RFID and BIM-Enabled Smart Industrialized Construction

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Construction matters for the world economy
... but has a long record of poor productivity

Construction-related spending accounts for 13% of the world’s GDP
... but the sector’s annual productivity growth has only increased 1% over the past 20 years

$1.6 trillion of additional value added could be created through higher productivity, meeting half the world’s infrastructure need

Construction is a sector of two halves

Fragmented specialized trades drag down the productivity of the sector as a whole

Construction productivity by subsector
Value added per employee, indexed total sector=100, 2013

- 100
- 104
- 119
- 124

% of construction value added

Total
Building
Civil
Industrial
Specialized

(Shaping the Future of Construction, World Economic Forum 2016)
Our Research on Construction Industrialization

01 ➤ We focus on large-scale, complex, and interdisciplinary collaboration in the area of Construction Industrialization by integrating expertise of researchers with diverse professional knowledge and background.

02 ➤ National Research Programmes + NSFCs + ITFs + GRFs + PPRs

03 ➤ A solid international collaboration with internationally leading research institutions such as University of Cambridge and University of Alberta in this area.
Examples of research projects undertaken

Innovation and Technology Commission: Innovation and Technology Fund + Public Sector Trial Scheme
RFID-enabled BIM Platform for Prefabricated Housing Production in Hong Kong
• To help creating smart construction infrastructure where real-time construction data are captured using advanced ubiquitous devices;
• To provide service-oriented decision support systems for facilitating decisions and operations at three key stages of the house construction project lifecycle;
• To provide real-time information traceability, visibility and interoperability tools that integrate and interact with existing information systems

National Basic Research Programme - Ministry of Science and Technology (6.3): National Standards on Critical Technologies for Construction Industrialization
• Comparative analysis of standardization framework among different countries
• Investigation and optimization of the supply chain for Construction Industrialization

National Basic Research Programme - Ministry of Science and Technology (7.1): BIM-based Key Application Technologies For Construction Industrialisation
• To enable effective management of the supply chain in prefabricated housing production
• To facilitate stakeholders to assess and manage the real-time data of a specific building project
RFID-Enabled BIM Platform for Prefabricated Housing Production in Hong Kong

In collaboration with HKU
Funding Schemes: ITF, PSTS
BIM + IoT + Construction Industrialization

Problems addressed:

- Coordinate different stakeholders
- Schedule precast in very small site
- Update BIM model with real data
- Avoid misplacement of precast concrete

......
The RFID-Enabled BIM Platform

The RFID-enabled BIM platform (RBIMP) aims to develop a **smart and intelligent system** for enhancing **prefabricated housing production**. Benefits of the integrated platform include:

- **Seamless communication and coordination among multiple stakeholders through improved information interoperability between processes**;

- **More efficient cross-border logistics and supply chain management (LSCM) through improved real-time information visibility and traceability**;

- **Seamless communication and coordination around construction sites to enable a Just-In-Time (JIT) delivery of prefabricated elements to the construction site**.
Overview of RBIMP

Key Users
- Client
- Contractor
- Manufacturer

Systems
- RBIMP
  - DSS: Prefab Production Management Services
  - DSMS: Cross-border Logistics Management Services
  - DBMS: On-site Assembly Management Services

Software Layer
- Data Brokering Service
  - Definition
  - Configuration
  - Execution

Gateway Operating System and Management Tools

Hardware Layer
- Cutting & Preparing
  - De-moulding
- Operator
- Data Brokering Service
- Truck Load
- Truck Unload
- On-site Receiving
- On-site Assembly

Data Source Interoperability Services
- Platform Service Management

Database

Platform Services Management

Traceability and Visibility Tools

Operator

RFID-enabled Building Information Modelling Platform (RBIMP)

Systems
- BIM System
- ERP
- MM System

Integration
- (SaaS)
- (PaaS)
- (IaaS)

Overview of RBIMP
Prefab Production Service

To manage and search prefabricated components from factory, buffer and laydown area in a more prompt and efficient manner by adopting RFID technologies

Productivity indicators:

- Stock management
  (e.g. number of precast components/assets being correctly selected, number of precast components/assets being prepared for pickup)

- Production lead time
  (e.g. time to locate precast components and corresponding position, delays in logistics activities waiting for precast components)
Cross-border Logistics Service

