Factors Affecting Open Building Implementation in High Density Mass Housing Design in Hong Kong

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Abstract
The vast majority of buildings being constructed in Hong Kong today are massive 40+-storey high-rise residential building towers housing hundreds of families. Immense resources – land, material, time, labour, money, energy – have been invested in their realization. However, almost all of these buildings, including those currently under construction and on the drawing boards, are not designed with adaptability and flexibility as a design intention and will cause major problems in the future: their lack of capacity for re-activation means that their only fate is demolition, thereby consuming even more resources, producing more waste, and causing more disruption to the environment. Unless we change our mind-set in mass housing design, today’s designs will inevitably become tomorrow’s problems. This paper studies the scenario design requirements and critical dimensions of use-territories in public mass housing in Hong Kong in view of extracting useful patterns for use in future designs. Case studies of popular residential layouts currently used in Hong Kong will be used to illustrate the kind of problems the majority of the existing residential building stock will face when the need for renewal and upgrade arises.

“Tomorrow is today.” - Martin Luther King Jr.

1. Introduction
In modern cities and countries, mass housing emerges as a more and more vital issue to the well being of the community. In places like Japan, Singapore and Hong Kong, a lack of developable land in urban areas makes multi-unit housing the mode of living for the vast majority of the people. In Hong Kong, such residential buildings typically extend over forty storeys to fully utilize the scarce land supply. At present, Hong Kong is the home to 24 of the 50 tallest residential building in the world1. All of these residential towers are over 60 floors in height with the tallest, Sorrento Tower 1, topping 75 floors at 256m (Fig. 1). The Hong Kong SAR Government provides and builds the majority of such high-rise residential buildings for both rental and sale, accounting for around 60% of all housing units currently occupied. At present, slightly over 50% of Hong Kong’s population live in some kind of public housing.

However, the room layouts variations of the present typical high-rise residential designs in Hong Kong are severely limited and cannot satisfy the highly variable spatial needs of the many users. Users have to make alterations to their units before moving in. Many even change the spatial layout of the units by knocking down brick walls and building new ones to form rooms that suite their requirements. Understandably, certain aspects of a building may become obsolete over time as the needs of the users also change. In this case, however, valuable resources - material, energy, time, money, manpower - are rendered obsolete before they are even put into use. Such immediate obsolescence is unacceptable in the light of the international direction towards a sustainable community. Flexible housing design can be a solution to this problem because with flexibility in layout configurations there is a better chance for the users to find a unit that can fulfil their respective spatial requirements.
One of the major objections to flexible designs is that flexibility entails complex construction and hence higher costs – the economy of scale through repetition is the main reason inadequate standardized designs are being used in the first place. This can be overcome by using a modular “kit-of-parts” to create the spatial configurations required for various spatial needs of the users. Although the room layouts inside a unit may vary, they are nonetheless composed of the same building elements from the modular “kit-of-parts”. Being modular, pre-fabrication technology can be utilized to further assure quality and save on costs. The Hong Kong Housing Department has itself identified prefabrication and flexible building designs as two key approaches to waste management in public housing production (Gabriel, 2000).

2. The Open Building System

The flexible or “open building” approach to mass housing design is actually not new. N. J. Habraken had proposed a similar approach to mass housing design in the 60’s and 70’s by organizing the built environment into a number of levels (Fig. 2). Within this hierarchy of levels, any given or fixed elements can be termed “support” and any element the user/designer is free to add in or change “infill” (Boekholt, Dinjens, Habraken, and Thijsen, 1976). Thus on the building lot level, the support is the government-controlled setting out of building lot boundaries (same level elements) and the infill is the buildings (elements of the next lower level) the lot owner would design and construct. The given support elements define the immutable framework around which one asserts control and is free to add and arrange any infill elements.

This approach to design allows decision on each level be made separately and systemizes the apparent unsystematic design process. As the designer moves from the higher levels (site, building, etc.) onto the lower ones (unit, room, furniture, etc.), what is put in as infill elements at a higher level becomes the support elements for the next lower level. The design of a building can therefore be simplified into selection of options from a solution set from each of the levels the design involves. A detailed description of this concept of designing residential buildings based on support/infill can be first found in Habraken’s book, “Supports: An Alternative to Mass Housing” (Habraken, 1972) and later further elaborated in “Variations: The Systematic Design of Supports”, which was co-written in 1976 by Habraken and three other then members of the Design Methods
Group of the Department of Architecture at the University of Eindhoven. This approach to housing design, which is also known by the name of “open building”, has been applied with varied success up to present. However, this concept has very seldom been applied in scales similar to mass housing in Hong Kong where towers typically reach 40 floors in height with 8 to 10 units per floors.

