Social Cohesive Approach to High-density Communities:
Co-living and Modular Integrated Construction as a Way Forward

Ying-Sheng Zheng¹, Alex Yeung¹*, Koon Kwan Shing¹, Mei Yun Law¹, Samuel Lee¹, Ivy Lee¹*

¹ Leigh & Orange Ltd. 801, Dorset House, TaiKoo Place, 979 King’s Road, Hong Kong
*alex.yeung@leighorange.com
*ivy.lee@leighorange.com

Abstract. Limited land resources and dense population result in high living density in Hong Kong, where the current housing supply is not able to fulfil the growing housing demand, which leads to a crowded living environment and an elevated housing price. Thus, there is an urgent need to accelerate the delivery of new housing. Moreover, this high density living might increase psychological stress, due to the reduction in privacy and limited social interactions. Under these circumstances, creating co-living communities using the Modular Integrated Construction (MiC) methods could be beneficial in addressing these issues. Co-living facilitates social interactions and reduces living costs through the sharing of living spaces, while applying the MiC method shortens the construction process, mitigates labour shortage and on-site pollution through its modularised design and off-site production.

This study aims to introduce a framework of creating a co-living community, through the case study of a pilot co-living project called “InnoCell” located in Hong Kong and designed by Leigh & Orange Ltd. In this project, diversified communal services are integrated to accommodate the increasing needs for social activities in addition to providing shelter. MiC methods of construction are applied to the living units, which shorten the construction time, mitigate the noise and air pollution on site, allow better quality control and minimise substandard works through off-site
production. Daylight and air ventilation conditions are also examined to evaluate the indoor environmental conditions. In micro and macro perspectives, InnoCell will not only influence the residents’ lifestyle, but is also likely to initiate a new trend of living in Hong Kong. This study introduces a well-considered co-living design framework with the application of MiC methods, which could be further explored in other regions, especially other high-density cities, e.g. New York, London, and Singapore, etc.

1. Introduction
Hong Kong is a high-density city famous for its dense population, high-rise urban morphology, and hilly-coastal topography. Its total land area is around 1,105 km², while only 24% of the land is permitted for urban development, and the rest is mountainous area served as country parks [1]. Hong Kong has a population of around 7.5 million, and the highest district population density has exceeded 60,000 persons/km² in 2018 [2]. Hong Kong’s population is projected to reach 8.2 million in the 2040s. However, the current housing supply is unable to fulfil the growth in housing demand and thus results in an elevated housing price with much of the housing stack beyond the reach of many. From 2007 to 2016, the average annual housing completions amounted to 25,700 units, down by over 50% from the corresponding statistics for the preceding decade from 1997 to 2006 (an annual average of 59,800 units) [3]. The application of MiC is one of the approaches to accelerate the housing supply as it has a higher time efficiency through the application of modularised design and off-site production.

On the other hand, lack of social cohesion under the existing high-density living environment has become a critical issue in Hong Kong. Due to limited land resources and high population density, 90% of the residents are living in high-rise buildings and have to share limited communal space without effective social connections [4]. As lifestyle and living requirements have changed in recent years, there is an increasing demand for flexible lifestyle-based housing rather than the recent traditional residential style in Hong Kong. People expect more opportunities for social connections, collaborations, and communities beyond the provision of basic living requirements. Under these circumstances, a new living style of co-living could be a way forward as it facilitates social connection and collaboration, optimises space utilisation, and reduces living costs through the provision of sharing communal living spaces.

2. Literature Review

2.1. Emerging trend of co-living lifestyle
Co-living refers to the situation in which two or more unrelated individuals or families share living spaces [5]. Moreover, shared living spaces facilitate social interactions and assist in the decrease in risks of mental illness caused by social isolation. Modern co-living lifestyle was first introduced in Denmark in the 1970s [6]. Co-living communities have now spread across Europe, such as “Tech
Farm” in Sweden, “Quarters” in Germany, and “The Collective” in the UK. Co-living life style has recently also become popular amongst Asian people, which is possibly due to the comparatively high density and young demographics in major cities of that region. The residents who live in high-rise residential developments in Hong Kong have been accustomed to share normally centralised communal spaces and residential facilities, which is a primitive way of co-living but also the basis for the emergence of co-living communities. Driven by the prevalence of shared economy and the change of lifestyle of younger generations, co-living communities have become increasingly popular in Hong Kong. There are approximately 22 numbers of co-living schemes run by private companies and property developers across Hong Kong operating today [7].