To facilitate the prefabricated components to be traced and delivered just in time

(1) Vehicle scheduling and task allocation

(2) Vehicle real-time traceability

Productivity indicators:
- Vehicle scheduling (e.g. time to arrange truck to arrive in factory/buffer/laydown area, matching truck and trailer)
- Task allocation (e.g. time to allocate the driver)
- Accuracy and frequency of the vehicle tracking
On-site Assembly Service

To integrate the information collected (in production and delivery) to monitor and control the assembly progress precisely for effective time and cost management

Productivity indicators:
- Assembly productivity (e.g. time to assemble each prefabricated component, number of errors in assembly, number of unrepaired prefabricated components)
- Efficiency of coordination
Smart Construction Objects

- Capture real-time data of **precast elements**
- Share real-time data among **major stakeholders**

[Images of construction site and technology equipment]
Smart Decision Support

- Coordinating orders for **major stakeholders**
- Tracking and monitoring individual components in a real-time manner
- Anticipating problems in **supply chain management**
### Implementation of the Platform in Housing Projects

<table>
<thead>
<tr>
<th>Items</th>
<th>HKHA</th>
<th>HKHS</th>
<th>Description (HS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of precast elements</td>
<td>Precast façade, staircase, semi-precast slab etc.</td>
<td>Prefabricated façade</td>
<td>Only prefabricated façades are incorporated in HS’s project</td>
</tr>
<tr>
<td>RFID tagging method</td>
<td>Fixed on the reinforcement bar of prefabricated façade</td>
<td>Glued on the interior surface of prefabricated façade</td>
<td>3 in 1 smart tag solutions which include RFID, NFC, and QR code</td>
</tr>
<tr>
<td>RFID tagging position</td>
<td>At underneath bottom left-hand-corner of window</td>
<td>At the left-hand of façade, 1200mm above S.F.L.</td>
<td>Tagging position is fixed on the left-hand of façade, 1200mm above S.F.L.</td>
</tr>
<tr>
<td>Data capture method</td>
<td>Hand-hold RFID reader</td>
<td>Wearable RFID reader</td>
<td>More convenient and portable compared with the hand-held one</td>
</tr>
<tr>
<td>On-site buffer</td>
<td>Large</td>
<td>Small</td>
<td>Two façade yards with small tolerance for schedule delays</td>
</tr>
<tr>
<td>Real-time monitoring on-site buffer</td>
<td>N/A</td>
<td>Two types of status: occupied and available</td>
<td>Displayed in different colors to signify the status of buffer</td>
</tr>
<tr>
<td>Production cycle time</td>
<td>6-day production cycle</td>
<td>6-day and 4-day production cycle</td>
<td>Production cycle time is supposed to accelerate to 4-day cycle</td>
</tr>
<tr>
<td>Real-time progress chart</td>
<td>Master program (RC works)</td>
<td>Installation progress chart and master program (RC works)</td>
<td>Installation progress chart is added into the project progress chart</td>
</tr>
<tr>
<td>Visualization in 2D floor plan</td>
<td>4 stages visualization</td>
<td>6 stages visualization</td>
<td>Two stages regarding ‘producing’ and ‘ready to install’ are added to the previous system</td>
</tr>
</tbody>
</table>

### Summary of highlighted differences between HKHA and HKHS
Site Visits during the Implementation
Benefits to Project Stakeholders

- Receive accurate and reliable information
- Enable efficient cross-border logistics and SCM
- Provide real-time monitoring: alert, alarm, action
- Make continuous improvement to existing process
- Provide seamless communication among stakeholders
- Avoid installation errors, immediate identification of errors
Summary and Conclusions

- Construction industrialization is the future of the construction industry
- More in-depth ground-breaking research is needed in this area
- Established a strong foundation for this special application
- The technology and the platform are getting more mature
- We have accumulated more experience and know-how
- Need customization of the platform for different projects
- Happy to explore possible collaborations with you
Sustainable Construction Lab

- Established in 2008
- Led by Chair Professor in Construction Management
- Focused on Sustainable Construction related research and development
- Supported by various sources of research funding
- Construction industrialization is one of the focus areas
- Established Strategic Focus Area by PolyU
- Strong collaboration with leading universities internationally
- Strong collaboration with industry practitioners as partners
Thank you for your attention!

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