direct and cognitive measures of behavior such as satisfaction with the environment can both be useful. Because of the inherent imperfection of current measures in housing appraisal, it is very useful to utilize more than one measure for each dimension of the behavior where possible.

Final concern involves in the mode of presenting results which could influence the impact of the housing appraisal. The summary of the findings should be presented with charts, graphs, photographs for an effective communication. The implications of the findings should be considered and clear recommendations should be made. Because the value of the evaluative information lies in its impact upon future projects, findings of the housing appraisal should become available to others in the profession through publications.

A Proposed Framework for Housing Appraisal

A <u>framework/model for housing design evaluation and</u> <u>appraisal</u> is presented (Figure 1). The model consists of vertical and horizontal dimensions. Horizontally, the residential environment is represented visually or numerically, then its performance is measured. Finaly the measured performance attributes, including the cognitive ones are evaluated against a number of <u>objective and</u> <u>behavioural criteria</u> like standards, norms, costs, benefits or comparison with an ideal state.

Vertically, the model includes five stages, i.e. <u>programming, design, construction, occupancy and post-</u> <u>occupancy evaluation</u>. <u>Inputs</u> consist of the objectives and structure of the client organization which initiates the housing procurement process. A programme for the residential facility is prepared by the client organization, designer or the specialist programmer. Programme should include <u>descriptive and comparative information</u> about the individual spaces in houses, dwellings, blocks,



Figure I. A proposed Framework for Housing Appraisal.

zones, the estate and the private and public outdoor spaces. Programme is then transformed into a design scheme or alternative schemes by the designer. Occupancy follows construction and housing-in-use is then appraised <u>quantitatively and qualitatively</u>. An important feature of the model is its provision of monitoring changes in the behavior or design related variables to examine relationships between the quantitative and qualitative attributes. Qualitative and quantitative aspects may be investigated on houses-in-use or on simulations of these.

The quantitative aspects include attributes of the spatial, environmental, functional and economical performance. Qualitative aspects consist behavior based information obtained from the users. User requirements,

422

preferences and behavior are recorded by means of techniques like surveys-interviews, questionnaires, and observations.

Three types of model output are noted:

Housing Appraisal Kits (HAK)

These are developed as instruments to use for post-odcupancy evaluation. HAK aim at enabling housing organizations to find out what residents think about the design and layout of their dwellings. HAK reduce the cost of appraisal to a minimum and cut out the need to plan a survey from scratch each time. Since HAK provide results in standard form comparisons can be made between surveys carried out at different times and on different users [12].

HAK should inculde <u>computer programmes</u> for testing the functional, spatial, environmental and economical performance of housing schemes. Results as performance indices can be represented graphically and evaluated against objective criteria. Because of their potentially widespread use and standard forms, HAK provide the opportunity for setting up <u>data banks</u> of housing survey material and performance attributes in particular cultural contexts. Although surveys carried out within one year of occupancy will be less reliable, there may be cases where an early feed-back might influence the design of a further stage of the same housing scheme.

Guidelines for Programming

The results of the HAK lead to formulating guidelines for programming which include <u>generic programmes</u> for housing, <u>descriptive and comparative information</u>.

<u>Guidelines for Designing Residential Environments</u> Housing design guides (HDG) are based on compilations of the latest research about <u>functional, behavioral</u>, <u>esthetic and technical determinants of design</u> [13]. They can be defined as comprehensive reports presenting the information necessary to make basic design decisions for housing or for the needs of special populations such as the elderly, the handicapped and the children.

HDG interpret and apply the latest research information on the environment/behavior interface to new design guidelines. <u>Housing desing criteria</u> included in the guides can be founded on basic research done in other desciplines, i.e. psychology, sociology, anthropology, social geography and physiology. HDG as the output of the proposed model should be presented in the form of broad, conceptual design ideas combined with detailed and specific criteria for various parts of the residential environment such as the children's play areas or house kitchens. They should facilitate a more informed design process, reduce the need to rely on intuition or personal experience and shed light on design issues that may not receive designer's attention.

The evaluator could make use of the proposed model in a number of ways:

o To appraise systematically a single housing scheme and modify it to obtain the best solution.

- o To combine the qualitative and quantitative attributes in housing appraisal.
- o To examine causal relationships between quantitative and behavioral variables in the residential environment.
- o To feed behavioral and quantitative information obtained from the housing appraisal study back to the programmes and new designs for housing.
- o In the light of the information gained from appraisal, to suggest modifications to former house designs or new uses for old houses.
- o To develop a data bank for housing from the HAK.
- o To formulate programming and design guides for housing available for use by the client organizations and the designers.
 - Discussion

The feedback approach in housing programmes undertaken in the developing countries with limited resources to design, build and maintain housing carries a special importance. <u>Housing Appraisal Kits, Programming and Design</u> <u>Guides</u> will lead to significant savings in public housing programmes.

As noted by Ostrander [14], the major value of housing appraisal is to utilize the research findings as a basis for learning through feedback. Housing appraisal should also be regarded as a form of research in the man/environment field that bridges the <u>applicability gap</u>. As to the implications on the future design and programming practice, a number of situations are noted where the proposed framework could have potential use.

- o Housing appraisal kits can be used for testing the performance of dwellings-in-use in different cultural contexts.
- o Programming and design guidelines for housing can be utilized in the new building and rehabilitation projects initiated by the local and central authorities.
- o The proposed approach can be useful in the systematic evaluation and selection of alternative design proposals for housing at the early design stages in public and private architects offices. Alternatively, it can be used in architectural competitions.

References

 Çakın, Ş. <u>Çevre Değerlendirilmesinde Bir Uygulama</u>, In Turkish (A Case Study in Environmental Evaluation).
 In Z.Ertürk (Ed.) Tasarım ve İnsan Bilimleri Semineri Bildirileri (Proceedings of the Seminar on Design and Human Sciences), Trabzon: Karadeniz Teknik Üniversitesi, Şubat 1979, pp.17/1-17/11.

[2] Lee, T. Psychology and the Environment. London 1976.

[3] Çakın, Ş. A Case Study of the Qualitative Appraisal of Jointly Used Spaces. Proceedings of the 4th International Architectural Psychology Conference, Louvain-la-Neuve: July 1979. [4] Çakın, Ş. Çevrenin Değerlendirilmesinde Yöntem Bilimi. In Turkish. (Methodology in Environmental Evaluation) In M.Pultar (Ed.) Çevre, Yapı ve Tasarım (Proceedings of the 1st Congress of Architectural Sciences), Ankara: Çevre ve Mimarlık Bilimleri Derneği, 1979 pp. 129-144.

[5] Wandersman, A. Applying Humanism, Behaviorism and a Broader Social Developmental View to Understanding and Researching the Design Process. In Suedfeld/Russell (Eds.) The Behavioral Basis of Design, Book 1-EDRA7. Stroudsburg: Dowden, Hutchinson and Ross, 1977 pp.9-20.

[6] Çakın, Ş. Evaluation and Participation in Design.Unpublished Ph.D.Thesis, Glasgow: University ofStrathclyde, 1976.

[7] Hillier, B., Leaman, A. A New Approach to Architectural Research. Proceedings of the Seminar on Four-Function Model. York: Institute for Advanced Architectural Studies, 1974.

[8] Broadbent, G. Design in Architecture. London 1973.

[9] Building Performance Research Unit Building Performance. London, 1972.

[10] Çakın, Ş. A Case Study of the Qualitative Appraisal of Jointly Used Spaces. Proceedings of the 4th International Architectural Psychology Conference, Louvainla-Neuve, July 1979.

[11] Campbell, D.E. Evaluation of the Built Environment: Lessons from Program Evaluation. In Suedfeld/ Russell (Eds.). The Behavioral Basis of Design, Book 1-EDRA 7, Strondsburg: Dowden, Hutchinson and Ross, 1977 pp.227-234.

[12] Housing Development Directorate, DOE. Housing appraisal Kit. Vol.1, London, 1978.

[13] Cohen, U. <u>Research Applications to the Profession</u>.A.I.A. Wisconsin Architect, September 1979 pp.17.

[14] Ostrander, E.R. Maximizing Cost Benefits of Post-Construction Evaluation. In Suedfeld/Russell (Eds.) The Behavioral Basis of Design, Book 1-EDRA 7, Stroudsburg: Dowden, Hutchinson and Ross, 1977 pp.241-245. The using of decreased energy consumption adhesives for production of leminated timber structures

Freidin A.S., D .Sc. (Eng.), CNIISK, Gosstroy USSR, Moscow, USSR

Summary. Increasing of economy of glued timber structures can be made by using decreased energy consumption adhesives in their synthesis, during the process of gluing and for ventilation and an environmental protection. Utilization of products made of combustable shale instead of resercine gives the possibility for a wide use of decreased energy consumption alkyl-resorcine adhesives FR-100, DFK-IAM, FRF-50, DFK-I4 of high quality for production of load-bearing and enclosure structures. Diminution of phenol content (about I%) in those adhesives and is a new phenol adhesive SFH gave the possibility for a considerable decrease of energy consumption for ventilation, heating and cleaning of the air in the plants.

The use of one-part phenol-polyvinylacetate and other water-dispersion adhesives without flammable and toxic substances for glueing of timber is very perspective.

Resume. L'economie de production du bois lamellé-colle peut être atteinte par utilisation des liants exigeant une consommation d'énergie réduite lors de leur synthèse et collage aussi bien que pour l'aérage et la protection du milieu ambiant. L'utilisation des produits du traitement des pyroschistes au lieu de la résorcine, donne la possibilité d'appliquer les liants à base alkoyie-résorcine ou phénol-alcoyle-résorcine à capacité d'absorption de l'énergie réduite, à la fabrication des éléments portants et protecteur en bois lamellé-collé. La réduction de la teneur en phénol dans ces liants a permis de dimineur considérablement la consommation d'energie pour la ventilation, le chauffage et l'épuration d'air.

L'auteur juge avantageux d'utiliser les liants a base phénol-acétate polyvinylique et autre colles en dispersion à base d'eau pour le collage du bois. The economy of glulam timber manufacturing is determined, among other factors, by energy consumption. Promising prospects in energy reducing can be found when using specially designed adhesives. The economy of energy is the product of the following:

I) to use the adhesives, which row material needs reduced energy consumption;

2) to use the adhesives, which allow to diminish energy expense in the process of glulam structure manufacturing;

3) to use the adhesives, that demand lower energy consumption for ventilation, heating and environmental protection.

The following are the results of some research in this field, made in the USSR.

I. It is well known that the highest quality adhesives for glulam structures are resorcinol and phenol-resorcinol adhesives. They are however very expensive, that is the result of a complicated manufacturing process of resorcin as row material for such adhesives. Besides, resorcin is applied in tyre production and that increases its deficiency and price.

The problem can be solved, however, by the application of resorcin derivatives, contained in the products of combustible slates at their thermal processing. During rectification of passing products, obtained in this process alkyl-resorcinols fraction is educed, that has 5-methylresorcin and similar products. This fraction has served as a basis for designing and commercial production of alkyl-resorcinol adhesives FP-IOO, DFK-IAM, and other for gluing wood, asbestcement, gas-concrete, foamplastics and other building materials. The application of alkyl-resorcin instead of energy-consuming resorcin decreased twice the cost of adhesives.

Still more economical are phenol-alkyl-resorcinol glues, for example, DFK-I4 where 30-50% of alkyl-resorcin is substituted by phenol.

All these adhesives are hardened similar to resorcinol adhesives, by adding of paraformaldehyde. All of them have the similar processing properties, given in Table I.

Table 1.											
Properties of resorcinol and alkyl-resorcinol adhesives											
Adhesives		Properties									
	solids %	visco- sity, sec. ac.VS-I	рН	pot life, h							
Resorcinol FR-I2	60	15-30	7,5- 8,5	2-4							
Alkyl-resor- cinol FR-IOO	55	15 - 30	7,9- 8,5	I							
Alkyl-resor- cinol DFK-IAM	60	15 - 30	7,5- 9,0	I - 2							
Phenol-alkyl- resorcinol DFK-I4	60	10-50	7,5- 9,0	2,5							

Alkyl-resorcinol adhesives are hardened at room or elevated tenperatures. Contact heating, high frequency current, etc. can be used for setting.

Some properties of glued joints (pine, oak and other species) with alkyl-resorcinol adhesives were detailed, as well as their cohesion, strength and deformability.

Cohesion properties of hardened alkyl-resorcinol adhesives are approaching those of resorcinol adhesives. Thus MOR and MOE of FP-100 adhesives are 620 and 25300 kg/sm² and of resorcinol adhesive FP-I2 are correspondingly 700 and 28000 kg/cm². The strength of these joints surpasses the strength of pine and other coniferous species and is quite comparable with the strength of oak, beech, etc.of hard wood. The resistance of pine joints with alkyl-resorcinol adhesives to cold and boil water (standard FOCT 17005-71) to cyclic temperature-moisture aging (TOCT 17580-72). to weatherability (FOCT 13100-73) to delamination of joints (ASTM IIOI-52) is similar to that of resorcinol adhesives.

Already 8 years have passed since we have started commercial production of straight and curved laminated bearing timber structures in coniferous species with much adhesives and their use in agricultural buildings, stores of mineral fertilisers, bridges, etc.

The use of alkyl-resorcinol adhesives in the manufacture of laminated structures, is envisages by the present USSR Standard. The licence for alkyl-resorcinol adhesives has been bought by Japan. 2. There are some ways of reducing energy consumption during the manufacture of glulam structures at the expense of adhesives. For example, the use of quick-setting adhesives reduces the pressing time and the energy consumed. Above mentioned alkyl-resorcinol adhesives FP-IOO and DFK-IAM belong to such adhesives. When the latter adhesives are used, glulam members achieve sufficient strength by 25-30% quicker than the members with phenol and resorcinol adhesives.

One component adhesives, that needn't preparation at the plants of manufacturing glulam structures can be used as a second way of reducing energy consumption.

Beside the known adhesives of a similar type, which are employed primarily in heated gluing (phenol adhesives, etc.), in the Soviet Union there are also phenol-polyvinylacetate adhesives PVAD-F; these are polyvinylacetate water dispertion, modified by phenol resin.

Gluing can be performed without heating, however the optimized alternative is the elevated temperature. Joints with PVAD-F resist cold and boil water, eccelerated aging, etc. They have less creep under permanent loading than non-modified polyvinylacetate adhesives including two-component (with the hardener) ones, but creep more then phenol and resorcinol adhesives. Due to this, the adhesive PVAD-F should mostly be used for end-gluing, for enclosure structures, doors, etc.

3. It is known that ventilation in the shop. where glue is prepared for processing and used, consumes a large amount of energy so that the allowable concentrations of toxic substabces, emitted in the course of manufacture are not exceeded. The most harmful substances, contained in the adhesives for timber are free phenol and formaldehyde; their allowable concentrations in the air of production premises shall not exceed 0,03-0,05 mg/m^2 according to the present standards. Acetone and some other organic solvents, introduced into some glues are also harmful. With such combustible substances in the adhesives it is necessary that mixers and extruders for adhesives shall be fire- and -explosure resistant, which naturally raises their price. Finally purification of sewage should be done, if any, thus increasing energy consumption.

Interchange of air and its heating and conditioning again results in the increase of energy consumption. Calculations have proved this to be the most considerable part in energy consumption.

The development of small-toxic adhesives without combustible solvents and their practical realization seems nowadays advantageous. Original phenol (SFH) and phenol-resorcinol (FRF-50) adhesives meet the above requirements and are already realized commercially.

In Table 2 the properties of FRF-50 adhesive are compared with the relevant adhesives made by leading firms of German Federal Republic, Sweden, Switzerland, etc. Data show that FRF-50 adhesive has free phenol I,5-3 times less comparing to the adhesives of these countries, although phenol-resorcin ratio in this adhesive is I:I. It's cost is 80% less than that of resorcinol adhesives. It doesn't contain any combustible solvents and is characterized by a long storage life of resin. It's processing and strength properties are quite comparable with those of resorcinol adhesives and its pot life is lengthened.

Phenol adhesive SFH has to I% of free phenol and formaldehyde at small alkaliscence. This is several times lower than toxic component percentage in the other similar coldsetting adhesives. It is set by a relatively weak sulphoacids and this reduces an agressive effect on wood.

It was found, that gassing toxic components in the air are not directly connected with their content in the adhesives. At 25 hourgluing with different adhesives, phenol can be emitted in the range of 0,7-2,8% and formaldehyde - 0,2-9,2% of their content in resin.

Besides sewage is absolutely excluded at the production af adhesives FRF-50 and SFH. Comprehensive practical evaluations have proved these adhesives to be adequate for all types of glulam structures.

Table 2.

				·		
Properties.			Adhesive	type		
Fropercies	USSR FRF-50	German Fede- ral Republic Rakoll RF-IOO	Finnland RF-30	Switzerland Aerodux 1858	France Sofrakol RF-70I0	Sweden Kasko 1710
	- 2		4			
Viscosity, sec, VS-I						
initial	8-13	4I	46	-	-	I33
final	-	300 (I ye- ar)	560 (4 months)	I27 (I ye- ar)	100 (2 y.)	900 (I/2 y.)
storage life of resin (months)	more 6	6	3	3 years	6	6
free phenol con- tent. %	3 - 6	15,3	3	18	5,5	7,0
pot life to I year. h	6–7	-	2	4	4,2	3
shear strength						
FOCT 15613-70, kg/sq.cm not less:						
pine	exc	ceeds the	strer	igth of	pine	
oak, beech	130 - 150	130-160	130-160	130-150	-	90
water proof						
ac. to FOCT 17005- 71	_	group	of higher	durabil ty	i- group of average durabili- ty	group of average - durabili- ty
cyclic aging resistance	group o: higher	durability	y group avera dural ty	o of age oili-	group of higher durabili- ty	-

Properties of phenol-resorcinol adhesives

<u>Conclusions</u>

I. Economical energy considerations at the production of adhesives for glulam timber structures include either glues with reduced energy consumption during their synthesis or at gluing, and arrangement of safety and environmental protection during manufacture.

2. It is shown, that new widely used decreased energy-consuming high quality alkylresorcinol and phenol-alkyl-resorcinol adhesives have been obtained from the products of combustible slate processing, which are used for bearing and enclosure structures.

3. Small-toxic phenol (SFH) phenolresorcinol (FRF-50) and phenolalkylresorcinol (DFK-I4) adhesives are less consuming in regard to ventilation, purification and heating.

4. One of the progressive trends are singlecomponent phenol-polyvinylacetate and other waterdispersed adhesives. Moment-rotation relationship for joints in roof trusses with metal plate connectors

Edwin N. Morris, B.Sc., M.Sc., F.I.W.Sc., Reader. Suresh Gajjar, B.Sc., Research Assistant. Department of Architecture and Building Science, University of Strathclyde, Scotland.

Summary

In order to make accurate analyses of timber roof trusses which are indeterminate structures with semirigid joints, it is necessary to have detailed information on the behaviour of the joints.

There have been many investigations into the strength properties of nailed joints and load-slip relationships have been developed, but in the case of joints made with metal plate connectors there is relatively little data.

This paper will show how the procedure used for analysing the behaviour of nailed joints can be applied to joints made with metal plates and will propose a method for deriving a general equation for the moment-rotation relationship which would apply to all types of metal plate connectors. A possible use of this general expression in conjunction with experimental data for the analysis of trusses will be discussed.

Sommaire

Afin de produire des analyses correctes sur les fermes de toit en bois, qui sont des structures indéterminées avec jointures semi-rigides, il faut avant tout posséder de l'information détaillée sur le comportement des jointures.

Plusieurs études sur la résistance des joints cloués ont été effectuées, ce qui a permis de développer des rapports charge-déformation, mais dans le cas des systèmes de jointures avec raccords à plaques de métal connectrices il y a relativement peu de données à ce jour.

Cet exposé se propose de montrer comment la procédure suivie pour l'analyse des différents comportements des joints cloués peut être appliqué aux joints à plaques de métal connectrices et offrira une méthode de dérivation d'une équation générale du rapport rotation-moment qui s'appliquerait à tous types de systèmes de raccordements à plaque de metal. L'éventualité d'une utilisation de cette formule générale en association avec les données expérimentales pour l'analyse des fermes de toit sera abordée.

1. Introduction

In recent years there has been an increasing use of timber roof trusses having metal plate connectors at the joints. This type of truss can be considered as being an indeterminate structure with semi-rigid joints.

To be able to analyse and design such a structure it is necessary to have detailed information relating to the joint behaviour under load for the following reason. When small loads are placed upon the truss a very small displacement will occur at the joints and they will be capable of resisting moments. As the loading is increased the displacement and rotation at the joints will become larger but following a non-linear relationship; this increased rotation produces a loss in rigidity, a reduction in the ability of the joints to resist moments and a corresponding change in the bending moment diagram for the rafters. Hence in order to establish the moments on the members for different loading conditions it is essential to have data relating to the joint behaviour, in particular the moment-rotation relationship. It is this aspect which will be discussed in this paper.

2. <u>Nailed Joints</u>

2.1 Load-Slip Relationship

Various formulae have been proposed for predicting the movement in a nailed joint at a given load.

Mack [1], [2] found that a general expression could be obtained by using a load reduction factor which was independent of the type of timber or nail size. For displacements up to 2.54 mm the short term load could be obtained from

where d = nail diameter (mm)

k = species factor

 $P_{2.54}$ = load causing displacement of 2.54 mm.

He gave the expression for R as

$$R = (0.126\delta + 0.68)(1 - e^{-3\delta})^{0.7} \qquad (3)$$

This form of equation was used by Morris [3] who showed that for softwoods the species factor could be obtained from

where G = specific gravity of timber.

By combining equations (1), (3) and (4) it is possible to predict the displacement due to a short term load in a nailed joint for a wide range of timbers and nail sizes. Although the procedure requires a number of equations the important feature to note is that once the load reduction factor R is established for a given displacement δ , it is constant for different timbers and nail sizes and does not have to be recalculated every time a change is made in the timber or nail size. The expression for the species factor k_s is relatively simple and it will be found that the entire method is easy and quick to use.

For displacements up to 0.5 mm Mack [2] found that R could be obtained from

$$R = 0.92\delta^{0.46}$$
 (5)

but that attempts to fit an empirical equation of a simple form to the load displacement curve for the range 0 to 2.5 mm have been unproductive. This would appear to suggest that there are limitations to the use of formulae similar to equation (5).

2.2 Moment-rotation relationship

W

Where a nailed joint is subjected to moments Perkins etal. [4] showed that the torsion formula as used for calculating riveted joints in steelwork could be applied.

Morris [5] used this approach as follows:-

For small angular rotations $\delta = \theta r_i$ (6) where δ = displacement

 θ = angular rotation

The moment carried by the nailed joint for rotation $\boldsymbol{\theta}$ is obtained from

$$M_{\theta} = \Sigma P_{\delta} r_{i} \qquad (7)$$
here $P_{\delta} = \text{load as obtained from equations (1),}$
(3) and (4) as described above.

Morris found that there was reasonable agreement between the experimental data obtained from tests on joints subjected to moments and the predicted moment-rotation relationship from equation (7). This indicates that the method of using a reduced load or load reduction factor is applicable to joints subjected to moments.

Table I. Values of reduced moment
$$m_1 = \frac{M_{\phi}}{M_{0.02}}$$

3. Metal Plates

3.1 Moment-rotation relationship

Having shown that it was possible to establish a theoretical moment-rotation relationship for nailed joints based upon a load reduction factor it was considered that a similar approach could be used for joints made with metal plates.

Aune [6] in an investigation into the behaviour of joints using metal plates had attempted to use an expression similar to that in equation (7) where the load on the nail of the metal plate was found from the loadslip relationship obtained from tension tests. However he noted that there was a marked difference between the calculated theoretical curve using this procedure and the experimental moment-rotation curves.

Because of the difficulty which Aune had experienced it was considered that it would be better to use a reduced moment or moment reduction factor instead of a load reduction factor, the reduced moment being defined as

	т _ф	=	$\frac{M_{\Phi}}{M_{\Theta}}$	••••	•••••		•••	• • • • •	(8)
where	Мф	=	moment	on	joint	producing	а	rotat	ion ¢
	м _θ	=	moment	on	joint	producing	а	speci	fied
			rotal	tior	nθ				
and	m.	=	reduced	1 mc	oment o	correspond	ine	to r	ota-

tion
$$\phi$$
.

Assuming that ${\tt m}$ was independent of the type of timber and connector, then

$$M_{\phi} = m_{\phi} k_1 k_2 \qquad (9)$$

where k_1 and k_2 are constants depending upon the type of timber and metal connector.

In order to ascertain whether this assumption was valid, bending tests were carried out on joints made with different timbers and connectors. For this series of experiments the limiting rotation θ was set at 0.02 radians

i.e.
$$m_1 = \frac{M_{\phi}}{M_{0.02}}$$

From the experimental moment-rotation curves the values of m were obtained and are given in table I.

C			Angular rotation (radians)								
		limber	0.0025	0.005	0.0075	0.01	0.0125	0.015	0.0175	0.02	
Twinaplat	e 125 x 50 mm	Pitch Pine	0.21	0.38	0.52	0.64	0.75	0.85	0.94	1.0	
"		Douglas Fir	0.21	0.37	0.52	0.64	0.76	0.84	0.93	1.0	
"		European Redwood	0.20	0.39	0.53	0.65	0.75	0.84	0.93	1.0	
"		Plywood A	0.24	0.44	0.60	0.72	0.82	0.89	0.95	1.0	
		Plywood B	0.26	0.43	0.57	0.69	0.78	0.87	0.94	1.0	
Gang Nail	125 x 50 mm	Pitch Pine	0.25	0.43	0.57	0.69	0.81	0.89	0.95	1.0	
17	"	Douglas Fir	0.25	0.44	0.58	0.69	0.80	0.88	0.95	1.0	
n	112 x 25 mm	European Redwood	0.25	0.39	0.53	0.65	0.76	0.86	0.93	1.0	
11	150 x 75 mm	European Redwood	0.21	0.42	0.56	0.68	0.78	0.88	0.94	1.0	
		Mean	0.23	0.41	0.55	0.67	0.78	0.87	0.94	1.0	

From table I it is seen that there is reasonable agreement between the values of m for the various types of joints and that m appears to be independent of the type of timber or metal plate.

In order to make a further check on the validity of the use of a reduced moment it was decided to apply this procedure to the test data obtained by Aune who had given moment-rotation curves for the range 0 to 0.07 radians. Using Aune's curves and putting θ = 0.07 radians another set of values of m was obtained and is shown in table II, in this case

$$m_2 = \frac{M_{\phi}}{M_{0.07}}$$

Table II Values of m₂ (from data given by Aune)

φ (rads)	0.005	0.01	0.02	0.03	0.04	0.05	0.06	0.07
^m 2	0.35	0.53	0.72	0.82	0.89	0.94	0.97	1.0

3.2 Reduced moment

Assuming that θ = 0.07 radians, $m_{0.07}$ = 1.0 and using the values of $m_{\rm p}$ based upon the data given by Aune, an expression was obtained for m_{h}

$$m_{\phi} = (3\phi + 0.79)(1 - e^{-100\phi})^{1.1}$$
 (10)

where ϕ = rotation in radians.

This is shown in graphical form in fig. 1. However it is important to check whether this theoretical curve will apply to the values given in table I.

The values in table I were based upon

 $m_1 = \frac{M_{\phi}}{M_{0.02}}$

By definition

Vinition
$$m_{\phi} = \frac{M_{\phi}}{M_{\theta}}$$

or $M_{\phi} = m_{\phi}M_{\theta}$
i.e. $M_{0.02} = m_{0.02}M_{0.07}$

Hence
$$m_1 = \frac{m_0}{M_{0.02}} = \frac{m_0}{m_{0.02}} M_{0.07}$$

..φ

and
$$\frac{\Phi}{M_{0.07}} = m_{\Phi}$$

 $\therefore m_{1} = \frac{M_{\Phi}}{m_{0.02} M_{0.07}} = \frac{m_{\Phi}}{m_{0.02}} \dots (11)$

Combining equations (10) and (11) gives the theoretical values of m_1 ; these are given in table III and compared with the mean values of m_1 obtained from the experimental data (see table I).

Table III Comparison of values of m₁

\$ rads	0.0025	0.005	0.0075	0.01	0.0125	0.015	0.2
(Calc.)	0.2	0.4	0.55	0.69	0.79	0.87	1.0
(Expt.)	0.23	0.41	0.55	0.67	0.78	0.87	1.0



Fig. 1. Reduced moment versus joint rotation based upon $m_{\phi} = 1.0$ when $\phi = 0.07$ rad.

It is seen that there is quite good agreement between the values. Fig. 2 shows this in graphical form.



Fig. 2. Reduced moment m_1 versus rotation ϕ .

In considering the reduced load curve for a nailed joint Mack [2] pointed out that he was unable to fit a simple form of equation to the curve for the range 0 to 2.5 mm but that he was able to do so for the initial part of the curve, i.e. within the range 0 to 0.5 mm. It is considered that a similar situation occurs with the reduced moment curve and it was found that the following equation could be used for rotations within the range 0 to 0.02 radians

$$m_{\phi} = 10.5 \phi^{0.6}$$
 (12)

This is shown in graphical form in fig. 3.



Fig. 3. Reduced moment $m_{\phi} = 10.5 \phi^{0.6}$ versus rotation ϕ .

Morris [7] has shown that for a nailed joint a major change in the moisture content of the timber affected the expression of the load reduction factor. It is considered that a similar situation will occur with joints made with metal plates. In addition it is thought that the size of the gap between the timber members at the joint is of considerable importance and that the duration and rate of loading can influence the reduced moment equation. All of these factors are being investigated and are the subject for further study.

4. Application of Reduced Moment

In order to obtain the bending moment diagram for an indeterminate structure it is essential to know the moments carried by the joints. For the case of a timber roof truss with metal plate connectors the task of obtaining the joint moments is made more difficult due to the fact that the joints are assumed to be semi-rigid. As was mentioned earlier, with the load on the truss increasing there tends to be a loss in joint rigidity; this is caused by an increase in the joint rotation which results in a reduction in the moment carrying capacity of the semi-rigid joint. Hence the relationship between joint moments and load can be assumed to be non-linear.

Test data relating to full size timber trusses with metal plate connectors were obtained from the Department of Civil Engineering, University of Edinburgh, and used to study the moment-load relationship for the joints. For this analysis the study was confined to the apex joint in W trusses.

Three different pitches of truss were considered as well as differences in the size of the members.

Fig. 4 shows a typical graph of the angular rotation of the apex joint plotted against the ratio of the design load for a truss having a 15° pitch. Other graphs were drawn for trusses having different member dimensions and in each case the curve was based upon data for at least three identical tests. In a similar manner graphs were drawn for trusses having pitches of 25° and 35° and in each case it was found that the curves followed the same trend.



Fig. 4. Ratio of design load versus rotation for apex joint, 15° pitch.

From fig. 4 it is possible to obtain the rotation ϕ for a given ratio of the design load. By using equation (10) or fig. 1 the value of m_{ϕ} can be found for a particular value of ϕ , hence by combining these two steps m_{ϕ} can be obtained for a given load. Fig. 5 is a typical curve of m_{ϕ} plotted against the design load ratio for a range of angular rotations 0 to 0.07 radians.



Fig. 5. Reduced moment versus ratio of design load for apex joint, 15° pitch.

432

If the constants for the type of connector and timber species k_1 , k_2 in equation (9) are known then this procedure could be used to obtain the moment on the joint, since

$$M_{\phi} = M_{\phi} k_1 k_2$$

The rotation at the apex joint corresponding to the design load for different truss pitches and member dimensions is given in table IV.

Table IV

Apex joint rotation at design load (ratio = 1.0)

Truss pitch	35 ⁰	25 ⁰	15 ⁰		
$\phi \times 10^{-3} \text{ rads}$	17 15	14 14 20	15 19 13		

It is interesting to note that the mean rotation at design load for all the tests is approximately 0.016 radians. Hence, this suggests that for design purposes the simplified moment rotation relationship given in equation (12) could be used. Once again it is important to note that the apex joint is under consideration in this particular study.

5. Conclusions

From tables I and III it was observed that there was reasonable agreement between the various values; since the experimental data were obtained from different tests and for a range of timber connectors it would appear

that the reduced moment concept is valid.

As was shown in fig. 5, if the angular rotation of the joints in a truss is known then this concept can be used as a possible means to analyse the truss.

6. Acknowledgments

The authors wish to thank CERTI, Department of Civil Engineering, University of Edinburgh, for the use of data relating to tests on full size timber trusses.

The investigation into the behaviour of joints with metal plates is being carried out in the Department of Architecture and Building Science, University of Strathclyde, and financed by an SRC grant. 7. References

- Mack, J. J. The strength and stiffness of nailed joints under short-duration loading. Div. of For. Prod. Tech. Paper No. 40, CSIRO, Melbourne 1966.
- Mack, J. J. <u>The load-displacement curve for nailed</u> joints. Journal Inst. Wood Sci. Vol 7, No 6, Dec. 1977 pp 34 - 36.
- 3. Morris, E. N. <u>The application of the slip modulus</u> <u>in the design of nailed joints</u>. Journal Inst. Wood Sci. Vol 6, No 2. Jan. 1973. pp 17 - 21.
- Perkins, R. H., Suddarth, S. K., and Dale, A. C. Rotational resistance of three membered nail joints subjected to bending moments. Purdue Univ. Agr. Expt. Sta. Research Bul. No 753. Purdue Univ. Indiana. 1962.
- Morris, E. N. The rotational rigidity of nailed joints with plywood gussets subjected to short term loading. TRADA Research report No E/RR/32 High Wycombe. 1968.
- 6. Aune, P. Investigations on strength and stiffness of joints made with hydro-nail truss plates. Acta Polytechnica Scandinavica Civil Eng. and Bldg. Constr. Series No 67. Trondheim 1970.
- 7. Morris, E. N. <u>An analysis of the load-slip curve</u> for a nailed joint and the effect of moisture content. Journal Inst. Wood Sci. Vol 5, No 1. Apr. 1970 pp 3 - 9.

Evolution of the insulated wood-frame wall in Canada N.B. Hutcheon - B.E., M.Sc., Ph.D., Consultant, Former Director, Division of Building Research, National Research Council of Canada, Ottawa, Canada. G.O. Handegord - B.E., M.Sc., Coordinator of Building Technology, Division of Building Research, National Research Council of Canada, Ottawa, Canada.

<u>Summary</u>.- Wood-frame walls based on 2-in. x 4-in. (50 mm x 100 mm) framing have been the most common form of construction in single-family dwellings in Canada. Over the past six decades much attention has been given to thermal insulation, vapour barriers and air leakage with corresponding changes in requirements and practices, whenever concern for energy conservation has arisen. The various stages in this development, linking field experience to laboratory studies, are outlined as a basis for current appraisal of wall-design principles, practices and performance.

Sommaire.- Les murs à ossature de bois en 2 po x 4 po (50 mm x 100 mm) ont été le type de construction le plus courant dans les maisons individuelles au Canada. Depuis les six dernières décennies on accorde beaucoup d'attention à l'isolation thermique, aux coupe-vapeur, aux fuites d'air et aux changements qui s'imposent aux exigences et aux pratiques, lorsque l'intérêt pour l'économie d'énergie se manifesta. Les diverses étapes de ce développement, mettant en rapport l'expérience sur place et les études en laboratoire, sont décrites en telle sorte qu'elles constituent la base de l'évaluation courante des principes de conception de mur, des pratiques et de la performance.

The wood-frame wall as currently widely used for single-family dwellings and other small buildings in Canada has evolved under the influence of practices known from other countries, economic forces and technical and scientific considerations. This paper identifies the more important changes that have occurred and the reasons for them, to provide a basis for appraisal of present knowledge and practices in design and construction. This discussion will also have implications for walls made of materials other than wood, and for floors and roofs.

Early development

The trees that had to be cleared from his land provided the early settler in Canada with logs for construction of his first crude dwelling and for fuel. When money and men with the necessary skills were available, preference could be given to the use of brick and stone but timber continued to be widely used in various ways [1]. Log construction was often displaced by timber framing, which was more economical in the use of wood. The European practice of filling between timber frames with various materials, as in half-timber construction in England and colombage in France, was introduced but was eventually displaced. When sawn timber and nails were available, boards were used for sheathing and cladding between and over timber frames [1] [2][3]. Secondary framing members, or studs, placed vertically between the principal members to support the sheathing could also carry structural loads and as their use increased, modifications were introduced in heavy timber practices.

The use of light-wood members developed steadily in the United States in the nineteenth century, resulting by 1830 in the appearance of a system based entirely on 2-in. (50 mm) lumber for framing members and 1-in. (25 mm) boards for sheathing, with nailed joints. This was called the balloon frame because of its light weight. It was later largely displaced by the platform frame. These frame arrangements also appeared in Canada and are still in use today in the highly developed, adaptable wood-frame construction system employed in about half of all residential construction [4] [5]. Almost all single-family dwellings and many other small buildings of three storeys or less for residential and other uses are of wood-frame construction. Practices in the northern parts of the United States are almost identical with those in Canada, and similar framing practices have developed elsewhere [6].

The basic wall

The exterior wall in common use 80 years ago was framed with vertical studs 2-in. x 4-in. (50 mm x 100 mm) nominal size spaced 16 in. (400 mm) on centres and nailed to top and bottom plates. Sheathing on the outside was of nominal 1-in. (25 mm) boards 8 in. (200 mm) or wider, applied horizontally or sometimes diagonally. Over this, one or more layers of building paper, the outer one being tarred, were followed by some form of horizontal wood siding, shingles or rendering. Plaster on wood lath was commonly used as the inside finish but this could be of horizontal boards over one or more layers of building paper. This wall was accepted for many decades as an adequate barrier against winter temperatures as low as -20°C to -40°C. All subsequent improvements have been made largely as modifications to this basic form.

Improvements and problems

Single-family houses were commonly owner-occupied so that heating costs had an influence on the choice of construction. Wood offered an advantage in both first cost and fuel economy but was not as highly regarded as brick and stone. Masonry constructions were often provided with an interior framing of wood, and today the appearance of masonry and the utility of wood are combined in wood-frame constructions clad on the outside with a thin wythe of brick or stone. There were undoubtedly many arguments over the relative merits of wood and masonry constructions as to

heating economy and over the ways to improve them. Some builders filled the space between studs with waste masonry materials. Others used back-plastering on the inside of the exterior sheathing, between studs, and this undoubtedly did much to reduce air leakage. Buildings on the great plains where high wind speeds were common and building materials and fuel had to be transported over long distances often used multiple layers of paper under interior and exterior finishes.

By the year 1900 the possibility of controlling heat loss from buildings with the use of insulating materials began to be appreciated. Marked progress was made over the next 20 years and governments began to promote the use of insulation as a means of increasing comfort and reducing fuel costs [7]. In 1922 Greig in western Canada was operating test huts to demonstrate the value of various insulating materials incorporated in wall constructions [8]. Bugge was doing the same thing in Norway.

The insulating materials available included sawdust and shavings used as bulk insulation between studs; a variety of batts and blankets made from natural products such as seaweed and flax straw; lightweight boards made from wood, sugar-cane or straw; and several forms of insulation made from mineral fibres such as rock wool. Shavings and mineral wool batts fitted between studs were popular, and provided a marked improvement in thermal resistance over the unfilled space.

Several insulating cladding materials made of wood. fibre and asphalt also appeared on the market. When tightly applied with cemented joints they provided a' tight air seal, some thermal resistance and a seal against rain entry. They were patterned on the surface to look like brick or stone and were commonly applied over the cladding of existing houses or used as the cladding in new low cost construction. Because the seal which was provided on the outside of the wall could also hinder the escape of water vapour, it was concluded that products of this type might be responsible for the rotting of walls.

Wet conditions and accelerated decay of wood and other materials were being found in insulated constructions and the use of insulation was suspected as a possible cause. Studies by Rowley [9] and others in the United States beginning about 1935 and later by Babbitt [10] in Canada demonstrated that wetting by condensation could take place if water vapour was allowed to diffuse from the warm side to be condensed on the back of the cold exterior sheathing under winter conditions. Vapour barriers were recommended to limit the entry of water vapour into insulated walls and roofs.

By the time of the post-war building boom in 1946, insulation and vapour barriers were being widely used in new housing construction, 2-in. (50 mm) mineral wool batts with integral vapour barriers being the most common. Loose-fill mineral wool insulation and cellulose fibre were being installed pneumatically in attic spaces and to some extent in the uninsulated walls of existing houses. Insulating blankets of reflective foil with an intermediate air space were being promoted as the equivalent of 2 in. (50 mm) of mineral wool.

Post-war housing activities and associated problems created a need for a clear recognition of the functional requirements of walls [11]. The appreciation of these requirements and the ways in which they can be met is still developing, despite the many contributions that have been made since 1945.

New agencies established

The Central Mortgage and Housing Corporation (CMHC) (now Canada Mortgage and Housing Corporation) was established in 1945 as the instrument for the implementation of government housing policy. It operated primarily by influencing the supply of mortgage money. It was also to be responsible for improving the quality of housing, and housing constructed under the provisions of the National Housing Act was required to meet certain minimum standards. The Division of Building Research

(DBR/NRC) was established under the National Research Council of Canada in 1947 with responsibility for housing and building research, technical support to CMHC and the periodic revision of the model National Building Code [12]. These two agencies working together had a substantial influence through research, information and codes and standards on subsequent developments in housing practices in Canada [4][5][13][14]. Developments in structure and cladding

The basic wood-frame wall has proved to be more than adequate in strength under vertical loads. Despite small changes in the dimensions of planed lumber widely used in Canada it has been possible to accept an increase in stud spacing from 16 in. (400 mm) to 24 in. (600 mm). The bracing requirements have been examined and it has been concluded that many of the sheathing and finish materials provide adequate resistance to racking deformation without the need for added framing once the wall is in place [5]. Structural testing and rationalization of framing practices have also led to simplification and further economy in the use of framing lumber [15].

Plaster applied on gypsum lath was gradually replaced by a single layer of paper-faced gypsum board having joints filled and reinforced with tape and nail heads covered to provide a smooth interior finish ready for painting. The thickness of the gypsum board was increased from 3/8 in. (9.5 mm) to 1/2 in. (12.5 mm) when the spacing of studs was increased from 16 in. (400 mm) to 24 in. (600 mm). The problem of "nail popping" involving protrusion of the nail head through the thin plaster cover some time after construction was eventually found to be due to cyclical changes in moisture content of the framing at the point of nailing. New installation techniques were employed to minimize the problem. Smooth interior surfaces with little visual evidence of the existence of joints can be produced.

Wood boards as exterior sheathing have largely been replaced by sheet materials of plywood, gypsum or various forms of reconstituted wood. Exterior cladding which was commonly of wood or asbestos cement shingles, horizontal overlapping boards or vertical board and batten is now frequently provided by reconstituted wood products or factory-finished aluminum made to simulate the traditional patterns. Stucco or rendering is also used in areas where the plastering trade has survived. Such materials are applied over water-repellent building paper with galvanized reinforcing wire mesh nailed to the exterior sheathing.

Thermal and moisture problems

Because exterior walls must act as separators of indoor and outdoor environments, they must provide the necessary control over heat, air and moisture [11]. Rain penetration has not been a serious problem with woodframe walls in Canada but the severe winter climate has made the thermal and moisture problems more critical so that much effort has been devoted to understanding and resolving them.

Variations in interior surface temperature resulting from convection in wall spaces, thermal bridges or poorly fitted insulation sometimes resulted in surface condensation or in "dust marking" over colder surfaces [16]. The patterns due to convection were more extreme in walls insulated with reflective foils and early investigations in the laboratory confirmed the observations in the field. Surface temperatures varied from low values at the bottom to a maximum near the top, with the lowest surface temperatures occurring over structural members at the base of the wall [17][18].

The effect of insulation-batt location and fit at framing members on wall surface temperatures and heat flow came to be recognized and supported the development and use of "friction-fit" insulation batts of glass and mineral fibre. Application costs and difficulties with edge fastening, coupled with the undesirable effects of convection in vertical spaces resulted in restrictions on the use of reflective insulation in the colder areas of Canada. Some walls constructed in this way were re-insulated with mineral wool pneumatically applied. It was shown later that convection between air spaces separated only by porous batts or blankets could greatly reduce the effectiveness of the insulation [19]. Fill insulations were not considered as suitable as preformed batts or blankets for walls of new housing because of the possibility of settlement. Loose mineral fibre and glass insulations were, however, used extensively as ceiling insulation in attic spaces of new houses and in some locations planer shavings, sometimes treated with lime to discourage insects, were extensively used.

Surface temperature variations due to framing members again became of concern when metal studs were introduced [20]. Manufacturers were able to develop designs that compensated for the higher thermal conductivity but the use of steel studding in exterior walls was largely confined to multi-storey apartment buildings.

Condensation problems in wood-frame walls have not been widespread and those that have occurred have usually been directly associated with holes or gaps in the interior cladding and vapour barrier or where drainage of condensed moisture and drying of wetted materials has been inhibited. Condensation in attic and roof spaces has been much more prevalent and has also been directly associated with air leakage paths rather than diffusion [21][22]. This situation is consistent with the pressure differences and winter air leakage patterns inherent in heated buildings [23][24][25]. Under the action of stack effect, infiltration occurs over almost the full height of the walls in houses with chimneys [23][25], with exfiltration occurring through the ceiling into the roof space and through the chimney. Leakage openings in both ceilings and walls often result

from the installation of electrical wiring and a common complaint from occupants in winter is that of cold air leaking into the house at electrical receptacles in exterior walls. Traditional wood-frame construction practice also results in discontinuities in the interior cladding and vapour barrier where interior partitions and floors intercept the exterior wall. Drying shrinkage of the wood studs or joists allows a crack to develop between the interior cladding and the framing members. Air leakage can thus occur between the space in the interior partition and the exterior wall space, or between the floor joist space and outside. In twostorey houses where exterior masonry cladding or "veneer" is only carried to the second floor level, the second floor joists are often cantilevered beyond the first floor wall framing and connect directly to the vented space behind the brickwork. Outside air infiltration into the joist spaces can occur at this location.

Current developments and prospects

Problems of supply of 2-in. x 6-in. (50 mm x 150 mm) studs and a technical concern for their suitability structurally and thermally have prompted consideration of other methods to achieve thicker spaces for added

insulation. Two such methods which also attempt to improve the airtightness of the wall are being introduced. Both involve the placement of a vapour barrier membrane within the wall construction to allow electrical services to be installed without penetrating the barrier. One method involves the application of nominal 2-in. (50 mm) furring strips over a polyethylene barrier on the inner face of the traditional wall framing, to provide an over-all 6-in. (150 mm) space for insulation [26]. The other method utilizes 2-in.x 4-in. (50 mm x 100 mm) framing spaced outward and away from the 2-in. x 4-in. (50 mm x 100 mm) structural framing to create a 12-in. (300 mm) wall thickness with the barrier installed on the outer face of the 2-in.x 4-in. (50 mm x 100 mm) structural framing. Both techniques

incorporate means to provide a continuous barrier across intersections with interior wall and floor construction.

Both approaches may come to involve the use of steel framing members as non-load bearing components or as structural members. With the increased thickness of insulation involved, previous concerns for convection in low density materials or for the thermal bridging effects of framing and fasteners will need to be reevaluated. Further developments will likely have to consider changes in erection and assembly procedures on site, as well as related field and laboratory evaluation studies to ensure accurate prediction of performance.

Concluding remarks

Economic forces have led to modifications of the products used for sheathing and cladding of the basic woodframe wall and there have been refinements in structural capability. Construction details have been shown to be important. The greatest change has been in the marked increase in insulation which is now required to provide thermal resistances of 2.5 or more times that of the uninsulated basic wall. This increase is now forcing consideration of new wall arrangements.

There have been substantial increases in the knowledge about wall performance but problems can still be expected. The use of insulation in walls was accompanied by condensation problems which are now known to have been due mainly to air leakage carrying water vapour. Air leakage has also been found to contribute substantially to energy consumption. The strong interrelationship of these characteristics and the dependence of performance on the building as a whole as well as on details of construction make it difficult to predict the effect of proposed changes in practice. Uncontrolled deviations in field applications and operation add further to the problems of prediction so that it is necessary to be familiar with performance in the field as well as in the laboratory. These difficulties can only be reduced if the required knowlege can be trasferred to those who make decisions about the way in which buildings are put in place.

References

1. Rempel, J I. Building with wood, 1st ed. Toronto 1967.

 Ritchie, T. Canada builds. 1st ed. Toronto 1967.
 Moogk, P N. Building a house in New France. Toronto 1977.

4. Central Mortgage and Housing Corporation. Canadian wood-frame house construction. Ottawa 1968.

5. National Research Council of Canada, Associate Committee on the National Building Code. Residential standards. Ottawa 1977. NRCC 15563.

6. Granum, H and Lundby, S E. Trehus 1965. Norges byggforskningsinstitutt. Oslo 1964.

 Hutcheon, N B. Early building research in Canada.
 In: Proceedings of the Conference on Building Research. (Ottawa, October 1953). Bulletin No. 1. National Research Council of Canada, Division of Building Research. Ottawa 1955 pp 22-26. NRC 3568.

B. Greig, A.R. <u>Wall insulation</u>. University of Saskatchewan, College of Engineering, Bulletin No. 1, 1922.
 Rowley, F.B., Algren, A.B. and Lund, C.E. Condensation of moisture and its relation to building construction and operation. University of Minnesota, Engineering Experiment Station, Bulletin No. 18, 1941.

10. Babbitt, J D. <u>The diffusion of water vapour through</u> various building materials. Canadian journal of research, A, Vol. 17, 1939 pp 15-32.

 Hutcheon, N B. <u>Fundamental considerations in the</u> design of exterior walls for buildings. Engineering journal, Vol. 36, No. 6 1953 pp 687-698, 706.
 National Research Council of Canada. Associate Committee on the National Building Code. The national building code of Canada. Ottawa 1977. NRCC 15555.
 National Research Council of Canada. Division of Building Research. The first 25 years. Ottawa 1973. NRCC 13240.

 National Research Council of Canada. Division of Building Research. List of publications. Ottawa 1947-1978.

15. Hansen, A T. A cost study of two wood-frame bungalows. National Research Council of Canada, Division of Building Research. Ottawa 1967. NRC 9590.
16. Nielsen, R A. <u>Dirt patterns on walls</u>. Transactions, American Society of Heating and Ventilating Engineers, Vol. 46, 1940 pp 247-258.
17. Handegord, G O. <u>Thermal performance of frame walls</u>, Part III - Wall surface temperatures. Transactions,

American Society of Heating and Ventilating Engineers, Vol. 63, 1957 pp 331-346.

Handegord, G O and Hutcheon, N B. <u>Thermal performance of frame walls, Part II - Air spaces blocked at mid height</u>. Transactions, American Society of Heating and Ventilating Engineers, Vol. 59, 1953, pp 449-460.
 Wolf, S, Solvason, K R and Wilson, A G. <u>Convective air flow effects with mineral wool insulation in wood frame walls</u>. Transactions, American Society of Heating,

437

Refrigerating and Air-Conditioning Engineers, Vol. 72, Part II, 1966 pp 111.3.1-111.3.8.

20. Sasaki, J R. <u>Field study of thermal performance of</u> <u>exterior steel frame walls</u>. Specification associate, Vol. 13, No. 6, 1971 pp 21-35.

21. Tamura, G T, Kuester, G H and Handegord, G O. Condensation problems in flat wood-frame roofs. <u>In:</u> CIB/RILEM 2nd International Symposium on Moisture Problems in Buildings. Vol.I. Rotterdam 1974, Paper 2.6.2.

22. Wilson, A G and Garden, G K. Moisture accumulation in walls due to air leakage. <u>In:</u> RILEM/CIB Symposium on Moisture Problems in Buildings. Vol. I. Helsinki 1965, Paper 2-9.

23. Tamura, G T and Wilson A G. <u>Air leakage and pres</u>-<u>sure measurements on two occupied houses</u>. Transactions, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Vol. 70, 1964 pp 110-119. 24. Tamura, G T. <u>Measurement of air leakage characteristics of house enclosures</u>. Transactions, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Vol. 81, Part I, 1975 pp 202-211.
25. Handegord, G O. The need for improved airtightness in buildings. Presented at Engineering Foundation Conference on Ventilation vs Energy Conservation in Buildings. Henniker N.H. July 1977. (Issued by National Research Council of Canada, Division of Building Research as Building Research Note 151.)
26. Quirouette, R L. The Mark XI energy research project - Design and construction. National Research Council of Canada, Division of Building Research, Building Research Note 131. Ottawa 1978.

Effective use of small logs and their products for house construction

Gorozo Iizuka

Professor, Yokohama National University Japan

Summary

Small logs from thinning trees or young forest is not always used effectively in building construction. U.S. Forest Products Lab. proposed an idea called EGAR (edgeglue-and-rip) system^[1] to make wide dimension lumber from small logs. And also exprimental pole-type structure^[2] ed by the same laboratory.

In this paper, the author intends to explain a couple of construction systems in which small logs and their products are widely used. One of them is a pole-type structure using logs for posts, glued timber composites for beams, and wooden panels for covering elements such as floor, wall and roof. Different width of siding boards are used to increase the yield of lumber as well as to fulfill the architectural design.

The other construction system intends to use 7cm square section which could be obtained from small logs of 12 -15cm diameter. This is a wall-type construction, and most of the joints are fastened by nailing which will eliminate skilled labour and particular fasteners.

The author is expecting that the above proposals will encourage local sawyers of his country to participate in house building through the fabrication of components in their mills. He also would like to suggest the effective use of unutilized forest resources in rising countries.

Background of the problem

The annual consumption of wood in Japan has increased along the years up to 117 million cubic meters in 1973. Though it decreased a little since then, still some 100 million cub.m. of wood are being used annually as shown in Fig. 1. However, as domestic products of them have been going down year by year, two-thirds of the annual use is imported today. As for raw materials(logs), 24 mil.cub.m of softwoods are supplied from North America and USSR, and 22 mil.cub.m of hardwoods are imported from South-eastern Asia.

One of the characteristics of the Japanese forest is the large proportion of manmade forest in it. It accounts for 36% of the total forest and corresponds to 9% of the manmade forest in the world(estimated as 91 mil.ha. by FAO). It is natural that such a small and over-populated country as Japan has to operate artificial forestry. However, owners of these forests are suffering from shortage of labour to maintain their forests, and are becoming to be unwilling to continue investing in their long term harvests.

Another problem is, how to utilize small logs resulting from thinning trees, which is an inevitable byproduct from manmade forest. It is estimated as 5.6mil.cub.m per year in the past decade. Such logs have been used for scaffoldings and temporary shelters, which have been overtaken by light steel constructions recently.

On the other hand, the annual production of wooden houses(dwelling units) in this country is expanding with years, though it dropped in '71,'74 as shown in Fig. 2. A more rational use of such forest resources as the above mentioned logs is expected.



Fig.1 Annual national consumptions of wood in Japan.



Fig.2 Annual productions of wooden houses in Japan.

A construction system of log columns with wooden panels

This type of structure was originated by the author in order to show the good use of logs produced from thinning trees or short period forestry. The proto-type of this house was operated as a model house in the Good Living Show in Tokyo 1972 (Fig.3). Few years later, the author built an experimental house for himself^{3]}, which contains the same idea with some improvements.

Round columns and composite timber beams bolted together at joints form the basic structure of this house as can be seen in Fig.4. The infilling panels of roof, floor and wall form the rest of the construction.

A notable feature of the load bearing structure are the central twin-columns on each of the external walls, which provide the beams and wall panels a larger area of contact for joints than a single column. The scissorgrip of the twin-columns gives additional stability to the cross beams.



Fig.3 A model house of log columns with wooden panels.

Columns and beams

Logs obtained from thinning trees can be used for the columns(15-18cm diam.). A metal shoe of 6mm plate is fixed to each column base by 16mm single bolt instead of two bolts, as it eliminates secondary stresses which could cause the column to split.

The columns are treated with preservatives against fungi and insect attack. The direct contact between the column base and the foundation is prevented by the 15mm gap created by shaping the column base. This gap intercepts the direct flow of rain water along the surface of the column and also makes provision for the treatment of the column base with preservatives later on.(Fig.5) The inner surface of the column, where it meets the beams, is planed for a proper sitting of the beam, also in order to provide the vertical reference plane of the construction. The four beams meeting the central single column are joined by means of metal brackets as shown in (F) of Fig.4, and Fig.6.

Beams and cross-beams are sandwich panels composed by blocks produced from small logs, and lined with structural plywoods on both sides which are glued by epoxy resin. These panels are prefinished with 15mm thick cypress siding boards.

The gable panels finished as flushed type construction. The connection of the gable panels to the adjacent posts are as illustrated in (A) and (E) of Fig.4.



Fig.5 Anchorage of twin column



Fig.4 Structural system of the log-column construction.



Fig.6 Connection of the beams to the twin column

Floor panels

The skeleton of the floor panels consists of four cypress timber of 36x150(mm) which form the frame of the panels, and 45x55(mm) joists placed every 40cms. 12mm thick plywoods are nailed to this frame on the upper surface of the panel to form a sheathing. On the other side(i.e. ceiling of the first floor), it is finished with clear edge-grain cypress overlaid plywoods.

Since the finished ceiling surface of the panels are 9cm deep, it is possible for the panels to be trnsported without injuring the ceiling. Moreover, panels can be joined together by nailing(30cm o.c.) along the sides of the frames as shown in Fig.7. This simple method of nailed connection is a notable feature of this system.

The panels are connected to the beams by sitting them on 5x5(cm) timber strips nailed along the sides of the beams, and secured by nailing them also to the side of beams at 30cm intervals.(Fig.8).



Fig.7 Floor panel connection.

By this method of panel jointing, a rigid inplane stiffness of the second floor is obtained to transmit the lateral force to the bearing walls. The exposure of nail heads used on the panels was less conspicuous, as they were of corrosion free galvanised steel. For future construction, decorative nails such as pyramidal type would be preferred.

Roof panels

The structure of the roof panels is somewhat similar to that of the floor panels. Ceiling finishes are of finished plywood overlaid by cypress veneers as in the case of floor panels. As kitchen has to be finished by in-combustible ceiling materials, calcium silicate sheets were used.

Unlike the floor panels, the roof panels has longitudinal members of 36X100mm, while the side fixed to the ridge is 30X150mm and 91cm long. (Fig.9) Each roof panel is fastened to the adjacent beam by nailing seven N150 nails at 15cm centers as shown in Fig.10. This type of nailing satisfactory against wind forces. Since the frame of this part of the banel is fairly broad, the risk of splitting it by nailing does not arise. Although there are other methods of fastening such as using metal plates, the author thinks this is the best way regarding the appearance and reliability. In general panels, where such type of nailing is impossible because of the deeper frames,metal fasteners have to be adopted.

Several tests were carried out by the authors laboratory pertaining to the withdrawal strength of nails used for fastening the rafters to the beams, resulted good.

As regards to water tightness of the connection the joint between panels are sealed by caulking and taping on the upper surface. On the lower surface, the adjacent longitudinal edges are shaped as to make a groove, and a strip tape is fixed into the groove.



Fig.8 Setting of the floor panels.



Fig.9 Lifting-up of the roof panel.



Fig.10 Roof panel connection.

Exterior finishings

Asphalt felts are laid on the surface of the roof panels, over which timber battens of 30x36(mm) crosssection are laid at every 30 cm intervals, and nailed across the panels. The roof covering is a preshaped steel sheet of 126x37(cm) dimension with PVC overlay, which is fastened to the batten by nailing from the nose.

Heat insulation blocks of foamed polystyrene moulded in accordance with the profile of the roof covering metal sheets are laid underneath. This provides firmness to the sheets and prevents their denting of them while workmen tread on.

Wall panels fit exactly into the space between the upper and lower beams. Exterior wall is finished by nailing 15mm thick cypress siding boards of three different width of 75, 100, 150(mm), which can be produced from small logs effectively. These are laid in the pattern of medium-wide-medium-narrow-narrow-wide-... to create variety for good architectural appearance.

Wiring and piping installation

One of the problem of this type of panel construction is the wiring and piping works. As ceiling boards are pre-fixed in the panel, nothing can be hidden inside afterwards. In this case, a distributing board is located inside the closet, and chord pendants were used for ceiling lights. Wiring and piping can be easily done in the walls because interior wall finishings could be done afterwards.

An electric floor-heating system was adopted in this house which consists of 900x1800x12(mm) heating unit fixed directly on the floor panel and covered with carpet. Heat loss downwards to the open space of pilotis was avoided by filling rockwool insulation inside the floor panels.

Proposal of the 7 x 7 construction system

This kind of construction was developed by the technical committee called 'Utilization of small log products in house construction' directed by the author and sponsored by the Forest Agency of Japan. 7cm squared timber is suggested as a profitable dimension obtained from logs produced by thinning trees. The structural safety of this building system was agreed by the Building Centre of Japan in 1979, and going to be built soon.

Outline of the structural design

This is a wall-type construction, and most of the joints are fastened by nailing which will be done without skilled labour or particular metalwork by the local sawyers. Fig.11 and Fig.12 illustrate the prototype of this construction which is characterized as follows:

(1) The whole structure is realized by using six kinds of structural members.

(2) Wall framings consist of 7 x 7(cm) cross-sectioned studs and 7 x 3.5(cm) timber as upper and lower plates.

(3) The above mentioned frames are covered with 12mm thick plywoods by nailing them on the floor and erecting them to their adequate position, which become bearing walls for lateral forces. Plywoods could be replaced by timber or particle boards depending on the convenience of materials.

(4) Joists of the floors are made of 6cm squared timber on which 12mm plywoods are nailed for forming the subfloor. The 2nd floor joists are supported by composite beams of plywoods and 7 x 3.5(cm) timbers nailed together as shown in the figure.

(5) Roof beams have the same composition as floorbeams on which posts are erected to support purlins. The purlins consist of two 7cm square timbers laminated by nailing plywoods on both sides.

(6) Rafters have the same dimension of 6 x 6(cm) as joists, and are fastened to purlins by nailing twisted steel plates at the top of the external walls. Roof sheathings are 12mm thick plywoods which can be replaced by timber or particle boards.



Fig.11 Structural system of the 7x7 construction.



Fig.12 An experimental house of the $7{\rm x}7$ construction.

Strength of a test house against lateral forces

[6] A two-storied test house (total 63 sq.m)was examined by applying lateral forces corresponding to 60 m/s wind velocity, as shown in Fig.13. To measure the natural period of frequency of this house, a seismic generator (EX-50, Ito Seiki Co.) was installed on the centre of the second floor. Fig.14 shows the static test diagrams.

The results of the tests were satisfactory as follows: (1) The diagram shows the displacements on the top and on the mid-height of the test building due to the alternative loadings. The load-deformation relation of this house was linear as far as 10 tons which is more than twice as much as for the designed load of 4.5tons.

(2) The ultimate load of this test was 16.75 tons, which is 3.7 times more than the designed load.

(3) Observed resonance period of frequency of the test house by applying the above mentioned forced vibration was 0.182 second. The value represents natural frequency of this type of building, which is shorter than that of the conventional houses of 0.2 - 0.3 second. It reflects the high rigidity of this construction against seismic motion.

(4) To investigate the relaxation the structure after suffering from large lateral forces, vibration tests were repeated after the static loading tests as described in (1). The resonance period after round trip of the designed load was 0.192 second which proves that the structure is elastic and rigid enough even after some extent of deformations.

Acknowledgments

The author wishes to express his gratitude to the Forest Agency of Japan for financing this series of works. He is also grateful to Prof. H. Sano for quoted diagrams from his report. His thanks are also to the students of his laboratory for their assistance in completing this paper.



Fig.13 Outline of the tests for $7 {\boldsymbol x} 7$ construction under rateral forces.



Fig.14 Diagrams of the static load tests for 7×7 construction.

References

- (1) Compton C., Hallock H., Gerhards C., and Jokerst R. <u>Yield and strength of softwood dimension lumber</u> <u>produced by EGAR system</u>. USDA Forest Service Research Paper FPL 293, 1977.
- (2) Doyl C. <u>Experimental pole-type structure</u>. USDA Forest Service Research Paper FPL 115, 1969.
- (3) Iizuka G. <u>An experimental house of log columns</u> with wooden panels. Bull. of the Facl., Yokohama National University Vol. 25, 1976.
- (4) Iizuka G., Hishinuma T. <u>Strength of anchorage of</u> <u>rafters to the external wall</u>* Report 2578 of the annual meeting of the Architectural Institute of Japan.
- (5) Housing and Wood-technology Centre of Japan. <u>General aspects of the 7 x 7 construction system</u> 1979.
- (6) Sano H. <u>Testing of a full-scale house of the 7 x 7</u> <u>construction under simulated windloads and seismic</u> <u>motions</u>.* AWCOM No. 37, 1977.

* Written in Japanese.

Recent research and development of wood house construction in Japan. Katsuyoshi łmaizumi Dr.Eng. Professor, Kogakuin University, Japan.

1. Introduction

A new construction method of wooden houses, Platform Technique of Wood Frame Construction Systems, has been introduced from North America in 1974 and the official notification No. 1019 was issued by the Ministry of Construction on 27th July 1974. In order to make more popular wood construction system, the research program was officially adopted as one of the National Research and Development Projects sponsored by the Ministry of Construction, and was managed by the Building Research Institute and was done by the research committee in the Land Development Technical Research Centre. This committee was consisted of two working groups, one was engaged in the study on the structural performance and the other conducted the study on the safety against fire.

2. Structural Performance

2.1 Allowable Stresses

Grading rules for timber used for the traditional wooden structures have already been formulated and the values of allowable working stresses have also been fixed by cabinet order No. 338 in 1950.

Basic principle of grading rules and working stresses for the framing lumber have been determined under the general concept of the same procedures at that for sawn timber of the traditional wooden structures.

Allowable working stresses for parmanent loading (LF) are derived from the following formula:

$$LF = \frac{4}{5} \times Fo \times \alpha \times \frac{5}{8} \times \frac{1}{1.5}$$

where, $\frac{4}{5}$ = reduction number related to variation of clear specimens.

Fo = basic stresses α = strength ratio

 $\frac{5}{8}$ = reduction number related to creep limit.

1.5 = safety factor

Allowable working stresses for temporary loading (sF) are derived from the following formula:

 $sF = \frac{4}{5}x$ Fo $x \alpha x \frac{7}{10} x \frac{11}{10}$

where, $\frac{7}{10}$ = reduction number related to proportional limit

 $\frac{11}{10}$ = increasing number related to duration of loading.

Strength ratio (α), which is the ratio of strength remaining after taking off the reduction strength for the effects of various deffects to the strength of the clear timber, were determined by the experimental works and the references of the framing lumbers.

Basic stresses (Fo) of the framing lumbers corresponding to the grading in Japan Agriculture Standard No. 600 were obtained from the results of standard tests on small clear specimens by dividing the statistical minimum value.

2.2 Testing and Evaluation Method for Bearing Walls.

a) Test Specimen.

b) Procedure

This method cover the procedures for determining the racking strength and rigidity of bearing walls for wood frame construction. The test specimens shall be chosen to conform to materials and construction details in actual use. The width of specimens shall be 1.82 meters. The height shall be chosen to conform to the height of that element in actual use. The test specimens shall be in air dry conditions and four walls of each construction shall be tested.

Load shall be aplied to the specimen through short timber bar of 90mm x 90mm cross section firmly bolted to the upper plates of the specimen. Loading shall be measured by means of load cell in linkage with a hydraulic jack used to applied load. Indicating dials are provided to measure the drift of the different parts of the specimen during test. The first specimen of the four was continuously loaded to failure. The other three specimens were loaded in the following three steps. The load was applied to one-fifth of the maximum load of the first specimen and then the load was removed to the load of zero. Then, the load was applied to the two-fifth and the load was removed to the load of zero. After the loading of three-fifth, the load was continuously applied to failure.





c) Performance evaluation

Allowable load of racking resistance was determined by the following formula,

 $Pa = 3/4 \times P_{1/300} \times \alpha$.

where, Pa = Allowable load of racking resistance (kg/m)

3/4 = reduction number retated to variation of specimen.

- P1/300 = Average value of racking loads when the value of shear drift ratio of 1/300 (kg/m)
- α = reduction factor in relation to the performance and workmanship in actual service decided by the discussion of the committee.

2.3 Full Scale Testsa) Test houses



Fig.2 Plans of Tested house

Tests were carried out on two single-family detached houses to determine their deflection characteristics under lateral loads. The houses were both two story buildings of wood frame construction. The lower story contains family room, kitchen and bath room and the upper has two or three bedrooms. Walls are of wood stud construction covered on exterior surface of load bearing walls with 75mm. thick plywood. No interior and exterior finishing materials of non-structural walls are covered at all in any parts of both series that houses. No attempt was made to procure high quality or special materials for these houses. All materials and installation methods in building site were essentially under the standard method of code by Housing Loan Cooperation. b) Loading system

Loadings were applied by means of hydraulic jack actuators installed with the steel structural loading frame. Instrumentations for measuring of loads and displacements were consisted of load cells, linear variable differential transfers, pressure transducers and digital multi-strain recorders.

Load were applied at the underside of the horizontal roof truss members and the level of the centreline of the second story floor joints. c) Test results

In the unloaded position after the first loading cycle, the residual displacement in this test was about 10mm., which is approximately 6% of the maximum displacement (175mm.) observed in this test.

The initial failure in Test-1 house occured in bending of the concrete foundation under the total load of 5,800 kg, and in Test house cracks in floor joist of lower level were observed under the total load of 6,800 kg.

Maximum total observed racking load in Test-1 was about 8,100 kg which is about 2.9 times of design load (2,840 kg) and is about 1.1 times of estimated maximum load (7,200 kg) based on the racking resistance obtained by the above mentioned racking test method.

Maximum total observed racking load in Test-2 was about 8,000 kg which is about 3.2 times of design load (2,490 kg) and is about 1.3 times of estimated maximum load (6,250 kg) based on the racking resistance of load bearing walls.

2.4 Summary

a) The proposed testing and evaluating methods for racking resistance of load-bearing walls for wood frame construction mentioned in 2.2 is available to get the data for the purpose of evaluating the in-plan shear force resistance and deformation response of load-bearing walls in actual residential house by wood frame construction system.

b) The maximum safety length of overhang of the second floor in a two-story house is less than 900mm. on centers.

c) The floor-ceiling diaphragm at the second floor level trended to act as a rigid structural element and to transtale as a rigid body when the house was subjected to lateral load.

d) The maximum distance between load-bearing wall lines on the same floor level is less than 12 meters, and the maximum horizontal area surrounded the load-bearing wall lines is less than 60 square meters.

e) All nail joints in the tested houses subjected to lateral load should be capable of transmitting displacements to structural elements without significant slip.

3. Fire Safety

3.1 Full scale fire tests

a) House tested

Fire tests in full scale wood frame construction buildings were carried out based on the results of the study of the performance of exterior wall and partitions against fire to examine the total fire resistive performance in the wood frame construction.

Two types of residential single house were tested. The test house for the first series was two story building of small type. Total floor area was 40 square meters. The second series of house was also two story house of the same planning as that of full scale structural test in this reports. Total floor area was about 80 square meters.

Both full scale fire test houses were constructed by the standard construction method of Housing Loan Cooperation.

Standard framing of floor consisted of 208 hemlock joist spaced 455mm. on center covered with 12mm. thick plywood sheathing. Exterior walls were covered with 9mm. thick plywood sheathings, gypsum wallboard as interior covering and asbestos cement board on plywood for exterior covering protections. The ceilings in the lower and upper story were covered with 15mm. thick gypsum wallboard and were installed by the authorized nails directly to the joists. The roof were covered with the colored galvanized iron sheets and 9mm. sheathing plywood. All window openings were fixed by the aluminum sash with 3mm. thick glass. Glass wool insulation butts were placed in air spaces of wall assemblies and under the sheathing plywood of roof structures.

b) Fuel loads

Total weight of combustibles, including the secondhand furnishings such as bed with plastic mattress, desk and chair, carpetings, clothes in the closet, bookshelf, books and magazines, television set, bureau, curtains, wood wastes, firewoods, straw-mattress and so on, which corresponds to a fuel loading of 27.6 kg/m² of floor area at the lower floor and of 18.35 kg/m² of floor area at the upper floor. In the second series, the 21.55 kg/m² in fuel loading was put in the first floor and the 30.01 kg/m² loading at the second floor.

c) Temperatures and Crib brands

All temperature measurements were mad with cromel-alumel thermocouples, each equipped with an electronic cold junction reference point. In case of the first series, temperature in living room were measured 16 locations, in kitchen were measured 9 locations, in bed rooms were measure 19 locations. Additionally, temperatures at stair way and in closet were measured 1 location each.

83 total thermocouples were placed in case of the second series.

Since the main goal of these tests was to observe fire development and running phenomena in a realistic fire situation, crib ignition method was considered. Crib consists of a grid 600mm. square and approximately 100mm. thick, made of kiln-dried, clear-grained, sapwood spruce, free from knots and pitch pockets. It is made of 60 strips of 20mm. by 20mm by 600mm. length rough dressed on four sides. The strip was placed in five layers of 12 strips each and each layer was spaced 33mm. apart. Strips were placed at right angles to those in adjoining layers, and were nailed at these intersections using a finishing nail at each end of each strip. Crib brands were placed at the corner of living room in the first floor and were ignited by the burning insulation fiber board strip soaked methyl alcohol. d) Observations

(1) First series Sabient features of the fire development may be summarized in a brief description:

- Following ignition, the paper made flash door ignited and the flames grew rapidly and reached the surface of the ceiling.
- 2) Flashover occured 6 min. after ignition with all combustibles becoming involved.
- 3) About 20 min. after ignition, flames became weaker in ignited room.
- 4) After a window glass was broken with a stone thrown by the order of the test leader, flames transferred to the upper floor through the broken window.
- 5) Plywood flashed door may prevent the flame spread for about 15 min. extending through the next room.
- 6) About 35 min. after ignition, major flashover occured at bed room on the upper floor.
- 7) Collapse of second floor assembly occured at about 40 min. after.



Fig.3 Time-Temperature Curves in the 2nd Test Series

(2) Second series



To summarize, flashover in the ignited room occured in 10 min. 45 sec. after. Although the first floor structure was totally involved by 14 min. after ignition, fire did not flashover the upper floor area until 15 min. 30 sec. after ignition. After 40 min. the corner of the second floor assembly was collapsed and some large brands of second floor fall down on the first floor.

e) Summary

Almost same phenomena were observed in early stage of fire development in test houses, compared with that in the fire resistive buildings. The effectiveness of isolation on spaces with noncombustible partitions has been expected essentially and it was intuitively clear that a fire in an enclosed space covered with gypsum wallboards will heat the entire interior until the whole interior will burnt into flames. In conclusion, it was confirmed that this construction system is respectably effective in preventing fire spread provided the space were covered with the noncombustible materials.

4. Conclusion

Significant efforts have been expanded towards consulting the safety in structure and in fire of the dwellings by the wood frame construction system in order to improve the design and construction methods which could be adopted easily under the traditional wood working systems and techniques in Japan.

The recommendation values for the allowable stresses of framing lumber were obtained without contradiction to the traditional consideration. The evaluation method to the load-bearing walls was also developed. The shear tests of full scale houses were carried out to clarify the total structural safety and to examine the racking test method.

Fire test in full scale houses was carried out to examine the total fire resistive performance of wood frame construction system. Almost same phenomena were observed in early stage of fire development compared with that in the fire resistive buildings. It is confirmed that the wood frame construction system is respectably effective in preventing fire spread provided the spaces were covered with the noncombustible materials. _ _ _ _ _ _ _

Summary. The initial strength of glulam timber members is discussed as well as its time-dependent variability. Some important factors changing the bonding quality of joints are indicated.

Besides, data are given on the gluline strength with different adhesive types in normal and elevated temperature conditions. Physical and mechanical properties of timber and their influence on the gluline strength are also showned.

Some effective quality control methods for gluline strength and glulam members are given.

<u>Resume</u>. L'auteur examine la résistance initiale des structures an bois lamellé-collé et as modification dans le temps en indiquant les facteurs principaux affectant la qualité des assemblages collés.

Il presente des données sur la resistance des assemblages effectués à base de colles de plusieurs types dans les conditions des températures ambiantes et élevées. Le degré d'influence des propriétés physiques et mécaniques du bois sur la résistance des assemblages collés.

Les méthodes efficaces du contrôle de la résistance des assemblages collés ainsi que des structures avec de tels assemblages sont aussi traitées.

The wide application of glulam structures is mainly determined by their durability, i. e. by their ability to maintain bearing capacity during the specified life. This factor is a direct result of the bonding quality of joints.

Glulam timber differs in its physical and mechanical properties from that of sawn timber, these properties are not being invariable. They can be directed in the process of manufacturing of glulam structures. The realization of the above concept will allow to produce glulam timber with a desired (higher) improved strength and exposure endurance as compared to the sawn timber. Commercial manufacture favours those elements with a reduced material consumption where such optimization of gluing leads to.

It is obvious that the strength of glulam timber is affected by the operations during manufacture, and here lies the clue to the optimizing the process.

How the glue joints are influenced by separate operations in the process of gluing assembling and pressing, can be established only after the comprehensive evaluation not only of the initial strength but also its variation with time.

Tests have proved that at constant temperature and relative humidity (55-75%) the initial strength of wood joints varies very insignificantly with different glues and types of setting. At elevated temperatures, however, certain strength reduce is observed, having it more apparent than for the specimens, glued on karbamide resin.

Thermoreactive adhesives can long endure heating, therefore such strength variation of phenol and resorcinol joints can be attributed to a worse wood strength in the area of the joint. Any effect of processing operations in this case is not observed. Karbamide joints while heating chiefly deteriorate in the glulines, that significantly reduces the strength of joints and increase the average wood failure.

Negative temperatures have quite a different effect on joints. Humidification and subsequent freezing increases MOR (strength) and MOE of timber. Thus irrespective of adhesive type and setting conditions the joint strength is increased.

Water resistant tests during 5 years of damping of glued specimens on KB-3 and PhP-I2 adhesives have shown practically no reduce in strength. At combined temperature variations and damping the process of strength decrease can be very intensive. Phenol-resorcinol wood joints (PhP-I2) present the highest and stable strength properties. Gluing with such an adhesive at a routine conditions with high -frequency heating leads to an practically analogous result. Quite different are the KB-3 adhesive joints. Regardless of the initial strength, almost independent of gluing conditions, the strength of such joints after cyclic tests decreases noticibly. This can be explained by the effect of h.f. heating, that leads to overheating of the adhesive and to

the subsequent development of strong internal stresses in the joint. All this results in strength decrease of a wood, adjoining to the wood, saturated by the adhesive. Despite the wood failure, general strength of bonding is falling down.

Exposure investigations of glue joints have revealed insignificant degradation of the joints, glued on PhP-I2, KB-3 adhesives. UKS adhesive joints have degraded considerably after 3,5 year exposure and completely failed to 5 years.

Permanent loading tests have proved, that not every gluline having high initial strength maintains it under static loads. However, in all cases, long-time strength of gluline was somehow lower than the strength of sawn lumber.

Wood together with adhesive influence the bonding quality of the joint. Moreover, if defect of wood (knots, slope of grain) and their effect can be determined immediately after the final product is subjected to failure tests, then the defects of shape (warp, etc.) moisture differencial of mating laminations, thickness range of laminations and weakening of bonding in the areas of glued knoty wood can be fully revealed only at the life time of the structure.

It is known that dimention lumber has different defects of shape (e.g. warp, etc.) that can't be eleminated after machining and end gluing.

To provide a very close contact of warped surfaces, it is necessary to make considerable effort. That leads to the development of internal stresses in the structure. Immediately after gluing they are distributed unevenly: in the sections under the points of applied pressure and between them, the value of normal to the gluing plane stresses ranges considerably (0,2-0,7 MPa). Average stresses in the lamination 20 mm thick is 0,39 MPa. With 40 mm lamination the value of average stress increases to 0,55-0,72 MPa. In worst cases, when internal stresses are added to life stresses, the structure with thick laminations can with time fail even without substantial external loading.

Deviations from optimal moisture per cent (8-I2%) don't favour the quality of the structure. The most dangerous is the moisture differencial in the adjoining laminations. When such an element is subjected to cyclic damping, the internal stresses developed in glue joints decrease their strength.

The investigations made have proved the maximum allowable moisture range in the adjoining laminations 40 mm thick not to exceed I-I,5%, and 20 mm thick - 2-2,5%. These requirements are met when the correct arrangement of drying is used - preliminary to transporting moisture $(20\pm3\%)$ - and final to (IO-I2%). The way of spreading the glue and the type of assembling affect as well the strength of timber.

If the adhesive penetrates to a desired depth in the laminations i.e. an area of the gluline is formed, consisting of the glue itself and the wood saturated with the glue , only then a specified strength of glue joints can be provided. This condition can be followed if the surface of a lamination got such an amount of glue that is sufficient to saturate it and to form a gluline between the two saturated laminations.

Certain effect has also the assemblage and pressing time.

If only on the one of the two mating surfaces the adhesive is spread, it trends to the deterioration of quality and simultaneously the time for assembling and pressing is prolonged.

Spreading of the glue on both surfaces, even at the same glue consuming, improves strength properties and their stability. Here is observed, however, to a smaller extent, some strength reduce and prolonged assembling and pressing time.

Experience has shown that the time from the moment of spreading newly mixed adhesive on the surfaces of laminations to the end of pressing shall be rigidly coordinated with the working pot life of the adhesive and shall be 30-35% less. stroy USSR, Moscow, USSR

Summary. The results of tests and of a statistical processing of wood-boards of four kinds are considered in the paper. Fibre boards made by a dry method of production, chipboards on cement adhesive and wood particle boards on synthetic and mineral adhesives were tested. The ultimate strengths of these wood-boards under compression, tension, bending, shearing and spalling and elastic modulus of those under compression, tension and bending were determined and are given in the paper.

<u>Resume.</u> L'auteur examine les résultsts du traitement statistique d'essais des panneaux en bois de quatre types (panneaux de fibres à fabrication sèche, ceux de copeaux aux liants synthétique et minéral) en traitant leur résistance à la compression, à la traction, à la flexion, au cisaillement ainsi que leur module d'alsticite en traction, en compression et en flexion.

The extensive use of wood board materials in construction puts forward the problem of comprehensive study of their physical and mechanical properties with the aim of specifying their standard and design resistances and strain characteristics.

Four varieties of boards were examined:wood-fibre boards, manufactured according to the dry method, (JBH) with the volume mass of 900 kg/m³, the thickness being 6 mm; I2 mm thick wood wool cement boards (JCH) with the volume mass of I300 kg/m³; I6 mm thick wood-particle boards on carbamide adhesive (JCH) with the volume mass of 750 kg/m³ and I3 mm thick wood-particle boards on mineral adhesive (MIH) (magnesial cement) with the volume mass of 850 kg/m³. The moisture content amounted 8, 7, 8 and 5%, respectively.

The boards were tested for the main stress states, namely for tension, compression, bending, shear and shear parallel to grain. Rectangular specimens sized I2x δ x20 mm (h) were tested at compression, those sized 30x δ x300 mm - at tension, specimens with the dimensions of 50x δ x200 (250) mm, I8(h)x δ x50 mm and I2(h)x δ x40 mm were subjected to bending, shear tests and tests for shear parallel to grain, respectively. The elastic modulus for compression was evaluated on prism-specimens sized 20x δ x60(h) mm. The specimens made of IBN were composed of pieces formed by two sheets glued along their depths. The standard dimensions of the tested specimens are given in Fig. I.

Fig. I. Standard dimensions of wood board specimens as accepted in compression (a,b), tensile (c), bending (d), shear (e) tests and in tests for shear parallel to grain (f).





Fig. II. Devices used in shear tests (a) and in tests for shear parallel to grain (b).

The compression, tension and bending tests were based on the methods employing devices similar to those used in testing timber and plywood. In shear tests and tests for shear parallel to grain as carried on according to the pattern of Fig. II (a,b), special devices were used.

During the shear test specimen I is placed into rectangular openings of the lower cramp 2 and the upper cramp 3. The tensile effort applied shear failure occurs along two planes. To obtain the shear stress the ultimate load should be divided by the area of the two sheared parts that is by the double crosssectional area of the specimen.

During the test for shear parallel to grain in the device under inventor's certificate No. 421912 the walls of the device move against each other due to the compression effort thus causing shear failure in specimen I. The device consists of two moving walls 2, supporting pieces 3, cantilevers 4, screws 5, rollers 6.

The test results were statistically treated by M220 Electronic Computer basing on the programme in the Algol-60 language.

To estimate the elastic moduli for tension and compression 20 mm-base tensoresistors were used while the elastic modulus at bending was meausred by clock indicators of 0.01 mm accuracy. The shear modulus was calculated by the well-known formula

$G = \frac{E}{2(1+\mu)}$

The results of the test to estimate the boards' ultimate strength are given in Table I. Table 2 contains the elastic and shear moduli and the coefficients of transverse strain.

It is clear from Table I that the strength of wood-fibre boards manufactured by the dry method (spalling strength not included) is I,6+3,I times higher than that of wood-particle boards on resin adhesive, for which higher pressure and pressing temperature can account. Tensile strength of wood wool cement boards and boards on mineral adhesive is I,3+ 2 times lower than that of particle boards on resin adhesive.

Table 2 shows that the highest elastic modulus at compression and tension is inherent to wood wool cement boards while at bending their elastic modulus is the lowest.

The coefficient of transverse straib ranges from 0,184 to 0,24. For boards with the 12% moisture content it can be taken equal to 0,21.

The ultimate strength and the elastic moduli obtained in the course of short-term tests can be assumed a basis inspecifying standard and design resistances and elastic moduli.

<u>References</u>

I. Ivanov Ju.M. Rekomendatsii po ispytaniju derevjannykh konstruktsij, CNIISK, Stroiizdat, M., 1976.

 Linkov I.M., Bojtemirova I.N. Predlozhenija po naznacheniju mormativnykh soprotivlenij tsementnostruzhechnykh plit, CINIS, Gosstroy USSR, NTPC, Ser. 7, vol. I, 1979.
 Prospekt firmy "Bison" (BRD). Drevesnostruzhechnaja plita.

450

	Ultimate strength, , coefficients of variability, , number of test specimens, , of wood-board materials. Results of tests under short-term loading															
Type	Type of Direction Type of stress state															
DOARDS OI IORCO		Compression			÷	Tension	n 	Bending				ear 		ear	para para	llel
		n	Mpa	♥ %	n	Mpa	* %	n	Mpa	× %	n M	pa	v %	n	Mpa_	v %
TIDI	along the length	119	26,07	16,8	108	25,41	29,8	120	57,08	11,9	110	18,66	8,3	104	2,23	28,8
ДВП	along the width	119	25,56	16,5	107	25 , 76	7,3	117	57 , 6I	13,2	119	19,41	9,2	119	I,95	20,6
1 CUT	along the length	118	16,23	13,5	80	5,23	11,4	93	16,50	12,0	116	7,95	26,6	1 1 6	3,01	21,3
LCII	along the width	115	16,37	16,3	86	4,17	15,8	93	16,10	8,7	110	9,55	18,5	110	3,54	14,6
ICII	along the length	120	16,11	14,7	67	9,55	16,6	49	22,33	19,6	57	9,09	18,1	III	2,76	19,1
H e	along the width	119	15,10	13,2	60	8,22	16,0	50	20,89	18,3	56	6,86	17,8	59	2,33	16,0
МДП	along the length	20	9,22	17,4	20	4,74	17,7	20	13,27	7,3	123	7,76	20,0	III	3,18	19,0
	along the width	20	8,85	10,1	19	4,17	17,1	20	9,44	15,6	48	1697	17,7	124	3,38	14,5

Table 2. Elastic, E, and shear, G , moduli and coefficients of transverse strain, of wood boards under compression, tension and bending

Type o	f Direction		Compres	sion		Tension				Bending	
DOALGS	of force	Number E G of spe- Mpa Mpa cimens			Number of spe- cimens	 Е Мра	 G Мра		Number of spe- cimens	Е Мра	
าน	along the length	12	5121,6	2062,I	0,24	12	5226,6	2097,0	0,22	12	7259 , 2
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	along the width	-	-	-	-	12	5082,2	2053,3	0,24	II	6806,8
	along the length	12	8319,9	3512,0	0,184	II	7526,6	3035,5	0,24	8	2350,0
ЦСШ	along the width	-	-	-	-	II	7274,7	2923,7	0,24	II	2020,2
IICII	along the length	5	2963,0	1204,5	0,23	I4	3690,0	-	-	10	4 5 43 , 8
доп	along the width	-	-	-	-	-	-	-	-	IO	3638,7
МДП	along the length	13	4326,8	-	-	I 4	4405,4	-	-	I4	3837,6
	along the width	13	3594 , 7	-	-	14	4196,3	-	-	I4	2834,0

Table I.

Effective utilization of nailed laminated timber construction in buildings

Dr. S.K. Malhotra, P.Eng. Associate Professor of Civil Engineering Nova Scotia Technical College Halifax, Nova Scotia, Canada and Dr. S.J. Mazur, P.Eng. Professor of Structural Engineering, Emeritus Nova Scotia Technical College Halifax, Nova Scotia, Canada

Summary

Various projects dealing with nailed laminated timber construction in buildings are discussed in this paper. The highlights of research and development studies, both analytical and experimental, related to these projects are outlined. The main thrust of these studies is to evolve fabrication techniques and develop scientific design methods so as to utilze small dimension lumber effectively and efficiently for a variety of buildings. Types of nailed laminated timber structures mentioned in the paper are: segmental latticed trusses, rigid frame construction, industrial buildings, garages for construction equipment and built-up beams, columns and beam-columns.

The fabrication procedures for nailed laminated timber construction discussed in the paper require unskilled labour using simple carpenter's tools, thus making this type of construction very well suited to socio-economic conditions of developing countries. <u>Résumé</u>

De différents projects concernant des constructions en bois de charpente laminé et clové, dans les bâtiments sont examinés dans cet article. Nous trouvons ici présentés les points les plus importants de le recherche et des études de développement sur ces projects conduites sur le plan analytique et experimental. Le but principal de ces études est de perfectionner les techniques de fabrication et de développer des méthodes de dessin scientifique afin d'utiliser de façon appropriée efficace du bois de charpente de petites dimensions pour de differents bâtiments. Les genres de structures en bois laminé et clové mentionnés dans cet article sont les suivants: fermes treillissées et segmentées, constructions en charpentes rigides, hangars à equipment de construction, poutres composées, colonnes composées et colonnes- poutres composées.

Les procédés de fabrication pour la construction en bois de charpente laminé et clové traités dans cet article exigent une main-d'oeuvre non-specialisée, utilisant de simples outils de charpentier, et par conséquent rend ce genre de construction trés convenable aux condition socio-économiquées des pays en voie de développement.

Introduction

Nails in various sizes, forms and shapes have been used for many decades and are continued to be used quite extensively as means of joining members in timber construction. Nails joints have definite advantage over other modes of jointing, as nailed connections, in general, require no or very little preparation of the members at the joints.

In nailed laminated timber construction, large sections and components are built up by fastening small dimension lumber by nails. A classical structure of this type should have either none or at the most very few other fasteners. Laminated construction, in general, offers the following advantages:

- Structures can be fabricated from small dimension lumber that is too small in cross section to be structurally useful otherwise. This makes a larger percentage of the available lumber useful for signicant structural applications.
- 2. Small dimension lumber can be laminated to form large size structural members to sustain heavy loads. This type of construction can offset the lack of sufficient quantity or nonavailability of large dimension lumber and can, thus, be of special benefit in areas where timber is available mainly in small cross sections and short lengths.
- 3. Low-grade material can be placed in locations of relatively low stresses and the better quality can be used at the points of higher stresses, thereby utilizing material more efficiently.
- It renders more flexibility to shape structures in many and varied forms.

Current codes, specifications and handbooks on timber design [1 to 5] either lack or provide a very limited information and guidance on design of nailed laminated construction, particularly for structures built up with 1-inch thick lumber. In the recent past, some research has been carried out on the fundamental behavior of nailed connections, but very limited work has been done on the applications to nailed laminated timber construction [6 to 10]. In recent years, many research and development studies have been conducted at Nova Scotia Technical College to seek answers to a number of unknowns related to performance of such construction. This paper outlines the highlights of those projects associated with buildings.

The main objective of most of the investigations was to develop fabrication techniques and design procedures for a variety of nailed laminated timber structures using 1-inch thick lumber. In addition, vast amounts of information and data were generated on strength of nailed connections and fundamental properties of eastern spruce lumber.

Nailed laminated timber construction

In nailed laminated structures, primarily trusses, two different techniques of construction can be distinguished: one based on the use of 2-inch nominal size stock and the other based on 1-inch nominal size stock. They differ in method of construction and perhaps also in performance efficiency. In the development projects reported in this paper, construction technique using 1-inch thick lumber was applied to trusses. This technique was further developed through research and its applications were extended to various types of structures. An exception should be noted that the investigations on built-up beams, columns and beam-columns included not only 1-inch size lumber, but

types of connectors. <u>General design</u> considerations

1. The fabrication procedure is to nail consecutive layers of laminae layer upon layer with the size of nail increasing from 1-1/2 to 3 inches; then the whole assembly is turned over and nailed with 3inch nails. Details of a 60 ft. span truss built with this technique are given in Figs. 1 and 2.

many other sizes of lumber and different sizes and

- The experimental studies were carried out with common wire nails of Canadian manufacture. Use of other types of nails require further study and may result in improvement in design.
- 3. In the present investigations, no scarfing or other method of longitudinal extension was used, only plane butt joints were provided. This requires careful attention to the location of splices and strict compliance with the following rules: (i) In any cross section of a built-up component, only one 1-inch by 4-inch piece may be spliced. (ii) Splicing in adjoining laminae must not be less than 4 ft. apart. This means that no piece of lumber may be shorter than 8 ft. This rule applies absolutely in tension members and tension chords of girders and should be attempted in other types of members. (iii) Splices in any layer should be staggered by at least 2 feet.

Special design considerations

To account in the design for the slip between laminae due to non-rigid connections, following recommendations are made. These recommendations are only tentative and require further confirmation by more testing. In computing effective section properties such as areas of cross section, moments of inertia and second moduli for bending, shear or torsion, reduce the areas of laminae (without changing the location of their centers of gravity) according to their relative positions to the plane of loading, using the coefficients below:

First lam. nearest to plane of loading or web --- 1.0 Second lam. nearest to plane of loading or web -- 0.8 Third lam. nearest to plane of loading or web --- 0.6 Fourth or higher order lamination nearest to plane of loading or web ------ 0.4 Horizontal lamination ----- 0.5 For webs of 2 layers at 45° inclination, reduce thickness by 25 percent and for webs of 3 layers, use horizontal thickness reduced by 50 percent. For plywood webs, apply principles of plywood design.

Research and development studies

Analytical and experimental investigations were conducted on a variety of nailed laminated timber structures. Tests were performed on full-size and scaled models of segmental latticed trusses and built-up beams, columns and beam- columns and on scaled models of other structures. All experiments were conducted on structures fabricated with construction grade eastern spruce lumber available in the Maritime Provinces of Canada. The results of investigations were applied to develop design procedures for the structures discussed below. Though the data and other information were developed specifically for structures made of eastern spruce, the design concepts and philosophy can be extended to other species of lumber to suit local conditions and design requirements.

Industrial buildings with segmental latticed roof trusses

Designs were developed for warehouse type buildings of 40, 50 and 60 ft. spans and for industrial buildings of 100 ft. width. Segmental latticed trusses were used for the roof system in the buildings. Figures 1 and 2 give construction details and typical design drawings for the roof trusses of 60 ft. span.



Figure 1. Layout of layers 1 to 6 in segmental latticed roof trusses.

Figure 3 shows a roof system made of segmental latticed trusses, ready for an ultimate load test. The roof system consisted of three trusses of 60 ft. span and 8 ft. rise, spaced 12 ft. center to center. The roof deck is composed of 2-inch by 6-inch purlins placed 16 inches center to center braced by spacer blocks over the trusses and at locations half-way between the trusses. Investigations were also conducted to evaluate economic proportions of the trusses

for various spans [11, 12]. For details on development design drawings, consult [13 to 15] and for information on analytical and experimental investigations on segmental latticed trusses, see [16 to 21].



Lumber - construction grade eastern spruce <u>Phywood</u>-douglas fitr, <u>Spacing of trusses</u> = 12³-0⁴

Figure 2. Layout of layers 7 and 8 and other details of segmental latticed roof trusses.



Figure 3. Set-up for test on roof trusses of 60 ft. span.

Designs were also prepared for two-hinged, semi-circular arches with vertically and horizontally arch ribs for spans 20 to 80 feet [22]. These types of arches can be used quite effectively for small span and high rise structures such as farm buildings, green houses and workshops.

Garages for construction equipment, with segmental latticed trusses

Designs were developed for standard type of a garage to house large construction equipment such as buildings, graders and scrapers and to provide a clear maintenance area of 50 ft. width [13, 23]. These designs have been used for actual construction by the Nova Scotia Department of Highways. A display model of this type of garage is shown in Fig. 4. Any length of the building can be obtained by, repetition of standard bays of 16, 18 or 20 feet. It ought to be noted that this type of construction is more economical for 4 or more bays.



Figure 4. Model of garage for construction equipment

Rigid_frame_construction

Designs were developed for structures of spans 20 to 150 ft. with possibility of further extensions to 200 ft. or more [24, 25]. Examples are community buildings such as theatres, community centers, schools, gymnasiums and skating rinks.

Built-up beams, columns and beam-columns

Design was produced for tapered nailed laminated built-up I-beams [26]. Theoretical and experimental investigations were also performed on built-up beam

investigations were also performed on built-up beams [25, 27]. The broad objective of this research was to develop efficient beam layouts and rational procedures for the analysis and design of built-up beams. The investigations on built-up columns and beam-columns were quite extensive [28 to 34]. Theory was developed for predicting the ultimate strength of mechanically connected built-up columns including layered, spaced, braced and box columns. Many series of columns built up with various sizes of lumber and using different sizes and types of connectors (nails, bolts, split rings), were tested to verify the theory. Based on the research, a rational procedure for the design of mechanically connected built-up timber columns has been develoed [30, 32]. A computerized approach to the analysis and design of such columns has also been presented [31].

As an illustration, Fig. 5 is presented here to show a comparison between theoretical and experimental results of the study on box columns. The columns were constructed with 4 pieces of nominal size 1 by 4 inches (corresponding actual size: $3/4 \times 3-1/2$ inches) and 2-inch nails. The spacing of the nails for the box columns represented on Fig. 5 was such that the column length was divided into 17 equal parts. The strength of box columns is also compared with that of the equivalent solid and layered columns. It can be seen that a box column is much stronger than its equivalent solid as well as layered columns.



Figure 5. Column stress versus length curves for timber box columns.

Figure 6 shows efficiency curves for different nail spacings in the type of layered column cross section sketched on the figure. Efficiency is defined as the



Figure 6. Column efficiency curves for layered columns with various nail spacings.

ratio of the strength of a laminated column to the strength of equivalent solid column of same overall dimensions as those of the laminated column. Graphs of the type shown in Fig. 6 can be a useful design aid to designers in selecting an optimum combination of lumber size and connector spacing.

Special advantages

Nailed laminated structures are quite safe as attested by a survey of such structures built throughout Nova Scotia during the past 50 years [17]. The principal component in the construction is 1-inch by 4-inch lumber which has for many years and is still the cheapest piece of lumber in Nova Scotia, Canada. The inexpensive connectors, common wire nails of local production, are used in the fabrication. The structures are relatively light, resulting in less cost of foundations.

Structures can be erected with unskilled labour using the most rundimentary carpenter's tools. Thus, the nailed laminated construction described in this paper is particularly suitable for community projects, where volunteer unskilled labour can be used. This type of construction is also very well suited to the socio-economic conditions of developing countries.

Conclusions

Nailed laminated timber construction can be used effectively and efficiently in many types of buildings. Special advantages of this type of construction can be quite significant in many local environments and condi-The potential of wide spectrum of design tions. applications of nailed laminated construction in buildings has been demonstrated in the paper. Based on research and development studies, designs and design procedures for many types of nailed laminated timber structures have been developed. Research is continuing to seek rational approaches for some design aspects that are presently considered on empirical basis.

Acknowledgements

Acknowledge is due to the Maritime Lumber Bureau, National Research Council of Canada and Canada Forestry Service for their financial support of many projects mentioned in the paper. The authors express their thanks to all individuals associated with various aspects of the projects for their assistance.

References

<u>Note</u>: References marked with^{*} are published by Nova Scotia Technical College (NSTC), Halifax, Nova Scotia, Canada, and those marked with⁺ are published by Department of Civil Engineering at NSTC.

 American Institute of Timber Construction. Timber construction manual. John Wiley and Sons, Inc., New York, 1974.
- Canadian Standards Association (CSA). Code for the engineering design in wood: CSA Standard 086-1976. CSA, Rexdale, Ontario, 1976.
- Laminated Institute of Timber Construction (LITC). Timber design manual. LITC, Ottawa, 1974.
- National Forest Products Association (NFPA). National design specification for wood construction. NFPA, Washington, D.C., 1977.
- 5. U.S. Forest Products Laboratory. Wood handbook: wood as an engineering material, U.S. Department of Agriculture Handbook No. 72. U.S. Govt. Printing Press, Washington, D.C., 1974.
- Goodman, J.R. and Popov, E.P. <u>Layered wood systems</u> with interlayer slip. Wood Science, Vol. 1, No. 3, 1969.
- Mazur, S.J. and Malhotra, S.K. <u>Studies in nailed</u> <u>laminated timber structures</u>. Engineering Journal, Vol. 56, No. 4, 1973.
- Niskanen, E. <u>Investigation of the buckling of</u> <u>compressed columns assembled by nailing</u>. Publication 63, The State University of Technical Research, Helsinki, Finland, 1961.
- 9. Rassam, H.Y. and Goodman, J.R. <u>Buckling behavior</u> of layered wood columns. Wood Science, Vol. 2, No. 4, 1970.
- Rodda, E.D. <u>Analysis of nailed indeterminate stru-</u> <u>ctures</u>. Forest Products Journal, Vol. 17, No. 6, 1967.
- ⁺11. McGraw, A.J., Mazur, S.J. and Choi, M. <u>Economic</u> proportions of roof structures with segmental <u>latticed trusses</u>. Essays on Timber and Timber structures, No. 11, 1965.
- ^{*}12. Wysocki, J. <u>Economic properties of roof struc</u>-<u>tures with nailed laminated, segmental, latticed</u> <u>timber trusses</u>. M.Eng. thesis, 1967.
- *13. Timber Research NSTC. <u>Segmental latticed trus</u>-<u>ses 40, 50, 60, 80 and 100 ft. spans</u>. Development Design Drawings, File No. 1, 1965.
- *14. Timber Research NSTC. <u>Warehouse type buildings</u> of 40, 50, and 60 ft. spans. Development Design Drawings, File No. 2, 1965.
- ⁺15. Timber Research NSTC. <u>Industrial buildings of</u> <u>100 ft. span</u>. Development Design Drawings, File No. 8, 1967.
- *16. Arora, S.S. <u>Model analysis of a nailed laminated</u> <u>lattice truss</u>. M.Eng. thesis, 1969.
- *17. Choi, M. and Mazur, S.J. <u>A historical and structural study of buildings with nail-laminated timber</u> <u>segmental latticed trusses in Nova Scotia</u>. Essays on Timber and Timber Structures, Nos. 10 and 13, 1965.
- *18. Gilkie, R.C. <u>A study of segmental latticed timber</u> <u>trusses with application to highway bridge design</u> M.Eng. thesis, 1964.

- ⁺19. Mazur, S.J. and Gilkie, R.C. <u>Interim report on</u> <u>the ultimate load test of segmental latticed</u>. Essays on Timber and Timber Structures, No. 3, 1963.
- ⁺20. Mazur, S.J. <u>Tentative specifications for working</u> <u>stresses in nail-laminated timber structures</u>. Essays on Timber and Timber Structures, No. 8, 1965.
- ⁺21. McGraw, A.J., Mazur, S.J. and Choi, M. <u>Design of</u> <u>nail-laminated segmental latticed timber trusses</u>. Essays on Timber and Timber Structures, No. 12, 1965.
- ⁺22. Choi, M. and Mazur, S.J. <u>Design of nail-laminated</u> <u>two-hinged semi-circular timber arches</u>. Essays on Timber and Timber Structures, No. 15, 1965.
- ⁺23. Timber Researach NSTC. <u>Garage for department of</u> <u>highways, construction equipment - 16, 18 and 20</u> <u>ft. bays</u>. Development Design Drawings, File No. 4 and 5, 1965.
- ⁺24. Timber Research NSTC. <u>Rigid frame structures</u> <u>and a feasibility study of ice rink</u>. Development Design Drawings, File No. 3, 1965.
- Chaboussi, J. <u>Bending of nail-laminated beams of</u> <u>I-section</u>. Transactions, Engineering Institute of Canada. Published in Engineering Journal, Vol. 13, No. A-8, 1970.
- ⁺26. Timber Research NSTC. <u>Built-up wood I-beams for</u> <u>the offices of Maritime Lumber Bureau</u>. Development Design Drawings, File No. 6, 1967.
- ^{*}27. Liu, C.B. <u>An investigation of nailed laminated</u> <u>built-up timber beams</u>. M.Eng. thesis, 1965.
- *28. Kwan, S.P.S. <u>A study of the strength of nailed</u> laminated timber columns. M.Eng. thesis, 1972.
- 29. Malhotra, S.K. and Van Dyer, D.B. <u>Buckling stren-</u> <u>gth and efficiency of built-up timber columns</u>. Annual meeting of Engineering Institute of Canada Halifax, Nova Scotia, 1976.
- 30. Malhotra, S.K. and Van Dyer, D.B. <u>Rational approach to the design of built-up timber columns</u>. Wood Science, Vol. 9, No. 4, 1977.
- 31. Malhotra, S.K. and Van Dyer, D.B. <u>A computerized approach to the analysis and design of machani-cally connected timber columns</u>. Proceedings of International Conference on Computer Applications in Developing Countries, Bangkok, Thailand, 1977.
- 32. Malhotra, S.K. and Van Dyer, D.B. <u>Analysis and design of spaced timber columns</u>. Proceedings of Annual Congress of Canadian Society for Civil Engineering, Montreal, 1979.
- 33. Malhotra. S.K. and Van Dyer, D.B. <u>Buckling strength and efficiency of timber box columns</u>. 16th-Midwestern Mechanics Conf., Manhattan, KS., 1979.
- 34. Seenappa, V. <u>Strength of nailed laminated timber</u> <u>beam-columns. M.Eng. thesis, 1980.</u>

Up-grading of wood structures by use of improved mechanical fasteners

E. George Stern, Earle B. Norris Research Professor Emeritus of Wood Construction, Dipl. Ing., M. S., Ph. D., R. A., Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Summary

In the light of the importance of effective jointing of wood and wood-base members and components in wood construction and assembly and the effective anchoring of wood structures to their foundations, improved mechanical fasteners for such jointing and anchoring can have an impetus on the up-grading of wood structures and innovation in this field. Information is presented on such improved mechanical fasteners which have recently been used with success, have recently been developed, and appear to be promising in leading to improved wood construction and assembly.

These fasteners include expansion anchors for fastening to concrete and masonry; powder-driven pins and studs for fastening to concrete, masonry, and steel; light-gauge steel nailing plates with integral prongs or teeth protruding from one or both plate faces; a composite plastic plate with each of the numerous steel nails protruding from both plate faces; slender, helically threaded, hardened-steel nails and spikes; and slender, annularly threaded, hardened-steel staples.

If the use of these and other promising fasteners and their fastening systems are given the needed impetus, they may make wood construction and assembly more effective and competitive than previously possible and even result in innovation in wood construction and assembly.

Résumé

Les assemblages ont toujours été un problème important pour les projeteurs de charpentes en bois. Jusqu'à l'introduction des assemblages renforcés, les joints, plus que les efforts dans les membrures, étaient souvent le facteur déterminant de la section des membrures de charpente. Aujourd'hui, elles sont définies par les efforts de calcul de base, et les joints sont prévus pour transmettre ces efforts avec des assemblages de résistance adéquate.

Ceci est possible avec les nouvelles possibilités des assemblages mécaniques renforcés. Ils comprennent un certain nombre de nouveaux ancrages à expansion, destinés à fixer le bois et le métal sur le béton et la maçonnerie; ainsi que les pointes et goujons enfoncés au pistolet qui permettent de sceller les bois et le métal sur le béton, la maçonnerie ou le métal. Ils comprennent également les plaques minces en acier avec ou sans dents ou crampons; et les plaques de plastique a pointes rigides métalliques, destinées aux assemblages de bois sur bois. Les pointes rigides renforcées éventuellement par un filetage hélicoïdal sur une partie du fut et jusqu'à la pointe, peuvent être utilisées en petit ou en grand nombre pour transmettre les efforts de bois à bois, avec ou sans plaque métallique clouable placée entre ou à l'extérieur des membrures en bois.

L'emploi de ces et outres assemblages mécaniques renforces rend les structures en bois plus efficaces et plus compétitives qu'elles ne l'étaient avant leur introduction.

Innovation in construction since World War II led to the introduction of new construction systems which are based, e.g., on the use of cold-formed steel, light-weight concrete, and more or less rigidly framed wood and wood composites. In these cases, the connection of the structural elements was one of the more serious problems with which the designer was confronted.

Some of the systems could be developed only after the introduction of improved fasteners which became the backbones of the novel systems. Thus, the all-nailed trussed rafters designed by the author [1,2] were based on the use of helically threaded, hardened-steel nails introduced for mass-production three decades ago [3]. Today's mass-production of trussed rafters became feasible only with the development of light-gauge steel nailing plates provided with integral prongs or teeth punched from these plates, to be pressed into the lumber to be joined [3]. Similarly, the engineered wood-framed house based on a system developed at and patented by the U.S. Forest Products Laboratory [4] was conceived with the use of these nailing plates in mind, to provide the required semi-rigid joints between the 2x4s as well as the structural components.

As a result of the introduction of such improved fasteners as threaded nails and nailing plates, the anticipated stresses in the members, rather than the joints, became the controlling factors in determining member sizes. Thus, the selected appropriate fasteners effectively transmit the stresses and provide for the performance required from the joints and the assembled structure.

In any attempt to innovate in the field of wood construction, it may, therefore, be helpful to be familiar with such improved mechanical fasteners which have recently been used successfully or developed and which appear to be promising in leading to improved construction and construction systems. It is the purpose of this paper to provide such information.

The mechanical fasteners to which reference is made are improved expansion anchor bolts for fastening and anchoring wood and steel to concrete and masonry as well as powder-driven pins and studs for fastening wood and steel to concrete, masonry, and steel. The fasteners also include light-gauge steel nailing plates with integral prongs or teeth protruding from one or both plate faces as well as multiple steel nails protruding from composite plates for fastening wood to wood. Reference is made to slender hardened-steel nails and spikes, provided with effective helical threads along the nail shank near its point. These nails and spikes can be used in small as well as large numbers to transmit forces from wood to wood with or without nailable steel flitch plates between and similar plates along the outer faces of the wood members. Attention is drawn to the potential resulting from the suggested introduction of slender, annularly threaded, hardened-steel staples, the availability of which could result in

opportunities in the field of wood construction and assembly previously not considered feasible.

Expansion anchor bolts

Improvements in expansion anchor bolts of many sizes are based on the more effective transmission of external forces via the bolt into the surrounding predrilled concrete* as far away from the concrete surface as is practical and economically feasible.

Traditionally, this transmission of forces is accomplished as a result of friction generated between the anchoring device and the surrounding concrete. The partially knurled and slotted, annular, expansion sleeve, located near the bolt end deep in the concrete, is automatically spread out during tightening of the bolt by a single, internally threaded, steel cone at the far end of the anchoring device and restrained from moving in the direction to the concrete surface by the expansion of a knurled plastic sleeve at the near end of the expansion sleeve (see Fig. 1). This plastic sleeve is designed to dampen vibration and shock forces.

In another type of anchoring device, a similar expansion sleeve is automatically spread out by a single, internally threaded, steel cone at each sleeve end in such a way that the two cones expand the sleeve more or less uniformly along its length (see Fig. 2). Thereby, a more or less uniform pressure is applied against the surrounding concrete along the full length of the sleeve and high frictional resistance is provided to the outward as well as inward movement of the bolt during the transmission of external forces.

While the two types of expansion anchors described develop their effectiveness as a result of the generation of friction between the anchoring device and the surrounding concrete, a recently introduced expansion anchor is designed to transmit forces into the concrete as a result of direct bearing of the expansion sleeve segments in the concrete (see Fig. 3). The predrilled hole in the concrete is undercut at the appropriate depth with a special drill. During tightening of the bolt, the segments of the expansion sleeve are spread out into the undercut by the conical end of an internally threaded cylinder. After tightening of the bolt, one end of each of the spread expansion-sleeve segments rests against an internally threaded bearing ring of the anchoring device and the other end of each of these segments bears directly against the bearing surface of the undercut in the concrete. Since the anchor effectiveness is not based on friction and lateral compressive forces in the concrete but on compressive forces more or less parallel with the anchor axis around the anchoring device, normally specified standard edge distances and spacings may be reduced for this novel anchoring device. For the same reason, this anchor can be installed with the bearing devices in the compression or tension zones of concrete members, since any expansion on the tension side of concrete in flexure has little, if any, effect on the bearing strength of the concrete, hence, on the effectiveness of this anchor.



Fig.1.-Expansion anchor bolt with knurled plastic sleeve (Hilti). Fig.2.-Expansion Fig. anchor bolt with of a two expansion pan cones (Liebig), in a

Fig. 3.- Simplistic version of anchor bolt with expansion sleeve segments in direct bearing (Liebig),



Fig.3a.- Predrilling of concrete, undercutting of concrete, inserting of expansion anchor, and expanding of sleeve segments resulting in direct load transmission to concrete (Liebig).

The three improved fastening devices can make the anchoring of wood as well as steel structures to concrete more effective and more economical. In the light of our awareness of the potential of extreme forces caused by natural and man-made disturbances, the emergence of these improved anchoring devices can be highly beneficial.

In the context of this paper, the term concrete also refers to masonry.

Powder-driven pins and studs

Extensive field experience in the fastening with powder-driven pins and studs (see Fig. 4) during the past decade has resulted in effective fastening of wood and steel to concrete, masonry, and steel with these fasteners. They are provided with such surfaces which are beneficial to increasing their holding power in given materials. The safety devices incorporated in the tools reduce danger to the workman to a minimum. Portable testing devices are used in the field to ascertain that a given driven fastener at a given location can safely transmit given forces.

Thus, the powder-driven fastener industry can be considered to have matured since the time when the Building Research Advisory Board study of the performance characteristics of powderactuated fastening systems was undertaken during the sixties [5]. At this time, the preparation of a proposed consensus product standard for powder-driven fasteners is under consideration by the American Society for Testing and Materials (ASTM) Committee on Performance of Building Constructions (E06) and its Subcommittee on Structural Performance of Joining and Fastening in Building Constructions (E06.13). This Subcommittee is also working on up-dating ASTM Standard E488-76 covering test methods for the strength of anchors in concrete and masonry elements [6].



Fig. 4.- Powder-driven pin, left, and stud, right.

Steel nailing plates with integral prongs or teeth Flat and deformed, prepunched, light-gauge, galvanized-steel, nailing plates of various types with integral prongs (barbs) or teeth (plugs) punched from these plates and protruding from one plate face have been used successfully in tremendous quantities principally for the butt-jointing of lumber in such building components as roof and floor trusses and in the assembly of semirigid frames [3]. The nailing plate industry in the U.S.A. involves approximately 30 plate manufacturers with more than \$100 million in sales and 1800 to 2000 truss and component manufacturers with more than \$1.50 billion in gross sales of trussed rafters and trusses requiring the use of approximately 4 billion board-feet of lumber [7]. Worldwide, the use of these nailing plates is, of course, even greater.

Many of the companies involved are members of the Truss Plate Institute (TPI) which is responsible for the issuance of the recommended design practices, that is, the industry's specifications and guidelines for metal-plate connected wood trusses [8]. Standard methods for testing the tensile strength properties and shear resistance of steel truss plates are under revision and proposed, respectively, by ASTM E06 and E06.13 [9, 10]. Similar plates with integral prongs or teeth protruding from both plate faces have been produced for experimental purposes (see Fig. 5). They are designed to fasten adjacent members face to face. The mass-production of such plates could open up many new opportunities in wood construction [11, 12] and assembly [13]. Multiple plates and long strips of such plates could be used for the assembly of composite wood, plywood, hardboard, particleboard, and fiberboard beams, joists, girders, and trusses. These plates could also serve in the spot and continuous fastening and anchoring of individual elements, components, and structures. Thus, double-prong plates could be used to provide for continuity of individual butted members during their assembly adjacent to each other and strips of plates could take the place of flitch plates between wood as well as wood-base members in flitch beams.

Composite plate with protruding steel nails

The Swiss "Menig" plate (see Fig. 6) is designed to serve a similar purpose as the described steel plates provided with integral prongs or teeth protruding from both plate faces [14]. This composite plate consists of two layers of plastics of approximately $\frac{1}{8}$ -in. overall thickness, in which dauble-pointed 1 x 0.041-in. steel nails are partially embedded and from which they protrude 7/16 in. in both directions. The nails are spaced $\frac{1}{4}$ in. apart in rows $\frac{1}{8}$ in. apart. The plates have been used successfully for and offer excellent opportunities in the fastening of adjacent wood and wood-base members face to face in the assembly of building elements and structures of up to 150-ft span, where the members are arranged in more than one plane.



Fig. 5.-Steel nailing plates with integral prongs, bottom center, and teeth, right, protruding from both plate faces (ABC). Fig. 6.-Composite nailing plate with steel nails protruding from both plate faces, left (Menig).

Helically threaded hardened-steel nails and spikes While slender, helically threaded, hardened-steel nails and spikes (see Fig. 7) have been used in the U.S.A. for wood construction and assembly in large quantities for many years and are included in the National Design Specification for Wood Construction [15], their use in other parts of the world has been limited. Their slenderness, toughness, buckling resistance, stiffness, and withdrawal, shear and bending resistance provide advantages which make these fasteners especially suitable in efforts to improve wood structures.



Fig. 7.- Helically threaded, hardened-steel nails and spikes of 5 and 6-in. lengths and 0.177-in. diameter and 7-in. length and 0.207-in. diameter.

Because of their slenderness, the number of nails per unit of weight is high. Also because of their slenderness, they can be placed in relatively small joint areas in relatively large numbers. Thus, the joints can be made at least as strong as the jointed members, in line with the experience that a larger number of small (slender) fasteners can be more effective than a small number of large (stout) fasteners in a given area. Because of their slenderness and buckling resistance, they can be driven into most woods used in construction without predrilling even if 8 or 9 in. long. Because of the holding power provided by effective helical threads, these nails and spikes can be driven into and even through the joint from one side, thereby eliminating nailing from two sides, provided the fasteners are of sufficient length. Because of their stiffness at high loads, these fasteners can transmit flexural loads deeper into the member section. Because of their high withdrawal resistance, they provide high ultimate lateral load-carrying capacity. Because of the effectiveness of the helical threads, the effectiveness of the fasteners is not reduced, on the contrary may be even increased, during seasoning of the wood after joint assembly. In the light of these and other advantages, the ready availability in the U.S.A. of these improved nails and spikes opened up many opportunities and resulted in improved wood construction and assembly.

The exclusive use of these fasteners is specified in certain types of wood structures, such as in the fastening of wood members to pressure-treated poles and posts in pole-type farm, marine, industrial, educational, public, and residential structures. Ready availability of these improved fasteners in other parts of the world, where construction with wood is feasible, might also result in the up-grading of wood for building construction and in improved wood structures.

Since these nails and spikes readily penetrate light-gauge steel, they can be used effectively in the fastening of coldformed steel to wood. They make the use of flitch beams attractive and economical, especially since these fasteners can be readily located in the outer wood member and driven through the wood or wood-base and steel members from one side of the assembly without predrilling. With this in mind, mass-produced flitch-beam foundation bents (see Fig. 8) have been proposed by the author [16, 12, 17]. They can replace similar prefabricated reinforced concrete foundation bents (see Fig. 9) as encountered by the author during 1979 just outside of Gérardmer, France, where they serve as the foundation for a locally prefabricated wood model house. Obviously, other composite wood structures are envisaged based on the benefits of the use of the slender, helically threaded, hardened-steel nails.





Fig. 8,-Installation of prefabricated house sections on massproduced flitch-beam foundation bents (VPI&SU).

Fig. 9.– Prefabricated wood house on prefabricated concrete foundation bents in Gérardmer, France, 1979.

A proposed metricated product standard for round wire nails, spikes, and staples [18], including helically threaded, hardened-steel nails and spikes, is under consideration by the ASTM Committee on Fasteners (F16) and its Subcommittee on Driven and Other Fasteners (F16.05). A proposed ASTM standard on methods of testing nails [19] is being letter-balloted within the Committee. The testing for toughness of helically threaded, hardened-steel nails of certain sizes with the Morgan Impact Bend Angle Nail Tester (MIBANT) has become a routine procedure for the acceptance and rejection of these nails by their manufacturers and users [20] on the basis of criteria established by the National Wooden Pallet and Container Association (NWPCA). Thus, hardened-steel pallet nails are required to provide an average MIBANT angle within the range of 8 to 28 deg for 25 random nail samples per lot, with none of the 25 samples allowed to exhibit partial or complete head failure and not more than 8 pct of the 25 nails to show partial or complete shank failure. These acceptance criteria are applicable to any hardened-steel nails, with or without deformations along their shank, of 0.106 to 0.135-in. (2.7 to 3.4-mm) wire diameter and $1\frac{1}{2}$ to 3-in. (38 to 76-mm) length [19]. The application of these test criteria to any hardened-steel nails of these sizes will provide assurance that these nails can be driven satisfactorily and will perform effectively during their use in wood construction and assembly.

Annularly threaded hardened-steel staples

Slender, non-coated and polymer-coated, 14 and 15-gauge, steel staples of up to $3\frac{1}{2}$ -in. length and 7/16-in. crown width --- driven with specially developed, automatic, high-speed, pneumatic tools --- have also been used effectively in wood construction and assembly in large quantities for many years. A metricated product standard [18] which includes these staples is being developed as was indicated previously.

Designwise, the two-legged staple is treated like two single nails of identical dimensions and finish. The performance of some of these staples has been determined experimentally by the author as well as others [21, 22, 23, 24, 25, 26]. Methods of testing these staples for their toughness are still in the development stage [27].

The benefits derived from the use of these staples are mainly based on the ease and speed of driving them and their slenderness which eliminates splitting of wood under field conditions normally encountered. The limitations of these staples in their effectiveness are based on the fact that the legs of non-coated and coated staples are plain, that is, without such mechanical deformations which have proven to be highly effective in the case of nails provided with effective threads along part of their shanks. Thus, non-coated staples, like non-coated plain-shank nails, have limited holding power and lose a large percentage of their initial holding power immediately after driving during subsequent seasoning of the wood into which the fasteners are driven. Certain polymer coatings alleviate this limitation, but only to a degree.

With this in mind, the author has recommended [28] that staples be made of steel wire preformed with highly effective surface deformations or that effective surface deformations be applied to the plain wire prior to the forming of the staple (see Fig. 10). In the latter case, the wire deformations could and should be discontinuous, that is, applied only where most effective along the staple leg near the staple point. If the deformations consist of annular threads, the holding power of the threaded staple could be compared favorably with that of two annularly threaded nails of same size.

Yet, the thread-root diameter would be smaller than the wire diameter and the thread-crest diameter would be larger than the wire diameter. The latter would be of influence on the design of the power tool's guide body and the support given the staple by the guide body during driving. The reduced root diameter of the threaded staple would decrease its buckling resistance during driving and its flexural and shear resistance while transmitting lateral loads.

For these reasons, the steel staple with effective leg deformations should be hardened after forming, instead of being polymer-coated, particularly since such coating would provide little, if any, improvement in holding power in the light of the high effectiveness of annular leg deformations.

Such a heat-treated and tempered staple would provide the advantages inherent to the slender staple as well as those inherent to the effectively threaded nail. The benefits derived from such improved staples could result in more effective and efficient wood construction and assembly, probably in a number of innovations in the use of wood, and in hitherto unforseen construction and assembly systems.

The recommendation is made that staple manufacturers make every effort to design and mass-produce hardened-steel staples with highly effective annular deformations along portions of the staple legs.



Fig. 10.- Annularly threaded hardened-steel staple.

References

 Stern, E. G. <u>All-nailed trussed rafters of "W" and scissor</u> <u>designs for buildings of 18 to 40-ft span.</u> Virginia Polytechnic Institute and State University, Department of Wood Construction. 1958.

[2] -----. <u>All-nailed king-post trussed rafters of 18 to 40-</u> ft span. Ibidem, 1960.

 [3] ———. Better utilization of wood through assembly with improved fasteners. Virginia Polytechnic Institute and State University, Wood Research and Wood Construction Laboratory.
 Bull. No. 38. 1959.

 [4] Tuomi, R. L. Lightweight truss-framed house. U. S. Patent No. 4,005,556. 1977. Also, Lightweight truss-framed house for safety and energy efficiency. Agricultural engineering, Vol. 58, No. 5, 1977, pp. 12–15.

[5] BRAB Special Advisory Committee. <u>Performance character-</u> istics of powder-actuated fastening systems. National Academy of Sciences – National Research Council, Commission on Sociotechnical Systems, Building Research Advisory Board, 1977.

[6] ASTM Subcommittee on Structural Performance of Joining and Fastening in Building Constructions. <u>ASTM Standard E 488-</u> 76 on standard test methods for strength of anchors in concrete and masonry elements. Annual Book of ASTM Standards, Part 18, pp. 911–919, American Society for Testing and Materials. 1978.

[7] Meeks, J. E. Industrial profile of the metal-plate connected wood truss industry. Paper presented at Metal Plate Wood Truss Conference in St. Louis, Missouri, November 13-16, 1979.
[8] TPI Technical Advisory Committee. <u>Design specification</u> for metal plate connected wood trusses. Also, <u>Interim guidelines</u> Truss Plate Institute. TPI-78.

 [9] ASTM Subcommittee on Structural Performance of Joining and Fastening in Building Constructions. <u>ASTM Standard E 489–</u> 73 on test method for tensile strength properties of steel truss plates. Annual Book of ASTM Standards, Part 18, pp. 920–924.
 1978. Fourth draft for revision letter-balloted. American Society for Testing and Materials. 1979.

[10] — . <u>Proposed ASTM standard method of test for shear</u> resistance of steel truss plates. Sixth draft letter-balloted. American Society for Testing and Materials. 1979.

 [11] Lindal, S. W. <u>Prestressed vertically laminated beam of</u> wood. U. S. Patent No. 3,605,360. U.S. Patent Office. 1971.
 [12] Kumar, V. K. <u>Industrialized foundations for low-rise light-</u> weight buildings. Virginia Polytechnic Institute and State University Research Division, Wood Research and Wood Construction Laboratory. Bull. No. 109. 1972.

[13] Stern, E. G. <u>Design of pallet deckboard-stringer joints</u>, part II: reinforced aspen pallet joints and aspen pallets. Virginia Polytechnic Institute and State University, Wood Research and Wood Construction Laboratory. Bull. No. 133. 1975.
[14] Moehler, K. <u>Experiences with Menig nail plates</u>. Recent experiences with mechanical fasteners. Forest Products Research Society, Proceedings No. P-73-8:14-26. 1973. [15]NFPA Technical Advisory Committee. <u>National design spe-</u> <u>cification for wood construction</u>. National Forest Products Association. 1977 edition.

[16] Cidras, J. M., V.K. Kumar and E. G. Stern. <u>Mass-produced</u> <u>foundations for mass-produced houses</u>. Virginia Polytechnic Institute and Stare University, Wood Research and Wood Construction Laboratory. Bull. No. 103. 1971.

[17] Kumar, V. K., E. G. Stern and T. Szabo. <u>Built-up and</u> composite beams. Ibidem. Bull. No. 110. 1972.

[18] ASTM Subcommittee on Driven and Other Fasteners. <u>Pro-</u> posed ASTM product standard for round wire nails, spikes, and <u>staples</u>. Fourth draft, American Society for Testing and Materials. 1980,

[19] _____. <u>Proposed ASTM standard methods of testing</u> <u>nails.</u> Revised fifth draft letter-balloted. American Society for Testing and Materials. 1979.

[20] Stern, E. G. <u>Toughness of pallet nails.</u> Virginia Polytechnic Institute and State University, Wood Research and Wood Construction Laboratory. Bull. No. 150, 1977.

- [21] . Lateral load transmission by 2¹/₂-in. 15-gauge
- Senco staples. Ibidem. Bull. No. 92. 1970.

[22] ———. Holding power of 2¹/₂-in. 15-gauge Senco staples.
 Ibidem. Bull. No. 97. 1970.

[23] ———. Performance of 2¹/₂-in, 15-gauge Pas-Kote pallet staples. Ibidem. Bull. No. 137. 1975.

[24] ———. Performance of 14-gauge Sencote staples. Ibidem. Bull. No. 138. 1975.

[25] ———. <u>Performance of 2¹/₂-in. 15-gauge Duo-Fast pallet</u> staples. Ibidem. Bull. No. 140. 1976.

[26] Ehlbeck, J. Performance of non-coated and coated Senco

staples in European spruce (whitewood). Ibidem. Bull. No. 160, 1978.

[27] Stern, E. G. <u>MIBANT tests on pallet staples</u>. Ibidem. Bull. No. 149, 1977.

[28] ———. <u>Auto-stapled pallets.</u> Ibidem. Bull. No. 139. 1975.

462

463

Design Methods for Timber Structures in Seismic Zones.

John A. Webster, BSc(Eng), MSc, PhD, MNZIE. Senior Lecturer (Structures) School of Architecture Victoria University of Wellington New Zealand

The problems associated with the design of timber structures in seismic zones are discussed, and some account is given of the philosophy behind the current design methods. Special reference is made to New Zealand practice, and to the recently completed design codes for light timber frames and for engineered timber structures. Current research activities in New Zealand are outlined, and some possible future developments are identified.

Les difficultés associées à la conception de structures de bois destinées à être utilisées dans des zones sismiques sont traitées, et l'on donne un aperçu de la philosophie qui inspire les méthodes de conception actuelles. On se réfère tout particulièrement aux methodes néo-zelandaises et aux codes récemment établis en ce qui concerne l'élaboration de structures de bois légères et lourdes. Un bref compte rendu est donné des recherches actuellement en cours en Nouvelle-Zélande ainsi que des développements que l'on peut prévoir pour l'avenir.

Introduction

New Zealand is located in a seismically active region of the South Pacific between latitudes $35^{\circ}S$ and $47^{\circ}S$. The climate is generally temperate, with a moderate rainfall. Maximum wind speeds are high in many coastal districts. Extensive European settlement began in 1839, and several major earthquakes have been experienced since that time.

Timber Construction in New Zealand

The first major earthquake to be experienced by European settlers in New Zealand occurred on 16 October 1848 near Wellington. Most of the houses erected by the settlers had been constructed of sod, rammed earth or brick, and damage was extensive. The comparative immunity from damage exhibited by timber framed buildings led to the general adoption of timber construction, and this experience was reinforced on 23 January 1855 when Wellington was again shaken by a major earthquake.

In the years which followed these events, timber construction in New Zealand evolved gradually. Construction methods were generally based on the established trade practices of the various immigrant groups, modified to suit local conditions and materials. Building regulations were local rather than national in scope, and were concerned with matters such as fire resistance and minimum room dimensions rather than with structural design requirements. No further earthquakes were experienced, but several major fires occurred in the rapidly developing cities. Under pressure from a more sophisticated society, which demanded that all public buildings be constructed in permanent, non-combustible materials, fire regulations were imposed which effectively limited timber construction to small domestic and commercial buildings outside the central business districts.

A long period of immunity from all but minor earth tremors ended on 17 June 1929, when a major earthquake occurred in the Buller region, and caused severe damage in the town of Murchison. Based on this experience, Dixon [1] compiled a series of recommendations for the earthquake resistant design of light timber framed buildings.

The greatest earthquake disaster experienced to date in New Zealand occurred on 3 February 1931 in the Hawkes Bay region. More than 250 lives were lost in the towns of Napier and Hastings, and the central business districts were devastated. Very few deaths could be attributed to the collapse of timber framed buildings, but a number of specific weaknesses in these buildings became evident. For example, the lateral support provided below ground floor level was often inadequate when piles or timber stud frames were used, the bracing provided in both the walls and the roof systems was inadequate when concrete or clay tile roofs were used, the tiles themselves were not adequately fixed, and the heavy brick chimneys, then in common use, were not strong enough.

The existing building regulations had been shown to be less than satisfactory, and the Government appointed a committee to examine all aspects of earthquake resistant design and construction. The model building byelaw formulated by this committee was finally published in 1935, under the auspices of the newly formed Standards Institution, as NZSS 95 [2]. This document comprised ten sections, which covered approval procedures, planning regulations, sanitary provisions, fire resistance, design loads and design and construction methods for timber, steel and reinforced concrete buildings.

NZSS95 permitted timber houses to be erected on free standing piles up to 750mm in length. When this limit was exceeded, lateral bracing was required. The specifications for the lateral bracing in walls were adequate within the context of the then current construction practices, but lateral bracing for roof frames was specified only in the most general terms.

The specifications for the construction of state owned houses had a significant effect on house construction in general. For example, the 1936 State Housing specification required that a continuous reinforced concrete foundation wall be provided around the perimeter of each house. While the wall was mainly intended as a precaution against termite infestation, and against relative settlements in expansive clay soils, the earthquake resistance of the houses involved was significantly improved. The 1939 version added the requirements that 150mm by 25mm let-in boards be used to brace the walls, that adequate lateral bracing be provided for the roof frames, and that chimneys be reinforced.

NZSS95 remained in force until 1964, when the system of building byelaws was altered, and NZS1900 $\begin{bmatrix} 3 \end{bmatrix}$ was introduced. While some minor amendments were made, the requirements for light timber frames buildings were virtually unchanged. In 1972, however, the Standards Association initiated a complete revision of the New Zealand Standards applicable to timber construction. A number of new codes have since been published, including NZS3603 $\begin{bmatrix} 4 \end{bmatrix}$, which covers engineered timber structures, and NZS3604 $\begin{bmatrix} 5 \end{bmatrix}$, which covers light timber frames.

Seismic Loads

In order to estimate the maximum lateral loads applied to a structure during an earthquake, the usual procedure is to construct a response spectrum based on the maximum accelerations which would be developed in a hypothetical single-degree-of-freedom structural system with variable mass, stiffness and damping. A typical response spectrum is sketched below.



Note that the response curves for 2 percent and 5 percent damping are similar in form to the undamped curve, although the magnitudes are reduced. The damping present in a structure depends on the structural system used and on the materials from which that system has been fabricated. While analytical methods can be used to determine the natural period, an extensive survey [6] during which actual structures were subjected to random excitations, and their natural periods

measured, revealed that a simple empirical expression gave an adequate guide for initial design purposes.

$$T = \frac{H}{10\sqrt{D}}$$

where T represents the natural period (seconds)

H represents the height of the structure (metres) D represents the relevant plan dimension (metres)

The maximum lateral force applied to any particular structural system can be determined from the product of a seismic coefficient (the maximum horizontal acceleration expressed as a fraction of the gravitational acceleration) and the seismic weight of the system (the dead load plus a certain proportion of the live load). The seismic coefficient is estimated from a response spectrum appropriate to the site location and the soil conditions.

For economic reasons, structures can rarely be designed to remain within the elastic range under earthquake accelerations which equal or exceed the maximum values expected during their lifetimes. Design codes are therefore based on seismic coefficients appropriate to a moderate earthquake. Now the application of an ultimate strength design method should ensure that a structure just reaches the point of collapse under sustained loads equivalent to the maximum dynamic loads thus estimated. In practice. each member suffers a series of load reversals, and a ductile structure will still have a considerable reserve of strength at this point. The less ductile a structure, and the greater the importance of avoiding minor damage, the more closely must the design forces approach the maximum expected forces.

Suppose, for example, that a particular structure can be assumed to remain elastic under the maximum expected forces. As indicated below, the structure would develop a characteristic lateral deformation under these conditions.



Suppose now that the yield point was at some lower level, but that the material remained perfectly plastic. Provided that sufficient ductile capacity was available, the weaker ductile structure would deflect to exactly the same extent as the original elastic structure. Depending on the structural system and on the material used, the deflections under the maximum expected lateral loads might be ten times the elastic deflections under the design loads. Joint and member design must be carefully considered to ensure that a structure can remain coherent and stable under these extreme conditions.

Seismic Loads : New Zealand Practice

The design seismic loads for most normal structural systems are specified in NZS4203 $\begin{bmatrix} 7 \end{bmatrix}$, and the maximum lateral force is calculated from the expression

V = C I S M R W

where V represents the lateral force

- C represents the basic seismic coefficient
- I represents the importance factor
- S represents the structural type factor
- M represents the material factor
- R represents the risk factor

W represents the seismic weight of the structure The basic seismic coefficient is determined from the following spectral curves.



The importance factor reflects the extent to which a structure must remain functional after an earthquake, and varies from 1.0 for private buildings to 1.6 for essential public buildings.

The structural type factor reflects the manner in which a structure resists earthquake forces, and varies from 0.8 for structures with ductile moment resistant frames or coupled shear walls to 2.5 for structures which depend on slender diagonal braces. Where energy is to be dissipated by plastic hinge rotation or by axial deformation in bracing members, the structure must be subjected to capacity design. Certain collapse mechanisms must be selected, and the relevant structural elements designed in such a manner that the required performance is achieved. The remaining structural elements must be provided with sufficient reserve strength to ensure that the selected mechanisms can be maintained under all conditions.

The material factor reflects the ductility of the structural material, and varies from 0.8 for structural steel to 1.2 for reinforced masonry.

A combined structural type factor and material factor is used for timber structures, whose seismic performance usually depends on energy dissipation at the various connections. The values tabulated below have been established on the basis of engineering judgement, and more research into the inelastic response of timber structures is needed.

	SM
Structure or Component	Factor
Shear walls or diaphragms formed with sheet	1.0
materials or diagonal boards fastened to	
timber boundary members with a large number	
of metal dowel fasteners which act in shear.	
Shear walls or diaphragms in which the design	1.2
load is carried by elastomeric adhesive.	
Moment resistant frames in which the joints	1.2
are formed by nails or bolts which act in	or
shear and which possess substantial ductility.	1.5
Moment resistant frames in which the joints	1.5
are formed by fasteners with limited ductility	or
such as pressed metal plates, shear plates and	1.7
split ring connectors.	
Moment resistant frames in which failure	2.4
occurs by flexure or shear in the timber	
members or by non-ductile collapse of the	
joints.	
Diagonally braced systems with timber members	1.7
which can act in tension or compression and	
with ductile end fasteners.	
Diagonally braced systems as above, with end	2.0
fasteners of limited ductility.	

The factor used for a ductile moment resistant frame depends on the number of parallel members at each level within the frame between which energy dissipation can be shared.

The risk factor reflects the risk to life and property which would follow partial or complete collapse of the structure, and varies from 1.0 for normal buildings to 3.0 or more for chemical factories and similar installations.

Timber Design Code

The design of timber structures other than those which meet the requirements for light timber frames must generally be in accordance with NZS3603. This code is based on elastic design for service loads, and has been much influenced by the corresponding Australian design code AS1720 $\begin{bmatrix} 8 \\ 8 \end{bmatrix}$.

The material in most common use is radiata pine, which is generally available as No. 1 Framing Grade and No. 2 Framing Grade. The latter grade is used primarily for non-structural elements, and occasionally for the interior laminations in glued laminated members. Better grades can be obtained, but high cost and limited availability restrict their use. Some form of treatment, based on copper-chrome-arsenate or boron compounds, is virtually mandatory in order to protect the timber against decay and insect attack. The table below gives the basic design stresses recommended for solid timber members and glued laminated members fabricated from No. 1 Framing Grade radiata pine.

	Solid	Timber	Laminated		
Stress Condition	Wet (MPa)	Dry (MPa)	Wet (MPa)	Dry (MPa)	
Bending	5.0	6.0	7.1	10.6	
Compression parallel	4.3	7.1	6.1	10.9	
to grain					
Compression normal	1.8	2.0	2.4	4.0	
to grain					
Tension	4.0	4.8	5.7	8.5	
Shear	0.8	1.3	1.1	1.8	
Modulus of elasticity	6500	8000	7300	8900	

Where timber has been mechanically stress-graded by an approved method, the design stresses appropriate to the grade thus established may be used. Somewhat higher design stresses are recommended for treated naturally round timber poles.

The basic design stress for the material is multiplied by a series of stress modification factors which take into account the location and function of the individual structural elements. For example, a load duration factor permits higher allowable stresses to be used for short-term loading than for long-term loading, a bearing area factor permits the allowable stress in compression normal to the grain to be increased when the bearing area concerned is less than 150mm by 150mm, a load sharing factor permits the allowable stresses to be increased in certain parallel support and grid systems, a form factor reduces the allowable stresses for members which are neither rectangular nor naturally round in section, a depth factor reduces the allowable stress in bending for solid rectangular sections whose depth exceeds 300mm, and a stability factor reduces the allowable stresses in columns and beams to take into account the effects of lateral buckling and flexuraltorsional buckling respectively.

Recent amendments to the fire regulations [9] permit timber construction in buildings with up to four storey levels in low or medium fire risk zones. Sprinkler systems must generally be installed, and all structural members must have dimensions which equal or exceed the following minimum values.

Member	Element Supported	Width (mm)	Depth (mm)		
Beam	Floor	150	250		
	Roof	75	150		
Column	Floor	200	200		
	Roof	200	150		
Pole	Floor	200 dia	umeter		
	Roof	180 diameter			

Structural members must either be solid timber sections or must be glue laminated using approved adhesives. Nail and bolt laminated members can be used only when the individual laminates have dimensions which equal or exceed the above values. The strength of the structural members after a fire can be determined on the assumption that charring proceeds at 0.6mm/minute during the fire rating period. The allowable stress after the fire can be taken as that appropriate to very short-term loading.

Light Timber Frame Code

A full account of the development of this code has been given by Cooney [10]. NZS3604 adds to and amends the traditional practices set out in previous design codes, and takes into account, on a rational engineering basis, the anticipated service loads for each structural system. Thus the minimum requirements for roof, wall and foundation system bracing depend upon the seismic zone and wind exposure zone within which a structure is located, the roof mass, the floor loading and the number of storey levels. In consequence, the new code is much longer than the previous design codes, with many more tables and diagrams. Since the structural requirements take into account the complex, highly redundant structural systems and the wide local strength variations characteristic of light timber frames, NZS3603 and NZS3604 are not directly comparable.

