Mapping Volumetric Urban Space: A Critical Development Analysis of Multi-level Morphology of High-dense Cities

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Abstract

This paper starts with a brief introduction of "volumetric city" through the redefining ground, exploring movement modes, and analysing layered functions of volumetric urban space. Volumetric is a specific typology shaped by topography, population, society, and cultural background. With the compact situation of contemporary metropolitan areas, volumetric has made possible keeping a balance between congestion and order, dynamic and confusion, historic context and future development in high-dense cities. We choose Hong Kong as a study context, which completed the transfer from vertical to volumetric firstly around the world. Trough mapping the volumetric urban space of Tsim Sha Tsui district, we explore Hong Kong's spacial characters after transforming to a volumetric city and essential elements contribute to volumetric generation. In this aspect, we propose a critical assessment of volumetric space in multi-level morphology and then discuss the opportunities and challenges of volumetric implementation in other high-dense cities.

Keywords: Volumetric urban space; multi-level morphology; high-dense; Hong Kong.

1. Introduction: from Vertical to Volumetric

The ever-increasing population around the world has been changing the urban morphology and special organization of contemporary cities. From the second half of the nineteenth century, more and more metropolitan areas, like Tokyo, Atlanta, Hong Kong, Manila, etc., join the "high-rise club" and cast their city life into the sky because of population concentration and multiple land-use requirements. To reply to this situation, local governments, architects, and stakeholders adopt various measures – intensifying and renewing the existing urban space, changing the natural situations (i.e. marine reclamation), or replicating ground through the utilization of elevated walkways and steep topography (Hwang, 2009).

As a consequence of natural limits and contrived measures, volumetric emerged in high-dense cities. The term "volumetric" can be broadly defined as multiple modes of movement and varied programs stacked up across many levels, which are above ground and below ground, and where a connection between the level is extremely effective (Shelton, 2011). Different from vertical concept, which mainly emphasis on the multiple uses in single towers or skyscrapers, the volumetric city pays more attention to the relationships between multiple buildings and urban environments. Concentrated vertical developments lead to three-dimensional multi-directional connection, and permeable and legible volumes (Shelton, 2011). Compare with the vertical pattern, volumetric has obvious practical advantages no matter on above ground, ground or underground levels. Volumetric has become a crucial pattern stream in the development of high-dense cities.

Basing on Shelton, Karakiewicz and Kvan, building or maintaining a successful volumetric character needs three aspects: the several ways in which ground is being redefined; the nature of movement on and between these "new" ground; and the layering of functions on them (Shelton, 2011).

1.1. Redefining Ground

In volumetric urban space, "ground" has various definitions, including Duplicate Ground, Split Ground, Multiple Ground and Borrowed Ground. A Duplicate Ground is generated mainly for walking across roads or connecting blocks and buildings to release part of the traffic pressure on the ground. The corridor can be seen as a common type of duplicate ground. Split Ground happens with complex geographic situations or topography limits in hilly cities. For example, there is a plenty of buildings locate their "front doors" in different levels because the main streets next to them are not in the same horizontal line (Fig.1). Multiple Ground is similar with the Duplicate Ground. However, these multiple grounds are not just copied levels. They have

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various directions and functions (Fig.2). The ground floor is a converge point and space users can find functional engagements of it. Borrowed Ground is created through changing natural geography, like pouring sand into the water system or changing the surface of hills. In some land-hungry places, borrow ground is an effective way to contain concentrated residents.

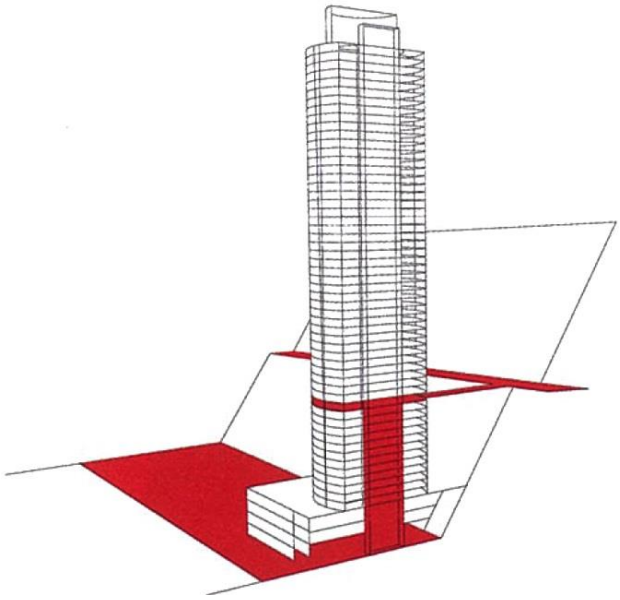


Fig.1. Split Ground and the entrances of various levels (Shelton, 2011).

