News Article for RISUD Strategic Focus Area (SFA) Scheme

		Name	Department
1.	**Principal Investigator**:	Geoffrey Shen	BRE
2.	**Name of SFA:**	Construction Industrialisation	
3.	**Project Title:**	A technology-enabled interdisciplinary platform for innovative façade design and installation in industrialized building construction	

4. **Third Year Progress/Achievement**

An Innovative Industrialized Load-Bearing Service Core System for High-Rise Residential Buildings with Optimized Productivity, Adaptability, Diversity, and Sustainability

1. Introduction

The construction industry accounts for 13% of the world's GDP, but it is often criticized for its slow improvement in productivity. According to a recent report published by McKinsey (2017), the construction industry has only managed to have about 1% annual productivity gain over the last 20 years, in comparison with 5-6% productivity improvement in other industries such as manucturing. Hong Kong's construction industry is of no exception of this global problem, and worse still it is coupled with extremely high construction cost of housing projects, which is ranked 3rd among global cities, and many housing projects have experienced significant cost overruns and schedule delays, 15.22% delay on average in public housing projects and there are around 260,000 applicants for public housing in 2019 (Arcadis, 2019; Housing Authority, 2019). The industry is also facing extremely challenging conditions such as harsh weather, congested site, and frequent labor shortages (Li et al., 2017, 2018). These hardships strain the industry's ability to execute work efficiently, and often result in considerably high capital costs. One of the innovative solutions is Construction Industrialization (CI) where a large number of components are prefabricated offsite in modules and are transported to site for installation and assembly. Both the Singaporean and Hong Kong governments are promoting similar approaches with "Prefabricated Prefinished Volumetric Construction (PPVC)" and "Modular Integrated Construction (MiC)" programs respectively. However, the current industrialized building systems (IBS) in the market under the name of PPVC or MiC are often challenged for their poor performance in addressing the increasing need for productivity, adaptability, diversity, sustainability, some even call them "fake systems". One of the promising IBS is the load-bearing service core (LBSC) system, but its suitability for high-rise buildings in densely populated cities such as Hong Kong needs further investigation.

This research aims at developing an innovative industrialized load-bearing service core (LBSC) system for high-rise residential buildings, and an associated collaboration mechanism among stakeholders plus a digital platform in supporting the implementation of the proposed system.

This research proposes an innovative IBS for high-rise residential buildings, and creates a collaboration mechanism and platform of digital technologies to improve productivity, competitiveness, and performance of the construction industry. This is closely related to the priority themes of the Government as announced in the Chief Executive's 2018 Policy Address: "The Government is proactively promoting the adoption of technology and innovative construction methods to improve productivity and cost-effectiveness." The completion of this project will help uplift the construction industry with advanced IBS and frontier technologies of digital twin, IoT, BIM, network analysis, and simulation technologies. This research proposal has already received overwhelming support from a wide range of key stakeholders in the industry including clients, consultants, and contractors, as organisational partners. All of them believe the proposed system, mechanism and technologies have a strong advantage in optimizing the productivity, adaptability, diversity, and sustainability, and they will work with the research team closely and implement the deliverables in their business.

2. Breakthroughs and Deliverables

This project creates a strong foundation to improve the construction industry significantly and address the grand challages faced by many high-density cities such as Hong Kong, with the following breakthroughs and innovative solutions:

(1) ***An innovative industrialized load-bearing service core (LBSC) system for high-rise residential buildings with optimized productivity, adaptability, diversity, and sustainability.***

Most of the existing MiC solutions do not offer individualized/customized products, as individuals are different from each other and from themselves through time. Current solutions are also not adequate to resist vertical and lateral forces (wind and seismic), embrace strong interlocking connections, avoid cast-in-place concrete (wet) trade on-site, achieve long-span floor system, achieve product dismantlability and recycling by using dry joints and avoid steel structure due to the fire safety. The concrete-oriented IBS structure also needs to reduce its weight for transportation, achieve cost-efficiency, and to ease the constructability on-site. There is an urgent need for new approaches, methods, and systems to address these issues.

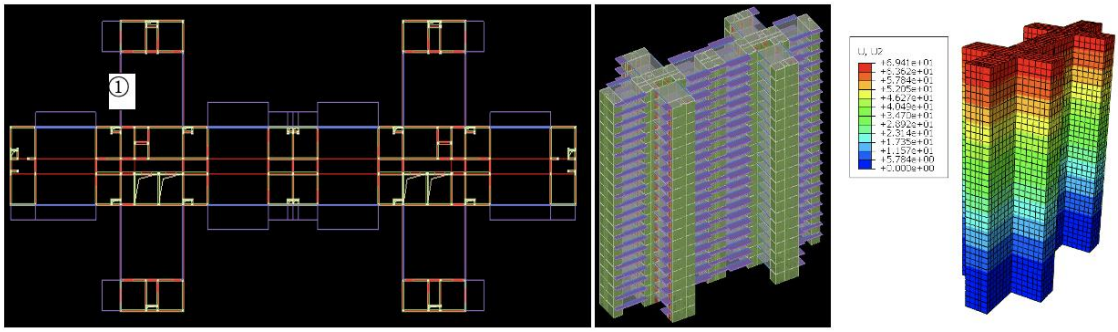

Figure 1 - Structural model of the proposed system

(2) ***A collaboration mechanism among stakeholders in the above value chain of construction industrialisation and improved understanding of their complex relationship and***

interactions. The industrialisation of construction involves many stakeholders with diverse occupational and professional backgrounds, broad geographical spread, and different interests in the project. The deployment of construction industrialization, if not planned and coordinated appropriately, may adversely affect the end results and become counterproductive. IBS settings should take into account project and industry factors such as product complexity in design and construction, informatics, customization, market and profit, and involves increasing the complexity of stakeholders who could influence, inhibit and catalyse processes (Mok et al., 2015). The success of construction industrialization will depend on the level of collaboration among stakeholders (e.g., owners, designers, contractors, suppliers, and customers) (Li et al., 2017).