NZS3604 permits the use of a completely piled foundation only for single storey buildings. External piles must be diagonally braced, while internal piles must be cantilevered from a substantial footing. For larger buildings, a continuous foundation wall must extend to ground floor level over the entire perimeter. The code provides specific details for subfloor diagonal braces, both in number and in location. Houses in which the superstructure is supported on a combination of posts, beams, foundation walls and wall frames, in order to provide basement vehicle access, are not covered by the code, and specific engineering design is required.

Tests conducted in recent years by the Forest Research Institute and the Building Research Association of New Zealand [11] have established that, under service load conditions, gypsum or wood based sheet linings, well fixed with nails, provide most of the shear strength and stiffness exhibited by timber frame walls. Diagonal braces make a more significant contribution under seismic loads. The lateral strengths of various bracing elements have been measured in accordance with a recognised procedure, and are tabulated in terms of bracing units per metre of plan length. For example, a typical element might involve a diagonal metal angle and a gypsum based lining material. On an external wall, lined on the inner face, such an element would yield 42 bracing units per metre. On an internal wall, lined on both faces, the element would yield 62 bracing units per metre. An element in which the diagonal brace was replaced with sheet material such as plywood would yield 83 bracing units per metre.

The minimum bracing requirements for various situations are set out in the following table.

A For earthquake:

Location of	Maximum	Minimum number of bracing				
storey	slope of	units per square metre in				
1	roof	earthqua	ake zone:			
		A	В	С		
Light roof						
Single	25 ⁰	3	3	2		
or top	45 ⁰	4	3	3		
Lower of	25 ⁰	6	5	4		
two	45 ⁰	7	6	5		
Lowest of	25 ⁰	9	8	6		
three	45 ⁰	10	8	7		
Heavy roof						
Single	25 ⁰	5	4	3		
or top	45 ⁰	6	5	4		
Lower of	25 ⁰	8	6	5		
two	45 ⁰	9	7	6		
Lowest of	25 ⁰	11	9	7		

B For Wind:

three

Location of	Maximum	Minimum number of bracing							
storey	slope of	units per metre in wind							
	roof	exposure:							
		Low	Low Medium High						
Single	25 ⁰	18	23	33					
or top	45 ⁰	44	44 53						
Lower of	25 ⁰	43	53	80					
two	45 ⁰	73	90	133					
Lowest of	25 ⁰	68	80	120					
three	45 ⁰	94	115	170					

12

10

8

45⁰

The wind bracing will be different in each direction, unless the building is square, since the value depends on the plan dimension of the building normal to the bracing elements concerned.

External walls more than 3 metres in length must develop an average 10 bracing units per metre. Internal bracing walls, parallel to the external walls, must be provided at no more than 5 metre centres between these walls, unless floor, ceiling or roof diaphragms are used to distribute the lateral forces.

Research currently in progress in New Zealand covers a wide range of topics in timber science and timber engineering. Some fundamental work is in hand. For example, at Auckland University Dr. G. Ferguson is investigating the effects of strain rate, temperature and moisture content on the strength of wood in compression parallel to the grain and on the fracture toughness of wood, while at Canterbury University Dr. J. Walker is researching techniques for measuring the timber hardness properties. Most research into timber properties, however, is directed specifically towards local materials and conditions. For example. both Gang Nails (NZ) Ltd., in Auckland, and A.R. Turner Ltd., in Napier, are carrying out tests to establish the allowable tooth loads for nailplates in coconut timber, while the Fletcher Timber Company, in conjunction with the Forest Research Institute, is investigating the strength and stiffness properties of machine graded radiata destined for the UK market. At the Forest Research Institute, Rotorua, Dr. B. Walford is studying the bending strength of Corsican pine poles as affected by steaming and shaving. A recently completed study on the structural sizes of radiata pine suggested that the smaller sizes are stronger than current design data indicate. A project by Mr. M. Collins demonstrated that particle board flooring has the same creep characteristics as dry solid wood.

The Building Research Association of New Zealand have completed a study of the corrosion of metal fasteners in timber, which demonstrated that fasteners in multisalt treated timber in damp situations must be protected. The particular case where galvanised bolts are used in naturally round treated poles was examined in detail, and shrink-on plastic tubing, polymeric plastic coatings and liberal coatings of grease were shown to be effective in preventing corrosion. A study of the corrosion of galvanised nail plates in subfloor timbers is now in hand.

Several research projects have been carried out in connection with the new light timber frame code. For example, Mr. R. Cooney of the Building Research Association and Mr. M. Collins of the Forest Research Association have developed a wall racking test and evaluation procedure to establish the relative performance of various bracing elements while, at the Ministry of Works and Development Central Laboratories, tests are to be carried out to investigate the cyclic behaviour of timber bracing walls which include energy absorbing devices in the base connections.

The recent amendments to the fire regulations have led to a good deal of research being directed towards large timber structures, and particular efforts have been made to develop and test joints which can provide adequate moment resistance. One such joint, suggested by the Forest Research Institute, uses nailed steel side plates to transfer bending moments, shear forces and axial forces between members. At Auckland University, Dr. A. Bryant is working on the formulation of design rules for moment resistant frames based on these joints, while at the Building Research Association, Mr. R. Cooney is studying the performance of power driven fasteners in Staff at the Ministry of Works and Development timber. Central Laboratories, in association with Mr. T. Mitchell of the Wellington District Office, have carried out tests to determine the strength and stiffness of these joints under cyclic loads. Full-scale glued laminated beams and columns have been used. Similar tests have been carried out on joints which incorporate fully ductile steel connecting plates.

Conclusions

Timber is a low-energy, renewable material. Welldesigned timber structures can develop excellent seismic performance and fire resistance. Construction costs are generally competitive with other materials, and a high-quality finish can readily be obtained. Until recently, timber construction in New Zealand has largely been restricted to light timber frames. However, the above factors seem likely to ensure that an increasing number of heavy timber structures will be erected in New Zealand, and in many other countries subjected to similar economic pressures and technical requirements.

While all recent multistorey construction has been based on plywood or reinforced concrete shear walls, the prospects for moment resistant frames seem to be excellent. Initial research work suggests that the full bending strength of glued laminated timber members can be developed when 4mm diameter nails, 50mm in length, are driven in a close pattern around the perimeter of a square or rectangle through predrilled steel side plates. High rotational stiffness is available under service loads and adequate ductility can be achieved. Computer controlled machines can be used to drill the plates and nail guns or compressed air hammers can be used to install the nails. The stiffness degradation experienced by these joints under cyclic loads appears to be no more severe than that experienced by well-detailed joints in reinforced concrete, while fully ductile nailed plate joints seem to respond in much the same manner as bolted joints in a steel structure.

These joint characteristics, and the substantial member dimensions needed to ensure adequate fire resistance, suggest that plastic, rather than elastic, design methods might be used. In any event, ultimate strength design methods would have to be applied to the timber members to ensure that the intended collapse mechanisms were realised in practice.

References

- Dixon, C.E. Earthquake proves superiority of wooden buildings. N.Z. Nat. Rev., Mar 1931, pp 45-58.
- NZSS95. Standard model building byelaw. N.Z. Standards Institution, Wellington, 1935.
- NZS1900:1965. Standard model building byelaw.
 S.A.N.Z., Wellington, 1964.
- NZS3603:1980. Timber design. S.A.N.Z., Wellington, 1978.
- NZS3604:1978. Light timber frame buildings.
 S.A.N.Z., Wellington, 1978.
- Recommended Lateral Force Requirements.
 S.E.A.O.C., San Francisco, 1974.
- NZS4203:1976. General structural design and design loadings for buildings. S.A.N.Z., Wellington, 1976.
- 8. AS1720:1975. Rules for the use of timber in structures. S.A.A., Sydney, 1975.
- 9. NZ1900:1964 (Ch 5). Fire resisting construction. Amendment 12, S.A.N.Z., Wellington, 1978.
- Cooney, R.C. The structural performance of houses in earthquakes. Bull. N.Z.S.E.E., Vol 12, No. 3, Sep 1979, pp 223-237.
- Cooney, R.C. and Collins, M.J. A wall bracing test procedure. B.R.A.N.Z., Wellington, 1979.

Energy-saving structural designs for wooden _ panel houses.

V.G.Zenkov, Engineer, TsIILP Grazhdanselstroy, Moscow, USSR.

Summary. This paper reviews structural systems of wooden panel houses from the point of view of their energy saving. The effect of both infiltration and humidity on thermal resistance of structural elements is evaluated. Heat losses through the wooden facade elements are evaluated separately.Based on this analysis advanced structural designs are proposed, which provide for higher energy conservation in wooden panel houses.

Sommaire. Le rapport rappelle les systèmes constructifs des bâtiments d'habitations préfabriqués en bois du point de vue de leur conservation d'énergie thermique.On évalue le mécanisme d'infiltration et l'influence de l'humidité à la résistance thermique des éléments constructifs. On évalue également les pertes de chaleur à travers les façades en bois d'une façon différenciée;on propose des solutions constructives qui garatissent une conservation d'énergie thermique plus élevée dans les bâtiments d'habitation préfabriqués en bois.

This paper deals with a number of our research projects aimed at a better understanding of the mechanism and the nature of combined climatic effects, at improved energy-saving designs in wooden panel housing construction and at substantiated consumption rates of domestic fuel.

A wider interest in research in this area of building sciencesis due to more strained energy balances of today and to problems engendered by the rapid growth of fuel consumption, from one side, and due to available opportunities and potentials in reducing the amount of fuel to be used for heating and hot water supply in dwellings, which total about 30 per cent of extracted fossil fuel, from the other. Industrialized wooden house-building is being given due consideration in this country with its large resources of timber and many remoted building sites; it plays an important role in the construction of low- storied housing. Prefabricated sectional wooden houses in low-storied village and small community construction are more likely to be economical then houses of other types due to their reduced weight, easier transportation and assembly, the possibility to use efficient structures and heat-insulating materials.

Combined costs of heating of buildings depend on the resistance of façades to heat transfer. Therefore an important problem in wooden low-storied construction is to develop and implement economically optimum thermal resistances of wooden structural systems with minimum aggregate costs.

Types of house walls are selected by the way of their economic comparison based on the same minimum permissible heat transfer resistance for given climatic conditions. With this approach, maintenance costs of heating, for wooden panel houses of different modifications under study are essentially identical; therefore the only criterion to be applied in selecting the most resonable façade element is its unit constructional cost. This approach to estimating the efficiency of constructional systems results in unduly high heating costs.

This approach runs counter to the criterion of assessing all alternative designs on the basis of their aggregate costs, which is widely applied in other industries. To obtain objective results for wooden structures for mass application one should develop comprehensive criteria. For this it is necessary not only to reveal the nature of thermal deficiencies in constructional systems, not only to explain the phenomenon qualitatively, but also to determine its numerical characteristics.

Not dealing with all the factors which are involved in heat transfer resistance, and with all potentially feasible alternatives of wooden panels, let us examine currently widely used constructional panels with a wooden frame made of mineral wool boards (MWB) with phenolic binders, which are faced with chip boards (CB), wood-fibre boards (WFB) or plywoods and are protected against atmospheric effects by paints or asbestos cement sheets.

The factors affecting heat losses by buildings include adsorption characteristics and infiltration of structural materials on the basis of wood. We have examined the constructional systems made of wooden three-layer panels. As a facing of these panels, chip boards, plywoods and wood-fibre boards have been used. The thickness of outer facing can vary from 0,012 m up to 0,019 m. Mineral wool boards based on syntetic binders with a unit weight of I20-I50 kg/m³ are used as a heat-insulating material. The thickness of a heat-insulation layer ranges between 0.124 m and 0.290 m depending on the estimated outdoor temperature. The bituminous paper and polyethylene film are used as vapour-isolation. For interior facing chip boards and wood-fibre boards of 0 016-0 019 m thickness are used. The panel frame consists of wooden bars and chip boards. Screened panels have a facing from asbestos cement slabs (ACS) which are put away from the walls at 0.020 m distance. Roofing slabs like walls are three-layer panels. The panels of houses with a higher degree of prefabrication are coated externally with water-dispersed paints filled with marble chipplings.

When air humidity is high, structural materials based on wood (WFB,CB,etc.) can swell which results in elastic stresses and higherthan-permissible deformations. Therefore in our investigations carried out since 1976 till February 1979 we studied a number of interrelated thermal properties which greatly influence heat losses in constructional systems and the physical parameters of which can be defined and measured. A humidity pattern of façade elements was investigated during two annual cycles with a view to determine and predict the humidity balance of structural materials in maintenance. During these tests, we did regular instrumentation measurements of linear deformations in wooden panels as well as those of environmental parameters in the rooms.

One of the problems emerged as a result of full-scale tests has become a more accurate analysis and assessment of the effect of humidity and temperature on thermal resistances of wooden panels.

As it is noted in [I],water-absorbing wetness of structural materials based on wood and the humidity effect on their characteristics have been investigated still inadequately, and some of the available findings are inconsistent. Hence, in order to assess heat losses of the wooden panel structural system, the dynamics of wetness pattern for timber, WFB, CB and WFB materials have been investigated.

The actual resulting wetness of materials was determined with representative samples of experimental wooden panel structures of houses in Minsk and Moscow regions, in the cities of Tynda and Yakutsk, and in Khor settlement of Khabarovsk territory, with the subsequent weighing of specimens after drying up to stabilized weight.

The sampling technique of heat-insulating and facing materials and the procedures of relevant tests meet Soviet standard rules and regulations. The minimum required amount of tests was estimated to the conventional procedure and taking into consideration the obtained values of a variability index II%, a coefficient of accuracy 6% and a confidence index I,3.

The study of humidity was conducted in winter 8 times a day, with periods of IO-I5 days. To measure the temperature and the heat flow we used thermocouples installed in the panels <u>-meters</u>. The correlation between heat and heat v conductivity factors for tested materials and their relative humidity by weight (in the range of 7% to 23%) based on 700 obtained values of humidity and heat conductivity factor for both positive and negative temperatures is shown in Figure I.



Figure I. Correlation between heat conductivity factor of wood,WFB,CB and MFB materials and a humidity for both positive and negative temperatures.

The obtained data enable to suggest that improved vapour tightness would contribute to their better thermal characteristics. In Siberia vapour tightness of building façades appears as critical for building structures. Because of the big difference between air humidity inside the rooms (60-80%) and the humidity of atmospheric air in Northern territories (30-40%), room air moisture enters vapour-penetratable walls much easier than it goes out of them. A process of vapour condensation takes place inside the panels and later the condensate freezes. The frozen glassfiber material reduces heat-isolating characteristics by 30-40%. The moistening of mineral-wool isolation brings about its contraction and areas free of heat insulation will appear.

The calculation based upon the assumption about the constant rate of vapour diffusion is very rough, so we have tested the humidity pattern for façades from wooden panels with mineral wool heat-insulating material (without additional vapour-isolation) in houses for Siberia, which had been in use for many years.Judging from the requirement of inadmissibility of long-term accumulation of moisture in the enclosures during a year maintenance, it was established that when heat-insulation of internal surfaces of façade panels is provided by way of mineral-wool boards it is necessary to install an additional vapourisolation layer with a resistance to vapourpenetration 7,5-8,5 mm of Hg,hr/deg.A synthetic film can be used for this purpose. The use of foil which also serves as a reflective heat-isolating material is most promising.

In sectional low-storied wooden houses with numerous heat bridges wooden elements of panel frames an increase in specific heat losses is due to a rather substantial specific weight of façade structures.

For a real structure of the wooden house, the heat flow is not one-dimensional, the wall surface cannot be considered isothermic and the heat bridges distort a symmetry of heatexchange. Therefore the analysis of thermal resistance of wooden panels has been made on the assumption of heat-stability pattern in the whole of the room with due account of its heat-storage capacity.

Structural modifications in panel joints improved apour-tightness, the increase in thermal resistance of wooden wall panels for low-storied houses with due regard for fuel costs and the use of triple glazing-all these measures help to reduce the indices of specific heat consumption for heating of sectional wooden panel houses by 40-50% (see Fig.2 and 3).



Figure 2. Dependence of the specific fuel consumption for heating of wooden panel houses from the temperature difference and the heat-conductivity of heat-insulating materi als.



Figure 3. Dependence of specific fuel consumption for heating of wooden panel houses from the ratio of fenestration for different winds.

These investigations in thermal aspects of building physics formed the ground for the improvement of wooden panels (with a screen, with an atmosphere-resistant facing, for a "room" and for a "house") and their joints.

<u>References</u>

I. Deviatko L.A. O komplexnom uchete temperatury vozdukha i skorosti vetra pri raschete teplopoter' zhilykh zdanii. Trudy IV Vsesoiuznogo soveshchaniia-seminara po obmenu opytom stroitel'stva v surovykh klimaticheskikh usloviiakh,t.IX,vyp.I,Krasnoiarsk,I968 g. 2.Lykov A.V. Teoreticheskie osnovy stroitel' noi teplofiziki. Minsk,izd-vo Ak BSSR,I96Ig.

SUBJECT 5A

Building documentation, information and local demonstration projects in developing countries

Documentation concernant le bâtiment, information et démonstration de projets locaux dans les pays en voie de développement

MANAGEMENT OF INFORMATION NEEDS OF HUMAN SETTLEMENTS IN DEVELOPING COUNTRIES

By G. C. Mathur, B.Sc. B.E.(Hons.) Director Government of India National Buildings Organisation (Ministry of Works and Housing) & U.N. Regional Housing Centre ESCAP, New Delhi.

Summary

The dynamics of population growth in developing countries is posing a great challenge to human settlements and eradication of slums and squatter settlements and improvement of rural habitat have to be tackled on priority basis. A viable information system designed to cater to the needs of the developing countries is needed, comprising of not only the work of collection collation and documentation of information, but also the work concerning dissemination, extension and application of research results.

Specific information needs of developing countries arise out of technical requirements pertaining to (i) promotion of improved use of local resources, (ii) low cost housing, (iii) disaster mitigation, (iv) appropriate technology; and also the information media covering the significance of (a) audio and visual media (b) motivation by demonstration (c) mobile system of information (d) appropriateness of information to actual needs. Impact of innovative approach adopted to cater to the information needs of developing contries has been briefly indicated highlighting the significance of demonstration projects.

The need for an international network structure of Information System on human settlements is brought out, in the context of which suggestion for augmenting the role of CIB in developing countries have been mentioned, which include setting up of focal points, technical co-operation, computerised information and data bank, etc.

Résumé

La dynamique de la croissance de la population dans les pays en voie de développement constitue un grand défi en ce qui concerne l'établissement des gens. Les tâches auxquelles il faut donner la priorité sont la supression des bidon-villes, l'évacuation des terrains occupés illégalement et l'amélioration de l'habitat rural. Un système approprié d'information, destiné à satisfaire les besoins des pays en voie de développement, est nécessaire. Un système qui ne comprenne pas seulement le travail qui consiste à recueillir des informations mais aussi celui qui consiste à divulguer, diffuser et appliquer les résultats des recherches.

Les besoins d'information spécifique des pays en voie de développement dépendent des ressources techniques concernant:

- 1) la promotion d'une meilleure utilisation des ressources locales
- 2) les habitations à loyers modérés
- 3) l'aide en cas de catastrophe naturelle
- 4) la technologie appropriée.

Dépendent également des moyens d'information:

- a) moyens audio-visuels
- b) motivation par la démonstration
- c) système d'information ambulant
- d) information appropriée aux besoins réels.

L'importance d'une façon nouvelle de pourvoir aux besoins d'information des pays en voie de développement a été montree par des projets mis en pratique.

Le besoin d'un réseau international d'information sur les établissements humains est mis en évidence. Dans ce contexte on a mentionné la suggestion d'agrandir le rôle de CIB, y incluant l'établissement de la liste des points centraux, la coopération technique, l'information par ordinateur, mémorisation des informations etc.

The challenge of human settlements

In developing countries broadly, two types of human settlements can be distinctly identified – the human settlements in urban areas and those in rural areas; the ruralurban dichotomy is great.

A vast majority of the population of the developing countries lives in rural settlements which have been growing fast due to high rate of increase in population. At the same time, migration from rural to urban areas has been taking place at an unprecedented rate resulting in the substantial increase in urban population.

Human settlements of today embody the outcome of generation of ideas, decisions and physical investments; it is not possible therefore, to achieve radical modifications overnight. But population growth and rapid changes in the location of human activities proceed at such pace that, by the end of the century, we shall have to build «another world on top of the present one». If properly directed, this formidable task could mobilize untapped resources and be turned into a unique opportunity for changing our man-made environment; this is the challenge of human settlement strategies.*

Information System

To meet the challenge of human settlements in developing countries, the importance of information is being increasingly recognised for developmental activities. The basic features of Information System on Human Settlements in developing countries are thus required to be oriented to:

- a) Collection and documentation of information;
- b) Promoting application of results of research.

The 'Wheel of Information' as illustrated in Fig. 1 explains the salient features of the Information System.

Report of Habitat: United Nations Conference on Human Settlements, Vancouver, Canada, 31 May – 11 June 1976 (p. 10).



F16.1

The work oriented to information collection includes the following:

- 1. Collection of information which entails -
 - procurement of information, publications and other relevant literature and surveys to pin-point various sources of information, specially from developing countries;
 - classified storage of information material including publications, films, trade catalogues which are increasingly being produced in developing countries;
 - quick retrieval of required information by adopting new techniques which are coming in vogue in developing countries.
- 2. Collation of information received which calls for -
 - compilation of relevant information as per the specific needs of developing countries;
 - scrutiny of information to ascertain its usefulness for the purpose it is required;
 - analysis of information to determine the extent of coverage and contents and to identify gaps, if any.
- 3. Documentation work which involves -
 - presentation of classified information;
 - organising the scheme of preparation of the documents;
 - reproduction of documents for distribution.

The work oriented to promote application of results of research of –

- 4. Dissemination of information which requires -
 - identification of communication media as are appropriate to developing needs;
 - arrangements for distribution of information material;
 - providing technical assistance and guidance in the use of information at different levels.

- 5. Extension work which aims at -
 - providing practical demonstration of application of information;
 - imparting training for creating proper appreciation of the information supplied;
 - organising mass personal contact to facilitate actual use of information.
- 6. Application of results of research which call for -
 - availability of all the ingredients that are required;
 - providing detailed know-how;
 - rendering technical advice and assistance.

At all stages in the 'Wheel of Information' presented above, great importance is attached to feedback of field experiences in order to direct these programmes so as to fulfil the actual requirements of the users. The Information system in developing countries should, therefore, constantly seek feedback of experiences to strengthen it, fill up the gaps in the supply of information and to provide information relevant to the needs of developing countries.

Specific information needs of developing countries

In many developing countries, specific needs have to be catered to in which field organising of efficient information system would be greatly instrumental in promoting development.

(a) *Technical Requirement:* Some of the important technical areas in which information needs of developing countries can be categorised include the following:

- Promotion of improved use of local resources: It is (i) incumbent on developing countries to make more profitable use of all local resources that are required for Human Settlements. Very little information and data is available, for example, on improved use of local materials, traditional construction techniques and skills. All possible efforts need to be directed at local, regional and national levels to obtain relevant information pertaining to these from all possible sources and to undertake effective work of documentation and dissemination of information. The importance of this could be appreciated from the fact that in developing countries generally building materials accounts for 70 to 75 per cent of the total cost of construction. A wide variety of local materials are available which have hitherto not been properly exploited. A case in point is the use of soil as a building material which has been practiced from ages and significant improvements in mud construction are yet to be evolved and adopted on extensive scale.
- (ii) Low cost housing: The developing countries are experiencing a serious problem of housing specially for low income groups. In urban areas slums and squatter settlements, in which generally 25 to 30 per cent of the population lives, in inhuman conditions are to be eradicated as soon as possible. In rural areas improvement in housing conditions is a problem of colossal magnitude as more than 75 per cent of the

population lives in rural areas under primitive living conditions. In order to improve the standard of living of the masses, it is necessary to make concerted efforts to achieve housing at low cost. Information on techniques to build houses and improve environmental conditions at low cost are of great value in tackling the housing problem in developing countries.

- (iii) Disaster mitigation: In many developing countries large scale disasters occur from time to time on account of perennial floods, cyclones, earthquakes, fire, etc. As large population is often involved in such natural calamities, ways and means have to be found to ensure safety of population to a greater extent by developing more scientific methods of design and construction of buildings and various other types of structures. In this specialised area of technical activity, appreciable efforts are required to be made to obtain relevant information and technical knowledge and to disseminate them for the good of the humanity.
- (iv) Appropriate technology: Technology should be considered as a tool for achieving economic development and social progress. Therefore, the implications of new technology in the context of the economic and social situation prevailing in the developing countries of the region should be carefully analysed and only such technologies as are relevant to the needs of the country concerned should be adopted for development. Stress is, therefore, required to be laid on such technologies which enable improved use of local resources and labour-intensive building methods, low energy technologies and technologies which build up selfreliance.

(b) Information Media Requirements: – In keeping with the social and economic characteristics of the population the information and documentation needs of developing countries in the field of human settlements should be designed in accordance with the following: –

- (i) Accent on audio and visual media: In many developing countries the literacy level of the people is low. This is particularly so in rural areas where human settlements have been created largely through selfhelp. On account of this the capacity to absorb information and the efficacy of printed words are rather limited. As such greater reliance will have to be made on transmission of information through audio and visual means, personal contacts, etc.
- (ii) Information for motivation: In many developing countries a vast majority of people live below the poverty line and income levels are low. This bring in a state of despondency which precludes response to change for improvement. As such motivation of the people is necessary through demonstration projects, financial incentives and other means. Information media should be designed to cater to these.
- (iii) Mobile system of information: In many developing countries, 75 to 80 per cent of the population lives in rural areas, many of which are located in remote places in a scattered manner. Mobile system of in-

formation requires to be developed to reach out to the villages in different regions to extend the coverage and flow of information and services.

(iv) Information appropriate to the needs: The technology in vogue, particularly in the countryside, is by and large of traditional type. The process of adoption of improved technology is rather slow on account of lack of information, non-availability of infra-structure facilities, skills, machinery and equipment, etc. as well as socio-economic factors. As such appropriateness of new technology should be carefully studied in the context of local conditions and information appropriate to the needs should be provided.

Impact of innovative approaches

Dissemination of information is a key area of concerted action by developing countries. Some notable experiences gained in developing countries in adopting innovative approaches for dissemination and documentation of information in the field of human settlements are briefly mentioned below:

(i) Building centres are becoming increasingly popular and are playing significant role in dissemination of information of practical use. A Building Centre was set up at New Delhi in 1966 by National Buildings Organisation (NBO) in which display of new construction techniques and materials, typical designs of houses has been organised for the benefit of architects, engineers and builders, including the common man interested in building his house (Photograph 1).



Photo 1. Information of practical value NBO building Centre, New Delhi set up in 1966 and six such centres in India have been contributing significantly to dissemination of information of practical value.

The centre provides technical and trade information and also advice and guidance on building problems. Setting up of a chain of Building Centres in principal cities of India is being promoted. As a result six such Centres have come into being. Building Centres in Sri Lanka, Tanzania and Iran are also being developed. In Indonesia Building Information Centres have been promoting improvement in rural housing.

- (ii) Audio-visual media is being increasingly utilized for propogation of building knowledge and information. The NBO has organised a technical film library which has a collection of 250 films on housing, building and planning. The films are supplied on loan to 250 members of film library in the country and on an average over 10 000 persons benefit from such film shows. Over halv-a-dozen films on low cost housing, new construction techniques, design and construction of earthquake resistant houses have also been produced under the sponsorship of NBO, copies of which have also been supplied to some developing countries. Radio and Television programmes have been put out frequently to propogate the techniques of low cost housing. Availability of video tape recording in developing countries would greatly increase the effictiveness of T.V. media for conducting demonstrations.
- (iii) Document reproduction facilities for quick supply of copies of documents, drawings and designs are being augmented in developing countries. The NBO which is also UN Regional Housing Centre of ESCAP has received documentation equipment under UNDP assistance programme to expand its documentation service for the benefit of developing countries.
- (iv) Exhibition of demonstration low cost houses had been put up by NBO at New Delhi to promote the adoption of new construction techniques and materials for low cost housing. The opening of the exhibition was timed with the Fourth Afro-Asian Housing Congress which was held in November, 1975 (Photograh 2). A similar exhibition was put up at Madras in



Photo 2 Popularising new concepts and techniques 65 dwelling units incorporating several innovative building techniques put up in the exhibition of demonstation low cost houses organised by NBO at New Delhi in 1975 on the occasion of the Fourth Afro Asian Housing Congress for popularising new concepts and techniques for low cost housing. 1977 on the occasion of International Seminar on Low Cost Housing. The performance of 65 dwelling units put up at New Delhi and 25 houses constructed at Madras, which are under occupation by the target groups is being observed over a period of time. These live exhibitions of low cost houses have been greatly instrumental in focusing attention on the problem of low cost housing and dissemination of results of research.

 (v) Clusters of 10-20 demonstration low cost houses along with environmental improvements have been put up in 17 selected villages in different regions in India by the nine Regional Rural Housing Wings of NBO which are engaged in research, training and extension in rural housing since 1959. Such demonstration projects have created considerable impact by propogating improved use of local materials and selfhelp in building rural houses at low cost and improvement of environmental conditions (Photograph 3). In Indonesia a large scale demonstration rural housing improvement programme has been taken up.



Photo 3. Motivaling improvements in rural housing A cluster of 20 demonstration low cost houses along with environmental improvement put up by Regional Rural Housing Wing of NBO at Village Amtbla in Assam, India which is subject to heavy rainfall and earthquakes, has given a thrust to improvement of housing conditions in rural areas.

(vi) Demonstration-cum-training plants for improved production of local materials like building lime and clay pozzolona have been put up at New Delhi and for producing better quality of bricks at Chandigarh, by NBO (Photograph 4). In Indonesia also the UN Regional Housing Centre, Bandung has set up some demonstration/pilot plants to promote improved use of local materials. As building materials account for 70 to 75 per cent cost of building, the propogation of techniques for improved production of materials from indigeneous resources is a matter of vital im-



Photo 4. Promoting improved techniques of production of local materials

The demonstration plant at Delhi set up by NBO in 1976 imparts training in improved techniques for production of building lime and clay pozzolana in ready-to-use form to effect saving in consumption of cement.

portance. Visitors from many developing countries have evinced keen interest in such demonstration/ pilot plants.

- (vii) Training courses and workshops are organised by NBO for imparting knowledge of latest developments in housing and building including social and economic aspects of housing. Over 65 such programmes have been conducted and many of these have been attended by nominees of various developing countries. In the field of rural housing over 230 training courses have been regularly conducted, in which some 2 500 technical and community development officials have been imparted training. An International Workshop on Rural Housing and Community Facilities organised by NBO in 1977 was attended by nominees of many developing countries.
- (viii) Proto-type houses for the poor have been put up by NBO at the India International Trade Fair held in November 1979 at New Delhi to demonstrate:
 - a) the techniques of water proofing of mud walls and fire retarding treatment of thatch for building houses for the rural poor at a cost less than 200 U.S. dollars, when built through self-help. (Photograph 5).
 - b) the concept of shelter-house for the urban poor which can be completed in four-stages at a cost ranging from 300 to 500 U.S. dollars using self-

help. Innovative techniques of construction incorporated in the project included use of three types of precast roofing systems employing site casting techniques that are labour intensive. (Photo 6).



Photo 5. Houses for the rural poor

Proto-type of twin unit house for the rural poor put up by NBO in India International Trade Fair at New Delhi in November, 1979 to promote the use of Waterproof mud plaster and fire retarding treatment for thatch roof. The house van be constructed at a cost of less than 200 U.S. dollars when built through self-help.



Photo 6 Shelter house for the urban poor The concept of shelter house to be completed in four stages of construction was demonstrated at the Indian International Trade Fair held at New Delhi in November, 1979. Such houses can be put up by the urban poor through self-help at a cost ranging from 300 to 500 U.S. dollars.

Network structure on human settlements information system

Human settlements concerns itself with a wide variety of scientific and technological disciplines. It aims to develop a comprehensive approach to technological matters considered in the light of socio-cultural and economic conditions. Among the factors which should be considered are adequate shelter; infrastructure; potable water; sewage, energy; roads; community services and facilities; education; health; recreation; transport; communications; culture; food and nutrition; labour; training and employment; means of social mobility; social security; environmental upgrading; etc.*

In the operational scheme of developing appropriate information system on human settlements technology, several institutions working at national, regional, state and local levels are involved. The national network structure should aim to devise a system in which the organisation at various levels could work together within a programme framework contributing effectively to each other's capabilities.

It is alco necessary to bring about participation in the network structure from governmental, semi-governmental, public as well as private institutions and organisations including specialist individuals. This is because in the field of housing and building the share of private sector activity is large. In developing countries, it would not be incorrect to assume that more than two-thirds of construction activities with regard to human settlements are undertaken mostly in the private sector.

In the developing countries, broadly, the institutions concerned with technology for planning and development of human settlements can be categorised as follows:

- (i) Institutions in the field which are implementing the technologies;
- (ii) Research centres engaged in evolving appropriate technologies; and
- (iii) Organizations that are intended to bring about transfer of technologies.

While recognising that human settlements are primarily the responsibility of national governments, it is clear that the implications of human settlements are so wide in scope and varied in nature that national efforts alone would not be enough. They need the international community, at both the global and the regional level, to provide valuable encouragement and support to governments, so that they could take effective action to improve conditions, especially for the least advantaged, in the rural and urban sectors.

Technical co-operation among the developing countries will be of great benefit as many countries of the region face similar type of problems. External assistance and resources must be directed towards supporting local, national and regional (multi-national) institutions to create the necessary capacity for problem solving. Also co-operation between developed and developing countries in the field of human settlements technology needs to be fostered on the following lines:

- (i) Building up in developing countries of the necessary structure of scientific and technological institutions to enable them to make the best use of science and technology in their development;
- (ii) Mounting of an attack, through the various organizations of UN systems on a number of specific problems either by obtaining new knowledge or by applying existing knowledge to development that is considered to be of high priority.

Augmenting role of CIB in developing countries

The need for giving special attention to building research and dissemination of information in developing countries is being increasingly realised to enable these countries to accomplish construction programmes with utmost economy and speed. Recognising this, CIB is devoting special attention to the research needs of developing countries and activities in this field are being augmented.

- a) Focal points: The proposal to establish two focal points for concerted action on research needs of the developing countries has been mooted by CIB and further action in this connection needs to be taken expeditiously. It is felt that the location of such focal points, in developing countries would be very purposeful in catering to the actual requirements of human settlements in developing countries and feedback of field experiences.
- c) Mutual co-operation: On account of the similarity of problems, geographical proximity, cultural affinity, etc. developing countries have been striving for mutual co-operation and some important programmes have been undertaken under bilateral assistance and collaboration programmes. Common problems of human settlements in developing countries should be identified by CIB for co-ordinated study and research and dissemination of information by various countries. CIB can provide necessary input to promote such cooperation.
- c) Computorised information and data bank: With increasing volume of technical information and results of research, innovative methods have to be devised for proper storage and quick retrieval of information for ready reference. This has been made possible if computerisation of information can be undertaken for developing a data bank. International co-operation could be generated by CIB to devise a suitable system with the participation of member institutes and organisations of various countries interested in availing its facilities. Such information system and data bank could be organised by CIB as a non-profit service which will be of great benefit specially to developing countries.
- d) Network structure: CIB working groups have been constituted to collect information and research activi-

^{*} Network structure of National Institutions and Organisations on human settlements technology and their relationships, functions and capabilities – ESCAP/UNEP Expert Group Meeting on Human Settlements Technology, Bankok 24–28 July, 1978.

ties on specific subjects. The co-ordinators of these working groups collate and compile research work done in different countries. It is necessary to activise this work and also make it more effective which can be done by organising a network structure of institutions and organisations in different countries whose activities on specific subjects, as designated by CIB, should be directed to bring about a synthesis of information on specific subjects.

e) CIB linkage with UN and its specialised agencies: The United Nations has been instrumental in creating world consciousness regarding the problems of human settlements and environmental improvement for enhancing the quality of life, specially of the masses living in abject poverty in the developing countries. The UN Centre for Human Settlements and the UN Environmental Programme headquartered at Nairobi have been set up as specialised agencies to deal with these problems. Other specialised agencies like WHO, UNESCO and Regional Economic and Social Commissions for Asia, Africa and Latin America are giving attention to problems which fall within their domain. As a Non-Governmental Organisation, CIB can play an effective role by establishing linkages with the UN and its agencies for lending support to activities generated by UN in this field. Considering the long standing of CIB and the significant contribution made by it, the UNCHS has agreed to liaise with CIB for mutual benefit, which should be institutionalised early to ensure continuity and effectiveness.

The following proposals may be considered for immediate follow-up action by CIB in collaboration with UNCHS.:

- A survey of institutions and organisations on human settlements technology in developing countries may be conducted with a view to bringing out a directory of such institutions.
- A study of the activities undertaken by institutions and organisations on human settlements technology and results achieved may be taken up with a view to preparing a classified catalogue of human settlements technologies in developing countries.
- A technical survey may be organised for identifying major problems in the field of human settlements thechnology for housing the urban and rural poor in the developing countries.
- An information system on human settlements technology to suit the needs of developing countries may be developed.

Roving seminars in developing countries

- an efficient way to reach building technicians and administrators with up-to-date information

Klaus Blach, Architect M.A.A.

Danish Building Research Institute

<u>Resum</u>e: Un "Roving Seminar" est une course qui voyage, soit d'un pays a l'autre, soit d'une ville a l'autre. Cette type de course a fait l'epreuve d'etre tres éfficace a un prix modeste.

Une description est donné pour les préparations et la conduite de telles courses.

Summary: A Roving Seminar travels from one country to another or from city to city. Roving seminars have proved to be effective at compar-

atively low costs. It is described how to prepare for and give a roving

seminar.

It takes time and money to organize any kind of course or seminar. First a synopsis must be worked out, then must be found the lecturers and last but not least the papers and other material necessary must be prepared. Then come rehearsals in order to ascertain that lectures are letter-perfect and that the various contributions are properly co-ordinated.

Finally comes the job of finding a place where to hold the course or seminar and of organizing the proper facilities for lecturers and participants.

As the first step mentioned above are the most difficult and time-consuming, it is tempting to repeat a course or seminar when once it has been established in a proper way. Thus was born the idea of the Roving Seminar which travels from place to place giving repeat performances of course with slight changes in contents to suit local conditions.

A great advantage in connection with roving seminars is that the cost of travel and participation will be low for local participants and thus many can benefit. For those sponsoring roving seminars it is also an advantage that they are comparatively cheap to organize. Experiences during more than a decade have proved that the cost per participant at a roving seminar is only about ten percent of the cost encurred with some other types of courses and seminars.

The United Nations Centre for Housing, Building and Planning (now: UN Centre for Human Settlements HABITAT) has for years been active in this field, together with sponsoring governments and host countries. The guidelines presented in the following are based mainly on experiences gained in organizing roving seminars in the regi just mentioned.

Preparing and giving a roving seminar

Many of the requirements are obvious, but there are several details which may easily be forgotten. The success of a seminar may finally hinge on such details. The following notes are meant as a checklist.

(a) Prepare printed material well in advance

Preparation of printed material for a seminar is a timeconsuming job, which unfortunately is often underestimated. Especially where reproduction facilities are limited, the production of printed material should be started six to nine months before the seminar.

(b) Printed material should be up-to-date

It is easy and, therefore, tempting to use old material for a seminar. But participants do not benefit much from such material. Material which is readily available from other sources should never be included in the material for a seminar.

Printed material should be prepared particularly for each seminar, and it should be up-to-date. Printed material is especially valuable if it contains information for which the participants would otherwise have to spend much time in obtaining elsewhere (e.g. international standards and research results, which often require a rather long time for printing and dissemination).

(c) Not more than about thirty participants

Even in cases where several persons cunduct a seminar, the number of participants should preferably not be very large. Based on experience, about thirty participants may be considered optimal. Such a number facilitates good communication, and the use of microphones might not be necessary. In case there are very many qualified applicants, the seminar should be repeated. Regardless of the number of participants, the seminar should usually be able to accommodate a limited number of observers interested in following certain parts of the seminar. Additional copies of seminar papers should be available to observers.

(d) Participants should represent more than one discipline

To prevent seminar discussions from becoming one-sided, several viewpoints should be represented among the participants, which may most easily be achieved by choosing participants from various disciplines and sectors. Thus if the main topic of the seminar is building, not only engineers and architects should be represented, but also administrators, manufacturers and contractors.

(e) Plan the seminar to sustain participants' interest Some seminars are planned with a few long sessions in the morning and a few in the afternoon. It is, however, hardly possible for even the best lecturer to sustain the interest of participants if he speaks relentlessly hour after hour. Lectures and other presentations should last from ten to twenty minutes only. In case a lecture necessarily (because of the subject) has to be longer, there should preferably be a break during the lecture.

Various forms of presentation might help to stimulate the interest of participants during the seminar as, for example, slide shows, blackboard demonstration, films and exercises to illustrate techniques, etc.

(f) Plan the seminar minute-by-minute

A "seminar-day" may last seven and one half hours. This leaves five full working hours which should be planned minute-by-minute by the seminar leader. Such a very detailed plan should not be presented in the seminar programme, but it is essential for the seminar leader so that he may at any time check whether the seminar is running as planned. A detailed plan is especially valuable in case the schedule must be rearranged, as when discussions are longer or shorter than foreseen. Sometimes special opening and closing sessions may have to be incorporated into the plan.

It is important not only to have a detailed schedule but also to stick to it. Those who conduct the seminar must be ready to start on time and also to finish on time.

(g) Inspire team-work

A seminar provides a chance for participants to work together in unusual ways. One way to facilitate teamwork is to have the participants seated at large tables in groups. The best size of group is three or four persons, and each group should have representatives from various disciplines.

(h) How to keep up communication after the seminar An extensive exchange of viewpoints and information usually occurs during a seminar. It may be even more

important that this communication be kept up after the seminar has ended. In order to make this possible, a list of the names and postal addresses of all persons involved in the seminar is necessary. The importance of having complete and correct postal addresses cannot be stressed too much - that is the first need, when participants are scattered after the seminar has finished.

(i) A questionnaire helps to improve subsequent seminars A good seminar would have been planned with the pre-

supposed needs and wishes of the participants in mind.

Participants might nevertheless feel that certain material was lacking, that certain items occupied too much time during the seminar, or that some of the materials should have been presented in another way. Before a seminar closes, the participants should be asked to answer a questionnaire wherein they may freely (even anonymously) state their opinion about the seminar and their wishes in relation to possible future seminars.

(j) Lectures and papers are two different types of presentation

It may be tempting to create a lecture by slavishly following a paper on the same subject. That, however, is hardly recommendable. First of all, the lecture may then be tiresome to the participant who has already skimmed the paper; secondly, especially in novel subjects, there is a considerable difference between teaching a subject and utilizing information about the same subject.

Papers remain after the seminar, and information contained in them should therefore be of such a character as to be easy to use in daily work. Lectures, on the other hand, should present a subject so as to give participants a thorough understanding of the matter. For this reason, lectures may contain many more examples than the corresponding papers. A special advantage of using different devices for presentations is that the lectures may be held in a relaxed way, without being read from a manuscript.

(k) Requirements for a seminar room

The room in which a seminar is held should preferably be rectangular, with the podium and screen at one of the narrow ends. This would facilitate the seating of participants, so that they may have a good view of the visual presentations, and that the seminar leaders may circulate freely, for example when the participants are working on exercises. Im amphitheatres, there are usually good possibilities for viewing, but circulation is difficult. A more simple, rectangular room is, therefore, often more suitable for a seminar.

The seminar leaders should be able to use a room nearby, with ample table space, for keeping in neat order papers to be handed out.

It is often desirable that the seminar room have one or two blackboards and some display panels for drawings, pamphlets, etc.

To ensure smooth presentations, it is important that the leaders be familiar with how the room should be darkened, and other vital operations.

(1) Make sure that equipment functions

Most seminars rely upon extensive use of audio-visual aids. Among these, slide- and film projectors are often the most important. Those who conduct a seminar should ascertain in advance that these aids function properly. The following points should be checked:

Screen(s) for showing slides and films should be large, preferably about 3 x 3 metres. The screen should be positioned vertically to permit good focusing.

Blackout curtains should be checked. Partly drawn curtains may be sufficient when black and white slides are shown. Electric lights. Arrangements should be made to have electric lights turned on and switched off quickly. It is an advantage if the electric light can be dimmed, permitting participants to make notes during a slide show.

Table lamp for lecturer. The lamp should have a switch, and it should be so weak that its light does not reduce screen brightness.

Microphones should be checked. The lecturer should be able to move freely between screen blackboard and manuscript.

Slide projector(s). The voltage should be checked. The focal length of the lens should match that of the condenser lens. For an audience of 30 to 40 persons, a 150 millimetre lens normally is suitable.

The position of the projector should be the same each time. The participants' view of the screen should not be obstructed by the projector. Projection should be perpendicular to the screen; otherwise, focusing will be bad (tables for positioning projectors are frequently too low). Low-voltage bulbs produce greater light without overheating slides. Projectors should cool off before being moved, otherwise the bulb will burn out quickly. The availability of outlets, extension cords and plugs should be checked, and spare parts (two extra bulbs, fuses and a fan belt) and a small repair kit should be available. If possible, the projector should have automatic focusing and remote control. Extension cords and the projector(s) should be secured against accidents.

Film projector. Checks should be made as for slide projector. A special stand may have to be provided if the focal length of the film projector is different from that of the slide projector. Is the sound track optical or magnetic?

(m) Good slides mean half the battle is won

Colour slides should be checked for brightness before being shown. The quality of colour slides is very important; it is advisable to show only a few really good ones. As many slides as possible with close-ups of details should be shown. Such slides will help the participants to grasp the subject.

Lecturers commonly keep a slide too long on the screen, and as a result the participants' interest wanes. For a half-hour lecture, about 50 slides should be used; some of them may be shown in rapid sequence. Another common mistake is that a lecturer may show a slide while supplementary explanations are given, viz. at the blackboard. In this case it is better to switch the projector off and turn the light in the room on while the explanations are given. It is best to prepare special original drawings, and to have slides made from such material. Slides made from illustrations in journals do not usually show well on the screen. Illustrations used for slides should contain a minimum of text, and only such text which the lecturer uses during his lecture. If there is too much text on a slide, participants invariably start reading the text instead of listening to the lecturer. Drawings may be "read" by everybody, while a text often constitutes a language (or dialect) barrier.

A special version of the normal 50 x 50 millimetre (2 x 2 inch) slide frame has a cut-out of about 40 x 40 millimetres. This size is big enough for simple, illustrative drawings and for up to ten lines of two-millimetre text. To make good, cheap slides quickly, the drawings and text should be made on thin plastic film, and inserted in the frame. Drawings and text may be made also in colour, i.e. with thin spirit-markers or nylon-tipped water colour markers.

The text on slides should be checked for legibility, especially for participants seated far from the screen. As a rule of thumb, two-millimetre-high letters on an A4-size original are legible to an audience of 30 to 50 persons, provided the recommended size of screen is used.

(n) Plan the use of overhead projectors and epidiascopes Positioning, brightness, etc. should be checked for this equipment similarly to what has been recommended for slide projectors. Material to be shown by means of overhead projectors and epidiascopes should preferably be prepared in advance. Originals should normally not be larger than single sheet A⁴. Large, folded drawings or thick books usually result in a poor screen image.

(o) Keep track of what material each participant receives Material to be handed out should preferably be kept in a separate room, and only one person should have the responsibility of distribution; otherwise papers tend to "disappear" mysteriously. Participants should at the start of the seminar be furnished with a detailed list of contents for the material to be handed out.

(p) Miscellaneous equipment and assistance

In the seminar room or nearby, staplers, adhesive tape, tacks, punchers, writing pads and pencils should be available for use. In case not all papers can be produced to international standard size A⁴, sharp knives or a cutting machine may serve the purpose. Whenever possible, binders or folders should be made available to the participants to keep the handout in an orderly way, and for use after the seminar is over. Towards the end of a seminar, it is normaly desirable to have a certain amount of secretarial assistance available, for typing draft recommendations, resolutions etc.

Locally organized follow-up seminars

Roving seminars may reach a large clientele, but even that will at best be a fraction of the potential customers. In order to reach more people it is desirable to follow-up with locally organized seminars, for example given by those who participated in the roving seminar. However, it is often an obstacle that audio-visual material, especially slides are not readily available. In connection with a series of roving seminars on modular co-ordination, component building and standardization an attempt has been made to overcome this obstacle through publication of a collection of lecture notes together with a set of slides. The lecture notes are accompanied by illustrations corresponding to the slides and the material has been so arranged that the short texts may be supplemented by the local lecturer.

Figure 1. The front page of the publication Slides and Lecture Notes. The publication and a set of slides are available free of charge to building research institutes, universities and similar institutions in developing countries.

Figure 2. An example of a two-page spread in Slides and Lecture notes. The simplified line-drawings are accompanied by short texts to be supplemented by local lecturers. For colour slides presenting case studies there are more complete texts.





Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a project.

Carin Boalt, Vitor Campos, Mirina Curutchet, Carolyn Hannan-Andersson and Ann Schlyter. Department of Building Function Analysis, School of Architecture, University of Lund.

Summary

This is a short presentation of an interdisciplinary documentation project on human settlement being carried out at the University of Lund as a pilot project in cooperation with counterpart institutions in Kenya, Mozambique and Zambia. The project has a user-orientated approach with emphasis on the micro-perspective.

Background

The human settlement problems of developing countries must be given increasing attention. Lack of information necessary to back up policy in this area is one well-known shortcoming. The main difficulties in this area are: 1) limited access to and control of information and technology by the developing countries, 2) little consideration given to local knowledge and initiatives necessary for a comprehensive and microapproach suitable to the complexity of settlement problems, 3) limited documentation resources. Documentation is one of many measures needed to cope with settlement problems.

Traditionally, documentation has been orientated towards compiling and classifying information, with little immediate attention given to its practical dissemination. Adequate systems of documentation should put special emphasis on aspects of selection and dissemination so that information can be readily available to all groups of interested users. Documentation efforts to date have been mainly determined by the needs of traditional groups of users - i.e. authorities, researchers, planners and other high-level professionals. Documentation systems ought, in the future, to be increasingly orientated to the needs of new groups of users.

Following the traditional trends in research and planning, most documentation is today discipline-orientated and specialised. Interdisciplinary documentation involving contributions from several fields or disciplines - e.g. technical and social sciences and perhaps even medical sciences - is clearly underdeveloped. Yet interdisciplinary research is increasing. The development of documentation on an interdisciplinary basis must be an increasingly important task.

Documentation on human settlement is being considered with growing attention, especially after the Habitat

Conference in Vancouver in 1976. The follow-up activities of the conference have included intensified work on international and national levels in establishing documentation centres and in efforts to disseminate research results for practical application.

Project Description

In line with the objectives and recommendations of the Habitat Conference (Vancouver 1976) to develop experience in documentation on human settlement, a pilot project is designed in cooperation with institutions in Kenya (Housing Research and Development Unit, HRDU), Mozambique (Direcçao Nacional da Habitaçao, DNH) and Zambia (Insitute for African Studies, IAS). This documentation will deal with the relationship between people, activity and environment. A multi-disciplinary approach is planned with emphasis on the the users. This in turn necessitates focusing on the micro-perspective. Emphasis is to be placed on the dissemination of the material collected. The process has as one of its prime objectives the development of the documentation capacity of the counterpart institutions.

Though the initiative for the project comes from Sweden, the counterpart institutions have a vital role. Their active participation will create the necessary conditions for the implementation of the project and its future viability. They have a central role to play in identifying the target groups and discovering their needs. It is thus of prime importance that contact is established with the counterparts and that a qualified person is recruited for permanent work at the documentation facilities set up at each of the above-mentioned institutions. Funds are to be made available for the employment of local documentalists.

The collected material will be compiled as national bibliographies. A further development entails the issue-orientated treatment of the material, e.g. according to subject areas, such as health, rural housing, urbanization and other areas of interest and relevance to the target groups. In these areas the users will also be involved if the material is to be transformed into usable forms for different purposes, e.g. education, planning, etc.

The practical experience gained through the project should contribute to the development of international documentation and information programmes. Close contact should be maintained with international documentation centres and international developments in documentation followed closely.

With regard to practical documentation, i.e. bibliographical description, indexing and abstracting, the international standards recommended by UNISIST (ISO International Standard Documents 690 & 214) are followed as closely as possible. A system of descriptors (keywords) chosen from a controlled vocabulary (thesaurus) is used. One of the main problems in this area is the fact that there is no thesaurus adequate for interdisciplinary documentation on human settlement. The UNESCO thesaurus has been chosen as the basis for indexing. SMUH's thesaurus is also used to a limited extent. A conventional manual storage system is used for the references collected. Two methods of retrieval are thus possible - using a registor of descriptors or a' visual punched card system. However, the system allows for the possibility of connection to an automatic retrieval system in the future.

The project is funded by research grants from the Swedish Council for Building Research and the Swedish Agency for Research and Cooperation with Developing Countries (SAREC). The project is administered by the Department of Building Function Analysis, School of Architecture, University of Lund, Sweden. Personnel resources comprise a project team in Sweden, local documentalists at each of the counterpart institutions and a group of reference persons who are employed as consultants when specialist knowledge is required.

Progress Report

The collected references now number approximately 1600. Among these can be found approximately 91 bibliographies. A total of 150 abstracts have been written. The main sources have been the acquisition lists published by SIDA, the Scandinavian Institute for African Studies and through Byggdok. Relevant information on series, publishers, research institutions, etc. is being compiled. The inventory carried out in Portugal produced approximately 120 titles on Mozambique and a large number on other Portuguese colonies.

The rate of progress of the project in the counterpart countries is not similar. This is a reflection of the local differences with regard to priorities, experiences and resources. The project programme must allow for adaption to the different local conditions and overall development in each of the counterpart countries. A flexible policy is necessary to cope with local difficulties.

Demarcation of the documentation area is central to the development of the project. Discussions within the Swedish team and with the counterpart in Kenya, Ms Myers, have led to the conclusion that, since a userorientated approach is applied, the demarcation of the documentation area can only proceed after the identification of the target groups and their needs. This demarcation can only be attempted in close consultation with the counterparts whose responsibility it is to contact the "users" and identify their needs. It can be assumed that the area of documentation will not be exactly the same in all three countries due to the different conditions and priorities.

Experience, information and documentation could, with benefit, be exchanged between the counterpart countries, given the similarity of many of the problems experienced. It is essential to foster contacts between the counterpart institutions which will lead to continued cooperation after they take over the main responsibility for the project.

After initial difficulties in Kenya due to problems of funds for local staff, a local documentalist was recruited, Ms Dorothy Myers. She visited Sweden in November 1979 for discussions with the Swedish team and with staff at BFR, SAREC and Byggdok. Ms Myers is at present involved in contacting target groups in Kenya and is carrying out an inventory of references in Nairobi.

After an agreement was reached with the counterpart institution (DNH) in Mozambique in March 1978, work was begun in December 1978. An inventory of references was carried out in Portugal during a period of 14 weeks. The counterpart institution in Maputo has been regularly informed of the progress of the project. Satisfaction with the progress was expressed in February 1980. However, at the same time, it was stressed that the development of the project would be delayed due to the difficult planning situation in Mozambique at present and the forthcoming reorganization of the DNH.

Progress with regard to the project in Zambia has also been delayed by difficulties in ensuring funds for the appointment of a local documentalist. But the difficulties have been overcome and a local documentalist will begin work in Spring 1980.

Planned Activities

The inventory of titles will continue. Abstracting will continue more intensively. The preliminary national bibliographies which will be available in the spring of 1980, will be distributed as widely as possible, especially in the counterpart countries, and supplemented and amended according to the responses received.

The main thrust of the doucumentation will, in the course of this period, be transferred from the project group in Sweden to the counterpart institutions.

The next phase is the issue-orientated. Special issues selected by target groups will be studied. The counterparts will play a key role in identifying the target groups and ascertaining their needs for this phase. The issue-orientated phase demands the active participation of the counterpart institutions. The initiation of this phase depends on progress with the implementation of the project in each counterpart country. Building Documentation, a Case Study in Turkey

Ülker Çopur, Ph.D., Asst. Prof. Dept. of Arch., METU, Ankara, Turkey,

Sevinç Yavuz, M.Arch., Instructor, Dept. of Arch., METU, Ankara, Turkey

Summary.

The aim of this paper is to propose a documentation system for buildings in general and, specifically, university buildings.

In recent years there has been a rapid increase in the number of university campuses and existing schools are being expanded to meet new demands in Turkey. A systematic documentation will assist in the planning of new university buildings, in the selection of appropriate technology and materials, in the programming of space requirements and in the planning of growth stages.

Following a brief history, the paper evaluates existing building documentation systems in Turkey. A computerized method of documentation system is proposed for university buildings and a pilot study is described as the basis for the preparation of such a data base. The Middle East Technical University (METU) Campus in Ankara has been selected for the study.

An integrated data base system for the university is presented, of which building documentation is a subset. This documentation is based on physical and user surveys as well as update surveys.

The paper ends with a brief discussion of potential applications of the model.

Sommaire.

Cet article propose un système de documentation de bâtiments, et plus spécifiquements de bâtiments universitaire.

Dans les dernières années on a assisté en Turquie à une augmentation accelérée de construction de nouveau campus et à une expension des bâtiments universitaire existantes afin de faire face aux nouvelles demandes. Une documentation systématique à ce but assistera la planification de nouvelles installations universitaires la sélection de technologies et matériaux, la planification de l'espace et la programmation des phases d'expension.

Dans cet article, après un bref appercu historique et une évaluation des systèmes de documentation existantes, une methode computarisé pour bâtiments universitaire est proposée. Cette méthode se base sur une étude pîlote de préparation d'une *data base*, qui fut réalisée à ce but au campus d'Ankara de l'Université Technique du Moyen Orient.

Un système intégré de *data base* pour l'Université est presenté, ou la documentation de bâtiments constitu un sous-ensemble. Cette documentation se base sur des enquêtes physique et d'occupants.

L'article se termine avec une discussion sur des applications potentielles.

Introduction.

There is a continuous increase in information at the same time that the world is facing shortages in other types of resource such as materials and energy. A valuable resource such as data requires to be treated as such. If a planned and systematic recording is not maintained there will be large losses of information.

The primary concern of this paper is a special set of information, that is, building information. Building data is necessary for the evaluation of the building stock at hand quantitatively as well as qualitatively. Nationwide building stock surveys only include basic data and omit comprehensive information on the different sectors of the stock. An extensive data base has to be developed for buildings where the impact of urbanization is severely felt. This is especially the case in a developing country such as Turkey.

History of Building Documentation in Turkey.

Only recently, comprehensive architectural inventories have been developed for computerized information systems. For example, the Canadian Inventory of Historic Buildings, started in 1970, is one of them [1]. Throughout history however, other recording systems, mostly selective, have been in use.

In the history of Turkey, one of the oldest documentation for buildings dates back to the Great Selchuk Empire (Ninth and Tenth Centuries,) and is a selective recording of buildings in Persia.

After the Seventeenth Century in the Ottoman Empire statewide statistical surveys were made once every forty, fifty years. Building ownership patterns, duration of construction, number of workmen employed, their wages, materials used, costs and maintenance were recorded and printed in books called "Tahrir Defteri."

After the founding of the Republic, the first nationwide statistical survey that also included buildings was done in 1927. This was a recording of basic statistics on buildings in each province, such as use, types of material, number of storeys. The 1935 and 1940 Census included building information only for the three most populated cities in Turkey, namely İstanbul, Ankara and İzmir.

In 1965 a sample building survey was conducted alongside with the Census. The first computerized survey was in 1970, [2]. This, however, was not a comprehensive survey, including again only basic statistical data such as building use, location and construction materials for each municipality. Squatter settlements around major cities were excluded from this partial survey.

Present Situation in Building Documentation.

Building documentation in Turkey is not centralized. Data on the building stock is collected at the State Statistical Institute. This data consists of general information on buildings. Building surveys are made every five years at the same time as the Census.

For those buildings that have occupancy permits, these records are kept by municipalities. Data on the housing stock exists in various institutions. The type of information collected changes with respect to the special areas of interest of the different institutions, such as the Building Research Institute in Ankara, (YAE - TUBITAK,) and the Ministry of Housing and Resettlement.

Documentation on historic buildings is kept at the Ministry of Cultural Affairs. The survey instrument used by this Ministry is based on a system similar to that of the Council of Europe Protective Inventory of European Cultural Heritage. This documentation system is not extensive and not entirely structured for computerization.

In summary, it is seen that documentation is scattered, not comprehensive and in general not computerized. Access by the user to raw data is minimal, therefore the questionable reliability of secondary information hinders research.

<u>Building Documentation for Educational Institutions.</u> There is a great demand for higher education in Turkey. The total number of students enrolled in universities, technical schools and academies has increased nearly three times in the last ten years. Those enrolled in universities alone nearly doubled in the same period. An inordinately large number however is unable to enter these schools. In 1979, only about ten percent of the 400,000 applicants could enroll in universities and academies.

Parallel to this increase in demand, there has been a rapid growth in educational institutions in recent years, with various new campuses around the country. However, this growth is somewhat haphazard, there is a lack of integration in the planning and design of these school buildings.

The planning of new schools needs to be based on a reliable body of data that will coordinate all the

information necessary for sound investment of scarce resources. A Unified Building Documentation System must be an integral part of this data base.

The diagram in Figure One shows the information systems of separate universities linked with one another within a unified system of codification. As new campuses are formed they can be easily integrated into the existing network. The successful operation of the model rests on the central headquarters (hq) that controls and coordinates the separate centers.



Figure One. Information network for universities.

Building Documentation: A Proposal for METU. The Middle East Technical University (METU) was established in 1956 to develop planning and technical expertise for Turkey as well as neighboring Middle-Eastern countries. The school was moved to its present campus outside Ankara in 1963 following the completion of the Faculty of Architecture buildings. Since then, about seventy buildings have been built, there are four separate faculties, thirty one academic departments and an English Preparatory School. A total of around ten thousand students are enrolled at present. The number of academic members is over eleven hundred. The physical as well as academic expansion of the school continues, with two new branches in Gaziantep and Mersin.

To date, a centralized documentation office for the university has not been established. Information is gathered at various separate locations, access for which is not always easy and rapid, [3]. The degree of redundancy is high, decreasing reliability and efficiency. Only staff payments, student registration and grades are computerized at present. The library is in the process of converting to a computerized system of cataloging and ditribution.

This brief discussion points out the necessity for a data base system for METU, identified as the University Information System, with its own management. Structure and Operation of the System.



Figure Two. Integrated Data Base System for the University.

As shown in Figure Two, the proposed Building Documentation System is a subset of the University DBMS, (data base management system.) On the other hand, it is linked to the National Building Documentation System. This necessitates a uniform codification language. Physical data provide the primary informationset for building documentation. These consist of comprehensive information gathered by physical surveys conducted taking buildings as data points upon their completion. In addition to this, user evaluations of campus buildings are collected by means of surveys at regular intervals.

The secondary set of information is comprised of the total number of students, staff, departments, programming, acquisitions, running costs, etc. These are stored in the data bank. The frequencies of updating vary, depending on the type of data.

In addition to this stored information, visual documents such as working drawings, photographs and slides are filed in a Visual Documentation Center. The same coding system should be used here in order to facilitate retrieval of information. The Archives Office of the Faculty of Architecture can be developed into such a center.

Physical Survey.

This survey covers more detailed information than traditional building surveys. The primary objective of this kind of extensive data collection is to serve a variety of specialized research. This set of operational data will be made available to different users.

The survey form enables collection of data on the following main variables:

. Building identification (province, city, district, street, number, use, name, code,)

. Date of occupancy (the date on which the occupancy permit is issued by the municipality,)

. Cost (construction cost, equipment cost,)

. Spatial characteristics (floor area, volume, height, identification of sub-divisions of space,)

. Surface characteristics (openings, texture, color, exterior and interior,)

. Structural characteristics (structural system of building, roof structure,)

. Characteristics of construction material (walls, floors, roof,)

. Equipment (heating and ventilation systems.)

This detailed survey is to be made once for each building, following occupancy. Each variable has been itemized with a set of alternatives. The survey was coded and programmed for SPSS (Statistical Package for Social Sciences.) Fifty four buildings have been included in the survey.

An updating on the building stock of the university is made each year with the objective of recording: . Changes in use, materials, space (removal of walls, partitioning, insertion of a mezzanine,)

. Physical condition (structural failure, surface condition, etc., location codes,)

. Maintenance and repair work (type and location code.) User Survey

The questionnaire has been designed around user attitudes, satisfactions and behavior in space. Frequencies of use of the different types of space in different buildings on the campus are tried to be established. The survey subjects have been asked to rate the spaces they most frequently use in terms of physical comfort which includes factors such as heating, ventilation, lighting, size, height and servicing.

At this preliminary stage, the user survey was conducted on the students, academic members and staff of the Faculty of Architecture. Sample size for students was fifteen percent. The entire group of faculty and staff were surveyed. The user survey is suggested to be updated every three, four years and be made part of the central data base. <u>Potential Applications of the Building Documentation</u> System.

This data base can be utilized in the future development and design of new campuses, campus buildings and the extension of existing structures.

A probable user of the building information would be the University Planning Commission. Prior to new planning decisions, the Commission would require an evaluation of use, space-allocations, the cost per square meters of existing buildings related to structure and material, growth rates of the student population, academic and non-academic staff, etc. Such information can be retrieved or drawn from the data base by the use of various programs. One example is given in Figure Three where two scattergrams [4] obtained from the results of the initial survey have been superimposed.



Figure Three. The increases in the number of students, academic staff and their relation to floor area of physical facilities in the Faculty of Architecture. Floor area = $12,675 \text{ m}^2$ for the entire time period covered.

In another example, the economic use of facilities can be assessed by the use of the data base. The frequencies of use of central buildings on campus such as the main library, gymnasium, cafeteria and auditorium are to be gathered by means of the user survey. One striking result of the pilot user survey for the Faculty of Architecture has been that the faculty auditorium and museum are hardly ever used by the students and staff of the faculty, as shown below.

Further uses of this documentation system can be in other aspects of building, such as:

. The comparison of new technologies and materials with existing, traditional techniques in construction,

. Construction management and its reflection in the architecture of educational buildings,

. Ageing and maintenance,

. Adaptiveness and flexibility.

Frequency of use	Auditorium (%)	Museum (%)		
Daily	1	-		
2-3 times a week	-	-		
Once a week	1	-		
Twice a month	-	-		
Once a month	4	<u> </u>		
Seldom	40	19		
Never	54	81		
Total	100	100		

In conclusion, the development of a comprehensive documentation system establishes a basis for the evaluation of the existing building resource of the campus from the point of view of building economy. This information can hence be utilized with the purpose of achieving guidelines for the future development of campuses.

Notes.

 L'inventaire des bâtiments historiques canadiens, The Canadian Inventory of Historic Building, Information Canada, Ottawa, 1972.

2. 1970 Binalar Sayımı (Belediye Teşkilatı olan Yerlerde.) 1970 Census of Buildings (for places with municipality,) Ankara Devlet İstatistik Enst. Yayın No 647, Ankara 1972.

3. Information on students was obtained from the Registrar's Office; academic and administrative staff, from the Personnel Office. Information on building cost, date of completion and floor area from the University Bureau of Construction and Assessment.

4. Nie, Norman H. et al, SPSS Statistical Package for the Social Sciences, New York, 1970.

Bibliography.

Bullock, Nicholas, Peter Dickens and Phillip Steadman, A Model for University Planning in Leslie Martin and Lionel March (eds.) Urban Space and Structures. London 1972.

Date, C.J. An Introduction to Data Base Systems. 2.ed. London 1977.

House, William C. (ed.) Data Base Management. 1.ed. New York 1974.

Nie, Norman H. et al. SPSS Statistical Package for the Social Sciences. 2.ed. New York 1970.

Yapı İstatistikleri Paneli (Building Statistics Panel.) Mimarlık, Vol 16, No 4, 1978, pp 17-28.

491

Modeling of Standards

Richard N. Wright, Director, Center for Building Technology, National Bureau of Standards, USA Steven J. Fenves, University Professor of Civil Engineering, Carnegie-Mellon University, USA James Robert Harris, Structural Research Engineer, National Bureau of Standards, USA

Summary

Standards are the primary communication and control mechanism used to describe building practices and products in communications between the various participants in the building process. Most prior research related to building standards has been concerned with understanding and improving the performance of building products. This work, in contrast, is concerned with improving the organization, expression and interpretation of the information contained in a standard. Techniques are described for objective and rigorous representation of the meaning of a standard. These allow it to be tested for aspects of clarity, completeness, consistency and correctness. Furthermore, the techniques allow alternative organizations and expressions to fit the needs of various users with assurance that meanings remain unchanged and that users will readily find and understand all provisions even in a new or unfamiliar standard.

Sommaire

Les normes représentent le moyen principal de communication et de contrôle utilisé pour décrire les pratiques et produits de bâtiment aux divers participants dans la construction. La plupart de la recherche entamée jusqu' ā maintenant relative aux normes de bâtiment essaie d'améliorer et d'approfondir la connaissance de la performance de produits de bâtiment. Le présent document par contre a pour but d'améliorer l'organisation, l'expression et l'interpretation des renseignements contenues dans une norme. Des techniques sont décrites pour représenter objective et rigoureusement la signification d'une norme. Ces techniques permettent la mise \widetilde{a} l'épreuve de la clarté, la portée, la suite des idées et l'exactitude de la norme. De plus, ces techniques permettent divers arrangements et expressions pour remplir les besoins de différents usagers tout en restant assurés que le sens demeure inchangé et que les usagers trouveront rapidement et comprendront toutes les spécifications appropriées, même dans une norme nouvelle ou inconnue.

1. Introduction

We use the term "standard" to include all types of formal documents used to define the qualities of buildings, building products, materials, or building processes. The term includes legal building regulations, standards such as those of the International Standards Organization, or proprietary specifications such as those describing proper installation of a window. Standards are used for communication between buyer and seller and for protection of public health, safety and welfare.

A standard usually is drafted by a small group of experts (hereafter called "experts") who: (1) define the scope, including the products or processes to be covered and their required performance attributes, (2) determine whether to express the standard as a performance standard (attributes in terms of user needs), procedural standard (attributes in terms of specified, rigorous technical evaluation procedures), or prescriptive standard (attributes given as dimensions or properties completely defining the acceptable configuration or procedures) [1], (3) formulate the standard and submit it to the organization responsible for promulgation and maintenance. The process of promulgation and maintenance may be of long duration. Modifications and interpretations may occur with out participation of or consultation with the experts who initially drafted the standard.

It is not surprising that problems arise from the process for the formulation and use of standards. Rapidly changing societal demands for building qualities, such as energy conservation, and rapidly developing technologies, such as air quality measurement and electronic computation, lead to many new subjects for building standardization and frequent changes in the standards. As a result users find it difficult to: (1) locate all relevant provisions in a standard, and (2) understand and correctly apply the provisions they select.

The process of standards development is expensive in itself because much time and effort are required from leading experts in the subject area and from those whose interests are affected. Most of this time and effort go to mutually understanding issues and resolving them. Even greater expenses associated with the present process of standards development come from the continued use of obsolescent standards and from failures and waste associated with the use of standards that are technically incorrect or are misunderstood. Computer-aided design practices potentially exacerbate these problems. It is expensive to develop the programs for applying a new or revised standard in computer-aided design. Errors due to misunderstandings of standards may lead to many errors in application as the programs are used. Furthermore, the great time and expense associated with updating programs to incorporate revisions in standards acts as an impediment to the application of improved technologies that can increase the economy, safety, or usefulness of buildings.

Standards often fail to make the intended performance attributes (such as safety, functionality, or durability) or pertinent mechanisms of failure (such as fracture or corrosion) explicit for each provision. This lack of clarity makes it difficult to assess the benefits and costs associated with a standard and therefore difficult to improve it through research.

2. Qualities of a Standard

The qualities of the organization and expression required for a standard can be expressed at three levels:

- Individual provisions need to be: <u>Clear</u> the provision yields one and only result in any possible application, <u>Complete</u> the provision applies explicitly in any possible situation, <u>Correct</u> the result of applying the provision is consistent with the objective of the standard.
- 2. Relations between provisions should make them: <u>Connected</u> - explicit cross references show the data required to use each provision and the use stipulated for the data produced by each provision, <u>Acyclic</u> the data produced by evaluation of a provision need not be known prior to its evaluation (no loops in logic), <u>Consistent</u> - uniform logical and technical bases are provided for comparable provisions.
- 3. The organization of the standard should be <u>Complete</u> - explicit scope so a user knows what subjects and qualities are covered by the standard, <u>Clear</u> - the arrangement and display of provisions is such that the user readily finds all provisions pertinent to his query.

The following sections illustrate how the model for standards provides a systematic means for providing these qualities in processes of formulation and expression for a standard.

3. Modeling of Provisions

A <u>provision</u> is defined here as a statement stipulating that a product or process shall have or be assigned some quality. A number of forms and types of provisions fit this definition: (1) a performance requirement, e.g., "the system shall maintain an adequate supply of hot water," (2) a performance criterion, e.g., "hot water temperature shall be controlled between 40°C and 50°C," (3) a prescriptive criterion, e.g., "the hot water tank shall have a capacity of 150 liters," (4) a determination or function, e.g., "the flow q = av." For purposes of modeling provisions it is necessary to stipulate that a provision should have a single subject and require or assign a single quality.

In the model a <u>datum</u> is considered to be associated with each provision. For requirements or criteria the value of the datum can can be either <u>satisfied</u> or <u>vio-</u> <u>lated</u>, for a determination or function the value can be numerical or a term such as "red" for color.

Recent work [2, 3] provides guidance on expressing provisions, such as using the active voice and making explicit the performance attribute to which the provision pertains in order to promote clarity, consistency and correctness. Often the logic of a provision is too complex to express in a simple declarative sentence. Then a <u>deci</u><u>sion table</u> is used to model the provision. Consider the following provision, from an early draft of tentative seismic provisions [4], that assigns a value to a datum

Soil Profile Type (SPT):

Site effects on building response shall be established based on three profile factors defined as follows:

- SOIL PROFILE TYPE A is a profile with:
- Rock of any characteristic, either shalelike or crystalline in nature. Such material may be characterized by a shear wave velocity greater than 2,500 feet per second, or
- Stiff soil conditions where the soil depth is less than 200 feet and the soil types overlying rock are stable deposits of sands, gravels, or stiff clays.

SOIL PROFILE TYPE B is a profile with deep cohesionless or stiff clay conditions including sites where the soil depth exceeds 200 feet and the soil types overlying rock are stable deposits of sands, gravels, or stiff clays.

SOIL PROFILE TYPE C is a profile with soft-to medium-stiff clays and sands, characterized by 30 feet or more of soft- to medium-stiff clay with or without intervening layers of sand or other cohesionless soils.

In locations where the soil profile is not known in sufficient detail to determine the soil profile type and where foundations are supported without the use of piles, Soil Profile B or C shall be used whichever produces the larger base shear.

Table 1 shows the <u>decision table</u> representation of the provision. The four parts of the decision table are separated by the rows and columns of asterisks. The <u>condition stub</u> in the upper left gives the logical conditions that pertain to the provision, for instance "1. Soil Type = Rock". The <u>condition entry</u> in the upper right is a set of rules. Each column contains one combination of condition values that define a rule, for instance rule 1 pertains when condition 1 is true (T), conditions 2, 3, and 5 are implicitly false (-) because of condition 1, conditions 3 and 6 similarly are implicitly true (+) and condition 7 is immaterial (*).

Table 1. Decision Table for Soil Profile Type (SPT)

oone	11210113				no	100		
			1	2	3	4	5	Е
1.	Soil type = Rock	*	т	_	_	_	•	
2.	Soil type = Stiff	*	-	Т	Т	-	•	
3.	Soil depth <200 ft.	*	+	Т	F	•	•	
4.	Soil type = Soft Clay	*	-	~	-	Т	•	
5.	Depth of Clay >30 ft.	*	-	•	•	F	•	
6.	Soil type known	*	+	+	+	+	F	
7.	Piles support foundation	*	•	•	•	•	F	
		*						
****	******	***	***	***	***	***	***	****
		*						
Acti	lons	*						
		*						
1.	SPT = A	*	Х	Х				
2.	SPT = B	*			Х			
3.	SPT = C	*				Х		
4.	SPT = B or C	*					Х	
5.	Else Rule	*						Х
The <u>action stub</u> in the lower left describes all possible values the provision can take and the <u>action entry</u> in the lower right shows by X which one value pertains to each rule. Note that a rule designated E for <u>else</u> corresponds to all combinations of conditions entries that are not explicitly included in preceding rules.

The clarity and completeness of the provision is analyzed by generating a decision tree corresponding to the decision table, as shown in Figure 1. For clarity we note that no terminal node fits more than one rule. If the latter were to occur there would be either redundancy (two or more rules that match the same set of condition entries and have the same action value) or contradiction (two or more rules that match the same set of condition entries but have different action values). For completeness we trace each set of condition entries leading to an E (else) node in the terminal row to see that no possible set of conditions lacks an explicit action value. Here we see problems in the example provision: (1) what soil profile type applies when condition 6 is false (F) and 7 is true, (2) what soil profile type applies when condition 6 is true and conditions 1, 2, and 4 are false, (3) what soil profile type applies when conditions 6 and 4 are true and conditions 1, 2, and 5 are false? These problems were noted for the drafters of the provisions, and they responded by accounting for them [4].



Figure 1. Decision Tree for Soil Profile Type (SPT)

Principles for forming decision tables and trees are given in texts such as [5], the techniques used by the writers are described in [6] and a result for the revised example provision is given in [7].

<u>Correctness</u> must be judged by the technical experts developing the standard. We have found, and this example illustrates, that the model of the provision with its clear presentation of the logic helps experts in expressing correctly their intent.

4. Modeling Relations between Provisions

A standard consists of a system of interrelated provisions. As <u>information network</u> is used to model these interrelations. Each node of the network represents a datum. Consider the following excerpt of a provision, from Ref [5], that assigns a value to the <u>Response</u> Modification Coefficient (R).

Type of	Vertical	Coef-
Structural	Seismic	ficient
System	Resisting System	R
Moment Resisting	Special	
Frame System:	Moment Frames	
A structural system	Steel	8
with an essentially	Reinforced Concrete	7
complete Space Frame		
providing support	Ordinary	
for vertical loads.	Moment Frames	
Seismic force resist-	Steel	4 1/2
ance is provided by	Reinforced Concrete	2
Ordinary or Special		
Moment Frames capable		
of resisting the		
total prescribed		
forces.		

To evaluate the response modification coefficient (the datum R) one must first know the ingredient datums: the type of structural system (GFC), vertical seismic resisting system (SRS), ordinary or special moment frame (FRT), frame material (FM) and ordinary or special moment frames capable of resisting total prescribed forces (FRTF). These datums are shown as nodes of the information network in Figure 2. The arrows on the branches connecting the ingredient nodes with their <u>dependents</u> (R for GFC, SRS, FRT, FM and FRTF) show the precedence relations between these datums.

The information network is extended as further relations between provisions are considered. Thus K is an ingredient to the seismic design coefficient (C_s) which is ingredient to the seismic shear force (V) that in turn is ingredient to the total prescribed force (TPF). This extention of the network has been simplified for clarity.



Figure 2. Partial Information Network

Here we see a problem revealed by the information network. Because the wording of the provision for R contains the requirement "Seismic force resistance is provided by ordinary or special moment frames capable resisting the total prescribed force," TPF may be interpreted as an ingredient to R. With this interpretation a loop exists because R is in its own ingredient subnetwork. In this instance the loop seems easy to break by

494

removing the requirement from the provision for R. It still can be applied in the standard but need not be an ingredient of R.

The information network defines explicitly all cross references in a standard so that the user readily can identify the flow of information. The information network is useful to determine whether appropriate cross references are provided or if some provisions seem to be unused - unconnected with the main element. The information network will help to test for <u>consistency</u>. It shows where the various datums are used, those uses can be compared for appropriate uniformity in technical and logical bases.

The information network provides information useful in ordering the text of a standard. Text must express the logic of the multiply connected network in a linear format that is easy and convenient to use. Different types of use are facilitated by different forms of expression. These can be related systematically to the information network and decision tables as described in Ref [1].

The precedence relations recorded by the information network are essential for programming for computer use in design calculations. Logical methods based on the information network [8] avoid use of incorrect data and minimize computational efforts for new data as design variables are changed.

5. Organization of a Standard

In concept <u>organization</u> includes both the <u>scope</u> and <u>arrangement</u> of a standard [3]. Scope is defined as the products or processes and the set of their required qualities to which the standard pertains. A clear statement of scope tells a user what he can expect to find in the standard.

Arrangement deals with the means of access to locate pertinent provisions. Potential means of access are: (1) the table of contents, (2) the index, (3) headings within the text, (4) proximity of related provisions in the text, and (5) cross references expressed in the text.

The model for organization of a standard given here deals explicitly with techniques of arrangement for means of access 1-4. The model of relations between provisions, the information network, gives techniques useful for means of access 1, 4 and 5.

The arrangement of a standard is expressed most visibly by the headings in the table of contents, their ordering, and their hierarchy of chapters, sections, subsections, etc. Objectives for the relations of the headings to one another and to the provisions are expressed as follows [3]:

- <u>Relevant</u>: each heading must be significantly related to its provisions; it must concisely express their scope.
- (2) <u>Meaningful</u>: the intended user must perceive the heading as relevant.

- (3) <u>Unique</u>: the headings must be distinct from one another to allow readers to access provisions unambiguously.
- (4) Complete: the total set of headings must cover the whole scope of the standard and nothing more.
- (5) <u>Graded</u>: the headings must show progressively narrower scope from chapter to section to subsection, etc.
- (6) <u>Progressive</u>: the headings at any level, such as chapter titles, should be ordered in a pattern meaningful to the user.
- (7) Intelligible: the depth (number of levels of subdivision) and breadth (number of headings at one level) should not exceed the average span of immediate memory for the ordinary reader (about seven).
- (8) <u>Minimal</u>: the headings should be permuted so that the total number of headings is minimized.
- (9) Even: the depth and breadth should not vary greatly from one part of the standard to another.

The first five objectives must be satisfied to provide the qualities stated in section 2.

For an example of a heading that does not meet these objectives consider the following provision headed

"1.4.2 SEISMIC HAZARD EXPOSURE GROUPS" [5].

All buildings shall be assigned to one of the following Seismic Hazard Exposure Groups for the purposes of these provisions: (A) Group III. Seismic Hazard Exposure Group III shall be buildings having essential facilities which are necessary for post-earthquake recovery. Essential facilities, and designated systems contained therein shall have the capacity to function during and immediately after an earthquake. Essential facilities are those which have been so designated by the Cognizant Jurisdiction."

The sentence underlined (our emphasis) is a fundamental performance requirement for essential facilities. It is easy to overlook beneath a heading that is not relevant to the requirement.

The model for organization of a standard can be illustrated briefly as it is applied for performance requirements. The initial definition of scope is accomplished by establishing a classification for the the subjects and predicates of the requirements. For the structural part of a performance standard for residential buildings [9] the trees of classifiers are shown in Figure 3.





The trees follow the logical criteria for classification of being exhaustive (over the desired scope) and mutually exclusive.

An outline is developed by systematically combining [3] the trees of classifiers as shown in figure 4. The standard writers decided to establish performance requirements only for the headings labeled with an "R" in figure 4(a) so the outline is condensed as shown in figure 4(b). This example illustrates "top down" organization useful when standards writers are beginning ab initio to define the scope and provisions of a standard.

The model for organization also can be applied to the reorganization of existing provisions, a "bottom up" approach. Again trees of classifiers are developed as in figure 3. Each provision is then assigned the uniquely most pertinent classifier from each tree that is relevant and is used for the organization. The classifiers assigned to a provision are called its arguments. The outline again is generated by systematically combining the trees of classifiers in an order meaningful for the intended user. A provision is entered when its arguments and no other, irrelevent classifiers are in the chain of headings.

The index is one other important means of access. It is developed by listing all classifiers in alphabetical order and listing for each classifier all provisions that use it as an argument. An extensive study of the model for organization is nearing completion.

Building	Building					
Structural System	Structural System					
Safety		Safety				
Fire Loads	R1	Fire Loads Rl				
Other Agents	R2	Other Agents R2				
Serviceability		Serviceability				
Force Loads	R3	Force Loads R3				
Other Agents	R4	Other Agents R4				
Interior Surfaces		Interior Surfaces				
Safety		Walls R5				
Force Loads		Floors R6				
Wall						
Floor		2				
Other Agents						
Wall						
Floor						
Serviceability						
Force Loads						
Wall	R5					
Floor	R6					
Other Agents						
Wall						
Floor						
(a) Full Permutation		(b) Selected Outline				
Figure 4. Example Organization of a Performance Standard.						

6. Uses of the Model for Standards

The model for standards provides a rational and systematic approach to achieving standards that are clear, complete and consistent. The model deals with individual provisions, precedence relations between provisions, and their organization for ease in use. The substance of the standard is described in a manner independent of arrangement so alternative arrangements can be used for different purposes without any change in meaning.

The model for standards defines the meaning of a provision in an unequivocal manner, as with table 1, but it does not verify the correctness of the meaning. That is the role of the standards writers, the experts.

As described in Ref [7], analysis and synthesis ideally are conducted in team activities of analysts and standards writers. We anticipate that standards writers soon will become skilled in using the models and specialized analysts will not be needed.

Computer aids implementing the model for standards have been used in studies for References [6, 7]. Work is underway to develop an improved computational resource.

Acknowledgements

Research on modeling of standards was initiated at the University of Illinois in 1965 by S.J. Fenves and continued since then at the University of Illinois, Carnegie Mellon University and the National Bureau of Standards. The writers appreciate the support of these organizations, the American Institute of Steel Construction and the National Science Foundation for this work. The writers' colleagues: E.H. Gaylord, J.W. Melin, R.L. Tavis, R.J. Kapsch, Kirk Rankin, S.K. Goel, and D.J. Nyman have made valuable contributions to the modeling of standards.

The writers had the opportunity to test the model for standards in a major study [8] conducted in parallel with the formulation of tentative seismic provisions [5]. It has been convenient here to illustrate several points with examples from it. This is not intended to suggest that it has an unusually large number of defects in its qualities of organization and expression.

References

- Fenves, S.J. and Wright, R.N. <u>The Representation</u> and <u>Use of Design Specifications</u>. Technical Note 940, National Bureau of Standards, Washington, DC, June 1977.
- Fenves, S.J., Rankin, K. and Tejuja, H.K. <u>The</u> <u>Structure of Building Specifications</u>. Building Science Series 90, National Bureau of Standards, Washington, DC, September 1976.
- Harris, J.R. and Wright, R.N. <u>Systematic Organi-</u> <u>zation of Standards and Codes</u>. Special Publication 518, National Bureau of Standards, Washington, DC, August 1978, pp. 145-160.
- Applied Technology Council. <u>Tentative Provisions</u> for the Development of Seismic Regulations for <u>Buildings</u>. Special Publication 510, National Bureau of Standards, Washington, DC, June 1978.
- 5. Pollack, S.L. <u>Decision Tables: Theory and Prac-</u> <u>tice</u>. Wiley-Interscience, New York, 1971.
- Wright R.N., Harris, J.R., Melin, J.W., Tavis, R.L. and Albarran, C. Technology for the

Formulation and Expression of Specifications. Civil Engineering Studies, Structural Research Series, Nos 423, 424 and 425, University of Illinois, Urbana, December 1975.

- 7. Harris, J.R., Fenves, S.J. and Wright R.N., <u>Analysis of Tentative Seismic Design Provisions for</u> <u>Buildings</u>. Technical Note 1100, National Bureau of Standards, Washington, DC, July 1979.
- Wright, R.N. Boyer, L.T. and Melin, J.W., <u>Constraint</u> <u>Processing in Design</u>. Journal of the Structural Division, American Society of Civil Engineers, Vol 98, No Stl, January 1971, pp. 481-494.
- Performance Criteria Resource Document for Innovative Construction, NBSIR 77-1316, National Bureau of Standards, Washington, DC, November 1977.

Assistance in organizing building information systems for the developing countries

Anna Gáspár, Engineer Architect, ÉTK, CIB W57, Hungary Ákos Terebessy, Information Scientist, ÉTK, CIB W57,

Hungary

Summary

In recent years the Working Group entitled "Supporting building documentation in developing countries" of the CIB W57 Working Commission has analyzed the documentation requirements and possibilities to be expected in the developing countries. Knowing the present situation concerning information supply and information requirements, the goal is the establishment of well organized building information systems in the developing countries. With the aid of these systems, the satisfactory information supply of researchers, designers, manufacturers and contractors as well as information supply of the population concerning low cost housing can be assured. Therefore preparation of such recommendations are required, which outline the possible models of up-to-date basic institute of information and information network, taking into consideration the experiences of developed countries and the economic technical and personal background generally characteristic to the developing countries. In these recommendations criteria concerning content and form of training the information experts in the building field are to be stated, because the qualified information experts have to know well both the results of research and development, and the means and methods of information. The programmes of these courses are to be determined in accordance with the goals of building industry in the country concerned.

In the study the authors proposed that certain organizations of the UN /UNESCO, HABITAT/ should join in the development of information systems in the developing countries and the training of experts for operating these systems. This would be an effective support /both intellectual and financial/ to the contribution of developed organizations in the building information field.

<u>Résumé</u>

Le Groupe de Travail "Aide à la documentation des pays en voie de développement" de la Commission CIB W57 dans ces dernières années a effectué l'analyse des exigences et des possibilités de documentation des pays en voie de développement. En connaissance des exigences et de la situation actuelle de l'information l'objectif est de créer des systèmes d'information de la construction pour aider les chercheurs, les bureaux d'études, les producteurs et les entrepreneurs en leur assurant les informations nécessaires pour leur tâches, ainsi qu'en assurant l'information de la population en ce qui concerne la construction des logements sociales. Pour cette raison il est nécessaire d'élaborer des propositions pour la création des instituts de base de l'information et des réseaux d'information en prenant en considération les expériences des pays développés et la situation économique, technique et personnelle caractérisant en général les pays en voie de développement. Dans ces recommendations il faut fixer les critères de formation des experts de l'information de la construction, parce que les experts ainsi formés doivent aussi bien connaître les résultats des recherches et des développements de la construction que les moyens et les méthodes de l'informatique. Les thèmes de ces cours de formation doivent être harmonisés avec les objectifs de construction des divers pays.

L'étude propose que les organisations specialisées des Nations Unies /UNESCO, HABITAT/ offrent une aide intellectuelle et matérielle efficaces pour la réalisation des systèmes d'information de la construction des pays en voie de développement et la formation des experts nécessaires, avec la contribution des organisations d'information de la construction des pays développés.

Introduction

In recent years, the Working Group entitled "Supporting building documentation in developing countries" of the CIB W57 Working Commission has analyzed the expected documentation requirements and possibilities of the developing countries in several studies. [1], [2]. These studies partly show the different possibilities of rendering assistance, partly they are concerned with the quantitative aspects of informations documents. Our present study raises the problems of the establishment of building information centres in developing countries taking into account the possibilities of assistance in an organized form. Our statements and experiences are based partly on the offer made by the Hungarian Information Centre of Building /Budapest/ for Algeria, concerning the organizing a basic institute for building information, partly on the training of the building information experts of Ghana in Hungary.

The present situation of building information in the developing countries

The information organization of the countries concerned has not evolved simultaneously with the industrial development in the developing countries. The lack of information organizations is attributable to several reasons:

- in the beginning, most of the developing countries were colonial and semi-colonial countries, respectively, in which a great part of the population was concerned primarily with the production of raw materials;

- in the period of becoming an independent state, the main aim was the establishment of their own industrial production on some level, and this own industry was based to a decisive extent on the "heritages" of the former colonial states;

- the technical intellectuals of the developing countries studied at the universities, colleges of the former colonial and other developed countries, mastering the language of the country concerned and the technological methods applied and known there; - the experts trained in other countries made an attempt to develop the different domestic industrial branches, thus that of the building and building materials industry as well, by making use of the acquired knowledge, but without the minimum necessary domestic industrial background;

- the experts of the developing countries already trained - thus the building experts as well - collected the information necessary for their work from those countries where they acquired their qualifications because it was entirely missing in their own countries.

Because of the reasons listed, in the developing countries there are either no information organizations of special fields at all, or they exist only to a small extent, not in accordance with the requirements, and functioning in an unorganized way. Since one of the important conditions of further development, if a certain industrial development level is reached, is the establishment of their own special information organizations, which provide for regular and organized information supply with knowledge of the needs of the country concerned, the developing countries are becoming more and more interested in the creation of such organizations. The establishment of the necessary information organizations is hindered by the fact that the information basis needed for regular information does not exist at all in the developing countries and the experts experienced in establishing of such organizations are also lacking.

We believe that at present, when the industrial development level of the developing countries has reached the desired degree and when their role in the world's economy has suddenly grown, the establishment and operation of independent information organizations is becoming especially significant for them. In all industrially developed countries, information centres and organizations of building have already been functioning for several years, which possess proper organizational practice for the efficient organization of information besides performing their own domestic tasks. Thus, they are able to undertake to render assistance to those countries which require the organization of professional building information, by training of the proper experts and by performing the necessary organizational work.

Building information requirements of the developing countries

The requirements arise characteristically on behalf of two categories of users: the <u>population</u> and the <u>experts</u>.

The mass information requirement of the population is associated with the problems of low cost housing: it can be grouped around the designs of residential buildings, type designs and catalogues, resp., moreover the acquisition of the information concerning the building materials associated with these. In the first step, the means of information supply are audio-visual ones and it i necessary to lay great stress on these in the developing countries. Thus, it is possible to provide the population with efficient and mass-scale information by means of the press, radio, television, moreover films, exhibitions and publicity publications. However, it is advisable to coordinate these informations forwarded in several channels in order that the information and the technical publicity should transmit the up-to-date, economical designs, materials and structures. The building information organization of the country concerned has an important role in this.

The information requirements of the building experts of the developing countries are discussed' according to the user requirements of researchers, designers, manufacturers and contractors, respectively.

The building researchers and research institutes, resp., have to know the investment, production, technical development, technical regulation, moreover research plans and results of their own /domestic/ building sector and the industrial background belonging to it. They also have to be familiar with the plans and results of foreign building and research activities.

The information requirement of the planning and design organizations is generally associated with urban planning, structural planning and architectural design. They need the following information sources: research results concerning urban planning and building design; methods of design, calculation and dimensioning; descriptions of building methods, systems and technologies; descriptions of technicaleconomic parameters and analyses; catalogues for products, equipments and structures; orders and regulations, design aids.

The techno-economic information requirements of <u>manufacturers</u> /building materials, structures, equipment, etc./ are aimed primarily at the development of their own /domestic/ economic market situation, the results of research activities concerning the local building materials and their use, the knowledge of inventions, patents and licences, the knowledge of foreign products and their adaptability in their own country, the knowledge of foreign and domestic standards, moreover the knowledge of production processes.

The information requirement of <u>contractors</u> occasionally of structure manufacturers as well - is associated with the subjects of the economic market situation, product development, technological development, moreover organization development.

It follows from the foregoings that both the mass information requirement of the population and the information requirement of building experts are highly manifold in their contents and form of appearance alike, therefore it is necessary to solve the establishment of a complex organization of building information, keeping in view the most important objectives of the building sector.

Establishment of a basic institute of building information and its network in the developing countries, with the cooperation of a developed information centre

In the following we should like to outline the process series of the establishment of a basic institute of building information to be established in a developing country with cooperation.

1. Preparation of a basic study with the justification of the establishment of the centre /the degree of development, raw material base, intellectual-professional base, international relations, economic situation, economic management system and the most important tasks of the building industry of the country concerned/. The place and role of the Centre in the building process of the country.

2. The functioning and organization of the Centre, determination of its services /on the basis of the characteristic requirements, and the staff group of technical experts of the country/.

3. Selection of the geographical situation and relations of the Centre and its network. 4. Preparation of the technical technological plan based on the services of the Centre /possibly associated with the technical feasibility plan/. The proposed organizational order, taking into consideration the services, the methods of information storage, the solutions of publication, the technology of exhibitions, the operation and maintenance. 5. Planning of information systems and computer technique on the basis of the subsystems of information flow, keeping in view the computer network, preparedness and facility stock of the country.

6. Putting the Centre into operation with cooperation. When organizing the own professional building information activity of the developing countries, it is not necessary - and it is even unreasonable - to strive for complete autonomy. It is advisable to make use of all the existing information services, which are already available in the language generally known in the developing country concerned /English,Fremeh etc./.

Considering that the most important problem in the developing countries is the satisfaction of the <u>low-</u> <u>cost housing requirements of the population</u>, special attention should be paid to this sphere of problems during the establishment of an information centre and during the determination of services, with special regard to the means and media of up-to-date audio-visual information. This fact makes especially justified the cooperation of a developed country in the establishment of the Centre because the satisfaction of the information requirement on a mass scale is extremely urgent occasionally the solution of the housing situation is a question of vital importance.

The cooperation of the building information experts and institutions of the developed countries in the establishment of the Centres is able to speed up this process fundamentally and to make it considerably cheaper by rational organization.

Training of information experts of the developing countries

The establishment of information organizations for the developing countries necessitates the training of the information experts operating the organization. We should like to detail our proposal concerning this in the following.

3-5 building experts travel from some developing country to a developed country possessing a building information organization, where they are trained for 3-6 months concerning the most important issues of information and the professional field, moreover the organization of information work. Having returned, these few experts start to organize the information work and to establish the information base. After 6 months following the starting of organization in their country, two experts of the training country, who have participated in the training, travel to the developing country, and together with the local experts, they optimize the concept of the information organization, carrying out the corrections of the already started organizational and preparatory works as well. This work should be done in harmony with the peculiar building objectives of the given country, thus on the basis of the development level of the building and building materials industry of the country and a survey of the peculiar local information requirements of the organized construction works.

The volume and the criteria of the contents and form of information should be determined in accordance with the number and composition of the trained building experts working in the given developing country, taking into consideration besides this the information requirement of the low-cost housing already mentioned. In certain subjects, it is occasionally justified to organize several kinds of services as well, if those are problematic and cannot be solved without this.

It is important that information should be organized with those methods and means of informatics known at present which are in harmony with the technical, economic and scientific level of the given developing country and which suit the information requirements of the building experts working in the country. This should be taken into consideration in the training.

The training of the information experts and the establishment of the adequate information organization in themselves are not enough to ensure that the building experts should be able to make use of the services for their work to the necessary extent, but it is necessary to provide for the training of users in informatics as well. Here, primarily the possibilities of the availability and usability of the services should be made known to those interested. It is appropriate if the developing countries regularly teach in their higher educational institutions the role and possibilities of professional information in a domestic and foreign relation alike.

In the harmonization of the training of information experts, the proper training of the users of information, the information organizations, moreover the necessary requirement-oriented information services with the building level of the given developing country, the developed countries are able to render considerable assistance for the balanced development of all partial fields of building.

Conclusions and proposals

Considering the situation outlined, which reveals the present state of the building information of developing countries, as well as the existing mass population and professional requirements, moreover, keeping in view the establishment of information centres of building and the training of their experts, respectively, <u>on the one hand</u> we propose to start the realization of the task in the short run without any particular financial effort as follows.

We propose that the building information and research organizations of the developed countries should make available the methodology of all their documentation and information materials which can be the efficient information forms and aids of the characteristic building problems of developing countries, such as e.g. methodologies of the preparation of technical-economic trends, methodologies of the investigation of the international standard, research methodologies, mass information methodologies, etc. These would be collected and forwarded to the proper organ of the UN for distribution by the CIB W57 Working Commission. With this method, it is possible to speed up the development of information centres already being formed in the developing countries.

On the other hand, taking into consideration the main objective defined in the deed of foundation of CIB, which envisages the promotion of international cooperation in the fields of building, housing and planning research activities and documentation, and the ultimate aim of which is identical with the aim of UN HABITAT, the development of human settlements [3], we propose that certain organizations of the UN /UNESCO, HABITAT/ should join in the development of the building information background in the developing countries. Both the organization of the necessary professional information and the training of experts call for significant financial efforts on behalf of the developing and developed countries alike. The realization of this would be greatly promoted by cooperation and financial support of such character.

Bibliography

- [1.] Kriest, J.C. Lindahl, B.: How to help documentation centres in the developing countries. CIB W57/20/77/06/22
- C 2.1 Lindahl,B.: The quantitative aspects of documents about building in developing countries. CIB W57
- C 3.] Dick, J.B.: CIB and International Building Research. Habitat International.Vol.3.No.3/4. pp.275-281.Pergamon press, 1978.

Information from Building Research in a Developing Country

Bjarne Hegdal, Architect, Norwegian Building Research Institute, Oslo, Norway

Summary

The paper takes issue with a model for communication and reciprocal exchange of information within building research in a developing country. The experience forming the basis for the paper is taken from Tanzania. Whether the various viewpoints presented are valid for other countries is left open.

The organization described, some of what has been put into practice in Tanzania, is based on the existing Mobile Construction Field Units. These are groups of people with technical knowledge and equipped to give technical assistance in construction work.

The paper underlines the importance of conveying knowledge in such a way that it is received, understood and applied. Ordinary publication of various written information is inadequate. More efforts have to be made to explain and interpret results by means of direct contact and collaboration.

Résumé

Ce document concerne un modèle de communication et d'échange réciproque d'information dans le cadre de la recherche du bâtiment dans un pays en voie de développement. L'expérience sur laquelle est basée ce document a été faite en Tanzanie. La validité, pour d'autres pays, des différents points de vue présentés reste une question ouverte.

L'organisation décrite, une partie de ce qui a été mis en pratique en Tanzanie, est basée sur les "Mobile Construction Field Units" existants. Ce sont des groupes de personnes ayant des connaissances techniques et équipés pour donner de l'aide technique dans les travaux de construction.

Le document souligne l'importance de communiquer les connaissances de façon qu'elles soient reçues, comprises et appliquées. La publication habituelle des différentes informations écrites est inadéquate. Plus d'efforts doivent être faits pour expliquer et interpréter les résultats au moyen de contact et collaboration directe.

Information from Building Research in a Developing Country

In developing countries, building research has to be down-to-earth, and solidly anchored in the problems that are the most urgent concern of the majority of the population and of the nation as a whole. To invest in building research is bound to be a burden for a developing country. Once the decision has been made, to accept this burden, there has to be an obvious yield in the form of a better standard of living, based on a sound use of resources seen from the point of view of the people and the nation as a whole.

Tanzania is one of the countries which has taken on the burden. The National Housing and Building Research Unit (BRU) has existed since the start of 1971. The experience forming the basis for this paper is taken from Tanzania. Whether the various viewpoints are valid also for other countries is left as an open question.

One of the largest and most important problems in Tanzania is the housing problem. In the rural districts, and to a large extent also in urban areas, houses are built as self-help-projects, either by private individuals or cooperative teams comprising a limited number of house builders. A large number of houses (500-600,000) are built or rebuilt every year. The standard of these houses is in all respect such that relatively simple improvements would give immediate results.

If any emphasis is to be attached to obtaining a satisfactory effect of investments in building research, the results of these activities must be given a <u>wide application at all levels</u>. To achieve this, it is necessary to have a well-developed and effective apparatus for communication and reciprocal exchange of information. This apparatus, with its activities, is in itself a measure requiring extensive resources. It is nevertheless absolutely indispensible. In most countries, and in developing countries in particular, the spread and interpretation of information will be the most important sector of the total activity. This is because it is not so much a question of "making new conquests" in research, as of utilizing and applying existing knowledge.

It is usual that ordinary information measures are limited to the publication of various forms of written information - reports, instructions of different kinds, handbooks, offprints of articles and lectures, etc. Written publications make up the far greater part of information activities. In addition come courses and seminars, teaching, information through the mass media etc. In the majority of circumstances, this is inadequate for a widespread dispersal of knowledge and a feedback of experience. And it is even more inadequate in a developing country. Here it is obviously necessary to attend to the written documentation of results and experience, but in order to make sure of a widespread application of these results, more efforts must be made to explain and interpret the results by means of direct contact and collaboration.

In developing countries - as previously also in well developed countries - the problem of acquiring skill in house-building has been left to solve itself. It was the custom that skills were passed on from one generation to another simply through practical participation in housing construction. If a man intended to build a house, he had no planning problem because he knew the shape and layout of the traditional house, he knew the materials to be used and how it was to be constructed. This pattern is still valid. Naturally, people have been more or less clever at putting these housing skills into practice. Different methods of construction also need different levels of skills.

The pattern of passing on skills from one generation to another provides few possibilities for real development in design, utilization of materials, or construction methods. It does not give any skill or knowledge beyond that involved in simply erecting a house in the traditional manner.

After independence, when emphasis was given to rural development, Tanzania experienced the problem of lack of basic technical knowledge and practical skills among the people participating in self-help-projects. The Government recognized that in most of the early projects, there was no proper technical background and guidance available at the construction sites.

To meet this problem, the Rural Development Division in the former Ministry of Regional Administration and Rural Development, established the Mobile Construction Field Units. A Construction Field Unit is a group of people with technical knowledge, equipped to give technical assistance in construction work. When established, a Field Unit should comprise one Field Officer in charge, and four Field Assistants (1972).

The group's equipment should include one tipper (sixton), one truck (five-ton), one Land Rover, soil-cement brick-making machines, wheelbarrows, and an assortment of masonry, carpentry and plumbing tools. The intention was to have one complete Field Unit in each District, which at that time implied a total of about 60. About 50 Mobile Field Units were established in 1972. These, however, were incomplete. (The number of districts today is about 90. The number of Field Units is the same as in 1972.) The prime function of the Field Units was to train people in construction skills, either directly in connection with actual self-help-projects, or by means of courses at the Integrated Rural Training Centres.

Although this was the main purpose of the Field Units, it was also intended that they should have a considerable effect in motivating people to use sound methods of construction and improve the quality of work.

Fully established Field Units thus provide the "tool" by which to reach all parts of the country in the effort to romote sound construction methods and technical skills.

Today the Field Units frequently are used for other purposes than originally intended.

In our opinion, the organization established in Tanzania, with its Mobile Construction Field Units, should be the envy of many developing countries. Certainly, it is not used to the extent it could be. But the pattern of organization provides the best possible basis for an effective distribution and two-way-exchange of know-how.



The figure illustrates a possible pattern for a fully developed system of reciprocal communication. It refers to conditions in Tanzania, where the organizational levels of the administration are the same as those in the figure.

The figure assumes a dispersal of information at four levels — the national level, regional level, district level and the group (cooperative) — family — individual level. In addition, there is the international level, represented, for example, by the collaboration within CIB. In the figure, the lines of communication are drawn between levels that are nearest. It is, however, not only possible, but necessary to arrange communication between levels that are farther apart. It would be preferred if contact lines could go between all units at all levels. In practice this would be unrealistic. It is only by basing one's efforts on the main pattern, whereby information is conveyed between the closest levels, that it will be at all possible to succeed in the information dissemination on a broad basis. However, research <u>has to get feedback</u> on the results, when applied in practice. So there has to be contact between practice and research. This contact must be arranged by means of the links and units <u>at all levels</u>, and directly between practice and research <u>to the extent</u> <u>possible</u>.

How then can a model of this kind be implemented? An organization like this will cost quite a lot of money. However, the best defence against this argument is to ask how much it would cost not to put it into practice. In a country with a population of 15 millions, with tremendous distances, and poorly developed communication — without measures of this kind it would take an <u>extremely long time</u> before the effect of a centrally placed research institution was felt by the majority of the population.

Within the research institution itself, the model will not lead to any great changes, except to clarify the responsibility as regards contact with, and thereby communication of information to the regions. Then if, as a minimum, one person was appointed in each Region to be responsible for communication with the Districts and the Mobile Field Units, the apparatus described should become a practical possibility. The organization may be built out gradually in the light of experience, and as possibilities for expansion develop. Ambitions should not be too high to start with as regards mechanical equipment — it is better to put the emphasis on knowledge, on personnel and on simple tools. A great deal may be achieved with very little.

It has already been said that, in a developing country, the activities of a research institution must be adapted such as to make use of the existing know-how. An important task of the institution will be to arrange this knowledge so that it can be used in practice. Another important task is to convey the knowledge to the Regions in such a way that it is received, understood, and then applied. This task implies two-way communication. The research institution shall, in fact, also make sure that it gets to know of the know-how that exists, and is gradually employed, at the Regional level. The main responsibility for the further communication of information to the Districts and the Mobile Construction Field Units must rest with the Regions. In all cases, and at all levels, it will be important to collect knowledge and experience from work in the field. As already mentioned above, there has to be direct contact between the research institution and practice.

The use of media to convey and interpret the information has to be limited. The emphasis should be placed on simple, instructive forms of publications such as illustrated data sheets and posters. This in order to demonstrate construction methods, use of materials etc. Communication proper should occur by word of mouth, by means of direct personal contact in meetings, seminars, courses and by <u>instruction and training at the actual</u> building site. This is the most important task.

Otherwise, it is obvious that the use of mass media such as the press and the radio will help to make known what is actually happening in specific cases, and thus contribute towards an increased effect at the national level.

Some of what has been described here has been put into practice in Tanzania. The organization is not systematically developed, however, and is by no means utilized to the full. Our recommendation is to start by discussing a model thoroughly and in detail, and then prepare a pilot project as an example, involving just a few regions.

We have placed the emphasis on housing, because it comprises in itself a significant building mass, and is an urgent problem. But it is obvious that the experience gained in this area can very soon be put to the benefit of all the various kinds of building efforts in the rural districts. Information Exchange on Human Settlements - Needs, Problems and Actions

Ingvar Karlén, Dr techn., Department of Design Methodology, The Royal Institute of Technology, Stockholm, Sweden.

Summary

The exchange and dissemination of information on Human Settlements for developing and developed countries do not only concern the provision and dissemination of general information, but also action-oriented information as support to Human Settlements processes (e.g. design, production, maintenance, running and use). This requires co-operative and co-ordinated work within the information community, and also closer relations to the building community. Co-ordination of information requires theory as a 'key' to practice. The statements are supported by references to projects on information exchange on Human Settlements for developing countries, and by references to CIB work (W52), and particularly from a CIB Forum 1979: Information and Practice -Perspectives and Priorities for the Eighties.

Attention is brought to Human Settlements information as a cross-disciplinary field. The aspect of co-operation and co-ordination in a more general field of knowledge than Human Settlements is illustrated by reference to a report by S. Schwarz concerning a developing project in Sri Lanka, whereby obstacles named the 'small system syndrome' are recognized.

Development in short

Development of information concerning building and planning as important parts of Human Settlements processes has been discussed through decades. During more than one decade computer-aided databases and communication systems have been developed and used. During the last few years these services have been supplemented with services by means of which the documents referred to in computer-aided bibliographies are available. The increasing costs of paper and printing have initiated uses of other media, such as micro-media, combinations of tele- and computer-communication, etc. The information as a resource for the building process has been studied parallel to the described development. Some studies have taken place internationally, not least within CIB; cf. Karlén & de Vries, 1977, in the preprints to CIB Congress 1977, where a survey is given.

The information serving directly the Human Settlements processes (design, production, maintenance, running and use) has to be decision- och action-oriented ('efferent information'). In the search for general information, 'afferent' information channels (directed to a central organ) are used. These differences are recognized and should be distinguished, and should be taken care of when developing rules and tools serving the information.

The consequences of 'information input overload' for the users of information have been analyzed, and the possibilities of a simplification with the help of harmonization and co-ordination of information have been investigated.

The development of information in the building field has - as compared with several other branches or fields of knowledge - progressed relatively rapidly as far as classification and other ordering systems are concerned, and as far as information services from various kinds of centres are concerned (research, information, documentation, etc.). The information development has, however, developed slowly with regard to computerization of communication systems for other purposes than administrative rationalization.

In the building industry many factors have caused demands for changes and improvements of the existing information systems serving the building industry. Such factors are for instance the economic situation of the industry in several countries requiring rationalization and an increasing need for information better adapted to support the complete building process (design, production, maintenance, running and use).

Information is often regarded too narrowly

Information, which takes so much of the practitioners' time in almost all processes of the complete building process, is not acknowledged as a broad concept. The concept of information in building is in many cases restricted to comprise editing work, preparation of directories, substitute information, e.g. bibliographies, information search and retrieval services, computeraided cost accounting systems, distribution of documents to receivers of different categories.

Useful information functions serving various purposes in a country, in an organization, etc. can be identified and mapped, and such a map or plan can guide the development. Thereby, the risk to regard information too narrowly is reduced. Also in developing countries such surveys are productive for the improvement of existing information systems.

The information community and the building community We can speak about the information community as comprising those who are dealing with information in a professional way. We can speak about the building community as comprising those who work professionally within the Human Settlements process (the complete building process).

We have followed the development of computer-aided bibliographies in various communication systems and nets. We can see how they are now coming closer to other kinds of information activities. This can be illustrated by a quotation from B. Tell (1980) in his review of a report from a conference 1978 in Pittsburgh, USA, with the theme 'The Structure and Governance of Library Networks':

"William Mathews, National Commission of Libraries, regarded the shortage of suitable software as hampering the development. Owing to the complexity of our information system, library nets get particularly vulnerable because the software is so undeveloped and lacks formalism. Our future is connected with similar worries for the future within ether-media, social information, interactive systems as PRESTEL, electronic post and satellite communication. Librarians and library nets should therefore 'disregard their accustomed xenophobia and join forces with the rest of the information community'." (translated in this paper)

I want to argue a step further, namely for the information community to join the building community, to come closer to decisions and actions in the complete building process.

The development of new computer generations and of 'small' computers may give us improved possibilities to come to a better balance than earlier between on the one side the agents' needs (when known) and human methods of work, and on the other side communication systems and machines. Time is short, however. The new technology is hunting us. Experiences from the use of a communication innovation as TV demonstrate how very difficult it is to use a medium so that it is progressive in a humanistic way.

The approach to get the complete information community closer to the building community makes it easier to get a common conceptual framework for the content and form of various kinds of information: cf. Karlén, 1979.

Information on Human Settlements requires co-operative and co-ordinated help from various bodies in the information community

Although we may start the international exchange of information concerning Human Settlements with activities for the provision of general information between documentation centres in different countries, we should not restrict our ambitions to the improvement of the machineries serving those activities. We must understand information as a broad resource which requires co-operative and co-ordinated help by a variety of information bodies performing useful information functions. The requirements for co-operation and co-ordination are evident, as there must be a certain 'formalism' involved to help the users, the brokers and the producers of information. Further, information should be free and not be too much dependent upon certain selected foci if this is not recognized by the parties concerned to be the best solution; cf. Karlén et al., 1976.

The promising co-operation between CIB-groups working with a range of building information problems will cer-

tainly give examples of co-operative and co-ordinated work in the future.

Theory helps practice

The handling of information activities transforming information resources into information products adapted to the needs and requirements of various kinds of users requires theory - theory as a key to practice; cf. Karlén, 1979.

We know that only a part of our activities in design, production, maintenance and occupancy of buildings is of common international interest. But I think we now have come so far that certain theories about the structuring of information - the formalism so to say - are of international interest, as well as experiences about the use of certain information methods in conformity with the theories - both methods for the formation of information, e.g. formalized statements for specifications of products, and methods for the application of tools 'extending' our brains and our hands, e.g. audiovisual media, word processors, classification tables.

Needs, problems and actions for exchange of information concerning Human Settlements

The title of this paper is taken from a preparatory paper to UN Department of Economic and Social Affairs (ESA) and to UN Centre for Housing, Building and Planning (CHBP); cf. Karlén et al., 1976. This approach to the problems concerned gave of course a broader basis than a proposal for an international Human-Settlements information system later on presented by ESA to HABITAT (cf. Habitat A/Conf.70/B/11, 3 May 1976).

In the first paper mentioned, the attention was brought to action-orientation of the information systems concerned. The development work was presumed to start from national and regional interests. Important tasks were to fill the gaps between existing information activities, to stimulate the creation of cores for development of information in countries where no information infra-structure existed, and to take away critical obstacles for exchange of information between countries. This approach comprised not only establishment and harmonization of 'current awareness information services', referral services and data-aided bibliographies, but also for instance: a set of proposals for information activities and demonstrations, guidelines for classification, thesauri etc., information research projects, particularly user studies, information systems for standards, regulations, tests and products. The basic idea was that information work should directly support actions, e.g. in programmes and projects, and thus not concentrate on large or encyclopedian databases which often have tendencies to get input- or output-oriented. The information should as far as possible be adapted to the needs of the users. Although one has to start at a right level of ambitions, the idea was to map a possible information infra-structure in a

country, region, discipline, etc., which could facilitate to judge priorities and programmes within a stepby-step approach. In this context, attention was also brought to the various information activities in CIB.

The second paper mentioned, the main paper for HABITAT, proposed actions to be taken up in the following areas: maximizing the servicing capacity of the existing facilities; filling some gaps at the international level; improving the national and regional levels; and establishing the tools and machinery for an international information system. The goal was explained to be a wholly integrated international information System.

In 1977, UN/CHBP arranged an ad hoc expert group meeting on 'Human Settlements Information Exchange and Dissemination' in Geneva with the help of which the earlier proposals were further promoted. This means that the users' needs, the formation of international work in the information policy at national level, the dissemination of information, the whole picture of supporting information systems for actions should be regarded as well as some tools, e.g. a well designed vocabulary of descriptors (thesauri). Information systems were proposed to serve actions, and required therefore support from general information supply (provision) centres (e.g. data-bases, fact-bases), etc., from special information supply (as regulations, standards, product information), from communication systems (like tele-communication, computer-based information networks, e.g. EURONET, SCANNET); cf. Figure 1. The co-ordination of these efforts was proposed to be guided by basic rules for co-ordination of information supply, processing and marketing.



Figure 1. Sketch of an information supply (provision) system for a country according to discussions at the UN/CHBP meeting in 1977 (from Karlén, 1979).

In the present programmes of Human Settlements there exists, according to information through CIB General Secretariat /P.C. 276(78)/, a subprogramme: 'Exchange of information', which seems to 'take care of information in a broad sense as discussed in the preparatory papers.

The development of the Human Settlements activities seems to have certain similarities with the development of CIB-activities in the field. They started with some important documentation centres' activities (e.g. abstract services, product information systems), rules for the form of documents and for classification. The CIB-work has later on extended over a large field of building information. Particular interest has been given to basic rules for co-ordination of general and of special information provision, as well as of co-ordination of information systems serving the actions in the building processes, their planning and managing.

If it were possible to reduce the complexity of the information systems of various kinds, a great deal could be gained. In a project for UN Development Programme (UNDP) in Teheran in 1974 (cf. Karlén, 1975), and in the mentioned study for the HABITAT project (cf. Karlén et al., 1976), ideas for a search for simplicity started. These have later on lead to a comprehensive study concerning informatics for building management, etc. (cf. Karlén, 1979). Part of the system theories applied in the last mentioned report has been applied in analysis of a co-ordination system for project information (cf. Bindsley & Karlén, 1979). Such a system theoretical approach has proved useful for the analysis and for the preparation of rules for information, useful to practice.

The CIB Forum 1979 giving new perspectives A CIB Forum was organized at Fulmer Grange on 12-15 September 1979. The Forum gave a very good help e.g. to the CIB Working Commission W52 for the planning of the future work, as well as a welcomed support to the accomplished work. It is therefore appropriate to make a short presentation based on the report.

Against the background of achieved results, e.g. as CIB reports and CIB proceedings, during some years' work of W52 project groups, the following main items were treated at the Forum. (Within brackets are given names of those persons who made the presentations.): Research information for building and planning (Mr B. Johnson, Stockholm); Translation of information into practicably applicable information (Prof. C. Boalt, Stockholm); How to communicate with ordinary users and politicians? (Mr K. Erikstad, Oslo); User situation, and user requirements, and other factors in evaluation of information efficiency - focusing on general trends for project information (Mr i. Freeman & Prof. J. Bennett, U.K.); Education and new technologies - focusing on education in construction industry information (Mr M. Munday, Glasgow); Information services and new technologies (Mr D. Bullivant, London); Meta-system for co-ordination of information, and as a basis for design of information systems (Mr B. Edgill & Mr A. Gilchrist, U.K.); Problems and methods of research information in the building field (Dr G. Kunszt, Budapest);

Design - information (Prof. O. Wåhlström, Stockholm); Special subjects for international co-operation (Mr K. de Vries, Rotterdam).

Some of the topics listed have been touched in the present work of W52. Project groups have worked with e.g. information harmonization in the construction industry and with information co-ordination systems for process information. The new topics together with the earlier topics (mainly reported at the CIB Congress 1977) create a field of work, supplementary to the field of supply of general information through information and documentation centres. Several of the topics could be regarded as being of a high priority interest, both to developing and developed countries.

The conclusions from the Forum comprised e.g. the following:

A policy statement should be prepared for CIB information activities as a whole, and in connection with that, conditions should be formulated for its accomplishment. It should be clear that no unnecessary duplication is being made with useful international work outside CIB. The relations to the third world should be treated carefully. The possibilities to co-ordinate efforts from various institutes should be taken into account. In addition to a policy statement, a 'business plan' should be made. The need for a CIB 'intelligence system' for continuous information about information development projects was recognized.

At the Forum, it was regarded as self-evident: <u>that</u> work should continue as regards the structuring of information (classification, thesauri, information arrangements, rules for expressing statements);

<u>that</u> the user needs should be identified and user requirements studied in the context; and

<u>that</u> work within CIB should be intensified concerning meta-system and concerning a general applicable theory for information as well as applied research about information theory.

All the items mentioned above should be considered when planning the future work, and certain topics should be given priority.

Comments can explain some items mentioned:

<u>Marketing</u> could help to bridge the gap between research and practice. Research information has grown to a research marketing problem. Marketing guides can be discussed. They can be backed up by tools, e.g. as CIB Reports Nos 18, 22 and 45 are backing up the improvement of trade literature.

In future work, much more emphasis than now should be given to the <u>information transfer problems</u>. The issues for further discussion accepted as relevant were:

the necessity of developing interdisciplinary documentation, linking technical, social and hygiene fields; means for interdisciplinary documentation;

translation from research to application must form a special area which needs resources for research and training of specialists;

adequate evaluation studied on different efforts on dissemination and application are needed;

the user of information must take an active part in developing the field of dissemination and information, and should not be treated as an - often hesitating and unwilling - receiver.

The discussion about '<u>project_information</u>' should be regarded in a wider perspective, also embracing the <u>design_and_management_of_buildings</u>. The design process is information-intensive, and information serving design and prepared as a result of design should, therefore, be on the programme, particularly with emphasis on CAAD (Computer Aided Architectural Design). This requires more knowledge about the design process, and thus an involvement by persons in practice and from outside to the circle of information experts.

<u>Methods for research planning</u> should be considered, e.g. within a separate group in CIB.

Information on Human Settlements as a cross-disciplinary field

It has been evident that the work with building information concerns many other programmes within CIB, e.g. organization and management of construction, application of the performance concept, and building economics.

In the information work within CIB, several kinds of people participate. Among the members in various project groups in W52, altogether about 55 persons (1978), one can find information scientists, building economists, architects, quantity surveyors, contractors, structural engineers, classification experts, librarians, documentalists, information officers, research managers, documentation and information managers, etc. This demonstrates another aspect of cross-disciplinary character of the work.

The 'small system syndrome'

Several projects have taken place for scientific and technical information (S&T) based upon bilateral cooperation between developing and developed countries, and in some cases presupposing support from global centres.

Obstacles recognized in such projects are of interest. In a report about the developing S&T information services in Sri Lanka, Schwarz (1980) uses the expression the 'small system syndrome', which brings attention to various obstacles and restrictions for development.

Some quotations from the report may bring attention to some aspects on international co-operation for human settlement information, and on the interactions between the 'user community' and the 'information community' (in this case represented by the library staff with access to factual information and to knowledge about theories and methods of $S\epsilon T$):

"It is noted in the analysis of findings concerning the R&D system and the system of S&T information provision in Sri Lanka, that the set of problems hindering the rise to an international 'standard of excellence' (except for limited areas enjoying favourable conditions) can be described under the general heading of the 'small system syndrome'." (Chapter 2)

The predicament of the information provision system can be characterised as a 'small system syndrome' with many different aspects and implications. Some are easily recognized: too small resources; fragmentation of efforts; too weak links with foreign I&D centers; too expensive services from developed countries; lack of equipment; lack of educational programmes in modern I&D techniques and ideas. (from Chapter 9)

"Finally, the role of information provision in R&D is not fully understood, with sometimes too great expectations associated with I&D services. It would seem that at least technical literature is to some extent rather an exponent than a promotor of technical advance, and in any case there is a complicated interplay between the

level of development of an S&T system and its ability assimilate and take advantage of S&T literature. Providing access to literature (information) does not by itself solve the problem of introducing innovations." (Chapter 2)

"But it must be observed that the small system syndrome that besets the system of information provision to research, has a more fundamental counterpart in the research system itself." (Chapter 9)

"One conclusion must be that the policies for use of resources for development of S&T information systems have to be designed to harmonize with the systems that are supposed to absorb and assimilate the information. Although it is possible to create a system for information provision that meets the objectives of approaching services offered in developed R&D systems, this will not be meaningful unless corresponding care is taken in developing the ability of the R&D system proper to use the information services provided. In order to come to a decision concerning an appropriate level of operation it would seem advisable to perform a more thorough study of potential needs and requirements. This could be done as a committee work similar to the work recently presented as the report 'Scientific and Technical Provision in Sweden', but with emphasis on the particular problems facing R&D in Sri Lanka." (Chapter 9)

Thus, in this study, as well as in some of the earlier mentioned studies, the surveying or mapping of potential needs and requirements, and of the functions capable of meeting them, are regarded as important.

Some final words

Time has passed since information could be regarded only as something on shelves, in card indexes and other stores, or as principles for the arrangement of contract documents. New technologies including computer aid to information processes could help to improve the building communication, including cross-disciplinary communication. Thereby, developing countries and developed countries may come to a better position to apply the results of research and development, to establish dialogues between practice and research, and to regard the human side - the user side - of technology, also information technology, more than is the case now.

References

Bindslev, B. and Karlén, I. Theoretical considerations for the development of the SfB-system. Paper 9A/1 to SfB Development Group Meeting. London 1979.

Karlén, I. Considerations concerning programme and building facilities for documentation and liaison division of BHRC. Report to the UN/DP project manager of the BHRC project Teheran. ByggVIS. Stockholm 1975.

Karlén, I. et al. Information exchange on Human Settlements - Needs, Problems and Actions. Study on International Information Exchange on Human Settlements, prepared for UN/ESA and UN/CHBP as a contribution to the UN HABITAT Conference 1976, with an annex to the study. Royal Institute of Technology, Department of Design Methodology. Stockholm 1976. To the report were joined the following reports:

Giertz, L.M. Information on human settlements problems and needs of African countries.

Mathur, G.C. and Singh, U. UN Regional Centre for ECAFE, New Delhi, India. Transfer of technology and exchange of information in developing countries in the field of human settlements.

Directorate of Building Research, UN Regional Housing Centre, Bandung, Indonisia. System of information exchange in the field of human settlements within the ESCAP region.

UN Centre for Regional Development, Nagoya, Japan. Information exchange in the field of regional and local development.

Brandreth, M. International Development Research Centre, Ottawa, Canada. Planning the international exchange of information about human settlements.

Centre d'Assistance Technique et de Documentation. Union Technique Interprofessionnelle, Féderation National du Bâtiment, Paris. Note au sujet d'un programme d'information sur les etablissements humains.

Servicio interamericano de informacion sobre desarrolo urbano, Bogotá, Colombia. Consideraciones sobre la situación actual en intercambio de information sobre asentamientos humanos, en América Latina.

Karlén, I. and de Vries, K. International work on building information: present and future (W52), in Alsop, K. edit. Construction Research International Proceedings of the Seventh CIB Triennial Congress, Edinburgh, September 1977, Volume 1. The Construction Press. Lancaster, England 1977. Joined to this surveying report are the following reports in the same congress proceedings, Vol. 1:

McDonagh, N. and Shanley, L.F. SfB Development. Sundh, P.H. Evaluation of information systems for the

construction industry.

Volbeda, A. Product files.

Kunszt, G. Computer languages in building. Bullivant, D. The improvement on manufacturers' literature to BS 4940:1973. Karlén, J. Informatics for Design, Production, Maintenance and Occupancy of Construction Works - a Search for Simplicity. Swedish Council for Building Research, Document D13:1979. Stockholm 1979.

Schwartz, S. Developing scientific and technological information services in Sri Lanka. The Royal Institute of Technology. Library. Papers in Library and Information Science. Report TRITA-LIB-1093. Stockholm 1979.

Tell, B. Review of Kent, A. & Galvin, T.J. The structure and governance of library networks. ed. Dekker. New York 1979. TD the Scandinavian Documentation Journal 35 (1979:6), p. 138.

Proposals for an international human-settlement information system. HABITAT. UN Conference on Human Settlements. Vancouver 31 May - 11 June 1976. A/Conf.70/B/11. A background paper for HABITAT contributed by the Department of Economic and Social Affairs of UN.

Report from Ad Hoc Expert Group Meeting on Human Settlements Information Exchange and Dissemination, convened in Geneva 28 November - 2 December, 1977 by UN/CHBP.

Scientific and Technical Information Provision in Sweden - Proposals for a new Organization. Ministry of Education & Ministry of Industry. Stockholm 1978.

Information and Practice - Perspectives and Priorities for the Eighties. CIB Forum 1979. Meeting arranged by the CIB Working Commission W52 at Fulmer Grange, Great Britain, September 12 - 15 1979.

An appraisal of Ghana's scientific and technological information system

Moses D. Mengu, M.Sc.(Planning); M.Sc.(Inf.Sc.); A.I.Inf.Sc.; Technical Liaison Officer, Building & Road

Research Institute, Ghana

Summary

The paper reviews some of the problems encountered by developing countries in establishing national scientific and technological information systems. In Ghana one major constraint is the excessive fragmentation of R & D activity which has resulted in a highly diffused and deficient substructure of information services. There is also the over-riding desire to superimpose a national system over this weak infrastructure. Attention is drawn to the need for re-directing local efforts at promoting user awareness and training. International assistance should be geared more towards supporting specific information projects and local re**se**arch.

Resume

Ce memoire examine quelques-uns des problemes qu' abordent les pays en voie de developpement lorsqu'ils cherchent a adopter des systemes d'informations scientifiques et technologiques. Au Ghana, une des contraintes majeures est la fragmentation exageree de l'activite R & D, ce qui a amene une substruction de service d'information tres diffuse et tres defectueuse. Il y a egalement le desire imperieux de surimposer un systeme national a cette infrastructure faible. On se preoccupe de la necessite de reunir les efforts locaux afin de favoriser la vigilance et l'education de l'usager. On devrait utiliser davantage l'aide internationale pour soutenir les projets specifiques d'information et les recherches pours nivies dans le pays.

Introduction

The need for developing countries to develop their scientific and technological information (STI) systems has been emphasised in many national and international forums in recent years.¹ The observation has even been made that too much emphasis seems to be given to developing country problems in the UNISIST programme.²

In spite of these developments there seems to have been no appreciable progress within most developing countries. The picture shows a widening gap between developing and developed nations as the latter start to join hands in highly sophisticated and often commercialized information networks.

In the developing countries themselves there are remarkable differences in the level of attainment. At the lowest level are those countries in which the need for developing an STI system is overshadowed by problems of much greater magnitude such as disease, drought, mass illiteracy, wars, etc. The second level of development occurs in a large number of countries in which the need for STI services has been recognised and some form of start has been made at developing them. At the primary level may be cited such countries as Brazil, India, Mexico, South Korea and the Philippines. In all these countries basic documentation and information services have been developed.³

Ghama ranks in the second level of development. There is no STI "system" in the real sense of the word. What exist are isolated areas of information activity within various research groups without any form of interconnection or co-ordination at the national level. A national STI "system" is still very much in what may be termed the "conference" or discussion stage. A period of realization of the importance and need for a national STI system has started in the country. The country is an active member of UNISIST and participates in many other international programmes concerned with the development of STI services.

However, the pace of progress has been exceedingly slow in view of a number of financial, technical as well as methodological problems. This paper reviews some of the attempts made over the last decade and points out key areas in which current efforts should be redirected. It must be noted here that the views expressed are entirely those of the author and do not represent those of the CSIR or the National Committee on Information and Documentation.

Recent attempts at STI development in Ghana

Although very early attempts were made by a number of research establishments and university institutions to build up specialised library collections in various fields these efforts were never coordinated at creating a comprehensive national network.

The idea of creating a national network arose out of a workshop in 1971 organised by Ghana's Council for Scientific and Industrial Research (CSIR) and the United States National Academy of Sciences (US-NAS).⁴ After a number of other workshops and meetings two ad hoc committees were appointed to study the problems of information dissemination and make appropriate recommendations.⁵

Their recommendations led to the CSIR being selected as the focal point to co-ordinate the activities of scientific and technological information in the country. In 1975, the National UNISIST Committee (now re-named the National Committee on Information and Documentation) was set up to plan and oversee these activities.

Since 1976 the CSIR/US-NAS workshops have been joined by the Canadian International Development and Research Centre (IDRC), and definite proposals for a national STI system were drawn up. The programme, covering a four-year period starting 1978, was to develop the main CSIR library into the focal point of the national network. To this was to be linked a number of nodal centres based on facilities at various research establishments. $^{\rm 6}$

In 1978 Ghana hosted the First UNISIST Meeting of Experts on Regional Information in West Africa.⁷ As in the **ca**se of previous workshops and meetings this regional meeting was another attempt at reviewing problems and formulating new plans.

Although the last ten years have witnessed considerable activity at the discussion level little can be said about real achievements in terms of new projects or physical improvements in existing services. Nor has there been any attempt at identifying the actual needs of research and industry for information. The organisation of R & D and its requirements for

The organisation of K & D and its requirements for STI services

As in most other developing countries, there is a lack of a well defined national policy on science and technology in Ghana. There is no effective co-ordination of research and development (R & D) effort at the national level. Consequently, there are no readily available figures on the proportion of GNP devoted to R & D, in spite of the fact that nearly all research is directly or indirectly government funded. Private funding of research is very rare primarily because private enterprise is on a very small-scale level, and also because it thrives on unskilled and semi-skilled labour.

In spite of the rather limited volume of R & D it seems to be too fragmented into a large number of small units. The real needs for scientific and technological information therefore appear diffused or non-existent.

The Council for Scientific and Industrial Research (CSIR) is the main state agency responsible for R & D. Administered by the Ministry of Industries, Science and Technology, the CSIR comprises nine research institutes and a number of special mission-oriented project units. Research is carried out in a large variety of fields but with special emphasis on agriculture, housing, construction and industrial technology. To a large extent, each institute is responsible for organising its own information services although the CSIR Secretariat provides some co-ordination.

The country's three universities also carry out some basic as well as applied research in addition to normal teaching. Each university has established within it specialised research units for this purpose. Here again emphasis is on agriculture and industry although there are projects running in the fields of land administration, rural development, health and education.

Between them the CSIR and universities employ the cream of the nation's scientific and technical manpower. It is here that the requirement for high level scientific information is apparent. There is therefore the need to provide them with facilities for tapping and making use of the world storage of high level scientific and technical literature, as well as the appropriate means for documenting and disseminating their own output.

In the public sector there are a number of specialist research-oriented agencies. The notable ones are the Ghana Atomic Energy Commission, the Environmental Protection Council. Standards Board and the Cocoa Research Institute. On a more dispersed scale than these are the large number of research units of the various government ministries, departments and corporations. Most of these are very small and are only intended to provide an inhouse service for their parent organisations. Research in the specialist state agencies and these departmental Units is of an investigatory or problem-oriented type, hence their information requirements are of a more practical nature. They require to develop their extension and monitoring devices in order to readily transmit information to users for practical application and the solution of problems.

The fragmentation of R & D as evidenced in the preceding description has a number of adverse effects on the development of STI services. Firstly, it does not enhance personal contact and the exchange of ideas between scientists. Secondly, and emanating from the first, it hinders the growth of "invisible colleges" which normally provide the impetus for the development of STI services. Thirdly, the existence of small numbers of scientists in scattered units tends to conceal the real need for any elaborate information systems. Finally, the limited funds and manpower resources available for research cannot be stretched far enough to cover information and extension services.

Thus, a solid substructure of information services does not exist upon which a national or centralised service can be built. It also implies that the creation of such a system depends, to a large extent, on a prior identification and remedy of the infrastructural deficiences in the existing services.

Deficiencies in the existing STI infrastructure

A preliminary survey of existing information and library facilities available within the country was undertaken in 1976 by a sub-committee of the National UNISIST Committee. 8

The survey identified a total of 76 agencies as being active in the field of science and technology, although not all of them possessed organised information units. The information aspects within these agencies were grouped in the following categories:

- i. University Libraries
- ii. Libraries/Information units of research institutes (CSIR)
- iii. Libraries of Government (Science) departments
- iv. Commercial or Industrial organisations
- v. International or foreign organisations

vi. Professional bodies and institutions

The survey took account of available literature resources (books, journals, monographs, etc.), manpower, library

512

services and equipment, and finance.

As would be expected the largest collections of published material were to be found in the university libraries and the research institutes. There seemed to have been a good coverage of the major English-language scientific and technical journals as well as abstracting and indexing journals. There was however considerable overlap of journal in-take. The collections of nonprint material (microforms) were available only in the university libraries, the largest single collection being only 2,000.

The acute shortage of qualified manpower was clearly evident from the results. There were only 45 qualified librarians, 63 sub-professionals, with no trained abstractors, indexers or information scientists. (As at now the CSIR has trained 4 information scientists). Government and private agencies are the least provided with qualified information personnel.

The majority of libraries issue Accession bulletins at monthly or quarterly intervals, and prepare bibliographies or literature searches on demand. Three libraries provide abstracting while six others provide SDI services. Only two libraries provide a translations service but most provide photocopying services. In spite of the paucity of microfilm collections a large number of libraries have microfilm readers. Only one undertakes microfilming.

Computerisation of the library and information system is non-existent. Although four libraries would have onthe-spot access to computer facilities they have so far not computerised any of their operations. Other forms of mechanisation of library and information services are equally poorly developed.

There is considerable variation between the various agencies in the organisation of their information and library services, a factor which makes national coordination an even more difficult task. Information services such as SDI, current awareness and enquiry services are undertaken only by some of the CSIR institutes. In most other research establishments only basic library services are provided.

In the university and government agencies information and public relations services are combined, and the two separated from normal library activities. The three university libraries and a number of the CSIR institutional libraries operate an inter-library loans scheme.

Building Information

There are no specialised information centres or services in the field of building and construction although this sector comes next to agriculture in terms of capital outlay and employment. The services provided by the Building and Road Research Institute in this field are however noteworthy. The Institute operates an information service based on its library, printing and consultancy services. The Institute's library now has a fairly comprehensive collection on architecture, building technology and civil engineering. It issues a regular Accession List, and provides photocopying and a loans services. The Institute also issues a quarterly newsletter, occasional information sheets on new technologies as well as report digests on some of its research publications.

More significant however is the Institute's proposed Building Information Centres to be cited in major regional cities to provide information and other technical and consultancy services. It is also proposed to provide space for exhibitions, conferences and to organise induction courses for the construction public. Methodological and other problems of STI development in developing countries

From Ghana's experience and those of a few other countries the general problems confronting developing countries can be identified as financial, sociopolitical, technical and the choice of an appropriate framework for development.^{9,10,11}

The main financial problem results from the very limited budgets on which research agencies operate in these countries. Invariably library and information services become the worse affected. In most countries as in Ghana, research funds tend to be tied to specific projects leaving library and information funds to be met out of the general recurrent budget. A second problem is that much of the funds for library and information services are required in the form of foreign currency to meet the importation of books, journals and reprographic materials and equipment. Finally, there is the problem of self-financing existing information units since most of their services have to be offered gratis or at a nominal cost only.

The socio-political problems are more difficult to isolate but the readily identifiable ones include the general ignorance of researchers and practitioners of their needs for scientific information, and the rather low status which is normally accorded workers in the information field. The latter problem tends to reduce job satisfaction and promotion prospects, thereby discouraging new entrants into the field. There are also the problems of restricted mobility (especially to attend international conferences and scientific meetings) imposed by political considerations and constraints.

The more pressing problems, however, are the technical ones. These include the paucity of the communications network, low computer capacity, the lack of library and information equipment, etc. Equally important are the lack of skilled manpower and the unavailability of accurate and reliable data upon which to assess user requirements.

It can be argued that the problems just described above are operational difficulties which tend to arise in any new sphere of development. More pertinent to the development of STI systems, however, is the problem of choice of an appropriate framework. The basic choice in Ghana and elsewhere is that between planning for a sophisticated, centralised system vis-a-vis making gradual improvements at the grassroot level. The choice seems obvious but its implementation is very highly illusive.

The first choice has the promise of rapid implementation in view of its international and socio-political attractions, and also avoids the past errors of the developed countries. Nevertheless, it is expensive in terms of capital and manpower investment, and has an inherent danger of producing results which are incompatible with the actual requirements of users in the developing countries. In the advanced countries the sophisticated systems of today evolved out of very rudimentary services developed in response to specific research and industrial requirements.¹² In Mexico and Ecuador this grassroot approach has been adopted with good dividends.¹³ In Ghana on the contrary, plans for a national network have been drawn up without a prior analysis of local circumstances and user requirements.

Another problem which has become evident in Ghana's approach is the overdependence on internationally formulated development programmes, ostensibly, in anticipation of the material and technical aid they promise. The result is that targets are being set too high and cannot be achieved with the given level of resources.¹⁴ For instance, the National UNISIST Committee in its five-year plan envisaged that by 1980,

- the scientific information resources of Ghana should have been effectively organised, assured of steady growth and readily available to research workers... through a cooperatively organised network of science libraries manned by suitably trained personnel, and supported by such modern technology and reprographic information requirements and financial resources.
- 2) Ghana should have been linked directly or indirectly to important scientific centres or science libraries in Tropical Africa, and to carefully selected major world scientific information centres....

It can now be said without any doubts (in 1980) that these objectives were too ambitious and could not have been met under the prevailing economic conditions. <u>Conclusions and Recommendations</u>

It is in the interest of developed and developing countries that the latter are aided to establish viable STI services and ultimately to participate more actively in the existing international networks and programmes. Nevertheless, care must be taken that this desire does not override local considerations and requirements. For, the informational requirements of research and industry in the developing countries are basically different from those of the developed countries. While in the latter, bibliographic, current awareness and on-line services in centralised locations are basic requirements, in the former, audio-visual aids, exhibitions and simple reprographic facilities within easy reach of the research worker are more important.