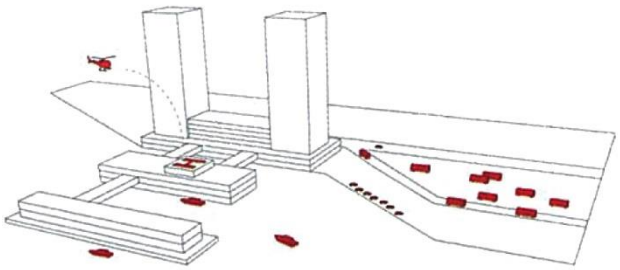


Fig.2. Multiple Ground: Shun Tak Centre/Macau Ferry Pier (Shelton, 2011).

1.2. Movement in Space

By redefining ground, the movement modes have to be redefined to access the various grounds of volumetric space. People's behaviours are shaped by mechanical ladders, elevated walkways, and roadways. Elevated transportation is a typical feature of volumetric urban space, especially in old and historical districts. Since the urban land is limited, old district renewal is necessary for high-dense cities' development. During the renewal design processes, part of unmovable properties cannot be ruined or changed in terms of historical value, architectural value or special belonging authority. So new throughways need to be built in upper grounds. The construction of mechanical ladders for transporting pedestrians followed. The transportation system in a volumetric urban space should be "volumetric" as well, or the emerging volumetric pattern cannot be sustainable and work well.

1.3. Layered Functions

To complement a ground that can be manipulated and multiplied, and access achieved in a variety of ways, functions can be freed from their conventional positions on the ground (Shelton, 2011). Mix-functional space has been created to fulfil various demands of compacted population in volumetric cities. On one hand, layered functions are planned by government or urban planning department for supporting the local retail market and offering more working positions; on the other hand, quite a few mixed functions grow up spontaneously. For instance, there are "roof streets" above high-rise towers. Dramatically contrary from the ground level scenes which maybe one hundred meters lower, the rooftop homes consist an amazing environment filled with living space, illegal shelters, and multiple stories (Fig.3). Same as the layered function growth, holistic volumetric generation is a coefficient consequence of human intervening and unprompted formatting.

Fig.3. Roof Settlements and Streets (Wu and Canham, 2014).

2. Research scope

The development of volumetric urban space is a complex process related to various factors, like topographic conditions, society or culture backgrounds, not only high-dense morphology. Some relatively sparse cities also show volumetric characteristics because of geographic limitation, like Auckland, Guanajuato, and Chongqing (Fig.4). Neighbourhoods are built on the steep lands or above water system. Natural multi-level grounds are generated to fulfil the living requirements of local residents. Besides, the cultural background has an effect on shaping a volumetric city. Although volumetric is an emerging concept, there are many historical towns have volumetric features. For instance, San Gimignano town of Italy has quite a volumetric scene because local people believe high towers are the representation of

treasure and family reputation (Fig.5). In our research, we focus on the volumetric space of contemporary multi-level city with high density. Geographic or non-architectural factors are secondary considerations.

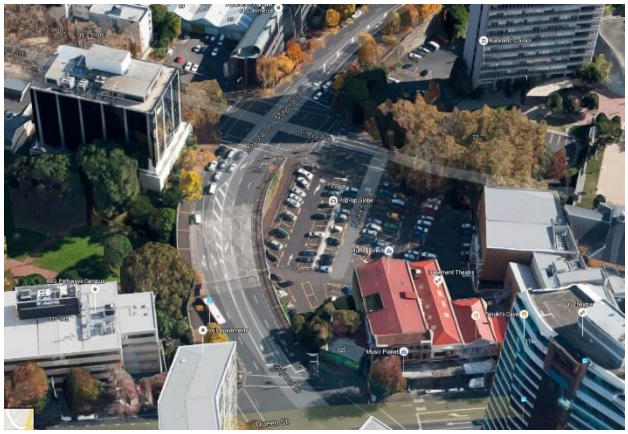


Fig.4. Multi-grounds in Auckland, New Zealand (Google Street Image, 2016).