2.2. Application of Modular Integrated Construction in Hong Kong

MiC is also known as “Prefabricated Prefinished Volumetric Construction” (PPVC) in some countries, e.g. Singapore and Australia. It is an innovative construction approach in Hong Kong, which challenges the statutory way of in-situ construction, and it has free-standing integrated modules (complete with finishes, fixtures, and fittings) prefabricated in a factory and then transported to the site for installation. The MiC method has advantages in simplified site management, better quality control, as well as a faster return on investment for the owner and contractor. A recent research has found that Hong Kong, US, UK, Malaysia, and Australia are the largest contributors of the promotion and development of MiC from 1993 to 2019 [8]. In Hong Kong, prefabrication with standard modular design was first applied to a public housing project in the 1980s [9]. The Hong Kong government has most recently been actively promoting MiC, with a series of measures introduced to encourage and regulate its development. The measures include incentives such as site coverage and gross floor area exemptions, and the release of the Code of Practice for Precast Concrete Construction.

3. Methodology – Case Study

3.1. Co-living project: “InnoCell”

InnoCell is a smart living project located in the Hong Kong Science and Technology Park, Tai Po, New Territories, Hong Kong. It consists of approximately 15,300 m² of GFA, laid out over 17 storeys, and will provide over 500 beds for Information Technology talents and their families. The building is created to serve as a platform to inspire interactions, collaborations, as well as smart and sustainable living.

3.2. Design considerations for spatial arrangement of co-living space

Previous studies have proved that architectural features in living environment influence the behaviour and psychological well-being of residents. Measures such as providing landscaped and well-maintained green public spaces and introducing natural & sustainable features in the living
environment assist in increasing residential satisfactions and hence overall well-being. The balance between community and retreat spaces, privacy and interaction activities is also paramount for a sense of well-being. Easy access to nature not only increases psychological benefit but also assists in reducing stress [10]. The provisions of basic living services are all critical to enhance satisfaction [11].

3.3. Daylight exposure and natural ventilation

Daylight is critical to regulating our bodies and also to energy saving. Spatial daylight autonomy (sDA) is a common measurement to evaluate the indoor light exposure, which describes the percentage of floor area that receives certain lux level for a certain percentage of annual occupied hours. Daylight requirements in WELL and LEED Building Standards could be referred to Table 1. The daylight exposure in InnoCell’s communal area on the 16/F was simulated using a widely applied daylight simulation software, Diva. Details of daylight simulation are listed in Table 2.

| Standard       | Feature/Credit | Illuminance | % of Time | sDA (% of Area) |
|----------------|----------------|-------------|-----------|-----------------|
| WELL v2.0      | L01            | 300 lux     | 50        | ≥ 70            |
| LEED v4 BD+C   | EQ-Daylight    | 300 lux     | 50        | ≥ 75            |

Adequate natural ventilation can effectively reduce building energy consumption by lowering the demand for air-conditioning whilst window positions, window types and building orientations are the key design factors for natural ventilation performance. Air ventilation may also be enhanced by locating windows in opposite directions or perpendicular to each other [12]. Furthermore, orienting the axis of the building with an angle of 45° rather than 0° to the prevailing wind direction can also be beneficial to the penetration of the prevailing wind into the indoor areas [13].