One other area which requires much greater attention than has hitherto been given is the promotion of user awareness through participation programmes and training. There is no doubt that when a user has been made to contribute to a particular scheme or project he is more likely to consult it for information.

Such programmes can be worked out at the individual institutional level rather than through regional or nation-wide information clearing houses and documentation centres. To make such schemes even more meaningful information dissemination services could be combined with the provision of practical services like materials and equipment testing, maintenance and repairs. International co-operation and aid will be more fruitfully utilised if it is redirected at such specific projects and programmes at the institutional level.

User education programmes should also be introduced in the universities and other higher institutions of learning like polytechnics and technical colleges. Basic techniques in information searching could be introduced in the first year syllabus of the universities. This approach is more likely to produce a cadre of information workers and users who will eventually build up and sustain viable STI systems in developing countries.

Finally, call must be made for more research into the various problems identified here. This will enhance a clearer understanding of the situation in developing countries. In this regard, international and professional agencies in the information field have a great contribution to make.

References

 UNESCO, UNISIST: Study Report on the feasibility of a World Science Information System, Paris, 1971.
 Clark, P.L. A survey of world science information

systems (Thesis), The City University, London, 1973, pp.65-70.

3. IAEA. Information Systems: their inter-connection and compatibility. Proceedings of a sympotium organised by the IAEA and co-sponsored by the FAO and UNESCO, Vienna, 1975.

4. CSIR. The scientific and technical information (STI) in Ghana: role of the CSIR in developing a national STI network; An Action report by the joint consultative committee of CSIR/US National Academy of Sciences/International Development Research Centre (Ottawa), Accra, August, 1976.

5. CSIR. The dissemination of scientific information to the general public: a report of an ad-hoc advisory

514

committee set up by the Legon Workshop sponsored by the CSIR, University of Ghana, University of Science and Technology, and the University of Cape Coast, Accra, 1974 (unpublished).

6. CSIR. Proposals for technical assistance from IDRC to develop national scientific and technological infor-, mation system and services in Ghana, Accra, March, 1978.
7. — Country report on trends and development in the fields of scientific, social and technological information in Ghana. First UNISIST meeting of experts on Regional Information policy and planning in West Africa, held in Accra, Ghana, 4-7 December, 1978 (unpublished).
8. Villars, J.A. Draft final report on existing facilities and organisational structure of a network for a national Scientific and Technical Information System, Accra, May, 1976 (unpublished).

9. Duffy, J. <u>The information problems of developing</u> <u>countries</u>. The Information Scientist, Vol.10, No.4, 1976, pp.137-138.

10. Adimorah, E.N.O. <u>Problems of Scientific information</u> work in developing countries. The Information Scientist, Vol.10, No.4, 1976, pp.139-148.

11. FID. Participation of small and less industrialised countries in world-wide documentation activities and information exchange. FID International Congress, Budapest, 1972.

12. Burket, J. Industrial and Related Library and Information Services in the United Kingdom, 3rd Edition, The Library Association, London, 1973.

13. Dextre, S.G. <u>Industrial Information in Latin</u> <u>America</u>. The Information Scientist, Vol.10, No.4, 1976, pp.149-156.

14. Vickery, B. Little SI, Big SI: a review of UNISIST.J.Libr. Vol.3 No.4, 1971, pp.267-274.

The role of education for information management in the building industries of developing countries

Michael Munday MSc DipArch MIInfSc RIBA Co-ordinator Construction Information Education Project University of Strathclyde - Glasgow United Kingdom (formerly of the Royal College Nairobi and the University of Hong Kong)

Summary

This paper introduces in outline the case for an international contribution in the role of education and training for information management to guide those in developing countries who are involved with teaching and learning about the design and production of buildings. It defines the building process, and the nature and management of the flow of information within it, and it stresses the importance of an appropriate level of understanding and skill on the part of the users of information, as participants in the process. A measure of the likely impact of advanced information technology is introduced, as are the differences and similarities of conditions in developing and industrialised countries. A brief account is given of the approach taken to the whole problem in the United Kingdom CIE Project and this is suggested as one possible starting point for further activity by CIB, through the pattern of international aid established in the UNESCO/UNISIST General Information Programme. The paper concludes with an indication of the form such aid might take, and a short exploratory bibliography.

Sommaire

Cet exposé présente, dans ses grandes lignes, l'éventualité d'une contribution internationale dans le rôle de l'enseignement et de la formation pour la gestion de l'information destinée à guider ceux dans les pays en voie de développement qui sont impliqués dans l'ensignement et l'apprentissage des projets de construction sur papier et leur réalisation. On définira le processus de construction, et la nature et la gestion du flot d' information à l'intérieur de ce processus, et souligne l'importance d'un niveau adequat de compréhension et de technique de côté des utilisateurs de l'information, en tant que participants au processus. On avance le degré d'impact probable d'une technologie poussée d'information, et de même on fait ressortir les différences et les similarités des conditions dans les pays en voie de développement. On présente un bref exposé de la maniere d'aborder le problème dans le projet CIE du Royaume Uni, ce que l'on propose comme un éventuel point de depart pour une activité supplémentaire de la part du CIB dans le canal de l'aide internationale établie dans le Programme Générale d'Information de

l'UNESCO/UNISIST. L'exposé se termine par des indications sur la forme qu'une telle aid pourrait revetre et aussi par une courte bibliographie de référence.

The information scene generally

In an age when predictions are so frequently confounded it still seems reasonable to suggest that over the next 20 years or so, two 'new' factors at least will substantially affect the design and production of even the simplest of buildings the world over. Energy will be one of these and Information the other. The influence of energy will arise from shortage and expense. With information, the opposite will apply, for it is becoming abundant and cheap. The one condition will help ensure care in use, the second will not and it is this point, together with the fact that information is the feedstuff of knowledge, decision making, action and control, which suggests it ought to receive some special attention.

Information is recognised increasingly as a basic resource. Along with human beings - in the developing world at least, as Harrison [1] makes clear - it is one of the few available that is actually growing. The existence of even the simplest of social systems implies some ability to produce and use this basic currency - to communicate - on the part of its members. As needs have become more complex and specialised they have tended to relate to their environment less by actual experience than through, what Artandi [2] describes as, 'indicators of experience' or information.

Man's facility for producing information has long outstripped his ability to use it unaided. The behavioural patterns and shortcuts that he has developed to try to cope with this, of the kind instanced by Munday [3] for example, are now being challenged by new technological aids. Kent [4] is one of many writers who explains that social groups, including those concerned with 'building', now have the means to store and manipulate information in greater quantity, more accurately, quickly and cheaply, and gradually, to open the way to its better utilization. As might be expected in a behavioural field, progress here will seem sluggish compared with the speed and optimism of technological advance.

Hitherto the main means of processing information has been through marks on paper. The new technologies are changing this and what has, so far, been a relatively democratic process - we can all read and write - now might separate information users from a provider elite.

Without 'user windows' into the software they deploy these technologies could determine the information needs of building industries and the people in them. As Halloran [5] rightly argues, the new machine-based abundance must not lead to a naive view of its power or value. Information is not generated, stored, retrieved and disseminated in a vacuum, and understanding on the part of its users is important if the consequences of its provisions are to be correctly judged. Without this, as many argue [6], there could be an avalanche of the irrelevant and inaccurate, not to say the insipid and banal.

If this situation were to apply only to information for building, the problems and the changes would be substantial enough. As Jenkins and Sherman [7] point out however, the contexts will be all embracing and no group, activity, industry or country, however developed, will be spared. Each will have a different set of resources to resolve the dilemmas posed. Fears will be engendered, patterns changed, capabilities enlarged and limitations freed - in building as in everything else.

Building and information management

From many studies it is well understood that the process of building comprises a series of iterative stages going from inception through design and production to completion, use and maintenance. For each project, of whatever location, size or complexity, these are carried out by people in different roles (typically labelled as clients, architects, surveyors, engineers, builders, etc) operating as interactive organisational groups ranging from gangs, project teams, firms and practices to consortia and departments.

It is also generally acknowledged that these organisations only survive through the successful operation of the process of management, as Pavlidou [8] illustrates. What is further recognised but much less well understood, is that central to the whole business of managing, of forecasting, planning, organising, motivating, co-ordinating and controlling the work of each stage, is the process of communication. Not only can nothing be achieved without it, but it requires doing well if the consequences of poor performance are to be avoided.

While there is as yet little measured and costed evidence of the benefits that can accrue to any industry in which its participants have a high level of understanding and ability in information management which is what, in essence, communication is - there is ample record in building, that such functions occupy a high percentage of their time, and that authoritative views put poor performance in this field at the root of a lot of failures.

CIE Project writings [9] [10] list many typical examples of both failure and benefit, and show that success for any building industry, and the specialised roles or 'professions' they embody, depends substantially on the ability of its information 'users' to handle information effectively and efficiently. All involved require this understanding of and skill in the process of which they are an inevitable part. Such ability should lead them to demand of providers an adequacy of answers, rather than, as White [11] puts it, an oversupply of information.

The process of communication as described, is based on a complex and sensitive management framework through which concepts, as ideas, facts, instructions, questions, etc are conveyed to and fro both in an informal unstructured way as well as in response to the more formal established procedural boundaries within which even the simplest of buildings emerge and the most participatory of projects are conducted.

In essence it is a two-way inter-active information transfer process comprising the act of 1) seeking out, finding, and assimilating information (searching) - what some call 'retrieval' or input - and 2) generating recording and disseminating information (presenting) output or 'storage' in the fullest sense. Neither of these acts can be done well without knowing something of the way their information content is organised (organising). Nor can information be managed effectively without knowing something of the nature of the information itself and the users involved. In addition it is necessary to know, to varying extents, how to manage the whole process combining the best in people and in manual and electronic aids, in a range of practical settings for building. These activities, put in the overall context of a pattern of information flow in any total building process provide a basic system framework which can be depicted simply as follows:-



Such a system can be applied constructively in all work situations and seems to be a robust and practical way of approaching the whole business of information in use. Viewed this way, it is clear that the information systems of any of the Industry's hierarchy of site and office-based groups are in fact management information centred - a core which sustains and drives them along. Feeding into and drawing from this core is the whole field of general information (including that judged as 'technical' at any point in time). Also drawing from and feeding back into the core is that field of <u>project</u> information specifically generated for the realisation, control and record of building projects.

It is a framework that helps ensure that as much attention can be given for example, to the content of computer-generated drawings, and the terminology of specifications, as to vocabularly, grammar and idiom. It can cover things like the tactics and techniques of speaking and the aptness of non-verbal behaviour as well as on-line interaction with databanks. It can also deal with particular information systems and techniques and with more general problems like the nature of organisations, group working and decision making. The role of education

Whatever grasp of, and ability in, the management of information people may ordinarily acquire will be tested beyond the presently accepted limits by the advent of the new technology. The task of making sure that those in industries such as building are able to meet these new circumstances, falls to the systems of education that serves them. As Tocatlian [12] points out, the best designed and most sophisticated information systems and services are of no value unless users take advantage of them. This suggests that the whole issue of user education in information management is fundamental, but while the importance of the subject and its nature may be in less doubt today. it is still too often viewed as unworthy of serious intellectual effort in comparison with the technical core on which user roles centre.

As Munday [13] points out, physiological limits and psychological barriers inhibit the ready acquisition of appropriate attitudes and understanding. Nevertheless, when users spend so much time seeking out and presenting information and so often fail to apply existing knowledge, education, in a more effective form that at present, would seem to be an obvious way to improved performance.

Teaching, of course, draws from both practice and research. As training, it is about skills for the present - as education, it is about attitudes, and abilities for the future. For the subject of information it requires a framework of the kind outlined here which can accommodate changes in technologies, procedures and roles and accept all kinds of information and projects of whatever situation or scale. This framework too can apply to whatever mix of manual and machine techniques is appropriate, and can lead to the ready evaluation of systems and services by users themselves. It can take account of, and balance, the theoretical and practical, and the social and technical, attributes of the subject. In defining information management as a 'subject' it has a functional logic appropriate to good curriculum design anywhere.

The dilemma of development

Whether or not one subscribes to the particular views of Meadows or Scorer [14] and others, there are strong signs that aid to developing countries should not be such as to lead to inappropriate technologically-based solutions to their problems. Information based on the activities of industrialised societies is not necessarily going to provide them with the answers they seek.

Even though, as seems likely, labour-intensive technical industries may be one of their future strengths, their elite, informed through education, may still copy unsuitable industrialised models of development with seemingly suicidal fascination. It is important therefore that any aid related to the handling of information, in a socio-technical context like building, is offered in the form of guidance and analysis that will allow all developing users to appraise their own problems and seek their own solutions - not in terms of progress as conceived elsewhere but as something new, acknowledging direct experience if required, and to scales that are relevant to their needs.

If one accepts this, it would suggest that teaching how to manage information should be not only a basic requirement in all education but should particularly be approached through a fundamental framework for that special education and training necessary for building. Paradoxically the technologies which pose one threat to relevant development are also the means by which it might be avoided. Their low cost and wide availability will, on the one hand, open up an information avalanche on users but at the same time it will help them retain that element of openness in communication necessary to control it. Control, of course, presupposes a level of understanding, skill and discrimination which only experience, or education, can provide.

International possibilities

Whether one accepts this particular view of user education or not, the analysis behind it suggests that it is necessary to ask what can and should be done about it not only nationally but internationally as well. United Kingdom experience, as gained through the CIE Project [3] [9] [10] [13] [15], seems to suggest that it is hard to find an obvious focus for this kind of work. In a field which crosses conventional practice and research boundaries this is not surprising. Certainly the approaches taken by most contributing agencies at an international level cover it only in part.

A French BNIST programme, the ARKISYST project, UNIDO and FID activities and a current WFEO programme, for example, are concerned only with information source material or the needs of one role. UNESCO on the other hand, particularly through the Intergovernmental Programme for co-operation in the field of Scientific and Technical Information (UNISIST) [16] has substantial experience in information training, and although much of this centres on documentation, information flow, utilization and provision there is an increasingly active concern for the user. Recommendations, from the 1979 UNISIST II Paris Conference on Scientific and Technological Information for Development (CSTID), for example, refer to the need for high priority to be assigned to programmes of activity for the promotion of the training and education of the users of information. They further urge, to quote, the strengthening of a user-oriented strategy in UNISIST work for those who participate in the process of development, as well as

the promotion of skills in the management of information and the development of syllabi, training packages and guidelines both generally and particularly for developing countries.

The role of CIB

If some means could be worked out to link all the contributory interests - building design, production, information, education, management, computing,etc - at an international level, and if a broad and considered view of information could be assured, then effective work could result for all countries through the current GPI/UNISIST pattern of international, regional, subregional and national co-operation.

CIB has a 30 year old information/documentation background (CIBD), Working Commissions (W52, W57 etc) active in studies of information systems and services, and links with UNESCO (in building, housing and planning). It is the only international building forum that has been researching in the field, and so would seem to be a suitable base from which to develop a building industry-based contribution to this GPI/ UNISIST pattern for both <u>information user</u> and <u>provider</u> education. For it to do so effectively and positively, however, requires greater representation from the worlds of building 'education', 'management', 'computing' and 'design' and 'production'. As Dick [17] has implied, CIB's original purpose needs to be reviewed and strengthened to this end.

Forms of aid and guidance

There is always a need to support curriculum proposals with teaching 'software'. It helps ensure that the planned objectives are reached, and that teaching is to a depth and coverage of the subject which suit the learning conditions. For developing countries this is vital.

As has been described, information management for building industry courses draws on and integrates many subjects. Not surprisingly, therefore, there is very little literature available that is directly suitable for teaching purposes. Most of what there is deals with systems and techniques and rarely introduces the principles on which they are based and by which they have to be evaluated.

The problem is further compounded by the dynamic nature of the subject, for as argued above, information management is a functional sub-set of general management (site, project and office) and, as Morris [18] describes, effective teaching needs to be actionoriented and learning experiential. Nevertheless, aid to back up any suggested curriculum framework is urgently required to guide educational authorities, teachers and learners. Initially this should come from a central source, such as CIB/UNESCO, to help ensure its quality and consistency. Ultimately though the aim must be to encourage teachers and others to contribute further material locally. A total programme of guidance for all countries, from the least developed to the most industrialised, would need to look not only at the framework, and at core teaching material, but would also need to examine the problem of teacher training, of a discussion forum, and of knowledge transfer in this subject field generally.

Conclusion and further reading

Wherever building information is handled, be it in the office or on the site, it is the same knowledge of the core functions which is required and the same skills which are being performed over and over again. These principal information handling functions form the base of a hierarchy of information systems operated by those individuals, groups and organisations undertaking the procedures of the design/construction process. The core system in more detail is as follows:-



If teaching is based on the logic of this model it would have a stability and an integrity that can only be an advantage in the context of a fragmented and changing industry. Such teaching would not be limited by role boundaries and would allow different kinds of change to be absorbed without disruption - a valuable attribute in a subject that is intended to strengthen user interdependence and be relevent to building now and in 15 to 20 years time.

The case that has been made is from one particular research viewpoint and draws on support from the

following limited, but topical, selection of writings. Is it likely that other views, from other work and in other languages, would not broadly concur?

1] Harrison,P. Inside the third world. Penguin Books. Harmondsworth 1979

2] Artandi,S. <u>Man, Information, and Society : New</u> <u>patterns of interaction.</u> Journal of the American Society for Information Science. January 1979 pp 15-18

3] Munday,M. <u>Education for Information Management in</u> <u>the Construction Industry.</u> Construction Industry Information Group Review No.3 Spring 1979

4] Kent,A.K. <u>Information as power</u>. Aslib Proceedings Vol.31 (1) January 1979 pp 16-20

5] Halloran, J.D. Information and communication.

Aslib Proceedings Vol.31 (1) January 1979 pp 21-28 6] Dertouzos,M.L. and Moses,J. The computer age -

a twenty year view. MIT Press. Cambridge Mass. 1979 7] Jenkins,C. and Sherman,B. The collapse of work. Eyre Methuen. London 1979

8] Pavlidou,M.T. <u>Management of construction in</u> <u>developing countries</u>. Proceedings of the 7th CIB Triennial Congress. Edinburgh. Section H. September 1977 Construction Press.Lancaster 1977

9] University of Strathclyde. Education in Construction Industry Information. Report for the UK NCC SC/ CDC. Department of the Environment Property Services Agency. June 1978

10] Munday, M. and Taylor, C. Construction InformationA framework for teaching. Consultative DocumentUniversity of Strathclyde. August 1978

11] White,H.S. <u>Growing user information interdepend</u> ence and its impact on the library field. Aslib Proceedings Vol.31 (2) February 1979 pp 74-87

12] Tocatlian, J. <u>UNESCO/UNISIST activities in user</u> education. User education - towards a better use of information resources. Proceedings of EUSIDIC Conference, Graz. December 1976 European User Series No.4 Ed. M.McCafferty, Aslib London 1977 pp 122-126

13] Munday,M. <u>The information user and his education</u> <u>in the construction industry.</u> Current R+D Projects in User Education in the UK. I.Malley, Ed. Loughborough University 1979

14] Scorer,R.S. The clever moron. Routledge and Kegan Paul. London 1977

15] CIE Project. CIE News. Quarterly Newsletter University of Strathclyde 197916] UNISIST. Intergovernmental Conference on Scientific and Technological Information for Development. Final Report and Recommendations of UNISIST II Paris June 1979

17] Dick,J.B. <u>Presidential Address</u>. Proceedings of the 7th CIB Trienniel Congress. Edinburgh. September 1977 Vol.2 Construction Press Lancaster 1978

18] Morris, J. <u>Developing Managers for the Construc-</u> <u>tion Industry</u>. Proceedings of Conference on Management in the Construction Industry. London. November 1977 pp 113-122

Abbreviations

- ARKYSIST International Information System for Architects
- BNIST National Bureau for Scientific and Technical Information
- CIE Construction Information Education (Project)
- FID International Federation for Documentation
- GPI General Information Programme (UNESCO)
- UNIDO UN Industrial Development Organisation
- WFE0 World Federation of Engineering Organisations

The ÇEMBIL Information Centre at Middle East Technical University

Mustafa Pultar, Ph. D., Dean of the Faculty of Architecture, Middle East Technical University, Ankara, Turkey

Summary

This paper describes the purpose, method of operation and facilities of ÇEMBİL Information Centre in the Department of Building Science and Environmental Design at Middle East Technical University in Ankara.

The centre has been established in 1979 jointly by the Faculty of Architecture and the Society for Environmental and Architectural Sciences. It collects, processes and stores information on

- a. research institutions throughout the world,
- b. research bulletins of these institutions, and
- c. bibliographic data in the following fields:
 - 1. Man-environment relations
 - 2. Building science
 - 3. Design science and methodology.

It offers services in the same fields in the

- following forms:
- a. Open-access display.
- b. Current awareness service.
- c. Bibliographic surveys.
- d. Loan and duplication of documents.

Résumé

Cet article discute la raison d'étre et les méthodes de travail du Centre d'Information ÇEMBİL, dans la section des Sciences du Bâtiment et de la Conception (Design) de l'Environnement, à la Faculte d'Architecture

de l'Université Technique du Moyen-Orient (METU),

Ankara, et les facilités que cet établissement offre. Le Centre a été fondé en 1979, conjointement par la Faculté d'Architecture de METU et la Société des

Sciences de l'Environnement et de l'Architecture (SEAS). Il inventoire, procéde et emmagasine les informations concernant:

a. Les institutions de recherche (leur principes de travail et champs d'activité, leurs politiques

générales, leurs adresses, etc) à travers le monde.

b. Les bulletins de recherches de ces institutions.
c. Les informations bibliographiques dans les domaines suivants:

1. Les relations entre l'homme et l'environnement.

- 2. La science du bâtiment.
- 3. La science et la méthodologie de la conception.

Le Centre offre ses services dans les mêmes domaines et par les moyens ci-dessous:

- a. Exposition publiques.
- b. Service d'information des actualités.
- c. Recherche bibliographique.
- d. Prêt des documents.

The Backcloth

Documentation in architectural science (environmental, design and building sciences) in Turkey is a relatively recent activity and provided mainly through the following institutions:

a. The Building Research Institute (YAE), in Ankara, of the Scientific and Technical Research Council of Turkey. (TBTAK)

b. The Building Research Establishment (YAK) in the İstanbul Technical University.

c. The central documentation centre (TÜRDOK) of TBTAK.

d. Libraries of major technical universities.

In general, the material handled by these institutions is either too general in scope, as in the case of the university libraries or TÜRDOK, or too narrowly restricted to building science, as in the case of YAE and YAK, to be of functional use to a large portion of researchers and students in architectural science in its globality. One can easily say that the range of national and international journals collected by these institutions is fairly comprehensive. However, the information that they process and present to the user on on-going research in the world, both in the form of bulletins and abstracts and in the form of research reports is very limited. Furthermore, none offers bibliographic search services, except for TÜRDOK which does this for such a large clientelle with a small staff that its service is bound to remain unspecialized.

This is the backcloth against which the ÇEMBİL Information Centre at Middle East Technical University has to be examined as regards both its purpose and service.

The ÇEMBIL Information Centre

Middle East Technical University (METU), established in 1956 in Ankara, is a technical university offering instruction in English and has an international student body of ca. 13.000 students. It incorporates departments of science, social sciences, administrative sciences, engineering, planning and architecture.

In 1979, the Faculty of Architecture founded a new graduate, multi-disciplinary department with the aim of training academicians, researchers and high level administrators for issues related to the man-made environment including design and building. Called the Department of Building Science and Environmental Design (BSED), this new department offers the following fields as areas of specialization:

- Man-environment relations (including historical, sociological, psychological, administrative, economic and physiological analyses.)
- b. Building Science (including building physics, environmental controls, construction science.)
- c. Design Science and Methodology (including systems analysis and computer aided design.)

Instruction is built around actual research projects which are conducted jointly by staff and students are supported by various public and private institutions in Turkey.

The demand of the programme for strong research documentation as necessary for its healthy development and activity was the main reason for the foundation of an information centre within the premises of the department. It was foreseen that the centre would provide services immediately available to the staff and students of a nature not provided by other instutitions. The Society for Environmental and Architectural Sciences (SEAS), a national society composed mainly of academicians and building researchers at this time, supported the project as it was in line with one of the society's major aims; that of establishing a network of communication between researchers. According to the terms of a protocol set between SEAS and BSED, the CEMBIL (Environmental and Architectural Sciences) Information Centre was started as a joint venture. BSED provides space and personnel for the centre and is responsible for gathering, processing and storing of documentary material, whereas SEAS appoints one of its members to serve in an advisory capacity and one secretary for the running of the centre, makes annual donations to METU to cover a modest portion of the running costs and turns over to the centre all documentary material that it receives through various sources. The services of the centre are open to all students and staff of METU and to members of SEAS as well.

The ÇEMB1L Centre works in cooperation with and uses the facilities of the central library of METU, where material in the form of books and periodicals is collected and which is one of the major biblicgraphic centres in Turkey. The centre also uses the central computer facilities of METU for its files and bibliographic searches as well as the photocopy/ microfilm/microfiche facilities of the library and the registrar's office.

Material Gathered and Services Offered

Collection of material gathered in the ÇEMBİL Centre is guided by the main aim of the centre which is to provide information about on-going research in the world and bibliographic data in the fields of interest of BSED. Thus, the centre gathers:

- a. Information on the purpose, methods of operation of and annual reports from research units in the world whether these be goverment, university or private institutions.
- Newsletters and research directories from these institutions.
- c. Abstracts or synopses of on-going research at these institutions.
- d. Bibliographic material for its data files.
- e. To a lesser extent, research reports from research units.

The material is gathered mainly in the form of documents or in microfilm/microfiche format. Bibliographic material is stored in tape and disk files.

- The services offered by the centre are:
- a. Open access display of material.

522

- b. Running of a current awareness service. (This is published in the aperiodic news bulletin (ÇEMBİL Bulletin) of SEAS and is distributed nationally.)
- c. Running of a bibliographic data bank on a computer based system. (The service involves storage as well as search on the basis of keywords.)

 d. Loan of reports to researchers and photocopy service from documents and microfilm/microfiche.
 The range of the material handled by the centre is limited by the areas of specialization of BSED.

Implementation

The technique of implementation envisioned in the establishment of the ÇEMBIL Information Centre has been to start gathering all of the material and offering all of the services discussed above simultaneously and to facilitate growth in all directions simultaneously. In spite of the obvious drawbacks of this procedure, it has facilitated the immediate and total involvement of the centre in the academic life of BSED and this has been its primary aim. The volume of material and services handled at this time is very modest when compared to the scale of other specialized information centres. It is hoped. however, that the financial support necessary for handling greater volumes may be found once the centre demonstrates itself to be viable in face of the aims that have been set for it.

Building Information in Developing Countries;

International Support of National and Local Activities^X)

A. Volbeda and K.L. de Vries

Bouwcentrum, Rotterdam, 1980.

Summary

An outline for an information policy supporting building information in developing countries is presented in statements for discussion. A strategy that places the emphasis on strengthening the support of national information activities, instead of on concentrating on internationally collecting and disseminating information data is recommended.

Pilot projects are suggested.

An "Information Constitution" in five articles is added as an appendix.

Sommaire

Les grandes lignes d'une politique d'information à l'appui de l'information sur le bâtiment aux pays en voie de développement sont présentées sous la forme de déclarations qui peuvent être discutées. Une stratégie soulignant le raffermissement de l'appui donné à l'activité nationale d'information au lieu d'accentuant la concentration d'une collection et d'une dissémination de données d'information est recommandée. Des projets pilotes sont suggérés. Une "Constitution pour l'Information" rédigée en cinq articles se trouve dans l'annexe.

Introduction

 This paper is a contribution to a discussion on the possible future work of international organisations like CIB and others, with regard to the improvement of building information in developing countries. The statements in this paper are action-oriented; the motives given for our suggestions are only briefly described and therefore incomplete.

The statements are sometimes deliberately provocative.

Background

- Suggestions for discussion and for action are presented against the background of the work of Bouwcentrum as a national building information institute, with some experience in giving assistance to information services in developing countries. Moreover they have been inspired by work and disdussions with various international organisations.
- 3. A broader information philosophy, developed by Bouwcentrum, underlies the suggestions put forward in this paper.

This philosophy is explained under the heading INFORMATION CONSTITUTION as an appendix to this paper.

It is recommended to read this "constitution" before continuing with the following paragraphs.

 It should be noted that the broader information philosophy could only be partly based on the results of research.

Information research is scarce and incomprehensive, as far as information generally is concerned and even more so with regard to building information. However, many elements in the Information Constitution find support in the results of research in the fields of psychology, cybernetics, information theory and building information.

Policy

- Levels of information (production <u>and</u> consumption) include:
 - level J : individuals
 - level 2 : communities (settlements)
 - level 3 : districts ^x)
 - level 4 : nations
 - level 5 : regions
 - level 6 : international structures.
- 6. The majority of information efforts in industrialised countries aims at specialised groups of individuals ("publics") such as: architects, engineers, administrators, occupants of buildings and the like. For the support of building information in developing countries this emphasis must change.

<u>Statement 1</u> Information policies must focus on the improvement of information for and within communities (settlements): level 2.

<u>Statement 2</u> Priority should be given to the improvement of information for communities in the worst environmental conditions.

7. Principles of self-respect and self-reliance as well as the virtual impossibility of serving hundreds of thousands of communities with one single information distributing system are an imperative indication of the need for an aided self-help information policy.

<u>Statement 3</u> Improvement of information must be generated within the communities (level 2) with the support of the higher level(s) (district, nation).

x)This paper is a revised and updated version of a paper with the title "Some Remarks on Information with regard to Human Settlements", contributed by the authors to a UNCHBP Ad Hoc Expert Group Meeting on Human Settlements Information Exchange and Dissemination, Geneva 1977.

^X) The word district is used here as a common denominator for units like states (within a nation), provinces, counties etc. The word region (within a nation) has been avoided, in order to prevent confusion with level 5.

8. The idea of regional and international information centres acting as collectors, storekeepers and distributors of comprehensive information is not feasible for serving developing countries. Information handling should be extremely selective; support of national developments requires priority. <u>Statement 4</u> Regional and international activities (levels 5 and 6) should be geared primarily to the support of national information frameworks. <u>Statement 5</u> The handling of informative data on

levels 5 and 6 can be restricted to those data which can be made available by international co-operation only.

9. E.F. Schumacher's pronouncement "The gift of material goods makes people dependent, but the gift of knowledge makes them free....."^X) is only partly true. It may be paraphrased as follows : "The gift of information data keeps people dependent but the gift of knowledge how to retrieve, assess and use information makes them free". It is on the development of this knowledge on the lower levels that the support from higher levels should focus.

Strategy

- 10. If, in the countries concerned, the social, administrative and educational frameworks were available that could absorb the relevant information, the main strategy could be directed to the input of information in behalf of the communities (at the receiver end of the system) and the evaluation of the application of this information.
- 11. However, it seems that such an infrastructure is either lacking or insufficiently developed in many countries. Therefore the strategy should concentrate on those who are in a position to develop and improve the framework: the national bodies, if possible in conjunction with bodies on the "district" level.

<u>Statement 6</u> International and regional strategies should concentrate on the strengthening (and, as the case may be, creation) of national (and "district") bodies for the improvement of information on human settlements.

- 12. The duties of these bodies would be:
 - to develop and support the information framework
 - to encourage the generation of information on the community level
 - to organise the flow of information available on the national level only, including what has been made available on regional and international

levels, with the restrictions mentioned before and adding what can be drawn in from bilateral contacts with other national bodies.

13. The task on the regional and the international level would, apart from the direct support to national bodies, include the structuring and co-ordination of the input that can be made available from an increasing and confusing variety of sources of both a govenrmental and a nongovernmental character.

<u>Statement 7</u> International and regional strategies should include the structuring and co-ordination of resources to be made available to national and district bodies.

Logistics

- 14. The resources required for the implementation of policies and strategies include:
 - political potential (paving the way for the acceptance of policies)
 - finance
 - potential for organisation and management
 - information methodology (theory and methods of transmission, transport and reception of information)^X)
 - tools for the handling of information (thesauri, classification systems, media, equipment)
 - information systems (systematised application of methods and tools)
 - facilities for education and training
 - personal expertise and experience

<u>Statement 8</u> With regard to the development of resources supporting national developments, the following division of tasks is suggested:

	А	ъ	C	D
political potential	x			
finance	x		x	
organisation			х	
methods		x		
tools		x		
systems				x
education		x	х	
expertise		x	х	

- A = international governmental
- B = international non-governmental
- C = bilateral contracts
- D = third parties
- 15. It may seem strange that the production and dissemination of information data are not included in the foregoing suggestions for the develop-

x) See "Information Constitution", appendix.

X) E.F. Schumacher, "Small is Beautiful", Abacus edition, London, 1977, page 165.

ment of resources. However, the authors are convinced that, for the time being, the main emphasis should be on the development of the framework and the resources mentioned before. The flow of the information itself will automatically follow and is a matter to concern ourselves with in a next phase in the developments.

<u>Statement 9</u> The production and dissemination of information data is of less importance for levels 5 and 6 for the time being.

Action (theory)

- 16. The feasibility of the policies and strategies described before could be investigated by means of the creation of one or two experimental projects.
- 17. For such projects the following range of activities could be suggested:

<u>Activity 1</u>: Preliminary selection of a country and its national body.

<u>Activity 2</u>: Political "paving of the way", in order to come to an agreement on policy and strategy.

Activity_3: Seeking support from

- a. regional or international organisations (governmental)
- b. nations prepared to consider a bilateral contract.

<u>Activity</u> 4: Drafting of a programme, in consultation between the national body (+ its government) and international and national organisations prepared to support a programme. <u>Activity</u> 5: Invitation to international non-

governmental organisations (for instance CIB) to assist in the supply of methods, tools and expertise.

<u>Activity 6</u>: Contracts, money, start! etc. etc. Action (practice)

An example

- 18. As an example of the countries in which pilot projects might be set up, Indonesia could be mentioned. On various occasions the Indonesian government has shown a keen interest in the Improvement of human settlements and of information.
- 19. The National Housing Centre in Bandung might be interested in extending its activities to the settlement field. The Centre is the U.N. Regional Housing Centre for the ESCAP region.
- 20. There is experience in Indonesia with "district" organisations in the field of information and it seems about to be widened.
- 21. Regional support from ESCAP is within the range of reasonable expectations. The Dutch Government's interest could be investigated.
- 22. Bouwcentrum has assisted Indonesia in developing an information structure on earlier occasions, on behalf of the Dutch Government, and Bouwcentrum

International Education is now assisting the National Housing Centre in organising training courses for the years from 1978 to 1980. Rxtension of these courses with a specialisation in the field of information on human settlements could be considered.

Another_example

- 23. A situation more or less similar to the Indonesian exists in India: a national centre in New Delhi, a . regional (U.N.) function in the ESCAP region and decentralised activities, according to our information, in various Indian states. The situation seems appropriate enough to consider the possibility of a pilot project. <u>Alternatives</u>
- 24. Although situations like those of Indonesia and India seem to present fertile soil for the development of pilot projects, it could be queried whether preference should not be given to situations where hardly any information structure exists. It is a challenge to start "from scratch" in extremely deprived areas. However, the distance in time between the first decisions and the moment that experiences from pilot projects can be collected and evaluated will be considerably prolonged and the moment that the results can be used as "models" for implementation in a broader framework will be postponed. The choice lies with the decision makers.

Appendix

transmission.



 Information exists for and from the user and from and for research. A continuous output of sound and up-to-date information requires a continuous input of research results and feedback of user experience to research programmes.

SUBJECT 58

Advanced methods of documentation.

Méthodes avancées de documentation

ADVANCED METHODS OF DOCUMENTATION

Dr.-ing. Wilhelm Wissmann

(Informationsverbundzentrum RAUM und BAU der Fraunhofer-Gesellschaft Federal Republic of Germany)

Summary

The methods of information storage and supply took a breathtaking development caused by the progress in electronics. Information can be taken from information networks as energy from energy supply networks. Documentation systems reduce the effort of information acquisition and render information supply more efficient, without restricting the variety of communication ways.

Four parts work together in a documentation system: information, communication, information processing and information methods. The data bases offered in building mostly hold literature information. Efficient information retrieval systems render feasible that the user can have a dialogue with these data bases with the help of simple combinations of key words. A further decisive progress is the opening of official data networks.

The searcher of information dials with his terminal the next knot of a data network and by this way he can reach all data bases offered in this network.

New interesting developments are the international CIB-DOC data base system and view data systems. CIBDOC is the name of a collection of national data bases with literature information on building and construction. They will be connected with the aid of a polyglot vocabulary of the descriptors used for indexing of the documents. CIB-DOC may be the beginning of a difficult way to a harmonized international data base about building literature.

View data systems are a matter of coupling computers with the data bases implemented on them, modified «domestic» television receivers and the telephone line. The search of information follows ways shown by tree structures.

Within the framework of a pilot-study, in United Kingdom the PRESTEL-CONTELSYSTEM is going to be developed, whose information will cover statuary requirements, such as Building Regulations, advisory publications, product information, such as manufacturers and addresses, and British Standards.

Résumé

Les méthodes pour recueillir et distribuer les informations se sont beaucoup développées grâce aux progrès faits dans l'électronique. L'information peut être prise des réseaux d'information comme l'énergie des lignes d'alimentation d'énergie. Les systèmes de documentation réduisent les efforts d'acquisition d'informations et rendent leur distribution plus efficace, sans restreindre la multiplicité des voies de communication.

Quatre parties collaborent à un système de documentation: l'information, la communication, la cataloguisation des informations et les méthodes d'information. Les informations sur la construction viennent en grande partie de la littérature informative. Des systèmes efficaces d'apport d'informations donnent la possibilité d'utiliser ces informations à l'aide de combinaisons simples de mots clés. L'accès aux réseaux des informations officielles mène à un décisif progrès ultérieur.

Le chercheur se met en relation, à travers son terminal, avec le réseau d'informations et peut ainsi atteindre toutes celles qui se trouvent dans ce réseau.

Le système international d'information CIBDOC et les systèmes d'information visuelle ont été développés récemment. CIBDOC est le nom d'une récolte d'informations nationales avec littérature informative concernant bâtiment et construction. Ces informations seront mises en relation entre elles à l'aide d'un vocabulaire polyglote que les auteurs utilisent pour l'indexation des documents. CIBDOC peut être le début d'une voie difficile pour arriver à l'harmonisation des informations internationales concernant la littérature du bâtiment.

Les systèmes d'information visuelle sont basés sur le branchement des ordinateurs aux informations qu'on reçoit sur des écrans de télévision «ordinaires» modifiés, par ligne téléphonique.

La recherche d'information suit des voies ressemblant à la structure d'un arbre.

Le SYSTEME PRESTEL-CONTEL est en train d'être développé au Royaume-Uni, dans le cadre d'une étude pilote. L'information couvrira des spécifications telles que normes de construction, publications consultatives, information de produit, ainsi que noms et adresses des producteurs et Standards Britanniques.

1. The Importance of documentation today

Knowledge means advantage. The more the technical and economical development takes a fast-moving course, the more information becomes an equivalent production element beside capital, labour and soil. Naturally this is also valid for building. Not only the building research workers, but just the architects and engineers working in practice spend a considerable part of their working time seeking information. Any improvement of information supply increases productivity of building research and practice. It is worthwhile to think about the possibilities of information acquisition.

Not later than after the Second World War it became recognizable in science, technology and administration that the expert has to gain well-aimed further information beyond his immediate possibilities in his brain and on his place of work, if he wants to take problems efficiently and with prospect of success. This fact and the fast encreasement of the amount of scientific information (doubling about every seven years) lead to the building-up of documentation systems.

The methods of information storage and supply took a breathtaking development caused by the progress in electronics. Telephone lines and television channels, computers and data bases were tied up in a transmission system with many functions. With the help of telecommunication satellites a worldwide data transmission network was built up. Information can be taken from information networks as energy from energy supply networks. Today data bases, retrieval systems, operating systems, and terminals offer many possibilities when using telecommunication and the fast computers, at least the direct finding of literature references and the resulting problemrelated usage of the information.

The industrial countries are on the way to an information society. Official data systems opened the information market. Changes in information processing and storage interfere in ways of organization and production and sometimes even in social systems. Sometimes one can already hear the thesis: information and not gross national product is the ruler of futher encreasement. Building research and practice will duplicate the way shown by other branches of trade but temporally deferred and adjusted to the special circumstances.

The information problem seems to be founded not in a lack, but in oversupply. Information is available in unlimited amount to anyone, it can be reproduced, transformed, condensed and comprised and thus be worked up to new information. But how can one find out fast, sure, well-aimed and without expenditure just the needed information out of an amount of information?

2. Building-up and loosening of the CIB documentation system

Since decades there are considerations and efforts to harmonize and organize internationally documentation systems. E.g. in 1949 an UN conference in Geneva already dealt with problems of building documentation. The result was the foundation of CIBD (International Council of Building Documentation), today CIB. This organization endeavored the establishment of national building documentation centres treating building literature and establishing documentation stores. One had in view, that all important findings are published e.g. in journals, books, serials, research reports, theses, publications of firms and universities or norms and standards. The size of this literature had grown considerably and it was no longer easy for an individual to survey it.

In the part information about publications was recorded on cards. The national building documentation centres linked up with CIB exchanged these cards, so that each had knowledge of the literature seen by others. This saved each centre considerable effort. The result was an international co-operative network with CIB, in which the input work was shared. With the introduction of computer aided methods more and more documentation centres began to record information about current literature in a machine readable form and to built up data bases on their own. They were able to search these data bases directly by terminals. Only as a byproduct of those data bases printed publications such as abstract bulletins are produced. Each organization produced its data bases independently, with the consequence that printed publications derived from these data bases were no longer harmonized within CIB. At first progress in storage techniques and the better possibilities of access to information unfortunately had as consequence the loosening or at least the restriction of the international CIB documentation compound, because the documentation centres suddenly had a different, not harmonized level of development.

3. Supply of information

With what kinds of methods is an efficient building information centre working? First of all it has access to one or several information stores. In these stores are hold e.g. information about building products, producers and suppliers of building products, information about literature, about building research projects, about building laws, information about building expenses or erected buildings.

Regarding information supply one has to distinguish two ideal types: the storerelated, restricted information supply (SRIS) and the universal information supply (UIS). In practice mostly mixed forms have been realized.




In the case of SRIS (picture 1) there is a direct connection between questions asked to the information centre and the information received from the store. If the question is more extensive, the documentation centre restricts it to a store-related question. In this case the asking person receives information covering only a section out of the spectrum of his question. SRIS always works effective, when simple store-related standardized questions can be formulated. A classic example is building product information.

Many questions to a documentation centre however are of a complex nature and may not be answered by searching in one information store quasi by pressing button.

First the problem must be analyzed in the information centre by an expert staff member and often divided into its components. In order to render feasible universal information supply (UIS) not only the disposable stores (e.g. data bases, files) and collections (e.g. internal libraries), but also external libraries and information centres, as well as external experts e.g. building researchers are inquired. These may even contact others. In this multilayer process of communication it is of decisive significance, that the asking person has to contact only one information centre providing him with all the desired information (picture 2).

How information supply is organized with CIB? Two procedures are important:

1. Each searcher of information can contact an information centre with his problem, unimportant if this centre offers SBIS, UIS or a mixed form. As a rule national information centres answer inquiries from searchers coming from other countries. Consequently these CIB information centres may also, at least partly, cover the information need of those countries having not yet established an efficient working information centre e.g. developing countries.

2. The CIB documentation centres support each other in search and supply of information according to the model of UIS shown in picture 2. There is an international CIB communication compound between the information centres within CIB not being affected by the lossening resp. restriction of the international CIB documentation compound as a consequence of the introduction of computeraided documentation.

4. Individual and overall information

The two ideal types of information supply point out that it is a matter of personal as well as of technical communication proceedings, by which individual and overall information may be supplied.

Information are news that can be received and processed by technical and biological information processing systems. Individual information is stored individually in a human being. The availability of individual information requires a personal communication process. This exchange of information happens between individuals without technical auxiliaries. Overall information are stored outside human brains on data mediums of all kinds. It can be made available more or less worldwide and exchanged with technical communication proceedings. First of all this is a matter of telecommunication possibilities comprising all types of information exchange between technical and biological information-processing systems using technical auxiliaries. Meanwhile it became apparent, that in practice information processing can not be detached



from information transport i.e. telecommunication. In France this lead to the definition of an enlarged discipline «télématique» (telematics = tele(communication) + (info)matics). Today telematics and the hold overall information determine progress in documentation methods.

5. Information as resource

Information is a resource. From information to consumption by the user information passes through a range of processing and preparation procedures in various successions and combinations. These procedures will be explained with the help of some examples taken from building research:

Processing and preparation procedures	Examples taken from building research
Formation of information	When solving a building research problem new information is produced.
Storage of information	Information about building research is published in books, journals or research reports and stored in these publications. Literature as a whole is collected in li- braries being large depots.
Exploration of information	The building researcher himself needs in- formation as basis for his work. He discusses e.g. with experts, uses a library or inquires an information center
Acquisition of information	Single facts and dates have to be extracted from a wider context e.g. from a publica- tion to pass into processing. Results of re- search work are treated for transformation into building practice. Individual informa- tion are worked up e.g. to a state-of-the- art-reprt.
Transport of information	Lectures, phone calls, dispatch of journals or other publications, facsimile mail.

From the point of view of information science a research problem can be reduced to the three components information acquisition, information processing and information supply (picture 3).

Individual and overall information are extracted from many sources (e.g. documentation systems) to be processed by research work. The new produced information is supplied to customers by different mediums. It is made available to documentation systems mostly through appropriate evaluation of publications about the results of research work. Researchers and practical men can access such documentation systems. These systems reduce the effort of acquisition and render information supply more efficient.

The sense of documentation systems is not the restriction of the variety of communication ways and information processing. They are rather an integrated auxiliary in an extensive communication system. By holding and indicating information in an organized and partly mechanized way they are able to make information supply highly effective and in many cases they only render it possible.

6. Parts of a documentation system

Four parts work together in a documentation system: information, communication, information processing, information methods.

6.1. Types of information

The information hold in the known building documentation systems can be related to different types: references, dates and correlations, whereby as a rule mixed forms appear. E.g. a literature information often contains beside a reference of the original publication (bibliographic data, location) a comprised description (abstract) eventually with precise data. A product information gives data about



Picture 3 Research process form the point of view of information science

532

single characteristics of a building product and refers if necessary to additional information. A research information consists in facts and dates concerning the research project. In France there is an information system (ARIANE), showing correlations between facts and dates within an information. E.g. recommendations to a practical solution of a problem such as concreting under special conditions may be connected with the mentioning of suitable building products like certain cements.

6.2. Communication, information processing, information methods

Nowadays the fields communication, information processing and information methods can not be considered seperately.

6.2.1. Data bases

Data bases are produced for more than ten years. Today the large data base services offer worldwide more than 1 000 data sets in scientific-technical, sociological and economical fields. Typically they range in size from hundreds of thousands to millions of items.

In building this development started later. Analogous the offered data bases are smaller and hold mostly literature information. They are collections of bibliographic citations and abstracts very similar to those found in libraries. They may refer to journals articles, conference proceedings, technical reports, books, theses, noms, standards and other kinds of information obtained from worldwide sources. A citation would generally include the title, author's name and affiliation, bibliographic information, details of availability, abstract, key words and classification codes. The same data used to print an abstract journal may be used to create the computer data base. However, in complete contrast to the printed product which usually contains indexes which are limited both on cost grounds and because of the limitations of the human researcher, the computer data base is nowadays equipped with the most extensive indexes imaginable.

Data bases are implemented on computers and may be inquired interactive from terminals. These are display units or data typewriters connected with the computer by normal telephone lines or dedicated lines.

6.2.2. Information retrieval systems

The user can have a dialogue with the data bases. For this efficient information retrieval systems (IRS) were developed, rendering feasible multidimensional access to single information of a data base. One can search as example literature data bases for any criterion like key words, author's names, language information or regional terms and combine search keys to a question with the known logic operators (AND, OR, AND NOT) as well as with bracket structures. During the dialogue with the data base the question can be modified e.g. extended or restricted in dependence on the resulted answer. The retrieval systems allow not only to search for indexing terms given to an item already before storing it, but all parts of a text may be searched for fragments of words or sentences. Today these systems offer so much comfort, that the untrained user learns their handling within shortest time.

6.2.3. Hardware

An important cost factor for operation is the employed hardware. For long time the storage of information on magnetic film mediums (magnetic tape and magnetic disc) stood the test. During the last years the recording density has increased considerably, the cost went down even more.

New stores e.g. optical storage discs, being able to store with laser enormous data volumes on smallest space (a milliard of characters find space on a disc with the size of a long playing record, discs with the capacity of 10 milliards of characters are in development), will continue to lower rapidly the costs of storage. Even nowadays the costs of storage are not the decisive criterion for storing certain kinds of information or not.

The costs of computers will soon be no criterion if data bases are built up or not. In former times there were only large computers. Today there is a variety of small, efficient and relatively cheap machines on which retrieval systems can be operated. The use of microprocessors and microcomputers will lead to a further almost revolutionary diminuation of costs. Today a device finding place on a card or even on a chip of a few square millimeters size and available for a few thousand dollars, brings results, which ten years ago were only possible on a large computer worth many million dollars.

6.2.4. Telecommunication networks

A further important progress is the opening of official data networks connecting a range of so-called host-computers that offer data bases. The searcher of information dials with his terminal the next knot of a data network. By this he can reach all host-computers and search all data bases offered within this data network.



Euronat/diane + scannet Direct information Access Network for Europe + I&D Data Network for the Nordic Countries

Picture 4 shows as example Direct Information Access Network for Europe EURONET/DIANE and the I&D data network for the nordic countries (SCANNET), being connected by knots in Copenhagen.

Such networks including the communication satellites exist meanwhile in many variations and cover the industrial countries. They render feasible with the most modern data transmission technologies the economy-priced, fast and reliable access to the data bases. The location of a data base is no longer of importance to the searcher of information.

7. New interesting developments

7.1. International CIBDOC-data base system

Big international data bases in a harmonized documentation language, offered worldwide by telecommunication networks exist for a range of disciplines as chemistry, energy, biology, agriculture or medicin. But until now there exist no international data base concerning all the knowledge within planning, building and civil engineering. In 1978 the CIB Working Commission W 57 decided to set up such an international system called CIBDOC.

CIBDOC is the name of a collection of data bases with literature informations on building and construction. The system is co-ordinated by Informationsverbundzentrum RAUM und BAU der Fraunhofer-Gesellschaft in Stuttgart and is in progress of organization. The CIBDOC data bases come from different organizations in a number of countries, at the moment from France, United Kingdom, Sweden and Federal Republic of Germany. The Scandinavian data base offered by Sweden also includes the input of Norwegian, Finnish and Danish documentation centres, the German data base the input of Austrian and Dutch centres.

The CIBDOC data bases are stored together in one computer in Karlsruhe. The access is possible by normal telephone lines and by the EURONET telecommunication network. The CIBDOC data bases need to be co-ordinated in a way which brings together references to all documents from one speech area or nation. Such a structure gives a double benefit. To the user, the whole set of data bases offers a complete system. If he is looking only for information about publications in his mother tongue, he can search the data bases of the country from which he comes or in his own language. To the producer of data bases, they are able to limit their input to publications in their own language, which saves them considerable resources, because the building up and maintenance of data bases is expensive. The CIBDOC data bases will be connected with the aid of polyglot vocabulary of the descriptors used for indexing of the documents. This enables the user to seek informations in his mother tongue from data bases built up in foreign languages. In this way access to CIBDOC data bases is made easy. One hopes, that the CIBDOC data bases grow together to a harmonized data base in course of the next years.

7.2. Viewdata systems

In the last years viewdata systems have been developed. This is a matter of coupling computers with the data bases implemented on them, modified «domestic» television receivers and the telephone line. The viewdata systems do not allow the multidimensional access to single information, as information retrieval systems do.

The search rather follows a way indicated by tree structures. It goes without saying, that this type was chosen, because viewdata systems ultimately should be used by owners of television sets. By this they can e.g. ask for the latest news, programmes of theatre, quotations, timetables.

The development of viewdata systems took mostly place in United Kingdom being connected with the system PRESTEL introduced over there. The Department of the Environment – PSA is the sponser of a pilot service for the construction industry and has commissioned the National Building Agency (NBA) to act as the compilers of the work. The informations will cover statutory requirements, such as building regulations, advisory publications product information, such as manufacturers names and addresses, and British Standards. At the present the system is called CONTEL or PRESTEL-CONTEL. This pilot service is an attempt for both users and information providers to access any benefit viewdata service may have to offer.

The age of viewdata systems has just begun. At the moment one tries to reach the traditional retrieval systems with their data bases from single knots of the search trees of viewdata systems. This means a connection between the comfortable multidimensional retrieval techniques and the relatively simple tree-orientated search methods of viewdata systems. One can expect that the viewdata systems, outgoing from the studies in United Kingdom, will reach in building a broad usership. Management information system in the Hungarian Institute for Building Science

Judith Grad /Mrs/ architect, senior research officer, Hungary

The R+D management information system used in our Institute is based upon a computer aided data-recording system which contains the most important data about contractual R+D work.

The essence of the system is the so-called LOGEL method, worked out by Dr.Gy.Kunszt research director and dr.P.Futó mathematician. /1/. The LOGEL program-system developed on the basis of logical-mathematical models and algorithms is suitable for taking into consideration the internal logical structure of scientific R+D projects or other information to be retrieved. By this method logical modelling of inter-relations between research projects, proposals, programs as well as scientific disciplines and hypotheses can be solved.

The program-system presently contains 25 logical models. It is installed to different types of computers, eg. SIEMENS 4004, CDC 3300, IBM 370/145 and EC 1020 similar to IBM 360 series. We apply it to a TPA/i minicomputer, similar to PDP 8/E.

<u>Practical experiences with management in-</u><u>formation</u>.

The computer aided data-recording system is storing the economic and financial data of the Institute's research projects as well as a short key-word description about the <u>aim</u>, the <u>content</u>, the <u>method</u>, the <u>result</u> and the <u>utilization</u> of research work concerning each project.

All these data are stored on a <u>TPA/i_mini-</u> <u>computer</u>, which is compatible in software with the PDP-8/E minicomputer /made by DEC/. It's CPU capacity is 24 K words. The peripheries are:

l fix magnetic disc unit of 512 words capacity,

- 1 high-speed reader,
- l high-speed punch,
- 2 magnetic tapes,
- 1 line printer,
- l display as a console.

To the key-word indexing system used for describing the aim, content, method etc. of the research we developed a special thesaurus, containing not more then 3000 descriptors divided into 15 main groups. The sources of this thesaurus were the research reports worked out in our Institute in the period between 1970-74. Out of many thousands relevant terms those were chosen as descriptors which occured at least three times in the reports investigated. The thesaurus is of a mono-hierarchic type, in which every term occurs only once. In case of synonyms the most frequently used term was chosen as a descriptor. Homonyms - since they are rare in the Hungarian construction terminology - were groupped separately into the last main group. The main groups are as follows:

- Materials,
- Building structures,
- Sanitary engineering.
- Buildings, edifices,
- Settlements and public utility networks,
- Machines and instruments,
- Means of intellectual activities,
- Natural and technical properties,
- Economic and social parameters,
- Technologies, operations,
- Intellectual activities,
- Sciences,
- Economic and industrial sectors,
- Proper names,
- Descriptors not to be classified.

By developing the main groups we made use of the CIB masterlist inter alia.

For building up the thesaurus by computer, we used one of the 25 LOGEL models mentioned before, the so called <u>Generic model "thesaurus</u>" which is also a basis of it's continuous improvement.

Input data

Input data to the system are given partly by the Economic and Financial Department controlling the research contracts, and partly by <u>one</u> indexing expert, who is filling out the data sheets containing the key-words. The indexing work is made on the basis of a short text written by the researcher himself and with the aid of the thesaurus mentioned above. There are separate data sheets used for the beginning of a research-project /aim, content, method/, for modifying the data and for finishing the work /results and utilization/.

Output data

Beside the generally known output protocols, which contain the input data in a given order, the system is able to prepare some special models in the form of matrices. The most frequently used are as follows:

1 Affiliative Model /t-t type/ of a cognitive system containing terms only

This is an undirected graph, the vertices of which are the terms /in our system the keywords used for characterizing the research projects/. The vertices are connected pairwise by edges, the number of which equals those research projects the characterizing for which the terms /keywords/ were commonly used. This number giving the frequency of simultaneous occurence ot both keywords is the measure of their affiliative connectedness.

2 Affiliative Model /K-K type/ of a cognitive system, containing cognitive units only Cognitive units in our system mean the research projects. The model is an undirected graph, the vertices of which are the research projects or contracts. These vertices are connected pairwise by edges, the number of which equals the number of commonly used terms /keywords, descriptors/. Number of these edges representate the affiliative connectedness of the two research projects investigated.

How to use these models? Let us see some simple cases for their practical use.

Model 1: t-t matrix

As investigated the researches carried out during the year 1978 a frequency analyzis was made on the basis of the frequency order of key-words used for characterizing the content of the researches concerned. After choosing 33 relevant key-words of the greatest frequency the computer provided a t-t matrix. Figures occuring just behind the key-words show their frequency i.e. how many times they were used in the period investigated, while the others to be found in the intersections of two optional key-words show their simultaneous use for characterizing different research projects.

Frequency clusters to be seen on t-t matrices representing the global research work of the institute for a given period show the structural frame of the research activity, it's peaks and weak points as basic data for research management. As a result of investigations concerning the researches carried out in 1978 the following order of main topical groups could be determined:

- 1. Concrete and reinforced concrete construction and technology
- System building, system-components /light-weight and composite building systems/
- 3. Building machines and instruments
- 4. Energy conservation
- 5. Public utilities
- 6. Corrosion protection

This sequency order was justified by a detailed statistical analyzis the results of which are to be seen on table 1.

Model 2: K-K matrix

Analyzing the contract stock at the end of the first quarter of 1979 we could see some change in the sequence of main topical groups as shown on a K-K matrix of 30 projects selected according to the greatest key-word frequency. Here the figures occuring in the intersections of two optional research projects show the number of key-words used commonly for characterizing their content.

According to the big K-K matrix representing the global research activity the first place became occupied by system building and within this primarily the connectedness of light-weight construction development is remarkable.

Cost analyzis

Cost analyzis shows partly the numerical interrelations of research activity and partly the rentability of the Institute. Contract prices and terms are input data from the beginning, and now we intend to put into the system the invested costs /both estimated and recalculated costs/ as well.

Staff needed

<u>Indexing</u> is the work of <u>one</u> documentation expert only, and this system proved to be advantageous because of using identical terminology for identical topics.

Programming:1 personPunching:1 personControlling:1 person

Further development: 2 persons, one mathematician and one research expert. All these people do the work only in a part of their working time, say half of it, so the staff needed is approximately 6/2 = 3 persons regarding the whole working time.

Further possibilities of using the system

The management information system described above proved to be suitable for use outside the Institute as well. The problem: how to adjust the system to special industrial or scientific conditions, to governmental and even international aims, could be solved.

Governmental level

A decision preparatory work is continuously to be carried out for the Ministry of Building and Urban Development in the form of <u>long-</u> and <u>medium-range research program conceptions</u>. The LOGEL-method was already used in the period of the fifth five-year plan for working out the research program in such a way, that every proposal for a research project was characterized by 5-10 key-words. Then a frequency analysis of the key-words followed and a t-t /key-word - key-word/ matrix as well as a K-K /research topic - research topic/ matrix served as a basis for analyzing the research demands on the level of national building industry.

Taking into consideration the results of the analysis mentioned above forty complex research program proposals were worked out to which also an evaluation was prepared by help of the LOGEL program-system.

In the year 1979 we have got a new task, according to which a <u>new method for distribut-</u> ing the Central Technical Development Foundation and controlling it's allocation was to be worked out. As in fact a new data recording system of R+D contracts made by the Ministry to be financed from CTDF was concerned, we could well use again the information system of the Hungarian Institute for Building Science.

We proposed that instead of the marginal punched card system used until now it would be hetter to switch over to a computer aided data processing of research contracts or research topics. The methods of this data processing were proved in the frame of processing research data of more then thousand contracts concerning the years 1976 and 1977. Here we used the same system mentioned before, namely we characterized every contract by about five key-words /using the descriptors of our research thesaurus/ and after that investigations were carried out by help of the LOGEL system.

Using this method it will be possible to have a rapid glance over the whole research activity from more point of view, e.g. according to

- sponsors/contractors
- scientific disciplines /fields of research/
- institutes carrying out research work
- activity forms /applied research, pilot plants, licence purchase etc./
- KWIC-index.

As a result of the K-K matrix made for the contracts of hugest amount several overlaps had been found among the research contracts, so there is no doubt the necessity of coordination.

Main topical groups of researches	Concrete and r.c.	System building& components	Building machines instrums	Energy conser vation	Public utili- ties	Corrosion protect.	Тс	otal
Total number of contracts: 655 pc. Of these:	181	168	122	41	24	16	55	52
Procentual distribution $655 = 100 \%$	27 , 6	25,6	18,6	6,3	3,7	2,4	84,2	
Distribution according to	the chara	acteristic	of researc	ch:			pc.	Ж
O Preparatory study	5	6	5	2	4	-	22	4,0
l Basic & applied research	16	19	5	11	3	2	56	10,2
2 Development work	80	83	72	12	10	5	263	47,5
3 Industrial research	31	6	7	2	2	2	50	9,5
4 Architectural design	3	6	4	-	-	-	13	2,3
5 Regulation	1	9	1	4	1	-	16	2,8
6 Industrial introduction	17	24	13	1	-	-	55	10,0
7 Expert opinion	2 7	14	9	4	3	6	63	11,3
8 Other techn.activities	l	1	6	4	1	1	14	2,4

Table 1: Numerical and procentual distribution of research contracts according to topics and characteristics

<u>Summary</u>

In the study experiences with a special, computer aided research management system being in operation since 1975 are described. After a short information about the system as a whole, some results of detailed analyses carried out in the Hungarian Institute for Building Science are to be seen in form of tables and matrices, illustrating the topical structure of the Institutes research work. The system based upon the so-called LOGEL-method has been used for projects outside the Institute as well, e.g. for:

- a decision preparatory work carried out for the Ministry of Building and Urban Development in the form of long- and medium-range research program conceptions,

information system as an aid for distribution and use of the Central Monetary Fund for Technical Development, carried out for the Ministry of Building and Urban Development,
developing a management information system for the National Research Program for Computer Technique,

<u>Résumé</u>

L'étude présente les expériences acquises lors de l'opération depuis 1975 d'un système spécial de direction de recherches à l'aide d'informatique.

Après une brève information sur le système entier, des résultats d'analyses détaillées sont présentés en tables et matrices illustrant la structure thématique des travaux de recherches de l'Institut. Le système élaboré sur la base de la méthode LOGEL a été utilisé pour des projets en dehors de l'Institut, par exemple

pour les préparatifs de décisions élaborés à l'usage du Ministère du Bâtiment et de l'Urbanisme, en tant que conceptions de programmes de recherches à long et à moyen terme,
pour un système d'information en tant qu'aide pour la distribution et l'usage du Fonds Central de Développement Technique, élaboré pour le Ministère du Bâtiment et de l'Urbanisme,

- pour un système d'information de gestion, élaboré pour le Programme National de Recherches en Informatique.

Reference /1/

Dr.Kunszt György: <u>The use of logical models</u> <u>in solving topical problems of research mam-</u> <u>agement</u>. Annals of Library Science and Documentation, Delhi, Vol. 18, No 3, 1971, pp 105-118.

SUBJECT 5C

Management information systems. Construction project management, building sites management and technology, cost management.

Systèmes d'information de gestion gestion des projets de construction gestion et technologie des chantiers gestion des dépenses

ORGANIZATION AND MAN-AGEMENT OF CONSTRUCTION (W-65)

By dr. Louis Richard Shaffer (Technical Director, U.S. Army Construction Engineering Research Laboratory, U.S.A.)

Summary

This paper reviews the collaboration of the experts in Organization and Management of Construction (CIB Working Commission W-65) in research studies in management information systems, cost management, construction project management, and building sites management and technology.

Résumé

Cet article est un compte-redu des recherches de la Commission de Travail CIB-W65 concernant le système d'information de gestion, la gestion des comptes, la gestion des projets de construction et la gestion des chantiers de constructions.

Introduction

This paper reviews the work in W-65, Organization and Management of Construction (OMC), and draws attention to the most significant aspects of this work for current application and for future research. This work is presented as (1) Management Information Systems; (2) Cost Management; (3) Construction Project Management; and (4) Building Sites Management and Technology – as recommended by the CIB Programme Committee.

OMC in Management Information Systems (MIS)

Research in MIS has migrated to a single thesis with two research strategies. The single thesis is that MIS accommodate the multi-disciplined, multi-phased, complex organization characteristic of the construction project or the complex mix of hierarchical and matrix organizational structures in the building firm. No longer does MIS research assume a fixed, inflexible structure of either the project or of the firm. Of course, the research maintains the vital characteristic of an MIS, i.e., the complete integration of information from all sources. The two research strategies come from organizing the MIS either on the project configuration or on the firm organization. Both strategies exploit the current electronic data processing technology, and both exploit the time-phased progressive development of information to match the increasing detail in project information as it progresses from its initial stages through construction on-site.





MIS research based on the *firm* configuration is epitomized by the work of Dressel [1], Logcher and Levitt [2], and Diepeveen and Benes [3]. The work by Dressel is in cybernetic modeling via the IfA Control Circuit Model for setting objectives, planning, execution, control, and steering; these phases recur as system elements. The MIS is developed in IfA form and allows the complete integration of all functions and related information of the firm. Fig. 1 is a pictorial description of the IfA Control Circuit. The work by Logcher and Levitt is founded in data based management systems of modern electronic data processing technology to accommodate to the combination of hierarchical and matrix structures which typify large firms as seen in Fig. 2. Their research exploits data base management's (1)



Figure 2,

Matrix Structure for Project Execution (Logcher & Levitt [²])

low cost storage, lower processing costs of basic date and lower costs of data aggregation and (2) relational data structuring which allows direct storage in disaggregate form of some data for use by all aspects of the MIS. The work of Diepeveen and Benes configures the firm à la corporate planning. Their corporate planning contains three elements: policy definition; operational departmental planning; and MIS – which is to give relevant data to top management to take correcting measures if info suggests failure. This research is directed to describing the data content.

MIS research based on project configuration is represented by the work of Burger and Wolter [4]; Baltsan and Gil [5]; and Gurel and Armon [6]. In the Burger and Wolter work, the MIS is based on decomposing the project into physical segments for which information can be related to individual users, i.e., owner, architect, etc. Each physical segment is a single dimension of the project, such as location, energy system, structure, etc. These are placed in hierarchical levels with data collected and stored in each. Each user of the MIS sees only his image of the MIS and can use it independently. In the work of Baltsan and Gil, the project is configured by a condensed network. Each stage is blown up to a detailed form as execution stage approaches with the party responsible for the execution identified. The effort by Gurel and Armon is to develop a set of catalogs of standard descriptions of items in a construction process. Each description contains attributes of the building forms, components, and processes. These data range from physical properties through design details to prices.

OMC in cost management

All research in the building process measures its success via impact on the cost of a project. The research in Cost Management is distinguished as that which yields costs, directly rather than items which must be priced to yield costs. Research in Cost Management gamuts cost estimates in the initial phases of design through construction to annual costs. The concentration of current research is to develop an accurate cost for the client in the initial description of the project. This focus on the front end of the process is because of the payoff of this accuracy; as shown in Fig. 3 a as presented by Greven [7], as a design progresses the more impossible it becomes to change costs effectively.

The research is typified by the works of Greven [7], Green [8], Thurner [9], and Logcher, et. al. [10]. Greven's research is for a cost modeling tool (see Fig. 3 b) based on building elements which translate the client's needs into a building cost estimate as well as anticipating the long-term cost and benefits. The model is applied to the client's brief, the building design, the cost accounting of the building as well as projecting and discounting cash flows. Thus, the owner and the user become aware quickly in the early stage of design the cost consequences of wishes. The work by Green is on reducing the complex problem of costing to manageable proportions in the use of probability tree analysis. His model provides the most likely cost together with the change and extent of any possible over or under







estimate. The probability tree analysis requires breaking down the project into constituent parts, estimating the range for each part and then combining these ranges into one for project. Thurner's research also involves the application of probability to the obtaining of cost distribution functions, i.e.,

$C = \Sigma V_i \ \Sigma R_{ih} \ C_{ih}$

where C is the total cost of project; V_i is the volume of each i elementary product, R in is the requirement of the resource h in product i; and C_{in} is cost of resource h for product i. The resource requirement is treated as a random variable. The output is cost distribution of resource versus duration of project. The research by Logcher et. al. is of a computer system, entitled COSMOD, which models the role of the estimator. (See Fig. 4.) This system is used to build a unique hierarchically structured model of a project. In other words, it is not a fixed system against which every project is processed, but rather a project is evaluated via its characteristics and a system is stylized from the data given in COSMOD to suit.

Another focus of the research in Cost Management is for managers of public works who are responsible for financial planning and cost control of multi-, large projects in public works. This research is always characterized by a computer system. The work by Bromilow and Davies [11] resulting in

542



Figure 4, CASTMOD System Overview (Logcher, et. al. [10])

FINPLAN is typical; this system models the role of such managers to provide for more accurate, speedy and easy planning so as to use funds efficiently, and subsequent operational control. Drake's [12] work is also on financial planning and cost control but for a single project; his research is of a mathematical model of the S-curve which relates the cumulative value of work executed in any month to forecast (a) the value of the work to be executed 6 to 12 months ahead and (b) the likely works duration. Armon and Nawrath's [13] work also deals with the S curve, but it typifies a probability analysis of the S curve. Their probability calculation is based on a skeletal project network with discrete probabilities of prices and durations for the alternate performance of activities.

OMC in construction project management

It is hypothesized that a specific organizational form of the building process can be designed to accommodate to the client's mode of operation which will maximize the probability of providing the facility within budget and on time. The research which examines this hypothesis comprises two major thrusts: (1) models of a priori design of the building process to match client's needs and building requirements; and (2) the critical examination of the performance of ad hoc applications of organizational forms. The research focuses on three organizational forms and variations thereof, i.e., traditional, construction management and designbuild.



Figure 5,

A Conceptual Model for Predicting Organizational Forms Within the Building Process (Sidewell & Ireland [14]) Primary works in the a priori design thrust include those of Sidewell and Ireland [14], White [15] and Handa and McLaughlin [16]. The work of Sidewell and Ireland has resulted in a conceptual model of a building process to facilitate design of these organizational forms. (See Fig. 5.) The model isolates the relationship between the organizational form and the particular task environment which is the product of client limitations and project's requirements. Their results suggest that the most successful complex, high value projects are those which had specific organization forms. In his research, White provides a six-step analysis for design of a building process to meet the aims and objectives of the owner of a particular building project. His six-step analysis begins with identifying owner's aims and objectives, includes examining the assumption of risk by the participants in the various options, and terminates in selecting the potential candidates for the various participant roles in the optimal options. His results have established that the procedure anticipates and overcomes many of the problems encountered in a typical building project. The work by Handa and McLaughlin is for a procedure for analyzing to be carried out by the management team, i.e., project manager, construction manager, superintendent, etc. In their approach, the project manager in the pre-contract stage applies «responsibility charting» to select who will be responsible for what functions. Then a «control graph» is developed to measure if any team member is overcommitted. The «project organization chart» is then developed. Finally, the «socio-matrix» is developed to display the personal relationships among the members and to identify if any communication bottlenecks which may occur.

A category of research which is a subset of this thrust is that of developing contract forms to share the risk between the owner and the contractor. This work is typified by that of Erickson, Boyer and O'Connor [17]. In Erickson, et al., cardinal utility theory is used to assess the risk of the price differential between the owner and the contractor. The utility theory calculations show how much of the construction risk the owner should assume. If the proper amount is assumed, a potential cost reduction is identified and a contract form developed to capture this cost reduction. In the research thrust of the critical examination of ad hoc organizations, many studies have been made; the two reveiwed are typical. The study by Brown [18] established that for his environment the design-build technique is viable for large industrial plants and the project manager only for very large projects. His research shows that the traditional form is always preferred when cost escalation is not a major factor; the modified traditional - wherein subs are pretendered - is used when appreciable savings from cost escalation can be expected. Cleland [19] establishes the advantage of the construction manager form for public building programs where the volume of construction is high and speed of construction is of essence. Other studies recommended are by Balla and Szots [20], Sorgue [21], Chin [22], and Miners [23]. Balla and Szots examined organizational methods in dwellings in Budapest; Sorguc evaluated the Turkish State Hydraulic Works; Chin organized industrialized building construction in the West Indies and Miners for South Africa.

An extension of research in project management is that being undertaken by Diepeveen and Benes [24] and by Dressel [1]; their research is to the multi-project, i.e., corporation, level. Diepeveen and Benes are researching the development of a model of corporate planning to the management of a building firm. Dressel's research is in cybernetic organization modeling of a contractor's firm. (See Fig. 1.)

OMC in site management and technology

Research in this area focuses on models for the selection, allocation, and utilization of the «right» resources to improve site productivity as well as to develop technology to reduce complexity and number of tasks on-site.

In the resource selection's allocation and utilization thrust, the work is primarily in mathematical programming and in computer simulation. In mathematical programming, the work of Peer and Lazar [25] is of particular interest. This technique, albeit based on network theory, uses as input basic production data, i.e., quantities of work, production makes, external constraints, and other production characteristics. The model develops the activity durations and optimal crew sizes in balancing the construction process into a comprehensive system of production on-site. Haerli [26] is developing a backtracking search algorithm to the assigning of permanent working crews so as to have them assigned continuously on-site without interruption. An ambitious new start is the rigorous engineering-mathematical tool being developed by Blechman [27]. He has developed a structured array of concepts and characteristics which can be stylized into a precise model for each specific on-site production process on a project. Although his modeling is in 1:1 correspondence with actual on-site characteristics, its computational viability is not yet estab-



Figure 6 Model for Concrete Mixer (Pilcher & Davison [281]

lished. The computer simulation research of Pilcher and Davison [28] is to develop a series of computer programs that simplify and facilitate the simulation of construction operations by treating them as linked systems of repetitive, cyclical elemental processes. The model interlocks these elements into a construction operation via Monte Carlo Simulation. Figure 6 is the model for concrete mixes.

In the research in the development of technology, the work by Hospodarsh [29] is typical; his is directed to reducing tasks on-site via the use of standard forms for concrete construction. He states that, in the future, standard forms will enable the manufacture of entire rooms! The research Bieu, et al. [30], has resulted in the following criteria; (1) increase the containerization of materials; (2) increase the mechanization in handling and transporting of materials; (3) increase the utilization indices of storing spaces; and (4) provide service-type units.

The final thrust area in site management and technology is that of equipment maintenance and repair. With the increase in mechanization on the building site, this topic is becoming more interesting. The research in repair costs in preventive maintenance of heavy earthmoving equipment is highlighted by that of Jurecka [31]. His work is heroic in the data collection of the performance of heavy equipment for site operations; he presents these data in such graphs as «accumulated repair costs» which take into account working conditions; «failure rate of machines as a function of operating time»; and «working time of machine with failure rates decribed by Erlang distributions.» Work in this field is also being undertaken by Popescu [32] and Vorster [33].

References

- Dressel, G., IfA System for Cybernetic Organization Models, Proceedings of the CIB W65 Second Symposium, Vol. 2, Nov. 1978, pp 111-121-136.
- Logcher, R. D. and R. E. Levitt, Principles for an Integrated MIS for Design Firms, Proceedings of the CIB W65 Second Symposium, Vol. 2, Nov. 1978, pp 111-225-229.
- Diepeveen, W. J. and J. Benes, A Model of Corporate Planning in the Construction Firm, Proceedings of the CIB W65 Second Symposium, Vol. 2, Nov. 1978, pp 111-81-101.
- Burger, A. M. and W. F. Wolter, Project Configuration Model – A New Concept to Control and Manage Complex Projects, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp 11-135-157.
- Baltsan, Ch. and A. Gil, Application of an Operational MIS on the Design and Implementation of PWD Construction, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp 11-27-37.
- Gurel, N. and D. Armon, Standard Description of Construction Items as a Medium of Information Transfer in the Construction Process, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp 11-201-217.

- Greven, E. D. W., The Use of a Building Cost Element Model in the Early Design Stage, Proceedings of the CIB W65 Second Symposium, Vol. 2, Nov. 1978, pp III-157-177.
- Green, M. F., Construction Cost Forecasting The Potential for Using Simple Probability Techniques, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-185-201.
- Thurner, G., Probabilistic Aspects in Estimating Construction Costs, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-321-335.
- Logcher, R. D., G. Meyran, W. Shild and A. Hauber, COSMOD: An Approach to Cost Estimating for Planning, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-249-267.
- Bromilow, F. J. and V. F. Davies, Financial Planning and Control of Large Programmes of Public Works, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-119-135
- Drake, B. E., A Mathematical Model for Expenditure Forecasting Post-Contract, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-163-185.
- Armon, D. and J. Nawrath, A Two Dimensional Stochastic Cost-Flow Model, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-17-27.
- Sidewell, A. C. and V. Ireland, A Conceptual Model for Designing Organizational Form within the Building Process, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-151-165.
- White, J. C., An Approach to Process Analysis as a Procurement Selection Method for Building Owners, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-205-213.
- Handa, D. K., and W. A. McLaughlin, Planning and Controlling the Management Teams, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-97-113.
- Erikson, C. A., L. T. Boyer, and M. J. O'Connor, Risk Assignment in Construction Contracts, Proceedings of the CIB W65 Second Symposium, Vol. 2, Nov. 1978, pp III-177-199.
- Brown, L. J., Assessment of Management Methods in Design and Construction, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-47-61.
- Cleland, W. B., Multi-Agency/Multi-Projects School Building Programs: Design Management Imperatives, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-61-71.
- Balla, J. and A. Szots, Application of Up-to-Date Organizational Methods in Realizing 50 000 Dwellings in Budapest, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-11-25.
- Sojuc, V. D. Evaluation of Turkish State Hydraulic Works Organization, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp I-165-183

- 22. Chin, M. W., Industrialized Building Construction in the West Indies – Problems and Prospects, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp IV-35-51.
- 23. Miners, T. W., Client Problems in the Use of Industrialized Building in South Africa, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp IV-179-189.
- 24. Diepeveen, W. J. and J. Benes, A Model for Corporate Planning in the Construction Firm, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp III-81-101.
- Peer, S. and S. Lazar, Expansion of CPT, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-285-295.
- Hareli, M., Optimizing the Execution Sequence in Construction Project Which Have Repetitive Processes, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-217-231.
- 27. Blechman, I., Labor Cost Formula in Construction Item Processing, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-103-119.
- Pilcher, R. and G. Davison, Computer-Based Simulation Models for Use with Construction Projects, Proceedings of the CIB W65 Second Symposium, Vol. 1, Nov. 1978, pp II-295-321.
- 29. Hospodarsch, K., Modern and Labor Saving Systems for Housing Projects, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp IV-93-103.
- Beiu, E., P. Hossu, J. Mircen, and D. Florea, Input Improvement in the Activity of Central Storehouses in Building Enterprises, Proceedings of the CIB W65 Second Symposium, Vol. 2, Nov. 1978, pp III-29-51.
- Jurecka, W., Repair-Cost and Preventive Maintenance of Heavy Earthmoving Equipment, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp IV-127-153.
- 32. Popescu, C., Managerial Considerations Regarding Construction Equipment Freedom in Large Remote Projects, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp IV-209-225.
- Vorster, M. C., Equipment Management Logistics, Proceedings of the CIB W65 Second Symposium, Vol. 3, Nov. 1978, pp IV-277-297.

MANAGEMENT PROBLEMS IN BUILDING

Doctor of technical sciences, professor S. S. Atayev, director of the Byelorussian Research and Design Technological Institute of Organization and Management in Building, the Byelorussian SSR.

Summary

The peculiarities of the investment process in modern building and the imposed management problems are featured out in this report. Questions concerning the integration and harmonization of organizational forms are considered. The stages of the integration process evolution and the dominant tendencies to perfection of organizational forms for management in the Soviet Union and socialist countries are shown. New concept by Soviet specialist, based on the theory of functional systems, is presented. The problem of the long-term planning in the conditions of the developing integration process is considered. Some ideas concerning programme-goal methods of management in scientific and technical progress are given. Problems of control for technological processes are analysed. It is shown in this report that the main prerequisite for effective introduction of automated control systems for technological processes is the perfection of the technological basis meaning passing on to few-operations technologies and to continuous processes. A number of questions considered in the report are presented as problematic and this, in the writer's opinion, would be conducive to a live discussion at the Congress.

Résumé

Le rapport envisage les particularités d'investissements dans la construction moderne et les problèmes de gestion qui sont liés. On examine les questions relatives à l'intégration et à l'harmonistation des formes institutionnelles, en marquant les étapes d'intégration et les tendances, qui prédominent dans l'amélioration des formes institutionnelles de gestion en URSS et dans les pays socialistes. A cet égard, on expose une nouvelle conception des spécialistes soviétiques, basée sur la théorie des systèmes fonctionnels. Le rapport traite égalemant les problèmes de la planification avancée dans les conditions du développement d'intégration. L'auteur expose ses idées sur l'applicationdes méthodes de programmation orientée à la régulation du progrès scientifique et technique dans le bâtiment et examine les problèmes du contrôle des processus technologiques. Il démontre que la condition essentielle d'une introduction efficace des systèms informatisés de commande des processus technologiques consiste en amélioration de la base technologique des opérations (passage aux procédés continus et aux technologies, qui exigent moins d'opérations). Certaines questions du rapport sont considérées d'une manière problèmatique, ce qui, selom l'auteur, devra animer la discussion au congres.

In the Soviet Union, the problem of capital construction is an object of an incessant and prime concern. For the last decade this important and key industry of the country's national economy has undergone considerable qualitative and quantitative changes. The investment in building has acquired peculiarities which gave birth to the need for new solutions for organization and management problems.

Projects under construction have, to a large extent, become complicated which stemmed from the introduction of more efficient technologies into industry and from the growing functional requirements for house- and public buildings. Projects themselves have increased in constructional volume which resulted in the prolongation of the investment cycle.

In the country building has been transformed into a largescale machine industry the sphere of which involves numerous specialized building erecting, research and design bodies, thousands of enterprises producing building materials, ready-mixed concretes, reinforced concrete members, steel structures, and other building components. Building has strong ties with the suppliers of machines, electronic equipment, chemical materials and other most varied kinds of products manufactured in the country.

The scientific and technical potential of the industry has snowballed for the last years. It shuld be attributed to a wide application of fundamental science concepts and an active migration of scientific and technical achievements, gained in such leading industries of the national economy as chemical, engineering and electronical industries, etc. into the building industry. It is becoming more and more evident that the further development of this big and complex sector of the national economy is not possible without availability of a perfect system for construction organization and management.

In this report the following essential, in our opinion, aspects of the management problem are considered: perfection of organizational forms for management in building, longterm planning, control of scientific and technical development and control for technological processes.

Perfection of organizational forms for management in building

Building is a complex hierarchical system the viability of which greatly depends on the degree of perfection of organizational forms for management.

The organizational forms for management in building are characterized by the harmonization of the two contradictory trends: to differentiation and to the purposeful integration.

While the differentiation is ensuring rational division of labour in management and production sphere, the active integration is providing unity of organizational relationships working for the achivement of final goals and, therefore, should be considered as a main management task. The differentiation in building production takes the form of internal and external industrial technological specialization.

Inter-relations between the organizational system and the outside environment encompass co-operation with design institutes, clients, sub-contractors, suppliers, transportation bodies, etc. Participant organizations, under differnt authorities, might pursue their specific local objectives and incentives, often differing from the goals of general contractor.

The most vital means for weakening the general contractor's dependence on participating and co-executing bodies, belonging to other departments, is an integration within one organizational system. Combining successive steps of work, fulfilled by bodies under different authorities, within the bounds of an actual production system could be the first stage of vertical integration (still informal). This stage is characterized, besides a steady cooperation of bodies under different authorities, by a higher level of the external technological specialization and higher performance indices for specialized organizations. At the same time, the participant organizations could have contradicting aims. But, in spite of this, such production systems ensure more efficient achievement of final goals. In the Soviet Union and other socialist countries, taking into account progressiveness of the integration process, a great importance is attached to the creation of effective industrial building enterprises having organizational structure facilitating the effective achievement of a final target of the investment process - the most rapid putting into operation of manufacturing capacities and projects at minimal expenditures of material resources [1].

The formal integration of industrial bodies (industrial vertical integration) is ensuring unity of technological process, transformation of the external technological specialization into the internal one, and unity of participants' goals. Additional integration with design and research bodies guarantees shortening of the «planning – construction» period, eliminates the possible obsolescence of design solutions, raises scientific and technical level of integrated technological process.

In total, the vertical integration is providing the integration of technical ideas, design-technological solutions and of technological processes as well as the effectiveness of the achieved final industrial and social objectives. It is promoted, to a great extent, by weakening of the dependence of the integrated organizational structure on the bodies frome the outside environment.

It is appropriate to mention here that westworld experts, while analysing the dependence of the organizational structure on the outside environment, besides clients, suppliers and co-executors, consider inter-relations with the proprietary forms for means of production, relationships with trade-unions and competitors controlling resources and markets. Conflicting relations between partner organizations often have an antagonistic nature and induce tension in the management sphere. In this case, the main motivation for the behaviour of the leaders of organizations is to avoid dependence on other organizations or make them dependable.

With the socialist system of economy, means of production are the state property, the centralized planning eliminates competition and struggle for markets, all organizations participating in the investment process have equal responsibility to the society. Therefore, inter-dependence of bodies participating in the building process is mainly of organizational and technological nature, and under conditions of vertical integration, weakening of dependence factor raises the organizational level of a combined group of industrial units. This promotes constructive business relations between direct participants in construction and contributes to an effective achievement of final objectives in the national economy development.

The integration process in building has posed some specific problems. Since integrated organizational structures, before being combined, were under different authorities and in their activity pursued their appropriate aims, there has emerged a need for the change, at all the levels, to a new division of labour in the whole organizational and technological process. Thus, for example, aiming at high productivity of certain bodies, performing with narrow specialization, independent of the general efficiency in achievement of final goals, has no sense. Therefore, already at the stage of industrial enterprises combining, measures are being taken for maximum integration of technological processes and for reduction in failures at the junctions of specialized works.

The use of computers raises specific problems. Functional services, having high portion of procedures apt for computer usage (services A), tend to centralization and integration on the level of a combine. The specialization of the functional services A, in its traditional conception, is lowering due to the integration since the personnel of integrated services is specializing for automated methods for solving problems of information collection and analysis for manaerial purposes. Computer capacities allow to rapidly get the necessary and relevant information, therefore, personnel of such services aquire comptence for a wide range of questions.

A debalance arises between the services A and functional services working by traditional methods (servicesT). The latter have to considerably increase their effectiveness owing to the personnel growing in number and by raising level of specialization. These conditions are imposing the need for integration of services A and T on the basis of their balancing and proportionality [2].

The integration process, encompassing all activity spheres of organizational structures, is, for building, of particular importance because of the territorial dispersion of projects, ever-changing variety of technological process alongside with the mobile nature of means of production and a large number of participant organizations from the outside environment. The role of integration in building is particularly great, unlike to other industries, in view of providing unity for technological process.

The integration process and organizational forms of management in building are periodically undergoing qualitative changes. The evolution of the integration process in construction in the Byelorussian SSR is shown in Fig. 1.





^{--- -} dominant tendency of the organizational development in construction

Fig. 1.

The pattern of the organizational development of construction in the Byelorussian SSR.

The stage A is characterized by the existence of general contract bodies, having low capacities and comprising enterprises technically under-developed and fulfilling all kinds of building works. A low level of external technological specialization was typical for this stage. A wide network of specialized bodies has been developed, technical equipment has improved and the level of the external technological specialization in the industry has been steeply rising (sub-stage B-1) with the establishment, in the republic, of the Ministry for Assembly and Special Construction Works at the end of the 1960's. Formation, in the regions, of the groups comprising specialized adequately productive and technically developed organizations and steady co-operation with general contractors have led to the creation of inter-departmental actual industrial systems - informal vertical integration (sub-stage B-2). Organizational forms, stipulated by a high level of the external technological specialization in the conditions of the informal integration, provide achievement only of a certain level of labour productivity [2].

The further stage of organizational and technological development in construction coincides with the creation everywhere of industrial building combines in the conditions of formal vertical integration (C-1). Combining with the planning and research bodies, providing unity of a chain «research – planning – construction» (sub-stage C-2), is expedient only after the integration of technological process.

The increase in the degree of reliability and quality of the technological process control (sub-stage C-3) is acquiring a particular importance at the successive stages of development of integrated organizational forms. Since the reliability and quality of technological process control are strongly dynamic and unsteady parameters and are highly susceptible to the influence of casual factors there emerges the pressing need for effective operative control of

technological processes, directed to the well-timed prevision and prevention of crucial situations.

In this connexion, a new original system of operative data filtering has been developed at the Byelorussian Research and Design Technological Institute of Organization and Management in Building subordinate to the BSSR Gosstroy (the BSSR State Committee on Building). The system allows to use computers for selection, ordering and visual presentation of useful information for decision-making preventing crucial situations. Results of a test run of the system have confirmed the expediency of its practical application and prospectiveness of its further development, creating basis for the automation of decisionmaking procedures.

The demand for flexibility and dynamics in decisionmaking is getting stronger with the investment cycle becoming more complex in building. This is, in its turn, impossible without periodical perfection of organizational structures. Search for local ways of the solution of this problem, based only on common sense, intuition or traditional notions, does not always lead to positive results. Therefore, many specialists are concentrating their efforts at the creation of the theoretical bases for planning organizational structures in building. Moreover, the system approach to the solution of the problem is gaining evergrowing recognition.

In this context, the studies being undertaken in this country and devoted to the development of the theory of planning of building bodies, are of undoubtful interest. The methodological basis of the studies mentioned above is the so called theory of functional systems, developed in the Soviet Union as far back as the early 1930's. This theory founded on the analysis of biological systems is known to be used widely enough both in the USSR and abroad for the solution of organizational and technical problems in industry. The concepts of this theory are realized to a smaller degree in building.

Meanwhile, biological systems could be considered as a kind of ideal analogues for the creation of organizational building systems. The matter is that flexibility, reliability, adaptability, etc., just the qualities indispensable for reliable functioning of building organizational systems, in biological systems, have been developed up to an unattainable organizational perfection. The reliability of a system is meant to be provided not by the substitution of the «unreliable» or reservation for failing units but by the ability of units to transform with the change of conditions in which the system is functioning, aiming at safe provision of the prescribed result. There is no doubt that the above mentioned concepts, applied by Soviet experts for perfecting management in building, are very challenging and promising.

Problems of complex long-term planning

The integration process, taking place in building in the Soviet Union and other socialist countries, is imposing specific requirements for planning as one of the most important functions of management. In particular, it has put forward the need for developing common long-term plans for large building bodies. Up to now, the work has been carried on the solution of particular planning problems in the field of current planning which should guarantee balancing and time-dependent synchronization of building processes, involving erection and fabrication of building components at the big building enterprises, with regard to limitations in resources consumption. The work is, at present, going on the creation of adequate models of planning and management for building bodies, encompassing all building production processes and basing on imitation models and the use of modern technical means for data processing. Long-term plans defining strategies and proportions of the economy development and creating conditions for functioning of enterprises not financed by the state are the main forms of planning of the economy having centralized management. In market-economy countries, the methodology of prognostication founded on the extrapolation of formed tendencies is widely used. However, this methodology is unacceptable for socialist countries since there the bulk of building materials production, choice of alternative technical solutions is subordinate to long-term goals of the society but not to the spontaneous market forces of to-day.

The system of long-term planning of building industry development for the economic region (republic) has been elaborated at the Byelorussian Research and Design Technological Institute of Organization and Management in Building in co-operation with the Research Institute of Building Economy subordinate to the BSSR Gosstroy for the realization of functions of normative prognostication identical, in its essence, to the long-term planning. The linear economic-mathematical model for the construction complex of the republic is a central unit of the system. The model expresses inter-relations between different factors determining the trends of scientific and technical progress in building, and the development of its industrial base, namely: possible interchangability of technical solutions, availability of material and labour resources, capital investments, time-dependent wear and reproduction of funds, planned targets and their priorities, technicoeconomical indices of different units of the model, prescribed optimum criterion.

It is possible by this model to calculate the optimum variant of building development trend in the republic for the given limiting conditions and optimum criterion. For this, application level of some spatial lay-out solutions for various buildings and structures and design solutions for their structural units, balances for consumption and production of building materials and components, capacity usage balances, bulks of capital investments by kinds of reproduction are determined for each time interval of a planned period. Besides, each variant contains a number of indices for economical analysis of the calculated plan. For the present, the long-term planning system has been approbated for solving a number of particular problems but it is intended for application in planning of the development of the whole building complex in the Byelorussian SSR.

Management in scientific and technical progress

Scientific and technical progress is giving new possibilities for the production management perfection. It is inevitably becoming, in its turn, an object for management since rate and trend of its evolution depend on the degree of perfection of management.

In this connexion, the problem of management in such an important sphere of human activity as science and technics is acquiring prime importance.

The system of management for research and design works has been elaborated and is efficiently functioning in the Soviet Union [3]. The system forsees:

- scientifically justified choice of main trends for scientific research with regard to the prognosticated development of industry and achievements of fundamental and applied sciences;

- programme-goal method of management for technical development of industry or one of its branches. This method implies developing of complex measures for the most effective implementation of scientific and technical ideas, beginning from research, experimental and design developments and finishing by the introduction of the results into production process;

- further development of the management system in technical progress meaning the perfection of methods of planning for technical reorganization of the industry, perfection of statistical reports in the sphere of science, improvement of parameter control of technical systems, information provision, performance indices for research bodies, etc.;

- perfection of the managerial methods for educating and testifying scentific staff with regard to the long-term demands of the industry. The Soviet system of testimony for scientific and educational staff has sufficiently provided all industries of the national economy with specialists of high qualification. At the same time, this trend has its own problems. In particular, the system of planning and bringing-up of brainpower should be improved through the creation of the appropriate information systems, including the state data bank comprising information on the themes of these, results of their introduction into practice, on the work of specialized councils, etc.

These and other aspects of management in scientific and technical progress could also be referred to building which in spite of its stochastic and often spontaneous character of the development is following, in the main, the evolution of other industries of the national economy. Thus, for example, development tendencies of the industrialized house-building are, to a large extent, identical to the tendencies observed for the machine-building industry (orientation to large industrial combines, conveyerization and automatization of production, manufacture of fully-finished products, etc.).

Automated control systems for technological processes

Effective management of material production demands managing actions at all levels of a managed system. The control for technological processes is a lower and determining level of such a system.

The so called automated control systems (ACSTP) for technological processes are being actively developed in the Soviet Union. These systems, with the use of computers and means of automatization, ensure not only the control of technological process with regard to technical norms for products and plan requirements but also the run of the process at an optimum rate with the maximum attainable productiveness and quality for the given technological level.

Such systems are most successfully introduced at enterprises where continuous technological processes are predominating, f.i., in chemical, electronical and metallurgical industries.

As far as building is concerned, discrete processes are typical there. Therefore, automated control systems for technological processes in construction are used mainly at the industrial building enterprises and ready-mixed concrete plants where the nature and sequence of technological processes are more apt for automatization. At the same time, a number of research institutes and design-technological bodies in the country have got down to elaborating the ACSTP for direct use in the construction of buildings. It should be noted that, besides direct economic effect, introduction of ACSTP contributes to the growth of the total technical level in building. The matter is that the development of a system for automated control should be necessarily preceded by a definite normalization of the technological processes which often are under the yoke of technological heredity. In this case we mean not only the adapting of processes for algorithmization and the realization of statistical control of a process by extremum or adaptive algorithm but also bringing the processes to a continuous nature. Bringing processes to confirmity with modern scientific and technical means is an obligatory condition. Otherwise, the question is, according to the assumed by the Soviet specialists terminology, about the growth of technological reliability of the building production. The method of conveyer assembly of roof structures for industrial buildings created in the Soviet Union, might be referred to as an example of such technological normalization. This method, applied with success at the construction of large industrial enterprises, consists of the following: 60-120t large structuraltechnological blocks made of two girders, roof structures and suspended communication units, are assembled on a special conveyer and then mounted into a design position. Thus, the erection process for roofing buildings, earlier comprising discrete and difficult for automatization operations, has transformed into a continuous assembly process. And this, in its turn, gives birth to actual opportunities for introduction of automatization, having programme control, into the construction of industrial buildings.

The conveyer manufacturing of reinforced concrete panels for house-building, developed in the Byelorrussian Soviet Socialist Republic might serve as an example of realistic approach to the creation of automated control systems for technological processes. Denying the traditional multiple mould methods of panel fabrication, the specialists have developed a new highly productive fewoperation method of non-vibrational panel fabrication in special moulding machines, using the effects of the hydrodynamic compression and vacuum treatment.

Thus, not only definite technological operations have been automated but also the opportunities for automated control of the whole process have been created by shifting to the few-operations technology and bringing the process to a continuous nature.

Speaking to the point, the principle of passing on to technologies, having few operations, by the improvement of the main operation is, in our opinion, just the technological target to be got for ensuring most full realization of all advantages provided by automated control for building processes.

We think that wide introduction of automated control systems for technological processes into building should be accompanied by the solution of the following problems:

- perfection of technological processes by the use of fewoperations technologies through the improvement of the main operation and perfection of methods of technological process algorithmization at all the levels of formalization – from the development of a controlled technological process to the programme provision for the whole system. All relationships and peculiarities borne in actual technological systems should be taken into account in the mathematical description of the process;

- development of convincing enough criteria for evaluation of the ACSTP effectiveness. In the general case the effectiveness factor shows the degree of approximation to the extremum of the goal function, technical characteristics (parameters) of a controlled system are taken there for arguments;

- creation of programme-controlled manipulators especially for building. It could be supposed that the use of the simplest robots having 2–3 degrees of freedom would be economically justified, in the nearest future, for automatization of elementary processes taking place in the environment harmful for a human being or for operations in storehouses.

References

1. Evtuch V. G. Organizacionno-technologicheskie osnovy formirovania struktur proizvodstvennych objedinenij. Minsk, 1979.

2. Latchkov S. A. Organizacionnye struktury v uslovijach funkcionirivania ASUS. Paper presented to the Belorussian Technical Conference. Minsk, 1977

3. Trapeznikov V. A. (editor). Upravlenie nauchnoissledovatelskimi i opytno-konstruktorskimi rabotami. Moskva, 1979. N. Lemunge, general manager Mecco Ltd., Dar-es-Salaam, Tanzania.

Introduction

Although its importance is often underestimated in national economic planning the construction sector is of vital importance in the implementation of investment programmes. The industry serves many valuable functions in society and some of the basic social areas in which construction plays a significant role are housing, industry, education, commerce, utilities and transportation. It is out of this total awareness of the role of the construction industry that this paper attemps to look at the situation of the construction industry in Tanzania and in particular examines the problems of construction management and the ways they impede efficient implementation of projects as well as the application of science and technology for development. It is important to point out at the very beginning that contrary to general belief in Tanzania, management of construction is not limited only to the activities of the contractor, but engulfs all the activities from project conception, financing, design and consultancy, construction to commission and maintenance. It therefore demands not only a clear understanding of the country's policies and development plans but also the institutional arrangements and co-ordination between the various sectors. Using this conceptual framework, it becomes quite clear that there are many interrelated and interracting problems and relationships within the entire matrix of the construction process which demand systematic co-ordination of the various linkages of the construction chain so as to ensure that the construction industry is developed and functions in accordance with the declared government policies. Though the paper focuses on Tanzania, it must be borne in mind that the construction industry is guite complex and the exact situation differs from country to country but even in this complex situation there is ample room to learn from the experiences of others particularly so among the developing countries.

Construction Policies

Prior to independence in 1961 the construction industry was left open to the capitalistic market situation obtaining at the time. In 1967 the Arusha declaration was published. This declaration is the blue print for socialist development in Tanzania. The declaration stated clearly the government intention to place the major means of production under the control and ownership of Tanzania's people. Consequently policies for the construction sector were also formulated. First, the aim of the government is to try as hard as it can to use public institutions for construction works so as to eleminate exploitation by groups or individuals. Secondly, to distribute capacities for construction, construction materials, and technical support more evenly over the country. Thirdly, to establish control measures that will regulate the industry particularly as applies to the development of construction costs, quality of design and workmanship, as well as promoting efficiency and productivity. To achieve the above objectives, institutions have been formed. There are technical ministries, a faculty of engineering was established at the University of Dar-es-Salaam in 1972, Technical Colleges have been established, so also have trade schools, a Building Research Unit, an Ardhi Institute offering diploma course in Urban and Rural planning, design and housing management among others. Parastatal firms dealing in feasibility studies, design and consultancv. and construction have been formed. Ministries directlabour construction units have been formed in every district. Despite all these measures the construction industry has not been quite up to expectations and has come to be regarded as one of the problem sectors of the economy. The industry is now characterised by price escalations, lack of interest for tendering, delays, quality deficiencies and lack of impact in using known technologies and research findings to improve rural housing.

Construction Volume

Despite of the general recession in the world today caused mostly by the rise of oil and commodity prices, in Tanzania, the volume of construction activity continues to grow as the government is eager to develop the basic infrastructure for economic take off. Most of the activity is in the civil engineering side - roads, harbours and hydro-electric projects. As regards housing most of the avtivity is in the construction of non-residential and industrial buildings. Available statistics show that in 1975 total investments in construction constituted about 11% of the Gross Domestic Product and about 44% of the Gross Capital formation. At present about 18% of the employed population of Tanzania are engaged in the construction sector. In monetary term 40% of the development funds for the current Third Five Year Plan is spent on construction. This works out into a figure of more than T.Shs. 1.5 billion annually. For a developing country, this is a lot of money. It is out of realization of the magnitude and importance of the industry that an important study regarding the Tanzanian Construction Industry was commissioned by the Government in 1977 to look into the capacities of the construction sector starting with the capacities of public planning and control, design and consultancy, building materials, site production and manpower.1 This kind of study is essential to Tanzania because

¹ Local Construction Industry Study, led by H. P. Sundh of the Norwegian Building Reasurch Institute. The study came up with a lot of facts that are now being used by the government in formulating policy solutions for the future.

the government and its parastatals is the major investor in the construction industry accounting for about 80% of the construction volume. This almost monopolistic situation, one would expect, would make it easy for control mechanism to monitor construction costs as well as to plan and co-ordinate the essential inputs for the industry. Unfortunately as the study revealed, the organisation and management of construction is very much split up in Tanzania and at the various stages of the construction process there are very many serious bottlenecks that jeopardise meaningful development of the industry.

Public Planning and Control

Starting with public planning and control the situation is extremely confusing. At present, planning and control in matters of design control, building research, building regulations, tendering regulations, and training of the construction cadre are matters of divided responsibilities among many public institutions and Government departments and there is little co-ordination among them. As a result our planning and building laws and regulations are inadequate and in some cases totally irrelevant. Some of them, for example the «Township Building Rules» were prepared in 1930, have not been up-dated, and cover technical matters in a very shallow way. Further, within the industry, a kind of technological dualism has developed and continues to exist. While on the one hand institutional housing (e.g. schools, hospitals, hotels), industrial and commercial buildings in the urban areas have certain standard specifications of construction which take into consideration public health and hygiene aspects among others, on the other hand, traditional housing in rural areas where 90% of the population lives have been left completely in the oblivion. The industry is therefore developing on two quite different levels. The first is the formal sector of the construction industry, the one run by professionals on a high or conventional technology level and the second is the low-technology or indigenous skills own account construction for the masses. While there exists therefore at the rural level a serious demand for new technology for improving the traditional house, current research findings do not also reach the target group, the individual house builder.

Design and Consultancy

Implementation of construction projects commences with design. At present most of the design and consultancy firms are foreign based and owned, with a small branch office in Dar-es-Salaam which quite often is a subbranch of a branch office in Nairobi, Kenya. Quite a lot of work is channelled abroad by the Dar-es-Salaam subbranch. No wonder design and consultancy costs now account for about 14% of the total cost of the average structure. In the absence of design control, as mentioned earlier, the reliance on expatriate designers from different parts of the world results in the adoption of too many design standards. This has an adverse effect on the cost of projects, for quite often these designs tend to have a disproportionately high import content in terms of materials, fixtures and equipment. The Tanzanian client, in our case mostly the public sector, suffers costs in four distinct ways: –

First a costly design which results in a realitively costlier building; secondly a high import content built in which erodes further the already meagre foreign exchange of the country, thirdly he gets an inappropriate structure in terms of social and weather conditions, and fourthly he loses the opportunity of developing local talents and local materials. This last cost is quite serious, for while there is a shortage of local engineering manpower both trained and untrained, the foreign consultancy firms get compelled to carry out most of the planning and design work outside Tanzania, and in so doing their local office in Dar-es-Salaam is left desparately understaffed for any major engagement. Indirectly, this state of affairs leads to a more serious situation whereby no training whatsoever accrues to the young engineer wishing to gain practical experience in the country. As will be shown later, the building materials industry is very much underdeveloped in Tanzania. The development of local materials industry could very well be stimulated at the design stage if the designers were sensitive enough to the country's economic, social and political situation.

The client, in this case civil servants and parastatal executives, are also not free of blame. They have adhered rather too rigidily to the traditional way of managing projects whereby for any given building contract there must be an architect, a consulting engineer, a quantity surveyor (client's agents) and the main contractor supported by the various nominated and domestic sub-contractors. Often each party is a separate legal entity on its own right and each party is mostly interested only in its part of the project. This situation tends to erode any meaningful total project appraisal. This situation has also somehow blocked entry into the Tanzania Construction Industry of such things as, standardization, dimensional co-ordination, «Professional Construction Management Services»,1 Turn-key contracts, or Industrialized Systems Building (ISB). It is often stated that repeated failures and waste mark the record of ISB in most poor countries.² It is the writer's belief that given the on-going research on local building materials e.g. sisal reinforced concrete ISB can be a definite competitor to conventional handicraft building methods. As regards standardization the present state of affairs should no more be tolerated. At present there is a proliferation of differently edited and phrased tender and contract documents which vary from client to client and from consultant to consultant. This situation

¹ For details on Professional Construction Management Services see Vol. 105 No. C02 June 1979, Journal of the Construction Division, Proceedings of the American Society of Civil Engineers.

² Strassman, Housing and Building Technology in Developing Countries, MSU International Business and Economic Studies.

creates a lot of uncertainties which compel contractors to enhance their prices to cover for such risks. It is the writer's view that standardization is now of paramount importance to Tanzania which is now gradually building up a building materials and components industry. Standardization is often advocated as primarily a tool for large scale production and in so thinking it is often overlocked that standardization is also an indispensable tool for small scale production. The only way to co-ordinate the products of small scale industries, spread out all over the country, is precisely through standardization. However experience gained on construction sites in Tanzania shows that what is also urgently required is international standardization. In Tanzania we import a large number of building materials from all over the world, and the lack of dimensional co-ordination in these products is at times a source of waste and delays in finishing up building projects.

On-Site-Construction Management

The construction industry is traditionally split into two main sectors and each sector has its own characteristics as to the demand for labour, equipment and material in-put. Civil engineering works put more demand on equipment and spare parts. The building sector demands a lot of specialised and diversified building products and less machinery. In Tanzania most construction projects are carried out by mostly private contractors through competitive tendering. There are about 350 registered contractors in Tanzania but only about 10% are registered in Class I, that is those capable of handling single contracts excess US\$ 3 million. But even out of these major contractors, most of them take on mostly building works which as mentioned above require less machinery. Most of the civil engineering works are almost exclusively taken up by foreign contractors who have both the construction equipment and the know-how. Even then foreign contractors who respond to bids for civil works are very few. For medium and large projects there is therefore a shortage of construction capacity. Consequently competition has been low and this has led to high pricing and high profit margins. This in turn has to some extent led to lack of incentives for improving performance and labour productivity. It is not easy to diagnose the real causes of this situation, but some observers claim that there is too high a degree of uncertainty prevailing in the industry. First it is said there is uncertainty about private contractors' long term survival in a country aspiring to become socialist and self-reliant. In fact in a recent ILO brief survey of the situation some private contractors pointed out that their profit margin was of the order of 15% to 20% but for lack of long-term perspective the profit is not plouged back into the firm but instead is invested in capital assets such as hotels. Secondly there has been uncertainty about supply of construction materials and spare parts caused by the shortage of foreign exchange.

The general policy of the Government towards the industry is that, eventually, it should be totally under public control. Whilst the Government is firmly committed to developing the public sector, there are serious obstacles to achieving this objective. Foremost among these is the acute shortage of qualified and experienced manpower, and the lack of incentives. At present there is only one contracting parastatal, MECCO, with an annual turnover of T.Shs. 200 million vying with the large army of private contractors.

As regards construction site management the situation is also quite discouraging. Site management and organisation is poor, lacking serious work schedules for day to day planning and project execution. In many cases critical activities are not identified, thus leading to overall delays in project execution. The problem here is the lack of experienced site supervisors. It is interesting to mention however that even on building sites where European expatriate Project Managers and Site Supervisors have been employed the situation is no better. It appear that problems pertaining to on site construction management and technology are quite many and complex and there is no easy solution to any one of them. Some of the problems observed on site are centred mostly on:

- (a) Poor site organisation materials e.g. concrete blocks are stacked too far, unco-ordinated flow of work and others that lead to too much needless waiting, walking about, or other activities that fail to make the building grow.
- (b) Poor usage of labour often gangs are too big and there is overcrowding; a «skilled» worker often has two helpers (unskilled) but in terms of skills there is actually little difference between the three.
- (c) Underutilization of equipments and tools. There is a general tendency on site to use hand labour even though equipment capable of doing the work is available at site. On one site, excavated soil from foundations was removed from the site by using wheelbarrows even though the site had a tractor shovel. Often there is unnecessary re-planing by hand on site of timber that has already been machine planed. Quick check shows that this results from poor handling of the planing machine. Simple adjustments of the planing machine and sharpening of knives could completely eliminate the site hand planing. The tools used on site e.g. carpenter's tools and mason's tools are generally owned by the workers themselves, and many cannot afford a good set since wages and salaries are fairly low. If the contractor provides the tools, somehow they disappear fast from the site.
- (d) People are used of doing certain things in certain ways and will always do them the same way e.g. process of laying concrete blocks, of applying plaster, of painting etc. Experience has shown however that our people are quick to change and adopt new techniques when taught; but the problem is who will teach them?

(e) Shortage of Building Materials

The shortage of building materials is a serious problem and accounts for most delays in the implementation of projects. At present there is only one cement factory which is completely unable to cope with the rising demand. Two more factories are under construction. Even with the completion of these new factories, the problem may remain the same in several parts of the country since the transport network is very unsatisfactory. A lot of materials is imported e.g. glass, sanitaryware, iron-mongery, electrical installations etc. Steel though locally rolled does not always pass the specified tests. Thus while there is a shortage of this and that on site, the workers also feel no need for hurry, and thus productivity is low.

On could make a long catalogue of problems encountered on construction sites, but this approach does only show what the situation is like. What is urgently required is a systematic approach to improve the situation. It is the writer's view that time has now come to institutionalise construction management training. It is not enough to setup vocational training schools. It is also not enough to believe that individuals will pick the supervisory and managerial skills at random through long stay in the industry. The construction management course now conducted at the University of Dar-es-Salaam as one subject in the Civil Engineering course is also underdeveloped and in any case is only a rudimentary introduction to the subject. The East African Management Institute, which has recently been given a mandate to serve 17 countries in East and Southern Africa has through assistance from ILO and ISDA conducted some short-time workshops on construction management, but these workshops have been for too short a time and not well co-ordinated with actual field situations. It is exactly in this field that I think international research institutions, and many other research institutions in the advanced countries could be of great assistance to us. In Tanzania and indeed in most African States there is an acute shortage of Engineers trained in modern management techniques; an acute shortage of funds for research work, an acute shortage of scientific and research personnel, an acute shortage of links between resarch workers and the users of research results for translating the research results into practical application. In the advanced countries there is an immense amount of scientific and technological information which is of direct relevance to our situation e.g. cost-reducing innovations in building technologies, use of local materials in building, modular co-ordination etc. but such information and know-how is often not easily accessible to African countries. It is obvious therefore that there is ample room for cooperation in the field of technology transfer.

Conclusion

The paper paints a rather grim picture of the construction industry in Tanzania. In an international gathering like this one it would be good to compare the situation with other developing countries. It is encouraging to mention however that in Tanzania, those responsible for managing construction are aware of the situation. The new concept of SfB Tables as a tool for the

management of civil engineering projects.

Per L. Berge,	graduate engineer, manager
	Construction Department, NORCEM A/S
	Norway.
Ragnar Hansen,	graduate engineer, consulting
	engineer, project management,
	Norway.
Bjørn J. Nielsen,	graduate engineer, chief engineer,
	Oslo Municipal Roads Department,
	Norway.
Thorleif Sagbakken,	graduate engineer, chief engineer,
	State Roads Department, Norway.
Janusz Ziolko,	graduate engineer, consulting
	engineer, project management,
	Norway.

Application problems in Civil Engineering

When applying the three SfB Tables in the management of civil engineering projects, some problems arise as one discovers that the SfB classification tables are especially tailored to such objects as buildings and houses, and the most commonly used building elements within civil engineering are not covered by the tables, e.g. the body of a barrage, the body of a roadway with its foundation and superstructure, a retaining wall, a bridge head, a tunnel etc.

After having worked with these problems for some years on real projects, the authors suggest redefinition of some of the coding symbols to make the classification tables compatible with the problems of civil construction works.

Interpretation proposals in the 1st facet

The problems of the lst facet are proposed solved through applying the standard codes on the principle of analogy. This means that a barrage would be considered to maintain the function of a wall, and thus be coded as such (21) or (22). A retaining wall will fall into the same category. A roadway may be considered to be composed of a foundation, carrying a floor, which again is covered by a floor finish. All these concepts have their code symbols in the existing SfB Tables. What is needed, is a wider interpretation of the expressions used. It may also be practical to introduce a "parallel" table which carries expressions which cover the existing table, but which allow for this wider interpretation.

Interpretation proposals in the 2nd facet

If a new interpretation of the tables may solve the problems of furnishing symbols for a lst facet coding of the examples mentioned, what about the 2nd facet in the case of a barrage or a roadway?

The 2nd facet table does not have the same problems as the 1st facet as the construction works used in civil engineering are much the same as those used in traditional building. The tables has one exception through, namely in the field of earth structures.

In the existing table, work on earth structures is generally interpreted as excavation works before the "real construction" starts. In the field of civil engineering, however, a very large part of the costs of the project is connected with permanent earth structures, and this construction form is used in the same way as concrete or block constructions.

The traditional earth works, however are necessary as a part of "intermediate" structures (code D), and it is proposed to maintain the existing symbol C, and in addition introduce the symbol Q to cover permanent earth structures.

Table 3

The SfB Table 3, which defines resources, requires no modifications as it covers all resources needed in Civil Works.

Literature:

B.J. Nielsen, T. Sagbakken, F.L. Berge, J. Ziolko and
R. Hansen: Illustrert aktivitetstypekatalog for
anleggsprosjekter. (Illustrated Activity Type
Catalogue for Civil Works).
SfB anleggskomiteen av 1974, Oslo 1979.

Bjørn Bindslev: Data-koordinering i byggeprocessen. (Data-coordination in the building process), Nyt Nordisk Forlag, Arnold Busck, Copenhagen 1973.

J. Ziołko, B.J. Nielsen and P.C. Dahl: Quelques
resultats obtenues en Norvege dans l'application
d'ordinateur la coordination du proces de construction.
CIB Report 13 B, NBRI Report 57 B, nr. 6.15. - 1968.

557

X

SfB Tabl	SfB Table 1 - application on civil engineering projects			SFB A	SFB ANLEGGSKOMIT	
<u> </u>				SJART	, TUNNEL	
(0-) CC	ONDITIONS					

(10) (11) (12) (13) (14) (15) (16) (17) (18) (19) (1-)	GROUND, EARTH SHAPES SHAFTS, TUNNELS FLOOR BEDS FOUNDATIONS FILE FOUNDATIONS GROUND REINFORCEMENT SUBSTRUCTURE	(50) (51) (52) DRAINAGE, REFUSE (53) DISPOSAL WATER (54) GAS (55) (56) (57) VENTILATION (58) (59) SERVICES (5-)
(20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (2-)	WALLS COLUMNS FLOORS, BEAMS, SUPERSTRUCTURE STAIRS, RAMPS STRUCTURE	(60) (61) ELECTRICAL CENTRE (62) (63) LIGHTING (64) TELECOMMUNICATION (65) (66) (67) (68) (69) EL. SERVICES (6-)
(30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (3-)	FLOORS' COMPLETIONS, GRATES STAIRS' COMPLETIONS, RAILINGS COMPLETIONS	(70) (71) MARKING (72) (73) (74) (75) (76) (77) (78) (79) FITTINGS (7-)
(40) (41) (42) (43) (44) (45) (46) (46) (47) (48) (49) (4-)	WALL FINISHES COLUMN FINISHES FLOORS TINISHES STAIR, RAMP FINISHES EDGE FINISHES FINISHES	(80) (81) (82) (83) (84) (85) (86) (87) (88) (89) (6-)
		(99) TOTAL WORK

ILLUSTRERT AKTIVITETSTYP SFB ANLEGGSKOMITEEN AV 1 SJAKT. TUNNEL	EKATALOG 974	SIDE 2 78-12-01 (12)
	(12)A .0000	PREFAB. AV FORSKALINGSELEMENTER) TIL UTSTØPNING AV TUNNEL
	A3.0000 A5.0000 A8.0000 D5.0000 I0.0000 I4.0000	RESSURSPLANLEGGING) PRODUKSJONSSTYRING) PRODUKSJONSKONTROLL) ANBRINGELSE INKL. HJ.M. 1 TRE: ALMENT 1 LAMINERT TRE)
	(12)C .0001	FULLPROFILBORING AV TUNNEL
	A3.0000 A5.0000 A8.0000 B4.0001 C4.0000 D6.0000	RESSURSPLANLEGGING PRODUKSJONSSTYRING PRODUKSJONSKONTROLL BOREHASKIN FORMGIVING FERDIGGJØRELSE INKL. HJ.M.
	(12)C .0002	SPRENGNING AV TUNNEL
	A3.0000 A5.0000 A8.0000 D4.0000 D6.0000	RESUBSPLANLEGGING PRODUKSJONSSTYRING PRODUKSJONSKONTROLL FORMGZVING INKL. HJ.M. FERDIGGJØRELSE INKL. HJ.M.
	(12)E .000]	UTFORING AV TUNNEL MED PLASS- STOPT BETONG
	A3.0000 A5.0000) RESSURSPLANLEGGING) PRODUKSJONSSTYRING

- AS:0000 PRODUKSJONSKINTROLL D5:0005 UTSTØPING INKL. HJ.M. H2:0001 ARMERING Q4:0001 BETONG

SIDE 13 78-12-01

ILLUSTRERT AKTIVITETSTY SFB ANLEGGSKOMITEEN AV	YPEKATALÓG 1974	SIDE 1 78-12-0	.3)1
VEGGER, MURER		(21	.)
	(21)Q .0001	TETNINGSKJERNE I JORDFYLLINGS- DAM))
	A2.0000 A3.0000 A5.0000 B9.0001 C4.0000 C5.0004	PRODUKSJONSPLANLEGGING RESSURSPLANLEGGING PRODUKSJONSSTYRING PRODUKSJONSKONTROLL MASKINUTRUSTNING FORMGTVING UTLEGGING VERDMASE	
	(21)Q .0002	FILTERLAG I JORDFYLLINGSDAM	,)
	A2.0000	PRODUKSJONSPLANLEGGING	·)

0.21	A2.0000 PRODUKSJONSPLANLEGGING
2 2 7	A3.0000 RESSURSPLANLEGGING
ः 🖬 🖓	A5.0000 PRODUKSJONSSTYRING
.	A8.0000 PRODUKSJONSKONTROLL
	B9.0001 MASKINUTRUSTNING
	C4.0000 FORMGIVING
	C5.0004 UTLEGGING
1.	P1.0000 GRUS, SAND
\$ 2.Se.	

(21)0 .0003	BESKYTTELSESLAG I JORDFYLLINGS-) DAM
A2.0000	PRODUKSJONSPLANLEGGING
A3.0000	RESSURSPLANLEGGING
A5.0000	PRODUKSJONSSTYRING
0000.8A	PRODUKSJONSKONTROLL
B9.0001	MASKINUTRUSTNING
C4.0000	FORMGIVING

- - C5.0004 UTLEGGING E9.0000 NATURSTEIN: DIVERSE

SfB anleggskomiteen av 1974

SfB anleggskomiteen av 1974

SfB Table 2 - application on civil engineering projects

Constructions

- A Preliminaries, prefabrication
- B Demolitions
- C Excavations stone- and earth works (interim)
- D Site work (interim)
- E Cast in-situ constructions
- F Block constructions
- G Constructions of prefabr. components
- H Section constructions
- I Pipe constructions
- J Wire constructions
- K Quilt constructions
- L Flexible sheet constructions
- M Malleable sheet constructions
- N Rigid sheet overlap constructions
- 0
- P Thick coating constructions
- Q Constructions of earth and stone (permanent)
- R Rigid sheet constructions
- S Rigid tile constructions
- T Flexible sheet constructions
- U Facing constructions
- V Film coating and impregnation constructions
- W Planting
- X Completions
- Y Constructions
- 2 Production



		_		
_	_		_	
S	100	:2	5	2
	- 14	1	× .	1



The new concept of SfB Tables as a tool for the management of civil engineering projects.

Synopsis

Based on the SfB Tables, the paper presents an activity type catalogue for civil works and explains how the principle of activity type management can be applied in the field of civil engineering.

Une nouvelle application des tables SfB: Administration des projets de ponts et chausées.

Synopsis

Basé sur les tables SfB un catalogue de types d'activitées pour les projets de ponts et chausées est presenté. Il est expliqué comment le principe d'administration des projets par des types d'activité peut etre accompli dans le domaine des grand projets. Management by Objectives - The philosophies and techniques with reference to a case study of its application within a Building Contracting Company

by D. W. Cheetham, B.Sc. Tech., M.I.O.B., Department of Building Engineering, University of Liverpool, England.

Summary

There are many published accounts of the benefits gained by the introduction of Management by Objectives (MBO) to firms engaged in manufacturing industry but none of construction companies implementing this technique. MBO seeks to integrate company aims with management development through a system in which managers set their own targets in consultation with their superiors. The experience of a large regional construction company in implementing an MBO programme is described along with the resulting benefits. The problem encountered in operating the procedures are reported.

Résumé

On a souvent décrit les avantages que des compagnies de fabrication ont obtenus en adoptant la méthode 'Management by Objectives' ('MBO'); ceux qui attendent les compagnies de construction n'ont pas été exposés. La méthode 'MBO' cherche à intégrer les objectifs d'une compagnie au dévelopment des cadres que fixent eux-mêmes leurs objectifs en conférant avec leurs supérieurs. Cet article décrit les expériences d'une compagnie importante de construction qui a mis en application la méthode 'MBO', et examine les avantages qui se sont ensuivis aussi bien que les problèmes que la mise en practique a soulevés.

Introduction

Contracts Managers with reputations for being dynamic appear to do little but drive at great haste between sites and when they alight from the whirlwind yell instructions down the telephone. Site Managers spend much of their day rapidly moving about site solving minor technical problems and issuing instructions. When in the site office they are slaves to the urgent demands of the telephone. Operatives can be promoted to managerial positions without knowing the duties associated with the job. Their only guide being prior observation of others performance. What are they trying to do? They are busy managing!

Every manager should influence events. Unfortunately many managers let events rule them! Managers determine the success or failure of a business. Are they helping the company achieve its goals? Do they know their superiors assessment of their performance? Can they assess their own performance? Companies appraise and assess employees for salary review yet frequently the management employee does not know the criteria upon which he is assessed.

Management by Objectives

The proponents of "Management by Objectives" (M.B.O.) programmesbelieve that participation in assessment leads to understanding of the organisation's goals, a co-ordinated application of the knowledge, skills and experience of employees, a more determined approach by each manager and greater job satisfaction for all concerned.

Drucker (1) introduced the concept of M.B.O. some 25 years ago and since then the techniques have been extensively applied and developed by Humble (2) and others (3)

Humble defines M.B.O. as "a dynamic system which seeks to integrate the company's need to clarify and achieve its profit and growth goals with the manager's need to contribute and develop himself". It provides a system of integrating logical business planning with management appraisal and development. It facilitates the development of managers in line with company objectives, satisfies the manager's needs (opportunity to perform, control information and guidance) and encourages good teamwork. M.B.O. procedures formalise the continuous process of stating and critically reviewing an organisation's strategic and tactical plans by agreeing with each manager the Key Results Areasof his job and the performance standards he should achieve appropriate to company objectives. By measuring and discussing progress towards objectives at frequent performance reviews plans for management training can be developed to help each manager build on his strengths, overcome his weaknesses and accept responsibility for selfdevelopment. Each manager's motivation may be strengthened by effective selection, salary and management succession plans. The inter dependance of these procedures and the dynamic nature of the system can be seen in Figure 1.



The M.B.O. Cycle

M.B.O. provides an integrated system of management development and assessment. If follows a cyclic pattern of Job Analysis and preparation of Job Descriptions, identification of Key Results Areas and the Determination of objectives, performance in the job followed by a review of that performance. Key Results Areas are those activities which occupy a significant proportion of the manager's time. They are those parts of his job over which he can exercise control and is able to monitor progress.



Figure 2. The Management by Objectives Cycle

At the review meeting the manager discusses his progress with his superior. Discussion of past performance takes approximately one third of the meeting and most time is devoted to the manager and his superior discussing his objectives for the future. Obstacles to performance such as lack of information, poor organisation, communications or relationships are considered and the means of overcoming them identified. The job may be redefined. Assessment of performance leads to definition of training needs. The relevance of past training courses will be discussed. The review also assesses potential for promotion, job enlargement may result so the person emcompasses greater areas of responsibility and increased experience. Ideally the job holder takes the initiative and his superior counsels him. Advantages of M.B.O.

The purpose of M.B.O. is not to frighten people into working but to develop them as managers by recognising their strengths and weaknesses. This results in individuals at the same grade working to different targets appropriate to their needs. Emphasis is placed upon management development rather than appraisal though appraisal is a necessary step in determining needs. M.B.O. is only concerned with the past to gather information to plan the future. The interview is for problem solving, the superior looks for ways to help the subordinate achieve better results. Consequently, the performance review does not result in a secret report. This is radically different from traditional appraisal situations when the senior manager judges and unilaterally imposes his goals on each of his subordinates.

The determination of the job description, Key Results Areas and objectives by the manager jointly with his superior establishes understanding between them. Each manager knows that the job he is doing is viewed by his superior in the same manner as he views it. Each knows the basis for appraisal at review meetings. Each knows that the job is being appraised and may be redefined. The subordinate knows his superior's judgement of his performance and they jointly discuss how the job could be done more successfully in the future.

The Role of the Consultant

Determining and recording objectives is difficult to those unfamiliar with the process for objectives must be expressed in an easily verifiable form. It is customary for a consultant to advise those concerned. The consultant also advises the directors on the management structure and relationships between departments. In the company studied, the training officer who had gained experience of M.B.O. in the ceramics industry, acted as consultant.

Determining objectives for an individual manager requires the manager to be aware of the organisation's objectives for he can only be committed to organisational objectives if he knows them. An organisation without aims cannot plan and lack of planning makes development uncertain. Company objectives depend upon assumptions of the future e.g. market demands, price levels, material costs and availability, cash resources etc., Since those matters are of concern primarily at boardroom level it is logical that an M.B.O. programme must start there. Thus the first objective of an M.B.O. programme is the establishment of long and short term organisational objectives.

Introduction of the M.B.O. Programme to a Building Contracting Company

The programme was launched at a dinner which preceded a talk about the philosophies and procedures of M.B.O. Subsequently, preliminary departmental objectives were determined by managers within the head office (planning, estimating, buying, surveying, personnel, production control and bonus.) Contracts directors and contract managers also determined their objectives. They judged what could be accomplished after considering their department's strengths and weaknesses and the likely opportunities. Departmental objectives could not be established in isolation and considerable efforts were made by the training officer to ensure they represented a co-ordinated, interconnecting network that meshed in a complementary rather than contradictory pattern.

Job Descriptions

Each departmental manager prepared a description of his job, to whom he was responsible, who reported to him, and he identified Key Results Areas. These descriptions showed repetition of work, for example there was uncertainty between the estimating manager and the chief buyer as to which obtained prices for certain items in bills of quantities. The production of job descriptions was extended to include site based management, site managers and site quantity surveyors. These job descriptions showed repetition of work and uncertainty as to job purpose. Both sites quantity surveyors and bonus surveyors measured the same quantities. Individuals were found to consider themselves responsible to different people for different parts of their work. A site manager considered himself responsible to the contract manager for production but to the planning engineer for programming and short term plans. The job descriptions were considered by the departmental managers and the training officer. Gradually areas of overlapping work and responsibility were eliminated as each job description was revised. The result of the job analysis was that each manager received and agreed a job description listing the important aspects of the job (Key Results Areas). He knew his superior had a similar view of the job.

Establishing Objectives

Establishing objectives within Key Results Areas with each manager proved to be difficult. Site Managers, mainly ex-tradesmen, did not understand what was required of them. Typical objectives for site managers in the early stages of the programme included "to maintain a site diary" and "to ensure the clocking on clock is synchronised with G.P.O. clock each day".

These were suggested by contract managers as an indication of what it was hoped they would do. Once procedures had been established for performing these routine tasks they were transferred to the job descriptions.

An example of a typical objective within each of the Key Results Areas for a site manager can be seen in Table 1 below.

Key Results Areas	Typical Objectives	
Control of cost	To keep non targeted work below 7% of targeted work	
Progress of the contract	To work in accordance with the Contract programme and complete by 21st January 1980	

Materials and	To adhere to procedures for requis-
supplies	itioning and ordering materials
Plant & Equipment	To keep cumulative figures for scaffolding on site and check against monthly statement from Head Office
Industrial	To keep accident frequency rates
relations, safety	below last year's average of 42
and welfare	per thousand man days for the company.
Organization and	To maintain a correct working
Communications	relationship with the clerk of works
Quality	To ensure the company's own work
	and that of subcontractors is to
	specification and reasonable
	satisfaction of the Architect.
Table 1: Typical	objectives within Key Results Areas
<u>f</u>	or <u>Site</u> Manager

Some objectives resulted from reviews, production controllers complained of difficulties in issuing work tickets as site managers did not inform them of the work to be carried out in the immediate future. Consequently site managers were guided to "Introduce short term planning and programmes of work in line with short term plans".

Some objectives were found to be meaningless for objectives are not verifiable when generalities such as "to improve" "to make more effective use of" and "as quickly as possible" are used. The easiest way to make them verifiable is to put goals in quantitative terms.

Some managers agreed goals which called for effort, others thought that goal achievement would become a major determinant of salary and set easily attainable objectives to ensure they would be exceeded. <u>Performance Review Meetings</u>

The directors, contracts managers, chief quantity surveyor, chief estimator, chief buyer and chief planner operated on a quarterly cycle of objective setting and review. Other members of the head office management staff operated a 6 monthly cycle, while site managers and site quantity surveyors operated on a 12 monthly cycle of review meetings.

To ensure that both managers prepared for the meeting, a performance review form was sent to each two weeks before the meeting. This listed the Key Results Areas objectives previously agreed. Ideally the subordinate Manager monitors events between review meetings and continually appraises himself by identifying variance from standard, reasons for success and shortfalls in performance and by considering opportunities for improvement. The superior similarly prepared and at the review meeting the two assessments were compared.

Achieving some objectives proved more difficult than anticipated for action by other departments was required. For instance, to provide control data to enable site managers to measure materials wastage necessitated enlargement of the estimating department. After the meeting the training officer produced an action sheet listing the objectives agreed for the future. Copies were sent to both the manager and his senior and reference copies retained in the personnel office.

In the early stages of the programme the company discussed salaries at the review meetings but salary issues so dominated the sessions that the constructive lessons were forgotten. When comparisons between objectives and achievements was unfavourable to the manager, family and domestic matters were introduced into the discussion. Some over emotional sessions occurred, the managers were not in the frame of mind to discuss plans for self improvement. <u>An assessment of the System in Practice</u>

The Benefits

Whether by coincidence or not the company has increased profitability since M.B.O. was introduced. areas of overlapping work and responsibility have been identified and eliminated. Managers now have job descriptions, each knows the purpose of his job and the Key Result Areas on which his performance is appraised. They know that the job itself is being appraised and redefined. Fewer managers resign because they now know what is wanted of them. Many difficulties such as ease and availability of information have been identified and innovations to procedures initiated. Data is now compiled on both accident frequency and materials wastage. Both have been reduced since data on the performance of individual sites has been made available.

Job definition and delineation of responsibilities is encouraging improved performance from site managers for they now know the scope of the jobs they are doing. The firm knows the extent to which future vacancies can be filled by promotion rather than by recruitment. Managers talk to each other about their jobs as well as to their superiors. Indeed initial interest in this management technique was aroused by informal discussion of review meetings among site managers.

Interviews with head office managers suggested that they found the system acceptable and that it helped them improve performance. Many commented on the simple yet effective system of documentation developed. <u>Some problems</u>

Lack of balanced effort

Over emphasis on some objectives at the expense of others occurred, for some managers acted as though their objectives were independent of each other. Concentration on attaining a few objectives led to neglect of other aspects of their job. An example of this was provided by the sales manager of the joinery department who had an objective to increase sales. This he did by concentrating on the easier to sell low profit items with the consequence that the product mix changed and profitability fell. A site manager, whose accident frequency rate doubled the company average, reduced it by decreasing the labour force during a dangerous phase of demolition but as a consequence the contract became 7 weeks behind schedule. Lack of commitment

The training officer has had to help some managers set and write down objectives for they did not understand the concept of verifiability. Some of them subsequently complained when they received a typed copy of their objectives that they were not the objectives that they had set. Consequently they lacked commitment to them.

Challenge to self esteem

The programme has been less successful with site based managers than with office based managers. Some regarded M.B.O. as a challenge to their status, they identified the setting of targets with operatives and saw M.B.O. only as a performance appraisal tool. They controlled operatives by planning and recording progress against forecast and resented the compilation of information about their own job performance. They considered that they knew their jobs and regarded the setting of objectives as an impertinent experiment. There was resistance to the review meetings which were regarded as being an unnecessary interruption in the working day.

Failure to prepare for review meetings

meetings and disliked discussing their failings as well as successes with contract managers. Consequently improvement in performance occurred fortuitously. These men did not wish to change their ways. A list of jobs pinned to the door or chalked on a blackboard received priority. They doubted that they would become better at their jobs as a result of "yet another meeting with the contracts manager "despite the presence of the training officer. <u>Concern with short term problems</u>

Most site managers did not prepare for the review

Many of the review meetings held on site failed because frequent interruptions do not create circumstances suitable for considering long term objectives. Sometimes conflict occurred between contract manager and site managers over current site progress and control of labour costs. It proved difficult for them to detach themselves from current problems. Aggressive and anarchic behaviour

Site managers regularly argue over site matters and as a result cannot quietly discuss their failings without retaliation. Similarly site quantity surveyors look for loopholes. Their job involves negotiation over prices and interpretation of contract documents. Some argued over the interpretation of objectives while others would not admit to scope for improvement. It may be that the aggression necessary to run sites is rarely found among men with the ability to appraise themselves.

Failure of superior to attend review meetings

After the 3 or 4 cycles many contract managers failed to attend site review meetings to counsel site managers. The excuse that an urgent crisis had occurred elsewhere saved the effort involved in travelling to the site. In these circumstances the training officer has reviewed and revised objectives with site managers. Subsequently some site managers claimed that the training officer had "issued" the objectives. The suggestion of suitable objectives by the training officer has resulted in a standardised type of objectives being set.

Rejection of the Counsellor's Role

The dual role of the company training officer acting as M.B.O. counsellor has proved to be a source of difficulty. Though acting as an independant advisor to the manager and his superior at M.B.O. performance reviews he also has responsibilities for administration of a training budget and supervision of apprentices, management and surveying trainees. Some managers considered that their own needs for attendance at training courses could not be satisfied because of budget constraints imposed on the training officer. The site managers had frequent contact with the training officer concerning the training of their subordinates and many applied the aggression necessary to run sites to these telephone conversations.

At their annual performance reviews these site managers found it difficult to accept that the training officer was present to advise both themselves and their contract managers. They preferred to regard him as the person responsible for apprenticeship training. Some scorned the lack of craft background and technical knowledge of the training officer.

The need for more frequent reviews

Many site managers and site surveyors are working to obsolete goals. Many building contracts are completed in 2 or 3 years and with an annual review cycle there is a possibility that managers will be concerned with a different site, possibly in a different town, to that on which the objectives were established. Monetary objectives can be rendered obsolete by changes in tendering success rates and market conditions. Variations in clients requirements and inadequacy of design data also affect objective realisation. It is likely that objectives should be revised with every major change in project programme but this did not happen.

Many objectives were set in qualitative terms and are concerned with routine instructions rather than specific targets to be achieved, with revision at more frequently held review meetings they might well have been set in quantitative terms.

Failure to provide additional resources

M.B.O. has been run on a modest budget and one man has been responsible for introducing and operating the system for five years. Conflicting demands upon the training officer's time prevents him increasing the frequency of review meeting for site managers. Greater resources need to be devoted to operating the M.B.O. system and the non-provision of additional resources is considered by many site managers to indicate that the directors were not committed to the M.B.O. system. They cite in further support of this belief that the determining of objectives started at departmental manager level, not with the board of directors and managing director. This was incorrect. Lack of Communication of Company Plans

Unfortunately there was little indication to those managers outside head office that the company had established its business goals and that the review process was leading to revisions to the company strategic plan. Information concerning this plan was only available to directors. This failure to communicate a version of the company strategic plan, shorn of any confidential data, provided further excuse for lack of commitment by site based managers. Conclusions

The system has successfully identified problems and led to improvements in both the management control data produced and task allocation between departments. If the system had been restricted in scope to the departmental managers working at company headquarters it would probably have been completely successful.

The current behaviour of many site based managers shows that they do not accept responsibility for developing their own managerial skills. These men are used to the anarchic and aggressive behaviour common on building sites. There is a continuing need to teach the philosophy of the programme to them.

The frequency of site review meetings should be increased to enable objectives to be made more relevant and to be expressed in quantitative terms. This would require an additional counsellor but would also avoid problems associated with the dual role currently played by the training officer.

The benefits gained simply by improving internal systems and saving duplication of effort far outweigh the company's expenditure on introducing the system. M.B.O. is a cheap system to operate.

Even though the fullest benefits from counselling all managers have yet to be achieved the stimulus received by the organisation shows it has been worthwhile. It is better to attempt improvements and not wholly succeed than to remain passive in a changing world.

The firm's experience shows that M.B.O. can be applied to construction companies with benefit to the company and some of the managers concerned.

References

1.	Drucker, P.F.	The Practice of Management.
		Heinemann, London 1955.
2.	Humble, J.W.	Improving business results.
		McGraw Hill, Maidenhead, 1968.
	"	Improving Management Performance
		Management Publications 2nd ed.1969.
	"	Management by Objectives in Action.
		McGraw Hill, Maidenhead, 1970.
	"	The Experienced Manager, McGraw
		Hill, Maidenhead, 1973.
	"	Avoiding the Pitfalls of the M.B.O.
		trap. European Business Autumn
		1970 pp. 13-20.

3. See for instance

O'Hea, J.	Questions and Answers on M.B.O.
	Management Publications, London
	1971.
Raia, A.P.	Managing by Objectives, Scott,
	Foresman and Company, Glenview
	Illinois, 1974.
Odiorne, G.S.	Management by Objectives, Pitman,
	London 1965.
Morrisey G.L.	Management by Objectives and
	Results. Addison-Wesley,
	Philippines, 1970.
Carroll S.J. &	Management by Objectives - Applic-
Tosi H.L.	ations and Research. Macmillan,
	New York 1973.

•

An information system for the building industry - a stepwise approach -------Armando da Costa Manso

Eng,Building Economy and Productivity Dpt. Luis Arriaga da Cunha

Eng,Computer Science Dpt.

Laboratorio Nacional de Engenharia Civil Portugal

Summary

Since 1976 we have been developing a project related, in its first part, to the cost estimation and planning in civil engineering works, using computer methods.

This first module, reported to the 7th CIB congress, has been in full use in Portugal by the private and public sectors in real situations. A useful tool in itself, it also allowed us to gather a considerable amount of information on various types of constructions carried out in our country.

In this paper we will try to show how that information can be structured into a data base, and the type of enquiries one can make upon it. This second module is another step towards the development of an information system for the civil engineering industry.

The general outline of the information system in its present and near future form will also be presented in this paper. Short examples of use of the system are also shown.

Sommaire

Depuis 1976 nous developons un projet qui a compris, dans une premiere phase, le calcul des couts et le planning, en utilisant un ordinateur, dans le domaine de l'industrie du batiment.

Cette premiere phase, qui a fait l'objet d'un rapport presente an 7 ieme congress du CIB, est un pleine utilisation au Portugal, dans des situations reelles, par les secteurs public et prive. Ou a donc obtenu un volume considerable d'information sur des types de construction tres divers.

Nous presentons, dans ce rapport, comment on a essaye de structurer cette information dans une base de donnees et le genre de recherches qu'on en peut y faire. Cette seconde phase est un nouveau pas vers le developement d'un systeme d'information pour l'industrie du batiment.

On introduit le schema general adopte dans la forme presente et dans un futur immediat. On illustre le systeme par quelques examples d'application.

O. The integrated system for cost estimation and planning in civil engineering works, presented at the 7th CIB Congress, has been fully operational for almost a year. The work we present now is the development of a data base using the information gathered along the use of the integrated system.

This latter has been at the disposal of government departments and private enterprises, in Portugal and abroad. In general terms, the basic information used in it consists of LNEC's own data, updated in terms of productivity, and complemented by the firm's own information. As an example, we can refer that the works planned or estimated ranged from a global value of $£3x10^4$ to $£3.5x10^7$ for a new hospital to be built in Portugal.

Cost estimations were prepared at the various stages of developement of projects, allowing for the choice of several possible solutions; up to date cost estimations, due to inflation, could be compared with the variations given by formula price adjustment methods.