Fig.5. Volumetric Feature of San Gimignano, Italy (http://www.hbjzds.com/300861-san-gimignano.html).

We use Tsim Sha Tsui district, Hong Kong as the target context. Hong Kong is a super metropolis with 7.2 Million inhabitants and a land area of more than 1000 km^2 (Basic Law of Hong Kong, 2015). Tsui Sha Tsui is one of the most dynamic districts of Hong Kong. Most public movements are happening here. Basing on the comprehensive function concentration, Tsui Sha Tsui represents a typical urban morphology of Hong Kong – multi-level, high density, compact, vivifying and vibrant. The research area is in two approximate circles centred by Tsui Sha Tsui and Tsui Sha Tsui East metro stations, semi-diameter 800 meters (10-20 minutes walking distance). The gross research area is 1,456,000 m^2 according to the frontiers of land and roads.

3. Volumetric study

3.1. High-dense situation

It is widely accepted that denser living and building conditions in compact cities have more intrinsic potentials to become less resource consuming than more sprawling cities with sparser living and building patterns (Shelton, et al., 2011). Moving from urban sprawl to a compact city has been proposed as one way urban sustainability can be improved upon (Arbury, 2005). In terms of the population pressure and economic requirements impelling, the number of densest metropolitan regions in the world is increasing. According to Shelton (2011), Jenks and Dempsey (2005), high-dense cities have three major advantages:

1) Denser urban living makes possible more effective public transport, more journeys on foot through proximity, and more benefits to buildings such as insulation and shared services from adjacency; all of which lead to significant savings in energy use.

2) More homes can be serviced from less extensive infrastructure, which lowers the costs of constructing and managing services.

3) Greater concentrations of people mean that a greater range of social, health, recreational and other services can be offered in closer proximity.

Twelve high-dense cities are mapped at the same scale in Fig.6. Built-up regions are in black and peripheral regions are in grey. Hong Kong only has 273 km^2 but occupied by 7 million people. Tokyo, Atlanta, and London are quite typical high-dense cities. Hong Kong has 4.5 times population more than Tokyo per kilometre, 23.7 times than Atlanta and 4.6 times than London.

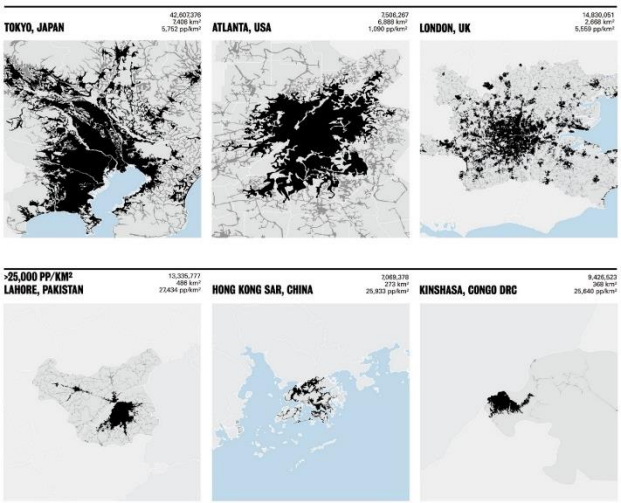


Fig.6. Mapping High-dense Cities around the World (Cities, health and well-being Hong Kong urban age conference, 2011).

Because of the World War II and the Chinese Civil War, Hong Kong's population increased rapidly from the1950s. A number of displaced people settled down, which makes the small village grew up into a big city shortly. This was the first wave of population concentration. After 1980, Hong Kong attracted a lot of

business explorers from mainland China. On reason is the Chinese Economic Reform offered relative loose political environment; another reason is Hong Kong as an important economic entity in the world had more opportunities for these "newcomers" from the mainland. This was the second population concentration wave. Through the two waves, huge numbers of people swarmed into this hilly place, Hong Kong turned into a volumetric city even faster than Chicago. Consider of the topographical constraints, the peak value of population in Hong Kong is 111,065 per kilometre, two times than New York City and 6.4 times than London.

