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Modular Integrated Construction (MiC) Development in Hong Kong

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About JLFC and the JLFC Report Series

The Joint Laboratory on Future Cities (JLFC) was set up jointly by the Faculty of Engineering and the Faculty of Social Sciences at the University of Hong Kong in July, 2019. It was founded by Dr. Keumseok (Peter) Koh, Mr Tong Leung, Professor Becky P.Y. Loo (Founding Co-Director), Professor Thomas S.T. Ng, Dr. Hayden So (Founding Co-Director), Ms. Rosana Wong, and Professor S.C. Wong. The main aim of JLFC is to establish a platform that facilitates studies on future cities: the people that live in them; the natural environment that they must coexist with; and the technologies that will enable these activities.

As urbanisation sets to become a global trend in the coming century, an increasing portion of the Earth's population are going to be migrating into cities on a global scale. Such massive increase in urban population not only put significantly stress on the existing infrastructure but also challenge every aspect of the human-environment relationship. To ensure the sustainability and resilience of future cities, there is a genuine imminent need to develop fundamentally innovative approaches of constructing and conceiving the ways in which future cities will operate. It is clear that any solutions to the challenges faced by future cities are going to require talents from a wide range of disciplines to innovate in an interdisciplinary environment.

The JLFC incubates such environment through a series of interdisciplinary projects, symposiums and workshops that involve academics, the industry, as well as the government. JLFC was made possible by the generous support by the Prosit Philosophiae Foundation. We also work in partnership with the Global Future Cities AI Lab.

The JLFC Report Series aim to provide state-of-the art reviews of key urban theories/concepts and real-life experiences. A particular focus is placed on the experience of Hong Kong as a high-density and compact city, and its relevancy to other metropolitan cities around the world. All reports in the JLFC Report Series are free for download by the general public. Comments and suggestions either on specific reports or the series may be directed to jlfc@hku.hk.

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1. MiC Definition

Modular Integrated Construction (MiC) is a construction method that employs the technique of dividing a building into individual units (with finishes, fittings, and most building services systems etc.) manufactured factory and then transported to the site for assembly (BD, 2022). The MiC approach integrates complex systems, modularity, and lean manufacturing principles into building construction (Wuni, 2022). The frequently mentioned concepts in off-site construction are prefabrication with MiC, and the concepts are sometimes confused for use. According to the definition of the Hong Kong Construction Industry Council (CIC, 2018a), the key differences are:

A. Site construction procedures. After the prefabrication components are transported to the site, most of the remaining structural parts still need to be constructed using traditional construction methods, followed by renovation and plumbing. In contrast, MiC only needs to align and connect the interfaces of the various facility modules and deal with joints after being lifted to the site.

B. Component elements. Prefabrication is a general term for prefabricated facades, prefabricated floor slabs, prefabricated interclub walls, prefabricated staircases, etc., and is only used as basic units for the structural expression of the participating buildings. MiC contains the assembled structural components and also have a complete and independent fit-out and building services programme, as shown in Figure 1.

Figure 1. Prefabricated component and MiC lifting process in Hong Kong (ITIB, 2021)

MiC is the highest level of prefabrication (Wuni & Shen, 2020). Several regions and countries, including mainland China, Hong Kong, Singapore, the UK and Australia, are using high-level prefabrication for the construction of buildings (Tsz Wai et al., 2021; Xu et al., 2020), as it is considered a disruptive construction method (Wuni & Shen,

2021; Yang et al., 2019) that improves the competitiveness and project performance of the construction industry in terms of cleaner operations, construction safety, project progress control, quality enhancement, cost conservation, minimisation of material wastage to improves sustainability (Jaillon et al., 2009; Wong and Loo, 2022).

2. MiC Development in the Public Sector

Stage 1: 1980s-1990s

The Hong Kong Government regards MiC as an invaluable construction method; prior to this, prefabrication was the focus. Discussion on modularity in construction began in the 1950s (Wong and Loo, 2022); still, prefabrication combined with modular design was used in public housing construction in Hong Kong in the 1980s (Jaillon et al., 2009), mainly for staircases, floor slabs and facades etc. (Jaillon & Poon, 2009; Mak, 1999). By the 1990s, prefabricated components/assemblies accounted for 18% of the average construction work of the Hong Kong Housing Authority (Ansah et al., 2021). Built between the mid-1980s and mid-1990s, Harmony 1, 2 and 3 Blocks have built-in standard modular forms using precast concrete facades, staircases and semi-precast concrete floor slabs with a work cycle of 4-6 days (MAK, 2020), as shown in Figure 2. At the same time, the prefabricated components industry has been transferred from local factories to the Pearl River Delta Region, Mainland China (Breitung, 1999) and mainly by trucks to Hong Kong (Li et al., 2016).