In planning, the system has been used before and during the execution of the works. Before the execution, various levels of planning detail were prepared, by analysing the project in different groupings of activities. During the execution of the works the planning showed the advantages of being able to replan forward, at any point of time, based only on the actual situation of the works.

In planning works with a great number of building activities the need to define the connexions between these activities can be extremely cumbersome and this is probably one of the heaviest tasks in planning. These operations have been divided, in our planning system, in modules of building activities with its internal logic; the connexions between modules are then separately stated and automatically integrated in the overall planning. Also worth to point out is the situation where there are several identical modules, in terms of internal logic, although not to be built at the same time. This situation can arise as an example, when a group of identical houses (same tender) are going to be built. A module could be defined as the logic of activities related to the execution of one house isolated. In this case one has to declare this module only, in terms of costs and tender, and then declare the relations between the different modules in order to reflect the real execution of the various houses. The costs are obtained by multiplying the values for one module by the number of repetitions. The use of the integrated system, in real situations, allowed us to go from 300 building operations to 2000. The files of basic prices were updated every three months using as source of information official and private data.

 The considerable amount of information not only of the basic data (prices, operations, standard specification statements) but also of the bill of quantities of the works being handled, led us to the construction of a data base of works.

Two alternatives seemed possible at this stage.

a)Go for a fixed schema, strictly integrating the information mentioned above, using a standard package for data base management.
b)Build a flexible schema, open to the appending of more types of information, developing specific programs for this purpose. The second alternative was preferred as it would lead, in our opinion, to a system really open to future development and also more efficient. We will outline in the following points the main features of the chosen solution

for the construction of the data base.

Each work in the data base is defined by 1.1. several items, (fields), eg, the designer of the building, the number of floors, etc. For a specific work each of these fields have a value, given numerically, according to a certain code. For instance, each designer could be given a code number; it is this number that would then appear in the corresponding field. This coding is done automatically, by order of appearance. The lists of codes for each field can be prepared for the user with different displays eq, alphabetical order or code order. The number of fields that define a work can be increased when necessary. At present, eleven fields are relevant for the definition (Key).

> Title of the construction Overall size Type of construction Public Department Designer Builder District Reference date considered for prices Data of execution Number of floors Codification system

- 1.2. Each work in the data base can be removed or updated in their definition, by the data base manager. Of course the normal user does not have the possibility of this type of changes. New types of information can also be added, in parallel files by the data base manager, in a way that the existing procedures remain valid, but working on a update data base.
- 1.3. New works are just appended to the data base without any need to reload it. Also, new items for the basic files (operations, materials, equipment, labour, codes) are just appended to the existing information.
 - 2. After selection of works from the data base a user is able to perform calculations on those works via the integrated system. The possibility for global/statistical analyses on the results of those calculations emerges then.
 - 3. The following diagram illustrates the general layout of the intended information system.



- 4. It is interesting now to enhance the most important goals to be met, from the point of view of the user.
- 4.1. The data base should be able to select the works that have certain common characteristics. E.g. Select works executed by a certain builder in a certain district, between a given period.
- 4.2. With the selected works, the integrated system can be used, for calculation of the sum of one component, or average values, E.g. For the works previously selected find:
 a) The overall amount of concrete used.
 b) The difference between the lowest and highest price, per unit.
 c) The average of the price, or amount per unit, of the materials, equipment or labour involved.
- 4.3. The system can be appended with more information without disturbing what is already implemented. E.g. - To the description of materials a parallel file with its producers or importers can be added.
- 4.4. The system must prevent itself to the user as easy to use and cheap (in terms of computer resources needed). In all the operations upon the information system, the user works with one interactive program only.
 - 5. Examples of the use of the information system. In order to work with the system the user must be provided with a listing of the codes that correspond the possible values of the various fields that define the works. We will show the dialog that the user could have, when operating the system. The user's answers are shown underlined. At certain steps of the dialog the computer presents several alternatives to the user (menu); the choice is made by typing the corresponding number.
Example 1: In this example a user wants to search, in a first step, the information about office buildings, built in a certain area A of the country, by builder X, with a number of floors less than 4. About these buildings the user specifically needs to know the title of the construction the overall size and the name of the designer. FINISH.....O SEARCH DATA BASE.....1 (MENU 1) MANAGE DATA BASE.....2 ANSWER: 1 GIVE NUMBER OF FIELD: 3 HOW MANY VALUES?: 1 TYPE OF CONSTRUCTION: 5 GIVE NUMBER OF FIELD : 6 HOW MANY VALUES ?: 1 BUILDER: 16 GIVE NUMBER OF FIELD: 7 HOW MANY VALUES?: 1 AREA OF COUNTRY: 12 GIVE NUMBER OF FIELD: 10 HOW MANY VALUES: 1 NUMBER OF FLOORS: LT4 (less than 4) GIVE NUMBER OF FIELD: 0 (end) At this stage the program will search the data base and will tell the user how many works have the chosen characteristics and ask what to do with them. 18 ITEMS FOUND FINISH.....O DISPLAY OF FOUND ITEMS...1 (MENU 2) FURTHER CALCULATION.....2 ANSWER: 1 IN FOLLOWING DIALOG YES=1, NO=0 TITLE: 1 OVERALL AREA: 1 TYPE: <u>O</u> PUBLIC DPT: 0 DESIGNER: 1 BUILDER: O AREA OF COUNTRY: 0 DATE OF TENDER: 0 DATE OF CONSTRUCTION: O NUMBER OF FLOORS: 0 The computer will print the 18 items found ITEM 1 TITLE : HEADQUATER OF BAB OVERALL AREA: 400 M2 DESIGNER: XPTO STUDIOS ITEM 18 TITLE: ASSON OFFICES IN LISBON OVERALL AREA : 1200 M2 DESIGNER :

INTERNATIONAL ARCHIT.LTD

Example 2: Lets consider that the user searches again the office buildings, as in Example 1. He then wants to know the 10 most important materials, in terms of cost, and their percentual importance. The dialog is the same, up to MENU 2, The user must then answer:

ANSWER: 2

A file will then be created, with a format acceptable for the integrated system. The integrated system will then calculate, for each of the 18 items mentioned above the prices of all the materials. A statistical procedure will then select the 10 most important and will find the percentual values.

Example 3: Having slected the 10 most important materials in the previous point the user could now wish to know the list of importers or local producers of these materials. The process is the same as stated above in Example 2 up to the selection of the 10 most important materials. With these materials the user can directly access the correspondent listing file of importers or local producers.

6. Details of implementation

- 6.1. Information is compacted whenever possible, in a manner completely transparent to the user in order to reduce storage needs and processing time.
- 6.2. Information is stored in separate files, so that each procedure only accesses the strict information it needs. There is no handling of information not pertinent to a certain procedure.
- 6.3. The system is implemented in FORTRAN language. All details of accessing, and compacting the information are presented to the programmer as primitives in the highlevel alnguage.
- 6.4. The definition under the user's request is done via a "menu-like" dialog where a tree of possibilities is followed:
- 6.5. The various files contain information that allows the system to automatically guarantee the safety of the information being handled.

7.Conclusions.

The strategy adopted since the development of the integrated system and carried on when developing the information system, now presented, has always been to proceed by steps, where each step corresponds to a tool usable in real situations.

This approach has proved to be extremely fruitful as corrective feed back is possible, new fields of interest are found, and each advance is based on a realistic and tested instrument.

This information system, now being implemented, is already going to be put to use by one major Portuguese institution of credit for building. A Microscopic Viewpoint of Work Breakdown Structure in Building Construction

Tadashi Eguchi, Professor, Dr., Musashi Institute of Technology, IAHS, AIJ, SJVE, Japan

Summary

In the past, results of labour requirements surveys, time studies and process analyses of on-site works in building construction were reported from several countries. This paper describes a concept of qualitative analysis of on-site labour work in relatively microscopic level.

The work breakdown structure(WBS) concept has been developed in the field of network scheduling technique and in separate contract strategy. In this paper, work breakdown concept is extended to fairly microscopic level as a tool for analysis.

One point to be described here is interaction between physical elements' composition, their function and the related works. When we analyze the function of building components from microscopic viewpoint, it is found that some of them have function performed in construction stage apart from function in occupancy stage.

Thus, three basic facets of breakdown shall be assumed: (a) Physical components breakdown structure, (b) Functional breakdown structure, (c) On-site work breakdown structure. And, consideration on the interaction between them can be useful in detail design, specification writing, value analysis activity and planning of quality control.

As an example, the function of furring in Japanese conventional wooden construction is discussed in comparison with North American wooden frame construction.

Breakdown structure concepts in construction management

A building is a complex of many factors. It can be analyzed in some separate manners according to the angles of view. To recognize a building mainly as a set of physical components is typical one among various angles of view. Another important angle may be to pay primary attention to services and function of a building or its particular portion.

From the viewpoint of construction management, the work to be done in each stage is a matter of basic concern. And then, time, cost, various resources and workmanship in relation to the work constitute various aspects of management problem.

Now, a building and its project can be recognized as a whole from a macroscopic viewpoint. On the other hand, we frequently examine a particular part of building from relatively microscopic viewpoint. Many concepts and techniques have been developed to connect the two viewpoints. Generally, any analysis in practice or research has a mission to connect them.

One of extremely developed concepts to intermediate the macro- and the micro- in a building is found within the structure of coding systems such as Sfb/UDC, CBC and the like [1]. These have been used also in construction management field, especially in cost information.

However, there are some differences between coding system for classification and so-called breakdown concept in management technique. The former should be established and generalized, while the latter should be quite flexible. The former can be predetermined statical system, while in the latter the practical format can be devised at each time sometimes waiting for to be replaced by better alternatives.

The phrasing of work breakdown structure (WBS) is mainly used in project management, often as a preparation for network type scheduling in various levels. Recently, it is also used in connection with value analysis [2],and in contract strategy the term "contrct work breakdown structure" (CWBS) has come to be used[3].

Generally, "work breadown structure" means hierarchical structure of work elements or work packages. In this paper after this, "breakdown structure" will be used not to mean any established concept, but merely to mean a way of looking hierarchy in complicated structures. In this meaning, it can be said that "functional breakdown structure" is very often discussed in performance concept and value analysis activities, and also "physical breakdown structure" is a common concept. Breakdown structure can be found in building cost, organization and the others as well.

Function analysis of furring

In the breakdown structure of physical components of a building, walls and partitions generally locate in the middle level. Though there are various structure of wall, for a while we think about wall systems which have some rough wall body as structural or sub-structural element and some plane wallboards as backing ground for finish painting or wallpaper.

Some building construction methods have "furring" of wood strips, metal channels or whatever else between rough body and wallboard. Japanese common wooden construction nowadays uses furrings where the wooden posts are concealed by wallboards or plywoods. Figure 1 shows usage types of furring in Japanese wooden construction.



Fig.1. Some usage types of wall furring in Japanese wooden construction

Furring is an end item in physical components breakdown structure. It appears that furring requires a little more consumption of materials, labours and dead space in floor. Using the style in the first step of value analysis, the question can be described as below:

(a) What is it ?

(b) What does it do ?

Figure 2. shows a tentative expression on function of furring. In principle, it follows to the style of functional structure tree often used in value analysis.



Fig. 2. Tentative description of function of furring

Several problems should be discussed here from a microscopic view point.

Difficulty in specifying "basic function" of a building component in single phrase

The description in the thin line boxes in the figure are out of the rule since they do not directly express the content of function. Originally, "basic function" of furring and cavity should be expressed in the boxes according to the philosophy of function tree. What is the basic function of furring ?

Though the object is tiny little, the answer is not so simple. It might be said that in microscopic level, component not always has basic function. However, the difficulty of this kind more or less lies in determining the basic function of a building component, especially when traditional or conventional construction methods are concern, except for mechanical or electrical equipments.

Adjusting function between structural body and finish surface

Figure 2 includes a box of "increase flatness of finish". Though this function is neither always minded

in detail design nor written explicitly in each specification, it is well known by wooden construction practitioners or carpenters. The followings are examples describing it.

C.M. Harris ed. [4]: "wall furring: strips of wood or metal, masonry tiles, etc., applied to the rough surface of a wall so as to provide a flat plane upon which a surface material, or assembly, such as lath and plaster, wood paneling, wainscoting, etc., may be installed."

F.S. Merritt ed. [5]: "Supplementary framing, or furring should be used (an ellipsis), or when the surface of framing or base layer is too far out of alignment."

It is worth noticing that this function of furring is closely related to the labour work procedures for structural wall body and those for wall finish. 3. Timber framing without furring

The timber (or wooden) frame construction common in North America and also used in some European areas has no furring in most cases today. Wallboards or plywoods are nailed directly to studs. Both the studs and wallboards are structural members in the system, but finish painting or wallpapers are provided directly on the surface of boards in not a few cases.

So-called platform type modern timber frame construction has been introduced with main materials into house construction in Japan since about ten years ago. The absence of furrings in the system makes the composition of members and construction process simply.

As the continuation of the question given before, the followings arise:

- (c) Can a wall system do without furring ?
- (d) Where does the function which furrings had performed go ? — particularly as to the function to secure alignment between studs and wallboards.

Labour work with furring and without furring

In autumn 1978, we observed in detail the labour work process in wall erection and installing boards in both the cases of Japanese conventional wooden system and of platform type timber frame system. The summary of the observed work related to alignment of plainness is as below.

Work with furring — in Japanese conventional system 1. Mark furring placement on posts and studs.

- Nail horizontal and then vertical furrings to posts and studs.
- Insert plywood pieces as shims between bosts/studs and furrings where necessary.
- Sometimes also after boards are once installed, the same work as 3. is repeated where necessary.

Work without furring ---- in timber frame system

 Inspect alignment of erected framing. Point out slant and un-evenness to be corrected on studs. (Criterion in the observed case was those over five mili-meters per a vertical and horizontal
meter.)

Correct slant, bowed or twisted frame using wood hammer.

The above shows only the labour works directly related to alignment of flatness of wall body, from after wall body erected to before boards installed regularly. In the both cases, the work to use leveling strings and plumbbobs are abbreviated in the description. In the earier age, other adjusting procedures using plane or chisel might be used. The observed usage of wall furring in conventional system was the second one from the right in Figure 1.

Furring mechanism as a factor characterizing each construction method

Furring in ceiling, floor and roof

Generally, the precision needed to structural body is not consistent with that needed to finish surface, in views as well in degrees. How to adjust the precision on the two sides constitutes a basic characteristic of each building construction method.

It goes without saying that the same things as in wall furrings have been devised in the other portion of building. The history and various usages of the term "furring" narrate the circumstances. The followings are a few quotation from Oxford English Dictionary.

1823 P.Nicholson *Pract. Build.* 223 Furrings, slip of timber nailed to joists or rafters, in order to bring them to a level.

1883 Harper's Mag. Nov. 88 4/2 The only combustible material is the wood used in the floors and their furrings.

Furring mechanism in general

The furring function has been devised not only in wooden construction but also in masonry, brick and concrete building. The following cases can be recognized.

 Some end components such as furrings or mortar layer perform the adjusting function with the related work.

(2) Without any particular component, the work for structural body performs the adjusting function. In this case, the requirements may increase a little and the criteria in quality control may be more severe than in the body work in case (1).

(3) Finishing material and the work for it perform the function. Plaster work or mortar finish belongs to this case.

(4) Coarse texture and pattern of solid materials can absorb the roughness in structural body especially when they have some sense in traditional preference.

(5) Sometimes, a monolithic material or prefabricated panels of complex composition serve both as structural body and as finish surface. In this case, the same conditions as in case (2) are required except when regarded as the same with (4).

In Japanese traditional wooden houses, interior surface of wall, ceiling and floor has furring mechanism equivalent to (1). But wooden pillars are similar to the case (4), for they, being used as polished plain texture, constitute decorative elements in traditional interior space.

The inward logic of modern timber frame construction system seems to be equivalent to the case (2). Being introduced into Japan, it has given a stimulus to the simplification of Japanese conventional method and many "rationalized traditional" wooden construction methods have been developed keeping a fairy part of traditional taste. Various queer, unexpected phenomena as the results of mixture of two distinct logical structures have been observed in microscopic level. Most of such phenomena cannot be analyzed from a single respect out of physical component analysis, function analysis and labour work analysis.

Function performed in work process

Concerning the interrelationship between a component, its function and the related work, at least the followings can be mentioned.

(a) Some of physical components perform a certain function for the work in construction stage.

(b) An functional interchangeability exists between the function of such component as in (a) and that of a certain work or a temporary construction equipment or scaffolding.

An example for (a) is seen in the role of sub-floor which provides effective platform for pre-erection assembly work of wall units. A set of several cases described before regarding the adjusting function shows the relation in (b).

Viewed from another angle, functions which a building component performs can be devided into two sorts as shown below:



functions performed mainly after building completion functions performed in construction stage

Forms, scaffoldings, temporary bracings and the like have function only in construction stage. As for building components, they seem to have function only in occupancy stage when observed from macroscopic point of view. However, when observed from a relatively microscopic viewpoint, some of them have function in construction stage as well as in occupancy stage.

Concept of qualitative work study in microscopic level

Many sorts of work study methods available have been developed by industrial engineers since the era of F.W. Taylor and F.B. & L.M.Gilbreth. However, direct application of those methods to field work process in building construction is not necessarily effective. It seems to me that some method or conceptual methodology of characteristics imaged below should be developed.

(1) The level of work-breakdown in the method is more microscopic than that in used in scheduling network but more rough and flexible than that of motion or micromotion study.

(2) Primary interest in the study is put in qualitative analysis rather than in quantitative analysis.

(3) Qualitative analysis, here, is intended first of all to throw light upon the interrelationship among the three: physical components structure, functional breakdown structure and work breakdown structure of each building construction method. The intention in this meaning naturally requires any observation in comparatively microscopic level.

(4) The method should have a certain merit even when applied to a tiny spot in a total building composition. Because, such a microscopic study cannot be applied at a time to all aspects in a construction method.

(5) However, pheraps it could not be a rigid, established procedure of study. As for basic concept or philosophy for work observation and analysis, there seems to be much room for development.

(6) Quantitative surveys regarding labour requirements or cost composition had better to accompany a qualitative and relatively microscopic analysis in the point which characterizes the construction method surveyed.

Now, a microscopic viewpoint has, of course, one side against which we should take precautions. From a

microscopic viewpoint we can recognize only a little fragments of the matter in concrete. Though some of such fragmentary recognition can be a useful clue for a problem, they should be examined in a macroscopic and integrative perspective.

Possible fragmentary information in microscopic level, by itself cannot have a positive role in the development of building construction. In the domain of end items or items next to end in breakdown structure of building construction, the networks of the interaction between physical composition, function and work are too dense and complicated to express comprehensively.

It might be mentioned, however, that consideration on the interaction in the level can be useful in detail design, specification writing, value analysis or planing of quality control.

References

- Information Flow in the Building Process, Full papers and discussions at the CIB Symposium, Rotterdam, September 1970
- O'Brien, J.J., Value Analysis in Design and Construction, New York, 1976, p.10,14,15
- Macedo, M.C.Jr, Dobrow, P.V., O'Rourke, J.J., Value Management for Construction, New York, 1978, P.142-3
- Harris, C.M. ed., Dictionary of Architecture and Construction, 1975, p.533
- Merritt, F.S. ed., Building Construction Handbook, 3rd ed., New York, 1975, p.13-14

573

The implementation of an innovation in building site construction

Gösta Fredriksson, Ph D and Gösta Andersson, Engineer, The National Swedish Institute for Building Research, Sweden.

English summary

In this paper we present some results from a study of the introduction of machinery equipment in the Swedish building construction.

The increasing importance of capital equipment in building production and the increasing complexity of decision making due to extended legislation and worker participation has changed the chain of decisions leading to technical development on the site.

We have, by means of case studies, analysed the decisions process leading to the implementation of new machines in the site construction. In this paper we describe how different actors within the building firms, have influented the implementation of a new type of dehumidifier on site.

The firms studied have a decentralized decision process where the site managers have a critical position. The workers have, in this case, only had indirect influence on the decision to accept the new dehumidifier.

French summary

Dans cet essai, nous présentons quelques résultats d'une étude sur l'introduction de nouveaux moyens mécaniques dans l'industrie du bâtiment en Suéde. La signification accrue du capital d'équipement et la législation plus poussée dans ce domaine, notamment concernant la participation au processus de décision, ont rendu ce dernier plus complèxe, surtout quand il porte sur le développement technique dans la construction.

A l'aide d'études de quelques cas précis, nous avons analysé le processus de décision concernant le lancement de nouveaux types de moyens mécaniques utilisables dans la construction.

Dans cet essai, nous avons rendu compte des différent agents qui, á l'intérieur des entreprises, ont influé sur l'introduction dans l'industrie du bâtiment d'un nouveau type d'engin pour assechement.

Par aileurs, il a été noté, dans les enterprises de construction étudiéés, une décentralisation du pouvoir de décision, laissant aux patrons des chantiers un rôle important. Dans ce cas, les ouvriers n'ont éxercé, dans la plupart des entreprises, qu'une influence indirecte sur la décision d'introduire cette nouvelle machine.

Introduction

Investments in capital equipment in the construction of buildings

Development in the Swedish post-war building production as been characterized by increased prefabrication and by mechanization on the building site. This has involved a process of interaction between the development of new mechanical aids, new materials and new methods of production.

The post-war period was characterized by intensive housing programmes and a relative shortage of labour in the building sector. Efforts were therefore made to diminish the need of labour and to make building trades more attractive for instance by the elimination of heavy items of work.

The principal aim of mechanization both during the 1950s and during the 1960s hence was to increase labour productivity. Labour-saving measures were necessitated by the labour shortage and by the rising labour costs. A combination of increased prefabrication, new components and materials and building site mechanization offered an increase in productivity which made it possible for a large-scale programme of housing construction to be implemented without any notable rise in building costs.

The changes undergone in building site work during the 1970s has been dominated by improvements to the

occupational environment and to planning methods. Devices to protect operatives from noise, dust and other physical or chemical stresses have been developed for the majority of mechanical aids. Improved energy economics has also come to be more and more vigorously demandes during the late 1970s, but measures to this end have been little in evidence on our building sites so far.

The decision process, to which we will return later, has evolved to a more "democratic" process with increasing degrees of worker participation. This, of course, has also contributed to a changed evaluation of the need for different kinds of mechanical equipments.

Lines of development

The course of mechanization will be set - at least in the long run - by the value of the machines's performance. As we have already seen, the limited supply of labour and the consequent rise in labour costs have caused a premium to be put on labour economization. There is a great deal to suggest that production will raise less rapidly during the 1980s and 1990s than it has been doing so far during the post-war era. This is particularly likely to be the case in the building sector, where in several European countries we have seen a decline in growth and an change in the structure of demand. It follows that we cannot expect the same predominace of labour-saving mechanization either.

Legislation and trends affecting the decision process The frames for decision making in Swedish firms has changed by the Right of Codetremination Act that has been in force since 1977 [1]. The most important new feature of the act is the rules which will enable employees to gain influence over labour management and company management issues by means of negotiation and agreements.

In industries with a long-time employed labour force this has meant that decisions concerning more important changes such as reorganization of the production process or localization has had to be preceeded by consultations with the trade unions. In most Swedish building firms the workers are employed for one building project at a time. This and the nature of the production process have been small. On the other hand the intentions behind the act seem to be reflected in a increasing degree of worker participation in decisions on the building site. The relative autonomous position of the site manager, the organization of workers in working teams and the competition for workers between the sites has meant that decisions concerning the daily work on the site has by tradition however been made under the influence of the workers. Today we can see the start of more systematic routines for participation. An example is regular meetings to discuss matters and problems on site.

Another recent act that has direct influence on the conditions on the building site is the Occupational Safety Act. The most evident feature is that the safety supervisors representing the workers has the right to suspend work in certain circumstances. More important is perhaps that the knowledge of the importance of the working conditions has increased throughout the industry. The organizations occupied with working environment problems have got increased resources and authorities.

The innovation

During the winter months the moisture from materials such as concrete or wet timber has for a long time been eliminated from the inner of a building by means of heated air. By the blowing of dry heated air through a room the humidity has been diminished. From the middle of the 70s a new type of machine using another principle has been introduced into Swedish building construction. It can be called a dehumidifier. Since 1973 half a dozen firms have introduced dehumidifiers operating with condensation or sorption. The history of the innovating firms has been described elsewhere [2]. Here we will describe the actions in the firms adopting the innovation e g the building firms.

The study

The study described here is a small part of a study of the development in the Swedish building industry. For the current subject we have studied the adoption process in the local operations of eight building firms ranging from big internationally operating companies to a family owned local building contractor with about forty employees. About twentyfive interviews has been made, with site managers and engineers and managers of capital equipment within the firms. Apart from that, some material from interviews with persons in firms producing, selling or leasing machinery equipment and with building workers has been used mainly to check the results.

The purpose of the study reported here is to analyse the adoption part of an innovation process that is studied in the broader context of our project. Seven of the eight companies or regions, had bought dehumidifiers at the end of 1979. The first ones were bought in 1974. All firms have tested some brand of the machines.

Due to the organization of building production we have found it useful to treat the material in two classes. We start with the decision to buy the machine and continue with the decision to use the machine in a specific building project.

Differences in buyer behaviour

We can illustrate the differences in buyer behaviour with descriptions of two of the firms. In firm A the capital equipment manager has quite an autonomous status vis-a-vis the site managers. He is active in finding new machines and attempts to evaluate their effects on the building site. In this case he

purchases some machines before there was any demand on site. He then pursuaded the site managers¹⁾ to employ the dehumidifier. One important way to do this systematically was regurlarly courses for site managers. In this firm it is not usual that the site managers hire machines in this class from external leasing firms.

In firm B, on the other hand, the capital equipment manager did not purchase dehumudifiers until he knew that there was a seemed demand from the site. The first machines used in this company was rented externally by site managers. First when the machine or capital equipment department could summarize the machines rented externally and conclude that the demand was

¹⁾ In some of the bigger organizations there are also a middle manager responsable for a small number of sites. In this text we have included those in th group "site managers".

575

	ration of the second se	ET EULIMENT	12 2 2 1 IL	8	Store Store	M LEASING	S S S S S S S S S S S S S S S S S S S
FIRM			\$ \$	250	/ 5 ž		
1							
2		•					
3		•					
4]
5		0	0				
6			0				
7		0					
8		•					

FORMAL DECISION

STRONG INFLUENCE BEFORE FIRST PURCHASE

WEAK INFLUENCE (COMMUNICATION BEFORE FIRST PURCHASE)

INFLUENCE ON DECISIONS FOR SUBSEQUENT PURCHASES

Figure 1. The purchase decision.

sufficient would they purchase some machines. These two firms represent the extreme in our sample. In the rest of the firms the influence of the site managers on the purchasing is between those extremes.

In the other five firms the decision was made after different degrees of consultation with or direct requests from site managers. (Figure 1).

The actor that influented the decision maker most was throughout the site managers either by discussions in

formal or informal meetings or by submitting orders for dehumudifiers for a certain building project.

The decision to use the dehumidifier

The formal decision is generally made by the site manager. He is also responsible for the project budget.

The influence from the machinery department or, in the smallest firm the general manager, differs widely. In some firms the site manager is quite free to hire



FORMAL DECISION

STRONG INFLUENCE ON DECISION FOR SUBSEQUENT USE

) HAS EXPRESSED POINT OF VIEW WHICH HAS INFLUENTED SUBSEQUENT USE

Figure 2. The decision to use the machine.

what machines he requires from the firm he wishes. In two of the firms it is only in extreme cases that the machines can be hired from outside leasing firms. In those firms the influence from the machinery department is considerable. (Figure 2).

Worker participation

The worker participation could, in this case, have been based upon working environment reasons. The traditional dryer in building production has the disadvantages that it gives air pollution and requires handling of fuel on the site. The electrical dehumidifiers are more easy to handle and give lesser risk of accidents. However, those aspects have not been brought forward as argument from safety representatives on any of the sites we have studied. The views of the labour force seem to have coincided with the managers. In all cases the site manager has decided on his own to take the machine to the site. After this the worker has had the chance to argue for or against the new machine. In one case this was following a routine with site-meetings once a week.

We have found great engagement only in one case. This was a machine tender who was very much interested in the dehumidifier. He appears to have contributed to a faster acceptance of the machine on that site.

When it comes to dehumidifiers we have not found any case where the labour force has played an active part in the spreading of the machine between the sites. In other studies we have found that this is quite common.

Other influential actors

The site manager has the idea of testing this new principle from different sources. The machinery department in the company is the most usual source, but also a leasing firm, colleagues, articles in a journal and researchers have been sources for the idea to test the machine.

The introduction

One of the machine producers attempted to introduce a dehumidifier already in the middle of the 60s. That trial failed.

The successful introduction in 1973 coincided with the "energy crisis". This meant that most people become aware of the need for economizing with energy. The traditional drying methods on the building site were, evident to everyone, a very energy consuming method. This made it possible for the machinery producer to convince some actors in building production to test the dehumidifier.

From 1975 to 80 the dehumidifier has replaced the traditional dryer at an increasing rate¹⁾. The reasons to use the new type of machines that has been mentioned are that it is easier to handle, less energy consuming and that the result is visible as the machine delivers water in a tube or a bucket. None of the site managers and only two of the machine department managers have based their point of view on test results. Those two of our site managers who did not prefer the dehumidifier had found that it did not diminish the humidity²⁾.

The costs were not used as arguments either for or against the machine. None of the persons interviewed knew the energy consumption of the machine but had a tentative feeling that the consumption was below that of the traditional dryer.

- This goes for drying in projects where it is possible to detach small volumes. In other cases and for other purposes, as heating, the tradition dryer still is dominant.
- 2) This can for instance happen if the temperature is too low or if the room is not sufficiently detached.

The decision process

In the seven companies with a special department for capital equipment the formal decision to buy machines was made by the manager of this department. The decision to use the machine on a specific building site was formally made by the site manager in all firms. However, the degree to which other parties could influence the decisions differed considerably.

In one extreme case we can see a firm where the machinery department has a firm control of the purchase. Information on new machines and their qualities reaches the production staff via the machinery department. The possibilities for site managers to require machines from outside firms are in reality limited. On the other hand extremes we have the firm where the site manager requires the machines he wants, it may be from external or internal stocks. The machinery depart-

ment buys machines first when it is necessitated by the production. The information about machines does not go through the machinery department.

The worker participation has been negligible in this case evidently because the attitude to the new devise coincided with that of the site managers. However, it was pointed out by the managers that it is almost impossible to introduce equipment that is not accepted by the workers on a building site.

Information routines

The critical actors in the adoption of new mechanical aids are the site managers. In some firms also the machinery or capital equipment department are central in the adoption process.

Routines or systems for spreading information on new mechanical equipment is not developed in most of the companies. In this case this might have delayed the spreading within some of the companies. A great deal of informal information channels has however developed. The may be defects are not that the information flow is to small but that it is unstructured and sometimes irrelevant.

Thus we can conclude that the large volume and unstructured form of information on new machinery are a hindrance to a quick spreading in building production. We can also conclude that the importance put on energy consumtion in the public debate has been a great help in the introduction of the dehumidifiers.

- <u>Arbetsmiljölagen</u>. Svensk Författningssamling (SFS) 1977:1160-1171.
- [2] Andersson, G, <u>Från koksgryta till avfuktare</u>. Byggmästaren, No 9. Sept 1979 pp 24-27.

Quality control in construction on site - Some observations of current UK practice

I L Freeman BSc FICeram FIOB and M J C Bentley HND Building Research Establishment, Watford, England

Summary

Observation of site staff dealing with questions of quality in site work has revealed some of the factors which contribute to the standards achieved. Formal checking and acceptance or rejection of completed work played a less important part than anticipated. The quality was primarily determined by adequacy of project information - particularly drawings - and the joint knowledge and experience of site staff directly concerned - site agent and clerk of works. Major weaknesses in either area were inimical to quality; weaknesses in both could be disastrous.

At the operative level, lack of skill was less of a problem than simple lack of care. A high standard of skill was seldom required, but when it was, it tended to be achieved by selecting operatives for whom the higher standard was natural, rather than by exerting pressure on poorer performers.

A disturbing number of quality problems, though identified on site, were not dealt with satisfactorily. Lack of real authority in the clerk of works' role seemed a common reason.

<u>Contrôle de la qualité de la construction sur</u> <u>chantier - quelques observations sur la pratique</u> actuelle au Royaume Uni

L'observation du personnel de chantier chargé des questions de qualité du travail sur chantier a révélé quelques uns des facteurs qui contribuent au niveau de la qualité obtenue. Contrôle formel ainsi qu'acceptation ou rejet du travail accompli ont joué un rôle moins important que celui anticipé. La qualité était essentiellement déterminée par la suffisance de l'information du projet - en particulier les plans et dessins - ainsi que les connaissances et l'expérience partagées par le personnel du chantier directement intéressé - c.a.d. le chef de chantier et le conducteur des travaux. Des défauts importants dans l'un ou l'autre domaine portaient atteinte a la qualité tandis que des défauts dans les deux domaines pouvaient être calamiteux.

Sur le plan ouvrier, l'absence de competence etait un problême moins important que l'absence de soin. Un haut degré d'expertise était rarement exigé, mais quand il l'était, on l'obtenait en choisissant des ouvriers à qui une perfection élevée était naturelle, plutot que par l'application de pression sur les ouvriers médiocres.

Un nombre inquiétant de problêmes de qualité quoiqu' identifiés sur le chantier, n'ont pas été traités d'une facon satisfaisante. L'absence d'autorité réelle dans le rôle du conducteur des travaux semble une cause courante pour une qualité médiocre.

Introduction

Throughout the ages, concern has been expressed about the standards of quality attained in construction work, and there is a long history of attempts by sanction or exhortation to improve standards. In former times, where craftsmen tended to work directly to the client. or to his 'clerk of the works', the client was able to assess directly the quality of the work being produced; but with the later emergence of the professional architect the client's direct involvement in the detailed supervision of work diminished. Most recently the emergence of main contractors, and the elaboration in project documentation necessary to ensure their proper briefing, has distanced both client and architect from direct control of quality. Whether quality standards are any worse today, with our complex systems of specification and control, may be argued. What is not disputed is that standards are still not all that are desired, or expected. Indeed, it is perhaps in the latter aspect, the lack of predictability of standards, that there is greatest cause for concern.

Accordingly, the Building Research Establishment recently undertook a study of the factors which contribute to the standard of quality that emerges on site in substantial one-off construction projects, in the hope that this might form a basis for recommendations on how standards might be improved.

Projects studied

The study was based on observations of 27 sites involving contracts ranging in value from £100 000 to £12m. All were in the public sector - either for central or local government, or for public enterprises - and included offices, schools, barracks accommodation, technical centres of various types, and sports accommodation, but no housing.

Research method

On the majority of the sites there was a full-time clerk of works*, and in these instances the BRE observer spent a continuous period of two to three weeks on the site, the bulk of the time in the company of the clerk of works, but the remainder of the time, where this was possible, in the company of the contractor's staff, usually the site agent**. The remaining, generally smaller, sites without a full-time clerk of works were visited in company with the travelling clerk *In the United Kingdom the <u>clerk of works</u> is ostensibly the representative of the client on site responsible for ensuring that the work is carried out in accordance with the specification. In reality, however, on most sites he reports via the architect, and acts as a 'middle man' between architect and site agent.

**The <u>site agent</u> manages all work on site on behalf of the contractor.

of works, on several occasions. Overall, about twothirds of the observational time was in the company of clerks of works, and the remainder in the company of contractors' staff.

The method of observation was to accompany the clerk of works, or member of the contractor's staff, continuously throughout the day, noting anything that required the clerk of works, the site agent, the architect, or indeed anyone else on site to pause in their work to consider the quality or 'rightness' of what was being built, or proposed. Each incident noted has been called a 'quality-related event', or QRE for short. This neutral designation was chosen because to have called all the instances noted 'quality problems' would be misleading; QREs varied greatly in their significance, and many were accepted as part of normal work.

Care was taken to ensure, as far as possible, that the presence of the BRE observer on site did not influence site practices. The BRE presence was deliberately 'low-key', and no opinions were ever expressed about any of the QREs noted. It seemed that it took site staff two to three days to become so accustomed to the observer's presence that he was largely ignored. As the majority of site visits lasted two to three weeks, any overall 'observer effect' was probably small.

Analysis of results

In all, 501 QREs were noted and in the analysis which follows these are examined in relation to their origins, their seriousness, and the success with which they were tackled.

Figure 1 shows the causes of the whole group of 501 QREs, and the success with which solutions were found in the various categories.

In the first, broad categorisation, workmanship problems accounted for 36% of the total, and questions over the design or project information accounted for a further 57%. Analysed further, workmanship problems were caused predominantly by lack of care on the part of tradesmen, rather than by lack of skill or knowledge, whilst the design/project information area was dominated by unclear or missing project information. Between them, these two factors - lack of care in tradesmen and inadequate project information from the designer accounted for no less than 42% of all the QREs noted. Site staff found it more difficult to deal successfully with problems of design, where the causes were outside their own responsibility, than with problems of workmanship.







Figure 2. Causes of 98 serious problems identified and success with which they were resolved.

Figure 2 presents a similar analysis, but only for those 98 QREs, out of the total of 501, which were considered to represent serious potential or actual quality problems. Such QREs comprised, in the main, those concerned with potential water-ingress (for example, inadequate or missing damp-proof courses, faulty roofing or roofing details, faulty jointing), potential structural hazards, or totally unacceptable aesthetics. Again, as in Figure 1, lack of care by tradesmen and inadequate project information were the major causes for QREs, though they represented a rather smaller proportion of the total. Lack of knowledge in site staff, and designs which simply would not work were also significant causes of queries. Once again, site staff had, proportionally, greater success in dealing with questions in the workmanship area than with questions of design and information; but the most disturbing and significant feature of these serious problems was the number of them which did not attract a successful solution at all. Thirty nine QREs were of this type. Since the aggregate period of observation on all the sites was 40 weeks, this means that on average, on the sites visited, one serious problem was being recognised every week and was remaining either unresolved or was treated only to an unsatisfactory solution.

This discovery that significant numbers of problems were being recognised on sites, but not satisfactorily dealt with, prompted a closer analysis of the roles of the staff involved. Why were they so ineffectual?

For the 39 problems inadequately handled, the reasons for the lack of success were found to lie in one or more of the following factors:

- 1 lack of authority of clerk of works;
- 2 problem would be costly (in time and/or money) to rectify;
- 3 the problem was not recognised as really serious;
- 4 the problem was basically a design fault, and as such not within the field of action of the site staff.

In practice, it was common for more than one of these factors to be invoked in any one case. To take only one example, one of the specific problems identified was with an upstand in a roof covering. The designed height of the upstand, at a rooflight, was clearly inadequate for the likely weather conditions. The clerk of works therefore made a report of the inadequacy in his site diary, and reported it to the architect. This was all the clerk felt he could do in the circumstances - reason (1) - but he also invoked reason (4), since to correct design mistakes was not strictly within his province, and reason (3), because there was no risk to human life. The BRE observer was left with a distinct impression, however, that reason (1) was the most important one: the other two factors were really only being used by the clerk to rationalise his inability to take the matter further.

Interaction between clerk of works and site agent The study has shown that the roles of these two individuals were, to a surprising extent, complementary in the effect they had on quality. It was the sum total of their experience that had the major influence on the standards achieved on the projects examined.

To understand how this could be so, it is necessary to recognise the realities of the work of these two individuals on site. Although the clerk of works' contractual role is primarily one of inspection and checking, this is not in fact what takes up the majority of his time. In an earlier BRE report(1) it was noted that, far from spending most of his time inspecting and checking the work, the clerk was more likely to spend it in the site office interpreting the designer's intentions from incomplete or ambiguous drawings and specifications, sometimes even in providing minor ad hoc design solutions where no design, or only an unsatisfactory design existed. The time remaining to him for carrying out his formal role of inspection was limited. Assessments made on a sample of the sites visited in this present study showed that, on average, the clerk spent only a third of his time on inspection, with the remainder spent sorting out problems with the contractor's staff and tradesmen, discussing problems with the designer (usually on the telephone), paper work (site diaries, monthly report and formal directives to the contractor) and attendance at site meetings.

The site agent, on the types of project under consideration, normally has little, if any, knowledge of the project before the contract is awarded. He is expected to absorb the details of the design, and its labour, time and cost implications, at the same time as he is starting on the actual work. The degree of support that he receives from his own organisation, in terms, for example, of planning and materials procurement, can vary widely, but to a large extent his ability to respond quickly to the project needs, as they arise, determines its success in the financial terms against which he is largely judged by his employers.

Although the clerk of works and the site agent may seem to have different, and mutually opposed, objectives - the clerk to obtain the best quality, the agent to produce the greatest profit - they also share a common desire to complete the project to an acceptable standard in an acceptable period of time; and in satisfying this mutual desire, the one has to depend very much upon the other. The clerk knows that, in the real world of the site, he may have to compromise on the ultimate quality standard if the project is not to be unreasonably delayed; whilst the site agent equally knows that completion on time, which has a major effect on his profitability, depends on achieving that compromise. Therefore, the ultimate quality depends to a degree on the relative strengths of the clerk and the agent but, interestingly, the evidence from the sites studied suggests that deficiencies in the competence of one party can, to some extent, be made up by strengths in the other. Their separate perceptions of the minimum acceptable standards of quality are not necessarily far apart.

Examples taken from two projects in the study illustrate this complementary nature of the agent and the clerk of works.

On the first project, the clerk of works was very inexperienced and ineffectual. Fortunately, the contractor was able to have two management staff on the relat-

580

ively small site - a young general foreman who looked after day-to-day problems and the site agent, an experienced and very capable man, who was able to take the longer-term view. This entailed ensuring deliveries of materials, checking drawings of work due to start in a few weeks time, and consulting the architect's office over any omissions and mistakes. Often construction details would be worked out over the telephone, and work would go ahead from the sketch drawn up by the agent on site. Thus, in this instance the site agent was in effective direct liaison with the designer. bypassing the clerk of works to a large extent. Good work was being produced, but it would have been even better had there been a proper contribution from the clerk of works. As an example: the site agent had had no experience with precast concrete panels and the problems of jointing between them, and an input from an experienced clerk might well have foreseen difficulties which occurred later in inspection of the jointing.

On the second site, roles were reversed, with a clerk of works who was very experienced and able, and an agent who was very inexperienced - on a project which involved accurate reinforced concrete construction, the agent had never before done any reinforced concrete

work. Notwithstanding, work on site was proceeding well, with the clerk virtually running operations, giving directions to the workmen, checking through the builder's mail and orders for material, as well as maintaining pressure on his own architect for drawings and correcting mistakes on them. When the builder's headquarters staff wanted any information about the site, they tended to telephone the clerk of works rather than their own agent. Just so long as the clerk's direct involvement at this level of detail was maintained, the quality standards achieved were very satisfactory; but the clerk was warned of the contractual dangers of so closely involving himself in the construction work, and was obliged to confine himself, in the later stages, to his contractual role, which was predominantly one of inspection. Quality thereafter deteriorated markedly, to the clerk's obvious frustration. Thus, problems on both these sites were caused by the inexperience of one of the clerk/site agent duo; but the problems would have been infinitely greater had the more competent individual in each case not been prepared to stray well outside his formal role, to compensate to a degree for his opposite number's inadequacies.

In general, clerks of works and site agents concentrated their efforts on improving the environment for quality by ensuring that the project information was as complete and rational as possible, and by selecting operatives for any particular task from those to whom the standard required was more or less natural. There was a tacit acceptance by all involved that quality ultimately depended on this match between operative and task. Formal acceptance or rejection of completed work was not a significant method of control.

Influence of architects and tradesmen About one in five of the QREs were originally raised by tradesmen: a surprisingly large number, given that the BRE observer spent no time directly observing them. Most tradesmen's QREs related to aesthetics. In some instances a good rapport developed between individual architects and tradesmen over the requirements for particular features or effects.

Architects' influence on quality was predominantly indirect, through specification briefing of clerks of works before work on site, and input to questions raised during construction. Architects' direct personal influence was unexpectedly modest. They were rarely seen on site, and when they did appear it was usually to preside at a site meeting. These meetings tended to concentrate on programming and on time delays, rather than on technical details. Some clerks of works were critical of the fact that, on the few occasions on which their architects did appear, it was seldom possible to discuss matters at length with them. Out of the 501 QREs, only 44, mostly concerned with aesthetics, were raised by architects, and 10 of these were on where, exceptionally, the architect acted also as the site agent.

Interaction between participants as a determinant of quality

From the foregoing it is evident that the standards achieved on the study sites depended heavily on the qualities of the leading participants, the extent to which these qualities were complementary, and the degree to which the participants could or would co-operate in achieving a satisfactory end result. It was noticeable that the sites producing what were, by common consensus, very acceptable standards were those where there was evidence of real commitment by staff at all levels. On these sites everyone became involved to some degree in raising and dealing with quality matters, and for this reason they have been designated 'consultative' sites. Two thirds of all study sites came within this category. In contrast, the sites where significant quality problems existed and were not being resolved tended to be those where, for one reason or another, co-operation between the participants had either never existed or had broken down, and had been replaced by formal communication, usually of complaints, according to the contract provisions. These sites have been designated 'non-consultative' sites. There was little difficulty in ascribing individual sites to one or other category; polarisation evidently occurred. It was not possible to determine absolutely whether or not the consultative nature of the good sites was an expression of cause, or of effect, but there was evidence that the formalistic non-consultative stance was adopted as a reaction to

unfavourable circumstances, such as poor or late project information. These two extremes of human behaviour are illustrated in Figures 3 and 4. Figure 3 illustrates the archetypal 'non-consultative' site. On this site extremely poor project information (the project had been delayed for some years at the design stage, and when it was eventually started the information was often incomplete and sometimes incomprehensible) may have been at the root cause of the difficulties, but was compounded by lack of care by the contractor. The resulting mass of problems had worn everyone down to performing strictly according to their formal, contractual roles. Thirty six QREs were noted during the BRE period of observation, and of these the clerk of works dealt with 29, seldom consulting anyone in the process. The clerk of works was unhappy at the quality level being achieved. The architect was reluctant to visit the site, since he knew he would only be inundated with queries arising from the drawings. In contrast, Figure 4 shows a typical 'consultative' site where almost as many QREs were observed - 29 - but action on them was shared between client's and contractor's staff, whilst almost anyone could be consulted in arriving at a solution. Quality standards were high. Here, the clerk of works was able to act in his proper role as a 'quality co-ordinator' primarily concerned with ensuring that the contractor's own system was dealing adequately with questions of quality.

Conclusions

A disturbing number of potentially serious quality problems, identified on the study sites, did not attract successful solutions. Several reasons contributed to this failure including, commonly, the lack of authority of the client's quality controller - the clerk of works.
 In general, quality standards did not rely significantly on formal checking and acceptance or rejection of completed work. Instead, they resulted from the work context created by designer and site staff.

(3) The designer's contribution to quality was predominantly through the quality, completeness and accessibility of the project information, both in the project documentation and in resolution of design problems identified during construction. Poor project documentation could have a very detrimental effect on quality, both because of the errors and delays arising directly, and because of the depressant effect on site morale.

(4) The clerk of works and site agent had key roles in determining quality actually achieved. To a surprising extent, their inputs were complementary. Particularly in technical matters, deficiencies in one's knowledge could be made up by the other, at the risk of some blurring of the proper distinction between their contractual roles. On balance, this willingness to work





outside formal limitations, by allowing fuller pooling of available expertise, was beneficial. Sites with acceptable quality standards tended to be characterised by a 'consultative' approach to problem solving - anyone could raise questions, and many individuals could contribute to solutions; whereas sites with low quality standards tended to be 'non-consultative' with only the clerk of works really concerned with quality matters. Whether or not this consultative/non-consultative polarisation reflected cause, or effect, was not clear.

The work described is still being analysed, and a fuller account will appear in due course.

Reference

 Burt, M E. A survey of quality and value in building: Department of Environment, BRE, Garston, 1978

Acknowledgement

The work described has been carried out as part of the research programme of the Building Research Establishment of the Department of the Environment and this paper is published by permission of the Director. Improved production planning and control, a cooperation between a Research Institute and 30 Building Contractors

Einar Gabrielsen, research officer and Odd Sjøholt, Head of division Norwegian Building Research Institute Oslo, Norway

Summary

The paper describes the experiences gained from cooperation between the Norwegian Building Research Institute (NBI) and 3 groups of contractors, each with ten members. The first group went through a 4-years programme starting in 1971. The third group finished its cooperation programme in 1979.

The objective was to develop a practical system for construction planning and control, and to establish construction project management as a permanent function in the participating firms. Testing of systems and establishment of routines was carried out in 3 building projects in each firm. An outline of the project was described in a paper to the CIB-congress 1974 [1].

This paper represents an attempt at evaluating the results in comparison with the objectives, and to state the problems involved in such undertakings.

This paper is divided into the following sections:

- 1. Outline of a cooperation project
- 2. Experiences with the cooperation and the learning model
- 3. Organizing the implementation of construction planning and control as a permanent function in a firm
- Systems and tools for construction planning and control
- How to utilize the project results in the building industry

1. Outline of a Cooperation Project

In the period 1955-70 NBI dealt with developing and introducing tools for better organization and management of building site processes. The institute, however, found the dissemination of its experience through publications, courses and more sporadic assignments to establish construction time schedules and programmes for single contractors, ineffective. The permanent changes in the firms were rather small.

In 1970 the institute developed a new approach to improve the impact of its research work in this field, and started a closer cooperation with a group of contractors. In 1971 ten of our client firms joined a cooperation group, declaring that their aim was to establish construction management as a permanent function in their organization. NBI took the responsibility of organizing the group work and joint activities benefitting the whole group. In addition NBI had the responsibility for further development of the procedures and routines of the management information systems, and the ways of organizing the management functions. Furthermore NBI had the right to publish and disseminate all the experiences to the whole industry by different means.

The programme for this first group was planned to last four years. As the cooperation was felt by the participating firms to be useful in many ways requests to organize further groups arose. NBI was engaged as consultant to the second group established by The Norwegian Constractors' Agency for General Service. Finally NBI organized a group consisting of smaller firms from different trades.

The two last groups had the same objectives as the first one. But for NBI the emphasis was more on the dissemination of experiences from the first group.

When the last group terminated its cooperation programme in 1979, NBI had contributed approximately 60 manyears in these activities, slightly less than half of which was consumed by advisory activities to each firm or group.

Most of the NBI work within the firms was financed by direct payment from the participating firms or by special research grants. In this way it was possible to double the institute's work in the field during this period.

Experiences with the Cooperation and the Learning Model

The main objective of each firm was to implement construction planning and control as a permanent function within its organization. Furthermore it was an objective to qualify itself for future development within its firm, and to correctly evaluate and to successfully utilize systems and tools that might be available.

The cooperation between NBI and each firm was focused on three successive building projects. In the first of these building projects, the management information systems developed by NBI were introduced and applied with the assistance of institute experts in cooperation with project managers from the firms. During the second project the institute experts involved future planning engineers of the firms to take part in the planning procedures as a training period. In addition the future planning engineers during a one years period participated in a series of group lectures, where the planning systems were taught and experiences were discussed. In the third building project the planning engineer was supposed to carry out as much as possible of the work on his own, while the institute experts closely monitored his progress.

The cooperation between NBI and the group as such mainly took place in information and experience ex-

change conferences. Three or four times a year a meeting was arranged between representatives of the top management and the planning staff of each firm, together with the NBI experts. In addition a common data bank was established within each group, consisting of specified time consumption data recorded from work operations during the 30 building projects.

Having completed this programme for the three groups, the overall conclusions are very positive. The results and the recommendations concerning the cooperation model as seen from different points of view are formulated in the following.

Important factors from the institute's point of view

- research and development in cooperation with the future users enhances the implementation of the results. The researchers learn to discuss and evaluate promising ideas.
- The great volume of such a project permits a more basic and comprehensive research work.
- The many different building types offer possibilities for experimenting with different planning systems and making the necessary modifications.
- The relatively long project period gives the researchers the necessary time for personal development, the improvement of creativity and personal involvement.
- The external financing of the services to the firms represents a considerable and stable income of importance which liberates funds for more basic studies within the institute.
- The mode of work in the building projects and the firms gave invaluable contacts with the building industry, and a large number of personal contacts.

The following factors are of special importance to the success of cooperation between the individual firms in the group

- The effect of this special cooperation seems to exceed what could be expected if the same amount of work had been carried out in each firm simultaneously and with no attempt at coordination.
- The cooperation inspires and challenges, and strengthens mutual obligations in spite of the many daily excuses for not undertaking the planned activities.
- The firms learn to understand the problems of cooperation and to appreciate the positive dynamic effects. It seems that every firm benefits more from the cooperation than it contributes.
- Cooperation projects will help firms and even their competitions to find forms of cooperation.
- The staff members who actively participate in the cooperation scheme gain positively in personal development and establish a net of personal contacts in other firms.

- The cooperation activities easily obtain wide attention and presentation in technical periodicals and newspapers inferring a positive image to the partners including the research institute.
- The cooperation model offers particular possibilities for exchanging technical information, distinct from management information, for instance about new production methods and equipment.

Having completed the initial programme, succeeding programmes may be established. Two of the three actual groups prolonged their cooperation during two additional stages.

Specially important aspects to ensure cooperation

- It is necessary to have a detailed programme that is marketable, establishes confidence and has a profitable aim.
- The organizing institute must have the necessary experts and know-how for fulfilling the programme.
- The institute must be prepared to educate a sufficient number of successors to those staff members who leave the institute during the relatively long project period. These planning engineers are rather valuable for the firms, and they will soon be offered jobs.
- It is beneficial for the cooperation if the invited firms are known by the institute beforehand.
- It is necessary that the members of one group seldom are competitors for the same jobs, and it is convenient that they are of approximately the same magnitude and interested in the same type of projects.
- It is absolutely essential that top managers are motivated for the cooperation project and have sufficient stamina to follow up and fulfill their obligation.
- It is a must that the necessary staff resources are engaged and educated in each firm.
- The progress in the cooperation activities within each firm and the implementation of production management ought to progress parallelly in all the firms.
- It must be supported and tolerated that the project management of the research institute has to be active and somewhat persistent towards the firms to get activities carried out within the right time and in satisfactory ways.
- The total payment from the firms for the institute's services must be agreed upon in advance, ensuring that scarce money for individual building projects does not prevent the necessary input from the institute's experts.

3. Organizing the Implementation of construction planning and control as a permanent function in a firm

The objective was to evaluate the different organization models and their suitability according to the properties of each firm during the 4 years project.

The basic principle was that the building site manager was responsible for planning and controlling the work on site. To support this function a specialized service staff could be organized in various ways. This service staff could be linked together with the central organization of the firm directly under the top management or in various ways under technical directors. The functions of such a staff might cover production planning, production monitoring and control, development of new or better production methods or design of building projects. It was anticipated that when such a staff exceeded one person, each should preferably specialize in some of the actual functions.

The advantage of having such a staff would be a capacity to support site managers in busy periods, a competence to select effective management tools and a way to get a centralized data bank of the firm's know-how.

As a result of the project the following experiences and conclusions can be formulated:

- An outstanding factor is the positive view of technical managers on the planning service. This will positively influence the site manager and his foremen.
- The head of the planning staff must personally join the work, and not allow his colleagues to get involved in activities outside their main functions.
- The planning staff must take care to fulfill their obligations in time, and not to get overloaded, with negative consequences for quality of their ordinary work.
- Specialization of the construction planning staff can result in negative effects, especially when dealing with routine activities, and a planning staff of more general competence seems to be most common.
- The educational function was underestimated, but probably will be more and more important. It concerns the motivation and education of site management people so that they can execute their planning and controlling functions more independently. The main tasks of the staff will then be to develop suitable planning methods and to introduce them step by step.
- It is a necessity to invest in the education of planning staff. From the beginning there were very positive experiences in the groups, but valuable planning engineers were also attractive to other firms, so a considerable number changed jobs. Promising individuals were also promoted or moved to site management jobs.
- There are negative experiences concerned with the education of the second generation of planning

engineers. The firms do not seem to recognize the same necessity as for the first person. In this way the competence weakens, and neither the service function nor the educational function can be fulfilled.

Systems and Tools for Construction Planning and Control

The objectives for a firm's production planning and control are to achieve the optimum of time and cost, and to obtain an overall coordination of resources. To rationalize the planning and control function in a firm, it is necessary to have some common systems and tools. These must cater for several purposes, and should be applicable both as an integrated whole and in other cases the parts should be possible to use as independent entities. The systems and tools should be adaptable to different types of buildings and constructions.

In the project there was also an assumption that the tools should lend themselves to manual date processing, but preferably the systems should be designed for electronic data processing.

As the cooperation project started in 1971, the NBI presented proposals for most of the necessary tools. During the project period these were tested, revised and developed and new tools were created.

It was agreed to choose an accepted tender for a construction contract as the starting point for the development work. The further process was divided into the following 4 stages:

Start of planning, review of assumptions

- Detailed and general preplanning
- Building site management
- Experience and data

The tools and routines mainly consisted of checking lists, forms for planning and recording, routines for filling in, disseminating and evaluating results, and for updating plans. For further description see [1].

Experiences from the test project

- A successful use of planning systems and tools depends for 80% on the organization of the planning process and only for 20% on the quality of the systems and tools. On the other hand routines are necessary for making the planning function work, and the tools have to be reasonably effective and practicable.
- Forms and routines for using them are necessary, but they should all be made as simple as possible.
- During the test projects all the tools were developed to an acceptable state. It is strongly recommended to use test projects also when introducing new routines or changes.
- A main conclusion that was not sufficiently anticipated in the test projects, is the necessity of a

step-by-step introduction of new routines. A starting period for may be one year, introducing only a simple part of the routines, may be appropriate. The next step may be to introduce and practice the normal extent of planning. Thereafter one may introduce some more special routines for important projects.

- A few of the routines were concluded to be rather complicated to handle manually. This is particularly true as regards satisfactory financial budgetting and control.
- After the project started, it was agreed to include the minimization of site accidents among the planning objectives.
- It must be stressed that the experience and the attitudes of the workers, foremen and site management has to be taken into consideration and allowance made for them in the plans. Otherwise the planning is still-born.

The planning functions have to be effectively established, as described earlier. The planners have to know their profession, and to offer the necessary assistance and information to the site management. They should be responsible for the adaption and further development of systems and tools for planning. And finally the firm must be willing to allot time and resources for planning and control purposes, otherwise it is better to continue with improvisation.

5. <u>How to utilize the Project Results in the Building</u> Industry

NBI's motivation to undertake such a project was to obtain experiences and develop planning systems for further dissemination in the building industry. As the project involved 30 firms and the likely aim should be to influence more than 1000 firms, the task is rather comprehensive. And since the establishment of planning routines is so integrated with the total organization, there exist no simple information methods. So far the institute has not found any complete solution of this dissemination programme, partly because of financial problems. In the following the real information activities are described. The system and tools are described step by step in a loose-leaf set of instruction-sheets. All the necessary forms are obtainable. Some EDP-programmes may be utilized through the institute or some service agencies.

For further dissemination in a firm there exist three types of services. The first is an open course organized by the institute and directed primarily towards persons who will become responsible for the planning function within a firm. Secondly the institute provides material for each firm to arrange internal study courses. As an alternative there exist material for a correspondence course, aimed at individuals in smaller firms. Finally the institute offers advisory services for internal introduction and establishment of planning functions, preferably as a package deal.

An important means to disseminate these new recommendations is through the education of engineers. Compendiums and problems are prepared for application in the engineering schools all over the country.

An efficient but very expensive method of dissemination is to educate and train planning engineers for longer periods. For example NBI staff members during the cooperation project became very qualified to continue the implementaion of the results from new positions in the firms. In the same way change of jobs especially from larger to smaller firms will contribute to the dissemination.

As a final conclusion it must be said that the cooperation project has had a permanent impact on the planning and control in the Norwegian building industry. It is hoped that these 10 years of consentrated efforts can be followed by 10 years of natural diffusion of the planning principles.

References

[1] Sjøholt, O. A production planning and control system for building contractors; a cooperation project.
Published in: The impact of research on the built environment; contribution submitted to the 6th congress of International Council for Building Research, Studies and Documentation, CIB. Budapest 1974. Vol. 1, part 2, p. 182-185. Need of education on the project management area on technical colleges and universities.

- Knut Gilboe, graduate engineer, secretary of education council, teacher at TIH, Norway.
- Janusz Ziolko, graduate engineer, consulting engineer, project management, Norway.

The failures and the lack of interest between engineers and architects for the basic questions concerning management, which is a phenomenon of our generation, can be followed directly to colleges and universities. The European schools have only recently introduced training in methods of thinking.

1. Scope

Students are still leaving colleges and universities, with their diploma in the hand, however without ideas concerning neither theory nor practical tasks within project management.

The young engineers come in touch with project management routines first within entreprises and engineering companies, which develop their own systems and procedures. The companies often consider these last ones a business-secret and competition subjects. In this way the common knowledge and exchange of experience is not easy to obtain.

This situation is independent of the branch of industry. It is of great importance to start a organized education within the project management area both in colleges and technical universities.

The following gives a draft concerning the general approach to the problem and a concrete proposal for a frame of an education programme on Norwegian technical colleges.

General draft

One proposes the following education and training programme to be introduced in the curriculum of the schools. As a frame for the programme one suggests three main parts.

- introduction, motivation
- theoretical background
- practical applications, training.

2.1 The introduction should cover a general revue of the practical applications of different types of procedures and routines within project management. This part of the lectures should have as its main task to create interest among the students for the subject, to make them aware of the importance of this discipline in practical life.

Probably the best arrangement of this part of education will be a collaboration between the teacher of the college and a representative of the industry.

The first one should be responsible for the pedagogical co-ordination of lectures, the second should contribute with a practical report from a series of actual projects where he is involved.

It could be desirable that these lectures would be preceded by the elements of edp-training. However, this is not indispensable.

This part of the programme should have more a character of popular talks than lectures, using examples from real projects. The speaker must describe the main rules of organization of the projects, their planning and execution. The position of investor must be explained as well as the necessity of a control apparatus.

It is of great importance that the teacher try to point out the similarity of the main rules of project management independently of the branch of industry (building industry, civil engineering, process industry, shipbuilding or offshore).

Is is recommended to use all accessible modern pedagogical tools to make the lectures as interesting as possible. During the period of introduction lectures an exhibition of samples concerning the projects touched by the teacher, could be arranged.

2.2 The lectures concerning the theoretical background should give the students sufficient knowledge of the essential disciplines to understand the main rules of project management games.

The following aims should be the subject of education:

- mathematical logic
- rules of classification
- coding theory
- accounting rules.

587

The extention of these lectures (number of hours, level of details) must be co-ordinated with other theoretical subjects which compose the total curriculum of education in the concerned school.

2.3 Practical applications should give the students the opportunity to build up and run a database connected to a project.

It is of importance to take a right decision concerning the choice of case-project.

If the teacher would get an opportunity to link this part of the education to a concrete project, actually running, in the neighbourhood of the school, it would be an excellent solution.

The case could be initiated by a presentaion of the project by the teacher and his friend from the site (contractor, quantity, surveyor). Later, when the students begin to run the project (or part of it), the school-training can be combined with site-visits, which will provide for reports concerning work-progress and cost control.

If the teacher (or the school) does not have any relations with contractors or investors, the teacher can combine the project management training with technical tasks solved by the students in connection with other parts of the general curriculum.

The following tasks should be treated during the training period:

- drawings administration
- specifications
- material take-off
- bidding, contract
- time scheduling
- accounting, progress control
- "as-built" documantation
- maintenance.

It is obvious that the practical education must be supported by an edp-system, designed especially for this purpose, and based on modern on-line and interactive technique.

3. Practical proposal for a frame of an education programme on Norwegian technical colleges

The technical colleges in Norway offer a 2-years education. To be admitted to a college, the candidates must have finished a 3-years secondary education (12 years in all). It is not required to have a site practice to enter the college. The technical college is a part of a regional college system and it is controlled by a regional council.

There are 15 technical colleges in Norway, 11 of them manage a section for building and civil engineering. Medio September 1979, the total amount of students completing their second year was 2.144, of whom 513 in the building and civil engineering section.

The education programme for technical colleges is coordinated by a set of branch councils.

As secretary of a building branch council, the author has proposed, in November 1979 the following recommendation:

- 3.1 obligatory, common lectures for all building / civil engineer students.
- 3.1.1 Economics I, 108 hours, including accounting, business studies, jurisprudence.
- 3.1.2 Project management I, 108 hours, including organization of projects, production technology, production management, calculation of work.
- 3.2 Optional, specialization. Further specialization within the areas of economics and project management is to each college's initiative and to the local teachers.
- 3.2.1 As an exemple, the programme drawn by the author for his college in Trondheim could be mentioned:

Project management II, 108 hours, comprising

- elements of project management
- the project phases
- 4 areas of project management
- information systems, data co-ordination
- system planning
- project planning
- progress control
- 3.2.2 The main part of the above mentioned disciplines is based on the SfB system.

During 1980 edp-systems will be brought into use. The SfB system is a well recognized international tool of information, recommended by the CIB-report no. 22 and other CIB-publications.

It is of importance that the Norwegian autorities will understand the value of the system, and contribute to a better understanding between the branch people. The CIB-council has a possibility to influence the responsible Norwegian organization to take an action.

It is necessary to collect all positive sides to promote information and propaganda in favor of better understanding of the importance of teaching project management in technical colleges.

Need of education on the project management area on technical colleges and universities.

Synopsis

The paper gives a general draft and practical proposals concerning education within the area of project management at technical colleges and universities.

Besoin d'education sur l'administration des projets dans les ecoles et universitées polytechniques.

Synopsis

Il est commenté sur l'education dans la matiere d'administration des projets dans les écoles et universitées polytechniques. Quelques nouvelles idées sont exposées. The Organizational Forms of Capital Construction Management

A.P. Krotov, NIIES, Moscow, USSR

<u>Summary</u>. The report deals with the existing system of construction management and the scope of construction on the level of the state as well as on the level of a building site.

The report also deals with problems of improving the organisational forms of management, the creation of all-Union construction and assembly units and large-scale specialised and combinated building organisations comprising such units. The principle of the structure and operation of newly created mobile construction units in building ministries is illustrated. Production construction and assembly units are to be focal in construction management.

The paper gives a characteristic of the organisational structure of units and their tasks.

The main directions for improving the management system which fundamental in drawing up overall management schemes in building ministries are denoted the appropriate management restructuring is to be effected during 1979-1981.

The method determining the efficiency of these means, design work, problems of research institutes and the application of progressive efficient methods of design are set forth.

<u>Sommaire</u>. Le contenu du éxposé réprésente l'échelle et le système existante de la gestion des grands travaux de construction en l'URSS de l'organ de direction de l'état à l'organisation des travaux sur les chantiers. On analyse les questions du perfectionnement des formes d'organisation de gestion, des créations des groupements de construction et de montage, la tendance de l'action, l'agrandissement, la spécialisation. Cet article indique les principes d'organisation et de fonctionnement des mobiles subdivisions de construction et de montage au sein du Ministère du Bâtiment.

Le groupement de construction et de montage doit être un chaînon principal de la gestion de la production du bâtiment.

L'éxposé donne la caractèristique du structure d'organisation du groupement et des problèmes resolus.

On montre les directions du perfectionnement du système de gestion. Le développement des schèmas généraux de gestion en Ministère du Bâtiment, réorganisation de gestion doit être executer pendant 1979-1981 années.

On cite la méthodologie de la définition de l'éffectivité de réalisation des mésures de perfectionnement de la structure de gestion du bâtiment.

Il s'agit de l'organisation du fonctionnement de l'institut de projet, utilisation des méthodes éffectives à projeter.

In the USSR the capital construction is a leading branch of the national economy, greatly influencing the development of the economy.

The scale of construction is shown by the following facts:

Only during the last three years (1976-1978) of the Tenth Five-Year Plan period 367 thousand million roubles were invested for the development of the USSR national economy and more than 700 large-scale industrial enterprises were put into operation. The increase in the fixed assets constituted nearly 25 per cent. If we take into consideration that such an increment of the production capacities had been achieved over the period of the first 45 years of Soviet power then the achieved rate of industrial development for the last years is becoming especially tangible. In different regions of the country the large enterprises of concentrated construction were created.

Every year on the map of the country there appear about 20 new towns and every week 40 thousand flats are commisioned.

More than 11 million people work in the building industry. At the building sites more than 1 million excavators, bulldozers, scr apers, cranes, trucks and other large construction equipment were engaged in 1978.

At present, the USSR construction is carried out by contracting and economic methods.

The contracting method is the main form

of construction organization.

The contracting method embraces more than 90 per cent of building projects in the country. Its auvantage consists in that this method of construction makes it possible to create the large building organizations with trained labour force equipped with necessary mechanisms and large scale production base of the construction industry.

The concentration of considerable resourses in a large-scale enterprise contributes to the manoeuvrebility in fulfilling the proauction programmes, organization of the activities with consideration of the advanced methods of labor and the achievements of technical progress in construction.

The organizational structure of management existing in the USSR capital construction consists in the following:

The management of construction is realized by All-Union building ministries having ramifide network of building organizations in the areas of concentrated construction - they are the highest (first) link in the chain of management.

In our country there are three Union-republic ministries of general construction organized according to a territorial and industrial basis. Through subordinate organizations in the areas of their action they control the construction of industrial enterprises, buildings, dwelling houses and projects of public services envisaged in the plan regardless of the branches of the national economy they belong to.

For instance, the Ministry of Heavy Industry Construction carries out works on the territory of regions and areas of the USSR where the construction of heavy industry enterprises predominates. Apart from the construction of these enterprises (steel and non-ferrous metal industries) this ministry building organizations carry out the construction for other ministries and administrations situated in the regions of the ministry's activities. Other All-Union ministries are organized according to the same principle. Within the zone of their activities these ministries conduct the construction of enterprises belonging to other branches of the national economy (dwelling houses and public services construction).

Agricultural construction on the whole territory of our country is conducted by USSR Ministry of Rural Construction.

Assembly and specialized works are headed by All-Union republican Ministry of Assembly and Specialized Building Work. To such works we relate the assembly of technological equipment, electric, chemical protection work, the construction of industrial furnaces, brick and concrete funnels, special hydrotechnical work and others.

The work is carried out through a wide network of trusts fulfilling special type of work and building and assembly departments in conformity with concluded contracts with organizations of general purpose construction ministries and other administrations.

According to the existing system of management the main links of management in ministries are represented by construction ministries in Union republics, main territorial administrations of construction, regional construction sdministrations, building and assembly trusts and administrations organizing the construction process at the very building sites.

The construction of special projects such as atomic, heat and hydro-electric stations, railways and nignways is carried out by Union special ministries.

The acting structure of management by industrial enterprises has been formed aepending on types of construction, regions of enterprise activities and the character of produced articles.

Thus in housing and civil engineering, house-building plants bringing together two spheres of activities one of which is the production of structures and parts of houses and the other, is their assembly at the building site, are an efficient management form consolidated with long experience of operation.

In the USSR, the creation of numerous house-building plans contributes to the acceleration of housing and the raising of their due to the completeness of prefabricated elements. At the introduction off.industrial output of houses and their assembly, the number of storeys was 5 or 6, now it raised up to 20 and more. The ratio of prefabricated housing constitutes more than 50 per cent in the hole volume of commissioned houses. Rural plants made a good showing. The principles of their work are similar to the organization of production at the house-building plants and summarised in the following. At industrial enterprises with a high degree

of mechanization, the production of rural prefabricated buildings of various types and purposes are made by line production; separate shops and spans of plants specialize in the production of definite parts in succession, which provides the complete set of planned projects.

Continuously raising volumes of construction work, intensive development of network of general purpose and specialized building organizations, acceleration of implementation of achievements in science and technology considerably complicated the relations and character of construction management and initiated its improvement in future.

Production construction and assembly units is a new progressive organizational form in capital construction. They are large production economic complexes of interconnected organizations which are characterized by production, organizational and economic unity.

The production unity is provided by subordination of activities of each link of a state unit to a general goal that is - a timely and qualitative output of construction production.

The organizational unity is reached by coordinated interaction of various production organizations under the leadership of a single machinery of the unit management. The economic unity is shown in the general interest of all subdivisions of the unit in the ultimate results of their activities with the most effective usage of all types of resources.

The next link of management after All-Union ministries is All-Union building and assembly units which are a united production and economic complex, as a rule, specialized in a certain type of construction and assembly work or industry projects under construction on the territory of the country or in the sphere of activities of the USSR Ministry of construction.

Among the organizations of a unit there are building and assembly muits trusts and other organizations of the same level as well as mobile construction organizations, industrial enterprises of the construction industry, transport organizations, project and research, project and design, project and technological, as well as other organizations and enterprises.

Such a unit may incorporate specialized organizations, conducting on the territory of our country, the assembly work of technological equipment, electric, sanitary, chemical and protection work or building projects of the same type such as elevators, heat and hydrotechnic power stations, sewerage or factory for the construction of steel and concrete structures.

The state unit carries out its work on full profit=and=ioss basis and must provide compensation for expenditures connected with the production of building and assembly work and of industrial enterprises, as well as expenditures for project and research work.

To the main tasks of All-Union building assembly units we refer:

- to secure the fulfillment of tasks for putting the production capacities and projects into operation;

- to fulfill building and assembly work by the time ensuring the commissioning of the production capacities and projects in proper time and to raise the efficiency of capital investments on this basis;

to provide technical progress, introduce the achievements of science and technology and advanced experience in construction;
to ensure the development of all production and economic complex and as a first priory overtaking development of production bases of the construction industry with due account of the prospects of building development in the region;

- to increase concentration, specialization, combination, the level of industrialization and complex mechanization in every possible way and of this basis to achieve the increment of efficiency of constructmon and industrial production;

- to improve know-how and organization of the construction production, widely introduce advanced methods of labor and on this basis achieve the increase in labour productivity; - to raise the role of economic methods in management, improve organizational forms and structures of management in a state unit, and introduce automatised systems of management in construction.

The unit management controls organizations and enterprises incorporating the unit being their higher organ and legal body. Board of managers and directors is formed to increase the responsibility of organizations and enterprises for the results of activities of a unit as a whole and to solve collectively the rising problems in a state unit. To the participation of the work of the Board specialists and leading workers are attracted.

The state units high-skilled specialists, innovators in industry, research workers are called to the economic and technical board.

Economic and technical board is responsible for developing proposals to use and introduct the achievement of national and foreign science and technology, scientific organization of labour and advance knowledge.

Among main tasks of a state unit are elso the questions of public services and living conditions of working people, the favorable and safety conditions of labour.

Concentration of the material and manpower resourses, equipment and mechanisms, transportation means, constructions and articles of enterprises makes it possible in necessary terms, to focus these means of construction for the fulfillment of the tasks.

Of late, in construction ministries have created mobile organizations which enter the All-Union building and assembly units. The work of these organizations (trusts or building and assembly units) is to ensure the acceleration of the commissioning of production capacities and construction projects.

Organizations, spesialized in a certain type or profile of work are equiped with necessary quantity of advanced building engineering, means of transportation, skilled personnel, which are located in the areas of a building ministry's activities.

On the order of ministry management the resources saved by mobile organizations are sent to the starting building complexes and projects for fulfillment of various works directed at speeding up the commissioning of projects.

The idem of the creation of mobile organization consists in accumulation ministries, of building reserve capacities of various types and profiles desiding, as a rule, fulfillment of operating schedule, and, in the form of mobile help to the main production subdivision, in carrying out the necessary amount of work by the fixed time. All-Union building and assembly state units subordinate to the construction ministry and are responsible for their production and economic activities.

The production building and assembly unit is becoming the main junior link in 2 or 3 unit system of construction management.

Such a construction unit is a large-scale territorial or specialized production and economic complex.

Units consist of building and assembly administrations or sites, constructuon engineering enterprises (concrete plant and jomers shops, transport and mechanization companies etc.) as well as of project and scientificand research organizations.

The forming up of units belonging to the lowest level solves many tasks of management.

Among these tasks are: - To increase the production efficiency on account of economic level of concentration (i.e. enlargement of organizations) which is realised on the basis of perfect mechanism of management of the participating organizations; - To centralise the management functions, strengthen the centralised management which creates more favourable conditions of operative production activities of the organizations directly engaged in the process of construction. Such functions as planning, finance, supply, external relations with clients and shippers are centralised as well; - To release the production staff from these obligations which allows them more purposefully organize their control over production and to give more attention to engineering preparation of the projects under construction:

- To introduce more progressive forms of labor organization, as well as more perfect forms and means of fulfillment of construction work;

To increase the operativeness and manoeuvrebility of existing resourses;
To introduce more wide specialization of construction work;

- To creation better conditions for decreasing the number of links in management of the construction process since the number of projects decreases and the volume of tasks of production character which are decided at upper levels of management shrinks; -To create the favourable conditions for the introduction of more effective methods of management and acceleration of scientific and technical progress;

- To establish more rational production ties with other participants of construction; - To organize control over the fulfillment of volume and terms of work at starting projects.

The building and assembly unit is the first link in the chain of construction management (in some cases it is substituted by building and assembly trusts) and is the comlex economic accounting organ.

The state unit may decide all the questions of production and finance activities.

On the basis of the construction plans adopted by Ministry of Construction and ALL-Union Building and Assembly Unit, a production building and assembly unit works out of putting the projects into operation, plans of finance, introduction of measures on scientific and technical progress, tasks of labor productivity and profit. State building units organize and control the fulfillment of plan indices and coordinates all the work at the building site.

The key and flow methods are the progressive and effective forms of construction organization.

The key method consists in dividing the starting complex into separate independent design and technological parts of technological cycle, the finishing of which is independent of the readiness of the whole project and may be accomplished after starting and adjusting works.

The assence of organization of work in the flow method consists in dividing the whole process of the project construction into technological interrelated types of work. This also relates to the continuity of transmition of the one stage of production to the other as well as the creation of general rhythmic work of workers and mechanical plant within the limits of separate sections, buildings, and other various constructions.

The optimization of project decisions in construction is to be carried out as a rule with the help of economic and mathematic methods and computers. The ensuring of the agreed terms of construction and the achievement of high technical and economic indices c can be a criteria of optimisation of the adopted decisions. In accordance with the adopted decisions, the restructuring of construction management is to be carried out according to general schemes of 2 or 3 link system of management and decisions on the further modernisation of construction management structure by ministries of construction during 1979-1981.

The economic effect of measures on the improvement of organizational structure and forms of management is reached from the savings both in the sphere of production and management.

The quantity of these savings is enfluenced by the level of construction, specialisation of production and modernisation of management. The influence of these factors on the main technical and economic indices of construction is reflected in the system of indices culculated in the corresponding intervals of the level of concentration and differentiation.

The total size of the expecting economic effect according to a developed methods is calculated from the results of measures foreseen by the general scheme of ministry.

The transition to the more advanced methods of management at all levels of construction will contribute to the increase in the e effectiveness of capital investment, acceleratio tion of commissionning of the production capacities and to the further growth of the national economy.

Construction project management in the Caribbean: an

educational approach

by	Peter Manning	and	Myron Chin
	Professor and Dean,		Senior Lecturer,
	Faculty of Architectu	re	Department of Civil
	Nova Scotia Technical		Engineering,
	College;		University of the
	"Unattached member" o:	f	West Indies;
	CIB; CANADA		TRINIDAD AND TOBAGO

Abstract

The administration of large-scale developmental construction projects in the Caribbean is complicated by needs for long-term planning and the observing of detailed procedures required by funding authorities. In any one year millions of dollars in approved foreign aid are held up because of continuing problems of managing their spending during the entire process of procurement from inception to completion. Some major difficulties are lack of communication among the various involved parties and coordination among the professionals.

In an attempt to solve such problems current financial support by the Canadian International Development Agency for the University of the West Indies includes proposals for developments in Construction Project Management. A major objective is to create within the West Indies, from local resources, the basis of a capacity by which top management in construction, the building professions, governments and funding agencies may achieve enhanced capabilities in cooperative working and specific technical skills. The paper reports on the detailed planning of intensive seminars in which multi-professional problem-solving groups drawn from the highest levels of these involved parties will work upon projective case studies as a way of fostering the needed capabilities.

Résumé

La gestion des projets de construction développementale de grosse entreprise est compliquée par les demandes de longue échéance sur la planification et sur l'observation de procédés détaillés exigées par les autorités finançantes. Dans n'importe qu'elle année donnée, des million de dollars d'aide approuvées pour des pays designés sont retenus parce que ces pays n'ont pas pu résoudre leurs problèmes de gestion financielle pendant le processus entier partant de l'obtention du commencement à la fin. Les difficultées essentielles proviennent des communications parmi les divers partis et de la coordination parmi les professionnels.

Le support de l'Agence canadienne de developpement international pour l'Université des Antilles comprend les propositions pour le dévelopment de la gestion du project constructionnel. L'intention présente est d'établir dans les Antilles, utilisant des ressources locales, la base d'une capacitée de la part des principaux gérants, et des professionnels en construction, des gouvernements et des autorités finançantes pour augmenter la portée du travail cooperatif et de l'abilité technique. Cet article s'addresse à l'organisation des séminaires intensifs pendant lesquels des groupes multi-professionnels composes de fonctionnaires tirés des plus haut niveaux seront engagés en des études projectives afin de développer des capabilitée. nécessaires.

Project management: the task and the need The several countries in the Caribbean region receive foreign aid for the construction of facilities that will aid local development. Funds are provided by, for example, the American, British and Canadian governments, and such other organisations as the World Bank. Projects so funded may include airports, roads, district water services, deep water ports, schools, hotels, and other building types.

The process of procuring facilities with which project management is concerned begins with the first awareness of a need. It continues with negotiations with funding agencies, development of procurement policies, and the determination or specific needs. There are major professional and industrial phases in design, construction and settlement of accounts. Project management concludes when the facility is eventually commissioned, though this stage may require evaluation of owners' and users' satisfaction with their new resource.

The responsibilities of project management involve the coordination of - among others - bankers, governments and their civil servants, consultant architects, engineers and quantity surveyors, contractors and specialist subcontractors, and the users of the new resource. Project management is an activity engaged in by project managers but those responsible for particular aspects of a major new facility (bankers, owners, engineers, architects, for example) are necessarily deeply involved in the processes of project management on top of their responsibilities for their own professional specialty. Their overview of the whole process must be adequate, otherwise they may not see where their role fits, or how the actions and decisions they take are or are not compatible with the actions and decisions of other participants. They need cooperative capabilities and certain particular technical skills. Planning an educational contribution to the need Support by the Canadian International Development Agency (CIDA) for educational developments at the University of the West Indies (UWI) has for several years included proposals for various kinds of courses in project management. Thus, during the 1970s V.K. Handa, of Canada's University of Waterloo, made extensive enquiries within the Caribbean region and drew up

proposals for degree and other programs in this subject. The Government of Trinidad and Tobago subsequently financed a special programme of training in Construction Engineering and Management, available to nationals of that country, at the St. Augustine campus in Trinidad of UWI. The programme comprises a masters degree, a postgraduate diploma and a certificate, besides occasional short courses and seminars.

During the spring of 1979 discussions between CIDA, UWI and Nova Scotia Technical College (Tech) established an objective of creating within the West Indies, from local resources, the basis of a continuing capacity by which top management in construction, the building professions, government and funding agencies might achieve enhanced capabilities in cooperative working and specific technical skills.

The reason why the objects of concern were top managers (rather than - say - middle-level managers) was because these are the people who make the crucial project management decisions. Moreover, there are suspicions elsewhere (Canada, for example) that middlelevel managers who have acquired new knowledge and skills may be frustrated in their use of that knowledge and those skills by top-level managers who are not so well equipped.

The means by which the overall objective was proposed to be achieved was a two-week long intensive seminar addressed to members of Caribbean governments and professions as an extension (or "extramural") activity. This was expected to be mounted in two centres: Barbados in the Eastern Caribbean and Jamaica in the West. Costs of the seminars were expected to be borne by the participants; instructors were to be found in the region. Tech was asked to provide the organisation that, in conjunction with UWI, would design, market, mount and evaluate these seminars.

Preparations for the seminars

The seminars were planned in twelve stages: Stage One: Familiarisation: A short visit to the region to gain understanding of the local scene, personalities and places; to provide insight for later design of a market survey; to seek local instructors and coordinators for seminar management and to explore possible locations for seminars.

Stage Two: Design of market survey: This involved devising samples of places and persons to visit, and developing procedures, checklists, questionnaires, itineraries and timetables for the survey.

Stage Three: Conduct the market survey: Potential seminar participants and related organisations were visited and their views recorded on prepared interview prompters.

Stage Four: Design for the first seminar: The results of the market survey, when analysed, were used to determine seminar content, arrangement, dates,

organisation, instructors and methods. Documentation mainly case studies and associated material - has been prepared. Instructors have been recruited and their briefing is in progress. The location of one seminar has been determined; the other, in Jamaica, has still to be settled.

Stage Five: Advertise the seminars: An advertising brochure has been prepared and will be printed and distributed in January 1980.

Stage Six: Assemble material: Instructors! teaching packages, all case study material and such other teaching aids as films, slides, etc. will be prepared ready for freighting.

Stage Seven: Conduct the first seminar in Barbados: The seminar will begin with a social occasion, to enable people to meet and to absorb late arrivals. The general rules for operation of the seminar, that were established at the beginning of the project, were that (i) seminars should be interactive and multi-professional; (ii) they should operate by means of projects, assignments and discussions, rather than through lectures; (iii) participants should be left with some tangible "means" they can take home and use.

Stage Eight: Evaluate the first seminar: A final session of the seminar will be arranged to provide feedback and an opportunity, in which both CIDA and UWI will be involved, for criticism of the seminar preparations and management.

Stage Nine: Modify the sessions: Depending on the results of the evaluation of the first seminar, the design of subsequent seminars will be modified as to organisation, staffing, classes, times, the presentation of case studies, and so on.

Stage Ten: Conduct the second seminar in Jamaica: The modified seminar will be re-presented in Jamaica approximately six months later.

Stage Eleven: Evaluate the second seminar: The second seminar will be evaluated, generally in the manner of Stage Eight.

Stage Twelve: Follow-up survey. Following an interval of, say, one year from the second seminar, a sample of the seminar participants will be visited to determine the value to participants' everyday practices and/or governments of the seminar material and experience.

The concept of the seminars

The seminars, it was expected, should interest those who are, or will be, professional project managers. It was decided, though, that they should be addressed primarily to the most senior members of the different professional groups - bankers, high government officials, principals in consulting practices, owners of contracting firms - who are likely to be involved in project management as part of their concern for substantial programs of construction. The general plan that evolved is that the seminars should take the form of multi-professional problemsolving groups (or "cohorts") working upon case studies of the procurement of particular facilities. Thus a seminar-workshop of between (say) 24 and 40 senior managers working upon a case study to improve the quality of education by the provision of new school buildings will be formed into three or more cohorts each comprising - so far as possible - members from different countries who are not normally accustomed to working together.

The membership of such a typical cohort might comprise: one Ministry of Education official; one member of a Public Works Department; one banker; one architect; one or more engineers (structural, mechanical, etc.); one quantity surveyor; one builder, and others.

An instructor will be assigned to each cohort as a non-participating observer.

The case study that is here used for example will set the scene for a typical educational project. Starting with social and political objectives, it will provide a description of a country, its vital statistics, a statement of its economy, and so on; to this will be added a description of present educational standards and practices and a statement of proposed new educational objectives.

Each cohort will have the task of developing a procurement strategy and of 'gaming' as much as it can accomplish of the procurement process. Thus a typical requirement will be to complete as many as possible of the following tasks:

- (i) Elect cohort chairman;
- (ii) Plan a timetable for the cohort's activities;
- (iii) Consider future patterns of education in the case study country and draft an educational policy statement;
- (iv) Consider alternative procedures for building procurement and draft a recommended procedure;
- (v) Consider alternative futures of building requirements and decide upon a probable typical need (eg, a school of a particular size);
- (vi) Draft a program of requirements (educational, social, managerial, economic, planning, etc.);
- (vii) Describe the required characteristics of typical building sites;
- (viii) Prepare alternative sketch designs; prepare alternative sets of specification notes;
- (ix) Draft alternative structural forms and servicing systems;
- (x) Prepare cost projections;
- (xii) Prepare a statement on possible alternative forms of construction organisation;
- (xiii) Prepare a construction plan and control system;
- (xiv) Plan utilization of human resources;
- (xv) Detail a proposal for procurement of materials: markets, alternatives, sequences, costs, etc.;

- (xvi) Establish a financial management system;
- (xviii) Consolidate all the detailed proposals in a summary document for presentation to the entire seminar membership;
- (xix) Prepare a method by which the completed facility might be evaluated.

If the case study had been the provision of (say) a new deepwater port, a similar set of tasks could have been stipulated.

This 'gaming' by the cohorts might take, perhaps, two days. Following this, a further day will be spent in presenting all the completed projects to the seminar membership as a whole. All particpants will have worked upon the same project but different strategies and design proposals can be expected from each cohort. Thus there should be several alternative strategies, procedures, designs and constructional plans to consider, criticize, argue and evaluate.

Inevitably, the cohorts' activities, and the following seminar discussions, will demonstrate working methods that could be improved and areas of technical knowledge requiring reinforcement. The next module of three days, then, will be alloted to the more formal presentation - probably in seminar-discussion form - of material to remedy the more important of these omissions. Some of these classes will be selected from the list that follows. Other subjects may be found to be needed only as a result of the dynamics of the interactions within cohorts; these, inevitably, may have to be arranged in-situ. The list includes topics similar to subjects in UWI's Master's degree in Construction Engineering and Management.

- (a) writing the program; establishing the brief for new construction requirements;
- (b) methods for multi-professional design team operation;
- (c) cost research, cost planning and cost control;
- (d) industrial engineering and building services;
- (e) optimisation of building structures;
- (f) estimating, bidding and new business development;
- (g) construction materials and equipment;
- (h) construction accounting and financial management;
- (i) project planning and control;
- (j) management of human resources and industrial relations;
- (k) organization and management of construction companies;
- (1) evaluation of building proposals and performance;
- (m) legal considerations in the construction industry.

A final three-day module will then be devoted to a further case-study. In tackling this second problem participants should benefit from both the experience of the first case study and the knowledge derived from the technical classes. It will be apparent that the principal teaching/ learning method proposed is self-education through group working. If suitable instructors can be found, social scientists interested in group dynamics and management specialists interested in decision processes are to act as observers during the cohort sessions so that they will be able, during the general discussion periods, to explain participants' actual working methods and propose more directed methods of collaborative working.

The market survey

During the period June-August 1979 senior Caribbean managers were visited in their offices with a provisional proposal for the seminars and a prepared list of questions. Envisaged by both CIDA and UWI as an integral and important part of the plans for the seminars, the 'marketing survey' had three main objectives. These were to:

- (i) create an awareness of the need for collaborative project management among the most senior managers in all sectors (eg, public, private) and all functional responsibility groups (eg, design, construction, banking, and so on);
- (ii) 'sell' the need for the seminars and thus recruit participants on a direct face-to-face basis; and
- (iii) discuss tentative proposals for the seminars to ascertain potential participants' general reactions and, more particularly, the specific needs they might express, including such matters as content, time, cost and location.

As a result of the survey, certain decisions were made:

- (i) to revert to the original decision to hold the first seminar in Barbados (a 'More Developed Country', or MDC) rather than in a 'Less Developed Country or LDC - as had been suggested following the familiarisation visit - in a hotel as distant as could be found from the distractions and interruptions of Barbadian business and professional life. This decision mainly derived from the need to attract parti cipants from the private sector, a majority of whose members live in the MDC's and appear perennially short of time and unlikely to travel to a seminar located in a LDC;
- (ii) to reduce the length of the seminars from the fourteen days originally planned to a new length of nine days (again, to encourage participants from the private sector);
- (iii) the original plan to hold the Barbados seminar in late April was amended to early May (to miss the expensive holiday season) while September for the Jamaica seminar was confirmed;
- (iv) the economic cost of the seminar (ie, tuition only, excluding board and lodging) was calcu-

lated to be about 750 Barbadian dollars (or about CDN\$450.00); this, it was discovered would be generally acceptable and should be charged to each participant.

Planning went ahead on this revised basis. An advertising brochure has been prepared for mailing to every participant who could be identified in the thirteen Caribbean countries that are the "target" for the seminars.

Case studies

The over-riding operational objective of the case studies is identical with the main objective of the seminar: ie, to create project management skills.

A secondary operational objective is to explore types of construction project management problems that may be expected to occur within the Caribbean region in say - the next five to ten years. In this way a body of experience and understanding can be generated now so that, later action can be taken with a flying start and greater certainty of success.

The educational methods have been developed so that the educational objectives are constantly in the forefront. They are:

- (i) to present project management as a collaborative (team) activity pursued by all participants in the procurement process;
- to simulate the experience of a multiprofessional work-setting so that participants may comprehend and exercise the needs for collaboration and communication in an interactive process;
- (iii) to provide government officials, construction managers, design and construction professionals and others with an over-view of the entire "front end" of the development process and, from their active participation in this multiprofessional role-playing setting, some understanding of the roles and responsibilities of other players as well as some new insights into their own;
- (iv) generally, to avoid a didactic lecture-type environment and instead to create a collaborative learning environment, in which participants may learn by doing (rather than by being told) and from their peers (rather than from professional teachers who, inevitably, are not constantly involved in the development process);
- (v) despite the foregoing, to provide for those who recognise their need an opportunity of acquiring understanding and some knowledge of theory, and some theoretical techniques, that may be used to aid the professional tasks of project management;

 (vi) to provide opportunities for the most senior managers in diverse but related fields to meet in an informal milieu to discuss, in the process of working upon projected problems of the future, the problems that commonly arise in the identification and preparation of development projects, and by so doing, to pool a range of ideas and experiences from several professions and countries.

The case studies to be used for the seminars have been prepared on the lines exampled earlier (in the section entitled "The concept of the seminars"). Thus one, focused on the industrial development of St. Lucia, has been summarised as follows:

"During this case study exercise participants, working in multi-professional and multi-national "cohorts", are asked to "game", in as much detail and as realistically as may be possible, the identification and delineation of a construction project management problem, including plans for industrial facilities that would most probably be located within the industrial estate at Vieux-Fort, St. Lucia.

The main activity of each cohort should be to examine the industrial, economic, technical and financial aspects of alternative possible developments and prepare a project. This should include a clear identification of a time-frame for decision-making on the most important activities, besides plans for the construction of a physical facility for which funds might be sought from a financial institution (that might be domestic, regional or international).

One possible answer might be a general-purpose type industrial building, owned by an agency of the Government of St. Lucia, that could be rented out to one large-scale manufacturer or subdivided and rented to several smaller manufacturers. There may be other forms of development that might be more productive so cohorts should spend some time examining possibilities."

The text of the case studies has been supplemented by other explanatory documents, including an 'Introduction to and explanation of the operation of the case studies'. This, briefly, describes the development project cycle, explains the methods of working of the multi-professional "cohorts" and concludes with detailed suggestions for each of the several kinds of professional expected to participate.

A "dry-run"

The case studies proposed differ in at least one major respect from the kinds of case study commonly used in business schools: they are projections into the future rather than 'historical' reconstructions of actual happenings. Though their form is unlikely to appear new or intimidating to anybody who has survived an academic program in architecture, they will probably be a new experience for the bankers, industrialists, civil servants, engineers and other non-architect participants who are expected to form the bulk of the seminar membership. For this reason, a "dry-run" of a case study was conducted in Halifax in mid-January 1980, to gauge participants' responses and to 'finetune' the method of presenting the cases. Membership of this pilot exercise was drawn variously from the Caribbean, from Nova Scotia, and from Ottawa and embraced all the 'functional responsibilities' required for the Caribbean seminars. The case developed was an examination of the future of Nova Scotia's existing stock of school buildings, in the light of present expectations of a decline in school populations, increased economic stringency, and continual change in educational philosophy and practice.

Two cohorts, each of eight members, spent seven hours working upon the problem. At the end of the day each cohort has developed a consensus, defined a problem and considered ways by which it could be attacked. Neither cohort, however, attempted solutions to the detailed project management issues. Therefore, as a consequence of experience gained from this dry run, the seminar case studies will be 'staged', to ensure adequate treatment by the cohorts of all appropriate stages of the project management process.

Tentative conclusions

The seminars that have been described, and the case studies of which they are comprised, are still in the preparatory stages, for the first seminar will not be held until shortly before the 1980 CIB Congress. It is, therefore, too early to present conclusions, except to promise that a critical review, based upon the evaluation that will be conducted at the conclusion of the Barbados seminar in May 1980, will be offered in Oslo in June 1980.

For the present, it should be said that the methods proposed for the seminars are generally seen to be breaking new ground. To some this has been cause for trepidation. Fortunately, for some senior managers in the Caribbean it is instead a main reason for enrolling.

Construction materials data base

Eugene L. Marvin, PhD, PE U.S. Army Construction Engineering Research Laboratory United States of America

Summary.

This study examines the feasibility of providing a central source of information about construction materials for use by the Army Corps of Engineers. A survey of a sample of potential users determined that approximately 58,000 manhours of materials research activities are performed in the Corps annually and that the survey respondents generally favor establishment of a centralized information source.

The survey determined 14 materials classifications that are researched by more than 40 percent of the respondents, and also indicated various functional categories of information requirements. Current sources of materials information are manufacturers and government agencies.

Survey respondents indicate a need for 18 different information service features. A centralized data base concept was then developed by considering alternative information processing schemes that would provide the desired information. A data base structure was devised to satisfy the functional information needs within the 14 classifications identified by the survey. A test of the data base concept is being conducted to verify that the proposed data base will satisfy user needs.

The proposed construction material products data base could serve users both within the Corps and private industry. Furthermore, this concept could be used in other countries to help optimize the use of human technical resources.

<u>Résumé</u>.

Cette étude examine la possibilité de constituer une source d'information centrale concernant les matériaux de construction utilisés par le Corps d'Armée d'Ingénieurs. Le sondage effectué auprès d'utilisateurs possibles a montré qu'environ 58.000 heures/travail au Corps d'Armée sont consacrées annuellement à des activités de recherches sur les matériaux et que, d'une manière générale, les personnes questionnées se sont déclarées en faveur de la constitution d'une source d'information centralisée.

Le sondage a déterminé 14 groupes de matériaux sur lesquels des recherches ont été faites par plus de 40 p.c. des personnes questionnés et a également montré diverses catégories fonctionnelles d'information. Les sources actuelles de renseignements sur les matériaux sont les industriels et les agences gouvernementales.

Les personnes questionnées ont indiqué qu'elles nécessiteraient 18 types de services d'information différents. On a ensuite émis l'idée d'une base de données centralisée en envisageant des combinaisons de procédés d'information alternatives qui fourniaraient les renseignements demandés. On a élaboré la structure d'un centre de données pour satisfaire aux besoins d'information fonctionnelle parmi les 14 groupes identifiés par le sondage. On procède actuellement à des tests sur l'idée de la base de données pour voir si la base de données proposée satisfaira aux besoins de l'utilisateur.

La base de données pour les produits relatifs à la construction proposée pourrait servir à la fois aux utilisateurs du Corps d'Armée et à ceux de l'industrie privée. De plus, cette idée pourrait servir dans d'autres pays et étendre au maximum l'utilisation des ressources techniques humaines.

Background of database study.

This study investigated the feasibility of providing a centralized information source for construction materials available within the continental United States and determined the U.S. Army Corps of Engineers' need for a system. The Corps of Engineers is made up, in part, of 31 District Engineering Offices, 1 Operating Division Office, and 134 Facilities Engineering Offices located throughout the continental United States. The District and Division Offices are responsible for constructing new facilities, such as roads, buildings, and utilities at Army posts and other sites within the continental United States. The Facilities Engineers are responsible for maintaining and operating these facilities on Army posts. These engineers and their staffs often need and are required to search out information about construction materials, products, and systems. Some form of technical support that will satisfy their information needs and eliminate the need for them to do the research is highly desirable.

Survey investigation.

One hundred and eighty-four potential users of the proposed database were surveyed by telephone. The purpose of the survey was to answer the following questions:

1. What are the materials information needs of the population conducting this research?

2. How is needed materials information now being obtained?

3. What does it cost in human technical resources to obtain the needed information?

The individuals who were interviewed were selected by defining specific organizations to be included in the survey. Organizations were selected on the basis of location in order to give wide geographic distribution

600

and by general mission categories in order to learn about the mixture of activities being performed. Once the organization selection process was completed, all individuals in each organization likely to be involved in construction materials selection were interviewed.

The survey indicated that the level of research being performed to evaluate material products for special applications varies greatly. However, nearly all of the individuals interviewed do perform some research-usually about 45 hours per year. Further analysis showed that a total of about 1300 individuals participate in these activities at an estimated annual expenditure of 58,000 manhours.

There is considerable opportunity for duplication of effort because many people at different locations are looking for basically the same information. Nearly all personnel interviewed indicated that they would use a centralized source of information if it were available. The survey indicated the specific topics that are researched by the respondents (See Table I). Nearly half of the respondents research each of the topics listed. Ten other topics are researched to a lesser degree.

Table I. Topics researched by more than40 percent of survey respondents

Percent of Respondents Researching Topic	Materials Research Topic				
46.2	Paving materials				
44.0	Structural materials				
45.1	Roofing materials				
46.7	Exterior building construction				
	materials				
42.9	Interior building construction				
	materials				
57.1	Insulating materials				
47.8	Plastic materials				
45.6	Waterproofing materials				
45.1	Paints and coatings, interior				
46.7	Paints and coatings, exterior				
52.1	Sealants				
43.4	Heating, ventilating, and air-				
	conditioning products				
46.7	Piping and valves				
40.1	Fire protection products				

Database content.

The survey results indicate that respondents need 12 specific types of data; Table II summarizes these requirements.

Table II. Specific materials information requirements

- 1. Manufacturers or producers
- 2. Suppliers
- 3. Installers
- 4. Engineering properties
- 5. Physical properties
- 6. Operating characteristics

- 7. Endorsements
- 8. Cost data
- 9. Uses and limitations
- 10. Specifications
- 11. Government specification conformance data
- 12. Maintenance information

An analysis was made to determine likely sources for providing the types of information listed in Table II. Table III summarizes the results of this analysis, which also showed that sufficient data can be stored in a computer to provide the information that is needed. This means that some activities currently being performed by highly skilled and scarce human resources can be automated, thus reducing research time and expenditures. However, very few of the information needs defined in the survey can be answered completely with current published data compilations, such as microfilm files and architectural catalogs. These compilations are the primary source for identifying manufacturers only, and are viewed as a secondary source for six other information needs. Manufacturers are the primary source for nine types of information needs. Users are the primary source for two types. The main problem seems to be the diversity of individual sources that must be queried, rather than interpretation of the data received.

Table III. Summary of potential sources versus specific information needs noted by survey respondents

No.	Machine Answerable	Published Compilations	Manufacturer/ Producer	User
1	Y	Р	S	
2	Y	S	Р	
3	Y		Р	S
4	Y	S	Р	S
5	Y	S	Р	S
6	Y	S	Р	S
7	Y		S	Р
8	Y		Р	S
9	Y	S	Р	S
10	Y	S	Р	
11	Ŷ		S	Р
12	Y		Р	S

Y = yes; P = primary; S = secondary; no. refers to requirement number from Table II.

Several options were considered for providing information to requestors. The first method would be manual centralization of materials research; i.e., when an information request is received, the staff at the central data acquisition site performs the research. The information gathered would be retained on file and kept available for other requestors. The main features of this process would be: (1) it would be centralized, (2) it would be activated upon demand, and (3) its operation would be totally manual. The second information-providing scheme considered would be partially automated and demand-oriented. It would be similar to the method described above, except that the file of information would be retained on a computer which could be easily queried.

A third processing scheme would use stored data supplemented by expert searches. A computer database would be maintained for use by experts at the central information site; upon receiving a request for information, it would be queried for related data. If these data were sufficient to answer the question, the information would be forwarded to the requestor; however, if additional information were required, an expert would research the subject for the requestor. This system would consist of a prestored database which would be continuously updated and which would be supplemented by expert researchers.

A fourth system would be totally computerized, consisting of a central computer database that would be accessed from remote sites. This system--the most sophisticated one that has been visualized--would provide instantaneous response to materials information requestors. However, the type of questions that this system would handle would not be as complete as for the other processing schemes discussed. The fifth processing scheme would be similar to the fourth type, except that expert consultation would be provided in addition to the computerized information service. Table IV summarizes the main features of the five schemes considered.

Table IV. Information-providing schemes versus operating features

						Remote
Pro-			Research	Data	Con-	Auto-
viding	Manual	Computer	on	Pre-	sultant	mated
Scheme	File	File	Demand	Stored	Service	Access
I	Y	N	Ŷ	N	Y	N
II	N	Y	Y	N	Y	N
III	N	Y	N	Ύ	Y	N
IV	N	Y	N	Y	N	Y
v	N	Y	N	Y Y		Y

Y = yes; N = no.

All of the schemes discussed above could be used to provide the 12 types of information listed in Table II. However, two additional factors affect the viability of these schemes. One is the scarcity of human resources available to perform the information-providing activities; thus, optimal use of human resources at the central site is necessary. The other factor is that system operations must be acceptable to information requestors. Eighteen desirable attributes or features were identified from the survey. Table V lists these attributes and summarizes the extent to which each scheme can be expected to exhibit them. All schemes exhibit more than half of the attributes, and Scheme V satisfies nearly all. Table V. Attributes vs. providing schemes

	Attributes Desired by	S	Scheme Numbers				
No.	Survey Respondents	I	II	III	IV	V	
1	Quick retrieval	N	N	Y	Y	Y	
2	Quick response	N	N	Y	Y	Y	
3	Easy to use	Y	Y	Y	Y	Y	
4	Instantaneous response	N	N	N	Y	Y	
5	Easy to access database	N	Y	Y	Y	Y	
6	User access to database	N	N	N	Y	Y	
7	Cross referencing	Y	Y	Y	Y	Y	
8	Current data	Y	Y	Y	Y	Y	
9	Manufacturers' literature	Y	Y	Y	N	Y	
10	Service readily available	Y	Y	Y	Y	Y	
	to users						
11	Computerized graphics	N	N	N	N	N	
12	Source of catalogs	Y	Y	Y	N	Y	
13	Well publicized	Y	Y	Y	Ŷ	Y	
14	Computerized	N	Y	Y	Y	Y	
15	Computerized and linked	N	N	N	Y	Y	
	to user via terminals						
16	Source of samples	Y	Y	Y	N	Y	
17	Central information source	Y	Y	Y	Y	Y	
18	Simple system	Y	Y	Y.	N	N	
	Total attributes satisfied	10	12	14	13	16	

It is apparent from the information provided in Table IV that Scheme IV would use the minimum amount of human resources to provide information after the system becomes operational. Scheme V would be the next most efficient, but would have the addition of expert consultant service, which is not provided by Scheme IV. It would therefore be desirable to use Scheme IV to minimize human resource requirements. Although Scheme IV does not totally satisfy attributes 9, 12, and 18, it may be used to satisfy them indirectly. Scheme IV can be used either to request the suppliers to send these items, or more simply, to furnish the requestor with the suppliers' phone numbers or addresses. Based on this reasoning, Scheme IV was judged to be the most viable.

Data base structure.

A full-text retrieval system with simple editing features is considered to be the most viable data structure that will both satisfy the information requestors' needs and minimize the use of human resources at the centralized information source. There is no practical limit to the amount of data that can be stored in such a system. Current technology provides for translating printed text into machine language, using automated optical scanners. The basic elements of such a database would consist primarily of blocks of data concerning specific material products. Information output from this type of database is achieved by searching out words or combinations of words which relate to needed information. Such databases use an inverted file which is, in effect, an index of the occurrence of

602

all significant words in the database. This permits the information seeker to retrieve references and text that contain any combination of the words stored in the database.

<u>Obtaining data</u>.

To provide requestors with needed data, a strategy must be developed for obtaining it from the three sources shown in Table III: published compilations, manufacturers, and users. This is a difficult problem, because there are many manufacturers and users. A few published compilations can easily be transferred to machine language; however, as indicated in Table II, these are mostly secondary sources of information. In most cases, the primary source is the manufacturer or producer. The most practical approach probably would be to solicit information from manufacturers about their products. Such a solicitation should indicate what information is needed; however, no special format for reporting the data will be required, because the full retrieval system can be used to obtain information from any format.

Obtaining user input is expected to present the greatest difficulty. There are three possible approaches to this problem. First, a list of users provided by manufacturers may be canvassed for input. Second, the database users may be invited to provide feedback concerning material products used. This may be done either informally as users obtain information worth reporting to the database, or in a more organized manner by periodically canvassing database users. Third, independent laboratory test results may be entered into the database. Another important requirement of the development strategy is that it provides for continuous input of new information and updating of old information.

Concept testing.

The concept developed for providing the U.S. Army Corps of Engineers with a centralized source of materials products information was designed in accordance with survey findings. The survey results have potential for error simply because the questions were subject to the interpretation of the respondents. The questions also may not have covered the subject being investigated completely, and some important questions may not have been asked.

The database concept is being tested to check its validity. One material subject area--roofing materials--was selected for testing the concept. All survey respondents have been invited to present questions on this subject that arise over a 3-month period to the U.S. Army Construction Engineering Research Laboratory. Scheme I will be used to respond to the information queries received. The objectives of the test are (1) to verify the completeness of the list of specific information requirements listed in Table II, (2) to evaluate whether or not the questions received are machine-answerable using a full-text retrieval system, and (3) to check on the volume requirements that were estimated based on the survey respondents' input. Conclusion.

A centralized construction material informationproviding concept has been developed to serve the U.S. Army Corps of Engineers. Development of the concept was based on a survey of construction material information needs and is being tested in a limited form. Full-scale development of the service is expected to begin in 1981, pending successful findings in the current feasibility study which is scheduled to be completed by October 1980.

It is believed that the centralized construction materials information concept has a wider potential for application that would include the private sector. Use of the service by architects and engineers throughout the United States will be investigated during the system's development. A problem that is foreseen in developing the system is the need to collect information from many sources, which will require extensive cooperation and participation by materials products producers and users. It is believed that the needed cooperation and participation will be easier to obtain if the system serves a large population of information requestors. In this case, the system will benefit both users and providers of construction materials products. The users will obtain information more easily, and the manufacturers will find it easier to inform users about their products.

It is questionable whether it would be practical to extend use of this specific service outside the United States for several reasons, including lack of both the use and availability of products in the database outside the United States, language differences, and specific information requirements; also, the need for inserting information into the database on construction products produced outside the United States would have to be addressed. However, it is apparent that the concept generally would be applicable in different parts of the world, and that its application would help optimize the use of human technical resources.

Acknowledgments.

Ms. Lisa Eubanks and Mr. Myer Rosenfield performed the survey discussed in this paper. Mr. Robert Neathammer conducted a statistical analysis of the data obtained, and Ms. Eubanks participated in development of the data base concept.
Management of construction

M.M. Mbilikira, General Manager, National Estates and Designing Company Limited, Tanzania

Introduction

Although its importance is often under-estimated in economic planning, the construction sector is of vital importance in the implementation of investment plans and capital projects to the development of a young nation. Tanzania is one of such countries and where in 1975 the construction sector alone accounted for 11 % of gross domestic products. As to the composition of construction, the trend showed a strong increase in works at the expense of buildings. From 1968 to 1972 the proportion of Civil Engineering works rose from 44 to 67 % of total construction, but from 1972 to 1973 there was a decline to a more normal level of 55 %.

Based on analysis of third five year plan of Tanżania, it may be drawn upon that total construction volume on the average is anticipated to be more or less in the same level as the later years, and the composition of construction will continue to change in the direction of more buildings and less works. It is very likely to cause strain upon the building industry requiring more skilled manpower and increased imports of building installation components.

Further it may be revealed that "Implementation Capacity" and "Capital" are the two basic constraints normally encountered within our country. But most serious is the "Implementation Capacity" for young nations as "Capital" can be arranged either from internal resources or externally.



Management of construction should be seen in the light of importance from this respect of capital projects to the development of young nations. In this presentation I like to restrict myself to the <u>Manage-</u><u>ment</u> part only construction projects. Related technical and other professional activities are not discussed now. It may be described as the process of planning, executing and controlling a construction project from inception to completion in a given time, at a given cost for a given end product and in accordance with available technical as well as human resources having flexibility to alterations due to basic change of assumptions, non-validity of original cost estimates, occurances of unexpected facts, changes and constraints so prevailing in our situations.

The principal aim is to achieve the intended objectives of the project in the best possible way and with the best possible results and not necessarily completion of a project exactly as planned.

The process

As construction projects cover the entire working process from inception of ideas to the successful use of completed structures, it consists of many individuals and interdependent activities and involves various organisations.

The working process can be divided into four stages as "Pre-Design". "Design", "Construction" and "Post Construction". The scope of these stages may differ from one project to another but their contents should be clearly defined in the terms of reference drawn up for each project. This allows clients to make necessary commitments step by step as regards the cost and benefits of the project. There are certain basic objectives for each work-stage which are required to be achieved by certain individuals or group of individuals on undertaking corresponding activities for successful completion of the process and the project. These basic objectives are stated in Annexure I.

Team work is very essential within individuals of each stage as well as amongst individuals of other stages for effective results. The Management team is generally headed by a Project Manager to coordinate the functions of four stages and may comprise of specialists as planners, administrators and supervisors depending upon the size and intricacy of the project. The understanding to the objectives and the motivation behind the project as well as the responsibility and authority to direct successful completion of the project are essential for any project manager who leads the team.

The frame work of construction process is formed by taking into consideration various aspects which are related to various stages for organisational conveniences these aspects can be divided into four main groups as: Functional, Location and Site, Constructional and Operational. The evaluation of each aspect begins with



the "Pre-Design" stage and continues in greater detail during subsequent stages until these have been satisfactorily dealt with. Well known process of date collection, analysis and recommendation is normally followed to reach a conclusion on each aspect.

In many respects each work-stage can be considered as a separate entity, however the conclusion of one forms the starting point for the next. In practice there is often a degree of overlap between various stages. To economise resources it is desired that various aspects at each stage should be carefully weighed, examined and developed only to the extent of detail required to fulfill the needs of that particular stage. The possibility and extent of influencing the design during various stages is illustrated in Figure III. The crucial



period is when project brief is being reviewed by the Client for final approval in the "Pre-Design" stage. <u>Management functions</u>

New and/or occasional Clients usually tend to underestimate the time, effort and cost of theirs which will be absorbed through different stages of projects.

Consequently these activities seek careful planning and setting aside of managerial resources for better controll.

The complex and interdependent tasks of various work stages must often conform with national, regional and local policies. This may call for the development of a general "Work plan", providing guidelines within which the project teams can relate their tasks to those of their collegues. Several separate activities are contained in each stage of "Work Plan" each of which demands its own separate organisational structure depending upon the size and character of the project, the existing institutional framework, the man power and to a certain extent the attitude and policies of Client's organisation. The workplan presents how the various activities should be carried out in what order, to what extent and by whom. This plan can be drawn up either by the client's own organisation or by appointed expertise. Annexure II gives the flow diagrams of activities of first three work stages and tentative guideline for work plan in relation to objectives stated in Annexure I.

<u>Planning</u> is an important management function which ensures that adequate resources are available at the right moment, that sufficient time is allowed for each stage and that all other components start at appropriate sequence. This may be called as the spine of the construction management.

Various methods are developed over the years to aid planning process, ranging from check-lists to net-work systems showing inter-relation of different project activities. However, all of them are based on certain characteristics which are important for any good plan. These characteristics are:

- Simple. The aim is to outline the complex situations in a simple way.
- Flexible. It should be possible to change certain elements of plan without disrupting the entire projects.
- Proper standards of expectations are provided by identifying quantifiable elements so that controls may be exercised when essential.

It is also vital that project activities should cover certain major aspects in order to be an effective aid to the planning process. The major aspects are:

- Time. A realistic time schedule is the most vital task of planning. It is necessary that a whole series of time schedules be prepared during different project stages and also be up-dated and detailed as the project proceeds from one stage to the other and as more informations become available. Appraisails and approval times should also be taken into account as these often are over-looked resulting in delays and shortage of funds.
- Designing and construction capacities and material supply. Often clients are not adequately equipped within their own set ups regarding these vital aspects of projects. In such cases they procure necessary resources from others normally.

in the form of:

- Design services from Consultants.
- Construction/installations from Contractors.
- Deliveries of plants, equipments and materials from suppliers.
- Funds. The time schedule provides the first indi-

cation of when funds should be made available and the management team may be able to assist with an assessment of how much fund is required at different stages. These funds are not merely meant for construction purposes but also for meeting overhead expenses.

- Staffing. Proper and adequate staffing is a very vital planning aspect and should begin at the "Pre-Design" stage. Ideally it should form a part of the briefing documents and may become an important factor in deciding whether the project is to be completed all at once or in different phases.

Control

Project control is an integrated part of the management process. The aim is to monitor achievements against planned progress. Control system should be able to identify immediately any deviation from the planned course so that effective remedial measures can be taken in time.

Effective control system forms the base for management decisions and should satisfy the following:

- Identify the exceptions and not the rules.
- True and meaningful comparisons should be possible.
- Indicate the nature of corrective actions, effective results and the initiators.
- Key control areas should be selective and results oriented.

A successful construction project require the control of three inter-related elements-progress control, quality control and economic control.



Progress control

Progress is often very difficult to measure as a percentage. Instead detailed time schedules and resource plans prepared during each work stage should be used as aids to control progress. Monitoring can reveal that the result deviates from the plan and immediate remedy is essential if the deviation is more than a certain pre-determined value. Figure V is an ideal curve for



the construction stage indicating the value of work done against the contract period. Deviations can easily be identified if actual measured values of interim valuations are marked correspondingly.

Delays may occur during any stage of work-plan causing extra cost. The cost consequences of delays are more appreciable during the construction stage. It is often difficult to determine who is liable for delays and thus disputes may occur. This underlines the need for an effective control of time schedules by various teams and keeping necessary and precise records of all events.

PRE DESIGN DESIGN	CONSTRUCTION	POST CONSTRUCTION
overall control decision making	control fullfillment of requirements	control building in-use
control stations	• • • inspections	special tests

Quality control

Client's stated needs and requirements are assured by effective quality control. It must be exercised in all stages of project. As a rule quality control should always feasible that all production informations are contained in the contract and this gives rise to additional instructions at site. All such instructions should always be confirmed in writing. Sometimes variations and alterations may also become essential for proper control of quality. Construction stage is the most vital stage and the last one for ensuring desired quality. Site supervisions are essential part of this control system and must always be strictly enforced. Economic control

It should be in the form of active control of final cost for a construction project instead of merely a passive registration of payments from time to time. The importance of decisions taken by client in the

606

early stages of a project is always to be considered significantly inspite of various limitations on which such decisions are made. It is however important to identify such limitations to the client by the project team.

The client's decisions are based on apparently reliable cost estimates but the cost informations available at such an early stage of project, on which the estimate can never be more accurate than the informations it is based on.

Three categories of informations can be identified as essential at various work stages of a project which may lead to a fair degree of cost estimate known as Operational Estimate. These are (a) information about resources (b) information about the buildings and its components and (c) information about prices.

The Project Budget is an estimate of the project cost. It should be in consistant with the aims of the project, required functions and quality standards if it is to serve as an aid to effective economic control of the project. Any budget must include contingency allowances for (a) inflation, (b) unlisted items and (c) inaccurate data and design alterations.

Cost control measures at regular intervals are necessary to ensure that the final project cost checks should be carried out by the design team while developing the design. A cost plan based on approximate cost estimate indication quality, quantity and unit prices for major cost elements as floors, walls, roofs, etc., is an effective aid for cost control. Payments and cashflow aspects of it is very vital in ensuring good economic control.

Clients must get value for money in accordance with contract before any payment is made. Management team should regularly compare the total payments made as against the planned payments according to the financial plan of the client. The financial plan indicates the expected distribution over-time, and the availability of funds during each stage of the project. Paying to Contractors have significant influence on the client's cashflow during the contract period. It is important that management team appreciates the cashflow situation from the Contractor's point of view also to avoid unnecessary delays. Figure VII shows three curves which



may determine Contractor's cashflow pattern. The Contractor's need for working capital could any time be shown by a vertical line between curves A and C. The gap (shaded) depends on the retention precentage and on the time lag, between when he receives the payment from client and when he pays for labour and plants etc. If this lag can be reduced then the possibilities of completing the Contract successfully by the Contractor will be significantly increased.

Training

Specifically for young nation like ours, extensive training of managerial staff is required to carry out construction projects successfully. This evidently forms an important management function for developing countries.

Project management training programme on a regular basis is to be introduced emphasising the managerial and technical aspects of planning, decision making and control the human aspect of team work, the structural aspect of transforming functional set ups into project type organisations and ecological links and regulations of major construction projects.

Training/Advisory programmes comprising of both consultancy and in the form of seminars and workshops are necessary to identify solutions to constraints which are so special for developing countries. The constraints may be in form of selection of project managers, appropriate tendering procedures, contracting incentives, the use of typical project management tools and economising the use of scarce administrative capacity.

The importance of linking training with practice is to be always emphasised and shall have to be developed from time to time in conjunction with the designs of improved project management procedures by integrating the production of local training materials with the system design from other training materials. Conclusion

The danger of strain due to increased construction activities is that cost and profit will continue to increase and that delays and deviciences will occur frequently unless they are properly managed by skilled managers trained to face unexpected limitations. This may eventually worsen the prevailing economic situations if timely actions are not taken in the beginning.

In this respect we must equally enlighten ourselves in the managerial aspects of construction along with the other technical and professional disiciplines of building industry and learn from the shortfalls of others without loosing much time. It is proposed that this aspect of construction industry is introduced in the academic curriculums of technical disciplines already prevailing in the developing countries regarding building design and construction prior to more extensive exposure to the course of Management of Construction thus increasing our scarce resource of "Implementation Capacity".

References

- [] General Report on Local Construction
 Industry Study Ministry of Works, Tanzania 1977
- Systems Analyses and Project Management By David I. Cleland and William R. King
- [3] A Guide to the Management Construction Project 1978
- Project Management, Procedure Guide 1974 Department of Environment, Property Service Agency.
- [5] Quantity Surveyours Code 1977 Department of the Environment, Property Service Agency

ANNEXURE I

- Stage I: "Pre-Design"
 - 1.1 Need Definition
 - 1.1.1 To define the need as an accommodation or financial return requirement.
 - 1.1.2 To define the constraints (financial and other) within which the need must be met.
 - 1.2 Need Evaluation 1.2.1 To devine and evaluate alternative ways of satisfying the need (which may not be new works).
 - 1.2.2 To determine whether the need shall be met by by new construction work.

1.3 Resource Planning

- 1.3.1 To estimate, obtain authorization for and programme capital costs for construction.
- 1.3.2 To assess, cost, make available and programme in-house staff and outhouse consultant requirements.
- - 1.4.2 To prepare a brief or specification of requirements.
- Stage II: "Design"
 - 2.1 Outlines Design
 - 2.1.1 To prepare alternative outline proposals and select the preferred alternative.
 - 2.1.2 To develop the preferred design sufficient to obtain client, user and statutory approval.
 - 2.2 Final Sketch Design
 - 2.2.1 To develop the approved outline design into a design solution fully integrated with constructional, structural and services requirements.
 - 2.3 Detail Design
 - 2.3.1 To prepare and have approved details design drawings, specifications, schedule, and bills of quantities.
 - 2.4 Contract Preparation
 - 2.4.1 To agree and complete negotiations or tender procedures and documentation for contractor, nominated sub-constractors and suppliers.
- Stage III: "Construction"

,

- 3.1 Constructional Pre-Planning
 - 3.1.1 To establish construction control, and communication procedures and programmes.
 - 3.2 Construction control3.2.1 To administer the contract up to completion on site.
 - 3.2.2 To test and commission.
 - 3.3 Construction completion 3.3.1 To do the inspections and documentation required for construction completion and hand-over.

- 3.4 Contractural completion 3.4.1 To complete measurement and valuation of WO's; to consider and recommend on claims and counter claims; to agree and certify the final account.
 - 3.4.2 To agree all consultant professional fees and expences.

Stage IV: "Post Construction"

- 4.1 Building Operation 4.1.1 To prepare procedures and organise resources necessary to operate the building.
- 4.2 Maintenance
 - 4.2.1 To determine maintenance methods and to allocate and organise resources for maintenance works.
 - 4.2.2 To carry out maintenance works and check delegated maintenance works.
- 4.3 Performance Appraisal 4.3.1 To appraise and evaluate performance and cost-in-use.
- 4.4 Improvement, Disposal 4.4.1 To design and carry out improvement and renewal works.

4.4.2 To demolish or sell

ANNEXURE II

Need Definition

- Objectives: I. To identify & record -(i) a need for accomodation or installation.
 - (ii) a need to derive an investment return or an existing estate

1.2 Need Evaluation

- To idendify record alternative ways Objectives: 1. in which the need may be met by:
 - a) new works, b) alteration/re
 - novation
 - c) leased/rented accomodation
 - Increased utilisation of d) existing areas etc.
 - 2. Evaluate the alternative ways.
 - 3. To determine whether new works are essential.

Resource Planning

Financial Resource Planning To obtain financial approval. Objectives: I.

> Design Resource Planning To determine how the works commitment shall be met, i.e. in house or by consultant.

- 1.4 Site and Brief
 - Objectives: 1. To give, if required professional advice on site selection if site is not already selected.
 - 2. To hold first project team meetinga) To ascertain that sufficient briefing information available
 - to start design work. b) To ascertain that sufficient
 - site information available to commence Stage 2.

- 3. To obtain additional briefing information.
- 4. To commission additional site studies.
- 5. To check/update operational estimate.

Outline <u>Design</u> Objectives: 1.

- - 2. To estimate construction cost and update operational estimate.

Prepare a preferred outline design and

validate it against the brief & site

- Monitor progress against project pro-3. gramme.
- 4. To obtain outline planning agreement.
- 5. To obtain user approval.

constraints.

- 2.2 Final Sketch Design
 - Objectives: 1. Develop the prepared outline design into the final sketch design and make firm decisions on:
 - planning layouts
 - _ construction method
 - structural system
 - service installation and cost
 - 2. Submit final sketch & estimate
 - to client/user for approval
 - to local authority for planning acceptance

Detail Design

- Objectives: 1. Prepare all working drawings, schedules for tender action.
 - 2. Produce all production information for nominated supply and sub-contracts.
 - 3. Pre-tender action for 2 above.
 - 4. Pre-tender action for main contract after 3 above.
- 2.4 Contract Preparation
 - Objectives: 1. To select nominated suppliers and sub-contractors.
 - 2. To select and recommend main contractor.
 - 3. Acceptance of both above.

Construction Pre-Planning

- Objectives: 1. Request main contractor to enter into sub-contract with sub-contractors and to place orders with nominated suppliers.
 - 2. To issue production informations
 - plan executing of works
 enter into sub-contracts

 - place orders for labour and materials
 - 3. Final Agreement with main contractor regarding:
 - site accommodation static plant/s - supply of water, electricity, gas,
 - telephone etc.
 - 4. To establish organisational procedures and communication system for - quality control, progress controll, valuation and cash flow control
 - 5. To give possession of site to main contractor



610

3.2. Construction control

PREPARE OPERAT

3.3 ESTIMATE DESIGN IN H DESIGN IN H USE/CONSUL TANT

NOMINATE DESIGN TEAN

appoint consulant

flow diagram stage1 contd.

3. To complete completion on drawings.

OBTAIN SITE

SIGN COST

SSEMBLE SITE

BRIEFING INFORMATIONS

BUDGE

Need Definition

1.2 Need Evaluation

ANNEXURE II

- Objectives; L.
 - To identify & record -(i) a need for accommodation or installation.

(ii) a need to derive an investment return or an existing estate

- To identify & record the constraints in which the needs of the client п. and user must be met.
- Objectives: To identify record I. alternative ways in which the need may be met by:
 - .)

 - new works, b) alteration/renovation leased/rented accommodation temporary works, e) increased utilisation of existing areas etc. a)
 - Π. Evaluate the alternative ways.
 - TTT. To determine whether new works are essential,



Outline Design

Objectives: 1.

- Prepare a preferred cutline design and validate it against the brief & site constraints.
- To estimate construction cost and 2. update operational estimate.
- 3. Monitor progress against project program
- 4. To obtain outline planning agree-
- 5. To obtain user approval.

2.2 Final Sketch Design Objectives:

ANNEXURE II

- Develop the prepared outline design into the final sketch design and make firm decisions on:
 - planning layouts
 - construction method structural system
 - service installation and cost
- 2. Submit final sketch & estimate
 - to client/user for approval to local authority for planning
 - acceptance.



flow diagram of DESIGN stage 2



ANNEXURE II Construction Completion: 3.4 Contractual completion Objectives: 1. To settle all claims and counter Objectives: 1. To ensure contractor complete all works as par contract. claims. To propare, certify and have paid the final account. 2. To complete the inspection and commissioning of theworks. 2. 3. To complete completion on drawings. 4. To have all defects made good. To take possession of works and hand over to the user. 5. **7**^{3.4} ^{3.2} 3.3 231 COMPLETE TESTING HAN & COMMISSIONING PMT DEFECTS LIST HANDOVER D USER OF MAINTEN EFECTS LIST APPROVE MAKING GOOD

FINAL

·遍

渇

JOB APPRAISAL

ACCOUNTS

END OF MAINTENANCE PERIOD

CLAIMS & COUNTER CLAIMS

NAL CERTIFICATE

REPORT ON CONTRACTOR

ACCOUNT PAID CLAIMS SETTELED

INAL.



336 RECORDS 3.34 PUBLICIT

PUBLICITY

3.5

J.4 Jeedback may start claims à counter claims may arjse

DELAY REPORTS

leedback may start

ð

ration of final account may stort



KEY to Flow Diagram

Economic methods of the Construction Management A.I.Mitrofanov, D.Sc.(Econ.), NIIES, Moscow, USSR

<u>Summary.</u> With due account of the principles of the planned conduct of the economy and the existing management structure of capital construction in the USSR, the report deals with the system of the economic mechanism of management and shows the close link between that mechanism, its forms and methods of managing the investment process and actual construction work.

The author reveals the character of the economic interconnection between main participants in construction work, the overall procedure and mechanism of economic incentives.

Sommaire. Cet exposé fait voir le système du mécanisme économique de la gestion, la liaison organique des formes et méthodes de ce mécanisme avec tous les échelons de structure, formes d'organisation et méthodes de la gestion du procédé d'investissement dans la construction en rapport avec les principes de l'économie planifiée et des structures de gestion des grands travaux en l'URSS.

La présence concerne le caractère des liaisons économiques entre les principales participants de la construction, l'ordre générale et le mécanisme d'effet de la stimulation économique.

The structure, forms and construction management methods in the USSR are linked with and based on general system of economic management in the country. The structural principles of this system maintained in the USSR Constitution are the most important scientific and practical achievement in the socialist economy and building of a developed socialist society.

The branch management in construction is carried out by the USSR State Planning Committee (Gosplan), Councils of Ministers of union republics, all-union and republican ministries and administrations acting as clients and through the system of contract construction ministries.

Contract construction ministries, which are all-union or republican economic management bodies, control construction and assembly work carried out by the subordinate republican ministries, the main board of construction, territory main boards of construction, all-union or republican construction and erection units, trusts and other organisations.

Territorial principle of the construction management is carried out by the **USSR** State Planning Committee, Council of Ministers of union republics, territorial construction board of the contract construction ministries and by the economic bodies of local Councils of people's deputies.

Technical policy in construction is controlled by the USSR State Building Committee (Gosstroy) through the ministries and administrative bodies as well as through Gosstroys of union republics. The USSR State Building Committee is responsible for design and estimates, quality of design, working out and realisation of measures for the reduction of construction costs and other problems of technical policy in construction. Supply of materials and machinery in construction is carried out by the USSR State Supply Committee (Gossnab) and supply agencies of the ministries and administrative bodies on the basis of the economic development programmes. The USSR State Bank of Construction, State Bank and corresponding organisations at the local level are the main finance and credit bodies in construction.

In the USSR, planning is the economic basis of the capital construction management which, in the opinion of Soviet experts, is a central managerial link closely connected with the economic mechanism using economic accounting, economic levers and stimuli. The most important principle of the economic basis of managements is the combination of centralised approach and directive tasks with economic independence and initiative of enterprises, units and other organisations, i.e. in combination with socialist initiatives. With such economic planning system each planning and economic link fulfils strictly definite functions in the capital construction management. A stable and strictly balanced five-year plan with the distribution of all tasks for each year is the main planning form of the national economic and social development.and the basis of economic activities in all economic and planning links, including capital construction.

Annual plans are prepared on the basis of the five-year plan and comprise economic and organisational measures ensuring fulfilment of the five-year plan. Work quota of annual plans should not be less than the targets of the fiveyear plan for a respective year and these plans are prepared with due account of the counterplans suggested by production collectives and as a rule surpass the tasks of the five-year plan. Mandates of the electors are taken into consideration in elaborating draft plans at all levels of management.

Planned targets and economic standards established for all the participants of the construction process as well as contract relations are the subject of management in capital construction.

Ministries and organisations are ordered: - the commissioning of basic production assets, production capacities and projects, including the growth of capacities owing to the technical modernization and reconstruction of the existing enterprises;

- limits of the state capital investments and construction work, including expenditures on technical modernization and reconstruction of the existing enterprises. The limits adopted in a five-year plan are not subject to reassertion in annual plans;

- standards of creation of productive development asset.

The state units and enterprises are assigned to commission fixed assets, production capacities and projects into action including increase in capacities owing to technical modernimation and reconstruction.

The transition to planning the existing pro-

duction and new construction as a whole is an important economic and organisational lever for more effective management of the investment process and a stimulus of the economical attitude to the capital investments on the part of a client. Therefore, in the five-year plans, capital investments for the development of material production industries envisage the planned growth of volume of production and service. As a first priority, capital investments and necessary material resources and equipment are envisaged in plans for technical modernisation and reconstruction of the existing enterprises.

The following data are set up to the ministries, administrative bodies and construction and erection organisations; - the commissioning of production capacities and projects including the increase in capacities owing to technical moderni^Zation and reconstruction of the existing enterprises; - the general volume of construction output and that carried out by own forces, (the construction work cost of enterprises, passed to the client, of starting complexes, lines, projects and production ready for output or of services.) with the distribution of the total volume between the clients. Respectively, the ministries and administrative bodies (the clients) approve the volume of the commercial construction output for the subordinated units, enterprises and organisations;

- increase in labour productivity;

limit of the number of workers and employees;total wages fund;

- profit (for separate organisations - cost reduction of construction work);

- introduction of new technology;

- volume of material supply, number of machines, mechanisms and other resources necessary for the fulfilment of the plan.

Besides, the payments to and the allocations from the state budget are approved in the annual plans.

Data of the commissioned production capacities and projects are also set up to the organisations assembling the main technological and energy equipment according to the contract. The decision on the new construction, reconstruction and development work is taken up on the basis of the respective economic and technical data:

- for the most important projects - by the Council of Ministers of the USSR submitted for consideration by the USSR State Planning Committee;

for other projects with estimated cost of 3 million roubles and above - by ministries, administrative bodies and Councils of ministers of union republics in agreement with the USSR Planning Committee and construction ministries;
projects with estimated cost less than 3 million roubles - by the USSR ministries, organisations and Councils of Ministers of Union Republics or in accordance with the orders established by them.

The Oryol builders method of drawing a two year plan every year (in this plan, targets of the first year serve as a working plan and those of the second - as a reserve plan) is the important means of providing continuous acting of current plans, which is especially important for building organisations.

Capital construction include those projects which are supplied with design estimates and drawings for a one-year volume of work approved by the 1 July of the year which is previous to the planned one.

The lists of construction jobs for the whole period of construction are worked out with the distribution of tasks per year on the basis of lists of new construction, limits of capital investments and construction and assembly work, projects, estimates and norms of construction duration. The lists of construction jobs for production projects are adopted in the same way as the lists of new construction. The lists of construction jobs for technological modernisation of the enterprises are adopted by managers of the production units (enterprises) in accordance with the established limits of capital investments, construction and assembly work and material assets irrespectively of the total estimate cost of construction work.

Adopted lists of construction jobs are plan

document for the whole period of construction which is obligatory for clients, contractors, planning, finance, bank and supply bodies, suppliers of equipment and construction elements. The data in the lists of construction jobs may be changed in the case of revision of the projects due to the implementation of more effective equipment or technology.

In this case, adjustment of estimate cost and capital investments is allowed within the limits of capital investments and construction work assigned to a ministry or to an administrative body for the corresponding year.

When the volume of work was, in the passed year, less than those fixed in the list of construction jobs the lag should be overcome in the next year at the expense of idle material and technical resources of the previous year and at the expense of reserves of ministries and administrative bodies.

The volume of construction and assembly work in the drafts of the lists of construction jobs is distributed per each year by the ministries and other clients together with the ministries of construction and other administrative bodies or on their instructions by subordinated organisations with due account of the necessity to provide rhythmical work of contractors and creation of technological reserve within the limits of time of commissioning of the production capacities and objects with the observance of construction duration set up by standards.

The state order of providing the capital construction by material and technical resources is characterised by the following.

Balances of material and technical resources and plans of their distribution between main asset holders are the basis of this order. These plans are set up in an established order by Gosplan, Gosmab (the main supply body), ministries and administrative bodies of the USSR and Councils of Ministers of Union Republics.

The supply of construction with materials, construction components and so on is realised through ministries and administrative bodies -

616

the contractors and their building and assembly organisations. Technological, energetic, electrotechnical, lifting and transport as well as non-standardised equipment together with corresponding set of machines, instruments, cables, special tubes are supplied by the ministries and administrative bodies - customers - through management offices of building enterprises and other special services.

The USSR State Supply Committee exercises complex supply of construction sites included into the state plan with materials through territorial bodies of material and technical supply in accordance with the demand specified by projects and estimates on the basis of the balances and plans of distribution of resources between asset-holders as well as on the basis of capital construction plans.

The system of production and technological collecting carried out by special organisations at all levels of the building production management forms an organisational and technological basis of complex supply of construction sites with materials, construction components and so on.

With the purpose of timely and complex supply of construction sites with the main technological and energy equipment as well as construction prefabricated metal elements, Gossnab gives to the ministries - manufacturers of equipment orders for supply of this equipment for the entire period of the construction which are in force till their complition by the suppliers, and for supply of prefabricated metal elements for two years as a rule.

The fulfilment of construction work and shipment of material and technical resources are realised on the basis of respective agreements.

The general contract is concluded with the general contractor organisation for the whole period of construction within two-months period after adoption of the state plan of capital construction by the client on the basis of a list of construction jobs for each year of construction on the basis of general agreement. General contractors agreement is the main document regulating the relations between the client and contractor, their rights and obligations as well as the property responsibility for observance of contract obligations.

According to a subcontract the general contractor has the right to entrust specialised organisations with the fulfilment of separate kinds and complex of work. With the consent of a general contractor agreements for the fulfilment of assembly and other specialised work may be concluded by the client with assembly or other specialised organisations. The agreement for fulfilment of installation of equipment is concluded by a client either with the general contractor or with the shipper of equipment.

Depending on the character of shipped resources and rendering of services, the presence of direct and durable economic ties, administrative adherence and subordination of interacting organisations and enterprices, direct economic ties of resources supply and rendering of services in construction are realised on the basis of agreements and various orders.

If economic disputes concerning agreement obligations arise they are settled in an established order either by topstanding economic bodies or by the organs of state arbitration.

On the initiative of labour collectives in construction the method of "team contract" with the implementation of levers of economic accounting is widely used in this country. As it has been written in the Main Directions of the national economy development for 1976-1980, the team contract must become the main form of labour organisation in construction and take further development in the current five-year plan period. By the end of the 10 th five-year plan period the volume of construction work carried out by the method of team contract should be brought up to 20-30 per cent in the industrial, 70-80 per cent in the housing and 60-70 per cent in the production agricultural construction.

In the case of team contract construction according with the decision adopted at the team meeting an agreement with the management of the construction organisation is concluded. According to it the team is obliged:

- to fulfil the construction work within fixed period and in strict accordance with the technical documentation, building standards and rules within the estimated cost of entrusted works for the team;

to provide the observance of preservation and rational expenditures of materials, elements for building production and the usage of applied building equipment and machines;
to timely provide the front of work to subcontracting teams;

- to provide the observance, by all the team members, the requirements for labour protection and safety measures.

The management of a building organisation is bound to:

- provide the project with the technical documentation as foreseen in the contract in accordance with the schedule of the construction work;

- to provide the team with high quality materials, elements and parts, machines equipment, tools;

- to create the conditions providing for the preservation of materials, elements, parts and tools given to the team;

- to exercise engineering and technical control and observe rules of labour protection and safety measures.

The agreement defines the order of payments for labour, sizes of bonuses for reached economy, shortening of construction time with a view to their quality for commissioning the object as well as sanctions for violation of contract liabilities.

The financing of construction is realised by the organisations of the USSR State Bank of Construction and State Bank in accordance with the plans of capital construction adopted in the established order in lists of construction jobs. The financing of the projects and expenditures without design estimates as well as without orders for equipment and structural steel in fixed period is not made. In financing construction, the bank organisations exercise control over right and effective usage of capital investments and over the fulfilment of the tasks of commissioning of the production capacities and fixed assets. They also control the fulfilment of capital construction and accumulation plans, tasks of cost reductions in construction work, the mobilisation of economic reserves and timely receipt of reserves intended for financing capital investments, observance of estimate cost of construction, planning, finance and discipline of payment as well as strengthening of economic accounting in construction.

The financing of works on the construction sites of the production purpose is carried out during the whole period within the sums envisaged in the adopted estimate. In case of overfulfilment of the construction plan in a given year, the financing is exercised on account of credit. For payment of large - scale technological and energy equipment the clients are given the credit. If the equipment and other means of mechanisation, automation and control supplied in full sets the client settled accounts with a general supplier for provided and assembled equipment as a single whole.

In 1981, in connection with the transition, in construction, to the accounts between the client and the contractor according to the commodity cost of construction for completely accomplished and commissioned enterprises, starting complexes, lines and other objects prepared for the output of production and rendering of services the client's advanced payments to the contract organisations for expenditures on unfinished production of construction work are substituted by bank loans.

The accounts between clients and project and prospecting organisations are settled down for completely finished and commissioned projects of enterprises, starting complexes, lines and projects.

The expenditures of the project organisations are covered by own circulating assets and credits. The assessment of the economic activities of construction and assembly organisations and of their economic incentives are made according to the results of putting the production capacities and projects, commodity construction production into operation as well as raising labour productivity and profits.

Economic methods of the quality construction managing play an important role in the system of economic mechanism in construction.