Coordination of multiple transportations is another feature of high-dense cities. London and New York City have the most connected metro, bus and rail systems. In Hong Kong, the first metro line was opened in 1979. Now the Mass Transit Railway (MTR) of Hong Kong includes 218.2 km as one of the most profitable systems in the world (2012 Annual Report of MTR Corporation, 2013). Different from western counties relying on automobiles, walking is a very important transport approach for Hong Kong residents. It relates to the urban forming manners and living habits as well.

Through the analysis of the comprehensive development index of main high-dense cities around the world, we find global cities' development lies different patterns of urbanization. Historically developed cities, like London, have relative stable urban morphology in the main urban regions. The space patterns are already optimized numerous times during the long-time development. Younger city generations have huge potential to be shaped. Hong Kong and other Chinese high-dense cities like Shanghai and Shenzhen, are changing rapidly under the dramatically effect of contemporary population, economy and society requirements. For Hong Kong, a volumetric urban form happened within the city limits. The super metropolitan region rises the city life into sky and sculptures an unbelievable multi-level morphology.

3.2. Multi-level morphology of Tsim Sha Tsui

Tsim Sha Tsui, means sharp sand mouth in Chinese, is located in the southern part of Kowloon, Hong Kong. It is a cape on the tip of Kowloon Peninsula pointing towards Victoria Harbour, opposite Central (Wikipedia, 2015). As a major urban core zone of Hong Kong, Tsim Sha Tsui is reclaimed from the Hung Hom Bay through marine reclamation. Some small villages were established in Tsim Sha Tsui region in the 1860s. Nowadays, this region has become a major tourist hub and movement venue of metropolitan Hong Kong. In this thesis, we choose Tsim Sha Tsui district as the research target.

The current ground and underground planning and design in Hong Kong mainly takes the safety, rational connection, and economic value into consideration. Although Hong Kong has relatively developed underground-ground connection systems, most of the underground space only has transportation and commercial function. As a place that relates to every citizen's daily activities, the underground space, especially around the metro station area, needs to be more mix-used and rich for public behaviours.

The building form research in Tsim Sha Tsui consists of three main elements: Public housing, Rooftop settlements, and Towers connect ground and underground levels. The mass housing and mass circulation of goods in Hong Kong result in surprisingly similar forms (Esther and Li, 2014). The high-rising residential buildings have been produced in quantity relying on the standardization of each housing unit (Fig.7). Public housing is a major type of housing in Hong Kong. There are approximately 3.6 million residents living in some form of public housing (Census and Statistics Department, 2015).

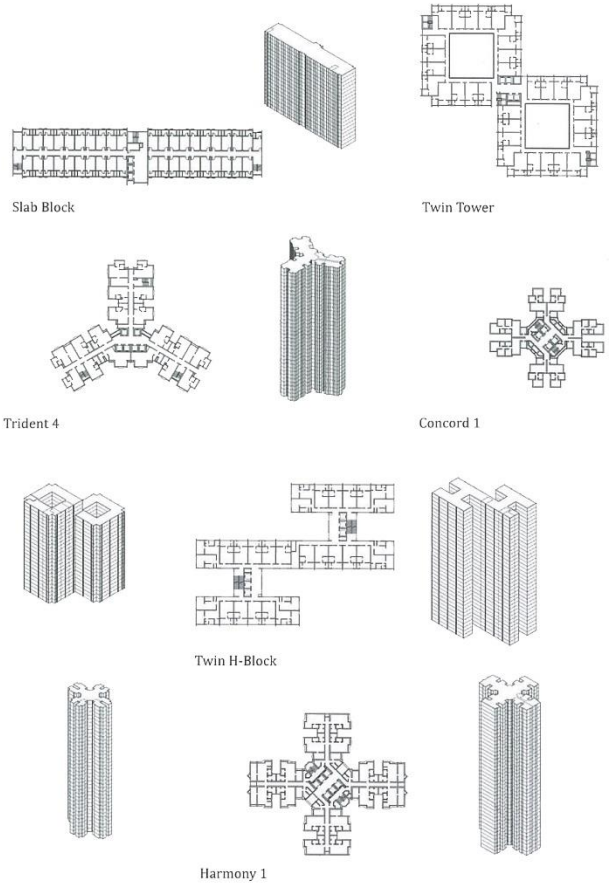


Fig.7. Public Housing Types (Ester and Li, 2014).