This remainder of this paper is divided into two main sections. The following section summarises the results of a study on the existing use territory conditions of public housing units in Hong Kong, which is a research funded by the Division Research Grant of the Division of Building Science and Technology of the City University of Hong Kong. The final section then applies some of the findings of the said study on ten different private mass housing developments to test their potential for flexibility on the room level.

3. Use Territory Study on Public Housing Units
To design a modular system that can satisfy the various spatial needs of mass housing users, one must first have a clear understanding of how they actually use space inside their units. Although there are many studies on the spatial characteristics of housing units and their layouts, none concentrated on use-territories and their implications towards flexible designs. Use territory is the area that is required for a human activity to take place. For example, each piece of furniture (e.g. a wardrobe) not only occupies space inside the room but also dictates an area around it in order for the function it serves to take place (e.g. the area immediately above the wardrobe must be kept clear for the user to open its doors to get to the clothes inside). Hence, the use “clothes storage” defines inside the architectural space we call “bedroom” a use-territory comprising two parts: the physical space occupied by the wardrobe, which has a definite boundary, and the space required to operate it, which has no tangible boundary.

The purpose of the investigation was divided into two parts. The first part is to study and survey the disposition of furniture and the space around them inside public housing units. The second part is to examine the results of the first part to identify patterns of use-territorial relationships. This investigation aims to provide information that is crucial to the development of a prefabricated modular system for housing design in future investigations and strategic research, which can provide sufficient flexibility for designers and economies of scale for manufacturers. The following are key issues to be addressed in this investigation:
1. What are the most common types of use-territories?
2. Are there recurring patterns of how use-territories are organized?
3. How are use-territories organized in the current standardized housing layouts?
4. What are the users’ actual desired use-territory configurations?
The survey consists of visits to public and private housing estates for measurement, interviews, photo-taking, sketching, etc. The furniture layouts within each subject unit will be recorded, analyzed and presented in diagrams. The furniture layouts and the space around them represent the use-territory for each associated user activity (e.g. dining table + chairs = dining, sofa set + TV cabinet = living, computer desk + chair = work/study, etc.). The following information was recorded: the layout of the furniture in a use-territory, the dimensions of the furniture, the dimensions of the space around the furniture, the dimensions of the use-territory, and the position of the use-territory in the room.

The subject of study was the latest Home Ownership Scheme (public housing for sale) housing block design by the Hong Kong Housing Authority that is repeated all over Hong Kong in public housing estates in towers reaching 40 floors in height is the Concord Block. This design is based on the common “cruciform” tower with four wings, which holds a pair of units each. This configuration forms an eight-unit typical plan with two unit-type variations – a 62 m² net area 3-bedroom unit and a 45 m² net area 2-bedroom unit. Looking at the internal layout of the Concord Block design reveals that the spatial configuration not only lacks variety but also the capacity to provide options for post-occupancy alterations resulting in different room layouts. Due to various reasons, one of which ironically is the adaptation of prefabricated building components and mechanized formwork, the main facade wall of the units is not straight. For example, in the 3-bedroom unit, the two bedrooms protrude about 400mm from the face of the living room and 1475mm from the face of the en suite bedroom. This makes altering the internal layout of the unit difficult.

![Fig. 3: Use-territory configuration variations in the 3-bedroom units.](image)

After interviewing 80 households – 40 in 3-bedroom units and 40 in 2-bedroom units – recording the furniture layouts in each of the units, the data collected was tabulated and analysed. The findings can be divided into two main topics: the tenants’ current use-territory configurations and their preferences for future re-configuration at the room level. The recorded use-territory configurations as reflected in the furniture layout in individual units show a wide range of different configurations within the relatively confined spaces in both types of units (Fig. 3). Despite the small sizes of the rooms, the tenants demonstrated that a high number of use-territory configuration variations remain possible. Some of the more popular configurations are tabulated in Fig. 4. From these “preferred” configurations, we can determine three important minimum dimensions regarding the width of rooms: 2500mm for living spaces, 1500mm for dining spaces, and 2100mm for bedrooms.
There are two ways to change the arrangements of the room-level elements in a residential unit: changing the size(s) of one or more room-level elements, and changing the number of room-level elements. It is therefore critical to take the potential desired changes into consideration when designing the initial layout of the unit and allow for the capacity to accommodate these future changes. This way, prospective tenants can determine the possibility for re-configuring the layouts before they purchase the flat and can therefore decide whether or not the unit type can meet their present and any future foreseeable needs and changes in needs. This is known as scenario design (Fig. 5). The survey discovered that the most common future re-configuration needs of the room-level elements of the units relating to their sizes and numbers are as follows: 1) increase the size of the living room, 2) increase the size of the master bedroom, 3) providing an additional room (as study or small bedroom), and 4) merging two rooms form a larger room (mostly to achieve the purposes of 1 and 2 when the number of rooms can be reduced). These scenario design requirements and the above critical dimensions will be applied in the next section to test the potential for future activation in terms of room layout flexibility in existing mass housing designs in Hong Kong.