With the purpose of provision of incentives for the participants for timely and complex supply of the resources and rendering of services, careful attitude towards resources and the increase in efficiency of their usage, commitionning of construction projects in time and ahead of scedule the economic mechanism as a whole, stipulates the use of incentives and encouragements as well as sanctions and fines.

For example, workers of building organisations are awarded a bonus for current work, for fulfilment of especially important tasks according to the results of socialist competition, in the form of a fee according to the results of a year, for commissioning the construction projects and for other achievements.

At present, the size of bonuses for timely putting the production capacities into operation increases, at an average, up to 3 per cent of the estimate cost of accomplished construction work. The necessary sums for rewarding are stipulated in estimates. On account of these sums the bonuses are paid to the builders, workers of a client and project organisations. Rewarding for the work of technical modernisation and reconstruction of acting enterprises is realised on a higher level than for new construction.

Now there is introduced the following order everywhere: in case of shortening the period of commissioning of production capacities by the contract organisations against established norms, the general contractor receives from the client 50 per cent of the profit forseen in the project for the shortened period of construction but no more than 0,5 per cent of the estimate cost of construction and assembly work for each month of shortened term of construction.

The abovementioned means are directed to the funds of economic incentives of the organisations participating in construction work. A differentiated system of percentage payment for credits is stipulated for all the participants using the credits.

For the violation of the contract obligations in supply, services and conditions of interaction the participants of construction pay fines or forfeit to the suffered side or to the budget.

Such are the main features of planning and economic mechanism of the capital construction management in the USSR in brief. The prospects for its further development and improvement are seen by the Soviet specialists first of all in more complete usage of the principles of democratic centralism, economic accounting and socialist initiatives , economic levers and incentives in capital construction management.

They also see it in the development and realisation of the principles of self-compensation in the activities of building organisations, in the gradual transition, in separate branches, to construction on account of credit for the construction and assembly organisations in the size of full construction cost with commissioning of ready enterprises to the client. An Investigation Into The Nature Of And Barriers To Feedback In Communication On Building Sites

Nor, K.M., M.Sc., Universiti Sains, Penang, Malaysia.

Torrance, V.B., M.Sc., Ph.D., Head of Department of Building, Heriot-Watt University, United Kingdom.

SUMMARY

The study examined the findings of contract supervisors on the types of information fed back to them by their subordinates which assisted them in detecting deviations of production performance and of resource utilisation on sites from plans and output standards. Secondly, their assessments of important factors which act as barriers to feedback of information from their subordinates.

Résumé

Cette étude examine les conclusions des surveilleurs de contrat sur les types d'information fournies par leurs subordonnés les assistant dans la détection des écarts de production et d'utilisation des resources sur les sites par rapport aux plans et aux normes de production. Deuxièmement, leur appréciation des facteurs importants qui agissent comme autant des barrières dans la transmission d'information par leurs subordonnés.

General Objectives of the Study

In general, communication on building sites as a field of study has been somewhat neglected by research workers. Previous studies in this field have tended to concentrate more on the efficiency of those information systems required to facilitate construction operations. Daltry and Crawshaw (1) carried out research on working drawings in use. Others have tried to study the possibility of using computer-based information systems on site. However, communications on building sites do not contain only technical information, human aspects play an equally important part in non-task information.

There is a need to establish a much more comprehensive framework of communication for the industry. An important part of the framework is control and adaption and the feedback mechanism forms a vital element in this phase of communication. Feedback clearly provides the crucial link between what was expected and what actually happened.

Much has been said about the importance of feedback in communication on sites but no literature exists which deals specifically with the mechanism in this context. Hence the reason for a study to ascertain the nature of and barriers to feedback on sites.

The broad concept of feedback in communication theory was used to examine how it could be utilised effectively to maintain a steady flow of information from subordinates to supervisors. Before a supervisor can exercise successful control over resources and costs he needs to establish and maintain the flow of negative feedback from the production centres. The frequency and accuracy of the information fed back involves human factors. This fact forms the focus for this study.

Formal organisations require efficient information systems in order to operate successfully. As an organisation grows in size, there tends to be an overload of data. The need to process these large amounts of data to extract small amounts of information have contributed to the increasing importance of computer-based information systems.

The basis of the study required the opinion (verbal testimony) of the contract supervisors themselves. Such opinion was elicited by a questionnaire which contained items or scales with various possible response categories.

In this study, the method of sorting and ranking of statements was chosen. The supervisors were asked to indicate their responses on the questionnaire. They then had to rank sets of given statements in order of usefulness or priority. This ranking experiment, testing the opinions of the contract supervisors, allowed sufficient data for statistical analysis which would lead to valid conclusions with known confidence limits.

Hypotheses

Because of the lack of previous analytical studies with respect to human communication on building sites, the study was essentially exploratory. The findings of the study are considered to be indicators rather than a set of hard and fast guidelines.

Faced with the constraints imposed on the study, these broad hypotheses were developed :

(i) Before a contract supervisor can identify the types of information to be fed back to him by his subordinates, he should be equipped with proper plans, targets, budgets and output standards. These tools should be available on sites and are essential for control purposes.

(ii) A general agreement exists among contract supervisors on the types of information to be fed back to them by their subordinates, and its usefulness in controlling production and resources on their sites.
(iii) There is a general agreement among contract supervisors on some major factors acting as barriers to negative feedback.

Research Methodology

To analyse the data collected, statistical tools were employed. Other studies using a somewhat similar approach (2)(3) were examined and the following procedures adopted :

(a) Non-parametric statistics; since continuous variate statistics could not be used.

(b) For this purpose, Kendall's coefficient of concordance (W) was used (4).

(c) The significance of this coefficient was determined from the conversion to chi square distribution.

(d) Values of the chi square calculated greater than that in a chi square distribution table set at a given degree of freedom and at not less than 0.2 level of significance were acceptable.

(e) To ascertain if any significant relationships existed between the factors ranked, Kendall's Tau partial rank correlation coefficient was used. The coefficients obtained are then compared with those in Kendall's Tau table with a given number of pairs of factors ranked at various significance levels (not less than 0.2 or -0.2).

Data Collection and Analysis

After the preparation of the questionnaire, 9 building construction companies were successfully contacted in August 1979. These firms gave permission for liaison with 18 of their site supervisors. Two of the firms did not employ full-time site supervisors but indicated that their directors and branch managers carried out the supervision themselves. Hence the reason that all of the participating individuals were categorised as contract supervisors.

The above arrangements resulted in 22 questionnaires being provided to 18 site supervisors and the 2 firms discussed. Of these, only 14 questionnaires were completed, i.e. 64% of the sample. In addition, four selected sites were visited.

In five out of the ten sections of the questionnaire the supervisors were required to indicate the order of usefulness or importance by ranking the items given. Six of the supervisors responded as expected but the other eight ranked the items correctly in one section but gave values (weightage) to those items in the other four sections. These values were interpreted and ranked so that the analysis could be carried out.

Since the respondents answered well in the last section which deals with barriers to negative feedback this assisted the study greatly.

Among the 14 contract supervisors participating in the study, 10 supervised contracts ranging from £1 million to £10 million and the other four supervised contracts varying in cost from £200,000 to £700,000. Their completed questionnaires were analysed and the data obtained is presented in the tables given below.

	Method	Frequ- ently	Sel- dom	Never	Effect ive
a)	SIMPLE BAR CHART	86%	0%	14%	86%
b)	LINKED BAR CHART	21%	72%	72%	14%
c)	CHAIN BAR CHART	7%	14%	79%	0%
d)	TIME/LOCATION BAR CHART	36%	14%	50%	28%
e)	ACTIVITY ON NODE NETWORK OR PRECEDENCE DIAGRAM	0%	36%	74%	14%
f)	ACTIVITY ON ARROW NETWORK	14%	36%	50%	14%
g)	FLOWLINE CHART	0%	7%	93%	0%
h)	LINE OF BALANCE CHART	0%	21%	79%	0%

Table 1 Planning Tools for Production On Sites Used By Site Supervisors.

a)	LABOUR REQUIREMENT SCHEDULES	43%	14%	43%	50%
ь)	WEEKLY WORK LISTS (with target man hours)	50%	14%	36%	43%
c)	DAILY ALLOCATION SCHEDULES	36%	7%	67%	14%
d)	RESOURCE LEVELLING (balancing of gang sizes)	36%	7%	67%	14%

Table 2 Methods To Plan Labour Requirements Used By Site Supervisors.

a)	METHOD STUDY by using flow diagrams and multiple activity chart	7%	14%	79%	78
b)	METHOD STATEMENT WITH ANTICIPATED DATES to arrive at heavy plant schedules	36%	14%	50%	21%
c)	THE 'CYCLONE' using queuing principle	0%	0%	86%	0%
a)	SITE LAYOUT PLAN	79%	7%	14%	50%

Table 3 Methods to Plan Plant Requirements Used By Site Supervisors.

From Table 1 it can be seen that 86% of the respondents used simple bar charts frequently to plan the flow of construction activities on their sites. Those who used the tool found it effective. Only 14% of the respondents used the activity on an arrow network (C.P.M.). This was considered to be surprising since about 72% of the contract supervisors were managing contracts worth more than £1 million each. For instance, contract supervisor 12 only used a simple bar chart although the contract he was managing was worth £4 million. Besides the list given, contract supervisor 10 indicated that he also used "bar chart with associated cost and measurement 's' curves". Contract supervisor 14 used "key trend" besides a simple bar chart.

Certain other features of the data contained in tables 2, 3, 4 and 5 are worthy of mention. Only 50% of the contract supervisors used a budget graph and 51% used a cost control schedule to arrive at standards of performance on their sites. Very few of them used other methods listed in this section. Site supervisor 1 only used a "bonus target" to do this. The use of scientific techniques to arrive at output standards as measuring devices in the control process were not given due importance by the supervisors.

		Frequ- ently	Sel- dom	Never	Effect ive
a)	BUDGET GRAPH based on pay- back period/cash flows	50%	O۶	50%	43%
Ъ)	COST CONTROL SCHEDULE based on the 'standard' operation costs of pre- viously completed work	51%	7%	42%	29%
c)	METHOD STUDY to arrive at a tolerable productivity level by using multiple activity chart/scale models/string diagrams/ process chart	14%	14%	72%	7%
d)	WORK MEASUREMENT to establish 'standard' time to do a specific task by using time study/ synthesis/analytical estimating	28%	28%	44%	29%
e)	STATISTICAL QUALITY CONTROL to arrive at quality control standards for concrete strength, etc.	28%	7%	65%	14%
£)	ACTIVITY SAMPLING to determine the tolerable percentage of non- productive time of operatives and plant	14%	7%	79%	78

Table 4 Techniques To Arrive At Standards Of Performance Used By Site Supervisors.

a)	MATERIALS SCHEDULES	72%	7%	21%	64%	
b)	SUB-CONTRACTORS SCHEDULES	28%	14%	58%	14%	
c)	BILLS OF QUANTITIES	100%	0%	0%	64%	
a)	QUANTITATIVE METHODS such as linear programming	7%	7%	86%	7%	

Table 5 Tools To Plan Use of Basic Materials On Sites By Site Supervisors.

	Information from	Available (Yes	on Site No	Usefu
1.	WEEKLY SITE MEETINGS (informal meetings with subordinates to discuss progress)	86%	14%	93%
2.	INFORMAL COMMUNICATION WITH TRADES FOREMEN	79%	21%	86%
3.	INFORMAL COMMUNICATION WITH OPERATIVES	71%	29%	71%
4.	SUB-CONTRACTORS ' MEETINGS	86%	14%	79%
5.	TECHNICAL QUERIES	64%	36%	57%

Table 6 Feedback Of Information On Control Of Production On Sites.

1.	ATTENDANCE RECORDS	93%	78	79%
2.	COMPLAINTS MADE ORALLY BY TRADES FOREMEN	79%	21%	50%
з.	ACCIDENTS REPORTS	93%	7%	43%
4.	COMPLAINTS MADE ORALLY BY OPERATIVES	57%	43%	43%
5.	RECORDS ON OUTPUT LEVELS	64%	36%	64%
6.	WEEKLY SITE MEETINGS	79€	21%	7 9 %
7.	TIME AND WAGE SHEETS	86%	14%	79%
8.	SHOP STEWARDS' INFORMAL MEETINGS WITH SITE SUPERVISORS	43%	57%	36%
9.	ALLOCATION SHEETS	79્€	21%	86%

Table 7 Feedback Of Information On Control Of Labour On Sites.

1.	PLANT BREAKDOWN RECORDS	79€	21%	71%
2.	INFORMAL COMPLAINTS FROM HEAVY PLANT OPERATORS	43%	57%	43%
3.	PLANT UTILISATION AND IDLE TIME RECORDS	36%	64%	43€
4.	WEEKLY SITE MEETINGS	43%	.57%	43€
5.	RECORDS ON DELIVERY OF PLANT	86%	14%	71%

Table 8 Feedback of Information On Control Of Plant On Sites.

	Information from	Available on	Site	Useful
	_	Yes	No	
1.	RECORDS ON MATERIAL DELIVERIES	93%	7%	86%
2.	RECORDS ON QUALITY AND QUANTITY CHECKS	57%	43%	79%
3.	RECORDS ON WASTAGE LEVELS	29%	71%	57%
4.	NOTES ON SPOT-CHECKINGS	43%	57%	43%
5.	WEEKLY SITE MEETINGS	57 %	43%	57%
6.	MEETINGS WITH SUB- CONTRACTORS' FOREMEN	64%	36%	57%
7.	MATERIALS STOCK RECORDS	50%	50%	57%
8.	MATERIALS CONSUMPTION RECORDS	36*	64%	50%
9.	INFORMAL REPORTS BY TRADES FOREMEN	57%	43%	64%

Table 9 Feedback of Information On Control Of Materials On Sites.

Only from 36% to 50% of the supervisors used the methods listed to plan their labour requirements. Contract supervisor 7 used a "working schedule with targets" besides daily allocation schedules. Contract supervisor 4 used a "weekly programme related to shortterm plan" besides weekly work lists for this purpose. The majority of the contract supervisors used site layout plans rather than other sophisticated techniques like the "cyclone" method to plan their plant requirements. Most of the supervisors used bills of quantities or materials schedules or both. Only 7% of the supervisors used statistical methods for this purpose. Contract supervisor 8 used "take offs from drawings". Contract supervisor 3 used a "master programme" besides bills of quantities to plan his materials requirements.

Tables 6 to 9, inclusive, summarise the responses of the contract supervisors concerning the availability of sources of feedback information within four major control areas. The extent of agreement or disagreement among the supervisors in their rankings of their responses was tested using the non-parametric statistical techniques. There was a high degree of agreement in the case of Information On Control Of Production, on Labour and on Materials. However, their appeared to be a low level of agreement in the supervisor's rankings on the feedback information on Plant. The test result obtained was only at the 30% level and must be treated with suspicion. Clearly, more data is required on the control information concerning plant on sites.

In the final section of the questionnaire, the contract supervisors were asked to rank 8 factors which could act as barriers to the flow of negative feedback from their subordinates. The factors, together with the final rating of them, are listed in Table 10. There was a high degree of agreement among the supervisors in their responses, which the statistical tests showed to be at the 99.95% level.

Conclusions

The control of production and resources on the sites was based on plans and output standards. Modern and more sophisticated techniques were found not to be in common use by the contract supervisors, who preferred simpler methods. These simpler methods provide better communication to control production and resources but were not effective enough to show clearly deviations necessary for any corrective measures to be taken immediately. Half of the supervisors used cost control techniques for their output standards. These techniques have been criticised (5) because cost estimates are only approximate, at best. Modern techniques measure levels of activity of the work force and more sophisticated ones measure levels of productivity. These techniques offer an effective means of supplying a measure of field effectiveness in the use of resources. Management effectiveness cannot be measured by such arbitrary scales as prebid estimates or production goals. Such comparisons are of greater interest to the head offices than to contract supervisors.

The contract supervisors did not use these newer techniques either because of their complexity or through lack of experience. Again, the one-off nature of the contracts and the ever-changing labour force at various stages of construction were not considered to warrant the use of these techniques.

	FACTORS	RANKING
1.	LACK OF COMPANY LOYALTY AND MORALE ON THE PART OF SUBORDINATES	2
2.	RIGID FORMAL PROCEDURES FOR REPORTING	8
3.	FEAR OF BEING OSTRACISED	5
4.	OPERATIVES ARE LESS ACCESSIBLE TO SUPERVISORY STAFF	7
5.	CARELESS ATTITUDE OF OPERATIVES	1
6.	SENSE OF GUILT AFTER CARELESS MISTAKES	3
7.	REPETITIVE NATURE OF TASKS	6
8.	INSTRUCTIONS FROM SUPERVISORY STAFF ARE NOT EASILY UNDERSTOOD	4

Table 10 Final Rating Of The Factors Based On The Combined Estimates Of The Site Supervisors

However resource utilisation using modern techniques would clearly be a better measure of performance rather than that based on cost estimates alone and well worth the extra effort entailed.

It was found that 50% of the contracts studied were behind the programmed period. It might be argued that this could be due to the preceeding bad winter. However, in the absence of effective plans and output standards and having regard to previous information on contract performance, it is difficult to accept this as the sole reason.

With regard to the barriers to negative feedback on sites, the following general inferences can be drawn, based on the results of the correlation coefficients obtained :-

(i) The contract supervisors considered that the lack of company loyalty and morale on the part of subordinates were factors which tended to relate to a sense of guilt in their subordinates after careless mistakes. They felt that a good subordinate should use loyalty to overcome feelings of fear or guilt and report immediately to his superior any mistakes in his work to enable corrective action to be taken quickly. (ii) Rigid formal procedures for reporting are regarded by the contract supervisors as having a relationship with the nature of instructions from supervisory staff which are not easily understood by the subordinates. A subordinate who finds difficulty in understanding some instructions from a contract supervisor will continue to experience difficulty when there exists a rigid formal procedure for reporting. In this situation, informal communication is not encouraged and he has to go through certain procedures, such as waiting until the next weekly meeting, before being able to report his difficulty.

(iii) Subordinates who are members of a group of operatives avoid trouble from the other group members by not reporting voluntarily to the contract supervisor mistakes committed by the group as a result of misinterpretation of the supervisor's instructions. (iv) The contract supervisors tend to associate the careless attitude (or lack of interest) of their sub-ordinates (particularly individual site operatives) with the fact that the operatives are less accessible to supervisory staff. Hence negative feedback is not frequent from the operatives direct to the supervisor.
(v) There is a relationship between the repetitive nature of tasks (in certain construction operations) and a sense of guilt after careless mistakes. This relationship was not expected but is not difficult to understand.

The hypotheses tested were supported by the data obtained, particularly the third hypothesis. The factors revealed were behavioural in nature and support the assertation that effective communication on sites is not only the efficient flow of task information but the additional efficient flow of non-task information. However, the factors highlighted should only be considered as modifying influences contributing to the less frequent flow of negative feedback. In effect, they only indicate certain degrees of relationship between cause and effect. Much more detailed information is still required.

References

(1) Daltry, C D and Crawshaw, D T. Working Drawings
In Use. B.R.E., U.K., C.P. 18/73, June 1973.
(2) Gupta, J P. Building Site Activity: An Input/
Output Model, Ph.D. thesis, U.M.I.S.T., U.K., 1966.
(3) Manteau, K. Factors Affecting Materials Control
On Building Sites, M.Sc. thesis, U.M.I.S.T., U.K., 1974.
(4) Neave, H R. Statistics Tables For Mathematicians,
Engineers, Economists And The Behavioural and Manage-
ment Sciences, George Allen & Unwin, London, 1978.
(5) Parker, H W and Oglesby, C H. <u>Methods Improvement</u>
For Construction Managers, McGraw-Hill, New York, 1972.
(6) Robson, C. Experiment, Design and Statistics In
Psychology, Penguin, London, 1977.
(7) Parker, H W and Oglesby, C H. Methods Improvement
For Construction Managers, McGraw-Hill, New York, 1972.
(8) Burgess, R.A. The Management of Resources On
Construction_Sites, B.R.E. Overseas Division, U.K.,
1978.
(9) C.I.B., W.52, Evaluation Of Information Systems For

The Construction Industry, C.I.B. Publication 47, Rotterdam, 1978.

Production process preparation in construction

V.V. Shakhparonov, Candidate of Sciences (Engineering), Deputy Director, and P.P. Oleynik, Dept. Chief, Candidate of Sciences (Engineering), TSNIIOMTP, Moscow, USSR.

<u>Summary</u>. The paper presents the objectives and basic principles used in elaborating a system for preparing the production process in construction and describes them as a complex of correlated preparatory steps and measures of an organizational, technical, technological and planned-economic nature that make it possible to develop and erect constructional project units and purposefully supervise their execution and timely commossioning.

It discusses such aspects of preparation for the process of organization, preparation for the construction of a project, and preparation of the technological processes.

It formulates the requirements to be met in preparing construction production and those that apply to the objectives and methods of developing and using documentation.

The paper also indicates ways to achieve the transition to the System of preparing construction production in accordance with such criteria as systematics, standardization and automation to ensure really efficient management of the construction of enterprises buildings, and structures.

Sommaire . Le rapport rappelle les

objectifs et les principes de base du système de la préparation des travaux de construction comme une complexe des actions correllées préparatifs du caractère d'organisation, technique, technologique, économique et planifié qui assurent la possibilité du développement et de la réalisation des travaux de construction dans le but de la mise des chantiers en exploitation opportunément.

On analyse des orientations dans la préparation des travaux de construction, - la préparation de l'organisation-entepreneur de construction, la préparation du chantier pour le travaux de construction, la préparation de la technologie. On formule des exigences à la préparation des travaux de construction d'après les fonctions, les tâches et les méthodes de la préparation et de l'application de la documentation.

On indique les voies de la transition envers la préparation des travaux de construction d'après les critères de la systématisation, de la standartisation et de l'automatisation dans le but d'assurer la meilleure administration de la construction des entreprises industrieles, des bâtiments et des ouvrages divers.

The system of preparation for construction production is understood as a systematized complex of correlated preparatory steps and measures of an organizational, technological, technical and planned-economic nature that make it possible to develop and erect project units and commission them on time.

The unity of the system of preparation for constructional activities (PSP) is ensured bhrough the use of:

- common terminology;
- the common composition of the objectives and methods;
- common procedure in elaborating and unifying the forms of technical documentation and the organization of its introduction into practice;
- common rules of action for all the executors;
- common norms and rates.

The elaboration of the PSP system is aimed at creating a single rational pattern of preparation for production at the constructional ordanizations in order to diminish the time and expenditure involved in its development and implementation, and to secure effective technical and economic indices in the construction of all project units by every constructional organization.

The reduction of time-terms for the preparation of production is achieved through regulating the process of elaboration and unification of the forms of technical documentation, through introduction of the means of automation to solve engineering, technological and administrative problems, and through improvements in the system of planning and control over production preparations.

The reduction in expenditures for the preparation of constructional production is achieved through the use of typical and standard solutions in the process of elaborating the technological documentation, by improving the methods of calculating the objectives and by rationalizing methods of planning and control over the preparation for production.

The structure of the system of preparation for process of construction includes:

- general preparation for construction;
- the preparation of a constructional organization;
- preparations for the construction of project items;
- preparation of technological processes.

General preparation for constructional production is a complex of organizational and technical steps and measures which are carried out prior to the beginning of the construction and mounting work on construction sites, and is determined by the relations and commitments of participants in capital construction, i.e., of the Customer, General Designer and General Contractor. The functions of the general preparations are: elaboration of technical documentation, checking and approval there of, carrying out of the appropriate steps and measures prior to the beginning of construction, compiling of title lists, the start of financing and the signing of contracts.

The preparation of a building organization is undertaken to create the necessary conditions for every division in the organization to fulfil the production programme of work in compliance with the assigned technical and economic indices. The preparation of a building organization includes long-term planning, plans to develop the building organization's capacities, projecting of organization for an annual programme of work, elaboration of a plan of organizational and technical activities of a building organization of annual programmes of material supplies and technical support.

Preparation for the construction of project units consists of a set of objectives, steps and measures to ensure a high level of organization on the construction sites and of the execution of the work of construction and erection at the project units. The basic stages in the preparation for construction of project units are: infra- and intra-structural work to secure engineering preparation of the site, preparation of the working drawings, development of projects for the execution of work, elaboration of documentation for material supplies and technical support for the entire period of construction.

Preparation of technological processes includes a set of organizational and technical solutions that ensure the assigned technological process of construction and erection work. The preparation of technological processes consists of: projecting to ensure the steady rate of constructional process, the rendering of the typical technological documentation, preparations for running constructional machinery, mechanisms and inventary buildings and engineering structures, preparation of the means of technological outfit, formation of working teams, the organization of the system of working teams' contracts, organization of the work guality control.

The functioning of the PSP system is ensured through the centralization, within the building organization, of the functions of the services responsible for the preparation of production and through assigning it the following tasks:

- planning for the production activities

of a construction organization;

- carrying out the organizational-preparatory work;

- providing the work of construction and mounting with project estimate documentation;

- elaboration of the organizational-technical documentation, and its introduction into production;

- material supplies and technical support. The transition towards the PGP system is being carried out in compliance with the principles of systematics, standardization, automation and development of the system.

Realization of the principles of systematics consists in formulating a general concept incorporating the following blocks:

PCP process (block-diagram of a process); PCP function (block-diagram of a function); PCP objective (block-diagram of an objective).

The principle of standardization ensures regulation and normalization of the PCP system. The objects of standardization are as follows: technological processes, methods of organization and accomplishment of tasks, documentation forms, norms and rates, methods of information processing, requirements applied to elements and blocks, terminology.

The principle of automation is directed at achieving automated solutions for the complex of tasks of the PCP, execution of the engineering-technological calculations, and elaboration of documents.

The principle of development of the systems provides for constant development and improvement of the organization and technology of the construction process, the introduction of new machinery and advanced technological processes, and for improving the mathematical and programme support in accomplishing the PCP tasks. The Role of Construction in National Development

A. Nagabhushana Rau, B.E. F.I.E. General Manager The Hindustan Construction Co. Ltd. Construction House, Ballard Estate Bombay 400 038, India.

(Affiliation : C.I.B. Individual Member)

Summary

In any fast developing country, construction activity has almost a fifty percent share in the development Plans. Its importance and the effect of its mis-management is not well realised. How to coordinate so many participants in the Industry with different approaches to achieve the objectives? Management of construction is a combination of management of natural resources, man-power and natural wealth.

The complexities of construction activity pose problems in 'Management of Contract' which is a vital controlling factor in the construction activity. Financing of construction by construction agencies and its management is another area needing attention.

The construction agencies lack even the basic management approaches in investigation, bidding, project planning, equipment selection, operation, man-management, material management, contract management, methods and techniques in execution of construction projects, and hence these areas need greater attention in research and industry. The technical education needs reorientation to infuse basic management problems of construction.

Why, even the management associations, institutions of engineers, institutions of architects, contractors associations, associations of consulting engineers and productivity councils and government authorities in the developing countries have neglected this vital subject matter?

The Construction Activity plays an important role in overall economy, social growth and develop ment in all countries by means of direct and indirect contribution to gross domestic product and employment. It has a vital role in satisfying many basic needs of the society. Its influence is predominent in overall commissioning of other industries to produce and distribute goods and services.

Construction contribution in national development Construction outlay forms 45 to 65 percent of gross fixed capital investment. In developing countries, construction sector may be only next to agriculture sector in economic importance and employment potential. The construction materials form about fifty percent of construction outlay. The construction activity is not only in new construction but also repair, maintenance and protection of works already constructed. The latter forms a'fairly large percentage of national outlays depending on the importance and priorities given to the aspect of safety as well as preserving the old structures.

Adoption of management techniques

Yet, there is not sufficient awareness of the role, the construction sector plays in national development. There is still no realisation of the complexities of construction problems especially of project management. Hence any mismanagement of construction sector has an effect on the overall develotment of the community. Even a small improvement in the management and productivity has a great saving and benefit to the community. The

628

Introduction

management techniques adopted in business and industry sectors have had no application in construction industry and construction project management. These analytical techniques need to be oriented for adoption in construction industry. The construction industry must be made aware of these and the benefit of adopting them,

Role of Governments in Construction

Construction is a complex process not only for technological reasons but because of large number of participants involved and conflicts arising out of their associated inter-dependencies, contractual or otherwise. The requirement of each constituent or agency is different and the approach or attitude to the activity at hand will always vary.

Another important factor is the role of the Governments in construction activity. It has a duel role as legislating authority as well as an active participant. The management of construction means the management of natural resources, man-power and the enviornment. All these are to a large extent controlled by policies and priorities laid down by the Governments.

Most of the construction works, originate in the public sector and as a major generator of demands in the construction activity the Government has a great role to play in developing the industry both in technological development as well as management development. The agency that handles the overall construction has to depend mainly on good management in coordinating various disciplines involved for the realisation of the project completion.

Contract Management

Construction Industry is a risky business. Construction activity is one where the product, for example a building, a bridge or a dam is 'priced' or 'sold' at fixed price before the product is made. This is quite unlike manufacturing industry where the product is made first and then priced and sold when the manufacturing cost is known. The origin of the Contract Agreement associated with construction industry is all countries, at all the levels of development, is due to this special charecteristics. Complexities to be covered in contract agreements Contract Agreement poses number of problems on account of the special nature of construction industry. It is seasonal, mobile, not continuous, lack of standard product, each product i.e. structure, being 'owners own idea' for his own needs and to suit the site. It is produced at site unlike manufactured goods, including some building materials like aggregate, bricks, blocks to be made at site. It has to consider geographical locations, location in different parts of the country, their own legislative acts and rules. The contract has to cover the special risks in long range contract due to natural disasters, unknown geo-physical conditions, inflation etc. Because of these complexities, there exists a complicated process of written documents which are very detailed in defining contractual obligations, specifications both general and technical, bills of quantities, legal and financial conditions and so on.

Government's role in contract management

As stated earlier, as the construction industry has to depend largely on Government spending, the Government largely dictates the terms and conditions under which the construction industry has to work. Even though the Government has a big say in most of the countries there is no central authority to guide the industry. Each department of State or Federal Government has its own contract document and enough attention not given to adjust these contracts to changed conditions and the complexities to be faced by the construction activity.

The development of construction industry in developing countries depend on an important factor, namely formation, adoption and management of an efficient and equitable contracting system and procedures. In this the Government has a decisive role.

Construction Financing

As stated earlier, the provisions of Government spending on the construction activity controls the financial outlays. Usually it is the construction activity which gets affected whenever Government spending is to be curtailed. The construction activity, or late, is also financed by the International monetary funds and aid by other developing countries.

Contract financing

The procedure adopted by the Government in allocation of funds to the project has a great effort in planning materials, equipment, progress etc. by the project authorities.

But most of the construction activity is by contract system, the problems faced by construction agencies in finances is an important factor, in most of the developing countries where capital is scarce. The construction agencies have to obtain finances mostly from private lenders at exhorbitant rates of interests. Now the owners who are mostly government departments, assist the agencies in short term financing out of funds allotted to them. But, for a long term acquisition of equipment, building materials, long term contract financing where initial outlay in preliminaries works are high, there are problems.

Financial Institutions and construction contracts The financial institutions are hesitant as the construction industry or the activity is considered a 'high risk' business. Inspite of construction activity accounting for large investments, the financial institutions in developing countries have not studied the complexities of the industry and guided the industry on the contract financing.

It is also true that construction agencies do not adopt modern finance management techniques as many are not aware of these and the usefulness of adopting them.

However, for the agencies own survival in this risky business and to induce financial institutions to assist the agency in financing, introduction of managerial accounting which play a decisive role in 'judicial' utilisation of finances by adopting the various techniques available suitably modified to suit the complexities of construction activity is essential.

The procedures introduced by the Governments in the contract agreements about bid bonds, security, mobilisation advances, advances against equipment and materials, regular payments for work done, settlement of rates and payment of final bills etc. have a great effect on efficient financial management in project execution and development of construction industry.

Construction Project Execution

For any agency - either public or private - to efficiently and economically execute a project, a detailed study of different phases are essential. Every agency is eager to start the project work,

630

irrespective of priorities, planning and preparation.

Pre-planning of construction project

Enough attention be given in terms of time, money, manpower and expertise and coordination and cooperation of different departments, during investigation, of a construction project. Soil data, geophysical investigation, problems of weather, climate, availability of material, availability of equipment, manpower, infra-structure facilities etc. determine the overall costs, time schedule and specification and technology to be used. Unless investigations are detailed, the tender documents as most works are done by contract - are not well prepared.

The time schedules given in many cases are so unrealistic and undue hopes are aroused in the community of the completion of the project, which does not get realised.

Selection of Technology

In construction activity, wide range of technology and methods could be adopted to execute any construction project. The technology to be adopted - either labour intensive, equipment intensive, or a combination, does need detailed studies. This depends on the availability of work force in nearby area, possibility of importing labours, existing equipment, time plan for import, service and maintenance, whether equipment fully utilised for this works planned and future construction projects planned, to make use of this equipment etc. are some of the problems that have to be examined by the Project Management.

Man management or management of human resources Another important factor in development of construction industry is the extent to which importance is given to man management or management of human resources. Since in most of the developing countries the construction activity is labour intensive, this needs a careful study. In most of the developing countries the construction labour is not organised. The problems of seasonal and casual nature of employment, mobility, training, wage and benefits etc. are the one that are to be tackled, Many countries have no social security and other facilities. Hence, when labour intensive techniques employment potential etc. are talked about in construction industry, the management of this important resource and human relations matters are not receiving enough attention. The authorities, engineers, construction managers and contractors have no basic training in man-management and the nature of employment which is seasonal, mobile, temporary, rural oriented, unorganised, no statutory safeguards etc. which are complex, make management of human resources more complex than in some other sectors.

Education and training

Even though engineers get school and university training, the subject matters are mostly theoritical and design oriented. Many times these are not relevant to the conditions prevailing in the country, in terms of material, equipment, manpower, skill and infra-structure available. The construction activity was not so complex and so vast in the earlier days in most of the\developing countries. As development activity increases and country wants to industrialise, the construction activity increases in volume, intensity and variety of technology adopted. Then management problems of all aspects of the construction activity need to be studied and understood. Education and training has to be oriented towards this. To achieve this, there must be regular and organised system of exchange of teaching faculty between the field and Institutions. It also will be necessary to have training periods sandwitched with class room studies.

Construction engineering and contract management Now construction engineering and contract management is not only civil engineering, but a combination of other faculties, a course of study incorporating practical periods, on construction engineering and construction management would go a long way to improve the industry. If the constructors can perform well, it will improve the image of the constructors and the industry in the community. Training of Contractors

Construction activity is carried out by many small contractors in most of the developing countries. These are either financiars or originally tradesmen. They do not have necessary basic training. The overseas construction companies usually do not encourage training of local contractors, or evolve techniques to suit local conditions, but enforce imported technology. So, it is necessary to formulate and introduce simple methods of training of contractors, Same holds good for many construction companies also.

Organisations and Associations connected with Construction Activity

In many developing countries there are no organisations or associations of contractors or construction agencies to voice the problems of the industry. Even where they do exist, their voice is not effective.

The engineers associations, management associations and productivity councils etc. have not appreciated the role of construction in the national development and taken up programmes to assist the construction industry, as they have done in other sectors of Industry and Services. All of them can play a big role in development of construction industry.

Even the research workers in the research institutions have gone more on theoritical and abstract subjects rather than those that are relevant to the needs of construction industry in developing countries. There is not enough data on feed back or case studies as to how far these researches and theories have been adopted and produced results in the construction industry in the developing countries.

Conclusion

Construction activity is a basic activity in national development plans. It has a big share. If this is appreciated by the Governments, the organisations and Institutions, whose aim is development and improvement of management and the construction industry is also included in their purview, the construction can play more effective role in developing countries in the National Development. Construction site population: estimating the size and structure.

Calin Popescu, Ph.D, PE - USA - Associate Professor, University of Oklahoma.

Temporary facilities and utilities for construction site are those needed by the general contractor and subcontractors for a limited period of time during construction and testing phase. For some projects located in remote, undeveloped areas, it counts up to 20% of the project cost. Of this costs labor camp facilities, such as dormitories, canteens, clubs, schools, etc. - represents a big share of the alocated budget. For designing and layout of the labor camp, establishing at an early stage the structure and size of the future site population, is a foundation of a good design and organization.

The labor force employed on a remote job site can be subdivided in three groups regarding the permanent residency distance from the project (fig. 1) as follows:

 L_1 = Local labor force - no lodging and transportation needs.

 L_2 = Nearby labor force - no lodging needs but daily commuting.

 L_3 = Far away from project location.

 L_4 = What requires provision for lodging in the future camp.



It is of a major interest for both designer and contractors to make a detailed evaluation of the actual environmental conditions where the future project will be constructed. This takes place in advance of the detailed design during the feasibility study. Information concerning labor, availability by trades, lodging facilities in the area are vital for estimating temporary facilities needs.

On the other hand for the designer it is important to estimate in advance - the number of the skilled and unskilled labor and managerial staff by periods in general no shorter than a month for 1-2 year job or quarters for long span projects 5-7 years.

To arrive at these figures a schedule of principal quantities as accurate as possible is the first step, followed by an estimate of the productive labor force needed to complete planned tasks. As a result, a rough estimate by periods and trades of the productive labor force is obtained (fig. 2).



From this hystogram another comment can be made regarding the population site structure; it is composed of constructors (10-15 trades), plumbers, electricians and mechanics. The ratio between these trades is function of the project nature and sometimes location (fig. 3).



For estimating the number of the skilled, unskilled workers and staff-managers to be employed for the project, the following orientative formulas may be used $^{(3)}$:

 $L_1 \text{ (high skill labor)} = 0.5L_c + 0.6L_p + 0.7L_m$ $L_2 \text{ (unskilled labor)} = 0.4L_c + 0.2L_p + 0.15L_m$ $L_3 \text{ (staff & managers)} = 0.1L_c + 0.2L_p + 0.15L_m$

 L_c , L_p and L_m have been established previously by dividing in each period the planned quantity by the average expected trade productivity.

The site population has tremendous needs regarding lodging, education and social life that should be reflected in the temporary facilities location, number and design. If we consider a few of the lodging needs by different categories by requirement these are grouped together in Fig. 4.

Temporary	Construction Site Population						
Facilities	Local Labor Force (L1)	(L2)	(L3)				
Lodging Facilities	-	-	Yes				
Drying Rooms for Clothing	Yes	Yes	Tes				
Showers	Yes	Tes					
Toilet Facilities	Yes	Yes	Yas				
Canteen	1/2	Yes	Yes				
Dining Rooms Only	1/2	-	-				
Tool & Equip- ment Lockers	Yes	Yes	Yes				
Offices	Yes (staff only)	Yes (staff only	y) Yes (staff only)				

Figure 4. Site population temporary facilities needs.

If these needs that are changing in time are not satisfied, a big turnaround among staff and labor force will be encountered, and as a final result a low productivity and a higher production cost will be recorded. The site population breakdown symbols by skill and recruitment to be used in further computations is condensed in Fig. $5^{(3)}$

				Lodg	ing Needs
	Total			Far From Pu	oject Location
	Population	Local	Nearby	Married	Unmarried
High Skilled Labor	L1 L1+ L12+ L13+ L14	L ₁₁	L ₁₂	^L 13	L ₁₄
Unskilled Labor	L ₂₁ + L ₂₂ + L ₂₃ + L ₂₄	L ₂₁	L ₂₂	L ₂₃ * (in general = 0	L ₂₄
Staff Managers	L ₃	L ₃₁	L32	L33	L 34
Total Productive Labor	$\frac{L_{T}}{L_{1} + L_{2} + L_{3}}$	L _{T1}	L _{T2}	L _{T3}	L _{T4}
Family Membera	F.	-	-	P	-
Total Site Population	$\mathbf{P} = \mathbf{L}_{\mathbf{T}} + \mathbf{F}$	L _{T1}	L _{T2}	L _{T3} + F	L _{T4}

Figure 5. Population breakdown by skill and recruitment.

To establish the number of employees with permanent residence far away from the project location the following relations are to be used:

The site population ${\binom{P}{1}}$ in need of lodging facilities is $P_1 = L_{13} + L_{14} + L_{24} + L_{32} + L_{34}$

Past projects have shown that number of married employees as a part of total labor living in the camp is a function of project or contract length--and represent an average of 15-20% for projects up to one year, 35-40% for projects of length between 1-3 years, and 50-60% for projects longer than 3 years. These percentages are only orientative and should be checked carefully by designer because they are affected by local environment and are changing with the standard of living in that specific area.

The designer after estimating the size and structure at the future site population using area indices as shown in Fig. 6 will evaluate for each type of temporary facility the needed areas and at a later date these figures should be converted in \$ for budgeting purposes.

Temporary Facility Type	Unit	Area/Unit M ²	
Dormitory	bed	6.50	
Bungalow	person	12.50	
Drying room - Dressing room	person	0.70	
Shower	person	.15	
Canteen	person	.85	
Dining room	seat	1.4	
Offices	staff	6.00	

Figure 6	Area	Indices	for	estimating	temporary	facilities.
rigure o.	Area	Indices	101	estimating	cemporary	i actiticies.

The average family site for workers skilled or unskilled living in the camp is an important parameter in design. As a rule of thumb 2.5 is a good estimate; this means that for each productive labor married (skilled or staff) brought on the job site for construction we assume in addition 1.5 persons for each family.

*Availability evaluated during feasibility study or prebid period.

It is the responsibility of the general contractor to provide adequate living, health and educational facilities for the employees and their family members.

The labor camp designed based upon estimated future population will be located close enough to the job site to minimize commuting time and expenses and at the same time in a dust and noise protected area for maximum comfort. Protection against fire and vandalism require additional costs is important too.

Over the years various layout patterns have been developed. The location of such camps should seek to minimize the hazard from windstorm, flooding and fire. Fig. 7 is a typical layout for 1000 laborer construction site camp.



Figure 8 shows a solution to site organization on a Philip Holtzman project in Saudi Arabia, and Figure 9 is a typical camp layout based upon trailer (portable units).

Conclusion.

Because construction projects in coming years are increasing in size and managerial complexity, the problems generated by temporary facilities and utilities become stringent and the design cannot be based anymore on the superintended rule of thumb.

Criterias and practical proved approach in developing labor hystogram related to project planning are the starting and most important point in estimating site population.

A poor evaluation of the labor force may lead to delays to construction, overrun costs and dissatisfaction at the end of a long period of concentrated efforts by contractors, engineers and managers.

The population structure, family size, areas indices are particular to a category of projects, to a particular country and location and are changing in time in the same way as the standard of living is changing.

Careful consideration of all the factors will avoid fluctuation on construction jobs that works against a sound management.





Fig.9.

Summary.

Temporary facilities and utilities for construction site are those needed by the general contractor and subcontractors for a limited period of time during construction and testing phase. For some projects located in remote, undeveloped areas, it counts up to 20% of the project cost. Of this costs labor camp facilities, such as dormitories, canteens, clubs, schools, etc. - represents a big share of the alocated budget. For the designing and layout of the labor camp, establishing at an early stage the structure and size of the future site population, is a foundation of a good design and new organization. Categories by recruitment sources, such as being close to the site area, near to the job site or far away from the site, or categories by major trades are analyzed and practical estimating formulas based upon a large number of observations given in the paper.

A poor evaluation of the future site population and structure may lead to delays in construction, expressed in costs overrun and owner dissatisfaction at the end of a long period of concentrated efforts by contractors.

References.

1.	AGC-ASC - Natio Utili	onal Guideline Temporary Job ities and Services, 1973.
2.	AGC; - Outl: Inves	Ine for Reports of Site stigations.
3.	Bodeam, Lupum;	Constructii Social Administrative Pentru Organizarea Santierului, Editura Technica, Bucuresti, 1973.
4.	Calin Popescu;	Projectarea Organizarii de Santier, Editura Technica, Bucuresti, 1976.
5.	Calin Popescu;	Large Construction Sites Design and Organization in Developing Countries, Society of Automotive Engineers, Technical Paper 790533, April 1978.
6.	Calin Popescu;	Temporary Facilities - Utilities Designing Steps, A.S.C.E April, Spring Convention, Portland, 1980.
7.	Walden Ian;	Letter to America, American Pro- fessional Constructor, Autumn 1979.

The relative importance of men and materials in determining the layout of a building site ______A.I.A. Saleh, B.Sc. (Arch), Research student and B. Whitehead, B.A., F.M.S., M.B.I.M., Senior Lecturer, Department of Building Engineering, University of Liverpool, England.

Summary

Little attention appears to have been given to the question of the efficiency of the layout of a building site as a factor in productivity.

In practice, the layout of plant, stocks and facilities is often left to the unguided judgement of the Agent.

Construction management textbooks generally discuss the matter in terms of such aspects as security rather than productivity and even those people who do adopt a more analytical attitude tend to assume for the purposes of their theses that the cost of moving materials from stocks to final positions in the building is the only factor worthy of note and calculation.

The purpose of this paper is to attempt to show that the cost of men moving between their places of work and such facilities as toilets, locker room, canteen and offices is likely in many cases to be at least equal to and often of a higher order than the cost of moving materials. Priority in location should then be given to facilities which are at present often placed in any odd corner.

Resume

Il paraît qu'on a peu considéré l'agencement efficace d'un chantier de construction comme un des facteurs de la productivité du chantier.

En effet c'est souvent un agent qui, de sa propre initiative, détermine la disposition du matériel, des réserves de matériaux, et des installations provisoires.

Dans les manuels qui traitent le management de l'industrie de la construction on discute des matières comme la sécurité mais, en général, on ne s'occupe pas de la productivité; même en faisant l'analyse du problème, on incline à supposer que le seul facteur qui mérite d'être remarqué et calculé est le coût du mouvement des matériaux qu'on porte des réserves à leur destination définitive.

Dans cet article il s'agit de montrer que le coût du mouvement des ouvriers, qui quiftent leur lieu de travail pour se rendre aux toilettes, aux casiers, à la cantine, aux bureaux et ainsi de suite, égale, et même dépasse souvent, celui du mouvement des matériaux. En agençant un chantier il faudrait donner priorité aux installations provisoires qu'on a actuellement l'habitude de situer n'importe où.

Introduction

Construction in general, and building in particular constitutes one of the most important activities in any economy, since it uses such a large proportion of national resources. In the U.K., for example, in 1975, it provided 7.6% of the Gross Domestic Product and 54% of the Gross Domestic Fixed Capital Formation [1].

Economically, then, it is of vital importance that carefully considered and detailed plans should be made for the most effective use of all relevant resources particularly before starting work on site when relatively cheap changes can be made on paper as opposed to later expensive alterations in already committed resour-This was particularly stressed in the Banwell ces. report [2] "...site operations have come to involve the deployment of expensive machines and labour on a very large scale so that their full and economic use has become crucial to the conduct of operations as a whole. To call in a contractor to a site on which a complicated scheme - the planning of which may have taken months or even years - is to be executed, and to expect him to be able to make himself thoroughly familiar with his task and to settle the right way in which to do it, when work must start within a few weeks or days, is unreasonable."

Longer planning periods are now more generally given and considerable prior attention is paid to the method and order of construction but it is suggested here that this attention frequently does not extend to the detailed layout of the building site, which is then left to the unguided judgement of the site management. Even when locations are fixed for major items of plant and/ or stocks of materials, little attention is paid to the economy of the relative location of facilities for site labour and staff.

This paper takes a part of the total problem of site layout and attempts to show that the often unconsidered trifles - the costs of men moving between their places of work and such facilities as toilets, locker room, canteen and offices - are likely in many cases to be at least equal to and often of a higher order than the costs of moving materials. The obvious inference is then that the emphasis in planning ought to be changed and priority in location given to those facilities which are often placed in almost any odd corner. Indications of relative importance

Stone [3] states that in U.K. just under a half of the value of building work is represented by the cost of materials and, of the balance, two thirds to three quarters is the cost of labour.

After being cheap in relation to other building costs from about 1940 to 1950, the price of labour in U.K. rose very considerably both in relation to the average price of materials and to general building costs. Roughly the same relation has been maintained since

about 1965. Clearly then labour forms an important element of total cost and needs to be used with discretion.

The situation in U.S.A. in particular is even more critical in that labour is more expensive in relation to the cost of materials than in U.K. and site as opposed to factory labour is particularly expensive.

A second indication is provided by the contrast between building and civil engineering work [4]. If the major categories of work in the two sections of the construction industry are compared, it is clear that the number of man-days per monetary unit of output (and therefore the relative importance of labour in relation to other factors of production) is much greater in building than in civil engineering work.

Within the building industry B.R.S. (now B.R.E.) surveys [5] have shown that the labour expenditure per house can in some cases be more than twice as great as in others. Also Broughton [6] has stated that unproductive time can in some instances reach as much as 12% of paid time, this high percentage applying particularly to contracts for high buildings.

Although the wide variations in efficiency and the large amounts of unproductive time which do occur are not, of themselves, indicators of the relative importance of labour in relation to materials in building, they do nevertheless show the great scope available for possible improvements in the management and utilisation of labour and, therefore, the desirability of concentrating attention in that direction. Building site layout and productivity

Obviously many factors such as the quality of the planning and programming, the degree of supervision and the motivation of the men affect the efficiency of site operations. Equally without doubt is the fact that the plant, the stocks of materials, offices and other facilities on a building site can be positioned in ways which either lead towards or detract from possible efficiency on the site.

Nevertheless, many firms, after devoting considerable attention to such techniques as critical path programming, leave the question of the layout of the site to the empirical judgement of the person in charge. Nor is that person helped in his task by most construction management textbooks which he (or students) might consult, since they tend to discuss layout almost exclusively in terms of such aspects as security rather than productivity.

Warszawski and Peer [7], on the other hand, stress the importance of site layout in its effect on total cost but base their work solely on the cost of moving supplies of materials from stocks to final positions in the building. Whilst this approach, though partial, may be valid and valuable when there is plenty of room on site and thus no competition for the best locations between stocks of materials, fixed plant and other facilities, it is perhaps less valid when there is restricted space.

Personnel movement about a site obviously becomes relatively more important as a cost with the application of successful mechanisation to the movement of materials - always assuming that the word "successful" implies the reduction of overall costs - and, in the extreme case of restricted space and advanced mechanisation being applied, it is likely that absolute priority should be given to the locations of facilities as opposed to stocks.

Theoretical example

In the following theoretical example, let us assume :-

- A single-stage job in which one pair of semidetached houses is to be built of traditional materials.
- A layout in which each store, mixing-point and facility is equi-distant (say,100 metres) from the houses to be erected.
- Materials are to be moved from the store or mixing point by fork-lift truck.
- Transport of materials
- 1. Weight

Eden and Pippard [8] have estimated the weight of materials in a pair of typical, semi-detached houses of traditional construction as about 280 tons, this being divided between the various trades as follows:-

	Ton
Bricklayer	153
Concretor	87
Plasterer	30.5
Carpenter	7.5
Roofer	6
Others	2

Some, such as hard-core, is of course, placed as nearly as possible directly in position, but, for present purposes, let us assume that all materials have to be transported from a store or mixing-point to the construction area.

2. Transport

Detailed studies of handling times on two and three storey; brick housing sites have been carried out by the British Building Research Station. Akam E.A. [9] has estimated that a 1000 Kg capacity fork lift truck has an average speed of travel of 120 metres per minute on a normal site and 95 metres per minute under difficult site conditions. He has also estimated that the maximum productive working time for such a fork-lift truck in a nominal 8-hour day is 6 hours 20 minutes. If it is further conservatively estimated that the normal load for the fork-lift truck would be $\frac{3}{4}$ ton and that the driver plus machine cost for each hour of a nominal 8-hour day would be £7, then:-

3. <u>Cost</u>_

- Cost of transport of materials may be calculated thus: a. 280 tons @ $\frac{3}{4}$ ton perload = 374 loads
- b. A 200 metre round trip on a normal site @ 120 metres per minute would take 1.67 minutes and under difficult site conditions would take 2.11 minutes. (loading, unloading and waiting times, which are the same for any distance travelled and are therefore not part of the comparison, are here ignored).
- c. $\frac{\text{£7 x 8 nominal hours}}{6.33 \text{ productive hours}} = \text{£8.84 per productive hour}$
- d. Cost per round trip = $\frac{1.67 \text{ or } 2.11}{60}$ x 8.84 =

£0.25 on a normal site or £0.31 under difficult site conditions.

 Cost of transport of 374 loads (280 tons) between store or mixing-point and construction area = £92 approximately on a normal site or £116 approximately under difficult site conditions.

<u>Human movement</u>

1. Amount

The total time required for the building of a pair of houses has been estimated [10] as in Table 1. Let us assume that:-

- a man's normal walking speed is 3 miles (4848 metres) per hour.
- b. the following journeys on foot are a necessary minimum:-
 - Each manual worker
 - walks from the locker-room to the construction area at the beginning of the day and back in the evening
 - visits the canteen three times a day for teabreaks and a meal
 - visits the site office every three days
- c. the management staff make, in total, 50 journeys from the office to the construction area during the construction period.
- 2. Cost

The total number of journeys, approximate wage costs per hour and the total wage costs of human movement on the above assumptions are shown in Table 2.

Category	Man	No. of	journeys to		& from	Total
	Dayb	Locker	Can- teen	Toilet	Office	Journ- eys
Labourer	179	179	537	179	60	955
Bricklayer	116	116	348	116	39	619
Carpenter	48	48	144	48	16	256
Plumber	15	15	45	15	5	80
Plumber's Mate	15	15	45	15	5	80
Roofer	6	6	18	6	2	32
Electrician	7	7	21	7	2	37
Electrician's	7	7	21	7	2	37
Mate						
Plasterer	56	56	168	56	19	299
Floorlayer	24	24	72	24	8	128
Painter	40	40	120	40	13	213
Scaffolder	16	16	48	16	5	85
Heating Eng.	10	10	30	10	3	53
Cleaner	4	4	12	4	1	21
Management					50	50

Table 1. Man-days and assumed number of foot journeys during building of a pair of houses.

Category	Total No. Journeys	Total Time (Hrs.)	Wage Cost per hour (£)	Total Wage Cost (£)
Labourer	955	39.6	2,88	114
Bricklayer	619	25.6	3.18	82
Carpenter	256	10.6	3,18	34
Plumber	80	3.3	3.37	11
Plumber's Mate	80	3.3	1.90	6
Roofer	32	1.3	3.18	4
Electrician	37	1.5	3,18	5
Electrician's	37	1.5	1,90	3
Mate				
Plasterer	299	12.4	3.18	39
Floorlayer	128	5.3	3,18	17
Painter	213	8.8	3.18	28
Scaffolder	85	3.5	3.18	11
Heating Eng.	53	2.2	3.18	7
Cleaner	21	.9	1.00	1
Management	50	2.1	3.00	6
TOTAL				368

Table 2 Cost of human movement between facilities and construction area.

Implications of theoretical example

The above simplified example indicates that when material movement on a building site is mechanised and when the locations of stocks, mixing points and facilities are given equal priority, the costs of human movement about the site may be three to four times as great as the costs of material movement.

Whilst the figures given may be subject to dispute, it is unlikely that the balance could be tipped in the opposite direction.

Conclusions

1. Greater attention in total ought to be given to questions of site layout since the influence of unproductive time on total cost can be much larger than is often realised.

2. As mechanisation on building sites increases, so greater relative attention ought to be paid to the location of facilities which men must visit on foot as opposed to the location of mixing points and stocks of materials.

References

1. Central Statistical Office, <u>National income and</u> expenditure 1966-76, HMSO, London, 1977.

2. Ministry of Public Building & Works. Report of the Banwell Committee, <u>The placing and Management of</u> <u>contracts for building and civil engineering work</u>, HMSO, London, 1964.

 Stone, P.A., Building Economy, 2nd Ed., Oxford 1976.
 Building & C.E. EDC's, <u>How flexible is construction</u>? <u>A study of resources and participants in the construc-</u>

tion process, HMSO, London, 1978.

5. Reiners, W.J. & Broughton H.F., <u>Productivity in</u> <u>house building</u>, second report, NBS special report no.21, HMSO, London, 1953 6. Broughton, H.F. Economic site organisation and building supervision, London, 1965.

7. Warszawski A & Peer S., Optimising the location of facilities on a building site, Operational Research Quarterly, Vol.24, 1973. pp. 35-44.

 Eden, J.F. and Pippard, S., <u>Site handling of</u> <u>materials for traditional house building</u>. The Builder, Vol. 181, No. 5674, Nov. 1951, pp. 686-691.

9. Akam, E.A., Building materials management: unit loads and fork-lift trucks, BRS Current Paper 40/71, London, 1 1971.

10. Oxley, R. & Poskitt, J. Management techniques applied to the construction industry, London 1968.
Project Management, an Experiment in Cooperation

Eigil Stang

Norwegian Building Research Institute Oslo, Norway

Summary

Project management applied to building projects has been an important topic at NBI for the last 15 years. During the first years the main attention was paid to activity scheduling systems (PERTH, CPM etc.). Gradually this developed into theoretical models and planning systems for the building process.

After some time it was realized that although this work certainly would be of importance for the understanding and future rationalization of the building process, it had very little effect on the present situation. It was then decided to try a new approach aiming at a closer relation between NBI and the building industry. The project described in this paper is a link in this approach.

Encouraged by experience from cooperation projects between NBI and contractors [1] a similar group was organized between NBI, building investors, architects and consulting engineers. The architects and engineers were representing private firms, the building investors were representing both private and municipal organizations. The aim of the group was to test and develop practical aids for the management of building projects. The testing was carried out on actual projects. The basis for the cooperation was a classification system for project management previously developed by NBI. Results from the cooperation project is presented in a report. The report also includes a project management manual.

Project Management Classification

Project management implies a number of topics. It is therefore neccessary to classify the different topics in a way which enables one to analyse a problem or a situation separately and deal with one topic or groups of topics at the time.

A classification system had been established by NBI previous to the project described here. A main task for this cooperation project therefore was to improve the classification system through experience gained by practical application on actual building projects.

The main classes of the classification system are as follows:

1. Organization

Under this topic are grouped the different ways of organizing the building process, including the different members' fields of work and responsibilities.

2. Working Prodecures

This implies procedures for correspondence, filing, writing of reports etc. And procedures for site inspections, meetings etc.

3. Time Scheduling

Under this heading are described systems for time scheduling and their application.

4. Cost Control

This implies procedures for value analysis and cost control during the building process.

5. Project Documents

This implies procedures for outlining and presentation of the brief; drawings, bills of quantities etc.

Organization of the Project

The project started in September 1976 and the final meeting of the group was in December 1979. Due to "historical" and partly casual reasons the group included:

6 building investors

- (3 representing private firms and 3 representing $\underset{\text{minicipal organizations.}}{\psi}$
- 2 architects
- 5 consulting engineers

(3 of which had specialized in project management) 1 contractor

Members of the NBI staff acted as secretaries and were also responsible for the documentation of the project. In all, six members of the NBI staff took part in the project. On the average, 2-3 NBI members were fully occupied on the project.

As compared to the groups of contractors, this group consisting of building investors, architects, consulting engineers and also a contractor was certainly less homogeneous.

Although they were all interested in further development and application of project management, it was soon realized that this was not a "neutral" topic. Naturally enough the attitudes of each member, or group of members, were closely connected to their roles as building investors, architects etc. For example, it turned out that "cost control" had a somewhat different meaning for the different groups of members. The building investors normally aimed at the lowest possible cost, whilst the architects and consultant engineers also stressed that one should pay greater attention to the quality and thus the value of the finished building. For the contractor, cost control had greatest significance in relation to his own production.

This example is a great simplification of the situation, but it illustrates that the project work was not always "straight forward".

A main idea of the project was to apply and test the NBI project management system on actual building projects. It soon appeared that only the building investors were in a position that they could utilize the complete system on their projects. 4 projects were found suitable as "test" projects. These were:

- A municipal library building
- A combined office and storehouse
- A school building
- An office building

One member of the NBI-team was responsible for the contact to each test project. The NBI-member and the project team in each building project cooperated in adjusting and applying the project management system. All the projects were fairly large. Only two of the projects were completed during the observation period.

The application of the project management system in some cases appeared to be more complicated than expected. The project teams were not always enthusiastic about the introduction of new systems which in some ways called for additional labour. Neither had the NBI members always sufficient experience to convince the teams of the significance of the system.

The most successful results were obtained in the cases where the building investor took full interest in the application of the system and convinced the project team to apply the system.

To inform about the progress in the test projects and to discuss preliminary results, the project group gathered regularly once a month. These discussions appeared to be very fruitful.

Although few of the building projects were completed during the test period, the project as a whole gave opportunities for a complete test of the management system from the start of the briefing process till the completion of the building.

To incorporate the experience from this project into the project management system the members of the group were partly reorganized during the last year of the project. 3 working groups were established. The main topics were divided between the working groups as follows:

Group 1: Organization and working procedures.

Group 2: Cost control and time scheduling.

Group 3: Project documents.

Description of the NBI Building project management system

Each main topic is divided into a number of subjects. (This is illustrated on the table "The NBI Building project management system" induded in this paper.) This subdivision facilitates a thorough analysis of each topic by dealing with one subject at the time.

For each subject the NBI members assisted by the working groups prepared separate documents describing the subject in general and also described procedures for application of the system to actual building projects.

A complete description of the system will exceed the limits set out for this paper, but as an example the different subjects under the main topic 1. Organization will be described below.

1. Organization

Under this topic is given a complete general description of the organization and managing of a building project. The organization and management system applied in any particular project may of course vary according to the size and kind of project, design and construction procedures etc. The aim of the general system is to give the investor and other participants in the project a general background and understanding of the facts that must be considered when deciding how to organize their project and subsequently choose the most suitable form.

Organization is subdivided into the following subjects:

10. Project organization and management in general. The following items are included in this subject:

- Introducing of the term "Project organization and management".

- Short description of all the subjects included in "1.0rganization" and relationships between them.

11. Organization of the project management team. The project management team is here defined as the complete team responsible for the total accomplishment of the project. The project management team may either consist of a group of persons - in smaller projects investor, architect etc., or - in larger projects - a group of sub-organizations.

Items included in this subject are:

- Application of project organization and management in the building process.
- The aim of the project organization and its suborganizations.
- Description of the sub-organizations (or members) of the project management team, their duties, responsibilities and relations to each other.
- Organization manuals for each sub-organization or member of the team.
- Selection and contracting of the sub-organizations (or members) of the team.

12. The investor's management team.

The investor's management team is here considered as a sub-organization under the project management team. The investor's management team will consist of those members of the investor's permanent organization who are engaged in the building project.

The number of persons engaged in the team will depend on the nature and size of the investor's permanent organization and the size and importance of the building project.

- The following items are described under this heading: The aims of the investor.
- The investor's duties and responsibilities in the building process.
- The different investor organizations.
- Organizing of the investor's management team.
- The investor's management team's relations to the other sub-organizations.
- 13. Organization of the predesign team.
- The predesign work is defined as:
- Definitions of user requirements.
- Documentation of the brief.
- Site selection.
- Consideration of economical limitations and evaluation of financial resources.
- Technical and architectural programming.

The predesign team may thus involve a number of persons with different backgrounds. Although the predesign work has a many-sided character it is important to consider this group as a team with a common goal.

It is also important to include members from the other sub-organizations in the predesigned team. This applies particularly to the design team.

- Items included under this subject:
- Definition of the predesign work.
- Organization of the predesign team.
- The duties and responsibilities of the predesign team.
- The predesign team's relations to the other suborganizations.
- Organization manuals for each member of the team.
- Selection and contracting of members of the predesign team.

14. Organization of the design team.

The design team includes the architect, consulting engineers and other consultants who may be enganged in the design work.

The items included here are similar to those under the previous subject:

- Definition of the work included in design phase.
- Organization of the team.
- Duties and responsibilities of the team.
- The design team's relations to the other suborganizations.
- Organization manuals for each member of the team.
- Selection and contracting of members of design team.

15. .Organization of the construction management team. The construction management team includes the contractors and others responsible for the execution of construction and installation work.

Items included under this subject:

- Definition of the construction work, i.e. the number of contractors and the responsibility of each contractor.
- The organization of the construction team.
- The construction teams realations to the other suborganizations.
- Selection and contracting of members of the team.

The other main topics of the system are similarly divided in definite subjects as shown in the appendix.

Altogether the managing system is quite extensive, but as previously stated it is meant to be a complete system from which one choses the relevant items for each project. The system also facilitates the investor at an early stage in the process to carry out a thorough analysis of how to manage his project, and thus outline a strategy for the accomplishment of the project.

To simplify the use of the system there is also produced a <u>Project management manual</u>. This manual only includes the list of items to be considered and the most important demands to be fulfilled under each item. The idea of the manual is to serve as a model for Project management manuals to be prepared for projects to be accomplished.

Experiences and results of the work

From a NBI point of view the results of project must be considered to be most valuable. We have had several opportunities of testing and further developing the management system. These tests appeared to be of vital importance to make the system operable. On the other hand the project appeared to be more demanding than originally anticipated.

It is also of vital importance for a project of this kind that the change of personnel is kept to a minimum. But with a total period of 3-4 years one must always take into consideration that some of the personnel will leave the project. To reduce problems due to change of personnel the project probably could have been divided into sub-projects each of a duration of 1-2 years.

As for the participants from outside NBI there has been no recording of opinions about the results of project. But the fact that they all paid a considerable sum to finance NBI's expenses and they also spent a number of working hours on the project without being paid, indicates that they were both interested and enthusiastic.

On the other hand the participants' engagement in the actual application and development of the management system have been variable. The most active participants accepted that the "trial and error" process often is unavoidable in project of this nature, whilst others have preferred to adopt a waiting attitude. At NEI we feel that the most active members of the group did get the best value out of their contribution.

NBI BUILDING PROJECT MANAGEMENT SYSTEM

0 GENERAL	1 ORGANIZATION	2 WORKING PROCEDURES	3 TIME SCHEDULING	4 COST CONTROL	5 PROJECT DOCUMENTS
00 The project in general	10 Organization and management in general	20 Working procedures in general	30 Time scheduling systems in general	40 Cost control and value analysis in general	50 Project documents in general
01 Introduction of the manage- ment system	11 Organization of the project management team	21 Procedures for correspondence, reports etc.	31 The main phases of the building process	41 Cost coding	51 Programming and documentation of the brief
02 Project classification	12 Organization of the owners' management team	22 Procedures for site inspections and meetings	32 Time scheduling in the design phase	42 Appraisal and estimating	52 Drawings
03	13 Organization of the predesign team	23 Filing	33 Time scheduling in the construc- tion phase	43 Budgetting and accounting	53 Specifications and bills of quantities
04	14 Organization of the design team	24	34	44 Cost control in the construction phase	54
05	15 Organization of the construction management team	25	35	45 Financing and cost forecasting	55
UE	16	26	36	46 Insurance and security	56
07 Project evaluation	17	27 Project management handbook	37	47 Value control	57
08	18	28	38	48	58
09	19	29	39	49	59

Education for building development in third world countries

Gilbert Turner MSc FRICS FCIArb FIQS

University of Manchester Institute of Science and Technology, Manchester M60 lQD, United Kingdom

Introduction

Post development studies show that some 50 percent of the fixed assets accreted by development arise from building construction activity. In consequence any nation to whom economic progress is vital, ought perhaps to review the question of its domestic education for building development and consider treating it as a special case.

This is not to argue that the need for building education has been neglected: far from it. Almost all third world countries have made a great effort to send students overseas; most have set-up or expanded craft training schools. Further, World Bank support exists as do aid schemes by the developed countries; that of our host country, for example, who supplied Norwegian building supervisors and training officers to the Kenya National Construction Company.

However it is possible to argue about the orientation of the general education policies in the light of their effect upon national development. A World Bank study concerned with the promotion of construction industries (1) found inappropriate education to be a major factor in accounting for the lack of productivity displayed. The investigation stressed the fact that virtually all the skills and knowledge, considered to be effective by the researchers, had been acquired on-the-job in employment. Thus the study indirectly indicts the educational systems selected by the countries observed.

Conceptual analysis

Needs and supply of personnel in Building

The creation of a balance between supply and demand is so axiomatic an aim in general education policy that the particular requirements of a sector such as Building can be bypassed in conceptual planning. Demand can be inarticulate in the developing countries and therefore a better picture is given when the practice needs of personnel are juxtaposed with the means of supply.

Needs and Supply differ in sense. Components of need have a lateral relationship one with another:-

Technical \gtrsim Professional \gtrsim Business This is because the skills and knowledge necessary to practice in any one area consummately, demand more than a mere acquaintance of affairs in the remaining areas. Supply, in contrast, is sensed vertically by educationalists:-

Graduates from the universities and polytechnics of the developed world Graduates of domestic tertiary education Products of trade or craft schools

Recipients of training within industry.

N.B. This classification is neither exclusive nor is it a claimed hierarchy of 'quality', it is merely an illustration of argument.

Systems and Legacy

It is perhaps improper to reference the educational system (3rd paragraph) as been selected by the countries observed, for doubtless the 'system' has merely grown over time in an ad hoc manner. Yet the reasons for such development are worth speculation, two in particular. First the views of traditionally-minded educationalists who advise governments. They are naturally inclined to recommend policies which lead to goals of academic excellence rather than to those considered to be inferior by their own selected rationale. Apropos to this view, we need to keep in mind the fact that widespread education for business and the professions, other than medicine and the law, has only quite recently become formalized in many developed coutries. Second, the less developed countries have a history of expatriate building contractors whose influence has a legacy. The excuse habitually offered by them to a designer for poor standards of construction or for delays was the shortage of skilled craftsmen.

Perspective

The last reasons, although debatable, do go a long way to explain the educational conditions which inadequately serve the construction industries of most developing countries. At least these ambient conditions do deserve to be set besides the analysis of Hirschman and others - (2) that:

- "amongst the proximate causes of development, the need for entrepreneurial and managerial talent now occupies a position of pre-eminence equal to that of capital."

(Incidently the lack of appropriately trained talent is also an explanation for the poor performance of Building relative to other sectors of the economy in several developed countries - notably the UK.)

It seems necessary to draw these parallels since the deliberate policy of several ex-British Colonies, for example, was - at least initially - to create imitations of UK educational institutions; a policy which conveys a most uneasy meld of advantage and disadvantage. An alternative route to future policy can be projected from the analysis offered in the UIA Seminar on Human Habitat (3) which classified three phases of national development:-

- ONE POPULATION AND URBAN EXPLOSION ... the result of improved health conditions without correspondence of birth control practice. The situation in the 'developing countries' where life expectancy, at birth, has risen sharply; where medical improvements support initial life expectancy and the numbers of children born annually threatens to become unmanageable (by hitherto orthodox measures).
- TWO POPULATION RESTABILISATION AND CONTROLLABLE URBAN DEVELOPMENT ... a situation apparent in the 'developed countries', but only after the number of children born annually has settled to a comparatively slight annual increase ... a period of about 70 years spans the extreme perceived conditions of population explosion and population control.
- THREE .. POST-DEVELOPMENT ... population growth has ceased ... urbanization is finished ... the future for the developed countries.

Sweden is already there - as Giertz puts it (4). Giertz continued, Sweden has no more need for mass urban housing and the related economic thinking "the problems of maintenance, remodelling and reruralization are in; the problems of urban growth are out". That which holds utterly for the THIRD PHASE holds partially for the SECOND PHASE its precursor.

The examples and the direction ambient in SECOND PHASE education exhibit a concern with the re-deployment of industry and commerce rather than with its FIRST PHASE inauguration: with re-housing a comparatively well-paid labour force than with creating the 'human capital' (5) adequately housed to foster economic growth. Yet perversely educational institutions of the third world continue to be modelled upon those of a foreign world which is transiting from the SECOND to the THIRD PHASE of development.

The data used as the basis for past decisions has been presented in a biased though accidental manner: one which has ignored the self-evident needs of a developing country and instead preyed upon human weakness. Since no matter how un-developed any particular developing country may be it must not be thought to be backward by its contempories; in consequence the 'show-piece' catering for a small minority has become a fashion in education, as it has in low-cost housing and public health affairs (6).

Discussion: craft training for Building

All change provokes further change and in the late 20th Century the microprocessor quickens the pace. Every European is familiar with the old technical colleges that grew from the trade guilds of the 19th Century, or so, and the grand old days of craft workmanship. Although Europe, by <u>force majure</u>, had to traverse such course; ought it - should it - have to be repeated by each third world country <u>de jure</u>? In the 'times of technology' that have reduced an old and time-acquired trade skill like lead plumbing, for example, to a do-ityourself plastic pipe-fitting exercise; is circa early 20th Century trade school the optimum outlet for a scarce financial resource to aid the economic development of building crafts in third world countries?

Even in a European context, if the fundamental purpose of the old technical colleges was to improve the quality of particular crafts, then arguably they failed: for only the poorest quality students went on to pursue the craft - in the main. Students passing with better grades themselves became craft teachers, or building inspectors, or clerks-of-works, or foremen passing into the line management of construction firms. All undeniably worthwhile pursuits but no short-cut to the objective of improving craft skills.

Today training-within-industry appears to be the most acceptable solution to learning more about site operations in developing countries. Doubtless it can be effectively supplemented by other means but the appropriate accent is supplementation and not a situation where the tail attempts to wag the dog. The comment of the World Bank researchers deserves endorsement, they "found little evidence to suggest that technical education was making anything other than a marginal contribution either to equip the student for a job in a chosen field or to meet the contractor's needs in trying to find suitable employees." (7)

Trades school products are largely absorbed by the "formal sector" of statistically enumerated large business and government employment and not by the "informal sector" of economic activity which will comprise mofe than half the total in non-monetary or semi-monetary society (8). Were it to be measured (and conventional national product accounting is unable) it is likely that informal sector building activity would represent some 60 to 70 percent of capital formation, each year, in the rural and semi-urban areas of the third world.

It follows that an investment in teaching a sub-craft level of low technology, shunting the agency of literacy and placing a reliance on the media of film, television and example would interest the people and improve the standard of self-help projects. Self-help economises fixed capital at least. More, it is usually the only hope for development in rural areas too remote or marginal to attract the interest of formal sector investment. Yet all investment contributes to the development of a nation, whether it be measured or not, after all how did the now developed countries start upon their paths to progress?

Discussion: tertiary education for Building

In the context of third world economic development the prime expectation of the polytechnics and universities

is the supply and maintenance of technico-economic managerial talent to fuel FIRST PHASE DEVELOPMENT. Clearly this expectation has not been met, a shortfall exists in both quantity and quality. Many reasons may be advanced to excuse the situation, none of which are mutually satisfactory to all viewpoints: most are quite unfair to the dedicated personnel who cope as best they may and all are underlaid with the bogey (or saving clause) of inadequate finance. Moreover the expectation mentioned is one which would seem unusual and ancillary to the commonly expressed aims and objectives of educational institutions.

Building education varies in form and content over the developed world. In the United States it was strongly associated with civil engineering, but today the links are weaker as the mentor relationship becomes less apt. In Europe the divisions between architecture and structural or building engineering have never had the fine distinctions that are drawn in Britain. And in Britain generally, Building has only shared the university system within the last two decades. In consequence Building may still suffer the remains of an obsession about its validity as a suitable course of study at a university level (9).

In fact the theories about what might, or indeed ought, to constitute the discipline are themselves still in the process of experiment, development and verification. Two sets of views often seem to conflict: they may be termed 'the integration approach' and 'the engineering science approach', each having strong advocates for reasons of equal strength.

To illustrate, in the UK some attempts have been made to bring the preparation of students closer to what the industry will demand from them. The Noel-Hall Committee on training in the Building Industry was the first to advocate joint education for architects, quantity surveyors, structural and services engineers (10) and emphasised the worth of an integrated approach to subject material. Yet it has been found to be difficult to break the traditional habits of education and training and only too easy to reinforce them by reiteration of yesterday's principles.

To continue the illustration, by convention university departments concerned with the purer aspects of knowledge like those of physics and chemistry for example, tend to regard the translation of knowledge into skills of application as somewhat impure and therefore non-academic (11). It being their belief that the place of the less-academic 'vocational exercise' occurs in practical employment. Moreover the time constraint of three year courses endorses the belief.

This influence is important - and it has particular relevance for the graduate who will return to a country in a very early stage of development - simply because it has been pragmatic for some departments of engineering and building to borrow such rationale rather than create one of their own. Adoption of the rationale is justified when the national demands of a country transiting from the second to the third phase of development can accommodate a diverse range of qualities in the graduate population.

This view arose as a part of the natural swing from the notion of craft-based building education to one of science-based building and, it would seem, the nature of the swing was not well understood when first perceived: for as Finniston demonstrates (12) there cannot be an industrial problem, separated from the engineering problem, divorced from economic problems and ignoring social problems; instead there is but a single problem. Unfortunately, it is in the nature of swings that they will tend to be polar. The general impetus of the swing was such that the economic and managerial influence of the professions was obscured. In terms of economic analysis, Building is a producer of both capital goods for investment and consumer durables, it is also a service industry and the contribution of the professions always dominate the centre of building affairs.

The effect of national economic issues upon building education ought to be influencial notwithstanding the particular phase of development any country may occupy. Happily, the earlier conclusion about the swing is now being overtaken by the gradual realization that the practice of building, as distinct from its science, is EQUALLY BASED IN TECHNOLOGICAL AND ENTREPRENEURIAL SKILLS.

Each skill deserves the same degree of emphasis in academic development if the aims of students and the needs of industry are to be met. Moreover an integrated understanding is required and indicated. One consequence of the separate and unequal treatment of science and management, technology and economics is the very lack of a clear identity and background to characterize the building graduate in the way that other graduates have become characterized.

Although characterization is properly seen to follow the maturity of a discipline, it is really a part of the same problem in my view. Building can hardly become a mature and fully respectable university discipline until it becomes able to well define its own approaches to its own constituent knowledge. Further, the approaches have to be recognized as valid alternative routes to insight by the parent disciplines that are already involved. This is no simple task: since the perceived parentage is wide, the well established disciplines of architecture, accountancy, economics, estate management, engineering (civil, electrical and mechanical), law, management science, materials science and quantity surveying all have relevance to what may be asked from tomorrow's builder and today's building graduate.

However the task is no longer impossible; neither in terms of programming a suitable course structure, nor of assembling research-derived lecture material although it remains arduous. The essential clues are equality of technological and entrepreneurial content and the aim of creating a central core of expertise to characterize and motivate the building graduate. The problems are one of judgement about the priority, scale and order of constituent knowledge.

In this connection one of the many differencies between the developed and the underdeveloped countries is inordinant. The developed countries possess an extensive infrastructure to deal with the multiramified aspects of building activity and its regulation for the public good. In consequence it is hardly of national importance if a particular building course in a developed land over-concentrates upon the scientific and mathematical aspects of construction and neglects to inculcate appreciation of the very factors which motivate and control construction. Yet this balanced understanding is essential for a developing country if it is ever to gain an ethical domestic infrastructure for the planning and construction of building development.

Whilst the judgement implicit in the differentiation between the acquisition of knowledge and the acquisition of skills - that the second be inferior to the first in academic terms - holds for disciplines like physics and chemistry that are utterly based in research-derived science: the judgement becomes wholly less apposite when applied to a rather practical field of activity like building. How can it be so? Building although ancient, is a long way distant from being a 'hard-centred science'. It is an industry, a technology and also a social system since shelter is one of the three basic needs of man.

Moreover the basic knowledge of Building has grown in a heuristic manner over the course of civilization, becoming confirmed or otherwise by empirical means over the ages. The data base is far from complete and is but recently starting to receive the aid inputs of appropriate science. It is quite conceivable that the difficulty of formalizing Building as a unique disciplined study lies less with academic issues and more with general knowledge or common sense: for precisely because the noun-verb - builder-building - spans a range of connotations, we do have problems with defining the centres and peripheries of our concern to people other than those who possess a wide appreciation of building activities in practice. Students traverse a motivation crisis that may be prolonged.

In contrast one cannot help but be struck by the lesson contained within the architectural discipline. Study of the interaction of aesthetics with ergonomics leave the former architectural student with a cultural and ethical background to his or her daily work that lasts a lifetime. Since this background can be acquired anywhere in the world, one is inclined to suspect that background is more a product of maturity in the discipline and less one of the aims, objectives and programming details included in any particular course of study. A suspicion accompanied by regret that building has yet to gain equal maturity and its students have yet to enjoy the benefit of a characteristic identity and associated background.

Indeed real dangers have been presented to students who have pursued an over-preoccupation with their personal selection from the disparate range of subjects that have constituted some past courses in building: for such unstructured selections have failed to equip graduates properly to enter identifiable careers in either the design or construction aspects of the building industry, where the absence of formal skills in their make-up has inhibited their promotion prospects. It is necessary to distinguish the components of technico-economic managerial talent on one hand, and on the other those components, that at best, will only produce a superior grade of technician to service architecture, structural engineering or materials science.

One final point, a value-judgement is often drawn about the successful inauguration of building courses being dependent upon an extensive capital investment in a variety of laboratories and the associated heavy equipment. Whilst the judgement holds undeniably for a building science course, it does not follow as an absolute necessity for a course concered more with the broad, though detailed, general knowledge about building germane to those countries that yet lack a developed building infrastructure. In fact the replacement of much time-intensive and repetitious laboratory work by the agency of field-studies, laboratory camps, selected film and possibly purpose-made film etc., would help to overcome the very timetable limitations that can serve to prevent a student from gaining a useful insight about the technological and entrepreneurial factors of building.

Conclusions

- There is a need for clear policies about education for building in the developing countries. CIB is in a position to make worthwhile recommendations. The only suitable policies are those which concentrate attention upon the problems of FIRST PHASE DEVELOPMENT.
- 2. The distinction drawn between the phases of development, and the related patterns of education, suggest that the usual courses offered by the typical educational institutions of the developed world, are not the ideal means to produce the technico-economic managerial talent desperately needed for third world development.
- Research to identify the scope and content of FIRST PHASE Building Education is overdue.
- 4. The notion of a sub-craft level of low technology, taught without the agency of literacy, is a challenge with which the governments of developing countries

ought to be faced. Again CIB is in a position to help.

- 5. Building practice is a technology rather than a science. All technologies are more than applied science alone: for technology involves mastery of the controlled repetition of phenomena, time and time again in an increasingly economic manner. Therefore the integration of technological and entrepreneurial skills has to become an axiom of effective building practice and education has to reflect that axiom.
- 6. It is unfortunate that much to do with low-cost economic development is still seen by elements of the university world to hardly constitute 'advanced work'. At best in the late twentieth century this attitude is incondite, at worst ..., for ripe areas that need local study in almost all less developed countries are:
 - advanced labour-intensive technologies;
 - advanced usage of local, and perhaps unconventional, building materials;
 - advanced alternative financing and contractual arrangements;
 - advanced design of building codes and regulations that will permit and encourage the above and other developments, and remove the sores and morés borrowed from Second Phase Development.

References

- (1&7) International Bank for Reconstruction and Development, Bank Staff Working Paper No 168. "A FRAMEWORK FOR THE PROMOTION OF CONSTRUCTION INDUSTRIES IN THE DEVELOPING COUNTRIES", 1973.
- (2) Hirschman, A.O., "THE STRATEGY OF ECONOMIC DEVELOP-MENT", 1958.
- (3) UIA Seminar on Human Habitat, Bucharest 1971, "Architectura", 1971.
- (4) Giertz, L.M., "AN INTRODUCTION TO THE PROBLEMS FACED IN EARLY DEVELOPMENT", CIB Symposium -Assessing the Economics of Building - Dublin 1974.
- (5) International Labour Office. "EMPLOYMENT, INCOMES AND EQUALITY: A STRATEGY FOR INCREASING PRODUCTIVE EMPLOYMENT IN KENYA." Geneva 1972.
- (6) IAHS Conference, HOUSING Planning, Financing, Construction; Turner, G. "LOW-COST HOUSING IN DEVELOPING COUNTRIES: PUBLIC HEALTH ISSUES WHICH NEED TO EFFECT THE COST-LIMITS OF MASS PROGRAMMES" Miami Beach 1978.
- (8) Elkan, W., "DEVELOPMENT ECONOMICS" 2. ed. Middlesex 1976.
- (9) Sidwell, N.C., "UNIVERSITY GRADUATES FOR BUILDING" Building Technology and Management, March 1966.
- (10) Joint report: RIBA ISE IOB RICS Joint Committee on Training in the Building Industry - Chairman Sir Noel Hall. Nov. 1964.
- (11) Ling, A. "JOINT TRAINING FOR PROFESSIONAL COLLAB-ORATION IN THE BUILDING INDUSTRY". The Structural Engineer, Aug. 1965.
- (12) Report of the Committee of Inquiry into the Engineering Profession. "ENGINEERING OUR FUTURE" Jan. 1980, H.M.S.O.

Organization of Construction Company

Abraham Warszawski

Associate Professor

Faculty of Civil Engineering

Technion, Israel Institute of Technology Haifa, Israel

Summary

The paper describes the procedure, findings and conclusions of an organization survey conducted in a large construction company.

First the existing organization structure of the company was examined, through interviews of the key managerial personnel and analysis of written records and procedures. In the course of the interviews the objectives of the company were formally defined.

Then the existing setup was analyzed in view of the defined objectives and the ambient market conditions, and alternatives were formulated and examined.

Finally a recommended alternative setup was presented and its advantages were explained.

1. Introduction

Effective organization is essential for efficient operation of a company, and attainment of its objectives. Organizing, as a managerial function is dealt with extensively in many textbooks, e.g. [1], [4], [5], [6], etc. Specific reference to organization of construction companies may be found in [2], [3], among others.

The paper describes the methodology, findings and recommendations of a management survey, conducted by the authors in Solel Boneh Co., one of the largest construction companies of its kind with a staff of over 20,000 workers, engineers and clerical and managerial personnel, not counting a large body of subcontractors. The company comprised, at that time, seven divisions, each of them specializing in a distinctive field of operations. Four divisions engaged in domestic and international contracting, and the other in production of building components and related services.

The purpose of the survey was to evaluate the company overall efficiency. It was conducted in two stages. The first stage was devoted to a search for problematic areas in the company, with a view to tentative recommendations and suggestions for the second and main stage (see below). It consisted in analysis of background information supplied by the Board of Directors, and in interviews with key personnel - division managers, heads of the company's staff departments, and members of the Board. The interviews lasted 3-6 hours each, and interviewees were requested to describe their activities. point out problems as they saw them, and refer to several specific topics raised on the strength of the background material and preceding interviews. The findings and recommendations centered mainly on the following items:

- Formal definition of the company's objectives.
- Formal procedures for long-range planning.
- Relations between line and staff personnel at the top management level.
- Organization of the contracting activity in the company.

The last-named item was taken up as the subject of the second stage, which involved mainly the Building and Public Works Division and various functions in other divisions connected with contracting work. The analysis of organization in this stage was to answer the following questions:

- are the company objectives which the organization structure is to serve, clearly defined?
- are all the activities necessary for attainment of the objectives performed?
- is there no duplicity in performance of these activities?
- is the departmentation (along functional, territorial or operation lines) within the company efficient, in view of the nature of its operations and the market it is to serve?
- is the management span of control on the various levels within the organization not excessive?
- is the authority and responsibility of the various units clearly defined?
- is the degree of centralization (or decentralization) within the company appropriate considering the nature of its operations, and the personality of the officers?
- is the formal and informal organization within the company compatible?
- are the human and material resources within the company efficiently employed?

A survey conducted for this purpose consisted in extensive study of operating procedures and reports at the main divisions and at related departments of other divisions, and in further interviews (based on a list of questions submitted in advance) with 40 line-and staff officers. Supplementary material was provided on specific points of interest.

The main findings and recommendations of this stage are presented in subsequent paragraphs. The recommendations were accepted by the Board of Directors and its management and were later implemented with some modifications.

2. Objectives

It was the opinion of the authors that proper evaluation of the organizational structure is impossible without a formal definition of the company's objectives, and of the operational policies involved in realizing each of them. This was done on the basis of extensive discussions with the management. The company's objectives, stated in general terms, fall into five groups as follows:

(i) Operations

The most important field of the company's activity is building and civil engineering construction. The relevant policies outlined, concern the interaction of the contracting divisions and other functions in the company, development priorities, and premises for long-range planning.

(ii) Standing in national economy

The company is to maintain its pre-eminence in the Israeli building sector. The relevant policies concern the scope of operations, research and development, the nature of preferred projects, independence in supply of products and services for contracting operations, and finally exploitation, in the market, of the leverage attained through the coordinated efforts of the divisions. Profitability

(iii) Profitability

The company is to conduct its operations in the best economic interests of the owners. The relevant policies concern measures of profitability economies of scale, optimization of the labor force, and inventories incentives, marketing of products and materials, and market studies for new areas of activity.

(iv) Public responsibility

The company is to provide the best possible service to clients and to conduct all its operations with due consideration for public interests. The relevant policies concern client relations, product quality, environmental quality, and the public image of the company.

(v) Employee relations

The company is to provide attractive working conditions, fair wages, and ample opportunities for advancement. The relevant policies concern compensation and benefit schemes, esprit de corps, encouragement of employee initiative, and programs for training and education.

It was realized that while certain objectives lead to similar conclusions, others (economic and social) may be sometimes incompatible, in which case compromises are called for.

It was also recommended that specific periodic quantitative targets will be set for each objective. 3. Present set-up

Under the existing set-up (see Fig. 1), the company comprised 7 divisions specializing in the following operations:

- Building Division building construction.
- Public Works Division roads, excavation work, and other civil engineering projects.
- International Division construction operations abroad.
- Systems Division sanitary installations, HVAC systems, elevators.
- Plants Division production of building materials, intracompany transportation services.
- Quarries Division quarrying of concrete aggregates and marble.
- Housing Division development and marketing of housing projects.

Almost all contracting activity was concentrated at the Building, Public Works and International divisions.



Figure 1 - Present Organization Structure of the Company

The Building division employed 2/3 of the company's labor force and accounted for about 60% of all domestic operations (including all construction work for the Housing Division); it consumed half the output of three other domestic divisions - Systems, Plants and Quarrying. Its field activity was conducted by 17 branches throughout the country. The branches were largely autonomous with regard to client relations and work planning (smaller branches receive considerable engineering assistance from the divisional engineering departments), but financial control, as well as hiring and promotion of professional and managerial personnel, are in the hands of company headquarters. Orders were placed directly by local clients, or alternatively through headquarters. Larger branches operated readymix concrete plants, prefabrication plants and other production facilities.

The <u>Public Works Division</u> accounted for about 15% of all domestic operations; it comprised 5 branches (with road and earthmoving equipment, readymix concrete and asphalt plants) whose status vis-a-vis the Division was much the same as above. The company president had under him three staff departments, whose heads acted as advisers to him in the areas of their activity, and as coordinators of respective staff functions in the divisions:

- The Department of Organization and Personnel, responsible for organization procedures and employee relations (including unions).
- The <u>Department of Finance</u>, responsible for financial control and accounting procedures within the company.
- The <u>Department of Planning and Economy</u>, responsible for budgeting, investments analysis, operation of the company's computer system, and dissemination of statistical data.

The advantages of the existing set-up, based on distinctive specialization, were:

- Separation of the contracting and industrial division - justified by the different nature of their operations.
- (ii) Separation of the different types of contracting which makes for better professional specialization in the divisions. The survey revealed that this advantage was more important at the operational (i.e. branch) level than at division level, where a comprehensive approach to construction and contracting - as well as managerial ability and character seemed to be more essential.
- (iii) Concentration of the best available professional talent in the divisional engineering departments, from which it can control the technical aspects of activity in the branches. The survey revealed however, that in practice - except for extralarge or complicated projects - advice is only effective to the extent that a branch actively seeked it, or at least was willing to accept it.

- (iv) Effective coordination of equipment and manpower transfer between branches. This was, however, often hampered by work agreements or union practices.
- Its disadvantages, on the other hand, were:
- (i) <u>Asymmetry</u>. About 70% of all domestic activity was concentrated at the Building Division (including the services rendered to it by other Divisions), which thus necessarily claimed most of the attention of the company's president and his personal staff, with the following undesirable implications:
 - If, in the absence of an appropriate staff functions for planning and control of building activities, the president were to rely exclusively on the head of the division for information and advice regarding current operations and future planning, then the success of the company will depend mostly on the judgement and qualifications of the latter who would inevitably become the key personality in the company, to the detriment of the president's authority.
 - Were the president to create such a staff function, the results would be duplication of staff activities (at the company and division levels), with the attendant waste of resources and inevitable conflicts between opposite numbers.
 - Were the president to resort directly to the services of the staff of the Building Division, it would, in the long run, prove unacceptable to the head of the division.
- (ii) <u>An overextended span of control in the Building</u> <u>Division</u>, (17 branches, 4 building equipment units, and a large industry of readymix concrete and prefabricated elements) considering the complexity and dynamics of the building operations (not to mention the internal asymmetry due to differences in hierarchical standing between units).
- (iii) Growing mutual estrangement between divisions. This trend was particularly evident in the relations of the two contracting divisions, and the corresponding units in others: in fact, there was a tendency in the branches to prefer outside subcontractors and suppliers, since it was felt that their greater dependence on the branch ensured better service. In large projects which required participation of both contracting divisions on equal terms, there were considerable managerial difficulties due to lack of a common local authority; in many cases of disagreement, each party was backed by its respective division headquarters, and the differences have to be referred to the president. Another consequence of this situation was emergence of parallel services

and industries in the divisions: thus, three divisions ran their own mix plants, two - asphalt plants, two - quarries; moreover, each of the contracting divisions began in time to undertake work which, by terms of reference should have been subcontracted to the other.

- (iv) <u>Considerable duplication in staff functions at</u> the Building and Public Works Divisions in the areas of personnel, finance, purchasing, inventory control and many aspects of the engineering work.
- (v) Emphasis on expansion of the scope of operations, which was more important in many cases to specializing divisions than efficiency and profitability. It seemed that, if a division was engaged in more heterogeneous activities in the same market, there might have been stronger pressure for efficiency by expanding the more profitable operations at the cost of the less profitable ones. Usually, the higher the level of comparison with other specializations, the lower the pressure for profitability at the operational level.
- (vi) Lack of regular sharing of information and <u>experience</u> (due to lack of an appropriate staff function at company headquarters) between the International Division and the two domestic contracting divisions, even though they engaged in the same type of operations.
- 4. Recommended alternative set-up
- (i) Large territorial units with broader autonomy. Since in construction (unlike other industries) production, marketing and utilization of the product take place in the same locality, stronger

emphasis is called for on the relationship with local factors, with more sensitivity to their needs and more authority to respond to them.

- (ii) <u>Integrated contracting activity within a terri-</u> <u>torial unit</u>, with a view to close cooperation between the different field units, avoidance of duplication, and improved exploitation of resources.
- (iii) <u>Improved local staff services to the field units</u>, through territorial concentration and application to specific problems.
- (iv) <u>Closer control by the company over contracting</u> <u>operations</u>, through effective implementation of staff functions plus economies of scale.

Accordingly, in the selected alternative (see Fig. 2) all major contracting activities were grouped in 3-4 domestic territorial divisions, plus the international one. The professional set-up was to be maintained at the operational (i.e. branch) level, where it was deemed most important. Engineering supervision was to be centralized as a divisional staff function, with emphasis on compilation and dissemination of information and on technical assistance in solving specific problems.

There were thus to be 7-8 divisions of approximately the same size, with immediate control over 4-5 foci of contracting activity. For this purpose, two additional staff departments were to be created at company level engineering, and equipment and inventory. With the aid of these departments the company was to be able to regulate resources, engage in research and development, formulate engineering procedures, assist in solution of special problems for the contracting divisions, and





Figure 3 - Organization Structure of a Territorial Division

coordinate production of materials at the industrial divisions.

It was assumed that a territorial division will be able to develop direct and more effective relationship with local clients and with local agents of national clients. It could also use more effectively the local labor, suppliers and subcontractors.

The staff functions carried out at the time of the survey by the branches were also to be centralized at division level, so as to relieve the field units of most of their administrative work and assist them in all problems of personnel, finances and engineering. It was also recommended that all divisional plants and equipment be placed under the direct authority of divisional headquarters.

After a careful investigation of the various services rendered to contracting by other divisions, it was recommended that, since almost all transportation was used at present for contracting, it was to be transferred from the Plants Division to the new territorial divisions. Conclusions

Proper organization structure is essential for effective operation of a company and attainment of its objectives.

A managerial survey of the organization may illuminate problem areas, exploit them and offer useful solutions. Such survey should examine company's objectives, the activities performed for their attainment, departmentation, management span of control, authority and responsibility of the departments, and the efficiency of human and criterial resources utilization. <u>Bibliography</u>

- Albers, H.H., "Principles of organization and Management", John Wiley & Sons, New York, 1965.
- Deatherage, G.E., "Construction Company Organization and Management", McGraw Hill, New York, 1964.
- Dressel, G., "Organization and Management of a Construction Company", Maclaren, London, 1968.
- . Hall, R.H., "Organizations Structure and Process", Prentice Hall, Englewood Cliffs, 1972.
- . Koontz, H., and O'Donnell, C., "Principles of Management", McGraw Hill, New York, 1959.
- . Litterer, J.A., "The Analysis of Organizations", John Wiley & Sons, New York, 1973.

The advanced use of Norwegian National Building and Civil Engineering specifications in project management

Janusz Ziolko, graduate engineer, consulting engineer, project management, MNIF, MRIF, Norway.

Norwegian national building and civil engineering specification - NS 3420, has been edited by Norwegian Standardizing Authorities - NBR and NSF in 1976.

This work consists of two parts. The first one comprises the general rules of specification of works, giving i.a. very precise rules concerning the requirements to exactitude of works corresponding to tolerance classes.

The second part is a library of standard items describing activity types within all the main groups of works. The book consists of about 33.000 items, partly in form of matrixes. Each item is bearing a code.

All items from the second part of NS 3420 have been transfered to a computer readable medium.

This item library is accessible by means of an advanced on-line computer system, and can be entered into all types of documents necessary for management of building and civil engineering projects.

specifications	cost control
bills of quantities	time schedules
bid documents	"as built" documents

The main advantages by use of the method are as follows:

- it creates a database for the project, which can be kept up-to-date during the whole "life" of the project.
- it gives the opportunity to select the information which is requested on a given stage of the project (bid, contract, site control, site settling of accounts).
- it removes expensive, time consuming and frustrating routines of selecting and copying information from document to document.

Once an information has been recorded, it is available for all partners of the project team, in a completely new way.

The owner (investor), contractor, architect, quantity surveyor, each of them has the opportunity to select the required information and present it in a form which is suitable for the given purpose.

 it accumulates project data on a common structure, established by the NS 3420. This fact opens quite new perspectives for different types of analysis concerning use of materials, execution methods, prices etc.

On a national base the method provides for collecting data for Central Bureau of Statistics, which will be able to present more reliable data. This will facilitate the taking of decisions for the authorities as well as for the building branch.

cost estimates maintenance programmes

NS 3420 codes are the main information carrier within all documents and represents an important co-ordinating factor for the whole Norwegian building industry.

The following illustration gives an idea how the method is applied in the establishing of specifications and take-off.



The advanced use of Norwegian National Building and Civil Engineering specifications in project management

Synopsis

The paper comments on the new Norwegian National Building and Civil Engineering specification Standard - NS 3420, of about 33.000 items - which has been made accessible by means of an advanced on-line computer system and thus may be applied in general project management routines.

L'utilisation avancée du nouvel standard norvégien national des specifications pour des batiments.

Synopsis

Il est commenté sur le nouveau standard norvégien national des specifications pour des batiments - NS 3420 - comprenant environ 33 000 textes, qui maintenant sont accesible par un systeme "on-line" avancé d'ordinateur, et qui peuvent etre utilisés directement dans des routines d'administration des projets.

.

General papers.

Documents généraux

An air supported pneumatic structure with a heat protection screen

Petrovnin M.I., Cand.of Sc.(Eng.) Andrienko E.G., Dipl.Eng.

CNIISK, Gosstroy USSR, Moscow, USSR

Summary. Some structural features of a pneumatic building with heat protection screen, some problems of its installation and the efficiency of its use in some regions with a hot and cold climate are considered in the paper.

<u>Resume</u>. Les auteurs présentent la solution constructive d'une structure gonflabe à écran calorifuge ainsi que sa mise en ceuvre et discutent l'efficacité de son utilisation dans les zones à climat chaud et froid.

Air supported pneumatic constructions have a number of structural features in comparison with traditional building structures; the design peculiarities markedly effect the forming of heat conditions in the premises. These features should include low thickness and ray transparency of the fabric produced enclosures, floor mass, complex geometric contours of the guarding constructions and necessity to support excessive air pressure in the inner volume.

Fabric shell of small thickness provides actually inertialles passing of heat perturbances from outer climatic influences and inner heat evolution sources, sharp daily variations in the temperature of guarding constructions at temperature difference with room air. Discomfort of heat conditions in most premises as well as high performance costs of fuel and electrical energy are determined by this fact. The above mentioned disadvantages are the limiting factors for wider application of the air supported pneumatic constructions in the national economy of the country.

Workers of the Laboratory for pneumatic constructions of the CNIISK have developed a new design solution for a pneumatic air supported construction which can be successfully used actually in any climatic zones meeting the sanitary-hygienic requirements to the buildings of different functional distantion. Combination of the protective shell and selfcarrying fabric cover (heat screen as the authors have called it)³⁴ is the base principle of the building arrangement intended for improvement of the heat protective qualities of the guarding constructions.

One-layer fabric-film warmer is produced from the light and cheap material (metallized film, rubber coated fabric with aluminized cover of 80-120 g/m² mass) capable to guard against heat radiation. The heat screen is suspended to force shell. The heat screen position in the useful volume of the construction may be changed for the reasons, including, for example, acoustic tasks and getting definite heat engineering effect by means of specially adjustable flexible bonds. The screen edge is fixed along the anchor contour and has regulated holes used for automatic levelling of the excessive pressure in the intershell space and in the useful construction volume.

The carried out experiments have shown that similar arrangement of the construction permits to decrease significantly the fuel consumption for heating, to increase comfort and to ensure the inner conditions. A system of regulated ropes without any difficulties easily and quickly permits to mount and dismount the heat screen for the constructions with up to 36 m span.

Proceeding from these ideas a standard pneumatic construction with BNC-A-24N3 designation calculated for mass production was developed and put into practice.

Dimensions of the construction provided with heat screen are the following: 24x48x9 m (span x length x height, m). The set of the construction includes inlet and transport locks with emergency outlet and engine room of the block type (I). The general view of the construction (facade and section) is given in Fig. I. Force fabric shell is made of rubber coated caprone fabric with A-OI trade name based on the TK-30-PO textile of approximately up to 8000 kg/linear metre strength. For more convenient sewing and mounting the fabric shell is divided into three mounting parts: two face and one cylindrical. The con-

Design solution of this construction is covered by author certificate No. 662674, published in "Bulletin of Inventions", No. 18, 1979.



Fig. I. General view of the pneumatic construction with 24 m span, equipped with a screen: I - an entrance lock; 2 - a force shell; 3 - a heat protective screen; 4 - fle-xible ties; 5 - an inlet lock; 6 - an engine room.

struction has a rectangular basement in the plan. The heat protective screen is made of a light caprone rubber coated fabric with added aluminium powder. In the mounting place the fabric shell is connected on the mounting seams of the loop-rope structure. There are some cuts in the shell for locks connection, the cuts are strengthened with the relieve ropes.

The transport lock is a collapsible-dismountable metal-fabric structure and it includes: face frames with portal fillings and intermediate frames in the form of the flat lattice elements made of float-rolled steel.

Along the length of the lock the frames are tied into integrated dimensional structure by means of longitudinal tubular ties and covered with awning. Lock-gates are of folding-rolled aside structure. The dimensions of the gate opening in the light are 3,2x4,I m, the lock length is 8,5 m. The inlet lock is of a similar structure. The dimensions of the inlet opening are 0,83xI,9I m, the length is 2,7 m. An emergency door is provided according to the existing fire-preventive standards.

An engine room (see Fig. II) is made in the

form of block sections of the bin type with complete industrial readiness. It provides for a project shape, carrying capacity of the pneumatic construction and maintaining in it necessary inner conditions in the warm and cold seasons.

An engine room has three parts with 5x25x x2,3 m dimensions for transport convenience. TT -2,5A heat generators with air productivity of I600 m²/h and heat productivity of 25000 ccal/h are placed in the first two parts. The third part consists of a U4-70 No. IO centrifugal fan with air productivity of 36000 m²/h at 80 mm Hg pressure with electrical motor of IO kWt power, two 38P diesel engines of 8 kWt power each with second order of automatization and control panel. The heat generators and centrifugal fan are provided with reverse valves and louvering regulating shutters positioned on the suction air ducts. The heat generators have also suction nipples and fanric controls. During mounting these parts are connected with each other, forming an integrated dimensional construction.



Fig. II. Engine room in plan: I - a blockbin; 2 - a fan; 3 - a regulating door; 4 diffuser; 5 - a reverse valve; 6 - a fabric air duct; 7 - a control panel; 8 - a heat generator; 9 - a recirculating air duct; IO a fabric regulator; II - a punched nipple; I2 - a diesel generator.

During winter season the heat generators operate under the partial recirculation regime, providing necessary comfort conditions in the construction as well as performance excessive pressure (approximately IO mm Hg).

In comparison with the known analogues the engine room proposed by the authors has a distinctive feature namely that during winter season of operation the same air temperature as in the heated construction is maintained there automatically. It can be explained by the fact that only recirculating air is fed into the engine room, the air then is mixed in the definite ratio with outer air in the suction nipples of the heat generators with punched holes. The air mixture is heated in heat generators and fed into the construction through the forced air ducts. Control of the recirculating air feeding into the suction nipples of the heat generators is accomplished by means of fabric regulators. Such an engine room structure permits to increase reliability of the equipment performance and

simplifies its maintenance by the operators. During summer season the recirculating air duct is closed.

A centrifugal fan is used as a reserve one and is switched on in the emergency situation (gale storm, snowfall, etc.), providing excessive pressure of about 40 mm Hg in the construction. During this period the heat generators may operate under the conditions of complete recirculation.

Two diesel generators are used as reserve sources of electrical energy feeding when electrical energy supply is ceased. They can provide for either two heat generators or a centrifugal fan with a heat generator. The pneumatic construction can function even with the operation of one diesel generator.

An automatic system meintains air temperature constant inside the construction, switches on the diesel generators when the main source of electrical energy feeding is switched off, provides for automatic switching on of the reserve fan when wind speed is above a specified level, when excessive pressure in the construction decreases below operational one or when the heat generators are put out of action.

Artificial lighting from the main electrical energy source and emergency lighting from diesel electrical devices are foreseen in the pneumatic construction, engine room, entrance and inlet locus.

Fabric air outlets with sewn in stiffness rings permit to connect quickly the heat generators, reserve fan and recirculation hole to the fabric nipples of the shell.

The main technical and economical values of BHC-A-2413 construction are given in the Table I.

A testing sample of the construction has been prepared and experimental studies are being

r	able I.
The main technical and values of BNC-A-24ND	economical construction

Values	Units	Amount
Useful area	m ²	1052
Building volume	m ³	7370
Dimensions:		
width	m	24,0
length	m	48,0
height	m	9,0
The complete construc-	,	
tion mass, including:	kg	
shell		2240
lock devices		1270
block-bins		10717
equipment		3617

carried out. After the tests performance the construction will be put into serial production (2). The construction assembling is carried out in the following succession. After carrying out of all preparatory works (arrangement of the anchor basement, mounting of the lock devices and engine room) the fabric shell is fixed on the anchor basement, the shell is put into the projected position by means of shrouds equipment. After the shell's lifting the fabric screen is rolled out, its fixing along the contour and putting the regulated ties into loops, positioned on the fabric screen and on the inner surface of the force shell are made inside the construction.

The screen mounting into operation position is accomplished by means of ties extraction, prepared from caprone ropes. After the screen mounting the ties ends are fixed on the anchor basement.

There are some peculiarities in the construction operation during winter and summer se ason. In hot days the holes along the construction perimeter are opened into complete section; the heated air in the intershell space is lifted upwards and removed outside through the open vent valves, placed on the force shell. Thus the natural-forced ventilation of the inner volume is accomplished. Besides the wetted air can be fed into the construction.

During winter season the holes for pressure levelling are opened to minimum, and the intershell space therefore is turned into closed volume. Heat protective properties of the air layer combined with the heat reflective properties of the fabric screen provide for sharp heat losses decrease and increased comfort of the conditions.

First of all the new construction type may find application in the country areas with cold climate to place there industrial enterproses, requiring higher comfort conditions as, for example, auto-stands, repair shops, production plants for metal, concrete-iron and wood goods, as well as for temporary placing of social and cultural establishments.

Heat rate design methods of rooms in air supported pneumatic constructions during warm and cold seasons of their operation have been worked out by the CNIISK in cooperation with Scientific Research Institute for Constructional Physics, Gosstroy USSR. The design methods make it possible to determine the ventilation-heating systems power, the air temperature in a room and the temperature of the inner surfaces of enclosures.

<u>References</u>

I. Petrovnin M.I., Andrienko E.G. Pneumatic constructions of the air supported type with heat protective screen.Abstract information of the CINIS of Gosstroy of the USSR, VIII series, 2 ed., M., 1977. Sound insulation problems in modern residential buildings

A. Klimukhin, Cand.Sc. (Tech); V.Angelov, Cand.Sc. (Tech); V.Sukhov, Cand.Sc.(Tech); NIISF, Moscow, USSR

Standard requirements to the sound insulation properties of the enclosing structures of residential buildings, methods of rating and theoretical calculation of sound insulation prescribed by the current Soviet Building Norms and Regulations ($CHu\Pi$) are presented in this paper. Also, the most common enclosing structure systems of houses and certain results of the field measurements of sound insulation properties of floors and partitions in residential buildings are presented.

6 8 8

Au rapport on donne les exigences normatives envers l'insonarisation des structures de protection des batiments d'habitation, le systeme d'appréciation de l'insonarisation et une methode du calcul ad**op**tés dans les Regles et codes de construction soviétiques. Aussi on donne les résolutions constructi ves le plus souvent employées dans les structures de protection des batiments d'habitation et les certains resultats des essais in situ de l'isolation des bruits aériens et d'impact par recouvrements et par les eloisons entre appartements.

Acoustic insulation is a very important operating parameter of the enclosing structures of residential houses, which largely determines the degree of comfort afforded to the residents.

Chapter II-12-77 "Noise Control" of the Soviet Building Norms and Regulations (CHuII) has been the regulatory basis in solving sound insulation problems.

According to the CHull airborne noise insulation is evaluated through index I determined by comparing the measured frequency characteristic of the insulation against the reference curve. This reference curve (Fig. 1a) differs somewhat from the one adopted by the ISO (R 717). The index is found as $I_B = E_B + 50 \, dB$. Impact noise insulation of floors is evaluated through a normalized impact noise level index I_y determined with the aid of the reference curve (Fig. 1b). Such index is defined as the ordinate of the horizontal part of the shifted reference curve: $I_y = 70-E_y (dB)$.



Figure I. Sound insulation reference curves. Thus the index values used in the USSR are somewhat different from those accepted by the ISO: I_a and I_i . The airborne noise insulation index $I_B^{=}$ $I_a^{-2}dB$; impact noise index $I_v = I_i + 2 dB$.

To avoid misunderstanding, the indexes used in this paper are those adopted by ISO/R 717: I and I.

Table 1 Prescribed sound insulation standards in residential buildings

	Enclosing structure	I _a dB	I _i dB
1.	Floor between two apartments, between an apartment and ba- sement or occupied attic	52	65
2.	Floor between apartment and not occupied attic	49	
3.	Floor between apartment and underlying store	57	65
4.	Floor between rooms of a two- level apartment	43	73
5.	Wall between two apartments, between apartment and staircase	52	19 a.c.
6.	Wall between apartment and store	57	
7.	Doorless wall between two rooms or a room and kitchen in one apartment	43	
8,	Wall between a room and sani- tary block in one apartment	47	
9.	Apartment door	32	

In the "Noise Control" of the CHuff methods for calculating the sound insulation are set forth and general recommendations are given regarding the structural design of walls, partitions, floors, windows, doors, with a view to assure comfortable sound environment inside the buildings.

The frequency characteristic of the airborne noise insulation by an enclosure of concrete (heavy- or lightweight), bricks, etc. is plotted according to the

scheme of Fig. 2a, point B coordinates being deter mined as shown in Fig. 2b; $f_{\rm B}$ is a function of the enclosure thickness h, m; $R_{B}^{}$ is a function of the enclosure mass m, kg/m².

In tentative calculations the airborne noise insulation index can be found directly, using the formulas:

 $I_a = 23 \lg m_e - 8 dB;$ when m ≥ 200 kg/m² $I_a = 13 \lg m_e + 15 dB;$ when m ≤ 200 kg/m² (1) (2) where $m_{c} = km$ is equivalent mass, kg/m^2 ;

for continuous slabs of heavy concrete (γ > 1800 kg/m^{3}) k = 1;

for lightweight concretes on cement binders $k = 2.26 \sqrt{\frac{E}{fr}} \ , \label{eq:k}$ E - elasticity modulus, kg/m²

for heavy concrete slabs with circular cavities, $k = 1.86 \sqrt[4]{\frac{J}{bh_{red}^3}}$; where J is a moment of inertia of cross-section, m⁴;

b is a section width, m;

 h_{red} is reduced slab thickness, m.



Figure IIa, Airborne noise insulation by a singlelaver flat enclosure



Figure IIb. Chart for determining point B coordinates; 1. $\gamma \ge 1800 \text{ kg/m}^3$; 2. $\gamma = 1600 \text{ kg/m}^3$; 3. $\gamma = 1400 \text{ kg/m}^3$; 4. $\gamma \le 1200 \text{ kg/m}^3$.

For floating false floor structures, the airborne noise insulation index is found from Table 2, depending on the bearing slab index I_{ao} and the resonance frequency fr determined from:

$$E_{r_{z}} = 0.5 \sqrt{\frac{E_{d} (m_{z} + m_{z})^{2}}{h_{z} m_{z} m_{z} m_{z}}},$$
 (3)

where E d is dynamic elasticity modulus of insulation material, kg/m²;

-

- m_1 and m_2 are masses of the load-bearing slab and floating false floor (without in-sulation layer), kg/m²;
- h₃ is thickness of compressed insulation layer, m.

				Έ	ible	2
Eleon structure		I _{ao} , dB			_	
	ΠZ	43	46	49	52	55
1. Wooden floor over girders	150	53	54	55	56	57
faid on insulation strips (E = 5×10^4 to 12×10^4 kg/m ²)	220 350 500	50 48 46	52 49 48	53 51 50	54 53 52	56 55 54
2. Floor over poured conc- crete or prefab.slabs (m ₂ = 60 to 120 kg/m^2) on insula- tion layer (E _d = 3×10^4 to $10 \times 10^4 \text{ kg/m}^2$; h ₃ = 2 to 2.5 cm	100 150 220	52 50 47	53 51 49	54 53 51	55 54 53	56 55 55
3. Same on layer of sand or slag ($E_d = 8 \times 10^5$ to 12×10^5 kg/m ² , $h_3 = 5 - 6$ cm)	220 350 500	52 49 47	53 51 49	54 52 51	55 54 53	56 55 55

Similarly, the normalized impact noise level index is found from Table 3 as function of the NINLindex of floor slab I_{i0} and oscillation frequency of floor laid upon resilient layer, f_{O} Hz, determined, using the formula;

$$f_{o} = 0.5 \sqrt{\frac{Ed}{h_{3}m_{1}}} \qquad (4)$$

Table 3

				l _{io}			
Floor structure	Hz	93	90	88	86	84	82
1. Wooden flooring over	150	68	67	65	64	63	63
(Ed= 5×10^4 to 12×10^4 kg/m ²)	220 350	70 73	69 71	67 69	66 68	64 66	63 65
2. Flooring over poured	60	70	67	65	63	60	58
or prefab.slab $(m_2 = 60)$	100	72	69	67	66	65	66
kg/m ²) over insulation layer $(E_d = 3 \times 10^4 \text{ to} 10 \times 10^4 \text{ kg/m}^2)$	150 200	77 79	74 77	72 75	70 73	68 71	67 69
3. Same over sand or	15 0	71	69	67	66	64	63
slag layer (Ed = 8×10^5 to	250	76	74	72	70	69	68
13x10 ⁵ kg/m ²)	350	80	78	76	75	73	72
4. Flooring on poured or	60	68	65	63	61	59	57
prefab.slab floor $(m_2 =$	100	72	69	67	66	64	62
120 kg/m^2) over insulation	150	76	73	71	69	67	65
layer (Ed=3x104 to 10x10 ⁴ kg/m ²)	200	77	74	73	71	69	67
5. Same over sand or	150	70	67	65	64	62	61
slag layer (Ed=8x10 ⁵ to	2 50	74	72	70	68	67	66
13x10 ⁵ kg/m²)	350	78	76	74	73	71	70

The enforcement of the Chapter of the CHuII elaborated by the Research Institute of Building Physics in collaboration with a number of other Soviet research and design institutes has been a very important step toward achievement of adequate acoustic comfort in houses.

Large-panel construction has the leading place in the Soviet housing programs amounting to about 60% of the total volume of construction in the USSR

A typical structural design of a large-panel residential building comprises transverse load-bearing partitions of reinforced concrete and floors of roomsized continuous reinforced concrete slabs. The sound insulation of inter-apartment partitions employed in certain standard designs has a thickness of 14 cm and has an index $I_{\rm a}$ = 51 dB which is a little below the prescribed value. The 14 cm thick loadbearing floor panel conventionally used in buildings of this series cannot ensure adequate insulation of airborne noise if the flooring is made of heat- and sound-insulating linoleum (felt-, synthetic or other soft base linoleum) laid directly on slab. Average sound insulation index of such floor structures $I_a =$ 50 dB, which is somewhat smaller than that of partitions of the same thickness. The reason is reduced insulation due to soft-base linoleum in the resonance region of the mass-elasticity system (the mass being the top layer of linoleum, with the elasticity being the soft base). In the resonance region the sound transmission loss of the floor structure goes down by about 4-5dB below that of to the bare slab. Outside the resonance region, the sound tran smission loss even slightly increases but the overall I_a values are still about 1dB lower.



Figure III. Sound transmission loss of partitions. 1-r.c. 140mm panel (Ia = 51dB); 2-r.c. 160mm panel (Ia = 52dB); 3-r.c. 180mm panel (Ia = 63dB); 4- ceramsite-concrete 200mm panel (1600 kg/m³) (I_B = 52dB); 5-two 80mm gypsum panels with an air gap of 40mm (I_B = 53dB)



Figure IV. Sound transmission loss of floor structures. 1 - r.c. 140 mm panel with parquet-rigid-soft WFB $(I_a = 53 dB); 2$ -r.c. 140 mm panel with felt base linoleum $(I_a = 50 dB); 3$ -r.c. 160 mm panel with felt base linoleum $(I_a = 51 dB); 4$ -r.c. 220 mm cavity panels with parquet boards on girders, WFB strips $(I_a = 57 dB).$

To compensate for the reduced sound insulation, an additional poured concrete layer has to be used or extra sheet materials (wood-fiber boards, gypsum boards, etc.) to be laid on the slabs. Satisfactory results are obtained when parquet flooring is laid on wood-fiber boards on resilient layer of, for example, soft wood-fiber boards (Fig.IV). The average insulation indices are $I_a = 53 dB$ and $I_i = 64 dB$.

Good results have also been obtained with a structure where parquet boards have been laid on girders on soft WFB strips (Fig. IV); $I_a = 55 dB$, $I_i = 63 dB$,

Wooden floorings on girders on soft strips are being widely used, yet, they provide adequate sound insulation when the load-bearing slab is 10 or 12 cm thick.

Since 1975 a new generation of large-panel houses has been introduced in Moscow, which is based on building components listed in the Unified Prefabricated Structure Catalogue. The Catalogue contains a list of standard components for 12, 16, 20 and 25-storey buildings featuring improved architectural design, both exterior and interior.

In these buildings the load-bearing transverse walls are made of 18 and 14 cm thick concrete; all the inter-apartment walls being 18 cm thick. This substantial increase in thickness of walls separating apartments and the higher cost involved had to be applied to meet sound insulation standards in these buildings. The sound insulation index of these walls I_a is 52 to 53 dB; the average sound transmission loss is shown in Fig. III.

The load-bearing reinforced concrete floor slabs used in this Catalogue's series are 14cm thick. Therefore, to ensure adequate sound insulation, the floor structures incorporating elastic layers or additional poured concrete layers have to be employed. Of course, this complicates the construction process and increases the builders' labour. The development of simple and economical floor designs for use in large-panel residential buildings is an urgent problem that is now in the programs of many research and design teams.

A straightforward solution would be to increase the bearing floor slab thickness sufficient for directly applying the soft base linoleum. However, the experiments have shown that an increase of slab thickness to even 16 cm would have an average index of 51 dB and do not attenuate the airborne noise sufficiently because of the above-mentioned insulation dumping in soft base linoleum. The thickness cannot be increased to a further 18 cm because the crane has limited hoisting capacity.

Apart from reinforced concrete, a large proportion of Soviet large-panel houses are built from lightweight concretes aggregated with porous materials, such as ceramzite, perlite, agloporite, foamed slag, shungisite.

The sound insulation index of the inter-apartment walls in such houses is provided by increasing the wall thickness to 20 cm (normally, an inter-room partition thickness of 12 cm is quite satisfactory in strength for a 9-storey building). According to field measurement data, lightweight concrete partitions of 1700 kg/m³ and 20 cm thick have $I_a = 52-53 dB$. The floors are designed as floating flooring over bearing slab of 10 cm lightweight concrete.

One of the recent developments in large-panel housesbuildings has been to enlarge the bearing partition spacing. In Moscow's pilot housing development Chertanovo-Severnoye, 16-storey houses have been built with the transverse bearing walls spaced at 7.2 m. The prestressed ceramzite-concrete floor slabs are up to 4.2 m wide and 22 cm thick; their airborne noise insulation index averages 53 dB which is within standard limits both with flooring of heat- and sound-insulating linoleum alone and with parquet flooring on rigid wood-fiber board on elastic layer.

These structural designs allow a wider utilization of lightweight non-bearing laminated partitions. They are constructed from individual prefabricated panels or in-situ ones made up of asbestos cement, or wooden frame, gypsum boards, and mineral fiber boards.

The execution of partitions separating the rooms of one apartment from the panels of the above-described type does not present a problem from the acoustical point of view since the requirements to such walls are fairly low $(I_a = 43 \text{ dB})_{\bullet}$ Suitable structures may be exemplified by a frame of 65 mm asbestos cement channel sections clad on both sides with 14 mm thick gypsum boards and insulated with mineral fiber boards of 50 mm thickness. If a wall of similar structure is used to separate aparbments, double gypsum boards have to be used on both sides of the same frame to provide the prescribed sound insulation I_a = 52dB, provided that joint insulation and general workmanship are superb.

Brickwall houses, although to a considerable extent superceded now by more up to date constructions, still constitute a material share of the total country's housing construction volume, i.e. nearly 30%. Beside the conventional scheme of three bearing walls (two exterior and one longitudinal interior walls) and floors of 6 m long reinforced concrete slabs, a combination of bearing external brick walls with an interior reinforced concrete framework or an even newer combination of transverse bearing brick walls and the lightweight suspended laminated panels of the longitudinal exterior walls are also in wide use now.

The bearing component of floors in brickwall or large-block buildings is a 22 cm thick slab with circular cavities (reduced thickness is 12 cm). The flooring structure is sequentially applied onto the bearing slabs - a wooden flooring (parquet board, etc.) is laid on girders with elastic strips; often a poured concrete layer is used on a sand or slag layer or on continuous elastic insulation of woodfiber, or peat boards. Normally such structures are expected to ensure the adequate insulation, although when sand or slag layer is used there is a risk that it will appear too rigid to adequately attenuate impact noise. However, insulation materials of higher elasticity modulus improve the indices to $I_a = 56-58 dB$ and $I_i = 58-62 dB$.

The inter-apartment walls are often the weak point in such houses from the sound insulation standpoint, Most inter-apartment walls are composed of the conventional double 8 cm thick gypsum or slag concrete panels mounted with an air gap of 4 cm. The sound insulation afforded by such structures $(I_a = 51-52 dB)$ is at the edge between satisfying and slightly violating the standard, It has been found in this connection that where such a wall rests on the floor slabs at the line of their contact with the underlying beam, the resultant insulation is somewhat higher and reaches up to the standard. In this case the reinforced concrete beams of the framework under- and overlying the wall play the role of vibration damping masses and also reduce the flanking sound propagation between rooms. A certain, though small, difference has been measured between the insulation provided by walls running along and across the floor slabs. In the latter case the sound insulation is a little poorer, apparently on account of sound propagation along the cavities in the floor slabs.

An analysis of the net short wave radiative balance of buildings within proposed urban complexes with different building densities, orientations and shapes for Lahore, Pakistan.

- I.C. Ward* B.Sc. and A Anis**
- * Lecturer, Department of Building Science, University of Sheffield, U.K.
- ** Associate Professor, Department of Architecture, Lahore University, Pakistan.

Summary

This paper outlines a computer analysis into the effect of building shape, orientation and plan area density on the receipt of solar radiation by a building within an urban complex for Lahore, Pakistan.

Résumé

Cet essai esquisse une analyse sur ordinateur concernant l'effet de forme de bâtiment, d'orientation et de densité d'urbanisation sur la réception des radiations solaires par un bâtiment situé dans un complexe urbain pour Lahore, Pakistan.

Introduction

The climate and economic development of Pakistan is of particular interest as the architectural trend of recent years has been to copy Western architectural form in the development of new urban areas (1). This has resulted in very low building densities which show a tendency to be environmentally undesirable (2). Therefore some guidelines to enable architects and planners to take into consideration at an early design stage the climate of Pakistan in determining the likely solar energy benefit of the proposed area would be of great benefit.

In order to arrive at the optimum shape, size and building density of buildings within an urban area for the desired solar energy budget it would be necessary to carry out a great deal of work. One solution is to use a computer simulation of the urban environment in which the above parameters can be varied quite easily and sufficient changes made to enable general guidelines to be drawn up.

Such a study was carried out by Terjing (3) in order to predict the urban heat island effect. Unfortunately this study oversimplified building construction by assuming that the urban area was constructed of continuous strip buildings which generally is not the case.

The present study therefore modifies the approach taken by Terjing in that discrete buildings have been used and the shape, size, orientation and density have been varied within certain limits. In order to predict the amount of solar energy received by a building within the complex a solar irradiance design curve had to be developed as there was no comprehensive solar data available from Pakistan. The study outlined in the following sections was carried out for the Lahore region.

The parameters which were varied in the study Building shapes

Work by Valko (4) indicated that the net irradiance received by a building is dependent on its shape and therefore several building shapes were used. The ones used in the study are shown in figure (1), and were chosen so that the range in building types from low rise dwellings to high rise commercial buildings could be covered.

Plan area density

A survey and subsequent analysis of 110 housing schemes carried out by Turner (5) suggested that the majority of housing layouts lie between 10% and 30% plan area densities. In this study five plan area densities have been used. These are 5%, 10%, 30% and 40%.

Orientation of buildings

Throughout the analysis the principal facade of the buildings was set at 180° from north and varied in 15° intervals from south towards east and west.

The solar radiation model

The subroutine of the computer model used in this study to calculate the direct and diffuse solar irradiances was substantially based on work by Rodgers and Souster (6). In the case of the reflected radiation received by a building surface from other building surfaces or the ground this was calculated using standard heat transfer techniques.

Direct irradiance

The model developed by Rodgers and Souster enables the direct irradiance on a horizontal or vertical surface to be calculated from a knowledge of the air mass turbidity and water vapour content. The mathematical relationship is as follows:

The value of C depends on the sun earth path length and is shown in table (1) for each month of the year. The values of the constants a_i (i=0 to 3) are dependent on the water vapour content of the atmosphere and for several water vapour contents are shown in table (2). The air mass is dependent on the path length through the atmosphere and hence the solar altitude angle. For solar altitudes greater than 10° the air mass is given by:

 $m = \frac{1}{\sin h} \qquad -----(3)$

Month	Jan Jan	Feb	Mar	Apr	May	Jun
ι 	1.035	1.031	1.02	1.004	0.985	0.97
Month	Jul	Aug	Sept	Oct	Nov	Dec
C	0.965	0.97	0.98	0.999	1.014	1.028

Table 1. Values of constant C in equation 1

Water Content mm	a _o x 10 ⁻¹	a _l x 10 ⁻¹	a ₂ x 10 ⁻³	a ₃ x 10 ⁻⁵
5	-1.123112	-1.002906	5.780368	- 9.519366
10	-1.023606	-1.253194	11.26850	- 50.53788
15	-0.923780	-1.513892	18.95737	-119.9147
20	-0.823634	-1.721594	24.79781	-170.4114
30	-1.170256	-1.567545	20.45444	-137.3211
40	-1.403276	-1.431340	15.41772	- 87.06496
(50)	-2.03467	-0.820616	-1.9358	62.639
(60)	-2.854898	0.062097	-27.17438	282.79

Table 2. Values of constants a_i , i=1,2,3 in equation(2)

Water vapour content

As no reliable data was available a study of the various techniques of determining the water vapour content was carried out. From this study it was found that work by Smith (7) who extended work by Reitan (8) was most appropriate. This resulted in the calculation of the water vapour content being a function of t_d and is given in the following equation:-

 $\ln(w) = (0.1133 - \ln(\frac{352.72 - t_d}{72.61})) + 0.0393 t_d^{--(4)}$

Therefore by using mean dew point temperatures obtained from the Pakistan Meteorological Department the water vapour content of the atmosphere was calculated using equation (4) and the results are shown in figure (2).



Turbidity

The turbidity coefficient used by Unsworth (9) was modified to take into account the sunshine hours, giving the following equation:-

$$t_a = -\frac{1}{m} \ln(\frac{G_{bn}}{f}, \frac{1}{G_{bn}})$$
 ----- (5)

Using equation (5) along with data supplied by the Pakistan Meteorological Department, hourly values of the turbidity coefficient for different times of the year were calculated and are plotted in figure (3)



The design curve for direct irradiance

Using the above relationships a design curve for direct irradiance for Lahore was calculated and is shown in figure (4). This curve is in good agreement with the Moon's curve (9) except for altitudes lying between 65° - 75° .



These differences are probably due to the fact that in early summer the atmosphere of Lahore is dusty, producing high turbidity whereas in late summer the atmosphere is moist producing high water vapour content both of which reduce the irradiance. In both cases the altitude of the sun is greater than 65[°] <u>Diffuse irradiance on a horizontal surface</u> The work by Parmelee (10) in which the diffuse irradiance on a horizontal surface is related to the direct irradiance if equation 6 was used.

$$G_{bh} = X + Y G_{bh}$$
 ----- (6)

The values of X and Y depend on the solar altitude. <u>Diffuse irradiance on a vertical surface</u> Rodgers and Souster have systematically analysed Parmelee's data for different clearness ratios and wall solar azimuths and produced the following relationship which was used in the computer model.

$$G_{dv} = \frac{3.15459}{90} \times 26h + (90-h) \times (ah + bh^2 + ch^3) - (7)$$

The values of a, b and c depend on the wall solar azimuth and the clearness ratio and an example is shown in Table (3) for a clearness ratio of 1.0. The values of the diffuse irradiance received by vertical surfaces within an urban complex were modified by establishing the sky factor for the proportion of sky seen by the facade when other buildings were obstructing part of the sky.

Wall-Solar Azimuth Band n	Wall-Solar Azimuth	ā	b x 10 ²	c x 10"
1	0-20	1.6048	-2.0261	0.3597
2	20-30	1.4651	-1.8775	0.2513
3	30-40	1.1418	-1.0944	-0.3302
4	40-50	0.9425	-0.7942	-0.4927
5	50-60	0.7318	-0.2205	-1.0074
6	60-75	0.4041	0.2959	-1.2400
7	90-180	0.1647	0.4809	-1.2359

Table 3. Values of a, b, and c in equation (9) for clearness ratio = 1.0

Reflected irradiance from other surfaces

In this part of the study standard heat transfer techniques were adhered to.

The total reflected irradiance ${\rm E}_{\rm r}$ can be found from the following expression:-

$$E_{r} = \frac{P_{1}G_{1}a}{\pi} \int_{-c}^{c} \int_{-b}^{b} \frac{x \cos \phi - a \sin \phi}{(x^{2} + y^{2} + a^{2})^{2}} dx dy --- (8)$$

where

$$a \int_{-C}^{C} \frac{B}{b} \frac{x \cos \phi - a \sin \phi}{(x^2 + y^2 + a^2)^2} dx dy ------(9)$$

is generally referred to as the view factor or shape factor.

Case 1 Shape factor from ground surfaces to vertical surfaces

In this case $\phi = 0$ and $b_1 = 0$

so that the streets were infinitely long but had a finite width.

$$F = \frac{\pi}{2} \left(1 - \frac{a}{\sqrt{a^2 + b^2}} \right) - \dots (10)$$

<u>Case 2</u> Shape factor from vertical facades of buildings to vertical facades of other buildings

In this case $\phi = \frac{\pi}{2}$

S 0

$$F = \frac{\pi}{2} \left(\frac{b}{\sqrt{a^2 + b^2}} \right)$$
 ----- (11)

In the calculation of the reflected irradiance care was taken to ensure that only surfaces which received direct short wave irradiance could re-radiate to other surfaces. This was carried out by use of several checking loops within the program.

Results of the study

Shading index

Depending on the layout of the buildings the shade received by a building facade is a function of the wall-solar azimuth, sun altitude and the spacing between buildings or building density. Figure 5 shows how the shading coefficient for a building shape 5 and with a building height/street width ratio of 0.48 varies according to the above-mentioned parameters. A series of such graphs has been produced covering a range in wall-solar azimuths thus enabling a better understanding of shading patterns to be reached.



Shape and density on the direct irradiance

A typical example of the effect of building density on the radiation budget is shown in figure 6 which gives the daily total direct solar irradiance received by all the buildings studied for June and December.



Two building shapes were used to illustrate how building density affects the receipt of direct solar radiation. Figures 7 and 8 show how the daily total direct irradiance received by shapes 0.5 and 5 is reduced due to changes in building density for the months of June and December.

By carrying out this analysis month by month it was possible to arrive at a general trend for the effect of density on the receipt of direct solar radiation.





Figure 9 shows how the ratio of obstructed to unobstructed irradiance for shape 5 varies according to changes in orientation for different building densities. It is clear from this figure that there appears to be a relationship between building density and the direct irradiance. This approach was extended to cover the other building shapes and is shown in Figure 10.



It was found that the range of results relating to the receipt of direct solar irradiance was so large that a simplified design chart was necessary. The logic adopted in the flow chart assumed that the direct irradiance on each facade of the building was calculated separately for the chosen day and hour using the solar irradiance curve developed for Lahore (Figure 4).

The design chart is shown in Figure 11. Details of the urban complex which must be known in order to use the chart are as follows:-

- (b) (a) the street width building height ratio
- (a) (b) the solar altitude, wall-solar azimuth and orientation of facade.

Using (a) and the design irradiance curve the unobstructed direct solar irradiance on the facade can be established. From (b) it is possible using Figure (5) or one similar for the required wall-solar azimuth to arrive at the shading coefficient which then modifies the direct irradiance value to give the actual irradiance on the facade.



<u>Diffuse irradiance under obstructed conditions</u> Although in the climate of Lahore the direct irradiance is the predominant factor a study of how the diffuse irradiance is affected by increasing the building density is of interest. Again shapes 0.5 and 5 were studied with respect to the receipt of diffuse irradiance. Figures 12 and 13 show how the values for the diffuse irradiance for shapes 0.5 and 5 vary for both December and June for three orientations of building facade. As would be expected the value of the diffuse irradiance falls with increasing building density.



Reflected irradiance under obstructed conditions The results shown in figures 14 and 15 give the ratio of daily total reflected radiation to the daily total direct (obstructed) irradiance for different facade orientations and building density for shape 5.



These graphs were produced for a ground reflectance of 0.35 and the building facade reflectance 0.5. From these graphs it can be seen that buildings facing south with streets running east west receive more reflected irradiance than buildings facing east or west, except when the building density approaches 40%. This is due primarily to the amount of shade in the street, for east west streets the amount of shade over the day is minimal whereas north south streets are shaded for a large proportion of the day.

In view of the importance of reflected irradiance a design graph was developed to establish the amount of reflected irradiance received by a point on a building facade from the ground. This chart is shown in Figure 16.

Conclusions

This study has shown that trying to relate in simple terms the constructional parameters which go to making up an urban area are complex and there appears to be no simple solution. General guidelines have been produced which show the various trends in the receipt of solar irradiance under different planning parameters and an attempt has been made to produce design charts to help designers tackle the problems of optimising the receipt of solar irradiance for Lahore, Pakistan.

References

 Siddiqi A.A. A study of the effects of shape and grouping of structures and their external landscape patterns on the irradiation or urban built form. Ph.D. Thesis University of Sheffield Ch.1 April 1978

- Stevens P.H.H. Densities in housing areas, Tropical Building Studies No.1, Dept. of Scientific and Industrial Research, BRE, H.M.S.O. London 1960.
- Terjung W.H. and Stella S-F Louie, A climatic model of urban energy budget, Geographical Analysis, Vol. 6. pp 341-367, 1974.
- Valko O. The effect of shape and orientation on the radiation impact on buildings, Proc.CIB Conf. Teaching the Teachers on Building Climatology, Stockholm 1973.
- Turner J. A comparative study of the land use and built form of 110 schemes, The Architects Journal, No.31, Vol.158 pp 265-280, 1973.
- 6. Rodgers G.G. and Souster C.G. The development of an interactive program for calculation of solar irradiances and daily irradiations on horizontal surfaces on cloudless days for given conditions of sky clarity and atmospheric water content, Internal Note BS28.Dept.of Building Science,Univ.of Sheffield 1976
- Smith W.L. Notes on relationships between total precipitable water and surface dew temperature, J.Appl. Meteor., Oct1966 pp 726-727.
- Reitan C.H. Surface dewpoint and water vapour aloft, J.Appl. Meteor., 2, pp 776-779, 1963.
- Moon P. Proposed standard solar-radiation curves for engineering use, J. Franklyn Inst., Vol. 230, pp 583-617, 1946.
- 10.Parmelee G.V. Trans.Am.Soc.Heat.Vent.Engs.60, 341-365, 1954.



Economic Substantiation of the Main Directions of Scientific and Technical Progress in Construction

I.L. Aparin, Cand.of Sc.(Econ.), NIIES, Moscow,

<u>Summary</u>. The report lays emphasis on the increasing importance of economic substantiation of construction works in the conditions of industrialisation, the increasing of technical solution variants, complication of building conditions in new regions, augmentating varieties of factors which influence on the level of efficiency of taken decisions, as well as in comnection with scentiness of labour, material, power and other resources.

The author underlines the necessity of working out scientifically grounded methods of economic efficiency determination and choosing optimal technical decisions, based on nationaleconomic approach to the assessment of these decisions. The goal can be achieved by comparison of expenditures paid on one occasion only and current expenditures (they have to be discounted accordingly) with the results of their realisation. It is pointed out that the substantiation has its peculiarities at the level of taking general-industrial decisions (unification, typisation etc.) reflecting in standards, regulations, standard projects and on the level of working out concrete projects. Deciding is exceptionally important moment and needs to be done on the basis of profound coordinated technical and economic researches.

Examples of economic substantiation, which show certain achievement of the USSR in this field are listed.

<u>Sommaire</u>. Dans cet exposé il s'agit de l'importance des bases économiques en raison de l'industrialisation de la construction, de l'augmentation des nombres des solutions techniques, de la complication des conditions de la construction en nouvelles régions, de l'accroissement de la diversité des facteurs, en tenant compte de la limitation des réserves de main d'oeuvre et des ressources énergétiques.

On examine la nécessité du développement des méthodes des définitions de l'éfficacité économique et du choix des solutions techniques optimales, dont la base est le plan de l'économic nationall. Pour cela il est nécessaire comparer les dépenses discretes et courantes avec les résultats de réalisation.

On note, que les bases économiques ont ses particularités sur le niveaux des solutions dans tous les domaines de la construction (unification, standartisation), on peuce voir dans les normes, les verbes, les projets - types et dans les projets concrets. On souligne l'importance de la prise une décision, que doit se réaliser sur la base des récherches scientifiques et économiques, bien coordinées. On cite en exemple les bases économiques cértifiantes les succés de l'URSS en ce domaine.

In conditions of building industrialisation, complication of building projects, increasing number of technical solutions and complication of construction in new regions on the whole, the importance of economic substantiation is increasing.

The diversity of factors influencing the level of technical solutions and scantiness in resources (labour, material, power) arouse the necessity of working out scientific methods of determination of economic efficiency and selection of optimal solutions. The national economic approach to the assession of these solutions must be laid down as a base of such methods. To achieve this goal it is necessary to compare all expenditures and results concerning the realisation of these solutions.

The economic substantiation has its specific features on the level of adoption of general industrial solutions. They are reflected in standards regulations, standard projects and in concrete projects. The unification of volumeplanning and design solutions, the typification

673

of project solutions, rules connected with the fields of using different patterns of building constructions and materials as well as other building norms and regulations influence the technical level and economic efficiency of building projects.

Deciding on mentioned directions is a very important aspect of the problem and must be implemented on the basis of profound coordinated technical and economic research.

Increasing the effectiveness of construction is a complex national economic problem and its solution directly depends on the improvement of economic, technical and organisational forms of activities, not only in construction but in other branches of the national economy which supply material resources. Introduction of scientific and technical achievements is one of the important means of raising the efficiency of construction, since in these conditions the results of the scientific and technological progress which is decisive in raising labour productivity and improving production quality at all stages of social production, are put into practice.

One of the main elements of emergence and introduction of new technology is its economic efficiency, which allows us to define the expediency of national economic input for its working out, to find the most rational fields for its usage in construction using with the aim of receiving greatest efficiency and to determine the demand for new technology in perspective.

As a rule any new technical solution replaces a traditional solution, which helps to solve a similar target problem. Such technical solutions are interchangeable and their economic expediency is reduced to calculation of comparable economic efficiency.

The calculation methods of comparable economic efficiency are regulated by "The methods (main provisions) of New Nechnology, Inventions and Rationalisation Proposals", approved on February 14, 1977, No 48/16/13/3. by the enactment of the State Committee of the USSR Council of Ministers for Science and Technology, the USSR Academy of Sciences, the USSR State Planning Committee, and the Committee for Inventions and Discoveries under the USSR Council of Ministers.