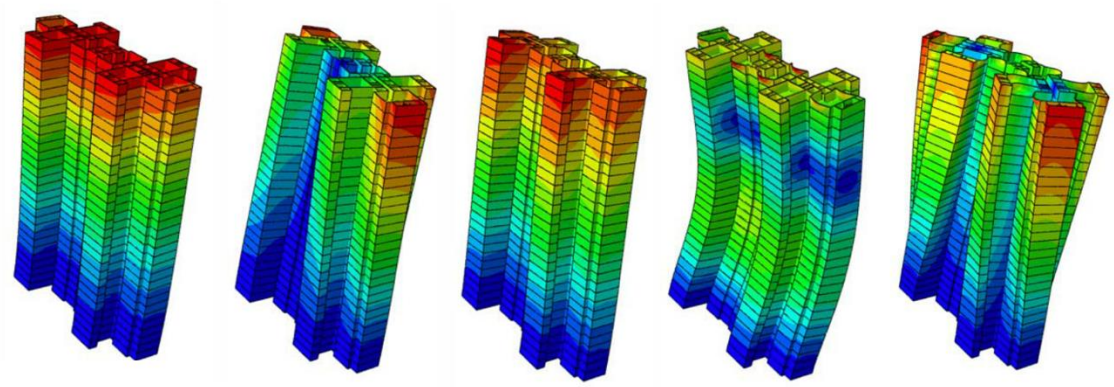

Figure 2 - Structural analysis of the proposed system

(3) ***An operational platform with enabling informatics and digital technologies to support the implementation of the proposed LBSC system for high-rise residential buildings.***

Innovation in construction informatization is key to facilitate and enhance collaboration (Li et al., 2019). Construction informatization consists of a range of computing technologies including digital twin, internet of things, building information modeling, sensing and tracking technologies, and simulation technologioes. Construction informatics can foster a collaborative platform for the complex network of stakeholders. Such integration of modularization with informatization would create a dynamic socio-technology system for construction industrialization.

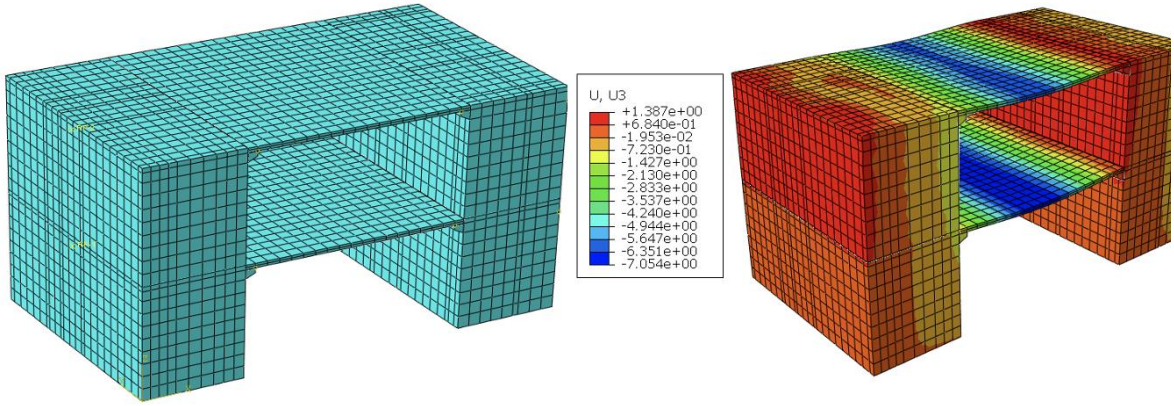

Figure 3 – Connecting the service cores in the proposed system

(4) A demonstration project to illustrate the viability and the superiority of the proposed system for high-rise residential buildings

It includes a detailed description of the innovative LBSC system for high-rise residential buildings with optimized productivity, adaptivity, diversity, and sustainability, a guide on the **collaboration mechanism** for stakeholders in the implementation of the LBSC system, based on improved understanding of stakeholders' interests, relationships, and interactions; and an **operational platform** with enabling informatics and digital technologies to support the implementation of the proposed LBSC system for high-rise residential buildings.

3. Potential Beneficiaries

In the short term, the proposed industrialised LBSC system for high-rise residential buildings will benefit major stakeholders such as government, contractors, designers, and suppliers in the residential development in Hong Kong, in terms of productivity, adaptability, diversity, and sustainability. The implementation of the proposed system will help resolve the urgent need for public housing to meet the need of the 260,000 applicants in the waiting list and to cater for their changing needs in the years to come. In the medium and long term, the general public with urgent and diversified housing needs in many high-density cities such as Hong Kong will benefit from the implementation of the system, with reduced waiting time for housing, improved adaptability and diversity, and improved sustainability in housing development.