**Fig. 5: Demonstration of scenario design in flexible housing unit prototype**

4. Future Activation of Current Building Stock
Following the study on existing use territorial patterns and preferred reconfiguration needs, ten unit layout designs of plan types commonly adopted in Hong Kong (Fig. 6) are analysed by applying the resulting scenario design and dimensional requirements. The plans selected are of 3-bedroom units from existing residential buildings in Hong Kong completed in the past five to ten years, ranging from 75m² to 88m² in gross floor area.
The selected plans are representative of the majority of the more popular typical room-level arrangements in mass housing blocks in Hong Kong.

In the above figure, the light-grey-hatched walls represent the non-structural wall that can be treated as removable infill elements. The solid walls mark either the structural shear walls or envelope walls that cannot be altered, and are therefore support elements in these layouts. It is obvious that in most of the above layouts, the shear walls occupy not only the external envelope but also the internal walls. Their location in the interior of the units severely limits the flexibility in terms of the arrangement of room-level elements. Almost all of the high-rise residential developments in Hong Kong adopts a concrete core and shear wall structural system. Unfortunately, with the high wind loads experienced by buildings in Hong Kong and their ever increasing heights, it becomes inevitable that one or more of the interior walls will be structural shear walls to resist the heavy lateral wind forces.

In applying the scenario design and dimensional requirements resulting from the use-territory study to the selected layout plans, it is apparent that the capacity for future room-level elements reconfiguration was not one of the main design considerations. There is no evidence of references to critical dimensions for the reconfiguration of use-territories and room-level elements in the designs of the units. As a result, most of the units can only support very minimal room-level element re-configurations (Fig. 7) in relation to those stipulated in the previous section:

1. Increase the size of the living room: This is only achievable in four of the designs without reducing the number of rooms. However, the increase in size is limited to a maximum of 200mm to 400mm because any further increase would reduce the width of the adjacent bedroom to less than the preferred dimension of 2100mm.
2. **Increase the size of the master bedroom:** Again, this is only achievable in four of the designs without reducing the number of rooms. The increase in size is further limited to a maximum of 100mm to 300mm and in two cases a master bedroom with an irregular shape would be created.

3. **Providing an additional room (as study or small bedroom):** None of the designs in the sample can support the common scenario design need of forming an additional room, unless a room without an external opening is considered acceptable.

4. **Merging two rooms form a larger room:** This is achievable in all the designs. However, in most cases this leaves the undesirable result of a secondary room larger than the master bedroom.

![Fig. 7: Scenario design analysis of some of the typical layouts](image)

The analysis points to a number of factors that are indicative of the flexibility of the room-level elements. These factors must be taken into consideration in conjunction with the scenario design requirements and critical use-territory dimensions when designing a mass housing unit to ensure that it can be re-configured to serve future use patterns. In practice, all of these factors must be considered concurrently as there are inter-related:

4.1 **Location of Openings**
In all but one of the layout designs, bay windows dominate the front facade of the unit to maximise views and natural light. As a partition wall can only be located at the solid wall between bay windows, the expense of the bay windows severely limited the options for re-configuring the room layout for these units. In most cases, the wall space measures only 500mm, which is the minimum separation allowed between bay windows.

4.2 **Location of Structural Shear Walls**
As explained above, structural shear walls are always present in high-rise residential units in Hong Kong. As an irremovable element, the arrangement of the shear walls in the layout imposes a significant effect on how spaces can be configured within the unit. Hence, the structural frame design should not be only aiming at structural efficiency but also maximisation of flexibility of room-level elements.

4.3 **Form of Unit-level Shell**
In general, the more complicated/irregular the form of the unit-level shell the more difficult it is to configure the space into regularly shaped rooms in different ways. From a morphological point of view, a simpler form facilitates flexibility in internal layout options, especially at the front facade where most of the rooms align against.
5. Conclusion
With increasingly rapid transformation of the life-style of residents, user preferences out-grow the capacity of buildings faster than ever before. In residential buildings, especially mass housing buildings that are not custom-designed to individual resident needs, this mismatch occurs across different levels: use territory requirements at the furniture level, spatial organization at the room level, flat sizes and distribution at the unit level, envelope configuration at the building level, and so on. Mass housing buildings that are designed to satisfy immediate needs only will eventually become obsolete when they can no longer serve the users’ changing needs. Unfortunately, the short-sighted approach driven by economic concerns and time constraints dominates the current market. Unless we review our design priorities and take a more long-term view of the impact of our designs, we are inevitably creating problems for the future generations.

References

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1 According to the records of the Emporis website (www.emporis.com) as of July 2007.