The national economic efficiency due to the introduction of scientific and technical achievements in construction manifest itself in aggregate economy of living labour (in the sphere of construction directly) and of means of production (raw materials, building materials, constructions, machinery, stock and rig.) which is received as a result of using new 'ıtechnology instead of traditional technical solutions. It is necessary to underline that the very sphere of building production is one of the stages of social production and, therefore, the concept of an efficiency of building production cannot be considered separately from national-economic efficiency of a building production (edifices, structures) on the whole. Therefore, in calculating a comparable economic efficiency all the expenditures are taken into account, i.e. expenditures of society for construction and exploitation of the production. The formula of mentioned expenditures, which is used in practice, is an expression of the sum of expenditures at all stages of social production and expenditutes.

The mentioned expenditures represent the sum of current expenses and expenditures for capital investments. These expenses and expenditures based on the certain year are spended or, to be more exact, should be spended by national economy for creation of a unit of output.

$$S = C + E_h K$$

- - E_h- standard coefficient of capital investment efficiency equal to 0.15 1/year;
 - K specific capital investments into production assets (expenditures paid on one occasion only), in roubles, year;
 - S given expenditures for creating a unit of output, in roubles.

674

Production cost of a unit of output materials, constructions, articles, rig., machinery, elements of edifices and structures) in the sphere of using is formed of expenditures in three fields:

$$C = C_{np} + C_{t} + C_{m}$$

- - Ct cost of transportation of a unit of output from the (plant) manufacturer to the building site, including expenditures for laying-in, package and storing of products, in roubles;
 - C_m production cost of assembling a unit of output, in roubles.

Specific capital investments represent the sum of expenditures for creation of production assets to manufacture a unit of output (K_{np}) and building machines and mechanisms used for assembling (K_m) ;

 $K = K_{np} + K_{m}$

In calculating economic efficiency, technical and economic indices of production and use of products (production cost and capital investments) are taken with the possibility of their changing in the nearest perspective (5 -10 years) due to the introduction of scientific and technical achievements, better organisation of production, increase in labour productivity, etc. Progressive design and construction solutions for erecting planned undertakings, the necessary date about change of prices on raw materials, semi-finished products and equipment in related branches of the national economy, as well as forecasted estimations based on the thorough analysis of home and foreign scientific and technical achievements in the field under investigation can serve as sources of information on future technical and economic data.

In comparing economic effectiveness of interchangeable traditional and new technologies used in construction, it is often impossible to confine oneself to accounting current and lump-sum expenditures for their creation. The operational costs connected with the use of the given materials or constructions are also of great importance. For instance, the losses of heat connected with thermal resistance of a construction and expenditures for current repairs and hermetisation of joints are included, as a rule, into operational costs (for external constructions). In roofing, the expenditures for repairs of hydro-insulating carpet and in flooring, the expenditures for floor polishing and repeated painting are included. The operational costs for all period of work of material, an article or a construction are determined by the following formula:

$$E = \frac{Ce}{E}$$

- where: C_e average annual operational costs (without deduction on renovation) connected with the use of a given kind of materials or constructions, in roubles per year;
 - E standard of bringing expenditures of different periods, equal to 0.1, 1/year.

Thus a detailed formula of given (nationaleconomic) expenditures for creation and operation of a unit of output can be expressed with a formula:

$$S = (C_{np} + C_t + C_m) + E_h(K_{np} + K_m) + \frac{Ce}{E}$$

From the point of view of national-economic interests the most efficient variant is that which helps to solve the technical problem with the least size of the given expenditures $(3 \rightarrow \min)$. The greater efficiency of new technical solutions in comparison with traditional solutions predetermines the following inequality:

$$s_h < s_{tp}$$

where: S_h - given expenditures for realisation of a new technical solution;

> S - given expenditures for realisation of a traditional solution.

In calculations of comparative economic efficiency it is necessary to consider variants of interchangeable technical solutions (product) with different durability (decoration materials, constructions of roofing, materials for flooring, piping systems of different kind of materials, etc.).

To take into account this factor let us reduce all variants to a standard. Let us take a standard with durability of more than 50 years. As to the variants with less durability the sum of current expenditures and expenses paid on one occasion only in the formula of given expenditures is to be multiplied by coefficient of durability (M):

 $S = (C + E_h K) + \frac{Ce}{E}$

where: $M = 1 + \frac{1}{(1+E)t} + \frac{1}{(1+E)2t} + \cdots + \frac{1}{(1+E)nt-1}$ where: t - time of action of given variant, years;

> n - number of full replacement of given variant (or its renewal during the work of a standard variant.

Quantity of a coefficient of durability (M) by (E=0.1) is equal 2.57 (durability - 5 years); 1.59 (durability - 10 years); 1.31 (durability - 20 years); 1.092 (durability - 25 years); 1.057 (durability - 40 years); 1 (durability -50 years).

Correct approach to an estimation of economic efficiency in a certain degree depends on a choice of comparison conditions of compared variants. It is necessary to underline that the concept of interchangeability is not limited to the solution of a technical side of a given task, but this concept must include an achievement of social effect (i.e. sanitaryhygienic conditions, architectural merits, aesthetics, comfort, etc.). This circumstance must be taken into account especially in research of economic efficiency of decoration materials, flooring, soundproof and other materials.

Use of interchangeable materials, articles and building constructions as a rule is connected with one or another constructive peculiarities in adjacent elements but sometimes demands changing project solutions of edifices as a whole. These peculiarities must be taken into consideration in calculating economic efficiency by method of comparison of technical and economic indices of interchangeable solutions in a completed shape for the with variable parts of conjugated construction elements. Economy of the mentioned expenditures for a construction product is formed of economy of living labour (labour expenditures in the sphere of construction) and materialised (past) labour (materials, fuel, energy, amortisation of machines and machinery).

In considering a question of the change of correlation between materialised and living labour, K.Marx pointed out that raising of labour productivity in the end is lessening the total sum of labour (living and past labour), included in the commodity. This proposition clearly indicates the perspective direction of the efficient construction development, since an introduction of scientific and technical achievements into this branch presupposes the reduction of material and labour intensity.

In the conditions of developed socialist society the importance of the intensive factors of social production development have increased.

The State Five-Year Plan for the development of the USSR national economy in 1976 - 1980 envisages abovementioned problem. In accordance with this plan the all accretion of the volume of construction works in this period is provided owing to raising the productivity of labour which is provided by the further industrialisation of construction, mass use of the effective materials and constructions as well as by the progressive project solutions. A finite element-based computer program for the simulation of the thermal behaviour of complex systems.

Ir. G.L.M. Augenbroe.

Staff member at the Building Physics Chair Department of Civil Engineering Delft University of Technology Delft, The Netherlands

Summary

It is well known that the differential equations describing the thermal behaviour of components in buildings, e.g. walls, solar collectors, storage media, etc., lend themselves very well to the finite element method approach.

The powerful space discretization, which is inherent to this method can be applied to every single component, using one-, two- or three-dimensional elements, often depending on the accuracy that is required locally. A particularly attractive feature of the approach described in this paper is the coupling of several components by means of macro elements; thus enabling the finite element technique to be retained in all stages of the discretization process. This is demonstrated on the example of a so called room element, which accomplishes the coupling of inside-air and surrounding solid due physically to convective and radiative heat exchange. Some attention will be paid to AFEP, the standard finite element package that is used, as well as to the solution of the resulting set of ordinary differential equations.

Some examples in the area of energy conservation in buildings serve to demonstrate the power and usefulness of the approach.

Résumé

Les équations différentielles décrivant le comportement

thermique des parties de constructions e.g. des murs, des capteurs d'énergie solaire, des parties de stockage de chaleur, se prêtent très bien à l'application de la méthode des éléments finis. La puissante discrétisation d'espace qui est inhérente à cette méthode peut être appliquée à n'importe quelle partie en employant des éléments mono-, bi- ou tridimensionnels, dépendant de l'exactitude requise.

Un aspect très attrayant de l'approche décrite ici est l'accouplement de plusieurs parties au moyen de macroéléments; de cette manière la technique des éléments finis peut être retenue à toutes les étapes du procès de discrétisation. Ceci est montré par l'example d'un soi-disant élément de chambre, qui accomplit l'accouplement d'air intérieure et d'enveloppe solide due physiquement au transfer de chaleur convectif et radiatif. Quelque attention sera donnée à AFEP, le programme de calcul d'éléments finis q'on a employé ainsi qu'à la solution de l'ensemble des equations différentielles ordinaires, qui en résultent. Quelques exemples dans le domaine d'économies d'énergie dans des bâtiments sont donnés pour montrer la puissance et l'utilité de cette approche.

1. Introduction

After introducing the finite element method (f.e.m.) which can be regarded more or less as a standard method for the discretization of differential equations, some comments will be made on existing standard packages with special emphasis on AFEP.

It will be shown how several special elements can be developed for temperature calculations in complex systems, thus retaining all merits of the finite element method.

Whereas the development of a so called room element will be dealt with in some detail, some others will only briefly be mentioned.

Some comments on the use of transform as well as time discretization methods for finding the trajectories of the resulting dynamical system will be given. Several examples are included for demonstration purposes.

2. Use of the f.e.m. for solving the heat conduction equation

From the increasing amount of literature in this field we suffice to mention [1] and [2].

As we are merely aiming at introducing some finite element concepts, let's consider the flow of heat in a solid body (fig. 1), consisting of homogeneous, isotropic material; all physical quantities are temperature independent.



x = vector containing space coordinates x ∈ V t = time_coordinate

t **E** [0,T]

Figure 1. Boundary parts R₁, R₂, R₃ of V

We are faced with the problem of solving $T(\underline{x},t)$ from

$$\rho c \ \frac{\partial T}{\partial t} - \operatorname{div}(\operatorname{grad} \lambda T) - Q = 0 \qquad \underline{x} \in V \qquad (2.1)$$

With boundary conditions

$$\Gamma(\underline{x},t) = T_{R}(t) \qquad \underline{x} \in R_{1}$$
(2.2)

$$-\lambda \frac{\partial T}{\partial n} = q_n(t) \qquad \underline{x} \in \mathbb{R}_2$$
 (2.3)

$$-\lambda \frac{\partial T}{\partial n} = \alpha(T - T_a(t)) \qquad \underline{x} \in \mathbb{R}_3$$
 (2.4)

and initial condition

$$T(\underline{x},0) = T_{0}(\underline{x}) \qquad \underline{x} \in V$$
(2.5)
ρc and λ are the heat capacity and heat conduction coefficient of the material;

- Q(x,t) = volume source
- $T_p(t)$ = prescribed boundary temperature
- q_n(t) = prescribed boundary heat flux
- α = heat transfer coefficient between solid and environmental temperature T
- $T_{\alpha}(\underline{x})$ = prescribed initial temperature

pplication of the "displacement-type" version of the inite element technique requires the following actions:

- Divide V in M disjunct subdomains (elements) V^e
- Choose N^e points (nodes) in V^e
- Choose a Lagrange-type interpolation for $T(\underline{x},t)$ in V^e :

$$\mathbb{T}^{\mathbf{e}}(\underline{\mathbf{x}},\mathbf{t}) = \sum_{i=1}^{N^{\mathbf{e}}} \mathbb{T}_{i}(\mathbf{t}) \mathbb{N}_{i}^{\mathbf{e}}(\underline{\mathbf{x}})$$
(2.6)

through requirements on the choice of basisfunctions $N_i^{e}(\underline{x})$, $T_i(t)$ will represent the value of $T(\underline{x}_i,t)$, i.e. the value of $T(\underline{x},t)$ in node i. Considering questions of convergence and correctness which impose other restrictions we refer to [1].

- Employ Galerkin's principle on (2.1); taking $N_i^{e}(\underline{x})$ from (2.6) as testfunctions and applying Green's theorem leads to [3]:

$$\int_{V} \rho c \frac{\partial T}{\partial t} N_{i} + \lambda \text{ grad } T \cdot \text{ grad } N_{i} - QN_{i} dV +$$
$$+ \int_{R_{2}} q_{n} N_{i} dR + \int_{R_{3}} \alpha (T - T_{a}) N_{i} dR = 0 \quad i = 1(1) \text{NP} (2.7)$$

NP = total number of nodes.

Through introduction of $\underline{T}(t)$ as the vector (1:N) with elements $T_{i}(t)$, (2.7) can be written as

$$M\underline{\dot{T}} + S\underline{T} = Q \qquad (2.8)$$

The global matrices M (heat capacitance matrix) and S (heat conductivity matrix) and the global vector Q (heat load vector) are defined by (2.7). Note thas S consists of a volume integral (S_V) as well as a boundary integral (S_{R_3}) , i.e. $S = S_V + S_{R_3}$ (2.9)

Only those elements having part of their boundary in common with R_3 contribute to S_{R_3} .

Conclusion

We have found that the finite element space discretization of (2.1)-(2.4) results in a set of ordinary differential equations (2.8). Likewise the initial condition can be discretized to

$$T(0) = T_0$$
 (2.10)

The popularity of the f.e.m. stems mainly from the choice of "local" basisfunctions N_i^e which enable the flexible "element-adding" programming routine. Furthermore the arbitrariness of element shape can be exploited favourably in dealing with complex geometries.

3. AFEP (A Finite Element Package)

AFEP was developed at the Mathematics Department of the Delft University of Technology [4]. It consists of a number of FORTRAN-coded subroutines, to solve general problems.

Contrary to command-like packages, the subroutines can be called in user-written programs. Due to this program structure there exists a great flexibility in using the package, furthermore the inefficiency generally inherent in "black box"-packages is circumvented.

Of course due to this philosophy the use is restricted to persons having some programming experience and some knowledge of the method. The area of application however is virtually unlimited because the user can add his own element routines, if necessary.

4. Introduction of a room element

Dealing with temperature calculations in and around airfilled enclosures (fig. 2) we find ourselves confronted with two phenomena that somehow need special attention in order to fit into the general finite element framework:

a. Convective heat exchange between air and solid

If we assume the air temperature (T_{air}) to be uniform, T_{air} enters the analyses as one additional unknown. The convective heat transfer q_n can now be written as

$$q_n = \alpha_c (T_s - T_{air})$$
 (4.1)



V_{air} = total volume of enclosure R_i = inner boundary

Figure 2. Enclosure

 $T_s = solid temperature on the boundary at s (fig. 3)$ $<math>\alpha_c(T_{air}, T_s, s) = convective heat transfer coefficient:$ it follows from empirical relations, expressing itsdependence on local (boundary) flow conditions. The $physical relations entering in <math>\alpha_c$ may somewhat compensate the inaccurateness of the homogenity assumptions regard ing T_{air} ; however if exact knowledge of the varying airtemperature is required one could attempt to use Navier- Stokes elements covering the enclosure. Turbulence effects tend to make the analysis very difficult, especially in three dimensions. This subject being far beyond the scope of this paper, it will not be discussed here. Derivation of the element matrices:

Consider a two-dimensional example with triangular elements (fig. 3).



Figure 3. Two-dimensional enclosure with triangular boundary elements.

Denoting by $q_{R_1}^{e_{\alpha}}$ the discretized heat flux in the nodes of element e_{α} on the boundary of the enclosure R_1 , we know from section 2 that the discretized form of (4.1) is

$$\underline{\mathbf{q}}_{\mathrm{R}_{1}}^{\mathbf{e}_{\alpha}} = \mathbf{S}_{\mathrm{R}_{1}}^{\mathbf{e}_{\alpha}} \left\{ \begin{bmatrix} \mathbf{T}_{1} \\ \mathbf{T}_{j} \end{bmatrix} - \begin{bmatrix} \mathbf{T}_{\mathrm{N}+1} \\ \mathbf{T}_{\mathrm{N}+1} \end{bmatrix} \right\}$$
(4.2)

Adding all elements on the boundary (the total member of nodes on R_i being assumed N) gives

$$\underline{q}_{R_{i}} = S_{R_{i}} \left\{ \underline{T}_{R_{i}} - \underline{T}_{N+1} \right\}$$
(4.3)

 \underline{T}_{R} contains all boundary temperatures, i.e.

$$\mathbf{\underline{T}}_{R_{\mathbf{i}}}^{\mathrm{T}} = \begin{bmatrix} \mathbf{T}_{1}, \mathbf{T}_{2}, \dots, \mathbf{T}_{N} \end{bmatrix}$$
(4.4)

and by definition

$$\underline{\mathbf{T}}_{\mathbf{N}+1}^{\mathbf{T}} = \left[\mathbf{T}_{\mathbf{N}+1}, \mathbf{T}_{\mathbf{N}+1}, \dots, \mathbf{T}_{\mathbf{N}+1} \right]$$

When we consider the additional equation, expressing the total heat flow balance in the enclosure:

$$q_{N+1} = \rho c_{air} V_{air} \frac{\partial T_{air}}{\partial t} - \int_{R_i} \alpha_c (T_s - T_{air}) dR$$
 (4.5)

or in discretized form

$$\mathbf{q}_{\mathbf{N+1}} = \rho \mathbf{c}_{air}^{\mathbf{V}} \mathbf{v}_{ir}^{\dagger} \dot{\mathbf{T}}_{\mathbf{N+1}}^{\mathbf{N+1}} - \mathbf{v}_{i=1}^{\mathbf{N}} \mathbf{q}_{\mathbf{R}_{i}}^{\mathbf{q}}(\mathbf{i})$$
(4.6)

If we add (4.6) to (4.3) the complete set of (N+1) equations can be put as

 $q^{e_R} = M^{e_R} T^{e_R} + S^{e_R} T^{e_R}$

As suggested by notations in (4.7), M^{e_R} and S^{e_R} are the room element (e_R) matrices, i.e. the element contributions to the global matrices M and S; the element e_R contains (N+1) nodes:

 $(\underline{\mathbf{T}}^{e_{R}})^{\mathrm{T}} = (\mathbf{T}_{1}, \mathbf{T}_{2}, \dots, \mathbf{T}_{N}, \mathbf{T}_{N+1})$ (4.8) Note that M^{e_{R}} contains only one non-zero element, i.e. $\mathbf{M}^{e_{R}}(N+1,N+1) = \rho \mathbf{c}_{air} \mathbf{v}_{air}.$ It is easily inspected that because $\mathbf{S}_{R_{1}}$ is symmetric, so is S^{e_R}.

b. Radiative heat exchange in the enclosure, thus linking all elements on R_i.

The linearized total heat exchange $Q_{\alpha\beta}$ (fig. 3) between the elements e_{α} (assuming an average element boundary temperature $\overline{\mathtt{T}}_{\alpha})$ and ${\mathtt{e}}_{\beta}$ (assuming likewise $\overline{\mathtt{T}}_{\beta})$ is expressed by

$$Q_{\alpha\beta} = -Q_{\beta\alpha} = \phi_{\alpha\beta} \alpha_{s} (\bar{T}_{\alpha} - \bar{T}_{\beta})$$
(4.9)

per unit area

$$q_{\alpha\beta} = \frac{\phi_{\alpha\beta}}{\overset{A}{_{\alpha}}} \alpha_{s} (\bar{T}_{\alpha} - \bar{T}_{\beta})$$
(4.10)

$$q_{\beta\alpha} = \frac{\phi_{\beta\alpha}}{A_{\beta}} \alpha_{s} (\bar{T}_{\beta} - \bar{T}_{\alpha})$$
 (4.11)

α_s = empirical factor, also accounting for the factor resulting from the linearization of the Stefan Boltzmannn 4th order terms.

If only black body radiation is considered (all emissivities $\varepsilon_{\alpha} = 1$) then

$$\begin{split} &\widetilde{\phi}_{\alpha\beta} = \phi_{\alpha\beta}^{}A_{\alpha} = \phi_{\beta\alpha}^{}A_{\beta}^{}, \text{ in which} \\ &\phi_{\alpha\beta} = \text{viewfactor between elements } e_{\alpha}^{} \text{ en } e_{\beta}^{} \\ &A_{\alpha}^{} = \text{boundary surface area of } e_{\alpha}^{} \end{split}$$

If for some surface areas $\varepsilon_{\alpha} < 1$, $\phi_{\alpha\beta}$ can be computed from $\phi_{\alpha\beta}$, this involves a matrix inversion [3]. Derivation of the element matrices:

Summing the heat exchange between e_{α} and e_{β} over all elements e_{β} we arrive at

$$q_{\alpha} = \sum_{\beta} q_{\alpha\beta} = \sum_{\beta} \frac{\varphi_{\alpha\beta}}{A_{\alpha}} \alpha_{s} (\bar{T}_{\alpha} - \bar{T}_{\beta})$$
(4.12)

discretization leads once more to

$$\underline{\mathbf{q}}_{\mathbf{R}_{\mathbf{i}}}^{\mathbf{e}_{\alpha}} = \sum_{\beta} \mathbf{s}_{\mathbf{R}_{\mathbf{i}}}^{\mathbf{e}_{\alpha}} \left\{ \begin{bmatrix} \mathbf{T}_{\mathbf{i}} \\ \mathbf{T}_{\mathbf{j}} \end{bmatrix} - \begin{bmatrix} \mathbf{\bar{T}}_{\beta} \\ \mathbf{\bar{T}}_{\beta} \end{bmatrix} \right\}$$
(4.13)

Note that we have used $S_{R_i}^{\alpha}$ in a generic way, it differs from $S_{R_i}^{e_{\alpha}}$ in (4.2) by a multiplying factor.

Introducing an appropriate averaging matrix $P_{R_1}^{e\,\beta}$ (4.13) can be written as

$$\underline{\underline{q}}_{R_{i}}^{e_{\alpha}} = \sum_{\beta} S_{R_{i}}^{e_{\alpha}} \left\{ \begin{bmatrix} T_{i} \\ T_{j} \end{bmatrix} - P_{R_{i}}^{e_{\beta}} \begin{bmatrix} T_{k} \\ T_{1} \end{bmatrix} \right\}$$
(4.14)
Carrying out the addition and writing (4.14) for all

elements e. on R. gives finally

$$\frac{e_R}{\underline{q}} = R^{e_R} \frac{e_R}{\underline{T}}$$
(4.15)

Notice that because of (4.8), R^{e_R} is found from (4.14) and the adding process, and the addition of an (N+1)th row and (N+1)th column, containing nothing but zeros. It can again be proven that R^{e_R} is symmetric; R^{e_R} is the room element contribution to the global matrix S.

Without having gone into details (such as the positive definiteness and other special properties of S^{e_R} and R^{e_R}) we can draw an important conclusion:

The coupling which occurs in enclosures due to convective and radiative exchange can be built into the global matrices M and S straightforwardly by "covering" the enclosure by a special element.

Consequently, once the standard element has been added to the element library, systems containing enclosures do not differ in complexity from the simple problem, described in section 2. Regarding the simulation of the thermal behaviour of buildings some additional comments are appropriate (fig.4).



Figure 4. Room element used in simulation of thermal performance of buildings

- Source terms (e.g. convective heat gain from a heat source, absorption of solar radiation, etc.) are readily computed within the element subroutine, forming the element load vector $\underline{q}^{e_{R}}$.
- Air exchange between rooms or air infiltration from the environment can be easily accounted for by a so called ventilation element e_v (fig. 4), the element has zero mass and a conductivity matrix as given below (\dot{m} = air flow rate)

$$S^{e_{V}} = m\rho c_{air} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$
(4.16)

- As indicated in fig. 4. room heating sources can be incorporated simply as part of R₁, i.e. of e_R; the only limitation on boundary shape is the rapidly progressing complexity of the $\phi_{\alpha\beta}$ -computation.

5. Two other special elements

When dealing with solar energy systems we had to introduce elements with which the governing transport equations in components such as air ducts and pebble beds can be built in discretized form. We will discuss both examples briefly below.

a. fluid flow in a duct (fig. 5)



Figure 5. Duct Element.

We assume homogeneous fluid temperature across the duct, along with a convective heat transfer coefficient and an average bulk velocity \overline{v} , which may be the result of natural or forced convection.

In the first case $\bar{\mathbf{v}}$ enters the analysis as essentially unknown, thus often necessitating iterative solution methods. To tackle this combined conduction-convection problem a duct element e_{D} (fig. 5) has been introduced; nodes 5 and 7 contain the fluid temperatures. Remarks:

- for "transparent" fluids (e.g. air) the radiation across the duct is taken into account,
- the non symmetric part of the conductivity matrix S^{ep}, being a result of the convection terms can be built in several ways, for example using upwinding.

b. Fluid flow in a packed bed (fig. 6)



Figure 6. Packed bed and corresponding element

An element used for one-dimensioned analyses is pictured in fig. 6, note that both phases are retained; nodes 1, 2 contain solid (pebble) temperatures, nodes 3 and 4 contain fluid temperatures.

6. Solution techniques

We are concerned here with the solution of the set of ordinary equations (6.1), resulting from application of the f.e.m.

$$\underline{M}\underline{\dot{T}} + S(\underline{T},t)\underline{T} = \underline{f}(t)$$
(6.1)

with initial condition

$$\underline{\underline{\mathbf{T}}}(\mathbf{0}) = \underline{\underline{\mathbf{T}}}_{\mathbf{0}} \tag{6.2}$$

M is usually constant; if $S(\underline{T},t) = S(t)$ the system is linear.

We will distinguish between two methods.

a. Transform Methods

If $S(\underline{T},t) = S = constant$ a feasible approach is to transform the time coordinate to the complex s-coordinate for instance applying the one-sided Laplace (**2**)-transform on (6.1) leads to ($\tilde{.} = 2(.)$)

$$sM\underline{\widetilde{T}} + S\underline{\widetilde{T}} = \underline{\widetilde{f}} + M\underline{T}_0$$
 (6.3)

After computing the solution \underline{T}_i of (6.3) for a set of discrete values of s: { s_i }, i = 1,2N, the inverse transformation can be performed along a suitable integration formed by {s_i}. Note that every solution of (6.3) requires the solution of a set of 2 * NP equations with bandwidth 2* NEW (NP, NEW, pertain to the

original set (6.1)).

Apart from the fact that the transform method is narrowed to few systems, large computing times will be necessary if the set $\{s_i\}$ has to be large. For studying system performance on the basis of sinusoidal input, the method is suited par excellence.

b. Time discretization methods

It is obvious that any of the well known time discretization methods (e.g. Euler, Heun, Runge Kutta, etc.) can be used for the solution of (6.1), which for that purpose can be conveniently rewritten as

 $\underline{\dot{\mathbf{T}}} = \underline{\mathbf{g}} \ (\underline{\mathbf{T}}, \ \underline{\mathbf{t}}) \tag{6.4}$

If S is time independent and there is only slowly varying input an A_0 -stable implicit method [5], enabling large time steps, can be appropriate.

In other cases an explicit method can proof to be advantageous, although numerical stability requirements impose restrictions on the choice of the time step. In most of the examples in section 7 use was made of a predictorcorrector method with enlarged stability region [6]. For "stiff"problems, that is $M^{-1}S$ has relatively large eigenvalues, a method by which part of the system is treated implicitly was developed.

Note that the system will be stiff if elements from the previous section are used due to the small capacity attached to the air temperature nodes.

7. Examples

The studies that will be reported on are or have been done to a great extent by students as a part of their Master's Degree requirements. At some stage AFEP was used to investigate the system performance. In view of the limited space available we can only mention a few studies very briefly. Descriptions will appear elsewhere in more detail.

a. "Crawl Space"

In traditional domestic building practice in the Netherlands a ventilated crawl space extends beneath the ground floor (fig. 7).



Figure 7. Crawl Space Basement

Goal of the investigation was to predict the energy savings that can be achieved by insulating the floor. In the two dimensional (2D) analysis a room element was used for the crawl space; the heat conduction equation in the soil was of course easily dealt with by using standard 2D elements. Note that this problem bears resemblance to the study of ground heat storage in some recent solar energy applications.

b. "Trombe-Wall"

The Trombe-wall (fig.8) was designed by professor Trombe [7] for the passive use of solar energy. The total system performance was studied for different parameter values. In the 2D-analysis, apart from the room element, duct elements (between inner glass plate and concrete wall) and 2D standard elements (for the concrete wall) were used. Note that in this case $S = S(\underline{T}, t)$ due to the nonlinear effects of the natural convection phenomena.

Remark: For the other walls a uniform temperature along the wall was assumed; this "lumping" approach is a fairly common practice in this kind of computation. Consequently simple 1D elements can be used for those walls, thus reducing computing times considerably.



Figure 8. Trombe Wall

c. "Givoni-House"

The system diagrammed in fig. 9 was designed by professor Givoni to be used in the Negev desert in Israel the whole year round. During winter solar energy is caught in the trap and stored in the gravel bed for later use if no immediate heating demand is present.

During summer the trap is shut; during the night, air is cooled by guiding it along the thin metal roof. Here again the gravel bed serves as a buffer, supplying daily cooling demands.

In the 2D analysis, apart from two room elements, packed bed elements were used for the pebble bed.



Figure 9. Givoni-House

8. Conclusions

It has been stipulated that through the introduction of special elements the thermal behaviour of complex systems can be simulated with the help of flexible finite element packages, such as AFEP. For the research on system design, for example in the field of solar energy use, the results can proof to be of great value. As can be expected, the research nature of the technique yet prohibits its use on a large scale. It is felt however that much effort should be put into making the approach more tractable to an other group of users as well: architects for instance might use it as a design tool.

References:

- Strang, Gilbert and Fix, George J. An analysis of the finite element method. Englewood Cliffs, N.J. 1973.
- [2] Zienkiewicz, O.C. The finite element method in engineering science. London 1971.
- [3] Augenbroe, G.L.M. Finite elements in building physics. Report DUT, Delft 1978.
- [4] Segal, A. AFEP. User manual. Report DUT, Delft 1978.
- [5] Lambert, J.D. Computational methods in ordinary differential equations. London 1973.
- [6] Praagman, N. Numerical solutions of (sets of) ordinary differential equations (in Dutch). Lecture series DUT. Delft 1976.
- [7] Trombe, F. Heating by solar radiation. Director of the C.N.R.S. Solar Power Laboratory, CNRS, Int.Rep. B-1-73-100.

Une hypothese de programmation de la recherche dans le secteur du bâtiment en ce qui concerne le contexte italien.

Giancarlo BEDOTTI, architect

Roberto VINCI, architect

Institut Central pour l'Industrialisation et la Technologie du Bâtiment(I.C.I.T.E.)-Italie

Préambule

La situation particulière de l'économie italienne, qui se caractérise actuellement par une insuffisance de resources qui ne cesse de croître, par la prévision de l'affirmation de cet état de pénurie et par un aspect général de la société marqué par des tensions et des conflits dangereux, ne peuvent certainement qu'avoir une influence négative sur le secteur du bâtiment qui se révèle "constitutionnellement délicat" en soi, et qui, justement derniérement avait donné l'impression de pouvoir se reprendre.

Mais, contrairement à tout ce que l'on s'atten dait, une série d'initiatives a mûri précisemént en cette periode, des initiatives de provenances et d'arguments différents, mais qui tendent toutes à engager et à conduire des recherches et à faire des expériences, surtout en ce qui concerne le développement des instru ments qui peuvent contribuer plus directement à la rationalisation du "processus du bâtiment" et qui représentent la garantie de la possibilité d'opérer mutuelle: la réglementation et le contrôle.

Le Gouvernement, avec l'approbation et l'étude de nouvelles lois, les Régions avec le financiement de programmes de recherche, et les Instituts de réglementation, de contrôle et de recherche, avec des initiatives à bref et à moyen terme, de mener le problème du bâtiment vers une solution, et ceci sur des bases réalistes.

En d'autres termes, il existe en fait deux sor tes d'approches au problème: d'un côté les hom mes politiques commencent, avec une série de lois et d'initiatives, à résoudre le problème de la "maison", en moderant le rôle des opérateurs, en favorisant le marché et en investissant de l'argent public dans réalisations dans le secteur du bâtiment résidentiel et de servi ces; de l'autre les chercheurs tentent de rationaliser et de réglementer les phases du pro cessus du bâtiment et de poser les bases pour une solution du prôbleme de la "qualité de la maison".

Dans le domaine des travaux d'un group de recherche qui est actuellement en activité, un programme de coordination a été spécialement mis au point, programme que l'on tente ce temps-ci d'appliquer et que l'on a sommairement transcrit dans ce rapport.

Ce programme avait pour but de fournir un tableau organique et articulé des recherches necessaires afin de doter le secteur du bâtiment des connaissances et des moyens expérimentaux nécessaires pour sa rationalisation, pour le contrôle et pour la finalisation vers une satisfaction des exigences dans des termes de qualité.

L'objectif de contribuer au développement d'un appareil normatif qui existe déjà, mais de façon inappropriée par rapport à la complexité et à la vasteté des problèmes, fait partie de la proposition.

A - Categories de recherches

Caractérisation des recherches nécessaires classées par arguments, par domaines de reche<u>r</u> ches, par méthodologies de développement,c'est à dire:

- Al-Recherches sur les performances du bâtiment
- A2-Recherches sur les niveaux de performance A3-Recherches sur les méthodes de contrôle des
- performances A4-Recherches sur les processus de mise en fo<u>n</u> ction et sur les contrôles relatifs
- A5-Recherches sur les propriétés caractéristiques des matériaux et des produits
- A6-Recherches sur les conditions d'integration des parties qui composent l'organisme du b $\underline{\hat{a}}$ timent.
 - ronnement: augmentation des encombrements, diminution de l'utilisation, variation de m<u>i</u> cro-climats, diminution des niveaux de sécurité, dispersion thermiques, etc.;
- les conséquences (dommages) de caractère technologique: reduction de l'intégrité des éléments, reduction de la durée ou de la vie utile des produits, etc.

Des recherches de cette catégorie impliquent des chercheurs spécialisés dans tous les doma<u>i</u> nes disciplinaires du bâtiment en plus des experts de chantier et de gestion et entretien des immeubles.

<u>B - Domaines d'application</u>

Pour l'individualisation des domaines d'application des recherches décrites, on a eu recours à une décomposition de l'organisme du bâ timent basée sur des critéres fonctionnels, c'est à dire sur les fonctions dominantes que chaque partie est appelée à derouler. Cette décomposition est tout à fait analogue à celles qui sont entrés dans l'usage commun aussi bien dans des normatives étrangères ou i taliennes, que dans les initiatives les plus récentes de type normatif ou expérimental qui ont été soutenus en Italie par des administrations ou par d'importants groupes publics. Dans l'individualisation, à travers la décompo sition de l'organisme, des domaines d'application possibles, on ne se refère qu'aux parties principales, en comprenant en elles toutes les spécifications secondaires qui peuvent être justifiées par la suite et dans des moments de utilisation plus détailles. On peut définir les domaines d'application de la façon suivante: B1-Organisme du bâtiment dans son ensemble B2-Fermetures extérieures verticales .1-Parois extérieures .2-Fenètres .3-Revêtements extérieurs

.4-Jonctions

```
B3-Division interieures verticales
.l-Cloisons
2-Portes
.3-Revêtements interieurs
.4-Jonctions
B - Domaines d'application
Individualisation des parties de l'organisme
du bâtiment qui représentent des unités distin
ctes du point de vue fonctionnel et souvent m\underline{\hat{e}}
me du point de vue productif, c'est à dire:
Bl-Organisme du bâtiment dans son ensemble
B2-Fermetures extérieures verticales
.1-Parois extérieures
.2-Fenétres
.3-Revêtements extérieurs
4-Jonctions
B3-Division interieures verticales
1-Cloisons
.2-Portes
.3-Revêtements interieurs
.4-Jonctions
<u>B4-Fermetures extérieures horizontales</u>
.1-Toitures
.2-Revêtements interieurs
.3-Jonctions
B5-Divisions interieures horizontales
.1-Revêtements de sol
.2-Jonctions
B6-Installations techniques et installations
   de service
B7-Structures portantes
```

<u>C - Situation des connaissances et des priorites de développement</u> Evaluation de l'état des connaissances et de la disponibilité des instruments, ou références normatives. Individualisation des priorités qu'il faut attribuer à chaque recherche (en cours).

A - Categories de recherche

<u>Al- Recherches sur les performances des éléments et sur les sous-systèmes du bâtiment</u> Les recherches de cette catégorie ont un carac tère méthodologique et appliqué. Sur la base des connaissances disponibles auprés des organismes de recherche italiens et étrangers, il s'agit de préparer des listes normalisées des exigences requises et des performances qui doivent par la suite fournir une base pour les recherches à caractère expérime<u>n</u> tal. Les listes devront être coordonnées entre elles, et elles devront provenir de méthodologies communes, du type de celles qui ont été élaborées à dessein par la Commission du Bâtiment UNI.

Lorsque les catégories les plus importantes de exigences requises (utilisation, sécurité, com fort, intégration, maintient de l'intégrité, gestion, etc.) pour les differentes sortes d'<u>é</u> léments auront été définies, il faudra explic<u>i</u> ter chaque exigence requise qui, d'après les Directives ISO, determine les comportements voulus aux éléments dans des conditions d'usage et de sollicitation déterminées.

<u>A2- Recherches sur les niveaux de performance</u> Ce sont des recherches à caractère méthodologique et expérimental. Il s'agit de definir les bandes de valeurs, d'un niveau maximum à un niveau minimum, qu'il faut attribuer aux performances des éléments afin d'en assurer la qualité, dans la mesure où les exigences des usagers, les ressources économiques et le potentiel de production le permettent. Du point de vue méthodologique général on peut présenter deux cas:

- s'il existe des normes italiennes ou étrangères de référence, la recherche consiste dans la vérification des valeurs proposées afin d'en assurer la validité et la possibilité d'application dans le contexte du bâtiment qui sera choisi, dans le fait de rendre actuelles les valeurs elles-mêmes sur la base des conditions de contexte, et enfin dans l'expérimentation de la possibilité d'assurer les valeurs correspondantes à travers des modalités d'essais opportunes;
- si par contre il n'existe pas de normes de référance, on se retrouve alors dans des sec teurs nouveaux ou qui ne sont pas suffisamment connus, il faut arriver à déterminer, à l'état d'expérience, les valeurs des niveaux de performance à travers des recherches appropriées sur la quantification des exigences des usagers et sur les comportements que l'on peut relever sur des produits présent sur le marché.

Les ressources nécessaires pour cette catégorie de recherches peuvent être reconnues dans:

- des groupes de chercheurs spécialisés;
- l'utilisation de laboratoires de recherche expérimentale.

<u>A3- Recherches sur les méthodes de contrôle</u> <u>des performances</u>

Ce sont des recherches à caractère méthodologique et expérimental. L'objectif des recherches de cette catégorie est d'individualiser pour chaque performance (d'après des critères opportuns de priorité) et pour chaque élément, les méthodes les plus appropriées pour la vérification des correspondances des performances avec les exigences requises et pour l'attestation des valeurs des performances en relation avec les niveaux fournis par les spécifications techniques.

Le procédé de recherche est le même que celui que l'on a suivi pour la catégorie de recherches précédente, mais elle se distingue par la nécessité de répéter plusieurs fois les expériences applicatives afin d'atteindre une stabilisation suffisante de la méthode.

En rappelant que les procédés de l'aptitude à l'utilisation à travers le contrôle des perfor mances ne s'appliquent que sur des éléments et des sous-systèmes, il faut définir les méthodes d'essai qui permettent, à travers la simulation des conditions d'emploi prévues, de vérifier le comportement par rapport aux sollic<u>i</u> tations typiques de l'utilisation.

Les méthodes d'essai cachent donc la double s<u>i</u> mulation des conditions d'integration dans l'immeuble (connexions, jonctions, structures, etc.).

Pour cela leur définition est particulièrment difficile et exige des cycles expérimentaux ap propriés, avant la mise au point définitive.

- essais sur assemblages réels, qui consistent à soumettre aux sollicitations différentes les éléments ou les sous-systèmes montés en laboratoire d'après les procédés déclarés par le producteur;
- essais sur assemblages fictifs, qui consistent a soumettre aux sollicitations différentes des éléments ou des sous-systèmes montés sur des chassis ou des structures appropriées en laboratoire, structures qui sub stituent et simulent les conditions réelles, afin d'isoler ou mettre en évidence des réaction particulières;
- essais sur chantillons, qui consistent à soumettre à l'action de plusieurs agents des échantillons significatifs de l'élément, afin d'en assurer le comportement intrinsèque, et cela indépendamment des conditions de jonction et de montage;
- essais pendant l'utilisation, de type non destructif, que l'on effectue sur le chantier et qui tendent à donner de nouveaux co<u>n</u> tenus au moment du contrôle, que l'on connait comme vérification "en situ".

Cette catégorie de recherche peut être dévelop pée si l'on a à disposition, en plus d'une équipe de chercheurs spécialisés, des laboratoi res et des appareils appropriés.

A4- Recherches sur les processus de mise en <u>fonction</u>

Ce sont des recherches de type analytiques et expérimental. Elles consistent en une analyse des opérations et des moyens de travail nécessaires pour la réalisation, (en général sur le chantier) d'éléments constructifs, et dans leur rationalisation successive afin de garantir le respect des exigences requises. L'objectif des recherches de cette catégorie est la traduction en termes actuels, rationnels et normalisés des régles de l'art, afin d'arriver à travers des "codes de pratique" à garantir pour des processus et des produits qui n'apportent aucune innovation, un niveau accettable de performance. Il faut trouver les inputs de ces recherches, d'un côté dans les recherches sur les performances globales de l'immeuble et partiales de ses parties constituantes, de l'autre dans la connaissance des technologies de réalisation disponibles, dans un moment historique précis, pour des bandes de marché déterminées. Les ressources nécessaires sont constituées par des groupes de chercheures spécialisés qui représentent les différents secteurs technolo-

A5- Recherches sur les propriétés caractéristi ques des matériaux et des produits et sur les contrôles relatifs

giques.

Ce sont des recherches à caractère appliqué et expérimental. Ces recherches équivalent aux re cherches analogues sur les performances des éléments, mais elles se rapportent toutefois aux propriétés caractéristiques des matériaux

et des produits pour lesquels il est difficile, voire impossible, d'individualiser des performances qui leurs sont propres.

La recherche continue avec l'identification dans les produits, d'après les destination pré férentielles, des propriétés desquelles dépendent ces performances.

Il sera donc possible d'établir des niveaux de valeurs pour ces propriétés et les procédés d'essai qui en découlent.

L'objectif de ces recherches est de parvenir à la mise au point des normes de conformité et de procédés pour le contrôle de conformité des produits au "type" pour lequel des essais de correspondance aux performances ont été prévus. Les recherches de cette catégorie impliquent. en plus des chercheurs qui proviennent du secteur du bâtiment, des chercheurs d'autres disciplines mélées et complémentaires aux disciplines du bâtiment, comme la chimie, la physique, la mécanique, etc.

A6- Recherches sur les conditions d'integration des éléments dans l'organisme du bâtiment

Ce sont des recherches à caractère appliqué et expérimental. Elles concernent les règles d'in tegration (dimensionnelle et fonctionnelle) des parties de l'organisme entre elles, et l'é tude des conséquences positives ou négatives sur les performances qui dérivent de la connexion.

Il faut examiner en particulier:

- les conditions dimensionnelles de connexion: coordination dimensionnelle, contrôle des to lérances, discipline des joints:
- les conditions fonctionnelles de connexion: maintient des niveaux de performance exigés par le milieu et fournis par les éléments;
- les conséquences (dommages) dues à l'envi-

<u>B4-Fermetures extérieures horizontales</u> .l-Toitures

.2-Jonctions

- <u>B5-Division interieures horizontales</u> .1-Revêtements de sol
- .2-Jonctions
- <u>B6-Installations techniques et installations</u> de service

<u>B7-Structures portantes</u>

Ainsi que l'on peut remarquer, les deux derniers point ne présentent pas de spécificationes ultérieures, dans le sens que pour celles-ci on a l'intention de limiter le domaine des recherches aux seules conditions d'integration (recherches de catégorie A2).

Ce choix est motivé par le fait que dans ces secteurs, qui impliquent trés souvent la sécurité, la 'recherche et la normative, même en ce qui concerne les performances, est plus évoluée que dans les autres.

Sommaire

Dans ce texte on traite les problèmes que la recherche dans le secteur du bâtiment doit affronter actuellement en Italie, à la lumière des perspectives et des volontés nouvelles qui ont émergé dans différents sièges institutionnaux, et on indique les principaux sujets de recherche qui seront approfondis au cours des années à venir.

Summary

In this report we deal with the problems which the building research must cope with in Italy now, in view of the new perspectives and wills, present at various institutional levels, and we also indicate the main subjects of research which will be studied in deep in the next few years.

*

Une banque de donnees sur les dispositions pour le bâtiment. Perspectives de gestion et d'emploi.

. Denate BERTOLA. chimiste

Gianni CAROLI, physicien

Fulvic NALDI, physicien

Reberte VINCI, architect

Institut Central pour l'Industrialisation et la Technolcgie du Bâtiment (I.C.I.T.E.), Conseil National des Recherches (C.N.R.) - Italie.

Préambule

La situation actuelle du système normatif italien. surtcut en qui concerne le secteur du bâtiment, présente encore sous certains aspects des graves lacunes et scus d'autres au contraire, des superpositions.

En consideration de ce fait nous estimons nécessaire de fcurnir dans la préface une série d'indications de information afin de permettre une interprétation plus immédiate du cadre institutionnel et des niveaux normatifs qui existen en Italie, tcut en apportant une série de simplifications sur les rapports "au contour" pour tenir compte des exigences de communicabilité en siège international.

La structure institutionnelle et les contenus generaux des normes aux differents niveaux.

Les "scurces" des normes en viguer en Italie sont surtcut les Organismes de Geuvernement, c'est à dire le Etat, les Régions et les Municipalités qui émettent des dispositions qui représentent les Lois, les Décrets et les autre types d'Actes délibératifs dans lesquels cn établit les dispositions relatives à la gestion du "Prc cessus du Bâtiment" et de ses cpérations.

Ces Lcis, Décrets et Actes Délibératifs peuvent fiser directement de véritables dispositions normatives: ils peuvent se rapporter (en les rendant ainsi cbligatci+ res) à des dispositions émises par d'autres Instituticns même si elles ne scnt pas publiées; ils peuvent denner mandat à des Organismes publics cu nen de déterminer des normes qui deviendront par la suite obligatoires.

En cutre, puisqu'en Italie in n'y a ni un Institut Central pour la recherche du bâtiment, ni un Organisme public de réglementation, les systèmes de détermination des dispcsitions son très hétérogènes.

Les normes, qui peuvent être établies au sein d'insti tutions publiques et privées, naissent essentiellement au moment cù une Loi dicte de façon autonome une dispositicn normative, cu bien indique et identifie une structure chargée de les élaborées.

Une Lci spéciale de l'Etat (D.lg.lt. 1/3/1945, nº82) confie au Conseil National des Recherches (C.N.R.) la tâche de "dresser des normes techniques de caractère gé néral....pcur l'acceptation, l'essai et l'unification de matériaux, instruments, appareils, machines et acces scires divers pour des emplois techniques et scientifiques, ainsi que de normes pour la réalisation, l'essai et la protection des installations et des constructicns".

A part le C.N.R. et dans le domaine spécifique des ncrmes relatives à la sécurité statique, il y a un autre Organisme public qui émet des dispositions : le Con seil Supérieur des Travaux Publics qui travaille à le interieur du Ministére des Travaux Publics.

A l'exception de ces organismes qui font directement partie de l'organisation de l'Etat, les normes sont établies par les différents Mnistères, les Régions et

les Municipalités à travers des procédures différentes comme par exemple:

-Conventions avec des Organismes Publics (Université, etc.):

-Conventions avec des Organismes privés de recherche et d'expérimentation;

-Conventions ou charges attribuées à des opérateurs pro fessionels.

Un discours à part doit être fait pour certains Organismes de réglementation qui, tout en n'étant pas pue blics et n'étant pas reconnus comme tels du point de vue juridique, cnt acquis avec le temps une efficacité et une autcrité telles que leur action est reconnue dans le dcmaine ncrmatif: il s'agit de l'Organisme Italien d'Unification (U.N.I.) et du Comité Electronique Italien (C.E.I.) qui partecipent cfficiellment, à travers des tâches relatives aux normes qui lui sont attribuées. (Fig. 1)

L'U.N.I. en particulier s'cccupé de "l'étude et la ré daction des normes techniques concernant l'unification": le C.E.I. s*cccupe au contraire de "l*étude et la rédac ticn des normes techniques concernant l'électrotechinique, ainsi que l'unification dimensionnelle relative". Un autre cas particulier dans le domaine des systèmes d'élaboration des normes en Italie est représenté par le procédé qu'on suit actuellement en ce qui concerne les normes nour le Bâtiment Résidentiel Public.

Dans ce secteur, cù la lci prévcit la promulgation de "normes techniques nationales" et par la suite de "normes techniques régionales", les normes techniques natio nales scnt mises au pcint par un Organisme mixte Etat-Régions: le Comité pour le Bâtiment Résidentiel (C.E.R.).



Figure I. Schéma des ccrrélations fonctionnelles qui existen dans la détermination des normes.

- 1:Organismes consultatifs de recherche, d'experimentation, techniques, professionels, etc.(C.N.R., Uni versité, U.N.I., C.E.I., etc.).
- 2:Organismes legislatifs (Etat, Régions, Municipalités).
- 3:Prccessus du Bâtiment.
- A:Les Organismes législatifs, au cas cù ils n'y pourvcient pas directement attribuent, à travers des conventions appropriées, la tâche d'élaborer des projets de norme.
- B:Les Organismes chergés élaborent des projets de nor me.
- C:Les Organismes législatifs transforment les projets de norme en normes obligatoires et émettent leurs ncrmeş.
- D:Certains Organismes particuliers, qui cnt comme tâche statuaire celle d'élaborere des normes (par exemple 1*U.N.I. et le C.E.I.), mettent au point des normes qui ont une valeur de "Recommandations". Ces Recommandations peuvent devenir obligatoires lcrsqu'en s'y rapporte dans les Cahiers.

Un systeme pour la gestion des donnees sur les normes Dans une situation de ce genre et en considération du fait que l'information sur l'existence et le contenu

des normes étrangéres représente un aide considérable pour le développment rationalisé du "Processus du Bâtiment", il faut souligner l'expérimentation que l'Institut Central pour l'Industrialisation et la Technologie du Bâtiment (I.C.I.T.E.), du Conseil National des Recherches (C.N.R.)a entrepris pour la gestion des données sur l'ensemble des données du bâtiment.

Un fait essentiel en faveur de l'ensemble des normes sur le bâtiment est représenté par l'organisation d'un système d'information qui utilise les techniques d'élaboration electronique les plus modernes, à travers lequel on peut réaliser la récolte et l'analyse des domnées, leur mise à jour constante et rapide, le caractére accessible de l'information pour tous les opérateurs intéressés, l'emploi des vérifications à reculons comme élément de correction des données, et qui assure un flux et reflux continu de renseignements "de" et "vers" les différentes centres de décisions et opérationnells, en se basant sur une récolte systématique et codifiée de façon organique des lois et des normes en viguer (en Italie et à l'étranger) avec les mises à jour respectives.

C'est pourquei l'I.C.I.T.E. a cré à l'intérieur de lui-même, un centre peur l'analyse, l'élaboration et la recherche automatique des informations techniques, en accordant une attention particulière à l'industrie du bâtiment, afin de permettre le repérage de toutes les informations sur les normes, les documents techniques, les expressions brèves, les dates, les profils techniques, les définitions particulières, etc..

<u>Fonctionnement de ce système</u>

Le SCRAIE (Système d'Interregation Directe pour la Recherche Automatique d'Informations sur le Bâtiment), est un système expérimental qui permet de trecuver des informations et de sélectionner des documents techniques, aussi bien à partir de la méthode <u>Batch</u> (c'est à dire en parlant avec l'ordinateur et en lui posant les questions, en changeant à fur et à mesure les stratégies d'interregation selon les réponses précédemment obtenues pendant la même séance) et de visualiser les informations les plus importantes des documents choisis, sur le terminal et/cu sur le papier.

Ce système prévoit, a travers l'U.N.I., la partécipa tion au "circuit <u>Isonet</u>, qui est un système international d'échanges et d'informations entre les différentes Organismes de Réglementation qui font partie de le I.S.O., et qui permettra notamment aux opérateurs de re cevoir immédiatement des informations à propos de l'exi stence de normes étrangères sur un sujet déterminé.

Les petites et mojennes industries surtout pourraient être très avantagées par un service éventuel dirigé par des Organismes comme l*U.N.I. cu le C.N.R.. Elles pouraient ainsi repérer plus rapidement les normes à respecter pour avoir accès aux marchés extérieurs, lors par exemple de concours internationaux d'adjudication ou autre.

On ne l'a pas enccre établi mais cn estime que des crganismes comme l'U.N.I. cu le C.N.R. pourraient le diriger, en prévoyant un réseau approprié de ter minaux sur tout le territoire national, en se servant éventeullement même du réseau de terminaux du CNUCE (qui existe déjà).



Figure II. Schema de synthèse du fonctionnement de ce systeme.

- A:Norme U.N.I., I.S.O., C.N.R.,...,Dccument technique B:Synthèse
- C:Classification et codification
- D:Gectcr
- E:Thesaurus
- F:Usager
- **G**:Interrogation
- **H:**Date de base
- :Mémcire
- L:Système de gesticn des informations
- M:Editcr
- N:Informations sur le système
- O:Informations statistiques
- P:Thesaurus
- Q:Impression des informations les plus importantes
- 3:Qui est-ce qui peut s'en servir.
 - Organismes cu Instituts de Réglementation et de recherche Service Technique du Ministère; Industries; Biblicthèques; Organisations dans le domaine du bâtiment; Commettants; Auteurs des projects; Usagers finaux.
- Le sense de l'expérimentation en cours.

Avant de commencer cette expérimentation on s'est posé le problème de trouver un instrument en mesure de poser et de résoudre les problèmes de recherche, d'orientation, de consultation et de découverte d'informations sur l'ensemble des normes techniques de l'industrie du bâtiment, ces problèmes que les opérateurs du procéssus du bâtiment doivent affronter chaque jour dans leur travail, et qui comportent des temps longs, la nécéssité d'une mise à jour continue, des difficultés de consultation.

On s'est servi beauccp de l'expérience d'autres pays, en la adaptant à la situation italienne et là cù il a été possible, en l'enrichissant de nouveaux contenus et en cherchant à comprendre les exigences des usagers à venir; ce système est toutefois encore perfectible et nous estimons (et c'est justement en relation à la possibilité de commencer un dialogue avec les "personnes préposées aux travaux" que nous avons voulu divulguer ce qui est encore un service "en devenir") que celà sera réalisable à travers les apports critiques de genre constructifs des opérateurs intéressés.

1:Qu'est-ce-qu'il y a dedans.

- Le texte contient sutcut le informations suivantes -pays qui a établi la ncrme;
- -ncm de la norme;
- -Organisme qui l'a émise;
- -validité de la norme (nationale et internationale); -scus-crganisme du groupe de travail par lequel le dccument a été rédigé;
- -titre de la norme;
- -prix de la norme;
- -descripteurs (leurs introductions ont été nécessaires pour conformer notre expérience à la collaboration internationale qui admet même uniquement l*emplci d*un Thesaurus pcsitif);
- *ccdification du contenu des normes selon le Code Décimal Universel;
- -résumé de la norme;
- -documents nationaux et internationaux auguels on -variations par rapport à l'éventuelle édition pré cédente
-
- 2:Qui est-ce qui le dirige.

Actuellement le Thesaurus et tous les termes introduits dans la machine pour chaque document (sauf ceux expréssement éliminés) permettent de poser des questions du genre indiqué plus lcin, en recevant comme réponse une liste de références, de documents avec abstracts, dates, titre. description, etc ..

- Exemples de interrogation.
- Recherches sur les dates (identification de l'enregistrement et du dccument).
- -Quels sont les documents postérieurs (entérieurs) à cette date sur tel suject?
- -Quelles étaient les normes en vigueur pendant cet intervalle de dates, sur tel sujet, afin de définir une contestation?
- -Quelles scnt les normes annulées remplacées, entre tel le et telle autre date?
- -Quelle est la norme qui concerne tel sujet?
- -Quelles normes sont devenue décrets-loi, et quand?
- -Quel est le numérc du dccument et la date d'émission de tel produit?
- -Quelle est l*crigine administrative, légale...de tel document?
- Recherches_sur_les_sujets_et_les_titres_(caractéristiques biblicgraphiques).
- -Y-a-t'il une norme sur tel produit?
- -Y-a-t'il une norme qui fornuit une prevue déterminée sur tel produit?
- -Y-a-t*il une norme qui décrit le matériel employé pour la fabrication de tel produit, destiné à....?
- -Quelle est la liste des normes qui se rapportent à tel matériel? (ex. acier)
- -Quelle est la liste de toute les normes italiennes qui traitent un sujet déterminé? (ex. chaleur, securité) Recherches sur la définition d'un produit (description
- du contenu). -Quelle est la définition normalisée (ex. les symboles) de tel produit?
- -Quelle est la définition normalisée italienne de tel produit correspondant défini par la norme étrangère X?
- •Quelle est la composition chimique normalisée de tel prcduit (ex. jet de fusicn pcur tel alliage) ?
- -Quelle est la 1ci qui définit tel produit?
- -Quels scnt les documents qui cnt la valeur X du C.D.U.?
- Recherches sur les documents reliés entre eux (rapports entre les documents du même territoire, nation ou non) -Quels sont les documents reliés par la norme X? "Y-a-t'il une norme francaise conforme à telle norme
- I.S.O. cu à telle norme d'un autre Organisme?

- -Y-a-t'il une norme du M.E.C. cu une norme internaticnale conforme à telle norme française?
- -Quelle est la ncrme en viguer qui ccrrespond à celle qui a été annullée?
- -Quelle scnt les normes francaise sur tel sujet traduites en telle langue?
- -Quelles sont les normes étrangères traduites dans la langue italienne?
- -Quelles scnt les normes U.N.I. qui appliquent les dispositions de telle norme fondamentale? (ex. les normes qui menticnnent des dimensions de produits calibrés s<u>e</u> lon la série de numéros normaux).
- -...?
- Recherches_sur_le vccabulaire ncrmalisé (Thesaurus). -Quels scnt les dccuments qui emplcient les termes définis par la norme X?
- -Quelles sont les normes qui contiennent des définitions sur tel sujet cu tel prcduit?
- -Catalogue de glossaires
- -Table des termes nomalisés
- -Vccabulaire de traduction des termes normalisés
- Recherches_pcur la_diffusion_sélective.
- -Quelles scnt les normes nouvelles sur tel sujet par mcis cu par an?
- -Quelles scnt les normes modifiées, remplacées cu non, sur tel sujet par mcis cu par an?
- -Nous commercialisons le produit X et nous avons des difficultés de terminclogie, de traduction de termes normaux. Quel est le term correct?
- -Catalcgue des glossaires et table des termes normalisés et publié selon la spécialité.
- Dans un avenir déscrmais voisin (probablement à la fin de 1980 si le staff actuel, limité, reste tel) cu terminera l'introduction de toutes les normes U.N.I., C.N.R.-U.N.I., C.N.R., I.S.O., et si l'issue des contacts qu'en est en train de définir sera positive, même de l'ensemble des normes techniques d'autres pays (par ex.la Pclcgne, la Belgique, la France, etc.); en. tre-temps cn continuera à mener des recherches pour déccuvrir de nouveau domaines d'interrogation pour une meilleure expcitation des données mémorisées,
- Les problèmes qui continuent à se poser.
- Grâce à ce système on peut repérer et chcisir des dccuments intéressants, sans le texte complet, aussi bien dans le domaine national qu'international.
- Comment obtenir le texte complet, cù trouver, comment faire pcur le consulter, etc....en temps et mcdes appropriés et d'une façon analogue rapides par rapport au système présenté (par exemple, à travers micrcfilm, introduction du texte complet, possibilité de reprodution phctcgraphique cu télévisive, etc.); vcilà les prcblèmes qui dcivent enccre être discutés et auxquels cn dcit si possible trouver une réponse dans l'inteéret im médiat de tous les usagers potentiels de ce projet de "Service".
- _____ BIBLIOGRAPHY:
- -Selection and acquisition of data base management systems. Report of the CODASYL Systems Committee. March 1976.
- -I.B.M. system/370 storage and information retrieval system/virtual storage, General information, I.B.M. nºGH12-5114.
- -J.B. FRY EHSIBLEY, Evclution of data management system ACM. Computing surveys. -Vcl. 8 nº1 March 1976.
- -G. BUCCI D.N. STREETER. A methodology for the design cf distribuited information systems, Communications of
- ACM. Vcl. 22 nº4 April 1979,

- -R. ERBR G. WALCH, A general interactive guidance for information retrieval and processing system. APL 1976 Conference proceeding. Ottawa 1976.
- -G. CAROLI F. NALDI.*Prcgettc SCRAIE, prccedure di ristrutturazione del Thesaurus ISO. Report 790906/583.
 -F. NALDI.*Thesaurus ISO: formato nastri e loro utilizzc. Report 771103/510.
- -G. CAROLI F. MUSSIO F. NALDI.*Progette BANOR il si stema di immissione e controlle delle norme Report 770329/491.
- -D. BERTOLA G. CAROLI F. NALDI R. VINCI.*La ncrmativa tecnica per l'edilizia : un sistema per una ccnsultazicne rapida. Repcrt 781221/558.
- -Principles guiding standardization in Italy.U.N.I./C.E Italian contribution to ISO/TC 59. February 1979.

SUMMARY.

This report includes a general foreward on the Italian institutional situation about regulations as well as the "phylosophy", the contents and the methods of a "Data Bank for Building Regulations" which has recently been created and we also give an outline of the running and use possibilities.

SOMMAIRE.

Dans ce texte , apès une préface à titre d'information sur la situation institutionnelle italienne dans le domaine de la réglementation, on présente la "philosophie" les contenus et la méthodologie d'une "banque normative des dennées pour le bâtiment" récemment cuverte, et on en trace les perspectives de gestion et d'emploi.

^{*} Internal Reports of I.C.I.T.E./C.N.R.

Concrete strength as function of time and water/cement ratio in isothermic setting
A.A. Bezverkhii,Cand.Sc., (Engineering), V. I. Nikitinskii, Engineer
Siberean ZNIIEP, Novosibirsk,U.S.S.R

<u>Summary</u>. On the basis of investigation of concrete as a composite material with a certain degree of structural disorder and consideration of the portland-cement hydration process as binder dissolution, the rate of which is determined by the topochemical reaction between water and cement on the grain surfaces of the latter and by the diffusion of the products into the bulk, an equation for the relationship between cement strength and the setting time and water/cement ratio has been obtained, allowing cement strength to be calculated for different setting times and water/ cement ratios after four empirical parameters have been determined.

Sommaire. L'équation de corrélation de la solidité du béton avec le temps du durcissment et le rapport eau-ciment a été reçu à la base de l'étude du béton comme un matériel composé, qui a la structure hétérogène non ordonnée d'un certain degré d'ordre et en considérant le processus d'hydration du ciment portland comme la dissolution du liant, la vitess duquel se détermine par la réaction topochimique eau-ciment à la surface des granules du ciment et la diffusion des produits en volume. Le résultat de ces études permet de calculer la résistance du béton pour les differents rapports eau-ciment après avoir déterminé d'une façon préliminaire des quatres paramètres empiriques.

General problem of controlling the concrete product quality involves predicting an increase in concrete strength (R_c) with time ($\boldsymbol{\mathcal{L}}$) for different water/cement ratios (W/C), i.e. obtaining an equation of the form $R_c = R_c$ ($\boldsymbol{\mathcal{T}}$, W/C). In the work reported here,this problem has been solved on the basis of an investigation of the relationship between concrete strength and porosity factor (P) and of the kinetics involved in portland-cement hydra tion process. On the basis of investigation of composite materials with a certain degree of structural disordering, a porous body strength equation has been obtained in /I/:

$$R = R_{o} \exp(-\frac{P}{I-P})$$
 (I)

wherein $R_0 = R$ when P = 0

G is strength reduction rate. The cement stone porosity $P=(W/C - x)/(W/C+I_3 x)$, wherein x is amount of chemically combined water; I.3 x is hydrated cement volume (it has been taken: **G** = 3.I g/cc; the value of x after complete hydration of I g of cement (a_m) is 0.25 g). By virtue of this, we may obtain a relation between cement stone strength R_{cem} and x:

$$R_{cem} = R_{OI} \exp \left(-\beta_{I} \frac{W/C}{x}\right) (2)$$

wherein: $\beta I = \beta/2.3;$

 $R_{OI} = R_{O} \exp (\beta_{I}).$

To check up Eq. (2), it may be transformed to: $x \ln R_{cem} = \alpha \ln R_{OI} - \beta_I$ W/C (3) The above equation is that of a straight

line in the x $\mathcal{E}n \xrightarrow{R} x$ coordinates, which permits, in particular, to calculate \mathcal{F}_{I} and $R_{OI}(R_{O})$. The graphical assessment of Eq. (3) is presented in Fig. I.



Figure I. Graph of dependence $x \ln R_{cem}=f(x)$ [2].O, 0, \odot , \bullet , Δ , x are W/C=0.157; 0.25; 0.50;0.65; and 0.80. R_{cem} is in conventional units (1b on gauge).

Now, to determine the concrete strength the effect of the filler materials must be taken into account. According to II:

$$R_{c} = \mathbf{O}^{a} R_{cem}^{I-a}$$
(4)

wherein **6** is aggregate stress at concrete specimen fracture;

a is volume fraction of the aggregate.

Assume that $\mathbf{6} = bR_{cem}$, wherein b is proportionality factor, then:

$$R_{c} = b^{a} R_{cem} = R_{0I} b^{a} \exp(-\beta_{I} \frac{W/C}{x})$$

To obtain $R_c = R_c (\mathcal{T}, W/C)$ we should know $x = x (\mathcal{T}, W/C)$. In /3/ on the basis of investigation of portland-cement hydration process as binder dissolution process whose rate is determined by the topochemical reaction on the latter's surface and diffusion of the reaction products into the material bulk, it has been obtained for the diffusion period of hydration:

$$\mathbf{x} = \frac{\mathbf{k}_{\mathbf{d}} \mathcal{T} \ W/C}{V(\mathbf{I} + \mathbf{k}_{\mathbf{d}} \mathcal{T}/\mathbf{a}_{\mathrm{m}})} , \qquad (6)$$

where k_d is difusion rate constant; and

 $V = W/C + I/\rho$. Substituting (6) into (5),we have:

$$R_{c} = R_{OI} b^{a} \exp \left(-\beta_{I} V(I/k_{d} \mathcal{T} + I/a_{m}) \right)$$
(7)

Equation(7) above gives the concrete strength (R) in terms of setting time (\mathcal{L}), water/cement ratio (W/C), and the volume fraction of aggregate a . To be able to calculate concrete strength, using this equation, four time- and water/cement ratio-independent parameters have to be known: R₀, $\beta_{\rm I}$, kd and b . R₀which characterizes the strength of the solid phase of the cement stone per se (R₀=R_{cem} when P = 0) and $\beta_{\rm I}$ -strength reduction rate with increasing porosity can be calculated, as mentioned above, from Eq. (3). The diffusion rate constant kd depends on temperature according to the Arrhenius law:

$$k d = k d_0 \exp(-\frac{E_a}{RT}),$$

where k_{do} is exponential factor; R is gas constant; T is temperature, ^OK; E_a is activation energy (approx. 8 kcal/mol)[3] and is calculated from the water combination kinetics from Eq. (6).

The value of b is determined from the condition of proportionality between the aggregate stresses **d** and cement stone strength R_{cem} , in which **d** is calculated as $d = k_g R_g / (k_f + R_g)$ [4], where R_a is aggregate strength; and k_d is stress at aggregate-cement interface determined as $k_d = I.4I(I-\beta) / \beta P_k^{I.5} / V$, obtained as a product of the aggregate volume percentage and cement gel volume percentage and one contact strength P_k [5].

Processing of test data has given the following values of the aforementioned parameters for compression strength calculations: portland-cement M400: $R_0=83.4$ MPa, M500: $R_0=$ 93.4 MPa; M600: $R_0=104$ MPa; b=I.2 (crushed granite-aggregated concrete); for bending tensile strength M400 $R_0=12.0$ MPa; b=0.68 (crushed granite-aggregated concrete); $\beta_I = 0.45$; $k_d = 0.22$ I/ day at 20° C.

Concrete strengths calculated according to Eq. (7) are given in Tables I-3.

Table I

Crushed granite concrete strength (a=0.74) under compression, MPa. Portland-cement grade M600, standard storage (data of <u>Rosenberg</u> <u>T.I. et al</u>.:numerator-calculated, denominatorexperimental). R = IO4 MPa; β_{I} = O45; k_d =0.22 I/days; b_{a} =I.15.

WZC		Setti	ing time,	days	
.,, 0		7	28	90	360 _
0.36	•	45.2	52.4	54.3	55.0
		44.7	49.3	51.3	54.6
0.45		<u>37.4</u> 40.3	<u>44.3</u> 42.6	<u>46.0</u> 47.8	<u>46.7</u> 51.2
0.60		27.2	<u>33.4</u> 30.9	<u>35.I</u> 36.8	<u>35.6</u> 38.7

Table 2

Crushed granite concrete compression strength (a=0.74, MPa. Portland-cement grade M600; added I6% NCM of the initial water weight; setting temperature $t = -10^{\circ}$ C (data of <u>Rosenberg T.I. et al.</u>) (numerator-calculation, denominator-experiment). R = I04 MPa; $\beta_{I} = 0.45$; k d = 0.04I I/days; b = I.15.

	_			
	1	Setti	ng time,	days
, .	7	28	90	360
0.36	<u>19.2</u>	<u>42.3</u>	<u>50.8</u>	<u>54.0</u>
	21.4	41.3	50.0	52.3
0.45	<u>14.3</u>	<u>31.8</u>	<u>42.6</u>	<u>45.6</u>
	15.8	28.3	40.7	48.6
0.60	<u>8.6</u>	<u>25.1</u>	<u>32.1</u>	<u>34.8</u>
	9.9	22.5	29.3	38.7

Tai	b1	е	3
10	~-	<u> </u>	_

Crushed granite concrete tensile strength in bending, MPa. Portlandcement grade M400, standard storage (data of <u>Rybiev</u> /6/; numerator-calculation, denominator-experiment). $\mathbf{R} \neq I2.0$ MPa; $\boldsymbol{\beta}_{I} = 0.45$; k=0.22 I/days; b = 0.68.

Material	wze	a	Setting	time,	days
Ma voi rar	, c	ű	.//	28	90
Cement sto:	0.23 ne	-	<u>5.9</u> 5.6	<u>6.7</u> 6.8	<u>6.9</u> 7.8
(0.25	0.23	<u>5.2</u> 5.2	<u>5.9</u> 6.2	<u>6.I</u> 7.I
Concrete	0.32	0.58	<u>3.9</u> 3.7	<u>4.2</u> 4.5	<u>4.7</u> 5.3
	0.38	U.70	<u>3.3</u> 2.8	<u>3.8</u> 3.6	<u>4.0</u> 4.1

Thus the obtained equation of the relation between the concrete strength and setting time,water/cement ratio, and aggregate volume proportion, as described in this paper, makes it possible to accelerate determination of estimated standard characteristics of concrete and their variation in time, which is one of the urgent problems in construction.

References

I. Bezverkhii A.A. "<u>Sviaz' svoistv materialov</u> <u>s energeticheskim sostoianiiem otdel'nykh</u> <u>komponentov mnogofaznoi sistemy</u>". Izv. VUZ'ov, ser. "Stroitel'stvo i arkhitektura",1972(vyp. 9).str. 68-74.

2. Taplin J H. <u>A method for following the hy-</u> <u>dration reaction in portland cement paste</u>. Australian Journal of Applied Science,v. IO, No 3, I959. 3.Nikitinskii V. I. "Kineticheskie zakonomernosti gidratasii i strukturoobrazovaniia portlandtsementnogo kamnia i betona". V sb. "Rekomendatsii po proizvodstvu rabot v zimnee vremia". Zapadnosibirskoe knizhnoe izdatel'stvo, Novosibirsk,1979,str. 49-55.

4. Bezverkhii A. A.,Milkov V. V. "Otsenka napriazhenii v zapolniteliakh po ikh epleniiu s rastvornoi matritsei betona". V kn."Primenenie kompozitsionnykh materialov v stroitel' stve". Izdatel'stvo KhabPI,Khabarovsk,I975.
5. Pines B. Ya., Sirenko A.F., Sukhinin N. I. "Zakonomernosti mekhanicheskoi prochnosti u tel,poluchennykh spekaniem poroshkov metallov" V kn. "Issledovaniia po zharoprochnym splavam" AN SSSR (t.3), M. 1958.

6. Ryb'ev N. A. Stroitel'nye materialy na osnove viazhushchikh veshchestv. Stroiizdat,M., 1978,str. 309 The balance method for value analysis in the construction industry

by Dr W.J. Diepeveen and J. Benes, eng.(Netherlands)

SUMMARY

The use of value analysis in the construction industry is confronted with several difficulties, mainly originating from the rather complicated construction process and the complicated product of the industry. So far most uses of value analysis for the construction industry have concentrated on the value of completed buildings. The balance method for value analysis in the construction industry however is developed as a decision methodology for evaluating alternatives in the choice of materials and components for enclosures, inner walls and partitions and finishings only. It is based on the assumption that on the market as a whole a certain point indicates an equilibrium between the average price of a product and its average function.

The balance method compares different products for a certain use with the average functions and prices of comparable products on the market. This is worked out in an evaluating system.

The method has been tried out for the use of window pane in dwellings.

2. Value analysis in the construction industry

The balancing of functions against costs is a continuous activity in the construction process. It should of course be done in design stage but several problems in the use of components have even still to be solved during the execution on site. The construction process is further a complicated process with several partners to collaborate. A good method to evaluate different solutions would be very welcome. It would help to solve many problems.

3. The concept of value analysis

Value analysis is a technique that wants to define (as exactly as possible) which function is needed. It tries to estimate the value of the function and wants to meet this function against the lowest possible costs. We present a systematic decision method that evaluates different alternatives step by step in order to find an optimal solution.

4. The concept of value analysis in the construction industry

Value analysis is needed in the stage in the building process where one or more partners have to reach decisions about the plan, the structure, the materials or components to be used. We think that value analysis is most urgently needed in design stage. In this stage there are different decision levels:

- 1st level decisions about general plan, design, functional parts etc.
- 2nd level decisions about structure, spans etc.
- 3rd level decisions about enclosures, facades, roofs etc.
- 4th level decisions about inner walls, partitions etc. 5th level decisions about finishings, fittings etc.

So far the use of value analysis has been investigated for the levels 1 and 2. This has led mostly to techniques for evaluation of plans, analysis of costs and results, methods for cost reduction etc. But it did not come down to true value analysis. This seems to be rather different in the construction industry.

In this study we try to apply value analysis for the levels 3, 4 and 5, the lower decision levels. Costing and evaluation of functions will then be easier. We limit ourselves to products or components for

-	finis	hings		level	5
-	inner	walls,	partitions	level	4
-	encios	sures		level	3

Our method should be used for one category of buildings at a time. Inner walls for dwellings cannot be compared with partitions in factories. Finishings in sporting halls should meet other demands than finishings of roads. Internal doors in dwellings are different from those in hospitals. Within a certain category however components can be compared easily.

We limit the balance method for value analysis to the fase of design and to those products and components that are in use for enclosures, inner walls and finishings of buildings.

5. The balance method

In daily life we often decide to buy a certain product (e.g. a house, a kitchen) on the argument: 'it's worth it', or 'it's a reasonable price' or 'we think it's normal'. In those cases we feel that there is a balance between costs and functions. Although this is a personal judgment it has a normative basis, because it is founded on a certain quantity of subjective opinions.

694

In a certain district different houses have their own market prices, depending on their attributed functional qualities. An exorbitant demand price will give the impression of disturbing the balance between qualities and costs. We will find that house 'too expensive'. The balance method makes use of this subjectivenormative point of equilibrium between properties and costs for different products and components. The method evaluates the average function and the average costs for different comparable products, all fit for a certain use or a certain building component. This average situation is considered to be a situation of equilibrium. Alternatives can be evaluated on the basis of this equilibrium.

The method is developed roughly as follows:

- . Within a certain category the alternatives for use of a product in a building component are established. The properties, which will influence the aimed function of the product are described.
- . Each of the properties of the product is evaluated in points weighted according its importance, since not every property is equally important. The market prices of the product are listed as well.

- . The total quantity used nationally of each product or product type used for a certain building component will lead to a weighted average of points per unit for an average product on the basis of the information for all products or product types (m³, m², pieces etc.)
- . In a similar way the weighted average of costs in guilders per unit of product can be found for the component concerned.

used for that building component.

- . The weighted average of points and costs per product unit for the component concerned on the balance is considered to be the subjective-normative situation of equilibrium (x points = y guilders).
- . The properties of each product that can be used for the component concerned are evaluated in functions (points) and costs (guilders). The balance shows whether the product is better than average and how much in points and guilders the advantage will be.
- We illustrate this principle in a diagram.

Figure 1



In order to weigh the differnt functions the successive comparing method of Churchman, Ackoff and Arnoff has been chosen.^['] This method uses a build-up of a total function through partial functions, as illustrated below.

Total function partial function

partial functions



The partial functions on the lowest level are weighted, e.g.

<u>step 1</u> four functions are placed in an order of importance:

$$\mathbf{s_1} > \mathbf{s_2} \left< \mathbf{s_3} \right> \mathbf{s_4}$$

<u>step 2</u> provisional values are attributed; the highest valued function has a value of $0.4 \ge 0.2 \le 0.3 \ge 0.1$

step 3 successive comparison and correction:

 $g_1 > g_2 + g_3 + g_4$ because: 0.4 > 0.2 + 0.3 + 0.1a correction is made: 0.8 > 0.2 + 0.3 + 0.1

it turns out that: $g_2 < g_3 + g_4$

this is correct.

١

it turns out that: $g_3 > g_4$ because: 0.3 > 0.1

no further correction is made.

Following values are established: $g_1 = 0.8$

```
g_2 = 0.2
g_3 = 0.3
```

```
g_4 = 0.1
```

1.4

- step 4: it can be an advantage if nominal values
 - are used, by dividing them by g_i (in this case 1.4).
 - This nominal value is indicated as g,'

$$g_{1}' = 0.8/1.4 = 0.57$$

$$g_{2}' = 0.2/1.4 = 0.15$$

$$g_{3}' = 0.3/1.4 = 0.21$$

$$g_{4}' = 0.1/1.4 = 0.07$$

$$1.00$$

These values - eventually multiplied by 100 - are called the weighing factors of the functions.

6. Evaluating properties

The properties of materials are valuated on the basis of criteria with regard to different functions. These functions are normally not comparable. In the case of our example (the use of window pane in dwellings) the function of isolation against noise will be expressed in dB and isolation against cold in $W/(m^2.K)$. For this comparison we will make use of a transformation curve.

This curve is worked out by writing vertically for each function a unit of measurement of a dimensionless character; horizontally we write the valuation range of the function. Values between 70 and 90 points can be scored vertically.

The average minimal value of properties of a component will be 70 and the maximal average will be 90.

The relation between score and value can differ according to the added value of the function. This relation can be linear , degressive or progressive. In an example we have worked out the system for the choice of window pane in dwellings.



Figure 3

7. Test of the balance method on window pane Window pane has as main functions to transmit light and to transmit image. But climate influences should be kept out as well. Therefore further conditions should be added to the functions mentioned. Other conditions are life time, easiness of cleaning, resistance against aggression, aesthetics and safety.

The successive comparing method of Churchman, Ackoff and Arnoff enables us to write all functions in a sequence of importance. This has been done in figure 3.

The different functions with the points scored by single and double glazing are described as follows:

	single double					
		glazing				
а.	transmits light	534		486	pts	
b.	transmits energy	76		87		
c.	transmits image	567		630		
d.	isolates against cold/heat	994		1246		
e.	isolates against noise	847		880		
f.	isolates against climate	2430		2214		
g.	life time	344		292		
h.	can be cleaned easily	0		0		
í.	resistance against calamities	962		962		
j.	can be replaced easily	708		588		
k.	aesthetics	0		0		
1.	safety	<u>350</u> 7812	+	<u>_360</u> 7745	+ pts	
	1					

We have simplified our task by limiting our test to only an average brand of glass as well for single as for double glazing. It was not possible to list all brands of glass.

In this test it has turned out that double glazing scores lower in quality than single glazing. This is due to the preference expressed by the testing group.

The normative/subjective equilibrium can be found as follows. In a table we have given the total national turnover of glass (1978) with its value:

brand	m ²	cost per m ²	total
single glazing	1.324.700	Dfl. 65.00	Df1.86.105.500
double glazing			
new construction	430.800	Df1.120.00	Dfl.51.696.000
renovation	18,000	170.00	3.060.000
private use	367.500	220.00	80.850.000
	816.300	•	Dfl 135.606.000

The weighted average (= Y) will be Dfl. 86.105.500 + Dfl. 135.606.000 = $(1.324.700 \text{ m}^2 + 816.200 \text{ m}^2)$.Y

 $Y = \frac{Df1.221.711.500}{2.141.000 \text{ m}^2} = Df1. \ 103.00/\text{m}^2$

The weighted average in points per m² (= X) 1.324.700 m² x 7812 pts + 816.300 m² x 7745 pts = (1.324.700 m² + 816.300 m²).X X = $\frac{166.708 \times 10^{10}}{2.141.000 m^2}$ pts 7786 pts./m²

The normative/subjective point of equilibrium $\frac{Y}{X} = \frac{Df1.\ 103.00}{7786} = Df1.\ 0.013$ per point of quality The practical use of the method is illustrated in figure 4, where the method is worked out for two

8. Use in practice

products (A and B).

There are two possibilities to use the form of figure 4. The first is to use the diagram as an instrument for decisions. The main advantage is that those who use it, will have a logical method to arrive at conclusions, although these are relevant only for those who use the method. They use their own evaluation of functions.

	FINCTIONS	WEIGHING	EVALUATION	UNIT	PRODUCT	A		PRODUCT	В	
	1001100	FACTORS	<u> </u>	- '	PROPER-	unneight- Ed Value	HEIGHT- ED VALUE	PROPER- TY	unneight- Ed Value	ED V
·	TRANSMITS LIGHT	6	70 75 60 65 50	7	80	82	492	89	89	† ₅
NOIL	TRANSMITS ENERGY		65. 80. <u>75.</u> 70. 65.	Z	72	86	86	82	78	7
, UNC	TRANSMITS IMAGE	7	41 45 50 55	POINTS	59	90	630	51	80,5	5
	ISOLATES AGAINST COLD/HEAT	14	60 55 50 45 40 35 30	₩ <i>Ætm</i> 2K	3	90	1260	5.9	70	96
	ISOLATES AGAINST NOISE	11	120. 25. 30. 35 ⁻¹ 40.	DB	33	86	946	30	83	91
	ISOLATES AGAINST (1 IMATE		42, 45, 50, 55,	POINTS	49	78	2106	56	86,5	23
₹	LIFE TIME		15 20 25 30 35 40 45	YFARS	20	73	292	40	86	34
ĒZ	CAN BE CLEANED EASILY	- 4								T
	RESISTANCE AGAINST CALAMITIES			FALLIN	s na	7/1	062	12	π	10
۲ ۲	CAN BE REPLACED EASILY		20. 15. 10. 5. weeks	TIME OF	13	735	598	1 0	88.5	7
	AESTHETICS					13.5	<u> </u>	1,0		1
-IOCH	SAFETY	5	20 30 40 50 y	POINTS	24	72	360	20	70	3
<u> </u>		- 	a total weigh B cost per M2	TED VALUE .	•••••		7722		DFL.	787 787 96
			C EQUILIBRIUM (B:A)		•••••	, DFL. PER PM	0,03 IT PER M	; 2	DFL. PER PNT	0, • PEI

The second is to use the form as an average evaluation for products for the construction industry. The form should be evaluated by a representative group of experts from different disciplins. The results of the evaluation can be made available for general use.

The balance method can also be helpful for those who are interested to know whether a new product will stand a chance as an innovation against the existing products on the market.

9. Further possibilities

The balance method seems to be operational by testing it for the evaluation of glass for window pane for the construction industry. The listing of functions and the evaluation of the functions however needs further experience.

The weighting of the different functions of a certain product to be used in a building component will need further practise. The editing of a list of properties would be helpful together with forms to list and to evaluate them.

Information about average costs and quantities used nationally of a certain product are essential as an indication of the costs of a certain product.

The balance method will facilitate the breakthrough of innovations for the construction indystry. It will be easier to evaluate them.

Although only the design stage has been tried, it will be necessary to test the method for other stages as well. The method has limited itself to the levels of enclosure, inner walls/partitions and finishings only.

['] Churchman, C.West, Ackoff, Russel L. and Arnoff, Leonard E., Introduction to operation research,

Résumé

L'utilisation de l'analyse de la valeur dans l'industrie de la construction est confrontée à un certain nombre de difficultés qui sont dues principalement au processus relativement compliqué de la construction et à la sophistication des produits de l'industrie. Jusque'à maintenant la plupart des applications de l'analyse de la valeur dans l'industrie de la construction ont portés sur l'evaluation globales des constructions.

La méthode de la balance appliquée à l'analyse de la valeur dans l'industrie de la construction est cependant développée comme méthodologie de décision pour évaluer les alternatives possibles dans le choix des matériaux et des composants en se limitant aux murs intérieurs, cloisons et finitions. Cette méthode se base sur l'hypothèse que dans l'ensemble du marché un point determiné indique un équilibre entre le prix moyen d'un produit et sa fonction moyenne.

La méthode de la balance compare différents produits destinés à un certain usage avec les fonction moyennes et les prix de produits similaires sur le marché. Ceci est effectué sur base d'un système d'evaluation.

La méthode a été appliquée à l'utilisation du vitrage dans les maisons.

On the non-destructive control of the strength of building materials ------L.A.Dikarev,Cand. Sc. (Eng.); A.S.Bychkov,Cand.Sc. (Eng.) (P.P.Budnikov VNIISTROM,Moscow Region,USSR)

<u>Summary</u>. Some peculiarities of the statistical analysis of graduation experiment data have been considered for elaborating methods of the reliable non-destructive control of strength of building materials. The asymptotical approgression problem with a single and stochastic regressor has been involved. The technique of statistical tests of graduation characteristics as well as the possibility of corresponding statistical acceptance control have been considered. Recommended procedures are illustrated by ultrasonic method of the compression strength control for silica blocks with cavities.

<u>Sommaire</u>. Le rapport rappelle les particularités d'analyse statistique des résultats d'expérience de graduation necessaires pour l'élaboration des methodes de contrôle non destructif de la résistance des matériaux de construction, y compris le problème asymptotique d'approgression avec le regresseur stochastique. On examine la technique de la vérification statistique des rapports de graduation, de même que les possibilités du contrôle statistique d'acceptation. Les procédés recommandés sont illustrés sur l'éxemple du contrôle d'ultra-son de la résistance des blocs creux siliceux pendant la compression.

The methods of non-destructive testing(NDT) are of great value to the industry of building materials (I). These methods help save materials and working time, raise the industrial efficiency and facilitate the acceptance control of production. The paper considers graduation problems arising in elaborating NDT-control of strength limit of building materials.

For constructing a graduation dependence, relevant tests are carried out. In the tests, values of a given parameter (measured by NDT) and of strength are obtained for individual samples of material. With this procedure, the two quantities are essentially stochastic; the error of NDT-parameter should be smaller than that of strength obtained by NDT for a given value of parameter. If strength is dis+ tributed normally in relation to its expected , values corresponding to a fixed value of NDTparameter and if all the measurements are free from systematic errors, constructing the dependence becomes a special problem of regression analysis.Graduation samples and those, strength of which will be determined by dependence and NDT-parameter value, are to be taken from the same general population. The transition from a hypothetical regression mo+ del which takes into consideration, in the quality of regressors, all the parameters describing the "raw material--technology--sampling--testing" complex to the single regressor model with a reliable correlation increases the variance of a regress_and (strength) and raises the validity of regression analysis. If the theoretical form of regression dependence is linear (or linearizable), the results of graduation are just adequate to the linear regression model.Hence, in the case of non-stochastic regressor, a graduation should be optimized by placing one half of corresponding results on each end of suitable regressor range. For constructing the dependence, methods of least squares are to be applied.

In practical terms most interesting is the case of unknown theoretical form of the dependence, of stochastic regressor and homogeneity of regressand variance within regressor range. Thereby, it is advisable to use Weierstrass's theorem assuming the continuity of theoretical dependence within the whole range and to have a large number of graduation tests (asymptotical case), whose results pack the range adequately well. Then, the dependence (response function) can be determined reliably by the optimum degree of approximating polynom, i.e. from the condition of the adequacy of graduation results to the regression model, linear in respect to whole positive degrees of regressor(approgression problem [2]).

According to Fisher's linear test, the adequacy occurs in case of non-significant difference between the direct estimate of regress and variance and the residual variance $\int \frac{2}{r}$ of regression. To solve the problem, the response function is expanded into Chebyshev's orthogonal polynoms. The solution gives an empirical dependence. It is reasonable to identify confidence band with a form of theoretical one and to use it for a given method of NDTcontrol of strength of the same material within the same regressor range in all other cases. The numerical form obtained is valid only for a given population of samples. The quantils of Fisher's distribution, if necessary, one tabulates according to inter-or extrapolation equation [3]. Of course, contrary to the programmed approgression method [4] recommended here, non-adequate methods of construction often are tedious and:or give inaccurate values of strength measured by NDT [5]. After obtaining the form of dependence, nonasymptotical graduations may be used for constructing working dependences. The half-width of confidence band of response function, equal to the product of standard deviation of the function and of Student's quantil corresponding to the number of graduation samples and required reliability (95 or 99 %), determines the accuracy of regression dependence, or socalled dependence of average sample value, and of the lower single-sided confidence (tolerance) limit of individual sample yalue, and so on. For a sample having a given value of NDT-parameter, the true average strength value, free from the statistical noise of graduation measurements and from that caused by imperfection of single regressor model, is disposed, with stated reliability, within corresponding limits of confidence band of dependence. The band calculation is carried out by a specific (sub)program. The readout of the value of \mathfrak{G}_r is to be provided by program. If \mathfrak{G}_r is 3-4 times smaller than the absolute value of the difference of strength values as obtained by non-and destructive testing for a graduation sample, this last is to be excluded. Then, dependence and band calculations are carried out anew. For asymptotical case, the residual variance is identifyed exactly with regressand variance 6^{2} . The number n of graduation samples (graduation sampling size) necessary for obtaining the tolerance maximum of variance max $D^2 \hat{Y}(x)$ of polynominal response function having the degree k is estimated according to formula $n=(k + I)\delta^2/\max D^2 \hat{Y}(x)[6]$. Due to permissible divergence of confidence bands on a co-ordinate plane, stability of regression dependences is easy to predict visually.

A regression dependence may be verified by testing the hypothesis of absence of significant deviations of its coefficients and of residual variance from corresponding quantities of dependence constructed by means of verification test for any sample [7]. The procedure may be standardized and programmed.

The lower single-sided confidence (tolerance) limit, which is determined by probability I-d of exceeding this limit by the given percentage of all the samplings, depends on regression curve and on all graduation errors including those of the model. In the case of straight asymptotical regression line, the lower limit is obtained by a parallel displacement of the line to the regressor axis by $u_{4} \mathbf{6} [8]$ where u is a suitable quantil of the normal distribution. In determining the distance between both dependences at given \mathcal{L}, \mathcal{S} is an important index of the acceptability of NDTcontrol of strength. Finally, the third graduation dependence (having the probable error of strength measured indirectly) is obtained simply by lowering the regression line by ${\sf G}$.

The graduation dependence covering the required ranges of strength and that of NDT-parameter enable one to fulfill the statistical problems of integrating production lots to reduce the sampling size to be tested.

Let us illustrate the use of the techniques by describing a new ultrasonic (U-) method of strength control of standard silica blocks with II cavities (blocks dimensions are 250mm x 120 mm x 138 mm); the blocks were produced. at plant. The graduation procedure was carried out by combining compression test according to GOST 8462-75 (a current test of product. strength) [10] with preliminary U-test, performed by measuring time of propagation of U-pulse along the block; U-transducers were placed on block headers adjacently to the middles of edges formed by headers and by the same stretcher. U-measurements were made with "Beton-5". The homogeneity of regressand variances was established by Bartlett's test within 75-II µs-range of regressor (U-time). The linear (adequate) approximarion for graduation dependence (strength vs time) was obtained at 5% significance level according to ALGOL-60-program of approgression using IIo experimental

points.Thus, the degrees all, beginning from the second, are less reliable. Figure I shows straight line of average strength value and its 95%-confidence band as well as corresponding lower single-sided 95%-confidence (tolerance) limit.



Figure I. The dependence of compression strength limit on time of propagation of ultrasonic pulse along the sample for silica blocks with II cavities. The straight line(I) of regression, adequate to graduation experiment (IIO points), the confidence 95%-band (dotted) of average strength value, and the lower single-sided 95%-confidence (tolerance) limit (2) of individual value are shown.

The regression dependence "strength vs parameter measured by NDT" determines all the graduation dependences necessary for non-destructive control of strength of building materials. The form of reliable dependence, adequate to graduation test, is tdbe obtained by program of asymptotical approgression.Subsequent constructing the regression dependence may be carried out for samples of smaller size. The dependence enables one to perform. statistical acceptance control of building material strength. The dependence verification can be normalized and programmed for using computers and/or calculators. The construction technique available have been illustrated by dependences of compression strength of silica blocks with cavities on the propagation time of U-pulse along the block.

References

I. Dshons,R. i Fekeoaru, I. Nerazrushay

ushchiye metody ispytanii betonov. Moskva 1974 2. Bandemer, H. u.a. Theorie und Anwendung der optimalen Versuchsplanung I.Handbuch zur Theorie. Berlin 1977.

 Bol'shev, L.N. and Smirnov, N.V. Tablitsy matematicheskoy statistiki.Moskva I965.
 Nollau, V. Statistische Analysen.Leipzig

1975.

5. Roethig, H. Zuverlaessige Fertigkeitspruefung von Beton mit Ultraschall durch verbesserte Auswertung. Materialpruefung, Bd 20, Nr 6, Juni 1978 S 225-229.

6. Bandemer, H. u.a. Optimale Versuchsplanung. Berlin 1976.

7.Storm,R. Wahrscheinlichkeitsrechnung,mathematische Statistik und statistische Qualitaetskontrolle. Leipzig 1976.

8. Bowker,A. <u>Computation of factors for tole-</u> rance limits on a normal distribution when <u>the sample is large.</u>Ann.Math.Statistics,Vol I7,pp 238-240 (I946).

9. Schindowski, E. u. Schuerz, O. Statistische Qualitaetskontrolle. Berlin 1974.

IO. GOST 8462-75. Materialy stenovye i oblitsovochnye. Metody opredeleniya predelov prochnosty pri sshatii i izgibe. Moskva 1975. Basic Trends in Energy Conservation in Precast Reinforced Concrete Industry in the USER ______ Yu.M.Chumakov,Cand.Sc.(Eng.), G.A.Obyeshchenko,Cand.Sc.(Eng.), S.E.Lensky,Cand.Sc.(Eng.). VI.IIZhelezobeton,Moscow,USSR

Summary. Energy balance of a modern precast reinforced concrete enterprise has been analysed in the report and the most energy-consuming fields of expenditure have been identified. An example of the most energy-consuming production stages helps to determine the basic trends in energy conservation. Energy balances of efficient plants for heat curing of concrete and prospects for new developments in concrete curing acceleration and other techniques which would lead to reduced energy consumption have been analysed.

Sommaire. Le rapport donne l'analyse du bilan d'énergie d'une usine de béton armé préfabriquée et montre les articles de dépensé d'énergie.Pour un exemple des usines on a déterminé les aspects fondamenteaux d'économie d'énergie. Le rapport analyse des bilans d'énergie des équipements efficaces pour traitement thermique des bétons. Ce rapport rappelle également les possibilités et perspectives des nouvelles méthodes du durcissement accéléré du béton et méthodes technologiques pour diminuer la consommation d'énergie.

The present stage in the development of poin the conditions wer engineering of a strained fuel-and-power balance demands normalization and optimization of energy consumption at industrial enterprises, for industrial technologies take about 60% of the total power consumped in the USSR.

Precast r.c. industry consumes annualy about 20 mill.t. of nominal fuel.This is considered rather high, thus bringing forth the tasks of more efficient utilization of energy.

The total energy consumption in the industry consists of the theoretically required amount, plus the accompanying consumption by the energy receivers (i.e. for creation of conditions for processing: heating of equipment for concrete curing acceleration, heat exchange thereof with the environment, losses in motors etc.),plus losses during the energy transfer and its transformation in power supply systems,plus losses dependent on operating pattern, and maintenance losses proper.

Table I below presents the expert evaluation of energy balance of a typical operating prefabricated concrete plant of the USSR. This table I shows that the biggest shares in energy consumption belong to the heat treatment of precast r.c. products (57.6%)and to the auxiliary needs (35%). That makes these two items the major ones to be taken as latent potentials of energy conservation and therefore subject to a more thorough analysis.

Energy balance of a prefabricated

				_		
	Items of MJ per I ST U	ener m o	gy co f con	nsump crete	tion,	
Energy type	transport of ingre- and preparation of concrete mixture reinforcement and welding	casting	beat-treatment	operations	auxiliary needs	total
Electric powe	$r \frac{36}{1,7} \frac{43}{2,0}$	<u>22</u> I,0	-	<u>12</u> 0,6	<u>67</u> 3,2	<u>180</u> دره
Heat energy	<u>4,5</u> - 2,1	-	<u>1215</u> 57,6	-	<u>670</u> 31,8	<u>1930</u> 91,5
Total	3,8 2 ,0	<u>22</u> I,0	<u>1215</u> 57,6	<u>12</u> 0,6	7 <u>37</u> 35,0	<u>2110</u> 100

Notes:

I.Numerators-absolute numbers; denominatorper cent of total consumption. 2.Auxiliary needs are understood to be energy consumption for ventilation, space heating, hot water supply, losses in the electrical or heating conduits, illumination, cooking etc.

In heat treatment, the USSR precast r.c. industry uses mostly the method of steaming concrete products in various steam-curing chambers. As a matter of fact about 95% of r.c. are being treated by this method. Out of total ammount of r.c. products about 60% undergo heat treatment in steam-curing chambers of periodical action,5% in continuous chambers, with 30% being treated in cassete-type molds, molds with steam jackets or ordinary stands. Today only 5% of all precast r.c. products are treated in various types of units using the electric heating of concrete.

The thermal balance of most common steamcuring chambers of both periodical and continuous action (with the account of Table I gradation) is shown in Fig.I a,b.



Figure I. Diagrams of heat balance of steamcuring chambers,%.

a-chambers of periodical action without heat insulation; b-<u>ditto</u>, continuous action; c-chambers of periodical action with insulation of its walls and bottoms; d-<u>ditto</u>, continuous action:

I-theoretical heat consumption (heating of concrete,reinforcement and metal of forms); 2-accompanying consumption(compensation for losses from the surface of chamber's walls after getting cooled during pauses in operation, into the earth and with condensate), 3-operational losses(heat losses in chambers, distributing conduits etc.).

As is seen from the diagrams, the efficient utilization of energy in the chambers comes to about 20%, the rest are losses. The major ways of energy conservation here are confined

to normalization and optimization of the chambers heat balance. Heat balance normalization assumes that energy consumption should be brought down to the theoretically established value (Temporary Standards for Calculations of Heat Energy Consumption in Steam Curing of Precast R.C. Products in the In-Plant Conditions", which were elaborated by VAIIZhelezobeton and AIIZhB).

A set of measures have been developed to bring the heat consumption in chambers down to the rated values by reducing operating losses. These measures include:

-organization of control system of heat utilization;

-increase in thermal stability of the chambers' steam supply system; -more reliable insulation of steam conduits and heat-using plants;

-automated adjustment of heat-carrier parameters.

These measures bring down the heat consumption by 27-30,2 without any changes in the process. It is understood that maximum reduction of energy consumption can be achieved by general modernization of steam-curing chambers and introduction of the most advanced technological processes, as well as by using more efficient energy carriers.

Conventional enclosure structures (walls and bottoms of steamcuring chambers are made of heavy-weight concrete whose thermal properties vary widely and do not meet the requirements of modern heat-using units. To reduce accompanying heat losses periodical-type chambers should be insulated from inside or built from some other materials (i.e. the light-weight concrete), whereas continuous chambers may be as well insulated only from the outside.

The operation of such heat-insulated chambers in the USSR proved the increase of heat availability factor from 20 to 70%, with the general decrease in heat consumption by 2-2,5 times (see diagrams at Figure I c,d). The expenditures for chambers' reconstruction can be reimbursed within half a year. No operational losses can be seen in these diagrams since they are offset by the normalization of the chambers' energy balance.

Acceleration of concrete heat-curing cycle is the direct way to reduce the accompanying energy consumption and the USSR technologies take advantage of it.

First, the use of fast-hardening cements allows to cut the period of thermal treatment, thus reducing power consumption by about 200 kJ/m^{2} (which is equivalent to cutting the accompanying losses by 30%).

In the near future, the Soviet cement industry will face the challenge of the complete abandonment of thermal treatment of concrete which would eliminate the most energy-consuming item in the balances of prefabricated concrete plants.

Bright prospects are brought about by the introduction of chemical additives into the concrete, which has many trends including energy conservation in producing precast concrete.For instance, the compound additive NNCC (nitrit-nitrate of calcium chloride) allows to cut the time of thermal treatment of conccrete by 30-35%, i.e. to save IOO-I40 MJ/m³ or cut down I5-20% of the accompanying losses of energy. The superplastifyers of IO-O3, S-3 types and some others make it possible to obtain (6CO-8OO) grade concrete from the cement of medium grades (400-500) and at the same time to cut down the period of its thermal treatment.

Heat curing of concrete can be intensified in special steam chambers with elevated pressure, which eliminates distructural patterns and increases the strength of concrete. Such chambers have been introduced at a number of plants in this country and proved to be capable of curtailing the cycle of thermal treatment by 3 to 5 hours as compared with the conventional procedure, thus saving IOO-I70 MJ/m^3 or cut down I5% to 25% of the accompanying consumption of energy.

Thermal treatment of precast r.c. products within the controlled moisture environment, double-stage treatment, steaming by means of guided circulation of heating media, etc. are some other process modifications allowing to save energy. It is natural, of course, that the total amount of the energy saved due to an integrated introduction of all these measures can not be determined by a mere arithmetical summing up of the energy saved by the introduction of each specific measure.

One of the new techniques,,i.e. preliminary steam heating of concrete mixture in special equipment(concrete mixers,hoppers of concrete placers etc.),is characteristic of its special energy-saving effect: in case of optimized organization of r.c. manufacture flowsheet, it allows to achieve the estimated heat consumption of 230 JJ/m^3 with minimum losses (I0%). In manufacturing large -size products with the surface module of 5-7 \overline{m}^1 and less, this method can provide the utilization of treatment in heat leakage-proof chambers with no additional supply of heat.

The method of using reduced shipping strength of steamcured concrete is also worth mentioning, the shipping strength to be chosen with differentiation in each particular case, basing on calculations and experiments. The investigations made by the VNIIZhelezobeton have substantiated the possibility of decreasing the shipping strength of a number of products down to 50%, thus cutting the cycle of thermal treatment by 2-4 hours and saving 65-I35 MJ/m³.

Due to the constant increase in electric power production by the Soviet power engineering industry (hydroelectric plants, atomic stations, helio-power units etc.), especially in the most dynamic regions of the country, like Siberia and the Soviet Far East, the share of electric power in all industries (and in precast r.c. production in particular) increases. At a number of prefabricated concrete plants there are installed chambers equipped with different electric heating devices (pipe-like, co-axial,net-like,plate-like ones and others). These chambers are mainly used for the treatment of light-weight concretes and disigned to achieve equilibrium moisture content, the electric power consumption in these chambers being 270-300 wJ/m³.

The method of continuous electric heating of concrete mixtures before casting has also proved to be effective, the in-plant power consumption being 230-250 MJ/m³.

Electrical induction - type chambers and units are being increasingly introduced for the thickly reinforced products, power consumption being 350 MJ/m^3 with an average cycle of treatment of 7-9 hours. The induction-type method in treating r.c. vibro-hydropressed pipes will cut the heating cycle down to 4-5 hours instead of 500 MJ/m^3 .

Hence, analyzing the factors affecting the energy consumption during the thermal treatment of concrete, it should be noted that the maximum potentials lie in the methods of preliminary steam heating of concrete mixture, heat-insulation of steam-curing chambers and in the use of electric power.

The second biggest item is the consumption of energy for auxiliary needs of precast r.c. enterprises, which apart from the inevitable expenses for ventilation, space-heating, hotwater supply, compressed air, illumination, etc. also comprises losses in the in-plant conduits, transformers and boiler units. Conservation of energy here can primarily be achieved by means of normalization and rationalization of the energy balance.

The normalization of the energy balance includes the following measures to be implemented:

-operative planning of daily schedules for the heat and electric power loads of energy consumers and power supplying units (boiler units, power transformers); -continuous control of production and consumption of energy resourses (steam,condensate,electric power,heat,fuel,compressed air, water) for auxiliary needs;

-heat-insulation of steam conduits in accordance with the standards;

-automation of hot-water supply, heating, ventilation and other systems.

These measures can bring about the saving of I80 MJ/m^3 or 25% of total expenses of energy for auxiliary needs (Table I).

A further saving in energy can be obtained through rationalization of the energy balance meaning a number of actual measures aimed at decrease of the rated level of losses in transmission and transformation of energy. For instance, using an individual transformer for illumination at prefabricated concrete plants saves 3-5% of electric power.

In-plant process-and-heating boiler units also involve some space for saving energy. For example,utilization of chimney gases I25- 300° C hot for water heating in the heating and venting system as well as for warming-up the water for concrete mixture allows to save about IQO MJ/m³ or cut I5% of the auxiliary consumption.

The operation of some enterprises where gas fuel is burnt in special heat generators (10K type) installed close to concrete curing chambers is certainly a subject of interest. The chimney gases serve here as a heat carrier for the thermal treatment of concrete and the losses during conveying heat to the chamber are minimized, thus sharply increasing the generator's efficiency and decreasing energy consumption by I20-I50 MJ/m³.

As is shown in Table I, the energy expenses for such process stages as preparation of concrete mixture, reinforcement and casting operations invove less than IO% of the total consumption of energy. However the reserves for energy conservation can be found even here. Thus, introduction of superplastifiers without vibration-type processing of concrete cuts down electric power consumption for preparation and casting of concrete mixtures. Subsequent (in time) switching of electrodes of multiple spot welding rigs allows to sharply decrease the installed capacity of the power transformer and cut its losses at idling. The energy can also be saved by introducing a circuit that limits the idling of welding transformers.

It should be interesting to have a look at the energy balance of future enterprises. Table 2 presents the energy consumption at prefabricated concrete plants whose energy balances are normalized and optimized to the highest degree.

Energy balances for future prefabricated concrete plants

Table 2

	Item Im3	s of of co	energ ncret	gy con te	nsump	tion	, WiJ <u>r</u>	ber
Energy type		transport of ingredied and preparation of ts concrete mixture	reinforcement and welding	casting	heat-treatment	other process operations	auxiliary needs	total
a)Energy	bala	nce o	faf	ully	elec	trif	ied p	lant
Electric	powe	r <u>70</u> 8,I	<u>35</u> 4,0	<u>15</u> 1,7	<u>300</u> 34,5	<u>10</u> 1,2	<u>440</u> 50,5	870 100
b)Energy ficient :	bala steam	nce o -curi	f a p ng ch	lant	equi Cs	pped	with	n ef-
Electric	powe	r <u>30</u> 3,3	<u>35</u> 3,9	<u>15</u> 1,7	-	<u>10</u> 1,1	<u>40</u> 4,4	<u>130</u> 14,4
Heat ener	rgy	<u>40</u> 4,4	-	-	<u>330</u> 36,7	-	400 14,4	<u>770</u> 85,6
Total		7 <u>70</u> 7 ,8	<u>35</u> 3,9	<u>15</u> 1,7	<u>330</u> 36,7	<u>10</u> I,T	<u>440</u> 48,0	<u>900</u> 100

Note: Numerators-absolute numbers; aenominatorsper cent of total consumption.

The analysis of the data given in Table 2 shows that with normalization, optimization and rationalization of the enterprises'energy balance their energy consumption can be decreased by 2.3-2.4 times. This suggests that in the USSR precast r.c.industry more than IO mill.t of nominal fuel can be saved annualy. It can also be seen from Table 2 that the energy balances of different plants are almost identical irrespective of the type of energy used. Therefore in designing, constructing and modernizing prefabricated concrete plants, the type of energy for their operation should be determined based on local conditions (rate of energy supplies in the region, prices of energy carriers etc.).

However, preference s' and be given to the enterprises using electric power since there the general standard of production is higher, contamination of the environment is lower and control and adjusting of processes connected with power consumption is easier and more strict to apply.

The share in energy balance becomes the biggest for auxiliary needs with future enter prises and it increases as the degree of mechanization increases, thus reducing manual labour.

708

A Computerized Method for Data Co-ordination for the Design Process for Component Approach of Buildings

Bülent Galip Çoker Dr. Dipl. Ceng. Building Research Institute, Ankara, Turkey

Summary

While designing a building by component approach a method for data co-ordination between the users of data is proposed in this work. To fill the communication gap, an information system with 6 sub-systems is taken into account, namely, user's requirements, external factors, building functions, types of building components, manufacturers of building components and properties of building components from which the first three and the last three sub-systems form two digital lists with three dimensions. While the first three sub-systems are a function of performance requirement of the user, the last ones are the function of performance characteristic belonging to building components. After a comparison between performance requirements and performance characteristics. through computer, the result expresses the most functional building components and the manufacturers fulfiling user's requirements under external factors. An optimum solution relating to building components is beyond the scope of this work.

<u>Résume</u>

Dans cette étude, on propose une méthode pour une coordination entre les utilisateurs qui vont utiliser les données, pendant réalisation de leurs projets, et une approche des composants d'un bâtiment. Ce système d'information, que l'on vise à remplir une brèche de communication, contiens 6 sous-systèmes; les exigences des utilisateurs, les factors exterieur, les fonctions des bâtiments, les types des composants des bâtiments, les producteurs de ces composants. Le premier trois et le dernier trois forment deux listes digitaux avec trois dimensions. Le premier trois sous-systèmes sont une fonction de performance d'exigence des utilisateurs, et le dernier trois sont une fonction des caractéristiques des performances en ce qui concernent les composants d'une bâtiment. Après une comparaison entre les exigences des performances et les caractéristiques, par l'ordinateur, le résultat contiens le plupart des composants d'un bâtiment et des producteurs qui servent bien pour remplir les exigences des utilisateurs sous les factors extérieur. Une solution optimale, ayant rapport des composants d'un bâtiment, est hors d'étendue de ce travail.

1. General

Upto now several information systems serving during the design process of buildings have been proposed and used. Some of the systems as SfB, CI/SfB, CBC etc.which enable the communication between the users of data and serve to fulfil the user's requirements can be grouped according to their function. In our century the continuos development of every factor(social, cultural, psychologic, financial etc.) has reached a high degree of standardisation and the amount of data has increased immensely. The information systems became unable to fill the gap of communication between the users of data in the building process.

Most of these systems serve for classification purposes which tend to put a label on the item. The building design process needs besides sorting which the computerized classification systems do, harmonic relations between building geometry, performance and cost. In order to remove this disadvantage, filing of items according to characteristics of usage may enlarge the aplication field of information systems. Some other systems are complicated but not detailed enough although they have a wide base. A group of systems have national aspects i.e. they are structured according to the conditions and requirements of the country they belong. Besides the systems which are not convenient for the design process some systems as the ER-system enlighten the method proposed.

Building components with different structures which seem to have the same function in the building may have different performances during the use and maintenance thase. A functioning feedback mechanism can send commands to improve the performance requirements belonging to building components. As the production of building components and the design activity in the industrialized system is in the same process, the feedback mechanism has to be structured on the levels 'building' and 'building components'.

Informations:

- A:User's requirements
- **B:External** factors
- Activities:
- l:Determination of performance requirements of building components.
- 2:Design team activities relating to modular coordination, reducing of building component types, performance analysis, works of research institutes.

3:Control of building components.

- 4:Accumulation of performance characteristics and other data (price, conditions of delivery, transportation etc.)in data bases.
- 5:Mass production and storage of building components.
- 6:Evaluation of building components which should fulfil user's requirements.
- 7:Fulfiling user's requirements with optimum solutions relating to building components.



- 8:Detailed analysis of the selected system(scale 1:1).
- 9:Analysis of the planning modul.
- 10:Analysis of functional relations(scale 1:100).
- ll:Design of the project(scale 1:100).
- 12:Construction of the building.
- 13:Use and maintenance of the building.
- 14:Evaluation for feedback purposes.

In order to determine the performance requirements, user's requirements, external factors and the evaluations relating to design and use and maitenance must be clarified(Fig. la). Besides inputs of performance requirements, manufacturers of building components have to co-operate with research institutes to obtain solutions with economic and technical aspects. The design team which is a subdivision of the building components manufacture has the same properties and qualifications as the building design team with the except of the disciplines such as material, physics, chemistry etc. is included in the first. According to Figure 1 the second phase of the building process begins with the activity number(6) in which the client and the building design team co-operate with each other. The users of data are equipped with the potency including various information about building components, namely manufacturers of building components, price, conditions of delivery, payment dan, transportation, about performance characteristics of building components and user's requirements. To implement the potency for the benefit of the design process an information system enabling the harmony between the design process and the component approach as well as the communication between the users of data is proposed.

2. The sub-systems of the information system proposed

- (1) User's requirements
- (2) External factors
- (3) Building functions
- (4) Types of building components
- (5) Manufacturers of building components
- (6) Properties of building components
- 2.1.User's requirements

User's requirements depend on the environment and personal factors, for instance economic-, cultural-, geographic-and genetic factors(1). According to the user's physiological-, psychological-, socio-cultural- and cultural properties a set of requirements are determined which are called user's requirements. Amongst other requirements the requirements relating to building spaces are important. In the study of Blachere (2) some of the user's requirements are classified as follows⁽¹⁾ A Acoustic requirements

- Al Impact noise requirements
- A2 Installation noise requirements
- A3 Traffic noise requirements
- A4 Resonance requirements
- A5 Intimacy requirements
-



- Figure 2. The model relating to human requirements(1).
- (1) The codes in the classification are symbolic.

- F Miscallenous requirements
 - Fl Magnetic field, electric field and atmospheric ionization requirements.
 - F2 Sunshine requirements
 - F3 Limitations of radioactive radiation requirements.
- 2.2. External factors (3)
- 1 Loads and forces
 - 1.1 Own weight(property)
- 1.2 Useful load
 - 1.3 Lond of the nature
 - 1.4 Deformation load
 - 1.5 Supporting reactions from other building elements
 - 1.6 Operations, processes and phenomena
- 2 Water and moisture
- 2.1 Water sources
- 2.2 Moisture
- 3 Heat
- 3.1 Heat of heating
- 3.2 Heat from different kinds of activities

- 2.3. Building functions
- In the study nr. a35 some of the building functions are detailed as follows(4):
- Military facilities
- Scientific facilities Multipurpose facilities
- Storage facilities

2.4. Types of building components

Two dimensional building products which perform several functions during use and maintenance and which are manufactured according to the rules of modular coordination in factories is the definition of building components.

Some of the building components are classified as follows⁽¹⁾: 1 Openings

- 1A Doors
- **IAA** Flexible doors
- IAB Glazed doors
- IAC Wing doors

- 7A Suspended floors
- 7B Service-integrated floors
- 7C Tessalated floors
- .

2.5. Manufacturers of building components

To fulfil a function relating to user's requirements several building components are manufactured by several producers according to different methods. As the materials including in the composition of building components may differ from one product to another there must be a variety in performance characteristics of building components.

The classification of this sub-system may be as follows⁽¹⁾:

- 101 Manufacturer 1
- 101A Screen walls
- 101B Suspended floors(type l)
- 10lC Suspended floors(type 2)
- 102 Manufacturer 2
 - 102A Roof element(prestressed)
- 102B Floor element(prestressed)

2.6. Properties of building components⁽¹⁾ (3):

- 1 Mechanical properties
- 1.1 Strength properties
- 1.1.1 Compressive strength
- (1) The codes in the classification are symbolic

. 7 Floors

1.2 Endurance limit
1.2.1 Ultimate strength
2 Mechanical processes
2.1 Deformation
2.1.1 Elastic deformation

3. The information system for data co-ordination

Three of the subsystems i.e. user's requirements, external factors and building functions define the first three dimensional digital list and the other three sub-systems the second three dimensional digital list.

3.1. The relation between user's requirements, external factors and building functions

			buito	ing_	funci	ions			
external factors user's req.	Þ	^b 2	р <mark>3</mark>	•	•	Þ. İ	•	b _n	
	P ₁₁	P _{12r}	P _{13r}	•	•	P _{1ir}		p _{1nr}	
a ₂	P _{21r}	P ₂₂ r	P _{23r}	•	•	P _{2ir}	•	P2nr	
a ₃	P ₃₁ r	P32r	P _{33r}	•	•	P3ir	•	p3nr	
· ·	•	•	•	•	•		•	•	
·	•	•	•	•	•	•		•	
k	Pk1r	Pk2r	Pk3r	•	•	Pkir	•	P _{knr.}	
·	•	•	•	•	·		•	•	
a _m	Pm1r	Pm2r	P _{m3r}	•	•	Pmir		pmnr	μ -

Figure 3. The relation between user's requirements, external factors, building func tions.

The first dimension is named user's requirements (a_k) , $k:1,2,3,\ldots,m; m>0$. The second dimension (b_j) is called external factors, j:1,2,3,...,n; n>0. The last dimension of the first digital list is (D_r) which is called building functions, $r:1,2,3,\ldots,w;w>0$. The relation between these three dimensions can be expressed mathematically, (1)

 $p_{kjr} = f(a_k, b_j, D_r)$

 p_{kjr} is a function of the first three dimensions. From Eq(l) it is obvious that there is only one value of p_{kir} for single values of three dimensions.

For instance.

(sk):Winter comfort of the user(user's req.) (bj):Outside temps rature(external factor) (D_r) :Home(dwelling) (building function)

Here, pkir is directed towards 'the termal transmission' of building components and is called'performance requirement of the user'. Taking the performance requirement into account there is an imaginary envelope to have the most appropriate performance characteristic (thermal transmission) according to the user's requirement between the user and outside. The value of pkjr can be calculated by various methods. The first digital list on cartesian coordinates is shown in Fig.4. 3.2. The relation between types, manufacturers and properties of building components

prope	rties	of b	uildin	J CO	mpor	rents	_			ī
types of ma building nutac compo turers of cents building companents	٩	d	d	•	•	ď		d		
ʻ ¢j	911s	912s	913s	•	•	q_{1is}	•	91vs		
¢2	q _{21s}	922s	9 ₂₃₅	•	•	q _{2is}	•	q_{2vs}		
C3	q_{31s}	932s	933s	·	•	°3¦s	•	q _{3vs}		1
	•	•	•	·	•	· ·		•		
· ·	•	•	•	•	•	1.	•	•		
Ch Ch	9 _{h1s}	q _{h2s}	q _{h3s}	•	•	a _{his}	•	9 _{hvs}		
· · ·	•	•	•	•	•	•	•	·		
C _V	9v1s	9v2s	q_{v3s}	•	•	q _{vis}	•	9 _{vvs}	μ	1

Figure 5 The relation between types, manufacturers, properties of building components.

In the second digital three dimensional list, the first dimension has the symbol(ch) which is called manufacturers of building components. The second dimension(di) indicates types of building components. The third dimension $(E_{\hat{S}})$ is the symbol for properties of building components. The same ideas are valid here, i.e. h:1, 2, 3,, y; y>0. i:1, 2, 3,, v; v>0. s:1,2,3,...,z; z>0.



Figure 4. The three dimensional digital list showing the relation between user's requirements, external factors and building functions.



Figure 6. The three dimensional digital list showing the relation between types, manufacturers and properties of building components.

The relation between the mentioned dimensions is, $q_{his} = g(c_h, d_i, E_g)$ (2) Equation (2) (1)

Equation(2) expresses that for the value of (c_h) , (d_i) , (E_g) , there is only one value of q_{hig} indicating the performance characteristic of building components produced by several manufacturers. The second digital list on cartesian coordinates is shown in Fig.6.

3.3. The comparison of performance requirements and performance characteristics

If an envelope is to be built according to user's requirements the calculated values of performance requirements (p_{kjr}) are given as input data to the computer which has the values belonging to performance characteristics in it's data base(Fig.7)



Figure 7. The comparison of performance requirements and performance characteristics.

If (ε) is the least positive number, the difference between performance requirement and performance characteristic should be equal or less than (ε) .

 $|p_{kjr} - q_{his}| \leq \epsilon$ ($\epsilon > 0$) (3) From Equation(3) it is obvious that the absolute values of the difference of p_{kjr} and q_{his} which have the same unit must be minimum.

Equation(3) is processed by the computer and values of q_{his} fulfiling equation (3) form the solutions which indicate bullding components produced by manufacturers 1, 2, 3,..... The ideal solution of (3) is.

$$\lim_{\varepsilon \to 0} |\mathbf{p}_{\mathbf{k}\mathbf{j}\mathbf{r}} - \mathbf{q}_{\mathbf{h}\mathbf{i}\mathbf{s}}| = 0$$
(4)

Thus

$$p_{kir} = q_{his}$$
 (5)

The flowchart for the calculation of the values of $\mathbf{c}_{\mathbf{his}}$ is following,





References

- (1) Çelik A. P. Biyoklimatik kullanıcı ihtiyaçlarının incelenmesinde bir model, 1. ed. Ankara 1978.
- (2) G. Blachere, Les Exigences Humaines, De la Recherche a la Pratique le Defi de l'Application, CIB 5 e congress, Juin 1971, pp55-57.
- (3) Koski L. Laine E. Saarimaa J. Sneck T. Performance Analysis Check Lists 1970, 1.ed. Otaniemi 1970.
- (4) Çoker G.B. Teknik Enformasyon sağlanmasına ilişkin bir Yöntem: Anghtar Sözcük+CI/SfB. l.ed. Ankara 1977.

Some aspects of the design process in Irish towns

John O. Costello, Land Economist Raymond A. Mulvihill, Sociologist.

An Foras Forbartha, Dublin, Ireland.

Introduction

In Ireland at the present time there is some concern that much of the physical change occurring in our towns and villages is unsympathetic to the character of these places and thus fails to realize its full potential.

This physical change is associated with social, economic and demographic and technological change, including technological and structural change within the building industry. These changes are associated with prosperity and in many respects they are positive. The positive aspects include the provision of higher standards of comfort in housing, hotels, lounges and restaurants, more efficient factories and offices and distribution systems. The question this research addressed itself to was: why are these changes occuring as they are. More precisely we set out to discover who makes the decisions that govern the visual character of our towns. Such information would assist town-planners to control the design process.

Methodology

The approach taken was essentially a sociological analysis and has had precedents in that area of sociology defined as the sociology of art. A leading spokesman for this area, Howard Becker, (1), suggests that a sociological analysis of any art form looks at the division of labour connected with it, how the various tasks in the production of an art object are divided among the various people involved. It is suggested that our interest in the production and conversion of buildings is closely related to this subject and benefits from this kind of analysis. Becker emphasises the inter-dependence of the various parties involved in the production of art objects and provides examples of how people with guite subsidiary roles, those not usually designated artistic, can influence the outcome of the production of even what might be termed high art.

In a detailed examination of the making of photographs, Rosenblum demonstrated how their production by the three professional categories investigated, news photographers, advertising photographers and fine art photographers were very strongly influenced by technological and bureaucratic factors, ancillary occupational groups, various styles of professional client relationships and even the distribution systems for the products, (2). These precedents suggested that in order to understand the contemporary treatment of buildings in Irish towns it was necessary to examine carefully the organisation of people involved in the production or alteration of them, the styles of relevant professional client relationships, and the distribution systems for the materials used in them.

A semi-structured questionnaire was prepared which included questions concerning the identification of those responsible for the formulation of design objectives and design solutions, the selection of materials, the origin of the designer's idea, the network of people involved and the influence of neighbouring buildings on the buildings concerned.

A field trip to forty towns was undertaken in order to identify suitable sites for fieldwork. These towns had urban district councils and in Ireland would be considered medium sized towns. Three of these were selected on the basis of the following criteria.

- (1) Size was a criterion. The U.D.C. group of 49 towns was divided into three population ranges:
 below 5,000; 5,000-10,000; and over 10,000. One town was selected from each range.
- (2) Each town should have some visual and urban design interest.
- (3) Each town should display some evidence of recent change and development.
- (4) The towns should be within reasonable commuting distance, both in relation to each other and Dublin. On the basis of these criteria, the towns selected were Birr, Co. Offaly, Thurles, Co. Tipperary and Ennis, Co. Clare. Their 1971 populations including suburbs or environs were 3,882; 7,087 and 10,840 respectively, (3).

In these towns buildings built or significantly altered in the period 1969-1978 and considered to exercise a significant visual impact were listed and a sample of 50 was selected. In general these buildings occupied important sites within the commercial centres of the towns. Though the sample selected was small, and this is not offered as a justification, exposure of the results of the study at four regional seminars attended by the majority of these responsible for planning in similar towns in Ireland met with support for the general picture presented by the results.

The administered interviews took place in the winter of 1979. The main respondent or informant was the person responsible for the maintenance of the property, generally the owner. The respondent was asked to give an account of his recent building job. In some cases, particularly where professional designers were involved an accounts methodology (4), was employed to verify whether their account of the building job, in particular the designation of design responsibility, compiled with that of the main respondent. The person attributed with design responsibility, when he was not the person
responsible for maintaining the property was a secondary or minor respondent.

Results

Three aspects of the results are presented here: a description of the building work and types of buildings, the groups involved in the building process and, in particular, the identification of those mainly responsible for the design aspects; and the important design influences and objectives as expressed by the main designer.

Building types and work done

The primary functions of the buildings were as follows: 31 were shops, 9 were public houses, 6 were residences, 2 were restaurants and 2 were offices. Since 1930, 36 of these buildings had changed use. Of these 36, 26 had changed since 1969. The majority of the buildings were over 50 years old and 20 were over 100 years old. Five of them were new.

The building jobs were classified as major or minor. A job was categorised as major if it involved the construction of a new building or significant alteration and extension to an existing building. Minor jobs were generally superficial in nature and did not involve significant structural work. On this basis, 26 of the jobs were classified as major and 24 as minor.

As the unacceptability of the visual changes associated with modernisation was one of the basic reasons for undertaking the project, an attempt was made to obtain some indication of the visual character of the buildings before their recent changes. Some respondents were able to produce photographs of their building and others made comparisons with nearby buildings to indicate this. On this basis the majority of the buildings were considered 'old' and the remainder, 15, were considered to be not of 'old character'. Groups involved in the building process Builders were engaged in 34 of the 50 jobs and architects were engaged in 26. Direct labour, i.e. building workers working directly for the person undertaking the development, was engaged in 15, engineers were engaged in 9, shopfitters in 8, draughtsmen in 6 and a surveyor was engaged in 1. In most jobs more than one professional was involved. The most common combination was architect and builder. Architects, engineers and draughtsmen were more likely to be involved in major jobs. The action most often mentioned in getting a job underway was the contacting of an architect. The planning system appeared to have a limited detailed influence on the work involved. Only 2 respondents said they had sought planning permission as their first move but 38 of the respondents had sought planning permission.

A number of measures were used to indicate what professions were responsible for the work generally and

for the design idea in particular. These included investigating which professions were responsible for the preparation of working drawings, the supervision of building work, the ordering of materials, the design work and the origins of the design idea.

Working drawings were prepared for 42 of the 50 jobs. Architects prepared them for 24 of the 26 jobs in which they were engaged. The other 2 jobs were minor and no drawings were used. Engineers prepared them for 5 of the 8 jobs in which they were engaged. Architects prepared them in the other 3. Draughtsmen prepared the drawings in 5 of the 6 jobs in which they were engaged.

Builders ordered the materials for the 34 jobs in which they were engaged. Architects did this in 2 jobs, direct labour in 8 and respondents in 6. Thirty six of the 44 commercial jobs involved the purchase of a sign. Respondents selected 26 of these and architects selected 5. Eighteen of these were electric, 9 were plastic and 4 were hand painted. Most of these were supplied by Dublin based firms.

Respondents designed 36 of the 50 jobs. In 12 cases responsibility was attributed to an architect, in 1 to a shopfitter and in 1 to an engineer. Although architects were engaged in 26 jobs in 14 cases their role was apparently limited to that of technical adviser. As previously stated care was taken to verify the attribution of design responsibility by contacting the principal parties involved.

Design influences and objectives

Sixteen of the 36 respondent designers admitted to having consciously copied other buildings. Twelve claimed they had developed their own idea and 7 stated that the existing building or the streetscape had been the main source of their idea. One had based his idea on a design he had seen in a design book.

Of the twelve architect designers, 5 stated their idea originated in response to the existing building and 4 stated they had responded to the streetscape. In 2 cases the idea was jointly developed by the architect and his client and I acknowledged another building as the source of his idea.

In considering design objectives the relevant building categories will be dealt with separately. Shops: The most common objective mentioned for shops was display, in 23 of 31 cases. Appearance was mentioned in 20 cases and floorspace in 12. Other objectives included harmony with the existing building, maintenance, access, daylight and harmony with the street. The objectives of display and appearance seemed to be interpreted as implying the need for a frontage with as much glass as possible and an eye-catching impact.

Pubs: Appearance was mentioned as an objective in the 9 cases. Other objectives included floor-space, harmony with the existing building, improved facilities, privacy, maintenance and harmony with the streetscape. Houses: The 6 cases included floorspace as a design objective, appearance in 5 and harmony with the streetscape.

Office and restaurant: Objectives included appearance and floorspace.

When asked what were the major influences on their design only 7 designers mentioned streetscape. However, when a direct question on streetscape was asked later 22 stated that they were in some way influenced by streetscape considerations.

Conclusions and discussion

The results described above relate to buildings recently constructed or renovated in strategic situations in three Irish towns. Most of them were commercial properties and their principal function was retailing. In general economic reasons rather than essential structural work for their preservation dictated their alteration. The most common design objectives stated by those responsible for them were the increase of display space and the increase of the building's ability to attract attention. In some towns this appears to be giving rise to design incompatible with sensitive urban design considerations.

The majority of the design solutions were the responsibility of people who were unskilled in design. Even when architects were involved they were more likely to act as advisers rather than as originators of the design idea. No other professional group appeared to have any significant influence on the design work investigated. This is contrary to the belief sometimes expressed that in rural areas draughtsmen are engaged in design work. It is possible they are engaged in the design of housing and even of housing estates but the survey, because of its focus on the commercial centres of towns, would not have been likely to discover this.

The planning system did not appear, with one or two exceptions, to have had any detailed influence on the work investigated. It is possible, however, it had a strong invisible influence insofar as it precluded the selection of design alternatives known to be unacceptable.

No "branch" buildings under the control of large organisations, either public or private, with multiple locations, were included in the study. It was considered that it would be too difficult to determine design responsibility in such cases.

To increase influence over current building work, the primary role of the building owner must be appreciated. Though well-intentioned he is usually unskilled in design. If it is considered that design should be guided in a direction different from its present one the planning system must provide this guidance. The objectives of the designers must be appreciated and their economic motives recognised. Advice or control that recognises this is more likely to succeed. This study has identified the design decision makers, their objectives and the influence of those generally involved in the design process. To increase the likelihood of success town-planners must present a design framework which includes desirable images of their towns that have meaning for the public and are possible to realize. In addition they must guide the designer's effort to find his design solution within that framework. This requires a truly participatory sytle of planning and a conviction regarding the importance of implementation.

References

- Becker, Howard S., <u>Art as Collective Action</u>, American Sociological Review, Vol.39, No.6, 1974, 767-776.
- (2) Rosenblum, Barbara, <u>Style as Social Process</u>, American Sociological Review, Vol. 43, (June) 422-438.
- (3) Central Statistics Office, Census of Population of Ireland 1971, Vol. 1, Dublin 1972.
- (4) Brown, Jennifer and J.D. Sime, Accounts as a General Methodology, University of Survey Staff Paper, 1977.

Quelques aspects du proces du dessin dans les villes Irlandaises

Le project décrit en ce papier examine les forces qui influent sur la production et la modification des bâtiments en trois villes moyennes en Irlande. On reconnaît de plus en plus le caractère visuel des villes irlandaises et la nécessité de comprendre les forces qui les changent pour que l'on puisse les conserver effectivement.

La pespective est sociologique, en particulier une perspective assez commune dans la Sociologie de l'Art ou la production artistique est entendue comme une action collective. Cette perspective n'a pas été utilisée jusqu'a date dans le domaine de la Sociologie du Logenent ou la Sociologie Urbaine. Le papier vent prouver que la méthode peut contributer a la comprehsion de l'environment physique.

On a demandé aux responsables des bâtiments (les sujets de l'enquête) d'évaluer le caractère de leures villes et d'identifier les changements majeurs. On a etabli les raisons pour lesquelles ils ont entrepris les travaux et les groupes de professionels y engagés. On a fait une enquête sur le rôle joué par chacun. On a fait attention à le détermination du responsable du dessin et en particulier, à l'origine de la conception du dessin. Some aspects of the design process in Irish towns The work described in this paper examines some of the forces affecting the production and alteration of buildings in three medium sized Irish towns. There is increasing recognition of the distinctive visual character of Irish towns and the need to understand the forces of change affecting them in order to take effective action to protect them.

A sociological perspective is employed, in particular that common in the Sociology of Art where the production of art is viewed as collective action. This perspective has not been employed previously in the areas of Housing Sociology or Urban Sociology but this paper will demonstrate that it can contribute to the understanding of the physical environment.

Those responsible for the buildings included in the study, the subjects, were asked to evaluate the physical character of, and identify the major changes in their respective towns. The reasons for undertaking the various projects were ascertained and the professional groups engaged in them and the roles played by them were investigated. Considerable attention was directed to determining who was responsible for the design work and in particular, the origins of the design idea.

Application of large-panel structures in public buildings including ground floors of dwelling houses

Deutschmann, Eberhard; prof.Dr.Ing.habil. Technical University Dresden German Democratic Republic

Summary

Application of large panel structure in public buildings is mainly connected by introducing the storey height 3300 mm, because components with corresponding dimensions can be still transported and assembled with the usual technique of large panel construction. Realization of the storey height 3300 mm in public facilities is critical in relation to the climatic comfort, especially near to the cold interior surfaces of large sized window panes. In respect to the functional and statical conditions, the vertical geometrical parameters in relation to the bearing and completing structural components are described. The main elements for realization the storey height 3300 mm are exterior and interior wall panels, frames and other skeleton components as well as curtain walls. Expecially frame structures in combination with large panels are suitable for demanded openess in ground floors of residential buildings.

Résumé

L'application de la construction en grands panneaux préfabriqués pour bâtiments publics est notamment fonction de l'introduction de la hauteur d'étage de 3300 mm, parce que les éléments préfabriqués correspondants sont encore à manier à l'aide de la technique habituelle de transport et de montage.

La réalisation d'une hauteur d'étage de 3300 mm dans les bâtiments publics pose, cependant, le problème critique de la garantie d'un confort climatique, particulièrement à proximité des surfaces intérieures froides de grands vitrages. Les paramètres de la géométrie verticale sont décrits en fonction des conditions fonctionelles et statiques de la structure porteuse et des éléments d'aménagement. Les éléments principaux pour réaliser la hauteur d'étage de 3300 mm sont les panneaux muraux intérieur et extérieur, constructions en cadre et d'autres éléments d'ossature, ainsi que les parois légers extérieurs (murs vitrines). Les structures en cadre en combinaison avec les grands panneaux se sont avérées particulièrement favorables pour assurer le dégagement exigé dans les zones de rez-de-chaussée des bâtiments.

Introduction

Due to the various advantages of panel structure, in particular the high degree of completion, the high accuracy and the easy assembling, we are looking for new fields of application. Above all this structure is suitable for all functions, which do not need a total openess in two directions. Longitudinal loadbearing panel structures with a span of 7200 mm are suitable for schools, ambulatories and gastronomies. If the wall panels are partly combined with skeleton components it is mostly possible to achieve the demanded openess. The application of concrete wall panels is advantageous regarding to acoustic properties and fire resistance.

1. Problems concerning the storey height 3300 mm

The main criterion regarding the application of panels in public functions is the storey height. The normal storey height of residential buildings -2800 mm - is suitable only for functions like kindergardens and hostels. This storey height has been also successful applicated for public facilities in ground floors if demand for openess is limited.

A large field of application is opened by enlarging the storey height from 2800 mm to 3300 mm. This height in accordance with a openess in one direction is suitable for such functions as schools, ambulatories, gastronomies and shops with a effective area to 200 m³ per equipment. The decisive criterion for introducing the storey height 3300 mm is the possibility, that these panels can be transported by usual trailers at the regular road routes.

The vertical geometry of the storey height 3300 mm is shown in fig. 1, concerning a construction systeme for a ground floor. The normal thickness of floor slabs is 140 mm, above the 1st floor however 240 mm.



Figure 1. Vertical geometry of a skeleton ground floor construction in the storey height 3300 mm /1/

To derive geometrical relations between the bearing construction and the external wall a skeleton structure with longitudinal beam is presumed. It is however also possible to replace the skeleton structure with bearing exterior wall panels.

2. Technical functions of structures in the storey height 3300 mm

The relevant technical functions are:

- climatic comfort
- heat insulation
- sound insulation
- fire resistance.

In ground floors of residential buildings are to expect more difficulties due to the combination of dwellings and public facilities.

2.1 climatic comfort

If we intend to accomodate functions with higher climatic demands such are shops for meat or fish, gastronomies and all functions with a high interior heat load, a ventilation is necessary. Because distribution of air and other mediums is firstly arranged in ceilings the permissible space is decisive for the air volume. If the crossing between ventilation conduits and heating tubes is taken into account the difficulties arise. In table 1 the relations are outlined. We notice, that a ceiling height of 450 mm is necessary to accomodate ventilations with a air capacity of 1800 m³/h at least.

Height	Ventilation		Heating	Crossing of	
of ceiling constr.	height of	air capacity	tube ø	ventilation and heating	
	conduit			height of conduit	tube ø
mm	mm	m ³ /h	mm	mm	mm
300	<u>160</u> 200	700 1100	20108	<u> 160 </u>	to 20
450	160 200 250 315	700 1100 1800 2900	20108	160 200 250 315	to 57 to 57 to 57

Table 1. Geometrical restrictions for accomodation ventilation and heating equipment in ceilings.

Another criterion is to achieve the climatic comfort especially near to the cold interior surfaces of large sized window panes as we use them in gastronomies. In this case it arise a cold falling stream, which we need to drive upwards by a adequate violent stream of heat air produced by heating equipment. The position of convectors is relevant to this effect (fig. 2).



Figure 2. Influence of the thermal jet to the deflection of the cold falling stream in dependance from the position of convectors /2/.

a = distance between convector and glass surface

2.2 Sound insulation

The sound insulation is a dominant criterion in connection with the arrangement of public facilities in ground floors. In relation to the different functional requirements, insulation degrees against airborne sound should be limited as follows: $E_{T_{i}} = + 3$ db, $E_{T_{i}} = + 5$ db, $E_{T_{i}} = + 10$ db.

To ensure reliable the value $E_L = +$ 10 db it is necessary to arrange a solid concrete floor slab without hollows in the thickness 240 mm at least, completed with a floating floor and a additional ceiling with sound insulation.

3. Components of structure in the storey height 3300 mm.

- The components of the struture are:
- solid bearing external wall panels
- lightweight external wall panels (curtain walls)
- bearing interior wall panels

- skeleton components compatible with panels. The compatibility of wall panels and skeleton components is a important premise for ensuring a large field of application /3/. In most cases it is however sufficient to use only a small assortment of supplementary skeleton components and realise the given problem with a share of 70...80 % panelstructure.

3.1 bearing external wall panels

These panels are needed for following purposes

- longitudinal wall structures with a floor span of 7200 mm up to 4 storeys applicated in schools and other public buildings,
- cross wall structures with a floor span of 6000 mm up to 11 storeys stabilized partly by external walls, applicated in residential buildings.
 It is possible to verify both requirements with
- a equal geometrical configuration. The bearing

layer of a solid sandwich panel amounts in this case 190 mm.A wall panel for longitudinal wall structures is shown in fig. 3. This element has a weight of 5,7 t by using constructive lightweight concrete of $\mathbf{P} = 1600 \text{ kg/m}^3$ in the quality B 300 /4/.



Figure 3. Loadbearing external wall panel for schools, $3300 \times 7200 \text{ mm}$.

b) lightweight external wall panels (Curtain walls) for public facilities in ground floors.

It is necessary to supplement the solid panels by curtain walls in such cases where large size glazing is demanded. Such wall components should have following properties

- fully completed frame elements or sandwich-panels
- mountable by crane without special fixing devices
- uniform basic elements like windows for the
- preferable storey heights: 2800 mm, 3300 mm, 4200 mm.

A favourable assortment with a great degree of interchangeability of different components can be achieved by 3 preferential heights: 2250 mm, 2550 mm, 2850 mm (fig. 4).



ventitation area

Figure 4. Vertical structure of curtain wall elements for ground floors in residential buildings, applicable in the storey heights: 2800 mm, 3300 mm and 4200 mm.

Frames

Frames are well compatible with panels since they can be transported and assembled in the same technology like panels. To achieve as much as possible openess cross sections of columns and beams should have maximum dimension 240 x 580 mm (fig. 5).



Figure 5. Precast concrete frame compatible with panel construction, weight 3,7 t.

4. Application of frame-structures in panelbuildings

Frames can be located in following positions within the building /5/:

- supporting the longitudinal exterior walls
- supporting the longitudinal interior walls
- supporting the interior cross walls
- as bearing components for a longitudinal and gable annex to the main building.

4.1 Structural base

A free combination of frames with panels is above all dependent on the statical and functional conditions. A maximum of openess like shown in fig. 6 is however not necessary because staircases must be enclosed by walls due to the requirements on fire resistance. As to the functional conditions the openess is needed only in the area of, main functions, | while the areas of storage and social functions can be enclosed by walls with openings.

Important is the open structure under exterior walls to guarantee a free communication through the building. If possible a annex should be provided to enlarge the area for main functions.



Figure 6. Frame structure in the ground floor of a building in large panel construction.

4.2 Stabilization

In usual 5 storey section buildings with loadbearing cross walls the walls of staircases and gables are sufficient for stabilization in cross direction.

In multistorey buildings to 11 storeys it is only possible to place frames under the cross walls if they dont have openings. To give more freedom in structural design in multistorey buildings are arranged 240 mm thick wall panels with door openings of 1500 mm width instead of frames. By this solution we dont have any difficulties to ensure stabilization in cross direction.