4. Results

4.1. Spatial arrangement of co-living space

Innocell provides a large open space with well landscaped greenery at ground level, where only necessary functions such as the entrance lobby and necessary technical rooms are provided in order to maximise the space availability for public events (Figure 1). Communal areas, which are located in the centre of typical floors, consist of a co-working space of 57 sq. m (620 ft²) and a communal area of 120 sq.m. (1,300 ft²) on each floor. Bedroom, bathroom and mini-workstation are private spaces, whilst the kitchens, dining areas and large co-working and co-living spaces are communal, i.e. shared.
Residents with similar working background and interests will be grouped to live closely, since they are expected to have better connection in their work and social life, and a greater collaboration is expected. The communal spaces support services such as communal cooking & dining rooms, games & music rooms, gymnasium and other amenity facilities including a roof garden for wider social gathering and even urban farming (Figure 1). The later two items provide opportunities for wider community interactions. The design of InnoCell encourages the residents to step out from traditional vertical habitation to share beautiful spaces and daily events with others.

Figure 1. Co-living space of InnoCell at different vertical levels

4.2. Smart and sustainable living environment

The co-living environment of InnoCell demonstrates advantages in both social and environmental sustainability. In terms of social sustainability, emphasis on a shared community is the key difference between InnoCell and traditional shared vertical dwellings. It facilitates social interaction and collaboration through naturally occurring social activities, and planned workshops and classes, which could all be helpful to mitigate psychological pressure and social isolation. Convenience is improved as it offers a ready-to-move-in living service with the provision of utilities and necessary furniture. In terms of environmental sustainability, energy consumption will be reduced with a co-living operational model compared to a traditional model. It is predicted that energy saving will be around 55% for lighting according to the simulation results from the environmental consultant of InnoCell.

Smart techniques and passive design strategies have been integrated into the InnoCell. This creates an eco-system for a 24/7 innovative lifestyle of “co-working and co-living”, which takes the tenants’ living behaviour into consideration and blends it with smart techniques, such as a smart booking system and smart control systems, which are incorporated to support and enhance the communal living of tenants. The smart booking system improves the efficiency and use of space through online booking by mobile apps. Smart control systems optimise the energy use of the HVAC and lighting system based upon the real-time spatial usage and monitoring sensors.

Windows are thoughtfully designed to optimise daylight and natural ventilation. Skylights are
introduced on the roof of the building, which contribute to the enhancement of daylight conditions on the top floors (Figure 2, left). According to the daylight simulation results, an 80.7% of the communal space, having over 50% occupied hours will achieve a daylight autonomy equal to or higher than 300 lux (Figure 2, right). It fulfils the daylight requirements set by WELL and LEED V4 BD+C standards (Table 1). To facilitate cross ventilation in communal spaces, windows are located on the north and east sides of the building, allowing annual prevailing winds from the east to effectively penetrate into the building through openable windows on the east facade, which will enrich air movement in the communal areas. Double-height communal spaces are also valuable to vertical air flows due to the stack effect.

Figure 2. Communal space with natural daylight and air ventilation on top floors (left)
Daylight simulation result in the communal space (right)

4.3. Application of Modular Integrated Construction in InnoCell
InnoCell takes advantage of the proximity and relatively low-cost manufacturing resources of the Pearl River Delta Region of China to promote the application of MiC. The MiC approach shows advantages in off-site construction for higher labour productivity, achieves better built quality, and also addresses the local Hong Kong labour shortage in the construction industry. It is expected to have better environmental performance through more extensive material management and more efficient production control in the factory when compared to the traditional on-site construction. MiC units will be transported to site for installation, which will shorten the total project construction time by around 30% on average. Based on the on-site monitoring from the contractors, MiC method improves discharged water quality through reducing suspended solid by 50% and lowering chemical oxygen demand by 80%, and over 5% mitigation of construction noise level is observed. Furthermore, air pollutant concentration on-site is around 75% lower than the limit level set by Environmental Protection Department of Hong Kong.

A systematic framework of applying the MiC approach into design and construction processes has been proposed in the project. The framework includes technical feasibility study, quality control, waste management and pollution control. In the technical feasibility study, the design team examined the statutory compliance with preliminary design, and conducted visits to MiC factories. For quality control, complex analytical and simulation models were built to demonstrate the constructability and test the potential for the design to be executed. In order to review the design and undertake
modifications, a prototype module was constructed prior to mass production of the MiC units. There are four basic types of MiC living units, including co-living unit, standard unit, sleep box unit, and family unit (Figure 3). Necessary private living functions such as toilet, bathroom, bedroom and mini-workstation are well organised in MiC modules (with limited size of 18/36m²). The modular design of living units is transformative and convertible to accommodate different needs of residents.