Figure 2. Harmony Block construction project: (a) Precast façade. (b) Precast

elements during lifting. (c) Bird view in construction. (d) Elevation (Yip, 2002).

Stage 2: 2000-2017

Traditional on-site casting can be dangerous, polluting and labour-intensive (Zhang et al., 2018). In 2001 and 2002, the Hong Kong Special Administrative Region (HKSAR) government introduced the Joint Practice Notes 1&2, which granted gross floor area (GFA) exemptions for building developments using prefabrication (BD, 2001, 2002). A study found that in the construction of public housing in 2006, prefabricated elements were used primarily for structural components and panel wall partitions (Chiang et al., 2006). By 2013, prefabrication rates of up to 65% could be achieved, including prefabricated kitchens and bathrooms (Li et al., 2016). Figure 3 shows Greenview Villailla construction, the first subsidised sale project was completed in 2015 using prefabricated technology, the small to medium-sized units on offer were built to an overwhelming market response. Choi et al. (2019) suggest that the development of the building sector has been in the predicament of a lower level of prefabrication and has not been able to move to a higher level of modular reduction with volumetric applications, permanent modular buildings and accelerated bridge construction in Hong Kong.

Figure 3. Prefabricated component and construction of Greenview Villailla (HKGBC, 2016)

Stage 3: After 2017

MiC was first mentioned in HKSAR policy in the Chief Executive's 2017 Policy Address to promote innovative architecture and thus increase construction productivity; in 2018, the government further published Construction 2.0, which outlines the changes required in the construction industry, including MiC. Apart from these, the government has developed a range of local promotion measures:

A. Simplify regulatory review of MiC systems by establishing a pre-approval mechanism for universal design in 2017, which approved that MiC systems can be used for future projects for up to five years without needing approval again; 64 MiC systems have been agreed upon in principle to date.

B. At the International Conference on Modular Integrated Construction, the government established the Construction Industry Innovation and Technology Fund (CITF) in October 2018 to encourage the development of the construction industry through the use of modular building methods (Tam, 2018). Within the scope of funding, direct grants of up to 70% of the costs involved or HK$7.5 million, whichever is lower (Xu et al., 2020), are provided to contractors and consultants for MiC projects, 1651 MiC projects have been allocated a total of HK$115 million (LegCo, 2022).

C. 6% additional Gross floor area (GFA) to developers using MiC technology from May 2019; 1711 MiC concession applications approved up to August 2021 (LegCo, 2022).

D. Mandatory adoption of MiC for six types of government building projects (e.g. schools and office buildings) starting from April 2020 under the Capital Works Programme (CWP) (Jin et al., 2022).

In the subsequent years, the construction industry in Hong Kong has used MiC as an innovative and efficient technology for a number of construction projects. Pilot projects designated by the government, the first batch of public works projects to adopt MiC are InnoCell (2019-2020) in Tai Po and the Fire Services Department Disciplined Services Quarters (2018-2021) in Pak Shing Kok, Tseung Kwan O. In the aftermath of the pandemic, the government built Temporary Quarantine Facilities (TQFs) using MiC technology, with the success of four TQFs, including Lei Yue Mun Park, Penny's Bay on Lantau Island, etc. With the adoption of MiC, the start and handover were achieved in a short time.

Shifts in construction methods have changed the overall degree of modularity of building construction over time (Wong and Loo, 2022). With the substantial support of the government, there was a marked increase in level of prefabrication in the public sector from 1980s to now, as shown in Figure 4.

Figure 4. Development of the degree of prefabrication in the public sector. Photo source:(1-3) Sau Mau Ping Estate Redevelopment

Phase 5 (1998 - 2000) (Poon, 2010); (4) Precast Slab (HD, 2022); (5-6) Prefabricated components (HKHA, 2016); (7) Precast balcony (Poon, 2022); (8-12) Prefabricated components (DB, 2020). (13-14) Temporary Quarantine Camp in Penny's Bay (ASD, 2022); (15-16) Temporary Quarantine Camps at Lei Yue Mun Park (ASD, 2020); (17-18) Married Quarters for the Fire Services Department at Pak Shing Kok in Tseung Kwan O (CIC, 2022a); (19) InnoCell, Pak Shek Kok, Tai Po (Construction+, 2022);(20) Residential Care Homes for the Elderly ("RCHE") in Kwu Tung North (CIC, 2022c)