The stabilization in longitudinal direction of 5 to 11 storey high large panel buildings with a frame structure in the ground floor can be ensured in such a way, that only the frontal external wall is supported by frames while the backsides situated external wall is provided full in panel construction. This solution is acceptable because on the backside only small openings are required.

We found, that panel buildings of 11 storeys in height and 48000 mm in length can be total stabilized by external walls, in which the frontal by frames supported wall takes over 30 % of total stabilization load, in longitudinal direction. 4.3 Structural systems for application

The preferential combined panel-frame structures in ground floors of large panel buildings are shown in fig.7. A relevant problem is at this the loadbearing of loggia shafts. It is considered in buildings to 5 storeys set up the loggia shafts directly on the annex frame. In buildings to 11 storeys the loggia shafts are located on the foundations, thus we have a spreading in geometry of 1200 mm. The range of lift shafts can be fortunabely used for tracing technical equipment like ventilation conduits and other installations in longitudinal direction.

The annex to the main building in the ground floor can be provided at each longitudinal side and at the gables. On behalf of gaining area for technical and supplementary functions the annex has a commun level of basement with the main building. This solution is a premise to a effective building technology. Because we dont have a mezzanine floor for bundling the vertical tubes, the installation shafts must be conducted through the ground floor. For that reason are only such architectural solutions favourable to a functional underlay, which concentrate the installation shafts in the longitudinal axis of the building.

The research work regarding to the application of the combinated frame-large panel structure has been carried out in order and in collaboration of the building academy of the German Democratic Republic.



Figure 7. Preferable design variants of application a combined frame-panel structure in ground floors /6/.

- a) 5 storey building
- frames under cross walls and frontal exterior walls; loggia shafts located on the annex frame b) 5 storey building
- combined frame-panel structure under cross walls, annex at the front side
- c) 11 storey building: panels under cross walls (240 mm thick) loggia shafts located on the foundation, spreading of 1200mm, frames under the frontal external walls; annex at the frontside
- d) 11 storey building

annex at the backside, frames under both external walls. Longitudinal stabilization by interior walls necessary.

References

/1/	Deutschmann, E. Wöckel, H. Stärker, K.:	Konstruktionsprinzipe austausch- barer leichter Außenwände in Erdgeschoßzonen der Wohnungs- bauserie 70 Wiss.Zt.Techn.Univers.Dresden 28 (1979) 5, pp 12271234
/2/	Stärker, K.:	Beitrag zur Entwicklung groß- formatiger leichter Außenwände mit großem Öffnungsanteil in Erdgeschoßbereichen bezüglich ihres Kondensationsverhaltens und Diskomfortbereiches in Ab- hängigkeit von außen- und raum- klimatischen Bedingungen. Dissertation A, Techn.Univers.Dresden 1980
/3/		Allgemeine Grundregeln der kom- binierbaren Bauserien SKBM 72 und WBS 70 Bauakademie der DDR Beuinformation Berlin 1979
		Baumormation Bertin 1919
/4/	Strauzenberg, T. Schaarschmidt, T. Gruber, M. Thieme, H.:	Großformatige tragende Außen- wände für den Gesellschaftsbau. Baustoffindustrie 1976 B 5 pp 2428
/5/	Deutschmann, E.:	<u>CIB Report - Publication 55</u> Building Academy of the GDR May 1979
/6/	Deutschmann, E. Wöckel, H. Scheidig, K.	Entwicklung eines Konstruktions- prinzips für die Funktionsüber- lagerung bei mehr- und vielge- schossigen Gebäuden der WBS 70 in der Geschoßhöhe 3300 mm.

Bauzeitung 1980, 2

.

Bearing structures of residential buildings

N.A.Dihovichnaya, Eng., Chief Eng. of Dept., V.I.Lishak, Head of Dept., M.Sc. (Tech.) TSNIIEP zhilischa, Moscow, USSR

The report deals with the main trends in industrialization of housing construction in the USSR. The great attention is being paid to large-panel residential construction making up about 60 per cent of the total state and cooperative construction and, thus, being the leading form of construction of residential buildings,

There were investigated the ways for improvement of technical-economic indices and operating properties of existing panel structures, there were found out the possibilities and the ways for creating new ones. Considerable results were obtained while creating new structural solutions of foundations including pile ones, as well as floor slabs and roofs. The efficient properties of roofs without rolling with a warm garret are especially pointed out as at present they are introduced into building experimental practice in some towns of the USSR. There was revealed the role of National Catalogue of industrial elements used in construction under usual and seismic conditions,

A short characteristic is given to new developing forms of housing: box-unit and in-situ construction,

ж÷

Dans ce rapport sont examineés les tendances de l'industrialisation de la construction de logements en URSS.

Une attention particulière est accordée à la construction en grands panneaux qui atteint 60% du volume total de la construction aux frais de l'Etat et des coopératives.

Le présent exposé donne une analyse des indices techniques et economiques et des qualités d'exploitation des structures en panneaux; l'auteur souligne les possibilités de la création des structures nouvelles.

L'auteur décrit le progres important dans le domaine de la création des partis constrictifs nouveaux des fondations, y compris des fondations sur pieux, des planchers entre étages et des toitures. Une attention particulière est attirée sur les qualités positives des toitures sans rouleaux avec le grenier chauffé; actuellement on utilise ces toitures dans certaines villes de l'URSS comme expérience. Il est marqué le rôle du catalogue des éléments industriels utilisés pour la construction dans les conditions habituelles et dans les régions séismiques.

L'auteur caractérise le développement des formes nouvelles de la construction résidentielle: en blocs tridimensionnels et la construction en béton coulé en masse.

ж ж

The necessity of great volumes of construction especially after the damages of the Second World War and the necessity of solving social, functionaltechnical, operating and aesthetic tasks have required a qualitatively new basis to cope with the problem of housing construction in the USSR. This problem could be solved only on the basis of complete industrialization of construction turning it into a modern branch of industry.

The main trend in the development of housing-civil construction is the application of completely prefabricated elements manufactured at highly mechanized plants.

At present large-panel housing in the USSR is more than 60 per cent of the total state and cooperative construction.

Mass large-panel construction is carried out according to standard designs, the series of which are worked out for different natural-climatic and engineering-geological conditions of the country. The improvement of qualitative level of mass housing occuring periodically every 10-15 years demands the corresponding perfection of structural solutions.

Being started in 1958 mass large-panel residential construction will complete its transition to the third generation of standard designs in the nearest future. Simultaneously, considerable scientific-research work and investigations are carried out with a view to prepare the next stage of standard design development (the forth generation).

The goal of this work in the field of structures is aimed at bettering their operating properties and improving technical-economic indices of designs with due regard for a higher comfort of living and aesthetic qualities of residential areas.

It is expected that the adopted structural schemes with narrow spacing of cross walls (up to 3.6m), with wide and mixed spacings of cross walls and with longitudinal external and internal walls will be preserved in mass large-panel construction of the USSR for the nearest period.

The improvement of economic indices of standard designs and the perfection of structure operating properties will be obtained owing to: the modification of existing solutions and the application of new ones for certain structural elements; more detailed consideration for local natural-climatic, engineeringgeological conditions as well as for production and raw materials basis for construction; more complete calculation of combined spatial behaviour of structures; the application of new building materials and products for floors, partitions, finishing, thermal and sound insulating structures, joints sealing, etc; a higher degree of prefabrication and the reduction in number of assembling units as a result of enlarge ment of panels and the use of box units; weight reduction in precast elements owing to the application of laminated and cavity structures, light concretes on porous aggregate and non-bearing structures of non-concrete materials; unification of structures and especially their joint connections.

During recent years in the USSR there were widely introduced pile foundations without grating into building practice, their further improvement resulted in the application of square forms of pile heads allowing to increase pile spacing, and to reduce steel consumption and labour expenditure.

The in-situ concrete post foundations in rammed trenches are considered to be the progressive solution for foundations without grating,

Great attention is being paid to the perfection of thermal-technical properties of external walls and the enlargement of their elements with a view to reduce labour expenditure during erection. The leading role in this respect belongs to three-layer panels with effective thermal insulation and bearing keramzite concrete external and internal layers connected with flexible ties. For non-bearing walls there have been developed the types of reinforce⁻¹ cement wall panels, 3-4-storeys in height, strip panels 10-12 m long and light panels with sheet coating.

For floor slabs two below given main structures were adopted. The first is acoustically non-homogeneous structures in two modifications: complex light concrete slabs manufactured in one technological cycle with effective sound insulating gasket or flat r.c. slabs with flooring of parquet boards of modified wood placed on sound insulating backing. The second is acoustically homogeneous structures: one-layer light concrete flat slabs, 20 cm thick; three-layer r.c. slabs with an internal layer of large porous concrete; cavity slabs, 16 cm thick, with flooring of thermal insulating linoleum.

Different climatic conditions in the USSR, the adopted system of all-year-round construction, a constant search for site labour conditions improvement and the reduction in labour expenditure became the main factors entailing the creation of precast r.c. roofs without rolling, Already since 1961 this roof structure has come into common use in construction. The other essential improvement in roof structures is the introduction of "warm garrets" ensuring a better thermal-humid regime of upper storeys in residential buildings, a better ventilation and the simplification of assembling work. Since 1973 this roof structure has been widely used in Moscow and other towns, It consists of precast large-size elements with roll roofing. The further perfection of roofs is the combined solution of these above-mentioned structures. Roofs without rolling with warm garrets in different variants are being checked in experimental construction and will be included in the standard designs of the next generation.

One of the main ways for labour expenditure reduction in large-panel construction and the increase of prefabrication degree is the application of box units provided with engineering equipment, In mass construction of the USSR there are used completely prefabricated sanitary cabins, lift tubes, equipped with necessary devices under factory conditions, box units with lift machinery supplied with equipment at the plant, completely finished and equipped refuse chute cabins, spatial facade elements (loggias, bay windows, balconies, entrances). The application of box-units considerably reduces labour expenditure, simplifies the labour of building workers and cuts downs the terms of erection owing to the decrease in the number of assembling units and the transfer of labour consuming jobs into factory conditions.

The practice of construction has proved that large-panel buildings are reliable and economically efficient not only under usual conditions but under difficult hydro-geological conditions as subsident soils, mine workings, in permafrost areas, and in seismic areas where earthquake force is 7, 8 and 9. Mass large-panel buildings are worked out on the basis of "National Catalogue of unified industrial elements". This Catalogue includes elements for buildings constructed under usual conditions and in areas with earthquake force 7, 8 and

The role and objectives of the Catalogue in large-panel construction can be determined by the following:

9.

- the creation of the unified catalogue gives perspective possibility of transfer to an open system of unification, specialization and cooperation of house-building enterprises;

- the catalogue ensures one of the necessary conditions of readiness of house building industry to manufacture a wide and changeable nomenclature of industrial elements, that is its technological common character.

As the basis for creation of the Catalogue there was laid a principle of maximum unification of such parameters of elements which do not limit the construction of large-panel residential buildings which are different in their purposes and appearances.

The catalogue does not limit an architectural variety of buildings as it unifies only structural solutions and the parameters of elements which do not influence an architectural solution such as joints, structural connections, dimensions of panels, the configuration of their edges, the edges of window and door openings, reinforcement, etc.

Such unification allows to arrange a centralized manufacturing of a limited number of high accuracy mould shuttering types and inserts forming door and window openings and it, in its turn, ensures high manufacturing accuracy which is the main condition of high quality in construction.

During recent years in the USSR alongside with large-panel construction big experimental work is under way in the field of box-unit construction with the view to cut down labour expenditure to a maximum at the building site.

There have been developed and are being checked in experimental construction different structural schemes including combined panel-box systems with bearing and self bearing box units.

Bearing box units comprise premises equipped with engineering communications and those which are labour consuming during erection (sanitary cabins, kitchens, staircases), the other premises are made out of large panels. There have been developed the variants of designs where the whole structural system consists of box units with different structural variants of concrete box-units: box units without a bottom; box units without a top. The structural system with box units without a top is more widely used owing to its higher technical-economic indices.

The weight of units in the above systems reaches 17-18 tons and more and special cranes of big hoisting capacity are used for their erection.

At present the designs of panel-box buildings are under development with an aim to use cranes with 10 ton hoisting capacity. In this case the bearing box units have the area up to 10 sq.m.

In order to create urban focal points in some towns of the country there appeared multi-storey insitu residential buildings erected in slip forms or tunnel forms. Depending upon the material basis the structures of buildings including external walls are made out of different light concretes or heavy concrete, in this case external walls are three-layer structures. Depending upon the method of erection floor slabs are in-situ or cavity precast structures. Major trends in the development of building physics today

Professor V.A.Drozdov, D.Sc.(Engineering), Director, NIISF, Moscow, U.S.S.R.

Summary. In recent decades building physics has become one of the leading sciences in civil engineering, which is instrumental in solving the pressing problems regarding the construction of buildings and structures.

The report deals with the major trends in the development of such branches of building physics as heat and lighting engineering in construction, and building acoustics which are aimed at energy saving, longer service life for building structures, acoustic comfort in premises, more efficient systems of natural and combined lighting, comfortable lighting, etc.

Sommaire. Pendant les dernières dizaines d'années la physique de construction est devenue une des principales sciences de construction ayant une grande importance pour la résolution des problèmes actuels de la construction des batiments.

Le rapport rapelle les voies principales du développment de telles divisions de la physique de construction comme la thermotechnique, l'acoustique de construction et la technique éclairagiste visées à l'économie de l'énérgie, à l'assurance de la durabilité des constructions, du confort acoustique et lumineux des locaux et à l'augmentation d'éfficacité des systèmes d'éclairage naturel et artificiel.

Over the last few decades the construction of buildings and structures has become one of the leading branches in the national economy. Technical progress in civil engineering has been based on research and development in fundamental and applied sciences, many of which have broken away to form independent scientific disciplines dealing with civil engineering.

Building physics is one of these sciences and concerns itself with the laws of heat transfer, light and sound propagation, moisture and air transport in buildings and structures. It also deals with their effects on the microclimate of buildings, structures and residential areas, as well as the service life, operating qualities of enclosing structures.

The importance of building physics cannot be overestimated for the Soviet Union,where a large-scale capital construction programme, using industrial methods, is in full swing in a wide variety of climatic conditions. In 1955 a research institute was set up in the Soviet Union,which has been dealing efficiently with the problems of building physics since that time. It has come to be known as the Research Institute for Building Physics (NIISF). There are a number of educational and research institutions that have building physics research laboratories.

The main practical problems which building physics deals with, can be described as follows:

((a)improved termal insulation of buildings and structures to cut down the material costs of the enclosing structures and energy consumption for heating or cooling of premises;

(b)improved sound insulation of buildings to reduce noise in premises to prescribed levels with minimum material costs and consumption;

(c) working out new efficient architectural and civil engineering measures to cut down noise in housing and industrial areas;

(d) working out methods of noise control in industrial buildings;

(e)working out advanced methods of heat and lighting engineering, and acoustical calculations for buildings and structures;

(f)working out and improving building rules and regulations and state standards for heat and sound insulation, noise control, lighting in buildings and building climatology.

New methods of making heat engineering calculations were required to solve the problems of planning optimum heating conditions in premisies and devising structures with minimum energy consumption. The methods of analysing the building as a single energy system are the most promising ones. These calculations consist in solving a set of equations for the heat, moisture and air balance in the building to determine optimal ratios between the capacites of microclimate conditioning systems and the heat insulation characteristics of the enclosing structures. The minimum total normalized construction costs, with dates of repaying capital expenditures taken into consideration, may serve as a criterion in determining optimal ratios.

Provision of comfortable conditions in buildings with minimum energy expenditure and lower material consumption and construction costs is no simple matter. The specified and detailed climatic design parameters of construction, the improved heat engineering characteristics of enclosing structures and heat insulation materials are major lines in building physics, aimed at saving the heat and electricity used to heat and run the buildings in operation. This calls for optimal areas of light openings, the use of effective heat-insulation and hermetic sealing materials.

Designing buildings that are economical in power consumption is a new stage in the development of construction. In this respect, building physics is aimed at elaborating new requirements with regard to the enclosing structures and to the building as a whole, which would ensure a power saving and maximum utilization of the heat obtained from solar radiation.

The ever increasing scale and rate of construction, the use of effective light-weight and thinwalled structures and continuing trend to persistently decrease their mass call for a strict scientific solution to the problem concerned with longer service life of builbings and structures. This problem is becoming more acute with the immenent general energy crisis, which demands stringent economy in fuel resources. It is extremely difficult to find a solution to the problem, because of the long life of these structures and the gradual worsening in their charateristics. This is an impediment to the accumulation and systematization of the field data to be used for developing the scientific methods of predicting, current appraisal, and provision of adequate life-span to these structures.

In the long run, the successful solution of the building structures durability problem boils down to developing reliable engineering methods to forecast climatic, corrosion-resistant and fatigue stre th life-span. ways should be found to provide these qualities on the basis of today's scientific and technological progress, taking the special aspects of their long service life into consideration.

Climatic durability is resistance to temperature and the moisture effects of the environment, including frost-disistance of material. It is the major factor determining the longevity of the external enclosing structures, building physics mainly deals with. For the climatic durability requirements to be ensured, the material should meet, as far as its physical qualities are concerned, a number of requirements that must be followed strictly right from the very start of the manufactu ring process. If the external enclosing structures are to exhibit fairly high longevity, the material should feature a relatively high strength, high resistance to cracking and to stresses from the temperature and moisture effects. It should stand cyclic freezing and thawing, and also be corrosion-resistant to environmental attacks.

Two major trends are worth noting in the development of research dealing with the climatic durability of construction materials and structures. One is concerned with the development of physical models for the destruction of materials by the effect of temperature and moisture, especially where the phase transformations of the latter are taking place. The other development deals with the longevity theory of external enclosing structures. On the whole, the problem of the high climatic resistance of the construction materials employed for building enclosures is far from being resolved completely, and still needs extensive investigation and research.

In recent decades, the problem of noise control in the Soviet Union, as in other countries, has become an extremely pressing one. New technological processes in industries, powerful and fast-operating equipment, mechanized techniques, developed land, air and water transport, utilization of numerous types of sanitary equipment, household appliances, and utility systems installed in buildings have resulted in a situation, when man is constantly exposed to high levels of noise.

These circumstances have called for various investigations to develop standard requirements with regard to noise levels, to elaborate and try out methods for calculating and designing noise reduction measures with the use of construction techniques, to design and introduce effective noise-silencing and soundinsulating constructions.

The research and development activities carried out by the NIISF together with some other organizations, and the international experience in this field have made it possible to work out a unified set of guidelines for noise control, which consist of I5 national standards; Jasic national regulations dealing with combating noise by means of construction techniques, which are part of the SNiP(Construction Norms and Regulations) as a separate chapter entitled "Noise Control-Design Norms"; and relevant guidelines for noise control in many other industries to initiate measures to combat noise.

The basic document contains the rules and regulations for designing noise-reduction measures by means of construction, acoustical urban planning, and architectural and layout It specifies general requirements methods. for designing of noise reduction activities, procedures for acoustic calculations, the composition of sound characteristics of noise sources and the standards of permissible noise levels. These basic standard regulations set forth the main principles for determining the levels of sound pressure at reference points, the procedures of predicting the required noise reduction and guidelines for selection. calculation and design of noise-silencing and sound-insulating structures and devices, including the relevant measures. Manuals and handbooks are being put out, where various explanations, comments, examples of calculation and design of proper noise-reduction techniques are given. The publications are intended for architects and designers.

Now, you will be interested to learn more about scientific progress the Soviet Union has made in combatting noise and the relevant practical applications.

The protection of premises in dwellings and communal buildings from noise is primarily ensured by sound insulation with enclosures, and by muffling the noise produced by utility systems.

Sound insulation with enclosures is one of the most difficult problems in building acoustics. At present, using a theoretical analysis, methods have been developed for designing of sound insulation for enclosures from airborne . and structural noise. Extensive series of experiments have been conducted and recommendations have been made to improve the sound insulation of enclosing structures. All these innovations in sound insulation are being vigorously introduced in large-scale construction. In a number of cases, however, the soundinsulation properties of enclosures do not adequately meet the growing requirements to the maintenance qualities of buildings. The priority in this field is to improve the soundinsulation qualities of enclosures and to make them lighter. Also, the design of fillers

for window openings with improved sound insulation and individual systems of forced ventilation has become highly important.

Methods of reducing noise from utility systems of buildings are continually being improved. The techniques of sound and vibroinsulation of equipment have been developed and are widely introduced, Laminated and tube-type highly efficient noise silencers have been designed and introduced for air conditioning and ventilation systems on a large scale.

Noise protection on the shop floor at industrial enterprises should be achieved by every possible reduction in noisiness of the machinery, by use of soun-absorbing structures and devices, soun-insulating enclosures, cabins and housings.

In many cases modern industrial buildings cover very large areas and are comparatively low. In this case one has to have a knowledge of the calculation techniques for the sound field to design a proper noise reduction system in them. Use was made of both a theoretical analysis and experimental studies to develop, by way of modelling, the techniques for the tentative calculation of an expected noise level at one point or another in such premises.

To reduce the level of reflected sound in industrial buildings, a sound-absorbing linings is widely used.

The wider application of sound-absorbing linings requires further ways and means of **cut**ting costs thereof, mainly through the rational employment of fibrous absorbers. The thickness of the absorbing layer needs to be reduced to control the frequency characteristics of the sound-absorption coefficient, to devise materials with an optimum structure to ensure high absorption in the frequency band assigned with minimum consumption of raw materials.

New types of independent sound absorbers in the form of <u>coulissen</u>-type sound absorbers and "accoustical" beams have been studied,developed and introduced in a number of industrial buildings. Due to the edge effect,also known as the diffraction effect, they provide much greater sound absorption, than plane sound absorbing linings.

It has been found that sound-insulating cabins and hoods are among the most expedient means of protection from occupational noise. The studies carried out and the developments therefrom have resulted in cabins and hood designs that ensure substantial noise reduction (25 to 40 dB).

The methods of calculating the expected noise levels and optimal techniques, in acoustic terms, of town planning and construction have resulted from the study of the propagation laws of traffic noise and other noise sources in various planning, development and infrastracture situations of towns and cities. The planning solutions of a number of new housing estates, which have been developed jointly with design organizations, have ensured adequate protection of dwellings against traffic and rail+ way noise by buildings-screens, ac oustical planning and other measures. In these studies and developments, use has been extensively made of the method of modelling construction on special acoustic grounds.

The subject of building lighting science is lighting environment, which when carried out in cities and buildings, has a beneficial effect on man's activity and health.

The desire of designers to increase the building density in cities and to build-up "the potential capacity" of enterprises and buildings is acomplished by developing compact construction, by integrating , and by increasing the sizes of construction project units.

This is inevitably connected with the increasingly important part to be played by artificial lighting which is, in a number of cases, the only illumination feasible(e.g., in windowless industrial buildings, auditoriums, underground railway stations, etc.), or complementary lighting in parts of buildings a long way from the windows (e.g. in multi-storey industrial buildings and those with no sky lights, offices, commercial buildings, etc.)

Lighting in new environments should **CPE** for that all the workers, irrespective of their job, would feel constant contact with nature. This feeling is not only created by seeing the outside world through the windows or sky lights), but by way of association, too. The illusion of natural lighting is successfully employed, as a psychological device, in the stations of the Moscow metro. Psychological and aesthetic reactions are inseparably linked in their effect on a human being.

A new method of rating the lighting environment in buildings, which is being developed in the Soviet Union, is a comprehensive approach to design and the application of spatial criteria for estimating quantitative and qualitative indicators of natural and artificial lighting. Building physics deals with the urgent problem of making natural and combined lighting more effective, i.e. of creating conditions for higher labour productivity and improved quality of the jobs performed with minimum material and energy consumption costs of natural and artificial illumination.

This problem can be optimally solved, if only a definite relationship is established between natural and artificial lighting. New effective lighting can be designed by working out radically new techniques of optimization, which take all factors, including the climatic and economic characteristics of different regions of the Soviet Union, into consideration. Combined lighting of industrial, agricultural and communal buildings opens up new progressive opportunities for taking architectural and planning decisions. It will help in visualizing the optimal dimensions of buildings (in constructional, technological and economic terms).It will facilitate the provision of natural lighting and decrease capital and operational costs.

<u>References</u>

I.Bogoslovsky V.N.Teplovoy rezhim zdaniy, (Heating in Buildings),Moscow,Stroyiszdat,I979 2.Gusev N.M.,Kireev N. N. Osveshchenie promyshlennykh zdanyi (Lighting in Industrial Buildings),Moscow,Stroyizdat, I968 3. Gusev N. M. Osnovy stroitelnoy fiziki (The Foundations of Building Physics), Moscow, Stroyizdat, I975

4. Drozdov V. A., Savin V. K., Alexandrov Y. P. Teploobmen v svetoprozrachnikh ograznaayushchikh konstruktsiakh (Heat exchange in Light-Transparent Enclosing Structures), Moscow, Stroyizdat, 1979

5. Osipov G. L., Prutkov B. G., Shishkin I.A., Karagodina I. L. Gradostroitelnye mery borby s shumom (City Planning Measures to Combat Noise),Moscow, Stroyizdat, 1975 p. 125 6. Spravochnik proiektirovshchika. Zashchita ot shuma (Handbook of Architect,Noise Control) ed. by Professor E. Y. Yudin D.Sc.(Engineering),Moscow, Stroyizdat, 1974, p. 134

7. SNiP II-3-79 "Stroitelnaya teplotekhnika" (Construction Norms and Regulations, Construction Heat Engineering)

8. SNiP II-I2-774 "Zashchita ot shuma" (Noise Control)

9. SNiP II-4-79 "Estestvennoe i iskusstvennoe osveshchenie" (Natural and Artificial Lighting) IO. SNiP II-A 6-72 "Stroitelnaya klimatologia i geofizika" (Building Climatology and Geophysics). An investigation into the use of fixed horizontal shading devices to control the internal environments in <u>low latitude regions.</u>

- A.A. Fikry* B.Sc. and I.C. Ward** B.Sc.
- * Research student, Department of Building Science University of Sheffield, U.K.
- ** Lecturer, Department of Building Science, University of Sheffield, U.K.

Summary

This paper will outline a computer study backed up with scale model experiments into the effects on the internal lighting and thermal environments due to changing the parameters of fixed horizontal external louvres.

Résumé

Cet article illustre un programme pour ordinateur, supporté par des expériences sur des modèles, pour montrer les effets sur l'illumination interne et les environnements thermiques dues aux variations des paramètres des stores horizontaux fixés.

Introduction

In low latitude countries the design of buildings must take into consideration the sun. As by allowing sunlight to enter the building adverse heating effects can result and the worst conditions would be experienced from the point of view of reflected sunlight and severe glare. Recent changes in the style of buildings and the adoption of the so-called "International Architecture" have made architects tend to use greater areas of glass in the building facades, and in the adoption of the new trend in design, a consequently sharp increase would be experienced in reflected sunlight, glare and overheating on the internal environment. Therefore it is of vital importance to protect the inside of the building from the direct sun rays.

Controlling sunlight penetration can be achieved through two main categories, the first being the treatment of the internal environment by such devices as Venetian blinds, shutters, curtains etc., while the second approach is more functional in that it prevents the sun penetrating the building surface. Such solutions are the adoption of particular building shapes to give self shading or the application of external louvre systems. In this paper our concern is in the application of external horizontal louvre systems. External horizontal louvres would be most effective in excluding the solar radiation while the sun is in a facing position at a high solar altitude angle. The composition of the horizontal slats could take a multiple number of forms, which would all give the same amount of protection - Figure 1. Within this area of geometrical louvre slat aspect, a designer would form his own

system depending upon his aesthetic values and the architectural features of the building. The main concern would be in the amount of protection. The formation of such systems would be applied with complete negligence of the louvre slat parameter consisting of louvre slat number, slat thickness, slat angle and slat surface reflectance, which would affect `` largely the internal environment.



Four compositions of horizontal louvre slats consisting of 2,4and 8 slats, possesing equal louvre cut-off angle and giving the same amount of protection.

Systematic design methodology and guide lines should be provided to the designer in order to guide and enable him to choose the best solution for his problem.

The study carried out was aimed at analysing the previously mentioned louvre slats parameter in its contribution to the internal lighting and thermal environments. The parameters that were varied were, the louvre slat number from one to the height of window/20, the inclination of the louvres from horizontal to 30° below horizontal, sun angles from 45° to 75° , the thickness of the louvre slats from 0.06 to 0.16 m and the louvre slats surface reflectance from 40% to 80%.

The analysis of the louvre parameters would have been limited and extremely difficult to be accomplished if it was restricted to model study. It was necessary to construct a mathematical model to undergo the analysis, and it was verified against a designed and constructed experimental model of the same parameters. Experimental model

To verify the mathematical model a basic situation of a single room of dimension (4.0m wide by 4.0m long by 2.72m high) was constructed to carry out model study on a limited amount of louvre parameters. All the interior surfaces of the room (ceiling, floor and side walls) were all painted with a black matt finish to completely minimise any internal interreflection and to give the ability to examine the contribution of reflected sunlight from the sunbraker parameters by itself. One side of the room had a window with a 0.9m sill and a 0.22m lintel, the height of the window was 1.6m high by 4.0m wide. The window wall was fitted on both external sides with wooden slotted supports for the purpose of having flexibility in the louvre slat arrangement. The slats in the wooden support were made at 0.01m intervals with a thickness of 3mm. The model

was mounted upon a heliodon turntable and the sun was simulated by a 650 watt photographic lamp fastened to the heliodon's vertical scale. The lamp was focused upon the model so that the illumination from the lamp would be incident upon it, and so, by turning the turntable with the model forward it is possible to achieve any solar altitude angle required. The model was placed at a sufficient distance of 6.15 m from the lamp, so as to get a reasonably parallel beam of light. The horizontal bearing of the turntable was not used. As this study has been based upon incident illumination on the plane of the fenestration and the wall solar azimuth was kept zero.

The photometric equipment consisted of a cosine corrected photocell used as a reference cell and positioned on top of the model throughout the experiment and a lux meter with its measuring head positioned on an adjustable base fixed on an aluminium rod inserted through a slot in the model both at ceiling and floor level. The equipment was calibrated before and after the experimental work, and the whole experimental set up was positioned inside a lighting laboratory with all the walls and ceiling given a black matt finish to minimise any reflection off them onto the model.

The model itself, as an experimental set was verified against a similar experimental set up in the field,that was accomplished previously by plant (1). Complete reproduction of all the parameters of plants experimental model and set up was accomplished in the procedure of reproducing his results. Figure 2 shows the amount of illumination in $L m/m^2$ at sill level (91.4 cm high), plotted against distance from window of dimension (6.10 m high by 2.44 m wide) for both plants and the reproduction of his results. The reproduced curve is in good agreement with the plants curve.



Relation between illumination and distance from window for a sun position of 45deg. solar altitude and zero deg. solar azimth, with louvre reflectance of 70% and internal wall reflectance of 81% for both plants and the experimental results.

The experimental model was then fitted with two sets of horizontal louvre slats giving the same amount of protection, composed of 2 and 4 slats, figure 1, and a set of readings were taken along the ceiling and sill level (0.9 m high) at 0.5, 1.5, 2.5, 3.5 and 4.5 m away from the window. The resulting readings were plotted, figure 3, as percentages to the external illumination against distance from window.



Mathematical model verified against experimental model

Mathematical model

Once the mathematical relationships between the different louvre parameters and the internal room surfaces were developed, the irradiation of the louvre slat surfaces were calculated by means of an equation developed by Threlkeled (2), referred to as the view factor (1)

$$F = a \int_{-c}^{c} \int_{-b}^{b} \frac{(x \cos \phi - a \sin \phi)}{(x^{2} + y^{2} + a^{2})^{2}} dxdy \dots (1)$$

The program was then run given the same room and louvre dimensions and features as that of the experimental model. The resulting calculated internal illumination percentages to that of the external illumination were plotted against the distance from the window, figure 3, so as to verify the mathematical model to the experimental model, and it can be seen from figure 3 that both resulting curves of the experimental and mathematical results take the same slope and are in good agreement with an average deviation not exceeding 5%.





Room parameters

A standard situation of a room of dimension 4.0 m wide by 3.0 m high with the window wall possessing a window of dimension 4.0 m long by 2.10 m high with the sill at a height of 0.9 m, was chosen as a base for the analysis of the different variables mentioned previously. The



internal walls of the room were taken to be of zero reflection, so as to be able to analyse the contribution of the louvre slats parameters by themselves.

The readings were taken both along the ceiling and at 0.9 m high horizontal plane above floor level (sill level) on a central line perpendicular to the window. The internal illumination results were expressed as a percentage to the external incident sunlight upon the louvre slats, for convenience in applying the results on any magnitude of external incident sunlight upon the louvre slats.

Results of the lighting study

The louvre slat number was found to greatly affect the amount of reflected sunlight reflected onto the ceiling and sill level, as can be seen in figure 4.A and 4.B, where a series of louvre configurations consisting of different number of louvre slats having the same cutoff angle and giving the same amount of protection, were plotted against distance from window, and from the graph produced enables a better understanding of the effect of louvre number throughout the depth of the room where an increase in the internal illumination occurs with the increase in the louvre slat's number, reaching a maximum at six slats, where a decline is then followed. It is natural to view this increase due to the increase of the louvre slat area seen by the reference points inside the room. The louvre slats in figure 4.A and 4.B are of 0.06 m thickness, 80% reflectance and with a solar position of 45⁰ solar altitude and zero azimuth.





The louvre slat thickness was found to have a large effect on the internal illumination, where it can be seen in figures 5.A, 5.B, 6.A and 6.B, the louvre thickness effect on three points (A, B and C) inside the room at 0.5, 0.15, and 2.5 m away from the window respectively, for both ceiling and sill levels. The figures represent louvre thickness 0.06-0.16 m plotted against louvre slat number from one to the height of window/20, where it is clear that with the increase in louvre slat thickness a decrease in internal illumination is noticed for both ceiling and sill levels.



The maximum internal illumination is not achieved in all slat thickness at six louvre slats, but it differs in accordance with the louvre thickness, because with an increase in louvre slat thickness, keeping the louvre cut-off angle stable, the louvre slat surface seen by the point inside the room would decrease.



The relation between the louvre slat thickness and slat number was then established against the change in solar altitude angle, where it came to be a linear relationship. This approach was then extended to cover the slat surface reflectance and slat angle, which also resulted in a linear relationship. All this was combined in design charts both for ceiling and sill levels, figures 7 and 8.

The charts, figures 7 and 8, are restricted to rooms of similar dimensions and of equal window area as the standard room dimensions assumed. All that is needed is to choose any combination of horizontal louvres, then by knowing the louvre slat number and louvre slat thickness, the internal illumination expressed as a percentage to the external incident sunlight upon the louvre slats would be obtained for three positions inside the room away from the window from graph (A) figure 7 or 8 for a solar position of 45⁰ solar altitude and zero azimuth and of slats of 80% surface reflectance. From graph (A) using graph (B), the effect due to the change in solar altitude could be obtained, from (B) to (C) to (D), the effect of the change in louvre slat reflectance and angle on the internal illumination would be obtained. By knowing the magnitude of the external incident sunlight upon the louvre blades and multiplying it with the percentage obtained due to the provided horizontal louvre system parameters, the magnitude of reflected sunlight off the louvre slats onto the ceiling and sill can be calculated.



DESIGN CHART FOR LOUVRE SLAT PARAMETER



DESIGN CHART FOR LOUVRE SLAT PARAMETER

Results of the thermal study

The thermal study was confined to the effect due to the magnitude of short wave radiation reaching to the internal room surfaces where it would be transferred into sensible heat effecting in the internal heat gain of the room, graph 9, shows the relationship between louvre slats number for just one louvre slat thickness $0.06\ m$ and its effect on the average amount of short wave radiation reaching the internal surfaces of the room for points A, B and C reflected off the louvre slats as percentages to the external incident sunlight upon the louvre slats.

From figure 9, it can be seen that the louvre slat parameter can be the cause of excessive unwanted heat gain to the rooms and where a compromise between the internal lighting and thermal environment have to take place.



The average reflected short wave radiation off the louvre slats.

Conclusion

Through the work accomplished in this paper it has become clear that the choice of louvre systems should not be left without guide lines to guide the designer in choosing his form of louvres, and has highlighted and formed a base for further studies extending the conditions relating to louvre parameter and the actual size of the room and window, beyond that already investigated.

References

- 1. Plant, C.G.H. Tropical daylight and sunlight project. Final report. Stage I. July 1967.
- 2. Threlkeled, J.L. Thermal environmental engineering. 1962. p 356.

Large span membrane suspension roofs for Olympic sporting facilities in Moscow Trofimov V.I., Dr.Sc.(Eng.), Prof. Mikulin V.B., Cand.of Sc.(Eng.) Goldenberg L.I., Cand.of Sc.(Eng.)

CNIISK, Gosstroy USSR, Moscow, USSR

Summary. The structural solution of membrane roofs for two large span buildings "Olympic Games - 80" in Moscow: the cycle racing track in Krylatskoe and the multi-purpose sport center in Izmailovo are presented.

The cycle racing track in Krylatskoe is elliptic in plan with the principal dimensions I68xI38 m in main axis. The roof of track is erected in a form of membrane shell of sheet steel, 4 mm thickness.

The building of multi-purpose sport center in Izmailovo consists of several architectural volumes with the main hall having dimensions of 66x72 m in plan. All buildings are covered by some membrane shells of 2 mm thickness sheet steel. Shells are designed as surface formed by intersection of four cilindrical sectors.

<u>Resumé.</u> La conseption de deux grands objets destinés pour l'Olympiade de 1980 à Moscou du vélodrome à Krylatskoé et du gymnase polyfonctionnel à Izmailovo est décrite.

Le vélodrome a le plan proche de l'ellypse aux axes principaux de 168 et 138 métres. La couverture est une membrane en acier d'épaisseur de 4 mm.

Le gymnase composé de plusieurs volumes architecturaux a le plan rectangulaire de 72x66 m. Le bâtiment est couvert par les voiles membranaires en acier d'épaisseur de 2 mm qui présentent quarte surfaces cylindriques conjointes.

The in-plan shape of the roofed cycle track in Krylatskoe approaches ellipse with the main axes sized I68xI38 m (Fig. I). The track consists of two zones - the cycle track proper and the zone where subsidiary premises are located. The cycle track has a 333,3 m long path, the stands seating 6 thousand spectators.



Figure I. The plan of cycle track.

The cycle track's roof is assembled of steel structures combined in a system which consists of two interconnected membrane shells of negative Gaussian curvature. The area of the roof's plane is I7850 sq.m. The view of of the building is given in Fig. II.

The edges of the membrane shell are fixed to parabolic-in-plan hingeless inclined arches which ceil a I68 m span.

The arches of the membrane shells internal contours ceil the span without intermediate supports, they are united by a lotticed bracing to form a space unit. The external arches are supported in the middle of the span by the cantilevers of the stand's frame; the cantilevers are spaced at I2 m. The abutments of the countour arches in each membrane shell are coupled to be embedded in reinforced concrete foundations which are connected by a tie beam.

Each shell is formed by thin sheet steel bands 4 m wide and 4 mm thick. The bands are unwound over the span to be ceiled along guiding strips spaced at 6,2 m. The guiding strips are positioned according to design geometry to function as the basis during the erection of the membrane shell. The guiding strips are transversally connected by continuous purlins made of the bent shapes welded to them; the purlins are spaced at 3 m. Ensuring space interaction of the erection mem-



Figure II. The general view of cycle track.

bers of the membrane shell the purlins at the same time function as supports during the unwinding of thin sheet band rolls. The purlins are secured to the membrane by electric rivets to form in combination with the guiding strips the so-called "bedding" which performs cojointly with bands of the membrane shell. The membrane is topped by heat and water insulating layers. The roof of the cycle track has internal drainage realized through water--draining hoppers near supports, in the shell's valleys.

The membrane shell's rolled bands, contour arches and guiding strips are made of low alloy steel grade IO 2CI.

Transverse edges of the membrane are secured to the supporting contour through a transitional sheet member - "splash block" - welded to a "tee" at a variable angle on the level of a neutral axis of the arches' crosssections. The edges welded to the contour form a lapped joint; welding is combined with the use of electric rivets.

Longitudinal edges of the membrane are welded to guiding strips.

The contour arches have welded box-shaped cross-sections formed by 20 and 40 mm thick sheets; the cross-sections have equal over all dimensions of 2x3 m.

Lengthwise each arch consists of portions of two types of cross-sections: sections near supports and span sections. In exterior and interior arches the length of each portion near supports are 24 and 16 m, respectively; these portions are designed identical made of 40 mm thick sheets. The span portions of the exterior and interior arches differ in the sheet's thickness.

Constructionally the rigid fixing of the supporting parts of the arches is achieved in the following way: the reinforcing rods anchored in the foundation are placed in the cross-section of the contour arch's portion attached to the support to be welded to its walls; then the whole cross-section is filled with concrete, grade 300.

Steel expenditure for the membrane shell and the guiding strips was 35,2 kg/sq.m.

A Multi-Purpose Sporting Fagility in Izmailovo is designed for contests in heavy athletic (weight) during the Olympic Games of 1980.

The building of Multi-Purpose Spoeting Facility consists of two functional parts: the main hall of 66x72x28,5 m and the training hall of 36x72xI3,5 m (Fig. 3).

In the main hall a rostrum for contests in heavy athletics is placed, it is surrounded by stands for 5000 spectators and officials.

The frames of the two halls are made of precast and cast-in-place reinforced concrete; the roofs are metal. The foundation of the building is solved as piles united by a castin-place reinforced-concrete grill in which cast-in-place reinforced-concrete columns spaced at 6 m are embedded. On the top of the columns there are cantilevers for a supporting contour. Along the height the columns are intersected at different levels by galleries placed horizontally along the perimeter.

The supporting contour of the main hall's roof is designed closed. Vertically parabolic, it is built in precast and cast-in-place reinforced concrete, the cross-sectional dimensions being 0,5x6 m.

The halls are roofed by thin sheet membrane shells similar in their structural realization. These relatively lightweight shells are stabilized against wind effects and non-uniform loads on the surface by the roofs' own weight.



Figure III. The constructional scheme of multi-purpose sport center in Izmailovo.

In terms of a structural scheme the membrane roof in the main hall is a 60x66 m sheet, rectangular in plan, which is made of stainless IOXI8HIOT steel of 2 m thickness; the sheet is diagonally supported by steel strips - 25 mm thick "diagonals" made of steel I4I2 (Fig. IV). Each diagonal consists of two halves, each nearly 50 m long; the halves have variable width: being 5 m at the ends, it amounts I m in the centre of the roof. The ends of the diagonals are secured to the corners of the supporting contour; in the middle the four "half-diagonals" are connected by a cross-shaped element. Laterally each half-diagonal consists of two halves placed at an angle to each other. There is a gap left between them which is filled by flat triangle steel wedges made of steel bars; due to this the diagonals cross-sections have transversally trapezium shape.

The angle of gradient of each half of the diagonal corresponds to that of the tangent of the membrane's surface. The employed structural solution of the diagonals permits to provide the roof with the surface comprising four joined cylindrical shells. The initial sag over the diagonals of the total length of about IOO m is 4 m, while owing to the wedges inserted into the diagonals the sag of



Figure IV. The general view of membrane roof of multi-purpose sport center in Izmailovo.

the membrane near the supporting contour is 4,4 m. Similar geometry provides for the external drainage realized through the hoppers at the membrane's edges.

The membrane of the main hall has I4 openings sized 2x2 m for natural light lamps, ventilation and smoke expultion in the case of a fire. The weakening of the membrane by the openings is equilibrated by a steel lattice welded to the framing. To hang up lamps and sports equipment branch pipes spaced 6x6 m are welded to the membrane. Using cables let through the branch pipes scaffolds and various fittings can be pulled up to the membrane.

As the heater above the membrane rigid glass-fibre boards with a cement tie rod can be used. Water proofing is ensured by two layers of butyl rubber, cement and sand reinforced layer is used for fire protection.

The precast and cast-in-place reinforced concrete supporting contour of the training hall has the cross-section sized 0,5x4 m; it is designed closed. Its long side (the length of 72 m) is cut in the middle by steel and reinforced concrete strut which divides the roof's area into two surfaces with the overall dimensions of 36x36 m. Three sides of the contour rest on the columns of the training hall; rectilinear (horizontal) in bays the contour is slightly raised at the corners of each roof.

Both in the main and in the training halls the membrane is supported by diagonals that are 4 m wide at the edges being I m wide in the middle of the roof. The sags in the training hall amount I,5 m in the middle and 2,0 m at the edges.

In view of the novelty of the structural solutions of the large span roofs of the cycle track and Multi-Purpose Sporting Facility their reliability verified by calculations was also tested experimentally on models, the scale being I/20-I/25. Besides, full scale observations of the shell's behaviour have constantly been carried on both at the erection stage and after the termination of the construction. The results of the research and observations testify as to good agreement between theoretical and experimental data and to reliable performance of the structures as a whole. The Development of the Resort Complexes for Mass Recreation of the Working People.

V.Gusev, M.S. for Architecture, The Central Research and Design Institute for Experimental Designing of Resort, Sanatory , Tourist Buildings and Complexes, Moscow, USSR.

Summaries

In the USSR one of the important tasks in the development of mass resort complexes for mass recreation. The nomenclature of the health resorts gives a possibility to organize a variety of recreation kinds and takes into account the wishes of different groups of population. The Central Research and Design Institute for Experimental Designing of Resort, Sanatory., Tourist Buildings and Complexes heads designing and research work in the resort development field in our country.

In the Institute the main task of the creative work is designing and building of large-scale complexes of sanatoriums, rest-houses and boarding-houses for families, hotels and pioneer camps. Recently in the USSR a number of large capacity complexes from 2000 to 7000 persons were built for medical treatment and recreation of working neople.

La construction des stations balnéaires et thermales pour la récréation des travailleurs dans L'Union Sovietique est une tache très importante. Le vaste réseau au pays est mis déjà 500 areas with most favourable natural condien oeuvre. La nomenclature des stations et complexes de la santé assure une diversité de ces ressources et moyens compte tenu des voeux tout a fait différents. À la tête des activités dans ce domain se trouve L'Institut Centrale des recherches et projets experimentales à construire des stations et des complexes de la santé et du tourisme. De nos jours L'Institut s'occupe surtout des projets pour la construction les complexes développés: stations, maisons du repos, pensions de famille, hôtels et camps pour les jeunes. Les années courantes on a bati au pays des complexes nombreux qui peuvent recevoir de 2000 jusque 7000 persons le traitement et le repos.

In the USSR the development of the resort, sanatory and tourist complexes for treatment and vaious kinds of recreation for working people is an important government task. The rights of working people to health and recreation security are stipulated in the Constitution of the USSR. The Soviet people created a developed net of health- resort buildings. More than 300 balneological and climatic resorts, recreation zones have been built recently in different districts of the country.

The nomenclature of the health-resorts is various, such as sanatoriums of different medical purposes for adults and children treatment, rest-houses and boarding-houses, boarding-houses for families, dispensaries, different types of tourist buildings, pioneer camps, summer sanatory camps for youth, houses for fishermen and hunters, etc. Providing the working people and the members of their families with good conditions of recreation, improving their health and prophylactic treatment is a great social achievement of the Soviet society.

Trade unions pay a considerable part of the accommodations cost in the sanatoriums, resthouses, etc. and they pay almost full cost for children's stay in the pioneer camps and summer country houses where children of preschool age are taken good care of and the treatment there is free of charge.

The Soviet Union possesses the richest natural and medical resourses for developing the net of resorts. At present in the USSR there are more than 6000 different mineral sourses, more than 700 medicinal mud deposits, more than tions for the resort development. The work of number of research and design Institutes in the field of resort, sanatory and tourist development is headed by the Central Research and Design Institute for Standard and Experimental Designing of Resort, Sanatory, Tourist Buildings and Complexes of the State Commettee for Civil Development and Architecture attached to the Gosstroi of the USSR.

The Institute works out a large quantity of research works in the field of generalization of experience in development and running the resorts, scientific recommendations for improving existent and creating new types of buildings, new aevelopment standards and rules, methodical instructions and recommendations for designing. On the basis of the worked out standards and rules for designing, the development of the sanatorium buildings and complexes, rest-houses and rest-bases, tourist hotels, resorts and recreation zones put into practice. The research works of the Institute showed that the problem of the constantly increasing demands of population for resort treatment and recreation may be solved by the creation of large-scale sanatoriums, recreation and tourist complexes instead of separate buildings of that kind.

In recent years a number of large modern complexes for working people treatment and recreation have been built in the USSR. For example the sanatorium complexes : "Kujalnik" for 4000 persons, "Truskovetz" for 4000 persons, the boarding-house complexes: on the Kljazma reservoir for 4000 persons, at Pitzunda for 3000 persons, resort town "Adler" for 7000 persons, the children's health-resort complexes: "Artek" in the Crimea for 4500 pioneers, "Orlenok" on the Caucasian sea coast for 4000 pioneers, the complexes of the sanatorium pioneer camps: "Juzhni Leninetz" for 6000 pioneers at the Evpatoria resort, "Zhemchuzhina Rossii" for 3500 pioneers at the Anapa resort, the complex of the pioneer camps for 2800 pioneers at the "Naberezhnie Chelni", etc. The creation of large health-resort complexes for treatment and recreation gives a possibility not only to considerably reduce capital investments for aevelopment and operation but also to improve recreation conditions. The enlargement of the service system in complexes improves its standard by creating large medical and cultural centers with swimming-pools, sports halls and trade centers. Scientific research of the Institute shows that the erection of the sanatorium complex for 3000 persons in comparison with the buildings for 500 persons each of several sanatoriums with the same total capacity makes it possible to reduce capital investment at a rate of IO-I2% and operation expenses at a rate of 12-15%.

The designing of the complexes as complete ensembles gives possibilities to form the architecture of the resorts. The designes of large complexes worked out in the Institute such as the all-Union pioneer camp "Artek" in the Crimea, boarding-houses in Adler, sanatorium pioneer camps in Anapa, recreation pioneer camps in Naberezhnie Chelni, etc. show that the erection of large complexes makes it possible to create new recreation environment for working people on the basis of a more perfect service system and of a high level architectural solution of buildings and structures. The resort complex in Adler is one of the

examples of a new trend in resort development "Figure I". This complex is built by trade unions and provides comfortable recreation for families.



Figure I. Boarding-house complex in Adler. Accommodation building.

On the cerritory of this complex the following buildings and structures are located: four I5-storey buildings each for I000 guests (these buildings are connected by passages with the dining- rooms), several 4 and 8-storey dwelling houses, two open-air amphitheatres, an administrative building , cinema-concert hall which houses 2500 persons, a polyclinic, beach and engineering facilities. Service rooms and premises are located on the ground floor and the first floor of the multistorey building. On the other floors there are comfortable double rooms, each with a loggia. The sidefaces of the multistorey buildings face the sea and this location gives a beautiful landscape vista vision. The deep loggias and the system of the side barriers protect the rooms from overheating and allow for necessary comfortable conditions. The buildings are made of monolithic concrete in sliding shuttering.

Great attention was paid to the organization of public services and amenities, planting of of greenery and decorative illumination of the territory. The complex of buildings and structures with surrounding landscape is turned into a united architectural complex by means of monumental and decorative art. The resort town is intended for family recreation therefore on the area are created the children's playing town with a decorative pool and sculptures of the sea inhabitants: turtles, fish, sea stars as well as a number of volumentrical sculptural compositions.

Serious scientific research work had preceded the erection of such a large resort complex by working out the Instructions for resort designing, by choosing the optimal device of the architectural site planning and zonation as well as of buildings location on the site, by working out the Standards for building sites and beaches and requirements for their equipment, by area correlation of different functional zones, capacity calculation of different groups of buildings and rooms taking into account demands for them and frequency of visits, by taking into account natural and climatic conditions of the place and microclimate of the site.

The most important trend in the development of mass types of recreation buildings, such as pioneer camps, dispensaries, rest-houses is application of specially worked out unificated designs, the so-called "stendard" designs.

The complexes of sanatorium pioneer camps at the Anapa resort and the pioneer camps in the town of Naberezhnie Chelni are built according to standard designs, which had been worked out in the Institute.

The first phase of the sanatorium pioneer camps complex development at the children's resort Anapa (capacity for 3500 pioneers) began to function in 1975 "Figure II".



Figure II. Complex of sanatorium pioneer camps at Anapa resort.

Each pioneer detachment has its own accommodation building for 320 pioneers (in summer for 480 pioneers) with a dining room and school. The administrative and reception building is built to serve the camp. The medical buildings with diagnostic offices, mud-baths, water-cure offices with 3 pools and cultural center are under construction.

The area of the pioneer camps is provided with places for pioneer parades, camp-fires, open-air cinema, sports and playing grounds.

The complex of the pioneer camps and restbases (capacity for 2880) for Kamsky motor plant is erected in the green zone of the town Naberezhnie Chelni on the bank of the reservoir "Figure III". The camp is intended for summer recreation of children at the age from 7 to I4.



Figure III. Complex of pioneer camps and restbases in Naberezhnie Chelni town.

At school-time the complex operates as a restbase for the motor plant workers and employees recreation. The complex consists of 4 pioneer camps for 720 pioneers each. Dwellings, diningrooms, places for pioneer parades, camp-fires, morning gymnastics and sports training, pavillions for children's games and studies are located on the sites of these camps. The pioneer camps are amalgamated into the united architectural ensemble by the all-camp center. which is intended for cultural and mass entertainments. The pioneer house (with gymnasium, swimming-pool, cinema-concert hall, rooms for creative work, winter garden), stadium, sports grounds, summer cinema, park with pavillions and places for children's recreation are located at the all-camp center. Medical offices and isolation ward are located in the medical reception building.

Large-scale development of children's healthresorts favours the solution of an important social and economic task- to bring up a generation of Soviet people who would be strong physically and spiritually.

The Institute takes the leading place in the field of resort hotel complexes development. In recent years a number of comfortable hotels have been built, among which "Zhemchuzhina" in Sochi (for 2016 guests), "Jalta" in the Crimea (for 2740 guests) are worth mentioning.

The hotel complex "Zhemchuzhina" in Sochi "Figure IV" includes the main I9-storey structure with guest accommodations, the restaurant and cafe structure, the open-air swimming-pool with two baths of lukewarm sea water and beach structurs 300 meters long.

Reception and service rooms, cafe and coctail hall are located on the ground floor of the hotel. Bilateral location of the rooms(on the both sides of the corridor) is on the upper I4 floors of the hotel. On each floor there are 72 doubles and 2 suites. A 4-storey restaurant and cafe structure houses the groups of restaurants with different capacities.



Figure IV. Hotel complex "Zhemchuzhina" in Sochi.

The summer cafe and cinema are located on the roof of the hotel. Above the hotel's beach there is a bridge of sea-front II meters wide. Cloak-rooms, toilet-rooms, medical station, buffet, stock-rooms are located under the bridge. The beach is equipped with a covered slip and moorage, shade tents which cover 60 per cent of beach capacity, and a life-guard's tower.

The Institute works out the Recommendations for designing and location of hotels for foreign tourists taking into account specific features of the hotel designing for tourists.

The main trend in the field of resort development nowadays is creation of convenient and architecturally impressive complexes for mass recreation and treatment according to modern achievements.

The task of construction in creating a healthy and cultural housing environment
Ing.arch. Václav Kasalický, Dr.Sc., Director of the Research Institute of Building and Architecture, Prague, Czechoslovakia

Summary

Human requirements on the quality of environment are increasing progressively. Satisfying these requirements is not only a problem of technical capacities of the branches aiming by their activities at the formation, the improvement and the adaptation to the new social conditions of the environment.

This is a complex problem, which has to be solved at present by all countries and goverments, without any difference made in the degree of their economical development or social system. Differences in social system produce various approaches to the solution of these problems. But the material and technical solution remains the common solution for all the countries and social systems. This gives to the international organizations, active in the field of construction, architecture and environment, extensive possibilities of a fertile exchange of information and experience.

The requirements and the needs of the population in the sector of the living environment are being solved at present under constant pression of the energy crisis, which is deeply reflected in the development of the material production basis of the building process. On the contrary, the progressively increasing knowledge of the ecological problems has an influence on continual augmentation of requirements on the manufacture of building materials and constructions. The task of the research in this situation is to seek for optimal solutions able to satisfy energy economy and ecological requirements.

The demands of mankind on the chality of the human environment mark an upward trend. To satisfy these demands does not depend merely on the available resources, but also, perhaps above all, on the technical capacities of industries which are supposed to create the human environment, and to perfect and adapt it to new social conditions. It is a complex problem, facing all the countries and governments in the world, disregarding the degree of economic development or social system. Different social systems bring about different approaches to these problems, but the material and technical solution remains the same for all countries and social systems. This offers broad opportunities for international organizations active in the sphere of architecture, building and human environment, as for the exchange of information and experience. This particularly applies to CIB, an organization dealing with research, that is with systematic discovering of laws and rules for a successful development of the material and technical solution of the human, especially housing environment.

The requirements and needs of the population in the sphere of the housing environment are at present approached under the permanent pressure of the energy shortage, reflected in the development of the material and production basis of construction, and under the influence of the ever-growing knowledge of ecological problems, which in turn increase demands on the production of building materials and constructions. In this situation, research has to find solutions, which would be optimally accommodated to the energy economy and ecological demands. In many respects, e.g. when coping with the resistance of buildings against noise or when increasing their thermal technical parameters, one solution will cover both aspects; in other cases, e.g. when tackling the transport demands in construction, i.e. reducing the weight of the transported materials or elements, the favourable solution in one respect is opposed to the favourable solution in another respect.

The basic funds provided by construction in the form of buildings contain premises where man spends a considerable part of his life. It is an inner environment, with specific features and effects on man. This part of the human environment requires special care and attention. The original purpose of the inner premises was to protect man from the unfavourable weather, animals and enemies outside, but the purposes soon multiplied. The basic ones have remained, and perhaps a highly contemporary purpose could be added to protect man from some negative effects, often encountered in the present-day outer environment. The contemporary society

has technical means, and a full utilization of the function of inner premises is more of an economic and serviceable question. However, many problems arise today, especially in terms of utilizing of new building methods and materials; they indicate that the creation of the innder human environment /the so-called microenvironment/ is a difficult task, in many respects more difficult than the creation of the outer environment. The significance and urgency of these problems is such, that it is considered by international governmental organizations, e.g. by the Economic Commission for Europe. A seminar was held in October 1976 in Budapest, on building and human environment. Many participants from Europe and the United States confirmed the results achieved by our research.

The most relevant result of this seminar, in accordance with our research, is the finding, that providing the industrialization of the building industry takes a spontaneous course, without consistent consultations with ecologists and architects specialized in the creation of the inner environment, many mistakes occur and have to be repaired at large costs. The frequently unscientific selection of building materials and surface finish in interiors and outer covering is often harmful in terms of materials, which are also often uneconomic, particularly regarding energy, etc. The materials which have to be carefully tested or preferably excluded, are mainly lead, as it is sufficiently known, but also some plastics, synthetic glues and binders, asbestos and its products, paints and vernishes manufactured our of unsuitable materials, and in some cases even concrete and concrete elements. A construction or element may not be suitable because they do not correspond to some parameters of the protection of the inner environment from outer interfering effects /e.g. noise, cold or heat/, even though the materials used are not harmful. The seminar therefore declared the requirement, especially the Soviet delegation, of elaborating punified and agreed requirements on minimal qualitative parameters of building units, materials and constructions in current building, regarding the creation of the inner environment at constructions, and the measuring and verification of the real, achieved values of the inner environment. A lot has been accomplished in our country in this respect, but we are still at the beginning, especially as far

as the scientific foundation of the design building rules is concerned.

The process of capital construction, that is all the stages of extended reproduction of basic funds, takes place in the already built human environment, and it brigns into its current function many new elements and activities, which have been proved to have interfering effects. A positive influence of the construction process on the environment has so far been exceptional. The institutions and heads of organizations taking part in the investment process carry a highly important and momentous social task of restricting the negative effects of investment processes on the human environment to a minimum level.

The capital construction will continue having an important role in the protection of man from unfavourable climatic conditions, i.e. in the creation of artificial human environment. This does not mean only the creation of interior premises in constructions, of rooms, working premises, etc.,but also the creation of the artificial outer environment, i.e. of the urban environment.

The lastest research in this sphere demonstrates that all the problems related to this very demanding activity with a large share of artistic creativity have not yet been solved. Some ecological, town-planning and esthetic questions are still unanswered. The capital construction in cities is so far unable to srevent the penetration of air pollution, the residential buildings are not perfectly protected from the noise, particularly at night, the human movement is not separated from the movement of transport vehicles with noxious emissions, and mainly the recent times illustrate the growing problems of esthetic, architectonic shaping of large city ensembles built in a mass, industrial method. These problems are pursued not only by the Czechoslovak research, but also by international experts, governmental and nongovernmental international organizations, executing certain rules to improve the general situation.

Unfortunately, not even on a world level, there are no specific solutions of this problem, only general instructions, formulated rather as requirements, and their specific solutions have to bethought in the practical creative workd of an architect or designer, together with technologists and construction organizers. The adaptability of the building production to these urgent social requirements is a capital factor.

If the capital construction is to fulfill its social task in creating of the human environment for the contemporary society /by changing the existing environment originated mostly in other social conditions/, this task has to be recognized and adopted by all the participants of the investment process, it has to be anchored in its conception and in the methods evaluating its effects. This does not mean, as it were, any additional requirements on the investments, but in fact an improvement of the preparation of capital construction and its enrichment. Ecologists have to be integrated into design teams /not just be submitted designs for assessment/, the ecological criteria have to be included in the indispensable criteria of expert essessment and into the total evaluation of the efficiency of capital construction. The experience we gained recently from the expert assessment of housing ensembles bear out the justification of this procedure. They also prove, that respecting of ecological criteria has never caused exceeding of the established economic limits, contrarily, if they are not obeyed in the design, an additional perfection of the materialized construction will require more costs than would be necessary in a perfect design. The investment organization and the designer have an essential and principal role in securing the creation of human environment in a modern society. All the other participants of the capital construction will be subordinated to their intentions. The research indicates that the level of social consciousness of investment organizations and designers is still low, overcome by the consciousness of group, entreprise or local interests.

The use of building materials and their surface finish have a major influence on the human environment. Ecologically, the best building material is the classic burnt brick and lime plaster. This material is not suitable for industrialization of the building industry. or an adequate method has not yet been found. People are therefore shut among concrete walls, and other modern materials are used, although their long-term effect on human health has not been systematically and consistently registered. Some incidental research brings warning signals. Particularly dangerous effects have been discovered in asbestos-cement materials, although their production and use still grow all over the world.

Other materials also show unfavourable effects on the respiratory organs, skin, blood composition, and some are suspect of being carcinogenous. This applies not only to the utilization stage in buildings, but also to the stage of construction. The European Economic Commission received conclusions from medical examinations of ca. 40,000 building workers, in which the effects of the used building materials on their health had been studied. In the light of these findings, certain preventive actions were undertaken. The building industry has reached a development stage when a complete revision has to be initiated from the ecological viewpoint, and it will have to be transformed into a healthy and ecologically unharmful industry.

To a large extent, what has been said of the building industry can be said of the assemblies of technical and technological equipments, especially when using some new materials. First of all, we might mention the installation nuclei in flats, but the rate of new, ecologically not completely researched materials is growing in other than residential buildings as well. Their influence on the inhabitants is smaller, because they visit these buildings repeatedly only rarely, but on the other hand, these buildings constitute the working premises, in which the employees are exposed during their working hours. Consequently, their importance from the viewpoint of quality of environment is essential. A systematic ecological and health research of the individual parts of the artificially created human environment has not yet begun, some conclusions have been reached by the intermediary of examining the health condition of certain ill persons, and it was rather a suspicion than a proof of the negative effects of the used building materials or materials used for the production and assembly of some equipment on the health condition of the affected persons. However, these materials and other types of materials can also affect man favourably, but scientific proofs are lacking. The investment organization, as a representative of the future users of the basic funds, has to bear on mind these circumstances and effects, and to form not only an investment policy, but also a policy creating a healthy, unharmful human environment.

The collaboration of investment organizations and designers in the preparations of the industrialization process is indispensable to achi-

eve the targets and aims of the creation of the socialist human environment. The building industry and its leading representatives will logically and consciensciously strive for directing the building performances towards the accomplishment of quantitative indicators set by the plan, and in terms of quality, they will concentrate above all on the quality of the building implementation. It would be illogical to expect something else, and our long-term research and practical experience in investment and design confirm it. The changes in social quality, esthetic and architectonic level of constructions and urban complexes have to be guaranteed both by the investment organization and designer. They cannot be guaranteed to the detriment of the economic efficiency of construction, but they cannot be neglected onesidedly in favour of the technological facilitation of construction. In order to carry out their social tasks, which has not been the case so far, both the investment organization and the designer have to perfectly handle the industrialization process in the building industry, and the methods of typification and unification of constructions, building elements and structures.

The process of investment materialization /capital construction/ is composed of sets of activities, connected by time and place /stages/, usually identified as:

- finding of future needs and requirements of the society on the basis of scientific forecasts of its development, particularly in terms of way of life and the ensuing needs and cultural, social, health, educational, nutritional requirements, that is needs and requirements expressed in the targets of the policies and programmes of social centres;
- finding and assessment of physical /natural/ conditions of the territory in view of the optimal and rational utilization of resources provided by the territory at present and in the future;
- finding and assessment of economic conditions and prerequisites for the materialization of construction, based on economic forecasts of the economic development of the State, its areas and regions, forecasts of the development of industries, particularly from forecasts of the application of the scientific and technical progress in the production and in social activities, from forecasts of structural changes in production and in the activities complementing production;

- finding and assessment of social terms and the demographic development in the territory in vies of the socially optimal utilization of the qualification potential and capacity of the population in relation to the implementation of construction, particularly after the introduction of capacities into operation or utilization, bearing on mind the reality of changes in the demographic structure in these consequences;
- creation of investment intentions and processing of basic data for investment activities and construction in all its stages, organization, co-ordination and management work of the investment organization until the constraction is given over to utilization or operation, in which defects should be absent;
- designing, as an activity produced by investment impulses, but having its original character and course, especially in materializing the demands of the investment organization in a cultural, socially advanced form, corresponding to the material and spiritual needs of the present and future generations, during the lives of which, the basic fund provided by construction will still fulfill its purpose /which should be the principle of applying the socialist realism in construction/;
- contracting building, consisting in the organization of human work, machinery work and movement of masses from the building site to spoil heaps, and from the manufacturer to the places of further processing, pre-assembly or assembly, in a co-ordinated manner and to exclude useless losses economic waste in materials and energy /including human work/;
- controlling and supervising activities, following the maintaining of social standards and interests in accordance with the valid rules and administrative measures, inspecting the course and approving the results of the implementation stages. The controlling and supervising activities have to be included in the duty of the executive bodies of the investment organization, designer and supplier, but its essential part, although not the largest one in terms of time, has to be performed by executive bodies of public institutions, particularly national committees and expert facilities under their control /hygienic stations, inspection of air and water pollution, etc./ This gains importance especially in relation with the increa-

sing knowledge of the significance of development, creation and protection of the human environment;

- generally beneficial activities, cultural, etc., e.g. the protection of monuments, nature, etc. These activities should not represent only preventions of something, but they should be active stimuli orientated to the achievement of positive results in the creation of human environment or in its re-creation by capital construction.

The concluding results are, that the building research will in the future assume a major and highly significant part of being a scientific basis for a comprehensive protection of man from negative influences caused by natural forces, and by various activities of the human society. I am convinced that this universal, human requirement will gradually be reflected to a sufficient extent, in the activity of such an important non-governmental organization of building research as the CIB. The use of system dynamics in housing supply forecasting Dr. Gv. Kunszt

Research Director, Architect

Dr. L. Molnár

Senior Research Officer, Mechanical Engineer

Hungarian Institute for Building Science ÉTI Budapest, Hungary

Summary

Decision-making in long-term housing policy requires forecasts, based on the analysis of the objective processes. As housing construction is related in a complex way to the various fields of social life and economy, mathematical modelling offers the best method to draw conclusions from intricate effects. Of the many types of modelling procedures Forrester's system dynamics proved to be the most suitable for carrying out the necessary analyses.

The model worked out consists of two parts: the subsystems describing the variation of the number of population and the development of the housing conditions, respectively. The two subsystems are related to each other by means of an auxiliary variable derived from the quotient of the actual and the desired number of rooms.

The number of population depends on the birth and death rate and, if a region or town is concerned, on in- and outmigration, while the number of dwellings available is subject to new housing construction, demolition and ageing, as well as the abolishment of dwellings owing to urbanistic reasons.

With the aid of the model so constructed, using various initial data, approx. 60 simulations have been made. The runs show that, if efforts spent on maintenance building are not increased, the housing situation over the long run is to be expected to aggravate, even if the volume of new housing construction is increased.

Résumé

Pour préparer les décisions portant sur la politique de l'habitat à long terme il est nécessaire de révéler les procédés objectifs et de faire des pronostics sur ces bases. Étant donné que les conditions de l'habitat s'attachent de multiples façons aux divers domaines de la vie socioéconomique, c'est le modelage mathématique qui s'avère la méthode la plus adéquate pour mettre en lumière les conséquences des influences complexes. Parmi les diverses techniques de modelage nous avons trouvé le procédé de dynamique des systèmes de Forrester approprié à faire les analyses nécessaires.

Le modèle élaboré se compose de deux parties: des sous-systèmes décrivant le changement de la population et le changement de l'habitat. Les deux sous-systèmes sont réunis par le variable obtenu du quotient du nombre effectif et du nombre souhaité des pièces.

Le chiffre de la population est influencé par la natalité et la mortalité (ou, dans le cas d'une région et d'une ville les emménagements et déménagements), tandis que le chiffre des logements utilisables varie selon les nouvelles constructions, la démolition et le nombre des logements devenus inhabitables en raison de leur vieillissement ou de raisons d'urbanisme.

A l'aide du modèle ainsi conçu nous avons effectué quelque soixante simulations. Les analyses ont démontré que si les efforts de maintien ne se multiplient pas, il faut compter à long terme sur l'aggravation des conditions de logement même si nous augmentons le volume des nouvelles constructions.

At the ECE Seminar held at Gävle, Sweden, 1977, to discuss building research policies, it was stated that a reorientation occurred in the main trend of European building research: the ratio of building industrialization to maintenance building changed dramatically, the latter being placed first [1].

In Europe the situation varies from country to country. In the less developed countries mass housing and the increase of the existing housing stock is invariably a priority, which leaves small capacities only for the maintenance and modernization of the existing stock. In the most advanced countries mass housing to-day presents hardly any problems to be solved or tasks to be implemented. Attention is concentrated on quality and the improvement of the existing stock.

Regarding the above trends Hungary occupies an intermediate position. While the second 15-year housing construction plan commencing 1976 earmarks the construction of more than a million new dwellings, a significant proportion of the housing stock in Budapest (and in some other towns of Hungary) built in the decades about the turn of the century, is to be expected to deteriorate at a growing rate. It has become an important task to attempt to forecast the housing supply of the population of the country, both qualitatively, and quantitatively, for the coming century.

To implement the task of forecasting a mathematical model was required, capable of forecasting the housing supply available for population as a function of the construction of new dwellings, and of the demolition, leaving and reconstruction of existing ones. To solve the problem we have chosen Jay Forrester's system dynamics, and as a first step, we have attempted a rough approach to the problem.

As is known from the theory of system dynamical models, these consist of level and rate variables, as well as material and information links, which connect the rate and level variables [2]. By employing the notations generally accepted in system dynamical literature and also relying on the urban dynamical models of the Forrester group the system of relations, characterized to a first approximation by the process diagram in Fig.1 has been developed to model the housing supply in Hungary.

Construction of the model

The model consists of two subsystems:

- a/ the population subsystem
- b/ the housing subsystem

a/ The level variable of the population subsystem is the number of population, increased by the rate variable of birth and in-migration, and decreased by that of death and out-migration. In a model applicable to a country in- and out-migration can be taken to be 0 (as is the case here), however, for a town the difference may be significant.

The population subsystem consists of elements marked by 1-8. The variable No. 1 shows the annual variation of the number of population. This variable is influenced by two variables, the birth (No. 2) and the death (No. 3) rate. The two rate variables give the annual variation of the number of population. The values of rate variables are determined by the birth rate (No. 4) and the death rate (No. 5) factors. These factors give the numbers of births and deaths per thousand inhabitants.

The birth multiplier (No. 6) is a term expressing a specific relation. Above a certain level inadequate housing is assumed to have a negative impact on the birth rate. The birth multiplier shows this relation as a function of housing supply.

The variable No. 8 is a term showing what targets may be set for housing supply on society level. At present, the value 1 person/1 room is set as a target to be attained.

If the desired person/room ratio and the number of population are known, the desired number of rooms can be assessed (Variable No. 7).

b/ The level variable of the housing subsystem is the number of dwellings or the equivalent number of habitable rooms (No. 10), increased by the rate of new housing



construction (No. 11) and decreased by the number of demolitions (No. 12) and that of dwellings left empty (No 13).

The dynamical behaviour of the housing subsystem is assumed to be influenced by

 the so-called housing ratio, i.e. the quotient of the actual and the desired number of rooms (No. 9).
The intensity of housing activities (No. 20).

The variables No. 9 and 20 are similar in many respects but in some respects they differ substantially. Variable No. 9 is the term expressing the general stimulating effect of the housing shortage on the building industry via the housing construction multiplier (No. 18) whereas variable No. 20 shows the effect of the new housing to maintenance activities ratio (No. 19). At the same time this is the point where the finiteness of resources has been taken into account: with the increase of funds allocated to maintenance building the funds available for new housing construction decrease and vice versa.

Here, too, just as in the foregoing, the values of the individual rate variables, the housing construction rate, the demolition and the leaving rate, are influenced by constants (No. 14, 17 and 15, respectively).

The average lifetime of housing (No. 17) has been assumed to decrease abruptly with the increase of the age of housing stock, if maintenance building remains at the present level.

The housing construction multiplier (No. 18) and the leaving multiplier (No. 16) are assumed to depend on the housing ratio (No. 9) according to a given relation.

Thus, the two subsystems are related by the housing ratio (its present value is 0.62 room/person). The purpose of our investigations was to assess the amount of time required to attain the value of 1 person/1 room set as a target, based on the intensity of housing activity and on the given ratio of new housing construction to maintenance building, as well as the variation of the person/room value in general.

The time-dependence of the rate variables and the housing ratio have been estimated. The estimations describe the past 10-15 years accurately. The validity of the estimations for the future has been checked by the method of the so-called sensitivity analysis.

Run of the model

During the course of runs the behaviour of the systems was simulated by various initial data. The simulation algorithm was programmed in Fortran language. Each simulation was carried out for a period of loo years. In each case our investigations covered the number of dwellings and number of population on the one hand, and the room/person ratio, on the other. Of the approx. 60 cases considered, the results of the following 5 runs are particularly interesting.

1. It has been assumed that the figures concerning demolition, construction and leaving of dwellings during the past ten years remain unchanged in the future. (Approx. 90 thousand new dwellings, 20 thousand demolished and 6 thousand left empty per year. On the average each dwelling has two habitable rooms. The number of population of Hungary is 10, 5 million. The growth of the population averages 1, 2 %o/year.

2. The construction figures of the past ten year period have been assumed to stay unchanged for the future, however, the number of abolished dwellings, owing to insufficient maintenance activites has been assumed to grow first at a slow, later at a quicker pace. (The rehabilitation of a growing portion of the existing, old housing stock becomes uneconomical.)

For the increase of the number of demolitions we have assumed the following relation:

Years	0 - 10	10 - 20	20 - 30	over 30
Intensity of demolition	1	2	4	8

This means that the number of demolitions is supposed to double every 10 years as compared to that in the first run.

3. New housing construction increases by 10%. In this case we have investigated to what extent the increase of new housing construction can counterbalance the increased rate of demolitions. The rate of demolitions agrees with that in case 2.

4. The data concerning new housing construction agree with those of the standard run (case 1), however, the rate of demolitions varies as follows:

Years	0 - 10	10 - 20	20 - 30	over 30
Intensity of demolition	1	1.5	2	4

Thus the demolition ratio is approx. half of the demolition ratio of case 2.

5. As compared to the standard run new housing construction increases by 10%, the rate of demolition agrees with that of run 4. The results are summarized in Fig. 2.

Conclusions and further tasks

Fig. 2 shows the variation of the housing ratio as a function of time. The housing ratio has been defined as the ratio of the actually available number of dwelling units (habitable rooms) to the number realistically expected on society level, i.e. as the degree of housing supply. If the value of housing ratio is 1, the level of the actual housing supply has reached the target realistically expected by society. If the value of the housing ratio is smaller than 1, the actual housing supply is inferior to the expected, however, if it is greater, the actual supply exceeds the present expectations.

If, according to the result of run 1, the rates of new housing construction, demolition and leaving retain their present value, the level of housing supply corresponding to the realistic expectations of and the targets set by society can be attained by approx. 2010.


The probability for this is made questionable by the fact that for Run 1 we have assumed the demolition rate to remain constant as a function of time.

Owing to the growing obsolescence of the housing stock this assumption cannot be realistic, but an increasing demolition rate should be assumed. Assuming a demolition rate doubled every ten years results in the extremely unfavourable forecast according to Run 2, stating that although the level of housing supply would raise approx. up to 2000, this would be followed by a gradual decline and in the period after 2020 it would fall below the level of the supply in 1980, at a rate growing more and more critical.

To avoid such unfavourable developments, an increased rate of new housing construction or a more intensive maintenance activity would be required, which latter makes it possible to decrease the number of dwellings to be demolished owing to obsolescence. construction to be 10% higher than that assumed for Run 2. According to the results of Run 3 the increase of new housing construction to such an extent would but slightly affect the trend resulting from Run 2.

For Run 4 we have assumed the demolished volume to be half of that considered in Run 2. The results of Run 4 showed that the decrease of demolition volume to such an extent already influenced housing supply very markedly, in a favourable sense. In this case the level of housing supply attains the expected value by 2030, subsequently the supply level continues to improve slightly, and then it practically remains at a constant value.

For Run 5 we have again assumed a 10% increase of new housing construction, under the otherwise unchanged conditions of Run 4. The results of this Run also show that the 10% increase does not alter the trend, but raises the level of supply to a slight extent.

From the results of Runs 1-5 it could be stated that the future variation of the level of housing supply in Hungary, taking the value boundaries appearing in the runs into account, depends to a much greater extent on the development of housing maintenance activities than on the variation of the amount of new housing.

During the course of further investigations and the improvement of the model planned by us it should be attempted to expound this thesis more specifically and to consider the outcome of various further assumptions. In particular, it requires clarification how to divide the resources available for construction between new housing construction and maintenance bulding to achieve the most favourable result in view of the restricted availability of resources. These investigations may underlie the most important decisions to be taken by Hungarian housing policy regarding construction.

To obtain a refined picture it is necessary to take the age distribution of existing housing stock more specifically than hitherto into account. Mathematically, the model offers such a possibility, however, for a full range of investigations some of the required data have not been available yet.

Considerations should also be extended to the construction technology and to the architectural-ground-plan-functional solution of dwellings. Another important problem to be included in the investigations would be the effect of incomes, dwelling prices and rents on the variation of housing supply.

750

For Run 3 we have assumed the rate of new housing

Logond	
Legenu	

1.	Population	Р
2.	Birth rate	BR
3.	Death rate	DR
4.	Birth rate factor	BRF
5.	Death rate factor	DRF
6.	Birth multiplier	BM
7.	Housing desired	HD
8.	Units per person	UPP
9.	Housing ratio	HR
10.	Housing	н
11.	Housing construction rate	HCR
12.	Housing demolition rate	HDR
13.	Housing leaving rate	HLR
14.	Normal housing factor	NHF
15.	Normal leaving factor	NLF
16.	Leaving multiplier	LM
17.	Average lifetime of housing	ALTH
18.	Housing construction multiplier	HCM
19.	Housing construction and maintenance	НСММ
	multiplier	
20.	Housing activity multiplier	HAM
21.	Housing activity	HA

References

1. Building Research Policies,

A Seminar of the United Nations Economic Commission for Europe, Pergamon Press, Oxford, 1978.

- Forrester Jay W., Principles of Systems, 2. ed. Wright-Allen Press, Cambridge, Massachusetts, 1968.
- Forrester Jay W., Urban Dynamics, M.I.T. Press, Cambridge, Massachusetts, 1969.

International Comparison of Value Data in Construction

L.F. Miriushchenko, Cand.of Sc.(Econ.), NIIES, Moscow, USSR

<u>Summary</u>. The report shows the importance of an international comparison of cost data in construction work in conditions of extended scientific, technological and economic cooperation and the improvement of integrated construction management.

The paper provides a description of various methods of determining labour productivity level, the definition of currency parity in construction work in various countries. A methodology of the computerised and simultaneous determination of the coefficient of the labour productivity level and currency parity in construction is set forth. A developed economicomathematical simulation model is used as a basis.

<u>Sommaire</u>. Cet exposé indique l'actualité de la question des comparaisons internationales des valeurs dans la construction à la condition du élargissement de la coopération scientifique, technique et économique et du perfectionnement de la gestion de la construction intégrale.

On examine les méthodes differentes des définitions des niveaux du rendements de travail et de la parité des valeurs à propos des travaux de montagé dans les pays differents et on cite la méthodologie de la définition simultanée du facteur des niveaux du rendement de travail et de la parité des valeurs dans la construction à l'aide du computer sur la base du modéle économo-mathématique.

In conditions of extended scientific, technological and economic cooperation and integrated processes in the field of capital construction, the problems of determining the level and technical and economic data of the development of construction in foreign countries are highly important.

The level and technical and economic data correctly determined and their comparison help to define the factors intensifying construction, to find correctly labour productivity and dynamics of its growth in different countries and currency parities in construction work.

The last circumstance is most important in conditions of extended integrated construction, namely: joint construction of interstate projects, construction on compensating basis, participation in supply of material resources, etc.

Now there are various methods for calculating international comparison of labour productivity levels and currency parity in construction work. They are generally based on two principles: projects-representatives and economic elements of construction work expenditures.

The application of calculation based on the projects-representatives on the national-economic scale in various branches of construction is connected with some difficulties. The main of them are following: first, there is an essential difference in forming the estimate cost and distributing, according to items of production cost expenditures of construction work; second, the selection of projects-representatives with different technical and economic characteristics influencing the correctness of calculations is a highly labour-consuming work.

Calculation and comparison of expenditures on economic elements have a certain advantage over the method of comparison of projects-representatives, since in this case, first, it is much easier to bring the economic elements of expenditures (material resources, wages and salaries, exploitation of construction machines, overhead expences) into comparable shape. Second, in bringing into comparable shape, it is possible to level (by redistribution) the distinctions in forming estimate cost and to distribute expenditures on items in compared countries. Third, in using this method, technical and economic data can be received from the State statistics (in particular from interbranch balance). In this case there is a possibility to make comparison in a short time, with small expenditures and with a high degree of accuracy.

In the Soviet Union, there is worked out a method* of simultaneous definition of currency parity of construction work and of coefficient of labour productivity level. We used a computer as the next step.

The currency parity of the branch product is calculated from private parities: index of material resources prices used in construction, correlation of wages and salaries level, index of profit and other expenditures on construction work.

The calculation is carried out with the following system of equitations:

$$\begin{cases} B_{\mathbf{r}} \times P_{\mathbf{a}} = B_{\mathbf{a}} \times K_{\mathbf{a}} \\ P_{\mathbf{a}} = \frac{Q\mathbf{a}}{\frac{M\mathbf{a}}{\mathbf{I}\mathbf{a}} + F_{\mathbf{a}} : \frac{S_{\mathbf{a}} \times K_{\mathbf{a}}}{S_{\mathbf{r}}} \times L_{\mathbf{a}} + \frac{H_{\mathbf{a}}}{P_{\mathbf{a}}} \\ \end{cases}$$
$$\begin{cases} B_{\mathbf{r}} \times P_{\mathbf{r}} = B_{\mathbf{a}} \times K_{\mathbf{r}} \\ P_{\mathbf{r}} = \frac{M\mathbf{r} \times \mathbf{Ir} + F\mathbf{r} \times \frac{S\mathbf{a} \times K\mathbf{r}}{S_{\mathbf{r}}} \times L\mathbf{r} + H\mathbf{r} \times P\mathbf{r}}{Q_{\mathbf{r}}} \end{cases}$$

$$\begin{cases} P = \sqrt{P_a \times P_r} \\ K = \sqrt{K_a \times K_r} \end{cases}$$

- - MaMr specific weight of expenditures on material resources in common cost of construction work, per cent;
 - B; B average annual output per one worker in construction, in national currency;
 - P_a; P_r currency parities in construction work;
 - K_a; K_r coefficients of labour productivity level in construction;

- Q_a; Q_r basis for comparison, 100 units of national currency;
- F_a; F_r specific weight of expenditures
 for wages and salaries in com mon cost of construction work,
 per cent;

- average geometrical magnitude of coefficient of currency parities in structures of the compared countries;
 - K_r average geometrical magnitude of the coefficients of the labour productivity levels in construction in structures of the compared countries.

On the basis of the described model there has been worked out an algorithm realised in EC computer in the fortran language.

A greater correctness in international comparison of cost data is possible with full accounting of the factors which influence the shaping of one or another technical and economic indices. In our opinion, this is the way to further perfecting methodology of international comparison of cost data, since technical and economic cost data (specifically the volume of construction work) received as a result of recomputating at official rate of exchange do not provide trustworthy correlation. There are some causes. The most important of them are: differences in shaping foreign and home prices, divergence between rate of exchange and their real purchasing power, structural differences, a great variety of production, etc.

р

^{*}This method is proposed by Dr. S.N. Soloviev.

Besides, methodic ways of calculating technical and economic data of the construction development in individual countries, possess their national features. Comparability of initial technical and economic data of different countries is achieved by studying the specific features forming statistical data.

As a result of this work structural heterogeneity and differences in methods of statistical formation of economic data are overcome.

Methods of simultaneous definition of currency parity of the construction work and the coefficient of the labour productivity level make it possible to take into account the differences mentioned above.

On the other hand, automation of calculation in international comparison of cost data makes it possible:

- to calculate with a greater accuracy owing to increasing quantative of compared material resources varieties;

- considerably to shorten the time for calculation with the help of computers;

- to extend quantity of variants for comparison of data of a greater number of countries on a common methodic and informative basis;

- to unify procedure of international comparison on the basis of forming standard tables of entrance economic data;

- to provide with opportunity to accumulate considerable quantities of technical and economic data from a common centre.

Cost Estimation of Reinforced Concrete Framed Structures for High-rise Residential Buildings

Surinder Singh M.Sc., MIE, MIS, MBIM Lecturer Dept. of Building and Estate Management University of Singapore C.K. Murthy B.E., Ph.D., FIES, P.Eng Associate Professor Dept. of Building Science University of Singapore

Summary

Statistical relationships have been established between the quantities of constituents of reinforced concrete structures and floor areas for various number of storeys and sizes of flats in Housing and Development Board flats, Singapore. When the number of storeys is increased from 5 to 20, the increase in the quantities of both the concrete and formwork are about 19 percent, while the increase in steel is substantially higher at 33 percent. The variation in the constituents due to the change in the sizes of flats is much smaller. The charts developed are useful in making decisions about number of storeys at the planning stage, preparing approximate cost estimates, cost indices, budgeting of materials and for checking of estimates. Resumé

Des liens statistiques ont été établis entre les quantités des constituents qui entrent dans la composition des structures de béton armé et les surfaces de plancher des differents étages et dimensions des appartements du "Housing and Development Board flats" de Singapour (Ministère du logement). Lorsque le nombre d'etages passe de 5 à 20, la quantité de béton armé et celle du coffrage augmentent de 19%, tandis que celle de l'acier est nettement plus élevée à 33%. Les variations pour les composants, dues aux differences de dimensions des appartements sont beaucoup moins importantes. Les graphiques réalisés sont utiles pour décider du nombre d'étages pendant le stage de planning, à la préparation des études de prix, des indices de prix, pour budgétiser les matériaux et pour la vérification des évaluations.

Introduction

The cost estimate of structural systems for buildings is useful in making a choice between possible structural systems as well as for bidding along with other costs. Any attempt to base the computations on alternative details of a particular project is always laborious and time consuming. Alternatively, if the computations are not based on any rational method the results can be misleading. In the presence of these extremes, an effort has been made to evolve a fast and fairly accurate method of computing the initial cost of reinforced concrete framed structural systems for high-rise residential buildings. This paper describes the methodology adopted, results obtained and their application in the building construction industry. Aspects concerning foundations have been excluded from this study.

Choice of methods

The cost of any structural system can be cither computed based on the past records of similar completed buildings and the application of an appropriate cost index, or by pricing, with prevailing rates, the quantities of various trade items constituting the work involved. The accuracy of cost estimate, in the case of past records, depends on the degree of similarity and percision taken in the computation of cost index. Besides this, it also depends on whether the various structural components of completed buildings were designed using the methods being adopted at present.

The cost estimates can alternatively be based on the quantities of various trade items constituting the structural system, provided an accurate bills of quantities is available for the building under consideration or for another similar one. In Singapore, the construction industry adopts a lumpsum contract system without bills of quantities and hence the same is not available unless the contractors employ their own quantity surveyors to prepare them.

In the presence of difficulties discussed above, and on the presumption that the past information may not be accessible, it was decided to compute the constituent quantities of the reinforced concrete structural systems for the Housing and Development Board flats, Singapore.

Structures and analysis of frames

Plans having one to five rooms adopted for construction by the Housing and Development Board, Singapore, were taken for investigation (typical plan shown in Figure-1) and the structure of each was analysed with the STRESS package on HP 3000 series computer system for 5 to 20 storeys in denomination of 5. Elastic analysis was performed considering gross concrete sections for member properties.

The analysis and design were in accordance with the limit state design proposed in the British Code of Practice CP110: Part 1: 1972, the service loads being taken from the British Code of Practice CP3: Chapter V: Part 2: 1972. A basic wind speed of 35 m/s was adopted. Hollow block partitions of 100 mm thickness were considered in the design.

Design of structural members

Computer programs were developed to design reinforced concrete slabs, beams and columns, with the additional feature of computing the quantities of concrete, reinforcement and formwork. In accordance with local practice, characteristic strengths of 20 N/mm² and 410 N/mm² were considered for concrete and hot rolled high yield steel respectively.

Solid Slabs - The program provides both for slabs spanning in one direction and in two directions. For rectangular panels of slabs, supported on four sides, provision was made for torsion reinforcement at corners and the bending moment coefficients as given in CP110 were utilized for the design of such slabs. A minimum depth of 100 mm was considered for the slab and the dead and live loads per unit run over the beams were automatically computed by the programme for subsequent use in the design of beams.

Beams - In high-rise buildings, the depth of a beam is generally governed by architectural considerations and it is only the width and the requirement of reinforcement etc. which is to be decided based on the design forces. The program for beam was therefore developed with this in mind and the width and depth of each beam was to be fed as an input. The width was modified if required for accommodating reinforcement or from shear considerations keeping the depth same. From architectural considerations, a depth of 500 mm was used for all the beams in all flats.

Columns - A comprehensive computer program was developed to design both braced and unbraced columns, short and slender columns, and axially loaded columns with and without bending (both uniaxial and biaxial) based on the design formulae given in CP110. Given the section and design forces it is capable of checking the section and increase it, if need be. The minimum thickness of column was maintained as 200 mm and the elevation of exposed columns in any particular number of storeys was maintained same from aesthetic considerations. Further, after every 5 storey intervals the sections of columns were reduced where possible for economy.

Quantities of constituents

The quantities of constituents for different plans and for various members in terms of concrete, reinforcement (steel) and formwork were taken from computer results and those for common members between adjacent flats were halved to get the quantities per flat in various storeys considered.

The final quantities obtained are plotted for slabs and beams (Figures 2-4) and columns (Figures 5-7) and total for all above (Figures 8-10) on one axis and gross floor area of one flat on the other.

In computing the quantities of concrete for beams, the portion of the beam common with the slab has been included with the latter as per local practice (1). Similarly, in slabs, the formwork has been reduced to the extent of plan area of beam webs, and common portion of slabs, beams and columns has been accounted for in columns.

Statistical relationships

Statistical relationships have been established for each material with gross floor area per flat in the form of Y = a x^b

- where Y is the quantity of material per flat $(m^3 for$
 - concrete, kg for steel and m² for formwork)
 - x is the gross floor area (m^2) per flat per floor a and b are coefficients whose values are given in table-1.

These can be used in lieu of graphs. Thus, given the flat area per floor, the requirement of materials for the desired number of storeys, and for different members and total for the structural frame as a whole can be computed with ease and speed.

Observations

Slabs - The quantity of reinforcement increases as we go from small sized flats to bigger ones. The quantities of concrete and formwork required in flats are in proportion to their floor areas irrespective of their sizes, indicating that the thickness of slabs remain the same. This is true, because the minimum assumed thickness of 100 mm for slabs is adequate for even the biggest panels in flats which invariably span in two directions. The slab formwork is about 93% of the floor area of the flat.

Beams - For a given size of flat, the quantity of concrete required in the beams is approximately the same irrespective of the number of storeys within the range considered. The depth of 500 mm and the minimum width of 100 mm was adequate for most of the beams in all the plans, a width of 150 mm being used for some of the beams. Though the moments in beams at supports due to wind load increased with the increase in number of storeys, the reduced load factors applicable to combinations of dead, imposed and wind loads resulted in only a marginal increase in the design moments.

The consumption of reinforcement in beams per unit floor area is fairly uniform in all sizes of flats below 15 storeys, small differences arising at 15 storeys and above.

Columns - The real effect of both, the size of flat as well as the number of storeys can be seen from the increase in consumption of concrete, steel and formwork of this structural component. The increase in the quantity of concrete per unit floor area is about 110 percent for construction from 5 to 20 storeys. On the other hand, the effect of the size of flat can also be seen in any individual storey of construction. The increase in floor area of flat from 40 m² to 120 m² results in an increase of about 33 percent of concrete considering consumption per unit of floor area.



دم E

Formwork per flat

Figure I Typical plan of a flat





Figure II Quantities of concrete for slabs and beams

120 • slabs • beams 80 40 40 0 30 60 90 120 Area of flat m²

Figure IV Quantities of formwork for slabs and beams



Figure V Quantities of concrete for columns

Figure VII Quantities of formwork for columns



Figure VI Quantities of steel for columns



Figure VIII Quantities of concrete for total structure





Figure X Quantities of formwork for total structure

The reinforcement in columns has also increased considerably to as much as 144 percent to 167 percent measured per unit of floor area for construction from 5 to 20 storeys depending upon the size of flat, the lower value of the range being for small sized flats and higher values being for bigger sized ones. On the other hand the size of flat for a given number of storeys has only a small effect on the quantity of reinforcement per unit of floor area, the difference being of the order of 8 percent.

Compared to the increases in the consumption of concrete mentioned above, the changes in the formwork are comparatively less, being 58-80 percent for constructions from 5 to 20 storeys depending upon the size of flat, the lower figure being for small sized

Number of	Element/Constituents	Value of coefficient			
Storeys		'a'	1 bi		
5, 10, 15,	SOLID SLABS				
20	Concrete Steel	0.112 6.602	0.98 1.01		
	Formwork	0.902	1.02		
	BEAMS				
	Concrete	0.027	1.02		
	Steel	4.966	0.96		
5	COLIMNS	0.420	1.01		
,	O-manuta -	0.007	1 07		
	Steel	0.007	1.27		
	Formwork	0.082	1.37		
	TOTAL STRUCTURE				
	Concrete	0.1 4 4	1.01		
	Steel	14.660	0.99		
	Formwork	1.185	1.12		
10	COLUMNS				
	Concrete	0.007	1.29		
	Steel	4.144	0.98		
	TOTMWOLK TOTAL STRUCTURE	0.049	1.04		
	TOTAL SINGOTORE				
	Steel	U. 141	1.03		
	Formwork	1.033	1.16		
15	COLUMNS				
	Concrete	0.014	1.24		
	Steel	5.363	1.02		
	Formwork	0.079	1.49		
	TOTAL STRUCTURE				
	Concrete	0.147	1.04		
	Steel	16.739	1°.00		
0.0	I OI IIIWOI K	1.000	1.10		
20	COTOWN2				
	Concrete	0.016	1.25		
	Formwork	0.083	1.49		
	TOTAL STRUCTURE				
	Concrete	0.152	1.04		
	Steel	17.185	1.02		
	Formwork	1.078	1.17		

Table-1. <u>Values of Coefficients (concrete in m³, steel in kg and formwork in m²)</u>

flat having 40 m² floor area and the higher being for bigger flats with 120 m² floor area; while within the same storey of construction, the effect of the size of flats is to increase the formwork by an average of 60 percent, when the flat area changes from 40 m² to 120 m².

Total structure

An analysis of the total requirements of constituents for the structure as a whole indicates that on an average the increase in consumption of concrete, steel and formwork are about 19, 33 and 12 percent respectively for construction from 5 to 20 storeys. The corresponding figures are about 3, 2 and 17 percent when results are considered within the same storey of construction for small and bigger sized flats.

Applications

The results of this investigation can be utilized in the Singapore construction industry, and of any other similar studies at other places, for various purposes, some of which, are as under:

Decision about number of storeys - At the (i) architectural design stage besides considering other factors, cost is one of the important criteria in deciding about the number of storeys. In this computation, the cost of reinforced concrete frame is one of the major items which affects cost in vertical expansion. The results of this investigation (Figures 8-10) can be utilized to compute the cost of alternative number of storeys and a proper decision can then be taken. In estimating the cost, the rates are to be built up depending upon the rates for solid slabs, beams and columns. The proportions which can be utilized in building up these rates are shown in table-2 for concrete, steel and formwork.

Table-2.	Proportions	for	built-up	rates

Constituent	Number of	Proportion of the rate of		
	Storeys	Slabs	beams	columns
Concrete	5	0.7	0.2	0.1
	10,15,20	0.6	0.2	0.2
Steel	5,10	0.5	0.3	0.2
	15, 20	0.4	0.2	0.4
Formwork	5,10	0.5	0.3	0.2
	15,20	0.4	0.3	0.3

- (ii) Approximate cost estimation Approximate cost estimates are needed for various purposes and the information derived can beneficially be utilized for preparing the same. In estimating cost by approximate quantities method, it is generally a problem to cost the frame, the results of this investigation can be utilized to overcome this. Further, since the factors like the size of dwelling and number of storeys have been taken care of, the information presented can produce more realistic estimates.
- (iii) Cost Index Even in cases where past cost records of completed buildings are available, they need to be updated due to change in the price levels. This can be done with the help of results presented in this paper. Similarly, the information can also be utilized to prepare a cost index for updating the estimates of frame items which are based on the Standard Schedules of Rates since the rates in the latter are generally outdated.
- (iv) Budgeting of materials The requirement of materials for the reinforced concrete frames for residential buildings can be computed easily for placement of orders. Some work done earlier

- (v) Planning The construction of reinforced concrete frame in a building involves activities which are critical from planning point of view. In the absence of detailed quantities available for any building project for such items, for the purposes of drawing network, the quantities presented can effectively be utilized depending upon the flat area and number of storeys.
- (vi) Checking of estimates The quantities of relevant items for the reinforced concrete structure in a residential building can be checked by using the graphs or statistical relationships.

Conclusion

The charts developed in this paper give a good indication of the variation in the quantities of the constituents in reinforced concrete structures with varying number of storeys and sizes of flats. These can be conveniently used for various purposes in initial planning of buildings. Statistical relationships similar to the ones established in this paper can be developed for other structures using different systems and materials which would be useful in evaluating the structural schemes for buildings.

References

- The Royal Institution of Chartered Surveyors (The Federation of Malaya and Singapore branch). Standard method of measurement of building works. 1975.
- Singh, Surinder. <u>Manpower and material requirements</u> <u>in buildings</u>. Journal of the Institution of Surveyors, Vol. 10, No. 1, April 1969 PP 67-78.
- 3. Singh, Surinder and Sofat, G.C. <u>Manpower and</u> <u>material requirements for framed structures</u>. The Indian Concrete Journal, Vol. 47, No. 5, May 1973 PP 24-29.

Insolation and Sun Protection in Town-Planning

N.V.Obolensky, Candidate of Sciences (Eng.) NIISF, Moscow, U.S.S.R.

Summary. The results of the comprehensive studies conducted by a number of institutions whose activities were co-ordinated abd supervised by the NIISF of the U.S.S.R.Gosstroy are given for evaluating insolation criteria in a metropolitan and community planning in lighting, architectural, social, biological and economic terms. The significant contradictions that arise in choosing criteria for evaluating insolation in the Soviet Union and other countries are examined. It has been proved that insolation conditions have a great effect on decision making in town planning, on building plans, on development density and on the economic land use of the urban space available. The resources and preferable insolation conditions in the U.S.S.R. and the dynamics of solar lighting have been determined. Methods have been suggested for rating and calculating the insolation and the sun protection for residential, communal and industrial buildings, which take into account the former's energy-saving effect in the country's different climatic regions.

Sommaire. Le rapport présente les résultats des études integrales des critères d'estimation de l'insolation dans le développement urbain sous les aspects de l'éclairage, architectural-sociologique, biologiques, economiques qui étaient réalisés en 1975-79 par le groupe des Instituts sous la direction coordonnée du NIISF du Gosstroy de l'URSS. On a étudié des contradictions importantes au choix des critères d'estimation de l'insolation en URSS et dans les pays étrangers. On a montré l'influence importante des conditions de l'insolation sur l'arrangement et la composition des solutions urbanistiques, la planification des batiments, la densité de la site et l'économie des terrains urbains. On a déterminé des ressources et des conditions préférables de l'insolation sur le territoire de l'URSS, le dynamique de l'éclairage solaire. On a proposé des procédés de calcul et de normalisation de l'insolation et de la protection contre le soleil pour les batiments d'habitation, industriels et publics en tenant compte de l'importance énergétique de l'insolation dans les régions climatiques différantes du pays.

The insolation norms [1] which have greatly contributed to better residential buildings arrangement and healthier city environment have long been in effect in the Soviet Union. As mass and high-rise housing construction developed, the insolation standards came into contradiction with the flexibility needed in planning multi-storey residential buildings and the rational use of urban areas in difderent climatic conditions.

In 1975-1978 a number of research institutes guided by the NIISF of the U.S.S.R.Gosstroy, conducted comprehensive studies in rating the insolation and sun-protection of development areas all over the U.S.S.R., taking into account three major factors in evaluating insolation: (a) biological; (b) sociological and architectural; and (c) technical and economic.

The study of relevant rules and regulations showed how discordant the requirements for insolation in different countries were as regards the major effect, the evaluation criteria, the rate, the reference point and the reference period.

There were two factors, in the main, that served as criteria for setting these rates: the psycho-aesthetic and the biological effects of insolation.

Extensive investigations have been conducted in the Soviet Union to determine the resources of natural solar radiation and its effects on biological objects and the environment [1-5].

The investigations 6 of erythemal and bactericidal radiation for Moscow and Ashkhabad at midday on June 15 and March 16 showed that in Ashkhabad the scattered ultraviolet radiation alone on the area with a space between buildings equal to their height (1H)exceeds the total ultraviolet radiation in Moscow with a spacing between the buildings being equal to 3H.

The calculations which were verified by physical measurements revealed that the ultraviolet radiation intensity in swmmer for the built-up area in the southern city is equal to that in the conditions of a vacant horizon in Moscow, while in the spring and autumn months the intensity rises 1.5 times, respectively.

A comparative analysis indicated that the level of ultraviolet irradiation depends on the development density which can serve as a means of controlling the ultraviolet radiation rate inside the housing yards. This is evidence that it is not sufficient to evaluate the insolation of urban spaces according to its duration, and that its energy needs to be evaluated.

In aesthetic terms, one of the most important factors in overcoming the building compositional monotony is to have housing towers and lower buildings facing one another. This aaproach is, however, very often impossible because it impairs the principle of continuity of insolation [7].

The fact that the existing norms sharply limit the use of longitudinal houses with a greater width, than the latitudinal houses, is a drawback which tells on the economics of the city planning.

The analysis of the progress achieved in rating and calculating the insolation has made it possible to work out the main requirements, which should be met by new insolation norms:

1. The rated level should be based on the insolation value as energy and on the set of major criteria regarding its evaluation in biological, sociological, architectural, technical and economic terms.

2. The norms should indicate the method of calculating the rated level in the course of designing a development area and control by the State Sanitary Inspectorate (Gossaninspectsia) on the basis of graphic operations which are, in the main, acceptable and convenient for designers and doctors.

3. Norms should provide for greater freedom in chosing the composition of large-scale development areas and for the manoeuvrability of standard houses (especially, of the longitudinal type with a wide body); for reasonable spacing between buildings (especially, in northern regions, where the existing standards are somewhat lower, than in the central regions) and for land economy in non-built areas.

Computer assisted studies were carried out to investigate the solar radiation inflow to all the living rooms of residential buildings at different geographical latitudes, taking into account the orientation of the windows to all sides of the horizon and different building heights. The results of the studies showed that the duration of radiation is not characterized by the complex nonstationary radiation field, which determines the character and magnitude of photobiological effects [8].

Depending on the time of the day and season, the orientation of the windows and the type of development area, the equivalent in duration insolation may have multiple different radiation doses, and, therefore, different biological effects.

Therefore, the duration of insolation cannot be used as a rated value.

The physical research into the bactericidal effect of the solar radiation penetrating the premises, revealed that, in the case of double glazing, the bactericidal effect was mainly due to the visible spectrum, and the inactivation of bacteria took place when the total dose of radiation exceeded 0.5 mbt h/m^2 . These conditions could easily be provided in the case of a pilot project carried out in Moscow.

It is impossible to give a direct rating of the energy dose of insolation, at present, however, because methods have not been worked out for measuring the probable annual cloudness distribution.

A suggestion has been made that a certain "sector of insolation" (SI) should be standardised, that which is visible from the central point of the opening and which can provide an astronomically possible annual dose from 110 erg h at a latitude $65^{\circ}N$ to 175 erg h at a latitude $35^{\circ}N$.

The average dose in the U.S.S.R. territory of 140 erg h was taken in analogy with the existing hygienic norms (Fig.1).

This average dose can be produced by "a sector of insolation" (SI) equal to 45⁰ in the plane tilted to the horizon at an angle

where Ψ is a geographical latitude in degrees

and passing through the reference point at the centre of the window opening. This sector of the insolation is characterized by the openness of the sky in front of the opening, within the limits of which the total solar radiation can penetrate the premises.



Fig.1. The distribution of the possible annual doses of the total erythemal radiation in premises with spacings between the buildings as given in CH-1180-74 a and in the proposed system of rating the insolation sector (SI) at various geographical latitudes in the Soviet Union.

At latitude $60^{\circ}N$, the plane tilted to the horizon at an angle of 0 coincides with the celestial equator plane in which the sun's beam rotates on equinox days. In this case, the rated 45-degree sector corresponds to the three-hour visual duration of insolation of the reference point on the building façade.

The data from Table I indicate that at latitudes south of $60^{\circ}N$ the reference plane is located lower, and north of $60^{\circ}N$ higher than the celestial equator plane.

		Τa	able 1			
Geographical						
latitude	35	45	55	60	65	75
Celestial equator gradient	55	45	35	30	25	15
Rated plane gradient	36.4	34.2	31.4	30	28.4	25.2

Calculations show that with this system of rating it is possible to decrease the excessive spaces between buildings and orient them to the eastern and western sectors of the horizon. This permits the wider use of economical longitudinal living sections and higher development density. Here it should be borne in mind, that in a flat of the longitudinal section, the solar radiation per unit air volume is several times greater than in that of the latitudinal section.

With such a rating system, the amount of scarce development area available for construction will increase by 10-15 percent, and the application of longitudinal sections will rise from 10 to 50-60 percent. In this case, the amount of solar radiation penetrating the premises will be more uniform (Fig.1-b) throughout the country, as compared with the existing system CH-1180-74 (Fig.1-a).

The new rating system does not specify any continuity of insolation, since it ties up the designers and is of no use both in terms of its natural endowment (Fig.2) and because of a rather small volume and area of the premises which could be covered by this continuity (2-5%).



Fig.2 The annual rate of probable continuous sunshine in Moscow for its varying duration

Investigations conducted in recent years to study the residents' inhabitants' psycological desirability for the duration of insolation of housing in northern, central and southern regions of the Soviet Union indicated that the majority hold that an insolation from two to five hours is more desirable. The questionnaire information processed in computers also showed, that 2.5-hour-long insolation was believed to be the most preferable, which concurs with the ideas of Swedish scientists.

As a rule, the proposed system of rating ensures the solar radiation of a window opening for more than two hours (with orientation to southern azimuths, up to six to nine hours).

According to this system, the arrangement and the orientation of blocks of flats and communal buildings should provide for the sum of the insolation sectors (SI), which are visible from a reference point and given in Table 2.

Ser. Nos	Premises and grounds	SI	,	deg
	A. Indoors			
1.	Not less, than in one living			
	room in one-, two- and three-			
	room flats; not less, than in			
	two rooms for many-room flats;			
	in the bedrooms of sanatoria,			
	holiday homes and boarding			
	houses; in all the living rooms			
	of longitudinal houses		4	5
2.	In hotel and hostel rooms (in			
	no less than 60% of rooms)		30	D
3.	In hospital wards, in bedrooms			
	and the play rooms of boarding			
	schools, kindergartens and			
	nurseries		5	0
	B. Outdoors			
4.	At sports and children's			
	playgrounds		4	5
5.	At grounds with paddling pools		6	0

Minimal Admissible Sectors of Insolation

SI

The insolation sector is measured on a plane that passes through the reference point and is tilted to the south at an angle to the plane of the horizon, determined from formula (1).

According to the evaluation of the U.S.S.R. territory for insolation resources, the country can be divided into major zones with different insolation and sun protection requirements (Fig.3a).



Fig.3a. Zoning of the U.S.S.R.according to the real resources of the annual total solar radiation $(kcal / year cm^2))^{-1}$



Fig.3b. Zoning of the U.S.S.R.according to the length of a period with an outside air temperature, t^o 20°C per year. I - 20 days; II - from 20 to 40 days; III - from 41 to 60 days; IV - from 61 to 100 days; and V - 100 days.

Therefore, in the country's southern and northern regions, the following correction coefficient (C) should be applied before the constant factor in the formula (1): for the Ist and IIId zones (Fig.3a) - 1.05; for the IV zone - 1.1 and for the Vth zone - 1.15. This coefficient has been introduced to correct the spaces between buildings in different climatic regions of the country.

When orienting the premises to the northern hemisphere of horizon, the minimum values of the insolation sectors (SI) can be decreased with the angle (B) of the light window openings' orientation deviation from the eastern (western) direction to the north in degrees (Table 3).

Table 3

ß	5	15	25	35	45	
SI	43	39	. 35	32	30	

It is recommended that the hatched zone be calculated for illumination on the basis of conditions when there is a prevalently clear sky, taking the reflected sunlight during insolation of the structure into consideration.

In determining the sums of insolation sectors, the 15-degree sectors adjacent to the plane of the horizon are not taken into consideration.

764

As a reference point, in relation to which the rated level of the insolation sector is determined one can take:

(a) for indoors - a point, located on the surface of the façade at the centre of the opening of the lower floor;

(b) for outdoors - any point within the borders of sections, indicated in Table 2.

The opposite structures and trees more than three metres high, are considered to be shading objects.

Insolation should be calculated directly on the development plat with the aid of a transparent superposed chart, which is illustrated in Fig. 4.

The plot is a horizontal projection of the tilted plane of the sky sector. The parallel lines the plot are horizontals of that plane whose elevations are read-out from the initial level line passing through the reference point 0.

The requirements for limiting overheating and the blinding effects of the solar radiation are applicable to residential, public and industrial buildings and structures in populated districts located in the II-V climatic zones (Fig.3b).

The requirements for protection from the dazzling effect of the sun alone not only apply to the first climatic zone. The length of the period having an average day temperature of the ambient air outdoors of $t_0 20^{\circ}$ C is taken as a criterion for the need to protect the structure against overheating.

The application of sun-protection devices is called for when the duration of this period equals or exceeds 20 days.



Fig.4a. The graph used for calculating the insolation sectors (SI) $% \left(\left({{{\bf{SI}}} \right)^2} \right)$



Fig.4b. The geometrical method of plotting the graph for SI calculation.



Fig.4c. Basic cases of buildings location in relation to SI corresponding to the elevation of the given building over the reference point.

The major types of the sun-protection devices and their combination are employed as a function of climatic conditions according to Table 4.

Table 4

Climatic zones, Fig.3b	Sun-protection devices	Bearings on the ho- rizon circle
1 & II	Indoor and inter-pane	135-270 ⁰
111	Inter-pane or outdoor types	45 - 315 ⁰
IV	Inter-pane or outdoor types in combination with heat insulating glass	45 - 315 ⁰
V	Inter-pane or outdoor types in combination with heatinsulating glass and technical facilities	
	(artificial air cooling)	0-360 ⁰

Notes:

 Heatinsulating glass panes and permanent sun-protection devices are not allowed to be tilted in residential buildings, medical treatment and children institutions.
 In climatic zones IV and V, the areas accomodating children and sports grounds shall be equipped with shading facilities which would be effective in summer.
 The adjustable blinds and jalousies refer to indoor and inter-pane sun-protection devices; the adjustable and fixed windshields, screens, honeycombed lattices, jalousies and

marquees relate to outdoor types. In orienting the window openings of communal and industrial buildings, having I-IV categories of the visual task, to bearings 45-315° on the circle of the horizon, protection against illumination discomfort should be provided for in all the country's climatic zones.

Such a rating for insolation and sun protection has a great hygienic, economic and aesthetic effect on town planning. It allows the rational selection of development density, window sizes and types of sun protection. It opens up the way to shaping the appearance of contemporary and future southermand northern cities which are lacking many essential specific features so far.

References

1. Sanitarnye normy i pravila (Hygienic Rules and Regulations) CH-427-63 i CH-1180-74. 2. Zelenko A.U. Insolatsia kak faktor planirovki gorodov (Insolation as a Factor in Town Planning), Moscow, Leningrad, 1940. 3. Belikova V.K. Bakteritsidnoye znachenie izluchenia solntsa, pronikayushchego v pomeshchenie (The Bactericidal Effect of Solar Radi ation Penetrating the Premises). (Hygiene and Sanitation) "Gigiena i sanitariya", 1957, II.

4. Belinsky V.A., Gusslitser L.N. UF radiatsia i rak kozhi. Aktualnyie voprosy sovremennoy onkologii, cb.No.1,MGU,1968 (Ultraviolet Radiation and Skin Cancer. Important Problems of Contemporary Oncology).

5. Belinsky V.A. "Ultrafioletovaya radiatsia v kn. "Rukovodstvo po stroitelnoy klimatologii", M.,1976 (Ultraviolet Radiation in the Book "Handbook of Construction Climatology", Moscow).

6. N.V.Obolensky, O.A.Korzin. Insolation as One of the Components of Light Environment Determining Urban Construction. 6 Congress CIB, Budapest, 1974.

7. Obolensky N.V. Svetovaya sreda i arkhitekturnaya kompositsia. "Svetotekhnika" No.9, 1974. (Light Environment and Architectural Arrangements).

8. Bakharev D.V. Inzhenerny metod rascheta bakteritsidnoy effektivnosti insolatsii, Svetotekhnika, No.9, 1972 (Engineering Method of Calculating for the Bactericidal Efficiency of Insolation).

9. Pivovarova Z.I. Radiatsionnye kharakteristiki klimata SSSR, Leningrad, 1977 (Radiation Characteristics of the U.S.S.R. Climate). Comprehensive prediction method of environ-buts de la plicationment comfort in application of sun protectionsystèmes de

means in construction

N. V. Obolensky, Cand.Sc.(Eng.); A. I. Panurov, Cand.Sc.(Arch); V. V. Tokarev,(Eng.), A.V. Spiridonov (Eng), NIISF, Moscow, USSR

<u>Summary</u>. A comprehensive method for estimating and predicting comfort conditions in the interiors of buildings, which is based on the use of criteria that characterize the illumination and heat engineering, aeration and economic requirements for the sun protection, has been worked out. The requirements include, among others, light transmission, direction and uniformity of light fluxes in an enclosed space, relation to the outside environment, solar radiation transmission, daily mean amplitude of air temperature fluctuations, uniformity of distribution of air velocity, air inblowing in structures of the sun protection device, visual fatigue, etc.

The effect of the sun protection was shown to increase labour productivity in industrial buildings by 2-3% and to decrease spoilage and rejects by I5-25%, with lower operational costs in ventilation and air conditioning systems.

A comprehensive nomogram has been given for selecting the means of the sun protection, optimizing the microclimate and light environment.

Sommaire. Le rapport rappelle le methode d'estimation et de prévision des conditions du confort à l'intérieur des bâtiments basé sur la corrélation des critères qui caractérisent des demandes éclairagistiques, thermiques, aériènnes et économiques concernants la protection contre le soleil (la transparence, l'orientation et l'uniformité des flux lumineux à l'intérieur du local, la liaison à l'ambiance extérieure, les apports de la radiation solaire, les amplitudes moyennes journalières de fluctuations de température de l'air, l'uniformité de distribution de la vitess de l'air et le soufflage du dispositif de protection solaire, la fatique visuelle).

On a montré l'influence importante de la protection solaire sur l'augmentation de la productivité du travail dans les ateliers industriels à 2-3% et sur l'abaissement de rebuts de la production à I5-25%, ainsi que sur l'abaissement des dépenses pour l'usage des systèmes de ventilation et de climatisation.

On a présenté le nomogramme univer^{sel} pour le choix des moyens de la protection contre le soleil et des procédés d'optimisation du microclimat et du milieu lumineux.

Recent investigations which have been conducted in a number of countries including the Soviet Union show that the favorable (psychophysiological and sanative) effect of solar radiation may be accompanied (especially, in the southern regions) with bitter (light and heat) discomfort abusing hygienic requirements.

The most effective sun protection means (SPM), recognized in all countries, include sun protecting and light-regulating devices (SPD) installed in light openings.

The advisability of the SPD application has been proved not only in functional, but also in economic terms for all geographic regions.Onetime expenses for such devices pay back soon because of lower operational costs for ventilation and cooling facilities, better working conditions and higher labour productivity.

For the effective application of SPD in architecture, one should have a knowledge not only of their main functions and physicotechnical characteristics, but also their skilful putting into practice.

Major functional aspects of SPD are protection of premises from penetrating-throughlight-windows insolation, which creates light and heat discomfort, better illumination distribution in the interior, expressiveness of architectural and layout decisions.

In estimating SPD, the follow factors characterizing functional and psychophysical requirements set for SPD are employed: the level to which the light and heat discomfort can be restricted as a result of insolation and characteristics for providing visual contact with outside environment.

The extent to which'those requirements can be met is estimated by a set of illumination and heat engineering and aeration criteria, which have been developed by the Research Ingtitute for Building Physics of the USSR Gosstroy.In evaluating SPD and illumination conditions of premises, the following factors are taken into consideration:

-provision of rated and physiologically sufficient level of illumination indoors (illumination level E,light transmission coefficientt;;

-provision of the recommended qualitative indices of illumination, including:illumination uniformity (uniformity coefficient K_u), pattern of light scattering value and direction or light vector);

-provision of visual contact with outside environment (coefficient of transparency K_t and coefficient of spatial visual contact K_v and visual working ability;

-complete screening of direct sunlight (the coefficient of screening $K_{_{\bf S}}$).

In estimating heat engineering efficiency of SPD and indoor temperature conditions, the following indices are important:

-value of the total solar radiation indoors (estimated from the value of the solar radiation transmission coefficient K_{β});

-the temperature of structural elements of SPD, enclosure surfaces and air in the volume of premises (estimated from the amplitude of air temperature fluctuations during a 24-hour cycle).

The SPD effects on indoor aeration conditions is estimated by means of analysis of the distribution field of air velocity in premises (from the value of the coefficient of the velocity nonuniformity in premises K_d and coefficient of inblowing K_i).

Because of particular aspects of industrial production, the use of production characteristics becomes important as one of major criteria in evaluating the level of effective sun protection. They are productivity of labour, quality of products and fatigue of the worker.

Investigations conducted by the authors have made it possible to establish criteria which determine the functional efficiency of SPD and to find their optimal values.

A most important illumination engineering characteristic of any SPD, that determines its design, is a coefficient of screening K_s , obtained from the ratio of protection angle of the light window to the angle of 90°

$K_{s} = \frac{3}{2} \cdot \frac{3}{2}$.

It has been found that SPD accomplishes its protective functions with value of K_s 0.25.

Uniformity of light fluxes distribution indoors and, hence, of brightness values in the field of human vision is measured by the coefficient of illumination uniformity K_{α} which is equal to the ratio between the minimum and maximum illumination in premises. $K_u = \frac{E \min}{E \max}$

With $K_u = 0.3-0.6$ the distribution of brightness in the vision field can be considered most acceptable.

Pattern of light scattering is estimated by the value and direction of the light vector. SPD exhibits optimal light scattering if, in the vertical plane, the indicatrix maximum of light dispersion is directed upwards from the horizon and, in the horizontal plane, light scattering is uniform. This is practically possible, when the vertical angle to the horizontal projection of the vector $\mathcal{E} = 37^{\circ} - 43^{\circ}$ immediately at the light window, and when the angle is equal to $19^{\circ} - 23^{\circ}$ at a spot located far from the light window.

The relation to the outside environment is determined by coefficient of spatial visual connection K_V which is a product of the transparency factor K_t and index of horizontal and vertical vision ability of the outside environment through the light windows (in fractions of a unit).

$$K_{\rm w} = K_{\rm t} \cdot \Theta$$

Since with the same SPD type the characteristic θ can conventionally be considered a constant factor, the transparency coefficient K_t is a salient point, which is derived from the ratio of the area of the SPD transparent cells S_2 to the total area $S_I:k_t=S_2/S_I$. It has been found that in practice the optimal conditions of relation to the outside environment is determined by $K_t=0.4-0.6$.

Heat engineering estimation of SPD is made from the coefficient of transmission of solar radiation K_{β} , which is defined by the ratio of radiation intensity indoors to the total intensity of solar radiation incident on the appropriate (vertical or horizontal) surface (Kcal m⁻²). Investigations show that permissible magnitudes of K_{β} vary from 0.06 to 0.20. The corresponding coefficient of amplitudes of air temperature fluctuations in a 24-hour cycle K_{At} = 3.0-9.5.

Aeration of premises equipped with SPD is estimated on the basis of the coefficient of velocity nonuniformity $K_d = \overline{d_{min}}/\overline{d_{max}}$, which is a ratio between the mean values of minimum and maximum air velocities inside the premise This characteristic enables us to determine the effect of SPD on the intensity of air mixing; optimal conditions of aeration correspond to the following magnitudes of $K_d = 0.17$ -0.40. The aeration qualities of SPD are estimated according to the coefficient of inblowing $K_i = \frac{d_i}{d_0}$, which represents a ratio of the air local velocity in premises to the wind speed. Optimal conditions of aeration are obtained within the following range of value $K_i = 0.4 - 0.9$.

Psyhcophysiological studies of the effect of SPD on the conditions of visual jobs allowed us to find the dependence of visual fatigue on qualitative characteristics of light environment. If the level of illumination uniformity varies within 0.3-0.6, which characterizes better conditions of visual jobs, then visual fatigue falls by Ib-25%. In their comprehensive studies, the authors have found a close relationship between the above mentioned SPD quality characteristics and indoor environment, which is expressed by a nomogram of their interdependence (Fig I). Therefore, in selecting and designing SPD, making use of the given method, we can determine, with a sufficient accuracy, the efficiency of any device and predict the confort of environment in premises.

Figure I. Nomogram for the relationship of major factors of quality of the sun protection: α is the angle of tilting of screening devices.



- Développement de la préfabrication des maisons en éléments de grande dimension et
- activité du C.I.B. Plessein Boris D., cand. ès sc. tech., ing., membre du C.I.B. (U.R.S.S.) Tsaplev Nicolaï N., cand. ès sc. tech., ing., membre du C.I.B. (U.R.S.S.)

La pénurie de logements est le problème parmi les plus importants pour la plupart des pays, surtout des Etats sur la voie de développement. La solution du problème en question dépend de plusieurs conditions économiques, sociales, matérielles, techniques et d'autres.

Au nombre de ces facteurs se rapporte la nécessité de la construction massive des immeubles résidentiels aux frais minima et dans les délais réduits. La construction de logements en grands panneaux, réalisée en éléments préfabriqués de béton de dimension importante représente le mode de construction le plus progressiste de nos jours répondant aux exigences actuelles ci-dessus.

A l'heure actuelle la construction par grands panneaux est couramment répandue dans nombreux pays et son volume va en croissant là, où il n'y a pas de réduction générale de la construction de logements.

En R.D.A., Tchécoslovaquie on construit à partir de grands éléments préfabriqués environ 70% de logements, en U.R.S.S., Pologne et au Danemark plus de la moitié. La construction par grands panneaux s'effectue sur une vaste échelle en Bulgarie, Hongrie, Roumanie, Yougoslavie, France et dans d'autres pays.

L'extension continue de la construction de logements par grands panneaux résulte de ce fait, que par rapport à la construction en maçonnerie de briques les délais des chantiers sont diminués d'un tiers, la consommation de la main-d'oeuvre est réduite de 1,5 fois et le coût de la construction est abaissé de 8 à 12% (d'après les statistiques soviétiques de plusieurs années).

Le développement de la construction par grands panneaux a provoqué la création de l'industrie de préfabrication des maisons dont le volume de production ne cède pas aux nombreuses branches industrielles.

Outre la construction de logements, on édifie en grands panneaux des bâtiments publics (écoles, hôpitaux, hôtels, etc.). Cependant, la part des équipements collectifs réalisés en grands panneaux est de plusieurs fois plus faible que la part des immeubles d'habitation. Tout cela est occasionné par toute une série de facteurs, y compris la diversité suffisamment grande des types de ces bâtiments, de même que leur reproduction bien moins importante.

Dans le développement de la construction massive industrialisée une attention particulière est accordée au problème de réalisation des maisons en éléments tridimensionnels. Un volume relativement faible de l'édification des bâtiments en éléments tridimensionnels de béton prouve que ce mode de construction reste encore au stade de l'expérimentation industrielle. Pourtant, lors de la construction des bâtiments en grands panneaux de béton, en vue de diminuer la consommation totale de la main-d'oeuvre (usine + chantier) on utilise assez couramment des éléments tridimensionnels: blocs d'eau, gaines d'ascenseur loggias additionnés etc.

La pratique de conception et de réalisation des bâtiments préfabriqués a justifié un avantage technique considérable des systèmes constructifs à panneaux sans ossature par rapport aux systèmes avec ossature. Cela explique la préférence accordée dans la plupart des pays européens aux systèmes constructifs sans ossature qui prédominent dans la construction par grands panneaux.

Dans la construction des équipements socioculturels, au contraire, sont plus répandus les systèmes avec ossature, mieux assurant l'organisation spatiale et les plans dits "souples" des bâtiments d'usage public.

Accordant une importance particulière à la diminution ultérieure de consommation de la main-d'oeuvre et la réduction des délais de la construction des maisons en grands panneaux, la Commission W19 du Conseil International du Bâtiment conjointement avec l'Académie du bâtiment de la R.D.A. a convoqué à Dresde en 1979 un symposium. Le symposium a été consacré au développement de la conception et des techniques de production à l'usine des composants des bâtiments entièrement préfabriqués visant à la diminution de consommation de la main-d'oeuvre dans la construction par grands panneaux. 64 experts de 14 pays ont pris part au travail du symposium. Au cours des réunions les rapporteurs ont confirmé l'interrelation de la réduction des dépenses du travail dans la construction par grands panneaux avec le niveau d'organisation de toutes les opérations technologiques,y compris la production des éléments à l'usine, leur mise au complet, la livraison sur le chantier d'après le calendrier des travaux et l'assemblage dit "à partir des roues" sans stocker les éléments sur place. Ces conditions observées, le niveau de consommation totale de la main-d'oeuvre dans les entreprises de construction d'avant-garde ne dépasse pas 10 à 12 hom/heure par 1 m² de surface utile.

Une des réserves de réduction ultérieure de consommation de la main-d'oeuvre dans la construction par grands panneaux représentent les travaux de finition et post-assemblage à la part desquels revient 70% de toutes les dépenses de la main-d'oeuvre sur le chantier.

On a constaté que leur niveau respectif peut être abaissé dans les limites de 50%.

Dans plusieurs rapports l'attention a été portée sur l'importance du problème de modernisation des usines existantes de préfabrication de grands panneaux sans arrêter leur fonctionnement, vu l'usure matérielle et morale de l'équipement technologique.

Nombre de rapporteurs ont signalé que pour la réduction de consommation de la maind'oeuvre il serait opportun de rechercher la possibilité d'une large application dans la construction industrialisée des toits sans couverture en carton bitumé ou goudronné. Les recherches en question ont pour but de remplacer la couverture en rouleaux de plusieures couches par une structure exigeant moins de travail, permettant non seulement de diminuer la consommation de la main-d'oeuvre, mais aussi d'augmenter la fiabilité des toitures.

De grande importance pour la diminution de consommation de la main-d'oeuvre dans la construction de logements est la mise en place des chapes d'égalisation préfabriquées recouvertes d'un revêtement de sol en rouleaux.

La solution heureuse du problème mentionné permettra de réduire sensiblement la dépense du travail.

Lors de la construction dans les régions sujettes aux séismes, surtout quant il s'agit des bâtiments de grande hauteur, la préférence est donnée pour la plupart aux immeubles avec ossature, quoique la résistance aux séismes des bâtiments en grands panneaux ait été prouvée maintes fois au cours de plusieurs tremblements de terre à partir de celui à Tachkent (U.R.S.S.) en 1966.

Très intéressants sont les résultats de

comportement des bâtiments présentant de divers systèmes constructifs au cours du grand tremblement de terre qui a eu lieu aux Karpates en mars 1977.

Au symposium de Dresde les ingénieurs M. Ionescu, T. Ducle, I. Marcu (Roumanie) ont informé qu'à Bucarest les immeubles résidentiels en grands panneaux de 5 à 9 niveaux ont manifesté la meilleure résistance aux seismes par rapport aux bâtiments avec ossature et monolithiques. Les bâtiments avec ossature et les immeubles en béton coulé in situ après le tremblement de terre exigeaient des réparations respectives pour leur redonner les qualités d'exploitation nécessaires. En même temps 50 immeubles résidentiels en grands panneaux (6 mille appartements) n'ont pas reçu des détériorations apparentes au cours du tremblement et restaient en exploitation normale.

La résistance aux seismes élevée, dont possède le système constructif à panneaux, d'après les rapporteurs, due aux trois facteurs: - rigidité importante des structures réali-

sées en éléments de grande taille; - bonne qualité de production à l'usine

des composants préfabriqués de béton armé; - pouvoir des éléments porteurs d'absorber l'énergie au niveau des joints horizontaux

qui à ce moment subissent de faibles déformations résultant des charges séismiques.

La résistance aux seismes élevée des bâtiments en grands panneaux doit être toujours prise en compte lors de l'étude du problème de développement de la construction dans les régions sujettes aux séismes.

La Commission W19 du C.I.B. a l'intention de poursuivre dans son futur travail l'examen approfondi du problème d'élevation continue d'efficacité de la construction par grands panneaux.

Dans la construction par grands panneaux prédominent les systèmes constructifs avec murs transversaux porteurs espacés de 2,6 à 3,6 mètres et planchers à la dimension "d'une pièce" appuyés sur deux, trois et quatre côtés.

En même temps on constate la promotion ultérieure des systèmes constructifs avec écartement des murs transversaux porteurs agrandi de 6 à 7,2 mètres. Ces derniers systèmes permettent d'obtenir les plans des appartements plus "souples".

Avec écartement des murs ne dépassant pas 3,6 mètres sont utilisées les dalles de plancher pleines en béton armé épaisses de 12 à 16 cm avec ferraillage en acier ordinaire, de dimension "d'une pièce". Dans ce cas la chape d'égalisation coulée in situ n'est pas nécessaire.

Avec murs espacés de 6 à 7,2 mètres sont utilisés les planchers multicavitaires porteurs en béton armé épais de 22 à 26 cm ou dalles de plancher pleines épaisses de 16 cm. Dans les deux cas les dalles de plancher sont prétendues.

Pour le moment, le problème actuel de la construction de logements réside dans l'accroissement de l'efficacité thermique des bâtiments. Dans sa solution est de grande importance la diminution des dépenditions calorifiques par les murs extérieurs des maisons d'habitation.

Le problème de consommation économique du combustible dans les immeubles résidentiels en grands panneaux est résolu avec succès par la mise en oeuvre des panneaux sandwiches des murs extérieurs. A cet effet, sont plus largement appliqués des panneaux de murs extérieurs à trois couches avec calorifugeage efficace en mousse de polystyrène ou plaques rigides de laine minérale. Les panneaux à trois couches n'ont pas des ponts thermiques et la réunion des voiles de béton intérieur et extérieur s'effectue à l'aide des agrafes souples en acier non corrodable. Le développement de la construction par grands panneaux dans divers pays porte un caractère différent.

Cependant, l'influence qu'elle exerce sur l'architecture des implantations résidentielles, représente un phénomène universel. Il en résulte l'intérêt général à la préfabrication des maisons d'habitation de type varié avec remplacement périodique de leurs modèles.

La Commission W19 du C.I.B., en tenant compte de l'envergure de la construction par grands panneaux, poursuivra l'examen des problèmes de diminution ultérieure de consommation de la main-d'oeuvre. Son attention sera axée sur l'élaboration des mesures visant à l'augmentation de l'efficacité thermique des murs extérieurs et planchers des bâtiments préfabriqués, le perfectionnement des structures de plancher à grande portée, l'application de nouveaux matériaux et techniques avancées de préfabrication des éléments. 773

System in construction

Prof. Gyula Sebestyén, Doctor of Techn. Sci.

Director of the Hungarian Institute for Building Science ÉTI

Budapest, Hungary

Summary

It was not until very recently that the theory of systems (system analysis, system research etc.) found application in the construction industry, now spreading to various fields.

Systems are sets of elements related to each other in some form. They often consist of subsystems and can be visualized as graphs.

The architectural and the engineering design of buildings can be treated as systems.

The information flow in construction can be defined as a system.

A new application is "system building", construction with "building systems". Though this expression is widely used, a further clarification of its contents is needed.

Complex building systems include not only the building but the equipment installed, too.

Macroeconomic systems in physical planning, housing and construction and the system of building regulations are further fields of application.

Very complex systems can be handled by introducing mathematical models and electronic computers.

Sommaire

La théorie des systèmes (analyse, recherche des systèmes, etc.) n'a trouvé l'application que très récemment dans l'industrie de bâtiment; elle est maintenant en cours de développement aux domaines divers.

Le système est un ensemble des éléments attachés l'un à l'autre d'une certaine manière.

Fréquemment des systèmes se divisent en sous-systèmes et peuvent être représentés avec des graphes.

Les projets architectural et technique des bâtiments peuvent être considérés comme des systèmes.

Une application nouvelle est le "système building", c'est-à-dire l'emploi des "systèmes constructifs", en français souvent appelés des procédés nouveaux. Quoique cette expression est utilisée fréquemment, il est nécessaire de clarifier ce qu'elle signifie. seulement le bâtiment, mais aussi l'équipement installé. Des systèmes macroéconomiques au domain de la planification intégrée, l'habitation et construction et le système des codes de construction constituent quelques autres domaines de l'application.

Des systèmes très complexes peuvent être traités par l'introduction des modèles mathématiques et des ordonnateurs électroniques.

1. Theory of systems

The theory of systems is a relatively young sector of science; in the construction industry it is even younger than elsewhere. This sector of science has become known under different names: theory of systems, system analysis, system technique, system approach, system research etc.

The work of scientists who have laid down the principles of the theory of systems has become widely known both in Western (Churchman etc.) and Eastern countries (Sadowskij etc.).

A system in its most general form is a set of elements related to each other in some form. The system is often visualized as a graph, its points being the components of the system and its lines (edges) the relations between the components. The arrangement of the points and lines (i.e. of the components and relations) forms the structure of the system.

Systems often consist of subsystems and/or partial systems (in the same way as graphs do).

The handling of systems is in close connection with operations research.

Operations research helps to make decisions for systems where people and machines are involved, by employing modelling techniques, mathematical methods and making use of electronic computers.

Some of the well known operations research methods are linear and nonlinear programming, allocation methods, network analysis, stockpiling optimization, the theory of games etc.

The analysis of systems can be broken down to the following processes:

- the analysis of the task to be solved (system analysis),

- the first tentative overall and detailed design (planning) of the system,
- the planning of the functioning (introduction, use, maintenance, supervision) of the system,
- the final overall and detailed design (planning) of the system.

Des systèmes de construction complexes comprennent pas.

2. Types of systems

The two main types of systems are the open and the closed systems.

An open system is connected to the world outside the system, obtains information from and is influenced by the outside, subject to which it undergoes changes.

The system itself also conveys information to and exerts influence on the outside world.

A closed system does not have any considerable interrelation with the outside world.

The systems of the living world are open (biologic, social, economic etc.) systems.

Anorganic (not living) systems (e.g. machines) can (often) be regarded as closed systems.

The internal functioning of a system can be defined in a deterministic, or only in a stochastic way. A system defined in a deterministic way can be described by functions (mathematically) or only by some kind of algorithm (an established set of steps). If the internal function of a system is unknown, it can be considered a black box.

The components of a system can be manmade or natural. Systems can be related to products (including buildings), or to processes (including information).

Organizations consist exclusively or partly of people. In organizations decision making is of major importance. The theory of decision making deals with the problem of making optimal decisions.

3. Systems in construction industry enterprises

There are various systems in the economy. Enterprises (whether private, cooperative or state-owned) are systems too. They have a certain independence, which, however, is affected (narrowed down) by outside factors.

Systems used by enterprises (architectural and structural designers, contractors, manufacturers) are microeconomic; those used on a national or regional level are macroeconomic systems.

The engineering (structural, mechanical, electrical, airconditioning etc.) design of buildings was not considered earlier as one which forms a system. The design process used to be cut down to independent partial design processes, none of which had a bearing on the others. Recently, the buildings, their structural or mechanical totality and their desing process too have been handled as complex systems. Up-to-date modelling and computing techniques have been introduced.

Construction itself can be considered as a complex system. Its subsystems are

- construction processes (earthwork, concreting, masonry, sanitary equipment etc.),

- processes with certain specific character within the contractors' enterprises (purchase and stockage of materials, organization of labour force, functioning of building machines, bookkeeping, cost control etc.),
- the organized cooperation of enterprises and of units of the enterprises.

The information flow in building enterprises is also an extremely complex field and the development of information systems has been studied extensively by many researchers. Naturally, it is first within the designers', manufacturers' or contractors' enterprises that the information flow is systematized. A higher degree of systematized information flow is attained if a unified system can be used by all participants of the construction process. Thozgh this is highly desirable it is also much more complicated and has been realized only in few cases.

4. System building

"System building" is one of the newest application of the system approach in construction. "Building systems" are advanced forms of industrialized construction.

A building system (to be qualified as such) must have its components:

- the "hardware" component: the technical subsystems which have to be compatible with each other, (framework, external walls, floors, roofs, partitions etc.)
- the "software" component: meaning a consistent system of coding the components, details and design sheets, the elaboration of all designs according to this system, programmes for computer-aided design, programming, cost evaluation and cost control,
- the "orgware" component: meaning a relatively permanent system of interrelated organizations, each with clearly defined responsibilities in the development and maintenance of the system, for the manufacturing of components and for carrying out the construction operations as manufacturer, general contractor or subcontractor.

If any of the components is missing, an enterprise may advertise its know-how (for commercial reasons) as a building system, which is, however, not more than a quasi-system (a not completely elaborated system) or eventually a pseudo-system, (in which case most of the necessary features of a building system are missing). Much effort (money, time, work) is needed to have a complete building system at hand.

It is only strong organizations that have the means and market share for the development of building systems. It may often occur that subsidiary enterprises of big (steel or aluminium making etc.) firms become specialized in the development and maintenance of building systems.

In several building systems there is just one solution for each subsystem. There are building systems that make it possible to use different solutions alternatively for one subsystem (e.g. different types of external walls or partitions.)

A building system with just one set of subsystem solutions can be considered as closed. (The use of the terms "open" and "closed" is not quite the same for building systems as for systems in general system theory). The more alternatives possible for subsystems, the higher the degree of openness.

On a high level of industrialization technical progress is concentrated on the development of subsystems that can be used in many different building systems.

The high cost of developing a building system finds its justification in the speed with which new buildings of various size, lay-out and function can be designed and built by making use of the work carried out in advance during the course of the development of a building system.

Building systems can be made to function if their data bank is created first. Such data banks contain data on components, normative inputs for labour, materials and machines in manufacturing and construction, quantity and cost estimates, etc. Based on such data banks the construction of buildings can be programmed, supervised and controlled.

System building has been first developed for buildings with a structural frame. The frame (columns, beams etc.) is in most cases a steel frame, though it can be assembled from precast reinforced concrete components.

Lately, large panel construction e.g. for new housing, has also been treated as a field for the development and use of building systems. Such systems have much in common with system buildings with frame, however, there are certain specific characteristics too which apply to system buildings with loadbearing walls assembled from large panels.

5. Complex systems (buildings + equipment)

System building has found a special application: that of complex systems which include not only the building but also the equipment in the building.

So e.g. a complex school building system includes all furniture and equipment needed to make the school function. Contracts for new schools include in this case everything mentioned above.

Other types of buildings e.g. farm buildings, hospitals etc. may include all agricultural, technological, medical etc. equipment. The building in this case is an important item that houses all equipment, however, its value is only part perhaps less than half - of the total investment cost.

Such complex systems can be the application of systems originally open but as complex systems they become closed. From a theoretical point of view open systems are usually considered to be more advanced than closed ones; for complex systems this is not the case, these - if there is a sufficiently high demand for buildings of this type - offer economic advantages and are a very up-to-date use of systems.

6. Macroeconomic systems

Many problems related to the construction industry, housing, management and maintenance of buildings, the development and rehabilitation of residential areas and vhole settlements, physical planning, transport networks, built environment can be handled only on a macroeconomic (regional, national etc.) level and can be effectively treated only as systems. Longterm economic and physical planning on a macroeconomic level cannot be dealt with effectively without establishing some kind of a model that subsequently can be handled in an exact way. Practically, this means establishing macroeconomic systems for solving such problems.

Economic, technologic, demographic and housing forecasting are well known applications of this approach.

7. System of building regulations

One of the governments' tasks is the technical regulation of construction in the form of building codes, by-laws, etc.