Figure 3. Transformative and convertible modular design

5. Discussion and conclusion

Although sharing living spaces and ideas of communal habitation are not fresh concepts, the evolution of a more organised arrangement and the application of smart systems to a co-living community are unique. It not only offers people a well-designed and well-serviced place to live in, but also creates a socially-friendly and interactive environment for an enhanced sense of community. Residents are encouraged to adjust their mind-sets from the traditional living concept to a new concept of “living outside the box”, walking outside and sharing daily events with the community. It is a modern lifestyle that values openness and collaboration to improve social cohesion and offers a total living solution without excluding further external interactions.

InnoCell is presented to demonstrate how to create a high-density co-living community integrated with multi-functionally communal spaces and how MiC living units can be created. Communal spaces are thoughtfully designed to not only incorporate multiple residential functions of living, working and playing, but also to fulfil the practical needs of adequate daylight and natural air ventilation. Communal spaces are organised vertically in the centre of the building, which permits high transformability to fulfil the diversified living requirements of different age groups of residents and accommodate their various backgrounds. The MiC approach is applied to the accommodation parts of InnoCell, which are supported by convertible modular designs, but also results in a challenge to interior design due to the limited MiC module size. Innovative interior solutions are proposed in this study to contain the necessary living functions within the modules, which are determined by multiple factors including transportation and infrastructure.

This study shows that a combination of co-living lifestyle and the application of MiC is a way forward to achieve high-density community living, as it achieves a good balance among fast construction process, modularised but convertible design, improved living and environmental
conditions and activated social connections. InnoCell is a pilot project using MiC to create a specific co-living project, the design framework of which is expected to be further applied to other similar residential projects (e.g. staff accommodation, elderly apartment, and public/private housing, etc.) and other metropolitan cities (e.g. New York, London, Singapore, and Shanghai, etc.), to improve social cohesion and accelerate the availability of housing supply under high-density urban scenarios.

6. Acknowledgements

Special thanks are given to the InnoCell project design team of Leigh and Orange Ltd., and the project management team of the Hong Kong Science and Technology Parks Corporation for their valuable comments and supports on the research.

References:
[1] HK Planning Department 2016 Statutory Plan Index.
[2] Hong Kong Census and Statistics Department 2018 Population and Household Statistics Analysed by District Council District.
[3] Task Force on Land Supply 2018 Insufficient Land Supply leading to Imbalance in Supply-Demand. https://www.landforhongkong.hk/en/demand_supply/index.php
[4] Ng E Editor 2009 Designing high-density cities: for social and environmental sustainability. Routledge.
[5] Cho G H, Woo A, Kim J 2019 Shared housing as a potential resource for community building. Cities. 87 30-38.
[6] Milman D 1994 The History of Cohousing. Canadian Cohousing Network.
[7] Coliving.hk Limited 2020 https://www.coliving.hk/
[8] Wuni I Y, Shen G Q 2019 Critical success factors for modular integrated construction projects: a review. Building Research & Information, 1-22.
[9] Mak Y 1998 Prefabrication and industrialization of housing in Hong Kong. D. The Hong Kong Polytechnic University, Hong Kong.
[10] Connellan K, Gaardboe M, Riggs D, Due C, Reinschmidt A, Mustillo L 2013 Stressed spaces: mental health and architecture. HERD: Health Environments Research & Design Journal, 6(4).
[11] Bâldea M, Dumitrescu C 2011 Contemporary High-Density Housing. Social and Architectural Implications. Acta Technica Napocensis: Civil Engineering & Architecture, 56(3).
[12] Gao C F, Lee W L 2011 Evaluating the influence of openings configuration on natural ventilation performance of residential units in Hong Kong. Building and environment, 46(4).
[13] Weerasuriya A U, Zhang X, Gan V J, Tan Y 2019 A holistic framework to utilize natural ventilation to optimise energy performance of residential high-rise buildings. Building and Environment, 153, 218-232.