3. MiC Development in the Private Sector

Prefabrication has not developed as fast in the private sector, which continues to lean heavily on traditional construction methods, including cast-in-situ concrete with timber formwork and the use of bamboo scaffolding. Prefabricated technology was applied to private sector projects in 1998; before 2002, only four private residential projects in Hong Kong had adopted prefabricated facade technology (Zhang & Xu, 2022). The situation has changed over time, though private projects are still burdened with bank debt and considerable advance payment of prefabricated components (Ng & Ng, 2019). Currently, most private homes use prefabricated facades attributed to the Joint Practice Notes 1&2. However, the application of MiC in the private sector remains challenging. Tam et al., (2002) examined three options for housing construction in Hong Kong and concluded that the prefabricated alternative is the most expensive because it offers the shortest construction time. Prefabrication is not a preferred option for private contractors if it is not mandatory.

4. Current Dilemma

Despite the above policy incentives and MiC being considered the mainstream construction method of the future, some developers are not keen to apply the assembly method. In one survey, industry respondents identified inconsistencies in specifications, conflicts with traditional design processes and the lack of incentives as significant barriers to the widespread use of MiC in Hong Kong (Jaillon et al., 2009). MiC also faces additional challenges as follows:

A. Transport factors. Roads to building sites are often not wide enough to transport larger modules. As shown in Figure 5, the prefabricated components are large in size and roads in Hong Kong are generally only 3.3m wide or narrower, resulting in roads to building sites often not wide enough to transport larger modules (Pan et al., 2022). Developers will need to apply for an over-width goods transport permit if the components are wider than 2.5 m, and a traffic impact assessment report

if the components are wider than 3.0 m (BD, 2020).

Figure 5. Prefabricated components of brige and pipe (CIC, 2018b)

B. Technical factors. a) MiC has high dimensional and geometric requirements, with high corrective procedures and rework costs when defects occur (Tsz Wai et al., 2021). In addition, there are concerns about the difficulty of design changes (Wuni et al., 2022). b) Geographical constraints make the layout of buildings challenging due to the limited surface area available for construction, the generally small size of building sites, and the complex topography that makes it difficult to store and assemble components (Zhang et al., 2021).

C. Financial factors. MiC generally involves a high initial upfront payment (Bertram et al., 2019); one study suggests that using prefabricated components may cause unit construction costs to be approximately 15% higher than traditional construction costs (Liew et al., 2019). Abdelmageed et al. (2020) argue that even if floor area exemption is granted for assembled composite projects, the policy incentive is largely offset by the disguised reduction of usable floor area due to the additional structural walls required to apply the method.

D. Human resource factor. As shown in Figure 6, the construction of prefabricated buildings requires professionally trained workers, there now a shortage of professionally trained personnel (Khalfan & Maqsood, 2014), and almost all building components used in Hong Kong are manufactured in mainland China (Jin et al., 2018), raising concerns about the long-term impact of assembly methods on the livelihoods of local construction workers.

Figure 6. Prefabricated Construction Workers in Singapore and Hong Kong (P&T GROUP, 2019).

"MiC is mainly at the advanced demonstration stage in Hong Kong." (Anson et al., 2021) In addition to the policy benefits, sometimes there is a lack of momentum to beat traditional construction methods in Hong Kong.

5. Potentials of MiC

Despite the resistance above, over 70 MiC projects have been initiated in 2022 (HKSAR, 2022), as shown in the Figure 7. Broader applications in the future are likely to be initiated and funded by the government, such as school buildings, transitional social housing, hospitals, nursing homes, etc. For instance, it is expected that over 20,000 units of public housing will use MiC (Ng, 2022).

Figure 7. Courtesy of City University of Hong Kong, The Hong Kong Girl Guides Association Headquarter and Youth Hostel, Residential Care Homes for the Elderly

("RCHE") in Kwu Tung SNorth (CIC, 2022b)

In the future, Building Information Modelling (BIM) will be more widely used by MiC projects as an integration tool, as it allows for effective information exchange and interoperability during the planning and design, off-site construction and operational phases. Other technologies can also be integrated into BIM to facilitate information gathering and decision support for the construction process, e.g. the Internet of Things (IoT), construction robots, and cloud computing.

6. Summary

The construction industry in Hong Kong is facing challenges posed by limited land, high waste generation, and high risk and labour intensity. MiC is seen as an excellent way to address these issues. This document outlines the development of prefabricated buildings and MiCs and looks at their potentials in Hong Kong, with the hope that MiC can leverage the power of technology to emerge from their current predicament and realise their maximum construction potential. Meanwhile, the implementation of MiC has been supported by the government. However, it is still a novelty and imperative to overcome various challenges to its successful implementation in Hong Kong.

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