The technical regulations in construction worked out in earlier periods do not form a real system because they consist of independent, often overlapping and contradictory arbitrary rules. It is only the performance concept, this new principle of building regulations, that can become a basis for systematic approach.

Though the performance concept has been widely accepted as a basic principle in building regulation, and there are already many standards written in this spirit, there exists no international or national building code yet that could be considered as a complete complex system of regulations based on the performance concept. It is still a task for future work to reach this objective.

8. The use of computers

Complex systems contain usually many data, relations and other information. To make such systems work the use of computers is needed. A comprehensive integrated system of classification, coding and programming has to be worked out in order to have compatible subsystems forming complex systems in their totality. This again is a field where much work is still ahead.

9. Conclusions

The theory of systems can yield great benefits, however, it is not in itself a remedy for all maladies. A book (John Gall: Systemantics, Pocket Books, New York, 1978) rightly - and impishly - states that "New systems mean new problems" and "Great advances do not come out of systems designed to produce great advance".

The study (and teaching) of the theory of systems is not very advanced in the construction industry, though certain progress can be expected of its application and therefore systematic research and exchange of experience should be envisaged. 777

Analysis of Manpower Demand in the Israeli Building Sector

Dan Segal, M.Sc., Faculty of Civil Engineering, Building Research Station, Technion, Israel Institute of Technology, Technion City, Haifa, Israel.

Summary

In view of the major importance of long-range manpower planning in the regular activity and development of the local building sector, a study initiated and sponsored by the Israel Ministry of Housing was carried out at the Technion, Israel Institute of Technology, in 1975-1976. The methodology, final results, conclusions and recommendations are presented.

En vue de la grande importance de la planification à long terme de la main d'oeuvre dans l'activité quotidienne et dans le developpement de la construction nationale, une étude sous l'égide du Ministére de L'Habitations d'Israel a été effectué au Technion, Institut de Technologie d'Israel en 1975-1976. La methode, les résultats, les conclusions et les récommandations sont présentés ci-dessous.

1. Definition of problem

Building is Israel's largest economic sector in terms of gross domestic fixed capital, and fourth in terms of manpower (after industry, public services, and commerce). Because of its labour-intensive nature, it depends, for smooth functioning, on steady and adequate supply of skilled and unskilled manpower. In this context, there are difficulties due to the seasonal character of the work; the multiplicity and diversity of the operations involved; the rigorous ambient physical conditions; and finally, the loose links between employers and employees, due to constant displacement of the latter from site to site. In these circumstances, there is shifting of manpower to other industries and to the services, and low motivation for fresh cadres taking up these trades - with the consequent shortage in times of normal economic activity.

In view of the considerable uncertainty regarding most of the events governing the development of the sector, and the substantial time-lag between the decisions and their consequences - long-range planning of the resources, especially of manpower, is essential for smooth functioning of the sector. The main advantage of such planning lies in the possibility of advance assessment of the possible effects of different decisions under different action alternatives, with reduction of the risks inherent in long-range economic decisions or policies.

2. Object of study

The main object of the study was determination of the manpower requirement of Israel's building sites over the next decade (on the basis of the relevant building objectives and per-unit manhour rates, estimated with allowance for anticipated technological changes) and of the steps required for making up the expected shortage.

3. <u>Method</u>

The study covered the following aspects:

3.1. Building demand forecast

The building demand pattern for the period under review was examined by three methods:

(a) Extrapolation of past statistics.

(b) Examination of all demand and supply factors, and estimation of the building demand forecast according to changes foreseen in these factors, to the existing slowdown in the sector at the time of the study, to the expected general economic situation, and to possible alternatives of migration balance.

(c) Data and findings compiled from other sources.

In each case, the demand for construction was estimated separately for the residential and non-residential categories. Results for the alternative envisaging a positive migration balance of 20,000 per year, are summarized in Table 1.

3.2. Per-unit manhour inputs

The object of this stage was determination of the required manhour inputs per unit gross floor area, and their breakdown by trade, for different types of structures and method of realization. Data were compiled from literature, from unpublished research reports, and from information provided by company managers, site engineers, contractors and subcontractors.

The relevant substages were:

(a) Analysis of the heavy dispersion between the sources, and determination of the manhour requirements for basic operations involved in the building process.(b) Work-quantity analysis of standard residential buildings, and determination of average work quantities per unit gross floor area.

(c) Determination of manhour inputs per unit gross floor area, in residential building erected in conventional industrialized and total prefabrication construction methods.

(d) Analysis of input differences between residential and non-residential buildings.

Results - national averages - are given in Table 2, which served as basis for the manpower demand forecast. 3.3. <u>Manpower demand forecast</u>

The expected manpower requirement is based on the building demand forecast - estimated as described in paragraph 3.1.b upside, and on the required manhour inputs per unit gross floor area - estimated as described in paragraph 3.2. above - according to foreseen technolo-

Migration Balance (Persons/Year) + 20.000												
	Other Sources						Present			Extrapolation of past		
Dr. U. Baaral		M. of Housing	Dept. of Economic Planning		forecast		forecast Statistics		forecast			Year
Reside build	ential ling	Resid. build.	Residential Total building build.		Residential building		tial Total Residential Tota ng build. building bui		Total build.			
Dwell. units	Thous. sq.m.	Dwell. units	Dwell. units	Thous. sq.m.	Thous. sq.m.	Dwell. units	Thous. sq.m.	Thous. sq.m.	Dwell. units	Thous. sq.m.	Thous. sq.m.	
39,200	3568	44.160	39.800	4320	5520							1978
41.100	3740	44.160	41.300	4460	5680							1979
41.550	3782	44.160	42.050	4620	5870	43.415	4160	5300	54.115	5680	7300	1980
			42.800	4780	6050							1981
			43.550	4940	6230							1982
			44.300	5100	6410							1983
												1984
						47.810	4580	5840	60.070	6570	8260	1985

Table 1 Total and Residential Building Forecast - Comparison of Sources.

gical and managerial organizational changes. But since most of the expected technological changes are seen to be related to development of industrialized building methods, in connection with which are practicable and economically justified, two possible alternatives of development of industrialized methods in Israel were considered in determining the manpower demand forecast for 1985: a "minimalistic" one under which prefabricated and industrialized construction would constitute one-third (34%) of the total building production and a "maximalistic" one envisaging a two-thirds proportion (67%). (Obviously, the second alternative is relevant only in circumstances of a heavy demand for construction or of an acute manpower shortage, conditions essential for intense development of industrialized methods.)

This proposed forecasting procedure was verified first on available past statistics; in the second, it was used for determining the total manpower demand, with the corresponding breakdown by trade and by region.

Besides the main forecast, which results for a positive migration balance of 20,000 per year, are summarized in Table 3, an intermediate one for 1980 was obtained by interpolation. In principle, annual figures are also obtainable by this means, but since the underlying assumptions are long-range, the reliability of these intermediate results is relatively low. The forecast was supplemented, for the sake of completeness, by figures on rapair and maintenance manpower and also on construction manpower employed on security projects.

Table 2 Manhour inputs, per sq.m. gross floor area, breakdown by trade, for different building methods averages

	-		
Trade	Total prefabri- cation method	Industri- alized in-situ method	Convent. method
Formwork	0.85	0,85	3.06
Carpentry	0.55	0.60	0.65
Reinforcement	0.40	0.40	1.10
Concreting	0.14	0.14	0.43
Masonry		0.03	0.75
Plastering	0.76	0.91	2.23
Flooring	0.56	0.56	0.56
Wall tiling	0.10	0.10	0.10
Terrazzo	0.18	0.18	0.18
Exterior finishing	0.15	0.46	
Painting	1.39	1.39	1,50
Metalwork	0.15	0.15	0.15
Sanitary inst.	0.63	0.73	1.20
Electrical inst.	0.52	0.62	0.85
Glazing	0.10	0.10	0.10
Unskilled work*	5.55	5.66	8.14
Supervision	0.90	0.90	0.90
Building equipment operation	0.40	0.40	0.40
Erection crews**	0.95	1.83	
Joints, finishing	0.20	0.10	
Miscellaneous skilled work	0.06	.0.09	
Total	14.54	16.20	22.30

* Includes, apart from common labourers, helpers to the various skilled artisans.

**Includes industrialized in-situ erection of the skeleton and assembly of prefabricated elements.

Trade	Migr bal +20 perso	ation ance 0.000 on/year	Manpower in 1972***
	Alt. 2.	Alt. 1.	
Carpenters	7.260	9.750	14.200
Steel benders	2.100	2.860	2.200
Concreters	800	1.100	200
Masons	830	1.660	5.300
Plasterers	4.260	5.820	4.600
Terrazzo and tile layers	2.790	2.790	2.800
Painters & exterior finishing	5.330	5.160	6.200
Metal-workers	500	500	3.000
Plumbers	2.790	3.390	4.800
Electricians	2.160	2.500	2.900
Glaziers	330	330	400
Foremen	2.990	2.990	5.300
Equipment operators	1.330	1.330	5.200**
Erection crews	3.130	1.600	300
Unskilled workers	21.390	24.190	15.100
Miscellaneous	170	70	
Total demand	58.160	66.040	
Repair and maintenance workers	11.600	11.600	
Other Civ. Eng. projects*	10.500	10.500	
Total demand forecast for 1985	80.260	88.140	
Existing manpower 1972***	72,500	72.500	72.500
Difference	7.760	15.640	

Table 3 Manpower demand forecast for 1985, by trade

* Construction workers only, employed in other civil-engineering and security projects.

** Includes equipment operators as above.

***Excludes foreign workers employed in Israel.

3.4. Existing manpower resources

Information on this subject was obtained from the official Central Bureau of Statistics (general and specialized manpower surveys, the population and housing census of 1972), from the National Insurance Institute, from the Construction Workers' Insurance Fund, and finally from miscellaneous sources which need not be identified, as their data were in fact recapitulations of those mentioned earlier. The causes of the considerable discrepancies between these sources were examined, and the total and the breakdown-by-trade of the existing manpower in the sector, excluding foreign workers employed in Israel (Table 4) was determined.

In view of the slowdown in the sector at the time of the study, with resulting redundancy of manpower, 1972 a peak year in terms of activity and of volume of **em**- ployment - was chosen as reference, considering that once the economic situation has improved, the extra demand would be covered by the redundant manpower, without need for special retraining and/or absorption facilities.

breakdown by trade, 1972			
Trade	%	%	Thousands
Plumbers	9.2	6.6	4.8
Electricians	5.5	4.0	2.9
Carpenters	27.2	19.6	14.2
Foremen	10.1	7.3	5.3
Masons	9.6	6.9	5.0
Stonemasons	0.6	0.4	0.3
Terrazzo & tile layers	5.4	3.9	2.8
Plasterers	8.8	6.3	4.6
Steel benders	4.2	3.0	2.2
Metalworkers	5.7	4.1	3.0
Concreters	0.4	0.3	0.2
Erection crews	0.6	0.4	0.3
Glaziers	0.8	0.6	0.4
Painters	11.9	8.6	6.2
Total skilled workers	100.0	72.0	52.2
Unskilled workers		20.8	15.1
Building equipment operators		7.2	5.2
Total construction workers*		100.0	72.5

Table 4 Construction manpower resources,*

Resident workers only, excluding foreign ones employed in Israel.

4. Conclusion and Recommendations

4.1. Summary of manpower demand

Under the variant envisaging a positive migration balance of 20,000 per year - which seemed to be the most realistic figure at the time of the study - and the "minimalistic" alternative for the proportion of industrialized and prefabricated construction, the demand forecast for 1985 was about 88,000 workers. Accordingly, assuming that present foreign labour remains available, and the past and present dropouts are reabsorbed, the available potential, with or without retraining, should satisfy the demand. If changing circumstances increase the demand for construction or reduce the supply of manpower, the solution would lie in attracting fresh manpower, and in extending industrialization to the "maximalistic" level.

4.2. Recommendations

The main recommendations are:

(a) Guidance and training facilities for construction workers, with a view to improved skills and productivity. Provision must also be made for retraining cadres from trades with likely underemployment to those with excess demand. By this means, fresh manpower would be attracted, gaps left by retirement, etc. filled, and motivation provided.

(b) Encouragement of projects involving large sites, with a view to improved productivity through reduced running-in times for new projects, and further timesaving by obviating the need for displacement from site to site. In addition, this would facilitate long-range planning for the contractor, while enabling him to maintain a permanent professional staff and improve productivity by means of suitable incentives - all of this at reduced overall cost of the project. (c) Improved reliability of current manpower statistics by suitable refinement of the survey questionnaires; creation of a special body which would unify the activities of all agencies concerned with the subject, formulate exact definitions for the various trades, propose revisions for the standard classification, and set up a unified system for compilation and classification of data from all sources. (An up-to-date comprehensive census of the manpower in the building branch is also desirable.)

(d) Improved reliability of existing per unit manhour input statistics by establishing a practice which would oblige contractors of public projects to produce detailed evidence of invested working hours, and store the data thus obtained in a national data pool.

(e) Thorough study of maintenance activities, with a view to exact determination of the relevant manpower demand and its breakdown.

(f) Updating of the findings on a yearly or a biennial basis, in the light of changes in the underlying premises.

(g) Outlining of a simple and operative model which will give the short-term requirements of construction manpower according to different building policies.

In addition to the above, the significance of the present study lies, also, in the opinion of the author, in the following aspects:

- Exhaustive and systematic treatment of available information from every possible source.

- A comprehensive methodology provided for manpower analysis, including compilation and running updating of the relevant statistics.

- Identification of new aspects of interest.

Methods of thermal drying and burning of sludge of town sewage

Eng.Sverdlov I.Sh., TsNIIEP of Utility Systems Moscow, USSR

<u>Summary</u>. The practice of thermal drying of sludge is an effective way for their volume limitation and complete decontamination. Thermally-dried sludge is an excellent organic-mineral fertilizer. If it isn't advisable to use it as fertilizer, thermallydried sediment can be burnt.

In the USSR, there have been elaborated different methods of drying and burning of sludge: dryers-granulators with the suspended layer of sludge; the instalations with twoway gas jets; the cyclone vertical furnaces.

The most versatile is the method of drying in instalations with two-way gas jets. They have a lot of advantages: lower metal consumption, easier maintenance of installations, lower specific consumption of fuel.

Combined installations on drying dehydrated sludge and further burning of dried sludge without fuel consumption are being developed.

The installations have the apparatus for purification of exhaust smoke gases, which makes it possible to practically exclude the discharge of noxious gas and ashes out of the installation.

A standard series of such installations manufactured by the plants is being produced in the USSR, the capacity of which will be 1.4-2.2; 3.5-50 and 7-10 tons/hr in terms of evapovating moisture.

<u>Sommaire</u>. La dessication thermique des dépôts est une méthode efficace de la diminution de leur volume et de leur désinfection. Le dépôt seché s'utilise comme un bon engrais organominéral. En cas de l'inopportunité de son utilisation à titre de l'engrais on peut incinérer le dépôt seché.

De différentes méthodrs de la dessication et de l'incinération des dépôts, la construction des séchoirs-granulateurs avec la couche en suspension, des séchoirs avec des jets de gaz opposés, des foyers de cyclone ont été élaboré en URSS. La méthode de la dessication dans les installations avec les jets de gaz opposée paraît être la plus rationnelle. Une consommation faible de métal, un entretien simple, un débit specifique du combustible peu considérable en sont des avantages. On a également élaboré des groupes complexes des installations de dessiccation avec des dispositifs de foyer, permettant de sécher et d'incinérer le dépôt sans consommer du combustible.

Ces installations sont équipées des dispositifs de l'épuration du gaz échappé rendant pratiquement possible l'exclusion de l'éjection du gaz rejeté toxique et de la poussière.

Aux usines de l'URSS on fabrique ces installations avec le débit de l'humidité évaporée de 1,4-2,2; 3,5-5,0 et de 7.0-10.0 #h.

Thermal drying if dehydrate sludge of town sewage gives a possibility to a wider use of sludge in agriculture thanks to the reduction by 3-3.5 times of expenditure on its transportation and applying into soil as well as on its complete decontamination.

A number of Soviet organizations have conducted comprehensive research on seeking a more economical and simple in operation method of thermal drying of sewage sludge.

In particular, there has been elaborated a method of drying excess active sludge in dryers-granulators with the suspended layer of sludge. The parameters of operation of the installation have been determined (temperature of the process, consumption of gas and air, specific loading on the apparatus capacity and others) which make it possible to obtain a high quality of granulated product with maximum conservation of valuable substances incorporated in sludge. The obtained protein-vitaminic concentrate can be used as a valuable fielder ingradient in nutrition ration at, e.g. fur farms.

But a most versatile appears to be the method of drying in installations with twoway gas jets, which has been designed in the USSR specially for treating sewarage sludge (see drawing 1).

In these installations the feed of dehydrated sludge is done in two counterflow currents of combustion gases with the initial temperature of 600-800°C and the speed of over 100 m/sec. Additional drying of sludge is done by air spout and the particles are classified according to their size.



Drawing 1. Principle scheme of installation with counterflow two-way jets for drying mechanically dehydrated sludge: 1 - delivery pipes; 2 - nozzles; 3 - combustion chamber; 4 - pressed air feed pipes; 5 - fuel feed pipes; 6 - feeder-mixers; 7 - return flow; 8 - separator of air-passage type; 9 - system of suction and purification of exhaust gases; 10 - final product bunker; 11 - connecting pneumatic tube; 12 - receiving chamber; 13 conveyor of dehydrated sludge.

cut capitale costs by 2.5-3 times and operational costs - by 15-25 per cent. Substantial is the cut in heat consumption per one kg of evaporating moisture from 1100-1200 down to 800-900 kcal, as well as easier maintenance of installations. Installations with two-way jets have certain advantages also over pipe-dryers with mechanical crumblers used in a number of countries: smaller dimensions of installation, absence of moving mechanical devices operating in the zone of high temperatures, smallerspecific consumption of fuel. The dryer with two-way jets operates as follows. Mechanically dehydrated sludge gets through loading device into double screw worm feeders where it is mixed up with part of the previously dried sludge (a return sludge).

The mixed-up sludge is fed into receiving holes of the drying chamber. There to come combustion gases which are generated in two combustion chambers fit on the same axle in such a way that gases on leaving them move to meet each other. To ensure the process of burning and to preserve the required parameters of the drying agent, compressed air is fed into the combustion chamber at the inlet of the drying chamber.

The sludge getting into the drying chamber is entrained by currents of combustion gases, thus forming a gas-suspension which runs along the pipes by two counterflow currents.

At the collision of currents in the centre of the drying chamber, the sludge gets crumbled and intensively dried. Then, along the vertical pneumotube in which additional drying of the sludge takes place, the gassuspension gets into the separator, in the lower part of which big fractions of the sludge that come back to be finally dried are isolated from the gas current.

Small fractions of the sludge are isolated from the gas current in the upper part of the separator and get through the paddle-door sluice to be extracted as a final product.

Gases from the dryer are dedusted in the gas scrubber and ejected into the atmosphere. Silt which appears in the scrubber is poured down into the sewarage system.

The operation of the drying installation is controlled by changing gas and air feed into the combustion chambers, depending on the temperature of gas-suspension along the track of the dryer.

It is designed to produce a series of drying installations with counterflow gas jets, the capacity of which will be 1.4-2.2; 3.5-5 and 7:-10 tons/hr in terms of evapovating moisture.

Thermally-dryed sludge is an excellent organic-mineral fertilizer. However, with a view to economically feasible distance of transportation, it cannot be fully used every-

where. Usually, the use of sludge as a fertilizer is regarded efficient if an average distance of transportation is up to 20 km. Moreover, even at the possibility of using it,

If compared to drum-type dryers the use of dryers with two-way jets makes it possible to

there might be periodical difficulties arising from the shortage of fuel in winter, of transportation means in harvesting season, atc.

In all such cases, it it advisable that sludge be burnt to obtain inert residium in the form of ashes or alag.

In recent years the USSR has conducted research on burning dehydrated and thermally dried sludge in cyclone vertical furnaces.

In case of burning dehydrated sludge, the technological scheme of installation becomes simpler and capital expenditure on construction lower.

However, this method involves number of problems. First of all, it is necessary to have a reliable device for putting dehydrated sludge into the furnace in the form of a more or less homogenious gassuspension. In burning the sludge there come out bad-smelling substances, the purification of smoke gases of which is very complex. A reliable method to kill the odour is an increase in temperature of exhaust gases up to 1000-1100°C. In this case heat expenditure on the process rises considerably, and in order to keep fuel consumption on the admissible level it is necessary to have a device for utilization of exhaust gases in order to heat the air that enters the furnace. Such a device would inevitably be cumbersome and metal-rich.

Thus, burning of dehydrated sludge seems to be of little prospect. Today combined installations on drying dehydrated sludge and further burning of dried sludge are being developed; in this case smoke gases from burning are used as a drying agent.

In this case the installation on drying the sludge will be similar to the one described above (with two-way gas jets) except for the furnace which represents a free-standing vertical cylindrical apparatus with tangential feed of sludge and air. Thermal load on furnace capacity may amount to 1.5 mln Kcal/m³ hr, coefficient of air excess - 1.1-1.2.

When burning sewage sludge with ash content of up to 30 per cent and moisture of up to 10 per cent, an extra fuel consumption for dry ing and burning is 20-25 per cent of the consumption for drying when using gas or black oil as a fuel.

Exhaust smoke gases must be freed from sludge's particles. With this aim in view, before letting exhaust smoke gases out, a provision is made for one or two stages of dry purification in cyclones, after which they are either thrown through the chimney into the atmosphere or undergo an additional stage of "wet" cleaning, for example, in an ejector scrubber with a crop-catcher.

Dry sludge is extracted from the furnace in the form of slag because of the short range of temperatures in which dry sludge is preserved in the form of ashes.

It is advisable to use wet ash removal in which slag gets into water-bath, cracks into 5-10 mm particles to be further removed by a hydroelevator to ash storage tanks. Multiply wooden structures used for roofs of

sports facilities

V.I.Travoush, Dr.Sc.(Eng), M.Yu.Zapol, eng. The B.S.Mesentsev Central Research Institute for Experimental Design of Entertainment Buildings and Sports Structures, Moscow, USSR

Summary

During the recent 15-20 years glued wooden structures have become widely used in roofs of public buildings in many countries. The paper shows architectural and building properties of glued wooden structures by examples of two sports buildings under construction, designed by the Central Research Institute for Experimental Design of Entertainment Buildings and Sports Structures, namely a covered skating-rink in Arkhangelsk with threehinge glued wooden arches of a 63.0m span and a covered skating-rink in Kalinin with a glued wooden cantilever-beam system of a 57.0m span.

Sommaire

Au cours des dernières 15-20 années dans les nombreux pays ont reçu une grande application des structures en bois collées dans les revětements des bätiments publiques. Les possibilités de construction et d'architecture des structures en bois collées ont décrite au rapport sur des exemples de deux constructions sportives sur les projects élaborés par l'Institut Central Scientifique et Technique des projets expérimentals des bâtiments visuels et sportifs nommé B.S.Mezencthev, de patinoire couverte dans la ville Arkhangelsk revêtue par l'arc à triple articulation à la travée de 63 m et de patinoire couverte dans la ville Kalinine revêtue par le système en bois collées de poutre en console à la portée de 57 m.

For the recent 15-20 years glued wooden structures in roofs of public buildings have become widely used in many countries throughout the world. Structural properties of wood as a building material, the feasibility of erecting large span structures from prefabricated elements of various shape and outline, aesthetical expressiveness of the material as well as its economic efficiency ensured its wide application in construction of gymnasia and exhibition halls, clubs, trade centres and so on. All this can be attributed to such qualities of structures from glued wood as consmall dead weight compared to high strength and rigidity; low heat conductivity; absence of condensate on the surface; long service life and fire resistance. Such structures are good in processing, they are easily transported and mounted, their shop production is highly mechanized.

Architectural and structural merits of glued wooden structures can be illustrated by sports constructions designed by the B.S.Mesentsev Central Research Institute for Experimental Design of Entertainment Buildings and Sports Constructions. The covered skatingrink in the town of Arkhangelskin a construction designed for sports and other entertainment activities.

The building consists of a 63x72 m sports hall with a 45x69 m ice field, halls for training and service rooms. Dimensions of the ice field permit to conduct competitions in figure skating and ice hockey as well as training in ball hockey. In the hall there are stands seating 1500 people, and in case some public or entertainment activities take place, the hall can seat 3000 people. The framework, inter-storey floors and roofs of rooms adjoining the ice field are made from inflammable structures. The sports hall of a 63.0m span is covered by three-hinge glued wooden arches without the beams mounted on reinforced concrete supports spaced at 6.0m. The arch camber flight is 11.0m.



Figure 1a. Covered skating-rink in the town of Arkhangelsk, designed by arch.M.Konstantinov, I.Fain, M.Drozdenko, eng.M.Zapol, V.Travush, Yu.Kopylev. General view of the skating-rink under construction.



Figure 1b. Covered skating-rink in Arkhangelsk, cross-section.

On the one hand the thrust is transmitted on to the horizontal disk of the adjoining room and through vertical diaphragms spaced at 30m on to inclined r.c.piles, on the other hand, it is transmitted on to under-stand supports of the sports hall. The stability of the roof is secured by three horizontal trusses out of cruciform braces and load-bearing framework of roof panels.

Wooden members are glued into a package of a rectangular 320 x 1600 mm cross-section. Separate boards along their length are connected by means of a tooth joint. Hinged connection of the arch is performed with the help of metal support members placed at the end of semi-arches. The thickness of the glued member assumed in the design ensures high degree of fire resistance and sufficient stability in plane without additional vertical bracing. Glued wood is also widely used in finishing side façades. Sashes for huge windows are done of glued wood pylons up to 16m high and provide for architectural expressiveness of the construction and appropriate shade. The structures are fabricated at a shop in Arkhangelsk.

The roof of the skating-rink in the town of Kalinin (Fig.2) is designed according to another architectural and structural scheme. The hall of rectangular shape with 2000 seats stands is intended for the same purposes as in Arkhangelsk. The 30 x 60 m ice field is designed for ice hockey and figure skating. The 57 m span hall is covered with frames of composite section spaced at 6 m which are as-

sembled from 2 rectilinear and 1 curvilinear members. The members are hinged to one another and rest on reinforced concrete supports of different height. The cantilever member is laid on an inclined reinforced concrete support and is fastened by a metal diagonal. Bent and glued part of the frame is fastened to the load-bearing framework of the adjoining room by means of a metal tie beam. Edge members being mounted and fastened, a 30 m long middle rafter is mounted. The slope of the rafter is 1:8. The thrust is transmitted on to the inclined reinforced concrete cantilever support on the one hand and on to the inter-storey flooring on the other hand.



Figure 2. Covered skating-rink in the town of Kalinin, designed by arch. Yu.Schvartsbeim, Ya.Kalinin, eng.M.Zapol, E.Peskov, V.Travush.
The outline of the curvilinear frame was chosen so that approximately the same maximum design bending moments in all glued members might be obtained. The frame members are assembled from two squared beams of 200 x 1650 mm section bolted to each other. The curvilinear member is glued from boards, 19mm thick, the others are 35 mm thick. The roof stability is secured by a system of braces, longitudinal beams and roof panels. Out of the two design projects considered the one with a frame roof requires much more wood than that with an arched roof.

However in the latter case the hall volume and cost of vertical envelope of end walls decrease. The structures are fabricated at a shop in the town of Nelidov, the Kalinin region.

For both structures discussed here the same roof panel was assumed. The requirements for roof panels of public buildings are rather specific as they should provide for high architectural and acoustic properties, fire safety and longer durability. The panel is solved in the form of a spatial block, 6,0 x 1.5 m in plan, consisting of a load-bearing wooden framework, inner planking and thermal infilling. X/The load-bearing frame may be fabricated from glued ribs or whole wood. In the transverse direction ribs are tied by elements that don't go to the bottom of the panel by the height of thermal in-filling. In the upper zone to ensure ventilation a through air passage in the vertical direction is forseen. Air passage protects wood from moistening, secures the structure and increases its X/Author's certificate No.594270

service life. In the longitudinal direction air passage is blocked by end ribs which hinder smoke and flame propagation in case of fire. The cross-section of the passage is assumed as 1/700 of the roof area. On the side of the hall the panel is supplied with asbestos-cement-perlite sheets or wooden rods which protect the wood against inflammation during fire and retain its load-bearing capacity by more than 45 minutes. Between the thermal in-filling and perlite sheets metal sheets of a 0.8 x 25 mm section are fixed that keep the in-filling when perlite sheets fail at fire. Perforated sheets jointly with plates of thermal in-filling ensure the required sound absorption.

In both structures massive glued wooden members are fabricated from coniferous wood using FR-12 resorcin adhesive. Humidity of wood was 10±2 per cent. The outside surface of wood is protected by colourless water proof lacquer.

To secure fire safety of structures the following is envisaged: - wood of the framework panel is treated with antipyrens by the method of deep soaking; - thermal in-filling contains adhesive materials up to 6 per cent of weight; - in the longitudinal direction the panels are provided with diaphragms hindering propagation of smoke and flame if at fire.

The use of glued wooden structures in these halls resulted in substantial material savings as compared to similar structures designed from metal and reinforced concrete.

786

Prefabricated girder box units under unequal loads

Helmuth-Zdenko Wantur Dr.Sc.techn. Bauhütte der Pfalz

The development of prefabricated spatial building elements, like girder box units, arises from the original idea of design for industrially finished constructions under unequal loads. The structure of spatial elements is influenced by special theoretical problems. The distribution of stresses and strains over the plane part of the box unit with girder stiffnes can be approximated by the classical plate theory with elastic boundaries and the parabolic connection between stresses and strains in all cross sections of the girder cross area.

As well as known, is the maximum of bending stress distribution over the girder in the reach [1]

$$2 \int_{0}^{2} = \frac{\int a \ b}{\delta_{i} \ G_{max}} = \frac{2}{G_{max}} \int_{0}^{3} \ \delta \ dx$$
with
$$2 \int_{0}^{2} | > 2 \int_{0}^{3} | > a_{0}$$
when the whole plate is
under bending deflection
$$2 \int_{0}^{3} | > 2 \int_{0}^{3} | < a_{0}$$
when only the local ben-
ding deflection take place
$$a, b$$
are the box unit dimensions
$$a_{0}$$
is the distance between two girder

 δ_1 2 δ_0 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_1 δ_2 δ_2 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_1 δ_2 δ_3 δ_3 δ_1 δ_2 δ_3 δ_3 δ_1 δ_2 δ_3 δ_3

stiffnesses

The conditions of equilibrium for the rotation over the X axis is:[2]

$$\begin{pmatrix} m_y + \frac{\partial m_y}{\partial y} \end{pmatrix} dx - m_x dx - \int q_y dx dy = 0$$

For the equations of equilibrium and for the rotation over the both axis x and y with the translation along the axis z is:

$$m_x " + m_y " = \iint p_i(z) dx dy$$

with
 $E c_i^3$

$$m_y = \frac{E S_i^3}{12} v'' = N v''$$

12

With substitution in the first equation is:

$$N (w'')'' + N (v'')'' = \iint p_i(z) dx dy$$

$$q_x m_x$$

$$q_x m_x$$

$$p_i d_x d_y$$

$$y(v)$$

$$q_y$$

$$d_x$$

$$y(v)$$

The conditions of limits over the boundaries of the element are given by:

The finaly solution for the equations of the bending moments is given as:

$$m_{x} = N w'' + \Psi(y) \frac{E \Im_{x}}{d_{x}} w''$$
$$m_{y} = N v'' + \Psi(x) \frac{E \Im_{y}}{d_{y}} v''$$

 Ψ (y) and Ψ (x) are simultane functions with the similar development form like the girder box unit: in the field with zero value and in the reach of girder with the value one:



The definitive equation results by the summarise of $\mathbf{m_x}$ and $\mathbf{m_v}$

$$N(w'')'' \rightarrow N(v'')'' \rightarrow \Psi(y) \frac{EJ_x}{d_x} (w'')'' \rightarrow \Psi(x) \frac{EJ_y}{d_y} (v'')''$$

For the girder along x-axis is:

 $\Psi(y) = 0 \quad N(w'')'' \cdot N(v'')'' \cdot \Psi(x) \frac{E J_y}{d_y} (v'')'' = P_{ix}(z)$

For the girder along y-axis is:

$$\Psi(x) = 0 \quad N(w'')' + N(v'')'' + \Psi(y) - \frac{E \Im_x}{d_x} (w'')'' = P_{iy(z)}$$

Over the transformations

$$u = -zw' = -z \, \mathcal{C} \left(\sin \frac{\mathcal{K} \, \mathbf{v}}{a \, \mathbf{y}} \right)$$
$$u = -zv' = -z \, \mathcal{C} \left(\sin \frac{\mathcal{K} \, \mathbf{x}}{a \, \mathbf{x}} \right)$$

is possible to determinate the stress distributions in each point of the girder network in one level of the box unit, also for some different variations of unequal loads $P_{i_1}(z)$

$$\mathcal{O}_{x} = - \operatorname{Ez} \varphi'(\sin \frac{\mathfrak{X}_{y}}{a_{y}})$$

 $\mathcal{O}_{y} = - \operatorname{Ez} \varphi'(\sin \frac{\mathfrak{X}_{x}}{a_{x}})$

In the special case of the opening in one square girder network, the point of the girder cross can be shown als the area of the inside sharp angle as an imaginary "short plate" with a great axial curvature.

The stress distributions becomes after the transformation in the plane projection [3]:

$$G_{x} = -\frac{m_{x}}{a_{0} \cdot \delta \cdot \varepsilon} \left(\frac{\delta}{r_{0}}\right) \left[\left[1 - \left(\frac{\delta}{z r_{0}}\right)^{2} \right]^{2} - \left[1 + \left(\frac{\delta^{2}}{2 r_{0}}\right)^{2} \right] \right]$$

$$\left[1 + \frac{1}{3} \left(\frac{\delta}{2 r_{0}}\right)^{2} \right]$$

$$G_{y} = \pm \frac{m_{y}}{a_{0} \cdot \delta^{2}} \left[1 + \frac{2}{3} \left(\frac{d}{2 r_{0}}\right) + \frac{2}{5} \left(\frac{d}{2 r_{0}}\right)^{2} \right]$$

with:

 a_0, δ = dimensions of the imaginary "short plate"

r_o = radius of axial curvature

% = coefficient of dimensional relation

References:

- [1] D.L. Dean, C.O. Varan: Analysis of ribbed plates: Journal ASCE, March 1969
- [2] H.Z. Wantur: Teoretske postavke rjesenja "ostrog ugla"; Jugoslovenski Gradevinski Centar, Beograd 1973
- [3] H.Z. Wantur: Stress analysis of prefabricated bearing elements; IASS Congress Report, Montreal 1976

Summary

The development of prefabricated spatial building elements, like girder box units, arises from the original idea of design for industrially finished constructions under unequal loads. The structure of these spatial elements is influenced by special theoretical problems. The present paper gives the analytical solution for the distribution of stresses and strains over the plane part of the box unit with girder stiffnes approximated by the classical plate theory with elastic boundaries.

Sommaire

Dans le travail présenté, les résultats des recherches sur le nouveau dévelopment des charpentes et la construction des caisses à construction stabilisées par des fers.

L'analyse théorique au moyen des connaissances de base sur l'utilisation des nouveaux matériaux de construction a montré que, pour la sécurité des charpentes, la conception de la portance et la stabilité sont déterminantes.

= P_i(z)



•

Building research institutions in developing countries, a case study.

Institutions de recherche du bâtiment dans les pays en voie de développement; un exemple.

.

BUILDING RESEARCH INSTI-TUTIONS IN DEVELOPING COUNTRIES BRU – AN EXAMPLE

A. L. MTUI, Director Building Research Unit, Dar Es Salaam – Tanzania.

Summary

The aim of this paper is to highlight an example of a Building Reasearch Institute in a developing country. The particular reference is the Building Research Unit at Dar es Salaam Tanzania (BRU).

It starts with the background of visualizing a research institute in Tanzania in 1969, sighting different government plans and actions. The difinition of the terms of reference including set up, organization, and research philosophy are also clearly presented.

Research objectives for BRU have been those difined in the National goals and priorities. They have always been down to earth and geared to solving different everyday problems in housing. Its results have to be put into practical use by the intended users. Different methods used to disseminate research findings are described.

Present and possible future problems for the BRU are highlighted. It is likely that similar problems may exist in other building research institutions in the developing countries although BRU is still a young institution.

The need to establish building research institutions in developing countries is of a high priority. These may take the form of country, region or subregion co-operation depending on financial and economic capacities. Research results from industrialized countries have been of some benefit to developing countries, but they cannot replace the need for research within the developing countries. Furthermore due to the great variations in different countries imported solutions must be adopted to local conditions.

Résumé

Le but de ce document est de montrer un exemple d'un institut de recherche du bâtiment dans un pays en voie de développement. Il s'agit en particulier de l'Unité de Recherche du Bâtiment à Dar es Salaam en Tanzanie (BRU).

Il commence par montrer un institut de recherche en Tanzanie en 1969, d'après différents projets et actions du gouvernement. La définition des termes de référence comprenant la mise en route, l'organisation et la philosophie de recherche est aussi clairement présentée.

Les objectifs de recherche de BRU ont été définis dans le plan national des buts et priorités. Ils ont toujours été réalistes et tournés vers la solution des différents problèmes quotidiens de l'habitation. Les résultats doivent être mis en pratique par les utilisateurs auxquels ils sont destinés. On décrit également les différentes méthodes de propagation des résultats des recherches.

On attire particulièrement l'attention sur des problèmes présents et peut être futurs pour le BRU. Il est probable que des problèmes similaires existent dans d'autres instituts de 2recherche du bâtiment dans les pays en voie de développement, bien que BRU soit une institution encore jeune.

La nécessité d'établir des institutions de recherche du bâtiment dans les pays en voie de développement doit être considérée comme prioritaire. Elles peuvent être basées sur une coopération nationale, régionale ou sous-régionale, dépendant des ressources financières et économiques. Les résultats de la recherche menée dans les pays industrialisés ont été d'une certaine utilité pour les pays en voie de développement, mais ils ne peuvent pas remplacer le besoin de recherche dans ces pays. En outre, en raison des grandes variations existant d'un pays à l'autre, des solutions importées doivent être adaptées aux conditions locales.

1.0 Background

Immediately after independence in 1961 Tanzania found itself in a situation of an acute housing shortage. Like most developing countries the shortage was first felt in the urban areas where for the first time the familar pattern of rural - urban migration was experienced at a large scale. People migrated presumably in pursuit of employment and a better life assumed to be found in the urban areas. In this situation an ever increasing need for new housing was created. In rural areas much of the then available housing units were ill constructed, unsafe and temporary. Faced with this situation the government first acted on the pressing need to increase urban housing units in Dar es Salaam by creating self help building schemes and later on in 1962 a National Housing Corporation was established. From then on the need for both better and more housing increased as more and more urban areas became attractive to job seekers.

In the Second Five Year Plan the Tanzania Government defined housing as a basic need and that every person was entiled to a decent dwelling. It was then necessary that the housing problem in the country had to be analysed in the context of the actual state of its condition and the desired state as expressed by the national housing objectives. Once this was done one realised the general objectives provided insufficient basis for which to assign resources for the improvement of housing, and morever such objectives could hardly be used as a measure of performance. For this reason specific bodies had to be established to deal with specific problems in order to implement the housing objectives as outlined in the plan. One of the greatest problems was the high cost of house construction.

2.0 The establishment of the Building Research Unit

Research in housing and building materials was envisaged and recommended in order to carry out research in local resources in an effort to reduce the cost of construction in the country. It was recommended that such research should aim at the development of efficient building materials and a construction industry based on locally available building materials. Research was also intended to improve the use of traditional materials and layouts of buildings that will offer a more hygienic standard and greater durability, thus making possible to build good houses at the lowest possible cost.

In 1969 preliminary discussions were held between representatives of the Ministry of Lands, Housing and Urban Development and those ministries and parastatals mostly concerned with building works and it was agreed that a «Natioal Housing and Building Research Unit» be formed within the Ministry of Lands, Housing and Urban Development. In the same year this proposal was submitted to the government of the Kingdom of Norway as a project for possible assistance. The Director of the Norwegian Building Research Institute Mr. Ø. Birkeland was sent to Tanzania to investigate the feasibility of such a project. Mr. Birkeland's report supported the idea of establishing the Research Unit in Dar es Salaam and the Government of the Kingdom of Norway concured with his recommendation and agreed to finance the project. In 1971 the National Housing and Building Research Unit was started by a group of three Norwegians, two architects and one engineer, and a few Tanzanian members of staff.

3.0 BRU's set up

The Building Research Unit is set up as a special division in the Ministry of Lands, Housing and Urban Development. It is headed by a director and organized into five sections. At present there are 72 staff member with different qualifications. (See appendix 1 – Organization chart).

3.1 Technical Section

This section deals with the development and testing of materials and structures particularly those based on local materials and traditional technology. It also deals with scientific annotation of relevant research topics such as local wood based materials, stablized soils, concrete, organic materials, agricultural wastes, binders (lime, cement, gypsum etc.) and any topics of interest in the field of building materials industry in their production, use, maintenance, and protection. Building codes and regulations are also handled by a special branch of this section.

3.2 Building Economy Section

This section consists of economists and engineers. The economists deal with building economy in general, such as the building cost index, statistical analysis of the construction industry and related economic development of the country. The engineers deal with building technology on the site and research in such fields as site management and the rational use of equipment.

3.3 Human Requirement Section

The development of design criteria for low cost housing is the main task of this section. This includes the design of house types in accordance with settlement patterns, climatic conditions, family structure and family backgrounds. This section also collaborates with the National Bureau of Statistics in the analysis of housing data resulting from census and household budget surveys.

3.4 Information Section

This section is responsible for the preparation and distribution of research publications. They also follow up institutions which receive our publications and those who use the research results in order to obtain the necessary feedback for our researchers. They also conduct building seminars and maintain the library.

3.5 Administrative Section

This section consists mainly of administrators and the necessary support staff to serve the unit as a whole.

3.6 Terms of Reference

The National Housing and Building Research Unit operates under the following terms of reference: -

- To identify and clarify the countries' problems in housing and building.
- As far as possible to find ways of solving these problems.
- To co-ordinate efforts in research and facilitate an appropriate distribution of tasks regarding economic utilization of manpower, equipment and other resources from existing research bodies and institutions.
- To ensure that the results of local and foreign research are disseminated within Tanzania.
- To collaborate with government, parastatals and others in the purpose of getting practical utilizations of research results.
- To undertake research for government and other bodies in the construction sector and to give statements on research matters.

4.0 Research objectives

The general way of initiating research is to take up actual problems from the society according to the defined national goals and the priorities set up in the countries development plan. This way people's needs are emphasized and the research for technical solutions and improvements is guided by the aspirations of the people and society. For this reason research in the unit was initiated with a strong emphasis on housing problems in rural areas, permanent village housing and housing problems for low income groups. For practical reasons research topics are grouped according to their main characteristics and methods needed for analysing them, to ensure the maximum use of the limited funds and trained personnel (for list of research topics see Appendix II).

Initially the Research Unit started by identifying the properties of local building products, a knowledge that was necessary for the planning and construction of buildings. Laboratory testing is conducted through-out in order to learn the properties of such building materials together with methods of improving or projecting them. Elements of buildings are constructed and tested such as in floor, wall and roof components of different local materials. Stabilized soil, natural stone, bricks, pozzolime, clay etc. have been researched as low cost building materials for different parts of house construction.

The Research Unit has also began a compilation of building costs indices and is now in the course of preparing a cost index for the whole country. Building site management has been studied in the field of efficiency, procurement, time, labour, storage etc. Many housing co-operatives thoughout the country have benefited from this study. Simple site prefabrication and block making, on site training and simple fool-proof technologies have been demonstrated to various construction teams.

Research in human requirement is conducted in the context of improving the existing standard of living. This is so because the quality of life has a strong relation to housing and its surroundings. Sudden and big changes in housing conditions may have a negative effect on the social life and vice versa. In order to have people motivated for improvement and changes the Building Research Unit has undertaken the task of developing new solutions on the basis of traditional housing. This means studying problems of household activities, social life, housekeeping, cooking, food storage etc. This will result into homogenizing building design with traditions, social life, existing building materials and economic conditions in the country.

The Building Research Unit started off by studying traditional housing throughout the country. Such details as shape of houses, materials used, solutions for architectural details, use of space and facilities were thoroughly researched into as a basis for further improvement. Representative housing surveys in rural areas were conducted in order to provide information on consumer preferences in the quality of housing, and ability and willingness to pay for housing. At this stage the unit was able to produce the first recommendations for rural house designs including literature on the utilization of local building materials, construction methods and skills.

5.0 Dissemination of research results

As mentioned earlier research findings from the unit have to be of immediate use, a policy advocating the delivery of the research findings to the users. Faced with an expansive, highly rural country with minimal infrastructure and a low rate of literacy the Research Unit had to look around carefully in order to find effective techniques of disseminating its research findings. So far five ways of fulfilling this aim have been practiced and proved effective.

5.1 Building of demonstration houses

In Tanzania the great majority of the population live in the rural areas where the housing problem consists mainly of substandard housing which also lacks adequate community facilities. These houses are built mostly by peasants who lack the knowledge of modern construction techniques. There are plenty of traditional building materials available such as clay, wood, stone, straw, mud etc. The role of the Research Unit has been to demonstrate the techniques of improving the quality of the available building materials, introducing production planning and raising the standard of workmanship. In such projects, research technicians work side by side with the would-be dwelling builders so that they leave the technology behind. Such a method although highly time-consuming and expensive has proved to be very successful. Ten (10) such houses have been erected in different parts of the country to demonstrate the use of improved locally available building materials. These houses are built of mud blocks with plaster, soil cement, burnt brick, pozzolime blocks, sisal reinforced cement roofing sheets etc. to demonstrate that although cheap, these materials can be used in the construction of permanent houses. Backed with this experience, the Research Unit was able to publish a small booklet on Building Regulations for One Story Houses on Surveyed plots. This is the first attempt towards the development of local codes and building regulations to replace the inherited ones which are imported and highly irrelevant.

The development of self-help building techniques that can be used by the rural population with a minimum of guidance has been another great preoccupation.

5.2 Data sheets

The use of data sheets is an effective method for the dissemination of research results. This method was used right from the beginning of the Unit. The main receipients so far have been government departments and insitutions, schools, colleges and the University. The objective has been to supply these institutions with new data sheets once they are published. It is envisaged that in the near future, rural construction units would be formed in every district of the country. It is necessary therefore, that the Unit co-operates with these rural construction units, so that it may provide them with the necessary technical advice. The use of data sheets will be one way of fulfilling this objective.

5.3 Seminars on better housing

Sometimes a considerable amount of labour is available from people who are willing to construct their houses if given just a fair amount of knowledge in building. In such cases the Research Unit organizes seminars on better methods of materials production, utilization, construction, upgrading etc. In such seminars it is also intended to introduce to the people some of the relevant research findings that can be applied at their locality. So far, seminars have been conducted at various levels in the country, but the main target has been in the rural areas. In such seminars participants are also supplied with publications and data sheets from the Research Unit.

5.4 Booklets

Publication of booklets in simple and straightforward language is another way of disseminating research results. Today more and more people are asking for these booklets on such subjects as Climate and Design in Tanzania, Rural Low-cost Houses, Rural Housing in Tanzania etc. Efforts are being made to produce more booklets in the future where more drawings and diagrams will be included such as Small Expandable Houses, Urban Low-cost Houses etc.

5.5 Local newspapers

Another way of publicity has been through the local newspapers. The Research Unit in collaboration with the local paper has been awarded space for publication of research findings wherever they are available. This is also an effective way of disseminating results. As it has been observed more response and telephone calls are received after an article in the daily paper than from any other form of publicity.

6.0 Problems of building research in Tanzania

Like in most developing countries building research in Tanzania has been confronted with common problems resulting from the economic and social situation of the country. The Building Research Unit however, has been given all the necessary moral and material support by government and parastatal institutions. The population has always been very responsive to the research findings. The main problem for the Research Unit is to be able to reach them either by demonstration houses, seminars, publications, radio etc. There is a need to strengthen the Information Section in order to be able to get out the necessary information to building clients. At the international level the Unit receives all the necessary support from many CIB member institutions.

As far as manpower is concerned, there is a critical shortage of trained research specialists required to put up the necessary work to meet the demand for improved housing in the country. This problem is nation wide and has no short-cut solution. The Unit has developed a training programme for its staff to meet this shortage of manpower and meanwhile expatriates are recruited to fill the gaps.

A foreseeable problem is one of shifting of manpower due to insufficiently attractive salaries for research staff. As the Unit exists as a government department the salaries for researchers are in the civil scheme. At present, these salaries are slightly lower than those in the parastatal organisations a tendency that may create a drift from research to the construction industry or to other organizations where specialists are offered a better pay.

Financing for the Unit is divided into two categories i.e. local and foreign. Every year the Unit receives a sufficient budget of local funds for salaries and day-to-day running of the department. If however the present short supply of foreign exchange persits after the fairly new technical equipment and laboratory facilities are worn out, then the problem of providing the necessary replacement will arise since most of it will have to be imported. A similar situation will be encountered should expansion of technical facilities be envisaged. The problem of lack of foreign exchange however affects all sectors of the national economy irrespectively. Other problems related to the lack of foreign exchange for the Unit are the inability to purchase up to date literature and publications in building research together with the limited personal contact of researchers from other institutions either in the Eastern African Region or internationally.

7.0 Conclusions

The practical application of the results of research should be the ultimate goal for building research in the developing countries. Research institutions should also be aware of the need to ensure maximum use of the limited resources of funds, personnel and foreign exchange at their disposal. Costs can be reduced through mutual collaboration where research institutes in developing countries coordinate research programmes at national and regional levels, in order to avoid overlapping and duplication of work and to reach a more effective application of research results. Furthermore research institutions in developing countries must find a systematic way of disseminating their results in a way that they will reach those who need them or those for whom they are intended. In this way there is a need for the reasearch institutions to be in direct contact with the users. Tendencies of isolating the researchers from users should be avoided since the effectiveness of research results in developing countries must be communicated through training, demonstration and direct assistance to builders.

The construction industry in most developing countries varies in many respects. This is true even for countries which are close geographically, even if they share the same economic systems. It is necessary therefore, that each developing country should establish its own building research institution to enable it to deal with its down-toearth problems for its housing needs by using available natural resources. Efforts must be made to ensure that these research institutions do not slacken after taking off. Despite limited resources building research in Tanzania is very active. It has an overwhelming popular support particulary in the field of technical research such as the properties and durability of local building materials, general design and construction problems of low-cost and rural housing.

Lastly there has been a tendency for research institutes in the industrialized countries to specialize in housing problems of developing countries. These institutions conduct research on such topies as durability of building materials, thermal comfort in tropical climates, low-cost houses etc. in order to provide assistance to developing countries.

Although this kind of collaboration is welcome, it cannot replace the need for carrying out research in the developing countries themselves. The great variety of factors influencing the local construction industry, such as climate, technology and available resources, cannot always be successfully simulated in European or North American laboratories. There is and always will be a need for adoptation of foreign research results to local conditions.



Appendix II

Some recent BRU publications

- BRU D.2.1 Stabilized soil floors
- BRU E.3.1 Solid soil walls
- BRU E.4.1 Stabilized soil block walls
- BRU E.6.1 Burnt clay brick walls
- BRU F.7.1 Wooden roofing materials
- BRU C.2.1 Stone foundations
- BRU C.1.1 Site planning and preparation
- WR No. 17 Pozzolanas and pozzolime
- WR No. 16 Surface treatments for mud walls
- WR No. 15 Building cost indices
- WR No. 14 Sisal reinforced concrete roofing sheets.

Some ongoing projects

- R 0.03 Tanzanian building standards and codes
- R12.01 Gypsum products for low-cost housing
- R14.02 Burning bricks with coal at village level
- R19.01 Use of cashewnut waste as building
- materials
- R19.02 Use of coffee husks as a building material
- R25.03 Light weight concrete tiles
- R46.00 Building equipment and tools
- R60.11 Climate and design in Tanzania
- R60.13 Compost latrines
- R76.01 How to build a better house A book.

References:

- 1. This is BRU. Building Research Unit September 1978.
- Report on the establishment of NATIONAL HOU-SING AND BUILDING RESEARCH UNIT. Ministry of Lands, Housing and Urban Development. Dar es Salaam 1971. Pp. 1-7.
- Human settlements in Africa. The role of housing and building. United Nations ECA. Addis Ababa April 1976.Pp. 19-22 and Pp. 51-75.
- CIB The problems of building and building research in developing countries, with particular reference to low-cost housing. Edinburgh 14–21 Sept. 1977. C sorba E (Hungary). Grad Judith Objectives of Research in developing countries. H–Pp. 27–41.

BUILDING RESEARCH IN DEVELOPING COUNTRIES

Prof. Gyula Sebestyén, Doctor of Techn. Sci. Director of the Hungarian Institute for Building Science ÉTI, Budapest, Hungary

Summary

Economic, political and social conditions greatly affect the construction industry and building research. In some of the developing countries sufficient attention is given to building research, in several countries building research still is practically non-existent. In some cases building research can be organized on a regional (subregional) basis.

Building research in developing countries should focus its attention on the exploration of use of local materials, industrial and agricultural wastes; the study of local climate, economic and social conditions affecting construction: active participation in technology transfer and the study of knowledge accumulated in building research in developed contries in order to find eventual adaptations to conditions prevailing in the developing countries.

Résumé

Les conditions économiques, politicales et sociales exercent une grande influence sur l'indutrie de bâtiment et la recherche de bâtiment. Dans quelques pays en voie de développement une attention suffisante est accordée à la recherche de bâtiment, dans les autres la recherche de bâtiment pratiquement n'existe pas. Dans quelques cas la recherche de bâtiment peut être organisée au niveau régional (sous-régional).

La recherche de bâtiment dans les pays en voie de développement doit apporter toute attention à l'utilisation des matériaux locaux, des déchets industriels et agricoles; à l'étude du climat local, des conditions économiques et sociales influençant la construction, à une participation active au transfert technologique et à l'étude des informations accumulées par la recherche de bâtiment des pays développés ayant pour but de les adapter aux conditions locales des pays en voie de développement.

1. Economic conditions and other factors affecting building research

Earlier, developing countries constituted a relatively homogeneous group, members of which were all characterized by being economically backward.

The absolute and relative economic situation of individual countries or of certain groups of countries has changed to the better or worse slightly or drastically during the past ten years.

Some groups of developing countries can be characterized by certain common features.

a. The «rich» developing countries

Kuwait is a typical example which has the highest GDP/ person in the world (second perhaps only to Switzerland), well above 10 thousand US \$. Several other OPEC countries with a small population and a high oil production can be assigned to this group (Saudi-Arabia etc.).

b. The newly industrializing countries

Some countries in Eastern Asia (South Korea, Singapore, Hong Kong etc.) and elsewhere belong to this group where economic progress has been quick and substantial.

c. The group including the majority of developing countries

These have achieved different rates of economic progress (Latin-America etc.).

d. The least developed countries

These are the countries most affected by drought (e.g. the Sahel countries) and the steep increase of oil prices. They are mostly landlocked countries. The growing deficit in the balance of payments bites off all financial means otherwise badly needed for capital investment and therefore these countries are as poor or even poorer than they used to be.

e. Countries with economic conditions adversely affected by different factors

A special situation is created by political lability, inefficient government, internal turmoil or armed conflict which can – at least temporarily – completely paralyze economic development (e.g. earlier in Uganda etc.).

f. The biggest countries

Big countries can hardly be placed in any of the above categories (e.g. China and India); they have to be analyzed separately. Such big countries – even in the case of a low GNP per person – can concentrate sufficient means for certain objectives (e.g. building research), whereas in smaller countries this may not be economically feasible. 1978 figures show that there are 53 countries with a GNP/ person above US \$ 1200. These countries account for 35 per cent of world population, their economic output, however, exceeds 90 per cent of the world's total. This implies that countries with a total population of 65 per cent of world population account only for 10 per cent of the world's economic output. Several «developing» countries can be found in the «rich» group:

Kuwait	_	US	£	13 853
Saudi-Arabia	_	US	\$	9 330
Lybia	_	US	\$	6 680
Singapore	_	US	\$	3 285
Trinidad + Tobago	_	US	\$	3 090
Venezuela	_	US	\$	3 000
Puerto-Rico	_	US	\$	2 663
Hong Kong	_	US	\$	2 000

On the other hand (1976) GNP/person figures of other developing countries (the majority of countries in the third world) are more or less below the above figures: in several countries (Bangladesh, Laos, Mali, Nepal etc. under \$ 200/person.).

GNP/person figures fundamentally affect the financial and other means to be allocated for certain goals (e.g. for building research), there are, however, other factors, too. The size of the population has already been mentioned. Very small countries cannot afford to create and maintain a building research institute.

The size of the territory of the country, the existence (or nonexistence) of an adequate transport network (roads, railways) and the density of population are also factors to be reckoned with.

If the country is sparsely populated, transport over big distances is difficult and costly, anything organized centrally (building research, manufacturing of building materials etc.) is of a reduced or even negative economic efficiency, whereas traditional, local techniques remain justified. Mobile production units, which can be easily transferred after having saturated the needs of the local market, might be in some cases a useful solution [1].

The negative influence of armed conflicts, internal turmoils, political lability etc. have already been mentioned.

2. Construction in developing countries

The highly different economic situation in the various developing countries affects the pattern of the construction industry.

The main sectors of the construction industry in developing countries are [2]:

- the traditional (mostly or partly non-monetary),
- the national-conventional,
- the national-modern,
- the international-modern.

The increased income of some (oil producing) countries has created a great demand for construction in these countries. Owing to the huge construction programmes, the insufficient domestic construction industry and the limited internal labour resources, these countries have become net importers of construction. Foreign workers and foreign contractors are invited to these countries to carry out construction tasks.

At the same time most developed countries experienced a slump of domestic demand for construction. For many big construction firms it has become a matter of survival to extend their activities to countries with a building boom [3].

Some newly industrializing countries, on the other hand, have a relatively abundant labour supply and sufficient engineering know-how to enter into rivalry with developed countries' contractors. These countries (Soouth Korea, India, Yugoslavia) have made successful efforts to win construction contracts abroad, e.g. in the Arab states [4].

This resulted in increased foreign trade in the design and construction of buildings, civil engineering works and building materials. Several factors contributed to a strengthening of the domestic construction industry even in those countries which import construction capacities. Partnership agreements too have contributed to the development of the construction industry.

In the poorest countries the financial means and the favourable overall economic-social background to develop construction are not yet available.

A country by country review of construction reveals differing conditions. However, for the sake of further analysis we shall assume improving conditions in all aspects: political, military, social, economic. Through such an assumption is obviously overoptimistic it supplies us with the basic ingredients for a policy in the field of building research. Such a policy can be put into practice if conditions really improve and has to be scrapped if conditions become (or stay) unfavourable.

3. Building research

Earlier, the construction and the building materials industry were not considered an economic sector to be developed on a high priority basis. For some years past this situation has been reversed and it is now generally accepted that their development is of primordial importance for developing countries.

For a very long period building has been an activity based on trial and error, practical success and failure contributing to man's knowledge about building.

In the last century, and especially in the past decades, construction relied more and more on scientific research, on mechanical and civil engineering know-how. Building research institutes have been founded first in developed and later in developing countries. These institutes become more and more active participants in the development of the construction industry. They do not have to concentrate exclusively on basic research, on the contrary, their main task in most countries is to follow the track of research and development in other countries and to adapt results to conditions prevailing in their own country.

In the majority of developing countries building research has not developed at a desirable rate:

- in «rich» developing countries because they «import» much of the construction activity,
- in newly industrializing countries because they concentrate on «exporting» a substantial proportion of their construction activity,
- in the poorest and/or smallest countries because of a low level of construction activity and a lack of financial means for building research,
- in several countries because of lack of political, social, economic stability.

To a certain extent this unfavourable situation can be explained by the factors enumerated above. It should be a natural objective in developing countries to create favourable conditions for economic development and construction activity, hence for building research, too. For very small countries it would not be justified to establish building research on a national basis even under the most favourable conditions; in such countries regional (subregional) cooperation should be aimed at. UN ECA is sponsoring such cooperation for building research in Africa (CEPGL and ENTENTE countries). In some big countries (India, China etc.) and in some other countries building research has received the necessary attention and support.

Therefore

- building research should receive sufficient financial means from goverment and industry in other countries too, where building research can be organized on a national basis,
- in small or less developed countries joint (subregional etc.) building research institutes should be established.
 Such plans exist for the African region (CEPGL and ENTENTE countries).

Building research should not be organized necessarily in independent building research institutes. An institute for all branches of technological research with a section for building, could also represent a good solution. It may be a good start to entrust building research tasks first to university faculties.

4. The specific tasks of research in developing countries In developing countries building research efforts are concentrated mainly on certain subjects:

- the properties and use of local materials, including agricultural and industrial wastes,
- the characteristics of local climate (wind, rain, sun radiation, temperature etc.) and soils affecting the design and construction of buildings,
- the study of local economic and social conditions and building traditions affecting the design and construction of buildings.

I should like to add to this list two further areas that are often overlooked, ignored or at least disputed:

- the study of advanced technologies in order to advise decision-makers and to participate actively in technology transfer,
- the study of eventually locally different applications of research and knowledge usually considered to be «universal».

4.1. The use of local materials, agricultural and industrial wastes

Some developing countries have natural resources (raw materials) not used up to now for manufacturing building materials and components but which could be used for that purpose (clays, stones etc.). Research (exploration of resources and quality control) is needed to make good use of such raw materials e.g. for the production of cement, lime, gypsum, aggregates, lightweight aggregates (pumice, perlite, vermuculite, etc.), glass, bricks etc.

The efficient use of these raw materials is often facilitated by using small scale «appropriate» technologies (see later).

Efforts to use agricultural and industrial wastes led to various technologies. However, it is still a major task for building research to increase the use of these materials (slags, fly ash, paddy and groundnut husk, bagasse, grass, cassava stalks, saw dust etc.). 4.2. The study of climatic and other factors affecting buildings

Climatic factors prevailing in developing countries have to be studied to make an appropriate selection of materials and structural components.

Natural disasters (earthquakes, floods, tsunami, hurricanes, typhoons) still destroy many buildings though part of these could be safe-guarded by adhering to rules set by research.

«Normal» climatic conditions (rain, sunshine etc.) too could be taken into consideration more efficiently.

Certain other factors affecting buildings (termites etc.) can be eliminated successfully, relying on research results.

4.3. The study of building habits

Construction is in certain ways subject to tradition, social and economic conditions. Living, cooking, washing etc. habits are factors influencing ground plan arrangements in housing. On the one hand building traditions should be respected, on the other hand some of them should and could be improved.

There are many construction problems in developing countries (roofs, ventilation etc.) for which no readymade solutions are available. Though many of these problems have already been studied to a satisfactorily high degree we are still witnessing mistakes repeatedly committed in such fields.

4.4. The study of «exact» and «universal» knowledge still affected locally

The following quotation has a validity wider than often believed:

«The underlying principles of any science-based discipline such as engineering are universal, which leads the practitioner to believe that the application of those principles is also universal. An engineer who moves across international boundaries to practice this profession may make this assumption either knowingly or unwittingly» [5].

The principles and methods of structural design seem to be universally valid. However, craks and deflections that would qualify as unacceptable in industrialized countries may be accepted in developing countries and even a lower safety margin would be tolerated for the sake of economy. Hence, it is the task of building research to define acceptable deviations from rules otherwise found to be universally valid.

There is a natural reluctance to create something felt to be inferior but standards can in certain cases be lower «because the savings in reduced costs outweigh the penalties in reduced benifits» [4]. However: «There are occasions in the Third World when standards should be higher than in developed nations because of greater rigor in service conditions» [4].

4.5. «Appropriate» technologies and transfer of up-todate technologies

To achieve the objectives formulated in the 1975 UNIDO Lima Declaration it is absolutely necessary to increase have to be introduced and used. Technical solutions applied in developed countries often lead to inappropriate technologies for developing countries and therefore other technologies have to be invented or existing ones adapted to local conditions. The decisive factors are small scale, small capital investment, the maximum use of domestic (local) resources.

Instead of simply transferring the most up-to-date technologies, «alternative», «intermediate» or «appropriate» technologies have to be selected or worked out in order to achieve optimal economic efficiency [6].

The appropriate technology movement too is based in the wealthiest countries and therefore even this could degenerate into technological paternalism.

Research institutes in developing countries should be able to screen the various technologies and make the appropriate choices. It is their duty to assist the domestic industry in adapting up-to-date technologies too, otherwise it may often occur that these technologies do not function with the same efficiency as in industrialized countries.

5. Summary. Conclusions

The specific tasks set for building research in developing countries cannot be solved exclusively by institutes of industrialized societies. Research has to be organized in the developing countries themselves because these are needed for the development of the construction industry. The diversity itself of the sectors of the construction industry (non-monetary, traditional domestic, up-to-date domestic, international modern) in some developing countries calls for the activities of institutions for building research, quality control and building regulation.

In the manufacturing industries research is organized by the industry itself. In the construction industry this is seldom the case because construction is decentralized and most enterprises lack the sufficient means to maintain research organizations of their own.

Building is an economic sector where the establishment of a state-owned national (or regional) building research institute (or a building research section of a general technological research institute) is justified. Depending on the circumstances prevailing in the country, governments should define the optimum size, staff, equipment and scope of work for such an institute.

Bilateral cooperation with research and development institutes in developed countries and participation in international organizations should be encouraged.

Réferences

- 1. CSORBA, E. Épitöipar, lakásépités kutatás fejlödö országokban. Doctoral Thesis, Budapest, 1979.
- TURIN, D. A. Construction and Development: a Framework for Research and Action, paper for the IBRD London, 1972.
- 3. GAYLOR, R. F. Building in Saudi-Arabia. Building Technology and Management. 6. 1978. pp. 2–8.
- U.S. Contractors Losing Lucrative Middle East Jobs, International Herald Tribune, 11. December, 1979. pp. 19.
- MANSELL, D. S. Constraints on engineering in third world, ASCE Engineering Issues, October 1978, pp. 281–191.
- SEBESTYÉN Gy. Appropriate technology in the construction and building materials industry, UNIDO International Forum on Appropriate Industrial Technology. New Delhi, India, 20–30 November 1978.

Building Research Organizations in Developing Countries_ Turkey Approach

Deniz BAYTİN (M. Arch.) Research Architect – Building Research Institute – Turkey

Summary:

The post war structure of the monodisciplinary and compartmental research model, - which mainly concentrates on technology, of the building research organizations of developed countries are changing since a certain time. The priorities are shifting to social and economic subjects as well.

This post war research model, which is being abondoned by developed countries, due to its unsufficiency against the complex problems of the built environment is stil being used in developing countries. Since building research is not solely a technical subject, it requires a more interdiscipliner and comprehensive approach. Therefore it is important for the building research organizations of developing countries to follow a comprehensive model right from the begining.

Sommai re

"Les Centres de Recherches du Batiment dans les fays eu vore de dévelopment – La conception Turgue."

Dans les fays développes, les centres de rechuches du Batiment, créés four la flupart afer la seconde Gnerre Mondiale, voient changer fogressivement leurs structures mono-disciplinaries, compartimentees et accordant de l'infortance à la technologie, alons gue les sujets sociaux et économiques if gagment du terrain. Pour les fays en voie de developpement cette conception des recherches reste eucore valable bien qu'elle risque d'etre alandonnée pour etre insuffisante face aux problémes multiples de l'environnement constriut.

Mais la recherche en matiere de batiment n'est pas un sujet purement technique, elle demande mue alproche interdisciplinaire plus comprehensive – C'est four-guoi nons estimons utile gue les pays lu vire de developpement adoptent des le depart dans leurs ceutrs de recherches un modele comprehensif.

Introduction

After the second half of the twentieth century, most of the developing countries, which are going through a fast process of progress and industrialization, are faced with new needs and functions created by the rapid population growth and fast urbanization, as well as by the dynamic character of the socio-economic conditions and cultural values. All these facts add very important dimensions to all building activities of the developing countries.

Within this framework, the building problems of developing countries await rational, economical and humanitarian solutions, which would make maksimum use of the resources of the countries, and which would not contradict its interest. In order to attack such solutions, it is essential to make scientific research, oriented towards implementation and users' needs, in order to increase the productivity.

Analysis: State of Art

this group.

In almost all of the countries, building research is done by two main types of organizations:

a) Research organizations that are indirectly related to building industry and building research. These organisations either have their own research staff and other facilities for research or support the researches done elsewhere. Among the research work they achieve, there are subjects related to building, such as materials, standards, etc. "Belgian Centre for the Study of Corrosion," or "The Jutland Technological Institut" of Denmark are examples of

b) Research organisations that are directly related to building industry and building research.

This group of organizations can also be classified under two main headings:

b-a) Building research organisations that are specialised mainly on one subject:

"Cement Research Institute of India", or "Research Centre for Town-planning of France" are examples of this group.

b-b) Building researchorganisations of general character which deal with many aspects of Building and the built environment: "Building Research Establishment" of United Kingdom, "Research Institute for Building and Architecture" of Czechoslovakia, or "Building Research Institute" of Turkey, are examples of this group.

Countries are generally classified into two main groups, acording to their level of development \mathbf{x} :

a) Developed countries

b) Developing countries.

Building research organisations of these countries can also be grouped acording to the similar criteria:

a) Building research organisations of developed countries: Most of the building research organisation of these countries -with few exceptions - are generally established during or right after the second world War. Due to the similarity of the problems they faced after the war, the research model they followed in their first years were quite similar, mainly concentrating on building materials and components, building techniques and organisations. Their staff being mostly monodisciplinar, their field of study being mostly technical and their structures being mostly compartimental, that is separate divisions and departments, such as, Fire, Building techniques, Building materials, Geotechnics, Building climatology, etc.

During the last years, certain changes have taken place in the building research approach and philosophy of developed countries. The introduction of social and economic subjects, and a certain shift of priorities can be observed. In other words, there are alterations in the post-war "old" model of building research.

b) Building research organisations of developing countries: It is appropriate to group the developing countries under two main headings, acording to their degree of development.

Here the referance is not solely to GNP, but also at other factors.

b-a) Countries that are in the lower stage of development process, such as Bangladesh, Ethiopia, or Togo.

b-b) Countries that are in the upper stage of development process, such as, Argentina, Republic of Korea, or Turkey. These countries have a certain amount of research potential, they have a base resources for research, ie, certain amount of technical staff and scientics, and a certain level of acumulation of knowledge.

Therefore these two sub groups should be considered seperately.

As far as it can be traced from the CIB "Directory of Building Research, Information and Development Organisations", generally, the building research organisations in developing countries follow the "old" model from 1940s and 50 s of the developed countries. This influence is mostly due to the aid -in the form of various contributions and alvice - from developed countries, on how to initiate and organise building research in their countries. This compartmental model, contradicts with the structure of developing countries, because they have a shortage of specialized staff. Another basic characteristic of developing countries, is that, although most of them have building research organizations, somehow or another, they mostly lack a central, autonomy building research organizations in and national level.

Synthesis: Evaluation

The main aim of the building research is the accumulation of knowledge, to be used in the formation of the most appropriate built environment for human needs and requirements. Therefore it is evident that the activity field of building research has to vary in a broad spectrum from building materials to user needs and requirements, from physical environment to social environment, from safety to finance. Thus in the broadest sense, all the researches that could be done in order to raise the performance of built environment, should be within the study field of building research organizations. In other words, the complex problems of the built environment should be handled with a multidisciplinar and comprehensive approach.

Research is like a mosaic tablean, which is composed of bits and parts that can only be meaningful and have a value when it is a whole. Similarly, only a multidisciplinar and wholistic building research approach can contribute to the complex problems of built environment.

As a matter of fact, while the building research organisations of most developing countries still follow, and are recommended to follow, the "old" model of 1940s and 50s, most of the building research organizations of developed countries are changing their structures, and have established new divisions and departments, such as, Architecture, Design, Housing, Sociology, Urban affairs, etc.

In most of the developing countries there is a certain level of building research undertaken by various bodies. These studies are done by separate organizations which are directly or indirectly related to building (eg. sub divisions of various ministriesor universities), and these organizations are generally specialised on one specific subject – mostly technical. The subjects are dealt by these organizations with almost no coordination and coperation among them. Therefore, to prevent dublication, repetition, and irrational use of the limited resources, a central building research organization in national level – preferably autonomous – is avitalmust. Because, thus it is possible to unify support, organize, reorganize and provide a systematic communication, cooperation and interaction among the building research in national level. On the other hand, in various developing countries there exists, some central building research organizations similar to this character. But generaly – with some exceptions, – their structures, are influenced and therefore, quite similar to the early building research models of the developed countries.

This research concept generally neglects the technical and social aspect of building research which are equally, or even more as important as technical aspects. A limited model is not sufficient in undertaking the complex problems of the built environment, which arise from socio-economics aspects of the development phenomena. Meanwhile, in some developing countries, multidisciplinar and comprehensive research models can be observed in the building research. The Building Research Institute of Turkey, whose model shall be described below, is such an example, among few others.

State of Art of Building Research in Turkey

Bodies which are directly or indirectly concerned with building research in Turkey, can be grouped in 3 main headings, by the sectors:

a) Academic sector:

The universities inTurkey have a certain potential in the sence of equipment and manpower, especially the ones that are heated in metropols with environmental problems. The research bodies in the universities study in the fields of built environment. One important point to be mentioned here is that universities usually act as an incubation for the building research of the country.

b) Private sector:

Except for a Building Centre there is not much research studies in the private sector. There are very few rantive tests and researches for problems faced during either in production or construction.

Firms with foreign know-how and license, usually solve their problems via foreign experts, other firms, almost never demand a research

c) Public sector:

Building research in the public sector can be classified in two main headings according to their main functions:

ca) Organisations established for other purposes, also having building research sections and departments within their bodies:

Among many others, the main ones are:

- . Ministry of Public Works Research Department laboratories of General Directory of State Highways
- Ministry of Settlement and Reconstruction: Earthquake Research Institute - Materials General Directory -Research Department
- . Ministry of Energy and Natural Resources: Scientific Research Council - Laboratories of State Waterworks Departments - Mining Research and Exploration Institute
- . Other Ministries: Technical Research Department of Minister of Forestry, - General Directory at Land and Settlement of the Ministry of Rural Affairs.
- . Other Organisations: Construction and Engineering Groups and laboratories of Turkish Standards Institute, -Union of Turkish Architects and Engineers' Chamber, -Centre for National Productivity, -State Statistics Institute, - State Planning Department.
- cb) Organisation established directly for research
- Scientific and Technical Research Council of Turkey The Council undertakes its research studies either by:
 i) Research Groups, ii) Research Institutes.
 - i) Research Groups are:
 - Basic Sciences, Engineering, Medicine,
 - Veterinary and Husbandry, Agriculture and Forestry
 - Environment.

- ii) Research Institutes are:
- Marmara Scientific and Industrial Research Institute
- Building Research Institute

In general, it is possible to say that Turkey had a certain level of building research potential, with universities to raise staff for research and with specialized research organizations some of which have well equipped laboratories. The necesity of acentral building research organisation arose in 1960, and a research organisation, - that would utilize the present building potential, and evaluate it in the most appropriate way, according to the socio-economic conditions of the country - was established in 1970.

Building Research Institute of Turkey

Building Research Institute, as mentioned above, is a government research institute, within the Scientific and Technical Research Council of Turkey, and financed by it.

Objective:

Building Research Institute has been founded, to contribute to the solution for building requirement, and to solve the problems in the building field.

In its regulation, the main objective of the institute is stated as, "To formulate, solve and promote the solution of the problems in the fields of building research, and try to provide their realization, taking into consideration the requirements stated in National Development Plans and Programs. In general, its function is to carry out research, in the field of building, in order to contribute to the development of science, to promote solutions on subjects that are stated, in the National Plans, and for these purposes the Institute cooperatieswith universitie and other research bodies of the country. The State Planning Department sees the Institute as a means for bringing the building production to social and economic targets.

In its regulation, the duties of the Institute arestated as,

- a) To carry out research on problems related to environmental and structural systems and to building planning and construction, in reference to the technological, economic and social aspects of building, at material, component, building and settlement scales, to develop products and production methods in the building industry, to ensure an effective adaptation of new technologies to national requirements and resources.
- b) To disseminate the results of the research projects, to see to the implementation of these results and to prepare implementation programmes when necessary.
- c) To advise on technological difficulties encountered in building and construction management methods.
- d) To develop and produce the special tools and equipment required for research.
- e) To collaborate with universities and other research institute during research work.
- f) To educate and train the research and technical personnel of the institute, assist in the education and training of research and technical personnel in other research institutes.
- g) To organize scientific meetings such as seminars, symposia, congresses and conferences in all fields related to the activities of the Institute and to produce publications in these fields.

Organisation:

The Building Research Institute is administered by a director assisted by two deputies, one for scientific and the other for administrative affairs.

The staff is around 60 of which half are research workers, and the rest being support staff. Researchers are of various disciplines, su ch as, civil engineer, architect, urban planer, economist, quantity surveyor, physicist. The structure of research studies, in other words the Research Model of the Institute is given below. (Figure. I) As it can be seen from the diagram, the Research Model shows the interrelation of research aspects, scales, and divisions, with one another.



Fig:1 - BUILDING RESEARCH INSTITUTE RESEARCH INTERRELATION MODEL

The Technical, Economic and Social aspects of the Built Environment are the main contents of the research studies. On the other hand the Built Environment is undertaken in various scales, from building materials and components to building and to building groups and settlement, scales.

The research studies are undertaken by two main divisions, one concerning with building product, and the other concerning with building process. For the time being there are and two sections in each division. Each division is an organisational unit, which carries out the duties of the Institute within a particular scientific discipline. The names and the fields of interest of these research sections are as follows:

- . The Environmental Research Section:
- The section carries out the necessary research studies, are done in the fields of fields of, a) Physical, and b) Spatial environment
- . Structural Research Section:
- Carries out research on the structural system of the building in the fields of, a) Dynamic systems (i.e earthquake), and b) Static systems (ie super structure and substructure, including jeotechniques)
- Building Planning Research Section: The section aims to analyze the planning programming and design stages of the building process, in order tomeet the building need of the country in a rational way. Building Construction Research Section:
- The section undertakes the necessary research in order for the building process to be carried on, in the most positive manner. Studies are mainly on building operations, and equipment.

Thus, as it can be seen that the research approach of the Institute is a comprehensive and flexible model, wh**ich** provides possibilities for inter disciplinar group projects, either in one section, or among the sections, in various scales of the built environment. There are also two main support bodies to be mentioned. One of then is the Information-Publication-Documentation Unit of the Institute.

The other one is the, Advisory Comitties in the Project, section and Institute levels. Committies can be composed from the members of the Private, Public and Academic sectors, thus providing a possibility for the use of potential of other organisations.

The Institute has two specialization laboratories, namely The Environmental Control laboratory, and the Structural and Earthquake Engineering laboratory. The rest of the laboratory requirements are met by the already existing laboratories of the other public and academic organisations.

Activities:

The most important activities of the Building Research Institute is to carry out and conclude research projects concerning the building problems of the country. The priorities mainly concentrating on such subjects as, Appropriate Technology, Low Cost Housing, Energy, Earthquake, etc. The main theme being the rational use of limited resources.

Since the major building and civil engineering works are sponsored by the government the main work is public sector oriented. This fact provides possibilities for the implementation of the research results via regulations, standards, codes, set by the public sector. The other method is via the publication of the research results.

The publications of the Institute occupy an important place among its activities. These publications comprise research publications, such as the final reports of research projects, technical notes, data and information sheets, design briefs, translations, and general publications about the activities of the Institute.

At the same time the Institute collaborates with various institutions at home and abroad (she is a full member of CIB) participates and organizes meetings, symposia, seminary, in national and international level. Contributes to the dissemination of information in the field of building research.

It has been 10 years since the establishment of the Institute, during this period, due to certain reasons it has not reached the expected level, and therefore it is quite far from meeting the building research requirements of the country for the time being. But during this period it has reached a certain point, research programs are developed, many projects are completed, many research staff has been raised, and most of all a comprehensive research philosophy has been established. It is not a perfect or a complete model, it can be improved, but it shows that in a developing country, it is possible to have a multidisciplinar, comprehensive approach right from the establishment stage.

Conclusion

All the countries have their own special building problems, but in general the problems of the built environment are dynamic and complex. Therefore the solutions to these problems require a more wholistic and multidisciplinar approach than what a generaly used today. The building research that would contribute to these solutions

have to be also undertaken by a similar approach. This would of course effect the models and structures of research organisations.

The building research is not solely a technical subject, it also has its social and economic aspects. These aspects are dependent and in interaction with one another, therefore it is not possible to arrive at appropriate solutions, only dealing with one and ignoring the other aspects. As a matter of fact many of the building research organisations of developed countries have shifted from an out of date, monodisciplinar model - whose inefficiency has been realized - to a multidisciplinar one. Thus the social and economic factors are given greater attention and importance when undertaking technical research.

Among many other characteristics of developing countries, the fact of shortage of specialised staff from various disciplines, is an effective aspect in the research field. Therefore in the central research organisations it is preferable to have a flexible structure, rather than a compartmental one, which are composed of sections and divisions, - based on profound specialisations - and strictly apart from one another. The flexible model approach would establish interd isciplinary relations, which would provide possibility for multidisciplinar group projects, i.e., research groups that would cover the wide spectrum of both scales and aspects of the built environment. Thus an efficient use of the limited number of specialised staff can be achieved.

A similar model has been established in the Building Research Institute of Turkey. This general philosophy of a comprehensive model is appropriate to most of the developing countries, as long as it is modified with alterations acording to the socioeconomic conditions of the countries. Building research in a developing country

øivind Birkeland, civil engineer, Norwegian Building

Research Institute, Oslo, Norway

Summary

The appropriate technology of a developing country is neither the technology of the industrialized country to day, nor that of the industrialized country yesterday - and neither is it the traditional technology of the developing country itself.

The appropriate technology is very largely one which is non-existant, and often one which no-one is interested in developing.

The answer to this is to establish an institution which will undertake the necessary development work. Some such institutions have been successfull others not.

In the opinion of the author the following are decisive for the outcome:

- 1. The political leadership of the country
- The programme of work of the research and development institution
- Where the research and development institution is placed in the general organizational pattern of the country and in relation to the building industry.
- 4. The available apparatus for implementing the results of the work in practice.

Resume

La technologie appropriée pour un pays en voie de développement n'est ni la technologie d'aujord'hui des pays industrialisés, ni la technologie d'hier des pays industrialisés - et ce n'est pas non plus la technologie traditionelle du pays en voie de developpement lui-même.

La technologie appropriée est une technologie qui, dans la plupart des cas, n'existe pas et souvent une technologie que personne n'est intéresse à développer.

La réponse à cela est l'établissement d'une institution qui entreprendra le travail nécessaire de développement. Certaines de ces institutions ont réussi, d'autres non.

Selon l'avis de l'author, ce qui suit est décisif pour le résultat:

- 1. La direction politique du pays
- Le programme de travail de l'institution de recherche et de développement.
- La place de l'institution de recherche et de développement dans le système général d'organisation du pays et par rapport à l'industrie du bâtiment.
- 4. L'appareillage disponible pour la rélisation pratique du travail.

Introduction

Listening to building people discussing the development of building technology in a developing country one may get the impression that this is simply a question of transferring technology from one country to another.

In this connection the term technology refers both to the layout of the building and organization of the work, as well as to technology in the more usual sense of the word.

The technician from an industrialized country reasons thus: My country has progressed to an advanced level in this field, so if our technology is transferred to country x, all will be well.

The technician from a developing country who has received education in the building technology of the industrialized world reasons on his part: I know that country y is the most advanced in the world in the field of technology we need in my own country. So if the technology of country y can be transferred to my country, all will be well.

This reasoning is, of course, wrong. What is wanted, in industrialized and developing countries alike, is the technology appropriate to the country in question. There has always existed a building technology in the developing country - a technology adapted to the economic, social and technical conditions in the country at the time this technology was developed.

Similarly, in an industrialized country a technology will be developed that is appropriate to the circumstances prevailing in the country. In addition, there will also be traces of an earlier technology, applied before developments became so advanced.

The real difficulty in the so-called developing countries is that the appropriate building technology is neither the technology of the industrialized country to day, nor that of the industrialized country yesterday - and neither is it the traditional technology of the developing country itself.

The appropriate technology is very largely one which is non-existant, and often one which no-one is interested in developing.

The obvious answer seems to be to establish an institution which will undertake the necessary development work. Usually, an organization of this type will be called a building research institution. Several such institutions exist today. Some of them have obviously been successful in that they have contributed towards a building technology in the country where they are situated. It seems that others have not achieved this objective.

What is it that causes this difference - or which factors determine the result? In the opinion of the author the following are decisive for the outcome:

- 1) The political leadership of the country
- 2) The programme of work of the research and development institution

- Where the research and development institution is placed in the general organizational pattern of the country and in relation to the building industry
- 4) The available apparatus for implementing the results of the work in practice

Political leadership

The political leadership of the country must possess the firm intent and will have to solve the country's building problems, and to use the results of research to achieve this objective. It must give high priority to building problems.

In every country, building is important in itself. But it is also often the key to development in other sectors. A lesser percentage of the national product is used for building in developing country than in an industrialized country. In many developing countries a considerable part of house-building occurs outside the money economy.

But even under such circumstances, building will always play an important part in the development of a country - a fact which is not always properly understood in either the industrialized or the developing country.

The programme of work

The primary aim of the programme of work must be to develop materials, structures, rules for layout, and type drawings for dwellings. In addition, consideration will have to be given to how a building project should be organized, and to site management and technology.

In order to do these things in a manner which will be of benefit to the nation, however, it will be necessary to collect information on the numerous conditions affecting building operations, and to take these into consideration. The most important of these are as follows:

Economic conditions: What are the resources available for building? What are the prices of materials and labour? Is the building to be undertaken in a money economy, in a subsistence economy or in a mixture of both?

What kinds of raw materials are available for building purposes? What are the possibilities for transport of building materials? Such materials are usually heavy and bulky and are required in large amounts. This often makes it desireable, or even necessary, to use local materials. And by local is meant not only that they are produced in the country itself, but that they may be produced on, or in close proximity to the site, from materials available on the spot.

What are the qualifications of the workers who will actually carry out the building work on site? This does not refer only to trade qualifications, but also to traditions, social conditons and the like. In the case of dwellings in particular the work will often have to be done by self-builders.

How is the traditional building technology in the country?

What is the climate of the country like? Can the country be divided into different climatic zones, making it desireable to develop different designs for different parts of the country?

The resulting solutions must be such as to start a development which will continue as a wheel within wheels.

Building people from an industrialized country will often make the error of trying to organize design work and the administration of building projects just as they do at home. They forget that in their home country there are countless standards, regulations and all kinds of written and unwritten rules, and that these kinds of rules, which are only now being worked out in the developing countries, play an important part in the design and building process. Lack of this necessary background may easily make nonsense of what, from the point of view of a person from an industrialized country, seems to be the best possible organization.

The primary aim is to develop the necessary building materials, structures of materials, layout and type drawing for low cost dwellings etc.

However, part of the country's building operations will always be carried out by building contractors, using materials and structures similar to those employed in industrialized countries. In this connection, one of the obstacles to rational design is the lack of knowledge concerning properties of materials, wind loads, seismic forces and the like. Therefore another task of a building research institution should be to produce all this relevant knowledge.

In many developing countries, the building regulations originate from the country's former colonial status, and are copied from the building regulations of the colonial power. Obviously such regulations are quite unsuited to the country in question. Therefore the building research organization will also have to undertake the necessary development of a basis for more appropriate building regulations.

The majority of the work done by a really useful research and development institution is neither particularly advanced nor especially sophisticated. It will consist largely of finding solutions to local problems by applying knowledge acquired elsewhere in the world. So the research tasks will not be of the type which earns the research worker international prestige. And the results - the developed technology - will often be fairly simple. But to undertake the investigations leading to these results requires a creative researcher with a wide spectrum of knowledge, and one who has the courage to rely on his own reasoning. This calls for a really competent research worker.

Organization of the building research and development institution

The research and development institutions existing today in developing countries have been organized along different lines. One may find such an institution as a division in a ministry. This may be a good, and perhaps necessary solution to start with. But after a while, building people outside this particular ministry may feel that the institution is there to serve its parent ministry only, and is not intended to assist either other ministries of private firms. And these organizations also need the help of a research establishment.

Sometimes the research institution is placed at a university or other educational centre. This makes it possible on the one hand to enlist the services of postgraduate students. But on the other hand, it is easy to find examples where the programme of work has been influenced by the teaching requirements of the parent institution.

So it seems that the best solution is to organize the research as an independent institution where all matters in relation to the programme of work are decided by a Board or a committee, with representatives from all user groups. But an organization of this type will nevertheless have to be connected with one or other kind of Government agency from which it will receive its appropriations - for example, a national research council, if there is one.

The best place for a building research institution within the organizational pattern of a particular country will be finally determined of course, by local circumstances. The important thing is that the institution has a fair amount of independence, and that all groups to whom the results should be made available really feel that it is there to be of service also to them - it is their own building research institution.

Implementing the results in practice

All over the world it seems to be the case that only a few of the building agencies have a staff who are able to directly transfer the results of a research project into design and execution.

For this reason, most building research organizations have to take a lot of the responsibility for transfering the results of their research into practice. This applies even more, of course, in a developing than in an industrialized country.

The ideal situation is when it is possible to organize teams or small groups of building "experts" in each district of the country whose task is to give advice and assist selfbuilders and members of the building trade to implement the research results on site.

At the same time, however, the necessary documentation must be made available as data sheets and type drawings which may be used directly by the builders themselves.

This is not the place to go into details, however, as this matter is to be discussed during another session of this congress.

Conclusions

The ideas presented here with regard to a building research institution are valid for all medium or smaller building research organizations. Only the very large or specialized organizations will be able to accomplish more.

The task of most building research workers is, in fact, to employ knowledge developed elsewhere in order to solve the problems they have to face themselves.

The technology of a country cannot be formed by simply transferring a technology developed under entirely different circumstances. Research co-operation between the Building Research Establishment and developing countries

by M E Burt BA, CEng, FRAeS, MICE, Deputy Director, Building Research Establishment, United Kingdom

Summary

The Overseas Division of BRE supports the technical co-operation activities of the Overseas Development Administration (ODA) in relation to housing and construction in developing countries. The paper describes several research projects, some being carried out in co-operation with building research organisations in particular developing countries, and other being developed in Britain for general application. The projects include low-cost housing, environmental conditions, fire resistance, foundations, block-making and sanitation. Dissemination of information is also mentioned. Le Résume

La Division d'outre-mer de BRE soutient les activités de la coopération technique de l'Administration de Développement d'outre-mer (ODA) relativement à l'habitation et à la construction dans les pays non développes. L'étude decrit plusieurs projets de recherche, les uns sont effectués avec la coopération des organisations de la recherche des bâtiments dans les pays non développés spéciaux, et les autres sont développés en Grande Bretagne pour l'application générale. Les projets comprennent les habitations à bon marché, les conditions de l'environnement, résistance au feu, les fondations, la fabrication de blocs et les systèmes sanitaires. Aussi on fait mention de la dissemination des renseignements.

Introduction

The Overseas Division of the Building Research Establishment of the United Kingdom is primarily concerned with the technical co-operation activities of the Overseas Development Administration (ODA) in relation to housing and construction in developing countries.

The Division was set up over thirty years ago and initially provided professional services - in particular architectural, engineering and planning - in developing countries. In addition Overseas Building Notes and other publications were produced at regular intervals. During the last few years there has been a change in emphasis. There has been less professional services and more research projects, done whenever possible in co-operation with building research institutes in developing countries. This change reflects a deliberate policy to encourage and develop the research capability in the countries overseas.

Research projects are chosen to be of value in the country concerned, in particular to improve the quality or reduce the cost of housing for the poorer sections of the community, and also to have potential application in other countries. Great stress is laid on co-operation, the aspects best done in Britain being by BRE, and those best done in the country overseas by the co-operating institute. In most cases BRE staff spend a number of weeks or months in the developing country and staff from the sister institute spend corresponding periods at BRE. In many instances the research requires appropriate scientific instruments and these are often provided by BRE as part of the arrangement.

Such co-operation has benefits beyond those of the particular project. Apart from provision of equipment to the country concerned and potential application of results elsewhere it helps the institute in the develop ing country by bringing their staff into contact with research in Britain and by widening their experience not only technically, but also in research organisation, programme planning and project management. It also helps BRE by bringing its staff into direct touch with all the realities of problems abroad, ensures that the work takes full account of local materials, skills, etc, and increases the probability of the results finding early application in actual construction.

When an adequate research base does not exist in the developing country it may be necessary for a BRE officer to stay there for a year or so. This can be very fruitful while it lasts, but does cause problems in follow-up after he returns home.

Formal co-operation between two research establishments of differing countries of necessity requires Governmental approval from both countries, and due deliberation has to be given to the financial and other clauses. This often takes a long time, although some arrangements have been concluded remarkably quickly.

The remainder of this paper is devoted to brief descriptions of a number of examples of relevant BRE projects, some in co-operation with specific countries, and some of a more general nature. Projects with specific countries

Egypt

As part of a formal agreement with the General Organisation for Housing, Building and Planning Research, Cairo, a co-operative study is being made of environmental conditions in low cost dwellings in Egypt.

Architects and building designers in Egypt often produce buildings which need mechanical air conditioning systems to obtain satisfactory internal conditions. In low cost housing, such systems are clearly not feasible on economic grounds. The objective of the study is to obtain an understanding of the thermal performance of the wide range of building materials available in Egypt, so as to provide design guidance for Egyptian architects and designers.

A computer programme to predict temperatures in buildings in the United Kingdom has been developed at the BRE, and this is being modified to allow for Egyptian conditions and further developed to accommodate the effects of orientation and shading.

To test the validity of the results of such a design procedure and also to gather environmental data for a variety of building types, twelve small test buildings have been constructed at GOHBRP (Figure 1). The first



series of buildings has been constructed to study seven different types of wall construction, including solid brickwork, cavity brickwork, mud bricks and limestone blocks. The second series of buildings will study different roofs, including solid concrete, concrete with insulation and sheet roofing.

Each test building has been instrumented with thermocouples so that the surface temperatures (both internal and external) may be obtained, together with the internal and external air temperatures. The relative humidities, ventilation rates, environmental temperatures and wind speed and direction are being monitored. The thermal conductivities of the various building materials are also being measured.

Figure 2 shows typical measured surface temperatures for one of the buildings along with the corresponding internal and external air temperatures. These measured results are then compared with the results from the computer programme and initial comparisons shows a good agreement between the two.

India

The Central Building Research Institute of India is one of the foremost in developing countries, and there is a formal research co-operation agreement between BRE and CBRI. At present co-operation is taking place in two areas - fire research and foundation engineering.



Figure 2. Typical surface temperatures for solid limestone brick wall

Two main topics have been identified for collaboration on fire research. One concerns the computation of fire resistance and scaling of results from fire resistance tests, which will lead to economies in fire testing procedures. Various computational approaches have been considered and it is intended that the work will start with simple heat transfer problems. The analysis of structural components and the preparation of design guides might be produced after the initial heat transfer studies are completed.

The other topic concerns the validation of smallscale fire tests and their correlation with the fire behaviour pattern of materials in various building situations. This type of information is being sought by many research institutes and in India this may have a particular significance as much work is being done to develop indigenous materials.

Collaboration in the field of foundation engineering is intended to study the behaviour of conventional foundations in the expansive soils of India aimed at improving design and construction practices. One objective is to evolve a more scientific approach to the design of multi-bulb piles for use in expansive black cotton soils of India using (a) a conventional total stress approach (b) an effective stress approach. Field studies are being made of the properties of expansive soils at Indore in the state of Madha Pradesh. Test piles of 300 mm diameter are to be put down and will be instrumented so that loads may be measured along the length.

A further objective is to evolve a more scientific approach to design of multi-bulb piles in loose sands and silts and to examine construction practices with a view to improvement. This field study is being made at Dhandera, near Roorkee.

Indonesia

The BREcast system for constructing blocks of flats was developed at BRE some years ago. Battery casting allows the production of large concrete panels with comparatively inexpensive equipment. Nine four-storey blocks of flats have been erected at Jakarta (Figure 3) using the BREcast system, and many more are planned. A British company has now been assigned the rights to the commercial development of BREcast and has constructed 250 two-storey dwellings in Mauritius and is constructing 38 five-storey blocks of flats in Malaysia.

Following the successful development of the BREcast system, it was considered desirable to develop a lower cost system of prefabricated construction. Indonesia again showed interest and the development of a kit approach to low-cost housing took place in cooperation with the Directorate of Building Research, Bandung.

After initial trials, a kit of four basic precast concrete units was developed, from which one or twostorey structures and either detached or grouped houses could be produced. The concrete units have thin walls and are reinforced with galvanised wire netting in wall units and lightweight steel reinforcement in other units. Initial studies of housing forms led to the adoption of two-storey row housing for the first prototypes in Bandung. (Figure 4).



Figure 3. BREcast flats near Jakarta



Figure 4. Prototype BREkit housing at Bandung

Iraq

Collaboration is taking place between the National Centre for Construction Laboratories on the investigation of the bearing capacity of certain soils in the marshes of southern Iraq, which are being opened up by the building of roads.

The work involves instrumenting a trial embankment to be built from local materials including soil fill and reed matting for fascines. The expertise of BRE has been sought on the design of the experiment and on the selection of pressure and settlement gauges. BRE scientists will assist with the installation of the gauges during construction and in analysing the measurements which will be obtained over a period of several months. This will provide the data for the design of road embankments for the region in the future.

Jordan

There is a three-year collaborative research project with the Building Materials Research Centre (BMRC) of the Jordanian Royal Scientific Society. The project is a study of the engineering properties of Jordanian soils in relation to the design of building foundations.

A pilot study is to be made of engineering geological characteristics and soil properties in two areas of Amman; one area focussing attention on the foundation problems in superficial red clays and the other in bedrock marls. This study will later be widened to include all of Amman and Irbid, with detailed logging of clay sites. Research will be centred on the swelling properties of superficial clays and the compressibility and bearing capacity of the marls. In addition tests will be carried out to determine the insitu properties. The movement of buildings and ground below buildings will be measured by precise levelling and installation of geotechnical instrumentation.

St Vincent

At the request of the Government of St Vincent, a study is being carried out of the effects of earthquakes and hurricanes on low-income housing, in collaboration with St Vincent's Housing and Land Development Corporation. Initially an analysis was made of the probable forces which might be expected to occur during a 50 year period on dwellings in the Caribbean, and then structural techniques which made use of appropriate technology were devised to resist such forces.

The prototype designs, which have been adopted for aided self-help housing schemes in St Vincent, use a hardwood frame with galvanised steel connecting brackets to give resistance to the imposed forces. Hardwood was selected for economic reasons - supplies are readily available locally - and also because the building skills necessary to use the material already existed. An alternative design, using columns of reinforced hollow concrete blocks, has also been tried. The use of alternative materials may be more applicable to other countries.

Different sizes of house have been constructed, ranging from $19m^2$ with a monopitch roof, to $45m^2$ with a duopitch roof (Figures 5 and 6). Different forms of foundation and substructure have also been tried; these vary from solid reinforced blockwork and concrete for 'flat sites', to a high-set system on diagonallybraced hardwood columns with timber flooring for sloping sites. Wind speeds and seismic ground accelerations are being monitored in the trial houses to provide quantitative data on their performance.

In St Vincent the houses are being built for families earning about £20 a month. Each house is built by the family that will occupy it. The necessary skills are learned in the site workshop and a mortgage is obtained for the materials. The families also provide the labour to build the roads and services for the housing development.

The costs (materials plus labour) of the structure of the first houses built in St Vincent have ranged from £500 for the $19m^2$ house to £800 for the $45m^2$ house. In comparison with the public sector housing previously constructed in the island, these costs represent a considerable reduction, despite the fact that they have been specifically engineered to resist earthquakes and hurricanes. The portion of these costs directly attributable to the connecting brackets is some £25 to £50.

The work has recently been extended to the neighbouring island of Dominica following the extensive damage caused by hurricane David in August 1979. Recommendations have been made for the rebuilding and re-roofing programme in that country.

BRE Overseas Division is organising a regional seminar in the Caribbean in March 1980 with the object of making the information on hurricane and earthquakes resistant housing for low-income families available to all the territories. Subsequently it is expected that the work will be extended to other regions of the world where similar problems exist.



Figure 5. BRE-HLDC 19 m² house structure



Figure 6. BRE-HLDC 45 m² house structure

Other work

Development projects

A number of developments are being made by BRE which, although aimed at the needs of developing countries, have not been produced on a co-operative basis with a particular country.

Studies of low-cost sanitation have led to the development of prototype designs of permanent and emptyable pit latrines, designated 'PIP latrines' (Permanent Improved Pit Latrines. Figure 7). These latrines are intended for use in urban and semi-urban areas of developing countries where there are restrictions on the size of building plots. Some PIP latrines are now under construction in Botswana.

A hand-operated hydraulic machine has been developed to produce stabilised soil blocks. The use of hydraulic pressure results in a superior product to that produced by the Cinva Ram, in that strength has been increased and surface permeability has been reduced.





- Contents decompose while second pit compartment is being used.
- 9. Mechanical or manual emptying

Figure 7. The Permanent Improved Pit Latrine

Studies of low-cost roofs have indicated that greater use might be made of bamboo. Previously it has been difficult to make sound connections between lengths of bamboo, and traditionally village builders have used lashings. Some new designs of connections are now being devised and tested at the Building Research Establishment.

Information

BRE provides information to government organisations, research stations, universities and colleges and professional practices in developing countries. The main series is the Overseas Building Notes, published at two-monthly intervals. These Notes now have a regular circulation of over 3,000 and are sent to over 80 countries. The topics relate to building in tropical countries, and in recent years a number have been written by experts from developing countries. In addition, special publications are produced on specific topics. Recent publications have included topics such as 'Third world urban housing', 'Brickmaking in developing countries' and a 'Design guide for the Caribbean'.

The Division also assists in the mounting of Seminars. An international Seminar on Sanitation Engineering was held in Cairo in May 1979, in conjunction with the Egyptian General Organisation for Housing, Building and Planning Research. There were four expert speakers from BRE, five from Egypt and siz from developing countries. BRE helped support the CIB Seminar on 'Building Research for Developing Countries', which was held in New Delhi in February 1977.

Building research for both worlds

Thomas Lodewyk Webb Dsc Director, National building Research Institute, South Africa

South Arrita

SUMMARY

The value, planning, execution and financing of building research and the application of the results in both industrialized and developing countries are discussed with emphasis on the common nature of and differences in the basic problems and the mechanisms and approach whereby research findings can be meaningfully and effectively applied in very different situations having regard to different resources and the levels of technology and skills. The importance and unique features in developing countries, of research on housing, energy conservation, local materials and technology and building economics are discussed.

SOMMAIRE

La valeur, le plan, l'exécution et le financement de la recherche en bâtiments et l'application des résultats à la fois dans les pays industrialisés et en voie de développement sont discutés en marquant la nature commune et les différences dans les problèmes de base ainsi que les mécanismes et l'approche par lesquels les traits de cette recherche peuvent être appliqués dans des situations très différentes d'une manière significative et efficace en tenant compte de resources différentes et de niveaux de technologie et d'habileté. L'importance et les aspects uniques de la recherche dans le logement, de la conservation d'énergie, de matériaux locaux et de la technologie et de l'économie dans les pays en voie de développement sont discutés.

Introduction

In this paper, and based on experience in a country which can be regarded as partially developed and partially developing, factors influencing the usefulness, planning, execution, application and financing of appropriate building research in both types of country is outlined and compared. Its purpose is to identify and critically discuss in general terms common factors and essential differences with a view to promoting a better understanding in developed countries of the building research needs and problems of developing countries and an appreciation in developing countries of how they can best benefit from the research experience and acccumulated knowledge of developed countries.

Lastly some building research fields of particular importance to developing countries, namely housing, energy conservation, services to and in buildings, local materials and technology and building economics are discussed in some detail.

The usefulness of research

In all countries the resources of the building community are traditionally regarded as being money, manpower and materials. There is in fact a fourth, namely research, which differs basically from the others in that, if properly planned, executed and applied, it can extend or make more effective the other resources. Because this is especially true in developing countries, they stand to gain even more from research, provided it is planned, done and applied in the right way to fully exploit its usefulness.

In order to qualify as a useful resource, however, and this is true in all countries, building research must meet certain criteria.

First, it must be completely objective. While meaningful research is necessary as a basis for policy decisions, it is not the function of research to determine policy - this is and must remain the prerogative of policy-makers; it can, however, be most useful to policymakers if it is valid and impartial, and therefore gives a balanced picture of the matter under investigation. It is generally easier to be objective when relatively non-contentious technological matters are involved than when, for instance, policy, contractual procedures, economic matters or sociological topics are investigated.

Second, the research must be problem oriented and realistic in terms of its priorities, scope, execution, and practical application. This means that the problem and the research approach must be such that there is at least a reasonable chance of success, that the nature and complexity of the project is within the limits of competence and other resources of the research workers and the organization undertaking it, and that the results can be applied economically and without undue or radical changes in management, technology and labour in the country concerned.

Third, it must be demonstrably relevant and useful to the point where it is essential for the attainment of a given objective. In other words, the economic, social and technological impact of a valid research finding must meet a need and exceed a threshold value, either qualitatively in terms of its importance, or quantitatively in terms of the extent to which it can or will be used.

Fourth, meaningful building research must take into account all the factors concerned. In a complex, multidisciplinary activity such as building this generally means that, in order to be valid, research must cover a wide spectrum of disciplines or activities. These range from pure technology to sociology and financial and include the assessment of people's wants and needs, management, training and economics - all integrated into a goal-oriented effort, under a single leader and executed in a 'building' context.

Fifth, it must be planned, carried out and applied in close collaboration with those requiring the research. This demands good communication, mutual confidence and a full understanding by the research team of the needs of the 'customer' and an appreciation by the 'customer' of the principles and limitations of research. In this connection, research workers should remember that the industry, the professions, the national policy makers and above all the man-in-the-street are not interested in how clever research workers are; they are interested in how useful they can be.

Sixth, it must be completed, reported and applied in a reasonable time. A 'reasonable time' can be anything from a few days to several years. The duration of a research project is, however, frequently difficult to predict in advance, mainly because the project may involve many unknowns. Also, research projects are often interdependent and differ from a production activity in that the progress of the work cannot always be accelerated by putting more men on the job.

Seventh, and particularly in developing countries, where it is likely that the industry will sometimes lack the necessary specialist expertise, valid building research must go beyond the mere acquisition and publication of new knowledge. It requires action to ensure not only that the information emerging from research reaches those to whom it can be of value, but that, where required, guidance is given in its interpretation and application. This is one of the reasons why it is necessary for the research organization to disseminate information rather than knowledge.

Eight, and lastly, it must, seen in terms of the benefits derived, represent good value for money - certainly in the longterm and where possible also in the shortterm. Value and money have very different relative meanings in developed and developing countries, and in the latter particularly, the cost of research, in terms of critically short manpower as well as in monetary terms, must be very critically considered in relation to its likely value.

Planning, execution and application of research

While, broadly speaking, the same basic principles of planning, executing and applying research are valid in all countries, there are significant differences. Some of the more important considerations in developing countries are:

<u>Planning</u>: The research must be planned by people who either fully understand the local problems or who are fully prepared to do so - the 'man from outer space' syndrome must be avoided. This is because many of the attitudes that are valid in developed countries, simply do not apply and a different, though by no means necessarily less complex, set of criteria must be used. There is for instance a need to fully take into account climatic differences, local, ethnic, tribal and religious customs and beliefs, traditional living patterns, different criteria and priorities and above all the fact that as a country or a community develops, so their housing needs and aspirations and living patterns change. Such changes, both in terms of their direction and nature and

the rate at which they occur are often completely unpredictable and sometimes not even understandable to people from a different society. In meeting these very real differences it is neither necessary nor even possible for someone from a developed society to be fully aware of all these sometimes quite subtle differences and changes what is essential however is a high degree of sensitivity and tolerance and a preparedness to be guided by local circumstances and people. In this connection the full and ongoing participation of the community by consultation and dialogue with and the active involvement of the people for whom the buildings and related facilities are intended, not only at the planning stage, but as the research proceeds, is probably one of the most effective solutions to this very real problem in developing countries.

Evidence of a lack of appreciation of these planning principles is sadly all too often to be found in the well meant but misguided efforts of developed countries. Execution: In the direction and execution of research, as in its planning, there is a real need to take into account and accept local resources and constraints, in terms of limited facilities, hardware, infrastructure and communication aids and specialized human skills. Qualities such as mental resilience, independence of mind, strong motivation, persistance, patience, and the ability to communicate, to simplify and to improvise are infinitely more important than intellectual ability or academic achievements judged by the standards of developed countries. In general terms this means that in a developing country human and personal qualities and a pragmatic and empirical approach are much more important than the conventionally accepted criteria for good research planners and workers in developed countries.

Financing: First, the financing of building research in any country should be on a scale commensurate with both the size of the building industry and its level of sophistication. It should also be coupled, in a realistic way, to the growth of the industry, both in terms of its size and the nature of its development. These considerations determine the level of financing, which, in practice, varies in different countries from less than 0,05 per cent to as much as 2,5 per cent of the annual expenditure in the building industry, i.e. by a factor of over 50 - a disturbingly wide range. Generally, the lower limit applies in developing countries and the higher figures in developed countries, particularly those with a centrally controlled economy. Typical values for developed market economy countries lie between 0,3 and 0,6 per cent.

Second, one cannot generalize in apportioning responsibility for financing research as the situation will vary from country to country and in a given country from time to time, but both public and private sectors have a role to play. In developed countries fundamental or longterm research, essentially in the broad public interest, is primarily the responsibility of the central government, while shorter term <u>ad hoc</u> research aimed at solving a specific problem of direct interest to industry or the entrepreneur is, logically, largely the responsibility of the private sector.

In developing countries, on the other hand, where the building industry is relatively unsophisticated, both technologically and managerially, the primary responsibility should be with the central government, and progressively, as it develops, the industry should assume increasing responsibility for at least that research which is directly in its interests. Where developed countries undertake, finance or sponsor research in or on behalf of developing countries, there is a special need for the policy makers concerned to check and recheck the nature of the research undertaken and how and by whom it is to be applied.

A third important principle is that financing should be reasonably constant: building research, perhaps more than most human activities, and like the industry which it serves, proceeds most efficiently if not subjected to large and sudden changes in its level of activity. This can, in practice, probably be best achieved by accepting in principle and annually updating, say a three to five year rolling budget where the budget is known with certainty for one year ahead and with decreasing precision for the rest of the period. Financial provision should also take inflation into account.

A fourth principle that must be appreciated by research managers, is that today, and probably to an increasing extent in the future, research must compete with other activities for funds and manpower. This is especially true in developing countries and there is a real need for the recognition by both local policy makers and benefactors to developed countries to ensure that research of an appropriate type, and more particularly the application of the results, are not neglected in favour of other apparently high priority needs.

<u>Application</u>: In the application of research, certain important principles also apply:

- . The whole process of disseminating information and applying research findings is relatively much more important than in a developed country and consequently requires far more emphasis and effort.
- . Because of inevitable limitations in physical facilities, funds and skilled research manpower to under take research locally, much more use must be made of the research work done in other countries, developing as well as developed. It is for this reason that there is such a real need for good two way communication between the over 600 research insitutes in fifty two countries as listed in the CIB directory of building research, information and development organizations. Exchange schemes of suitable dura-

tion, between countries with similar problems and of comparable levels of development are particularly valid. The value of such scemes is substantially enhanced if research workers can be integrated into teams actually working on development projects rather than in research organizations.

- . The need to adapt research findings to local conditions and circumstances is of special importance in applying the results of research undertaken in another country, particularly where there are big differences in the levels of technology or development between the countries.
- . Because the traditional modes of communicating the results of research in developed countries such as the publication of research reports in professional or scientific journals or text books or academically oriented high level conferences, are impractical, ineffective, non-existent or simply unintelligible, the emphasis should fall on visual demonstration and word of mouth communication in an intelligibly and comprehensible way and at the appropriate level.
- . Repetition is frequently necessary and if something is not initially understood, a different approach is often valid. It must also be remembered that misunderstandings often arise because the intrinsic courtesy of developing people or a wish not to appear stupid often leads them to indicate that they have understood something when they have
- . not done so. Audio-visual aids and simple guide books, making copious use of vernacular language and phrases and simple illustrations, ideally of the cartoon type and based on familiar or local concepts, are particularly effective.
- . Education and training for building professionals and technicians is often best achieved in the classroom, and for artisans and operatives by means of on site workshops in the local environment where the trainees participate actively in the application of the research findings.
- . Particular importance must be attached to regional and local factors especially in areas where transport is limited, expensive or difficult, and where language varies. A sound principle is to take the knowledge to the job rather than trying to bring those for whom the information is intended to a single centre.
- . Information transfer in a developing country is a much more personal business than in a developed country and therefore good human and personal relations are particularly important. In this connection care must be taken to avoid any suggestion of paternalism and even appearing to talk down to people must be avoided.
- . It must be realized that different spatial perceptions, particularly in terms of dimensions, depth and scale,

frequently complicate the communication process, especially where drawings or models are involved. Similarly a frequent lack of understanding of physical or mechanical principles, and particularly of abstract concepts, largely due to the absence of a technological background, hinders effective communication.

. Although this is not always easy, the recipients and users of research knowledge should also make a conscious effort to understand the objectives of the research work as well as the findings themselves, and must pass it on to their associates and subordinates.

Research fields of special importance in developing countries

The priorities of research projects and the approach to them in developing countries are often determined by different and generally more basic considerations than in developed or affluent countries, and it may be useful to mention a few such fields and some factors that experience has shown to be of particular significance.

<u>Housing</u>: Here especially community participation on both an individual and a collective basis are of paramount importance in defining housing needs, priorities and aspirations. Recognition of basically strong family ties, the concept of the extended family and of a well developed and sometimes rigid hierarchical structure in families and communities is also important.

The use of a 'games' technique to establish and quantify needs is often valuable. For example, in matters involving the financial implications of, and decisions regarding, the relative priorities of the different components in a new or modified community such as the relative costs of say a school, a church, a shopping centre, a water borne sewage scheme or electricity reticulation, a very real difficulty is a full and meaningful understanding of their relative costs. This can often be most effectively achieved by expressing the costs of such amenities to the community in terms of a basic well understood standard unit such as a house for example one school equals 40 houses or a waterborne sewage scheme to serve a specified community equals 200 houses.

The concept of self help involving the provision of serviced sites and teaching and encouraging the people to build houses on them is one that has repeatedly been advocated in developing countries. In some cases this approach has been highly successful - in others disastrous and there is no doubt that a great deal more research is required to establish what factors determine whether self help is applicable and, perhaps most important, how it should be arranged and administered if it is to be successful. As a broad generalization it can be stated that properly planned and well administered with certain basic controls, self help is a most successful approach in many rural areas, but in urban areas it is often less successful.

Cost benefits and productivity, depend to a large extent on the volume and continuity of the work, and in large schemes may be as high as 15 per cent better than in small schemes. Housing schemes should therefore be as large as practicable but within the resources of the particular organization entrusted with the work. In medium to large housing schemes, the task force approach is often very valuable. This involves the training and well planned management of specialist teams, each undertaking one defined task in the erection of a house. For instance, team A excavates foundation trenches, team B places the concrete foundations, team C does the more difficult brickwork such as corners, team D does the simpler brick infilling, team E erects the roof and so on. This process, which can be likened to a motor car assembly line in which the teams, and not the product being built, moves from site to site, has been shown to substantially reduce costs and improve quality.

It has repeatedly been said that the answer to the housing problem in developing countries is population control, and while this may not always be true, there can be little doubt that such a course of action has much to commend it and would, in the longterm, certainly be in the peoples' interest.

<u>Energy conservation</u>: Even in developed countries the high and rapidly increasing energy costs in the shortterm, and the eventual exhaustion of fossil fuel resources in the longterm, have brought about varying degrees of energy conservation and have made research in this field one of the highest priority. In developing countries the problem is, in the longterm not only equally more important, but is in many ways entirely different. Factors which presently reduce the severity of the energy problem in developing countries and particularly in rural areas are:

- most developing countries have climates that require little or no artificial heating in buildings;
- solar water heating is generally a far more suitable proposition than in temperate countries;
- in some such countries traditional energy sources such as wood are plentiful and readily accessible;
- the living pattern and economic factors traditionally limit the amount of artificial lighting and other energy consumer devices used;
- low incomes and the high cost of energy consuming devices and electricity;
- traditional building materials, building methods, the use of labour and the design of buildings are such that relatively limited amounts of energy are required in the erection of a building.

Factors which will make the energy problem in buildings in developing countries very severe, especially in the longterm, are:

- a rapidly rising rate of energy demand as such countries develop;
- extremely and disproportionately high capital costs for power stations and distribution and reticulation networks, especially in areas of low population density;
- as populations and the degree of urbanization inevitably increase, and it must be remembered that the urban dweller typically uses anything up to five times more energy than his rural counterpart, so the energy problem will progressively become more serious;
- in most low income communities, energy and more particularly electricity and petroleum based energy, will be extremely expensive in relation to other commodities and services;
- the progressive depletion of traditional fuels such as wood will result in their becoming scarcer and more expensive.

These considerations lead to the conclusion that research on energy conservation in developing countries should be aimed specifically at:

- the development of low cost solar water heaters;
- the development and promotion of low rise building types and designs and living patterns that result in the minimum energy demand and which take full advantage of the local climate;
- educational, economic and legislative measures to encourage the use of renewable energy sources and energy conservation - this could be easier than in developed countries in which gross energy waste has over several generations become almost a characteristic feature;
- studies in town and regional planning to achieve built-in energy conservation - i.e. avoiding hilly terrains and thus steep gradients, rationally planning and operating public transport services and the planning of services such as water supply, sewerage and drainage to avoid or reduce pumping.

Local_materials_and_technology: Because of transport, energy and economic constraints, the maximum use of indigenous, and where possible, local, materials should be made and research planned to achieve this goal. The materials-manufacturing industry should be labourintensive rather than capital-intensive and the skills involved in their production and use should be within the capabilities and resources of the local population. Building material production should, as far as possible, be decentralized both in order to retard the urbanization process and to reduce transport costs.

The misused, if fashionable phrase 'appropriate tech-

nology' is probably nowhere more applicable than in developing countries and research should be aimed at:

- avoiding the extensive use of sophisticated capital intensive industrialised building methods;
- . the sparing and selective use of mechanization;
- ensuring that management and technical skills used are within the abilities of the manpower concerned;
- basic technical education and training, aimed directly at immediate needs and productivity and conducted in a comprehensible way at an appropriate level;
- avoiding rapid or radical departures from traditional procedures and technology.

<u>Building economics</u>: While they remain fundamentally valid, the accepted principles of building economics in developed countries have to be modified, sometimes drastically, in developing countries and research, both technical and in economics must take the differences into account. For example:

- the proportion of a family's income which can be applied to either rental or capital repayments is generally much lower than in developed countries;
- maintenance costs have to be lower and special financing procedures have to be worked out and adapted;
- rapid changes in family or breadwinner income from year to year should be accepted and planned for;
- financial incentives and property taxation which play such an important role in the financing and operation of services and community facilities in developed countries, have to be much more selectively used.

Conclusions

While building research, properly planned, executed and applied, is at least as important and probably more important in developing countries than in developed countries, and while many of the same principles apply to both, the following six basic but broad guidelines, combining many of the points made in this paper, are considered valid.

- Meaningful building research should, even more than in developed countries, be directed at reducing costs, improving management and labour utilization, and developing new and existing materials and techniques.
- Research for and in developing countries should aim at avoiding the mistakes inevitably made in the older developed countries - developing countries cannot afford too many mistakes.
- The dissemination and application of the results of research in a developing country is a much more

informal and personal business and generally requires a very different approach.

- When developed countries undertake, finance or apply research in developing countries, it must be remembered that an entirely different set of circumstances apply and that extreme caution, sensitivity and local knowledge is a prerequisite to constructive and useful action. The host country should clearly define the overall research objectives and development goals to avoid irrelevant research.
- Traditional associations and/or compatibility in terms of language, ideologies and political or governmental systems can substantially enhance the effectiveness of research assistance extended by a developed country to a developing country.
- Research in or for developing countries must be aimed at the solution of real and immediate problems with limited technical, manpower and financial resources. It should generally not try and compete in terms of its technological sophistication and academic respectability with research in the older and developed countries; such research is best done in developed countries. This does not mean that research in developing countries is easy; it can frequently be as complex and more difficult but also more rewarding and significant.

Authors index

		Page
Andrienko, E. G.	An air supported pneumatic structure with a heat protection screen	657
Agarwal, K. N.	Energy Conservation in multistoreyed buildings	249
Allen, W. J.	The properties and testing of limepozzolana mixtures	40
Alphan, Ahmed	On The Design of The Use and Discharge of Water in Building	252
Angelov, V.	Sound insulation problems in modern residential buildings	663
Anis, A.	An analysis of the net short wave radiative balance of buildings within proposed urban complexes with different building densities, orientations and shapes for Lahore, Pakistan	667
Aparin, I. L.	Economic Substantiation of the Main Directions of Scientific and Technical Progress in Construction	673
Armuth, András	Economic evaluations concerned with energy conserving improve- ments of the building envelope. Some Hungarian examples.	256
Atayev, S. S.	Management problems in building	547
Augenbroe, G. L. M.	A finite element-based computer program for the simulation of the thermal behaviour of complex systems	677
Basson, J. A.	An integral solar water heater for low income housing	51
Baytin, Denis	Building Research Organization in Developing Countries – Turkey Approach	800
Baytin, Nesil	Socio-cultural and Economical Factors Effecting The Spatial Arrangement of Dwellings in Turkey	140
Bedotti, Giancarlo	Optimisation énergetique des fenêtres	270
Bedotti, Giancarlo	Une hypothèse de programmation de la recherche dans le secteur du bâtiment en ce qui concerne le contexte italien	683
Benes, J.	The balance method for value analysis in the construction industry	694
Berge, Per L.	The new concept of SfB Tables as a tool for the management of civil engineering projects	556
Berkøz, Esher	Building Facade Design from the Standpoint of Solar Radiation and Air Temperature Control	266
Berkøz, Esher	A Dynamic Simulation Model for the Optimization of Solar Energy Flow Through the Building Envelope	262
Bertola, Donato	Une Banque de données sur les dispositions pour le bâtiment. Perspectives de gestion et d'emploi	687
Bezverkhii, A. A.	Concrete strength as function of time and water/cement ratio in isothermic setting	691
Bindal, Mine	Measuring Adaptability between Activities and Spaces in Dwelling Units	145
Birkeland, Øivind	Building research in a developing country	804
Bjur, Hans	Does alternative refuse, water and sewage systems offer new possibilities for town planning?	357
Blach, Klaus	Successful passive energy conservation – a highly insulated, traditional Danish house	275
Blach, Klaus	Roving seminars in developing countries – an efficient way to reach building technicians and administrators with up-to-date information	482
Blach, Klaus	Standards for low income housing – a new type of standard may make more informed choices possible	151

Blakey, F. A.	The use of grouping systems for the structural utilization of timber from multiple species forests	416
Boalt, Carin	Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a Project	486
Bogos, Constantin	La protection thermique des bâtiments et l'economie d'energie	279
Brocher, Erichbernd	The reduction of energy consumption in the heating	284
Brosio, Ermenegildo	Optimisation énergetique des fenêtres	270
Brundrett, G. W.	Advanced dehumidifiers for moisture control	57
Brundrett, G. W.	Field trails in well insulated houses	288
Budnikov, P. P.	On the non-destructive control of the strength of building materials	700
Burt, M. E.	Research co-operation between the Building Research Establishment and developing countries	807
Bychkov, A. S.	On the non-destructive control of the strength of building materials	700
Cakin, Sahap	Use of the Feed-Back Information in Housing Appraisal	420
Campos, Vitor	Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a Project	486
Cappelen, Paal		
	Extending the lifespan of traditional houses. Examples from Tanzania	22
Caroli, Gianni	Une banque de données sur le dispositions sur le bâtiment. Perspectives de gestion et d'emploi	687
Celik, Aliye Pekin	Bioclimatic Design of the Building Envelope in Vernacular Architecture	292
Celik, Aliye Pekin	A Model for the Analysis of Bioclimatic User Requirements	154
Cheetham, D. W.	Management by Objectives – The philosophies and techniques with reference to a case study of its application within a Building Contracting Company	560
Chin, Myron	Construction project management in the Carribbean: an educational approach	595
Chumakov, Yu. M.	Basic Trends in Energy Conservation in Precast Reinforced Concrete Industry in the USSR	703
Coker, Bülent Galip	A Computerized Method for Data Coordination for the Design Process for Component Approach of Buildings	708
Conan, Michel H.	Le changement de logement en temps de crise économique	158
Copur, Ülker	Building Documentation, a Case Study in Turkey	488
Costello, John O.	Some aspects of the design process in Irish towns	713
Cronberg, Tarja	User Participation in the planning of Residential Areas – an Evaluation of Four Experiments	163
Croome, Derek J.	Low Energy Building Design	60
Cunha, Luis Arriaga da	An information system for the building industry – a stepwise approach	566
Curutchet, Mirina	Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a Project	486
Dahlgren, Stefan	Sociological Research for Planning and Design	129
Delaval, Bernard	Le logement dans les villes du tiers monde. Les ressources et les besoins	169

.

Deshko, E. L.	The main measures of improvement of enclosing structures in mass construction of the USSR	296
Deutschmann, Eberhard	Improvement of the heat insulation of multipane window glazing in residential buildings	298
Deutschmann, Eberhard	Application of large-panel structures in public buildings including ground floors of dwelling houses	717
Dickson, D. J.	The Energy Implications of Ventilation in Houses	67
Diepeveen, W. J.	The balance method for value analysis in the construction industry	694
Dihovichnaya, N. A.	Bearing structures of residential buildings	722
Dikarev, L. A.	On the non-destructive control of the strength of building materials	700
Drozdev, V. A.	Major trends in the development of building physics today	725
Edvardsen, Knut I.	Extending the lifespan of traditional houses. Examples from Tanzania	22
Eguchi, Tadashi	A Microscopic Viewpoint of Work Breakdown Structure in Building Construction	569
Eisenblätter, Anselm	Solar technique in the building construction. Aspects in the field of building construction and design	122
Englöv, Peter	Infiltration of waste water. Some Swedish experiences	262
Esposti, Walter	Optimisation énergetique des fenêtres	270
Esposti, Walter	Performance Evaluation of Solarintegrated Buildings	77
Ertürk, Zafer	A Method for Determining Spatial Requirements with Special Emphasis on User Comfort	174
Fenves, Steven	Modeling of Standards	492
Fikry, A. A.	An investigation into the user of fixed horizontal shading devices to control the internal environments in low latitude regions	729
Finlayson, Kenneth A.	Community involvement in the identification of housing requirements and community priorities	179
Fleming, F. W.	Design, Construction and Instrumentation of a house incorporating high standards of insulation and a solar/solid fuel powered air and water heating system	72
Fredriksson, Gösta	The implementation of an innovation in building site construction	573
Freeman, I. L.	Quality control in construction on site – Some observations of current UK practice	578
Freidin, A. S.	The using of decreased energy consumption adhesives for production of laminated timber structures	425
Gabrielsen, Einar	Improved production planning and control, a cooperation between a Research Institute and 30 Building Contractors	583
Gajjar, Suresh	Moment-rotation relationship for joints in roof trusses with metal plate connectors	429
Gáspár, Anna	Assistance in organizing building information systems for the developing countries	498
Gertis, Karl	Energy savings by means of improved thermal insulation of the building envelope	304

Gilboe, Knut	Need of education on the project management area on technical colleges and universities	587
Goldenberg, L. I.	Large span membrane suspension roofs for Olympic sporting facilities in Moscow	734
Goodall, E. G. A.	Comparison of the performance of air/air heat pumps in small commercial premises	82
Grad, Judith	Management information system in the Hungarian Institute for Building Science	535
Granit, Michael	The geometric form of buildings – qualities and energy consequences. Four office-buildings analyzed	324
Granum, Hans	The Role of the Building Envelope	243
Guntvedt, Odd H.	Housing sociology. Human Requirements. Basic needs related to family and national resources	135
Gusev, V.	The Development of the Resort Complexes for Mass Recreation of the Working People	738
Guttormsen, Dag	Features of different types of «non-water-borne» toilet systems	366
Hallquist, Åge	Scandinavian timber frame house construction. Technical design and future trends	410
Handegord, G. O.	Evolution of the insulated woodframe wall in Canada	434
Hannan-Andersson, C.	Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a Project	486
Hansen, Ragnar	The new concept of SfB Tables as a tool for the management of civil engineering projects	556
Harris, James Robert	Modeling of Standards	492
Hegdal, Bjarne	Information from Building Research in a Developing Country	502
Helland, Haktor	Housing sociology. Human requirements. Basic needs related to family and national resources	135
Hjärne, Lars	Concerning aims and forms of tenant influence. Some preliminary considerations	184
Homma, H.	Natural Wind Effects on the Infiltration of Low-Rise Buildings	337
Hullmann, Heinz	Solar technique in the building construction. Aspects in the field of building construction and design	122
Hutcheon, N. B.	Evolution of the insulated woodframe wall in Canada	434
Iizuka, Gorozo	Effective use of small logs and their products for house construction	439
Imaizumi, Katsuyoshi	Recent research and development of wood house construction in Japan	444
Jantzen, Erik B.	User participation in the planning of Residential Areas – an Evaluation of four Experiments	163
Jensen, Ole	Planning of Housing Development and the Social Environment	221
Jerkbrant, Conny	Does alternative refuse, water and sewage systems offer new possibilities for town planning?	357
Johnson, M.	A low energy house for a warm dry climate	88
Karlén, Ingvar	Information Exchange on Human Settlements – Needs, Problems and Actions	505

Kartahardja, Albert	Development of locally produced building materials in developing countries	17
Kasalicky, Václav	The task of construction in creating a healthy and cultural housing environment	742
Klimukhin, A.	Sound insulation problems in modern residential buildings	663
Knase, Pavol	Reduction of heat losses in dwelling buildings by the application of new research knowledge	306
Kovalchuk, L. M.	Glulam timber strength as affected by variables in manufacturing process	447
Kozlov, K. V.	Timber-based structural elements in panel house- building in rural areas	405
Kristiansen, Rolv	On-site soil desposal of septic tank effluent	370
Krotov, A. P.	The Organizational Forms of Capital Construction Management	590
Kumarasuriyar, R. C.	Modular co-ordination in energy conserving design for living space	212
Kunszt, Gy.	The use of system dynamics in housing supply forecasting	747
Lebegge, Maurice	L'expérience belge en matière d'isolation thermique par injection de mousses isolantes dans les murs creux	311
Lee, Brian E.	The natural ventilation of groups of low rise buildings and the implications for energy conservation	316
Leicester, R. H.	The use of grouping systems for the structural utilization of timber from multiple species forests	416
Lemke, A. Y.	Timber-based structural elements in panel housebuilding in rural areas	405
Lemunge, N.	Management of construction	552
Lensky, S. E.	Basic Trends in Energy Conservation in Precast Reinforced Concrete Industry in the USSR	703
Lethermann, K. M.	A hybrid simulation technique for predictions of seasonal energy consumption	321
Lindquist, Margareta	Dwelling Habits and Dwelling Standards – Results of an Interview Study on 308 Swedish Households	227
Linkov, I. M.	Research of strength of wood-board materials	449
Liseth, Paul	A Norwegian Research Program for Treatment of Waste Water (The PRA Project)	376
Lishak, V. I.	Bearing structures of residential buildings	722
Malhotra, S. K.	Effective utilization of nailed laminated timber construction in buildings	452
Mandorff, Sven	Balancing of water-heating systems	94
Mandorff, Sven	The function of heating systems with thermostatic radiator valves having no pre-set maximum flow	100
Manning, Peter	Construction project management in the Caribbean: an educational approach	595
Manso, Armando da Costa	An information system for the building industry – a stepwise approach	566
Marvin, Eugene L.	Construction materials data base	600
Mathur, G. C.	Social and Economic significance of Housing in Developing Countries	191
------------------------	--	-----
Mathur, G. C.	Basic concepts for housing the poor in developing countries	198
Mathur, G. C.	Management of information needs of human settlements in developing countries	475
Mazalov, A. N.	The main measures of improvement of enclosing structures in mass construction of the USSR	296
Mazur, S. J.	Effective utilization of nailed laminated timber construction in buildings	452
Mbilikira, M. M.	Management of construction	604
Mengu, Moses D.	An appraisal of Ghana's scientific and technological information system	511
Mikulin, V. B.	Large span membrane suspension roofs for Olympic sporting facilities in Moscow	734
Miriushchenko, L. F.	International Comparison of Value Data in Construction	752
Mitrofanov, A. I.	Economic methods of the Construction Management	614
Miyazaki, Katzumori	Building design and air-conditioning systems for energy saving in NTT	109
Molnár, L.	The use of system dynamics in housing sypply forecasting	747
Montedison, Ugo Monaco	Optimisation énergetique des fenêtres	270
Morris, Edwin N.	Moment-rotation relationship for joints in roof trusses with metal plate connectors	429
Mtui, A. L.	Building research institutions in developing countries, BRU an example	791
Mulvihill, Raymond A.	Some aspects of the design process in Irish towns	713
Munday, Michael	The role of education for information management in the building industries of developing countries	516
Murthy, C. K.	Cost Estimation of Reinforced Concrete Framed Structures for High-rise Residential Buildings	755
Møller, Ib	The geometric form of buildings – qualities and energy consequences. Four office-buildings analyzed	324
Naldi, Fulvio	Une banque de données sur les dispositions pour le bâtiment. Perspectives de gestion et d'emploi	687
Newton, G. H.	Testing flat plate solar collectors in conditions of variable insolation	105
Nielsen, Bjørn J.	The new concept of SfB Tables as a tool for the management of civil engineering projects	556
Nikitinski, V. I.	Concrete strength as function of time and water/ cement ratio in isothermic setting	691
Nilsson, Ingrid	Human experiences of windowless environments in factories, offices, shops and colleges in Sweden	234
Nor, K. M.	An Investigation Into The Nature Of And Barriers To Feedback In Communication On Building Sites	620
Obolensky, N. V.	Insolation and Sun Protection in Town-Planning	761
Obolensky, N. V.	Comprehensive prediction method of environment comfort in application of sun protection means in construction	767
Obyeschhenko, G. A.	Basic Trends in Energy Conservation in Precast Reinforced Concrete Industry in the USSR	703

Oleynik, P. P.	Production process preparation in construction	625
Ono, Tetsuo	Building design and air-conditioning systems for energy saving in NTT	109
Panurov, A. J.	Comprehensive prediction method of environment comfort in application of sun protection means in construction	767
Parker, Kenneth J.	Low Energy Building Design	60
Pedersen, Tor Arve	Solution by dry and non-water-borne system and by infiltration	252
Perrier, F.	Distribution et évacuation des eux, les problèmes des pays en voi de développement	349
Petrovnin, M. I.	An air supported pneumatic structure with a heat protection screen	659
Plessein, Boris D.	Développement de la préfabrication des maisons en éléments de grande dimension et activité du C.I.B.	770
Popescu, Calin	Construction site population: estimating the size and structure	633
Poultney, G. F.	Field trials in well insulated houses	288
Pultar, Mustafa	The CEMBIL Information Centre at Middle East Technical University	521
Qihao, Gu.	The utilization of local materials in the development of block construction	45
Quere, Jaques le	Utilisation de l'énergie solaire pour le chauffage des bâtiments	114
Rabinovich, G. R.	Optimization of calculation of water treatment facilities with the use of computers	381
Ramstad, Trond Ø.	Scandinavian timber frame house construction. Technical design and future trends	410
Rau, A. Nagabhushana	The Role of Construction in National Development	628
Rehm, Horst	Improvement of the heat insulation of multipane window glazing in residential buildings	298
Rektor, Joab H.	Inhabitants' Appreciation of the Environmental Quality in Public Housing Projects	203
Ringsholt, Thomas	Development of Building Materials and Low-Cost Housing in Indonesia	29
O'Rourke, Charles	The quantification of steel and concrete product use, by sector, in the Irish construction industry	35
Rubanenko, B. R.	Improvement of architectural and technical solutions of dwellings in the USSR	206
Rubinstein, Michel	Utilisation de l'énergie solaire pour le chauffage des bâtiments	114
Sagbakken, Thorleif	The new concept of SfB Tables as a tool for the management of civil engineering projects	556
Saglamer, Gülsün	A Dynamic Simulation Model for the Optimization of Solar Energy Flow Through the Building Envelope	262
Saglamer, Gülsün	Measuring Adaptability between Activities and Spaces in Dweling Units	145
Sakata, Taneo	Modular co-ordination in energy conserving design for living space	212

Saleh, A. I. A.	The relative importance of men and materials in determining the layout of a building site	636
Schlyter, Ann	The Basic Need of Space. An Example from a Squatter Settlement	216
Schlyter, Ann	Interdisciplinary Documentation on Human Settlement in some African Countries. A Progress Report from a Project	486
Sebestyén, Gyula	Building research in developing countries	796
Sebestyén, Gyula	System in construction	773
Segal, Dan	Analysis of Manpower Demand in the Israeli Building Sector	777
Semenova, E. I.	The main measures of improvement of enclosing structures in mass construction of the USSR	296
Shaffer, Louis Richard	Organization and management of construction (W-65)	541
Shakhparonov, V. V.	Production process preparation in construction	625
Scherbakov, A. V.	The main measures of improvement of enclosing structures in mass construction of the USSR	296
Singh, Surinder	Cost Estimation of Reinforced Concrete Framed Structures for High-rise Residential Buildings	755
Siviour, J. B.	Theoretical and Experimental Heat Losses of a Well-Insulated House	329
Sjøholt, Odd	Improved production planning and control, a cooperation between a Research Institute and 30 Building Contractors	583
Spence, R. J. S.	The properties and testing of limepozzolana mixtures	40
Spiridonov, A. V.	Comprehensive prediction method of environment comfort in application of sun protection means in construction	767
Spooner, D. C.	Preliminary measurements of the heat losses from an unoccupied house	333
Stang, Eigil	Project Management, an Experiment in Cooperation	640
Stathopoulos, T.	Natural Wind Effects on the Infiltration of Low-Rise Buildings	337
Stern, E. George	Up-grading of wood structures by use of improved mechanical fasteners	457
Sukhov, V.	Sound insulation problems in modern residential buildings	663
Sunley, J. G.	Wooden constructions and wooden housing	397
Svensson, Anders	Thermostatic radiator valves – functions and requirements	118
Sverdlov, I. Sh.	Methods of thermal drying and burning of sludge of town sewage	781
Szabó, Karol	Reduction of heat losses in dwelling by the application of new research knowledge	306
Szöke, Klára	Economic evaluations concerned with energy conserving improvements of the building envelope. Some Hungarian Examples	256
Takakusagi, Akira	Building design and air-conditioning systems for energy saving in N.T.T.	109
Tammes, E.	The thermal insulation-index of buildings	343
Terebessy, Ákos	Assistance in organizing building information systems for the developing countries	498
Thomas, K.	Wooden constructions and wooden housing	397

Tokarev, V. V.	Comprehensive prediction method of environment comfort in application of sun protection means in construction	767
Tonsky, D. G.	Improvement of architectural and technical solutions of dwellings in the USSR	206
Torrance, V. B.	An Investigation Into The Nature Of And Barriers To Feedback In Comminication On Building Sites	620
Travoush, V. I.	Multiply wooden structures used for roofs of sports facilities	784
Trofimov, V. I.	Large span membrane suspension roofs for Olympic sporting facilities in Moscow	734
Tsaplev, Nicolaï N.	Développement de la préfabrication des maisons en éléments de grande dimension et activité du C.I.B.	770
Tsimbler, V. B.	The main measures of improvement of enclosing structures in mass construction of the USSR	296
Turner, Gilbert	Education for building development in third world countries	644
Vedel-Petersen, Finn	Planning of Housing Development and the Social Environment	221
Vinci, Roberto	Une banque de données sur les dispositions pour le bâtiment. Perspectives de gestion et d'emploi	687
Vinci, Roberto	Optimisation énergetique des fenêtres	270
Vinci, Roberto	Une hypothèse de programmation de la recherche dans le secteur de bâtiment en ce qui concerne le contexte italien	683
Volbeda, A.	Building Information in Developing Countries; International Support of National and Local Activities	423
de Vries, K. L.	Building Information in Developing Countries; International Support of National and Local Activities	423
Wai, F. M.	A hybrid simulation technique for predictions of seasonal energy consumption	321
Wantur, Helmuth-Zdenko	Prefabricated girder box units under unequal loads	787
Ward, I. C.	An investigation into the use of fixed horizontal shading devices to control the internal environments	720
Ward, I. C.	An analysis of the net short waves radiative balance of buildings within proposed urban complexes with different building densities, orientations and shapes for Lahore, Pakistan	667
Warszawski, Abraham	Organization of Construction Company	649
Webb, Thomas Lodevyk	Building research for both worlds	812
Weber, Helmuth	Solar technique in the building construction. Aspects in the field of building construction and design	122
Webster, John A.	Design Methods for Timber Structures in Seismic Zones	463
Westerberg, Ulla	Dwelling Habits and Dwelling Standards – Results of an Interview Study on 308 Swedish Households	227
Whitehead, B.	The relative importance of men and materials in determining the layout of a building site	636
Wissmann, Wilhelm	Advanced methods of documentation	529
Wright, Richard N.	Modeling of Standards	492

Wyon, David P.	Human experience of windowless environments in	
	factories, offices, shops and colleges in Sweden	234
Yavuz, Servine	Building Documentation, a Case Study in Turkey	488
Yilmaz, Zerrin	Building Facade Design from the Standpoint of Solar Radiation and Air Temperature Control	266
Yürekli, Hülya	Measuring Adaptability between Activities and Spaces in Dwelling Units	145
Zapke, Wilfried	The reduction of energy consumption in the heating	284
Zapol, M. Yu.	Multiply wooden structures used for roofs of sports facilities	784
Zenkov, V. G.	Energy-saving structural designs for wooden panel houses	469
Ziolko, Janusz	Need of education on the project management area on the technical colleges and universities	587
Ziolko, Janusz	The new concept of SfB Tables as a tool for the management of civil engineering projects	556
Ziolko, Janusz	The advanced use of Norwegian National Building and Civil Engineering specifications in project management	654
Özsoy, Ahsen	Measuring Adaptability between Activities and Spaces in Dwelling Units	145