The self-built settlement on the tops of high-rise buildings is a special building phenomenon in Hong Kong. Rooftop houses are built comprehensively in Kowloon Region, especially the old towns. They contribute to the making of a volumetric urban space. Creating a volumetric pattern for Hong Kong needs to take the rooftop settlements into consideration as well. Not only because the special building form in the high-dense city, but also the requirements of improving the living environment of vulnerable groups.

The underground network of Tsim Sha Tsui connects

with nearly all of the landmark towers, open spaces, and main roads and throughways. The longest underground walking distance in Tsim Sha Tsui is 700 meters from east to west and 550 meters from south to north. The locations of the metro stations and related underground systems affect the urban mechanism deeply. One of the most significant reflection is the towers and skyscrapers around are shaped by the underground space. The main towers in Tsim Sha Tsui include K11 Mall, iSQUARE, Harbour City, The Sun Arcade, The One, Mira Mall, The Kowloon Hotel, etc. we use the K11 Mall as an example. As one of the tallest skyscrapers of the Kowloon Peninsula, K11 is situated in the heart of the Tsim Sha Tsui business and tourist district. It is a multi-functional tower consist of a modern shopping mall (upmarket retailing and luxury brands), one five star hotel (Hyatt Regency, Hong Kong), 24-hour open resting area, and residential property (The Masterpiece). There are two subway entrances of Tsim Sha Tsui Metro Station connect with K11 seamlessly (Fig.8).

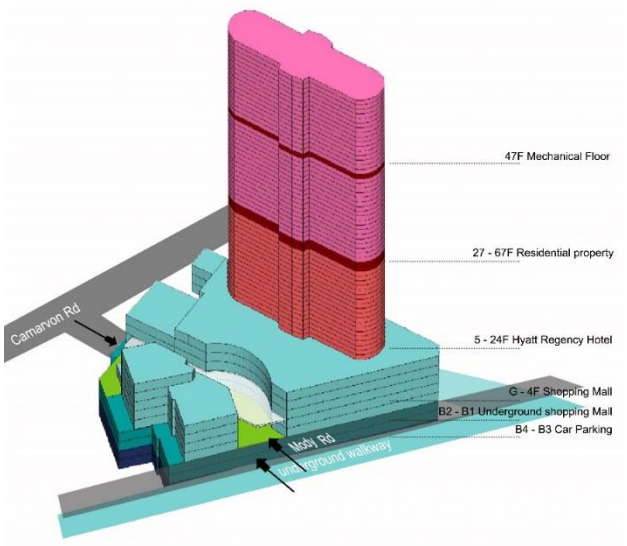
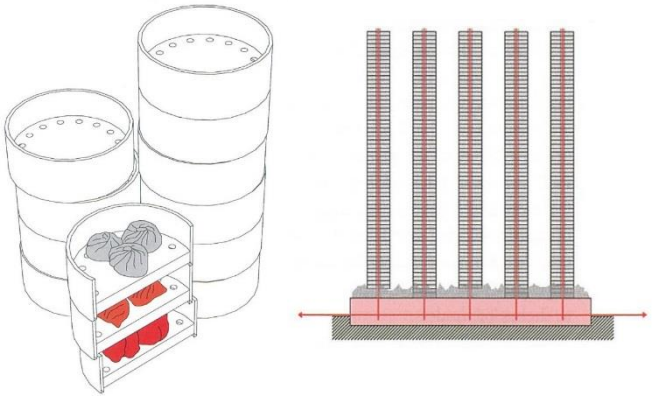


Fig.8. K11 Tower Rendering.

Barrie Shelton described the Hong Kong towers as Dim Sum containers -- a kind of identical stacking baskets for separating single food types (Fig.9). Fig.10 shows the typical tower and podium consisting of a town centre and single strand connections to isolated "tower neighbourhoods" above, in which floors are isolated from each other (Shelton, 2011). For the buildings at the connection point of ground and underground space, they mainly have two ways to organise the walking flow. One is transporting people from underground space to ground or upper ground floor, the other is transporting people to ground public transferring stations (Fig.11).

4. Evaluation and discussion

Hong Kong represents hundreds of super high-dense cities with extreme concentration population and high-rise towers around the world. Thus investigating the volumetric situation of Hong Kong is meaningful for the broader condition and associated issues. This is because we live in times when many urban and environmental experts are advocating the raising of densities as urban policy for compelling reasons: an impending environmental crisis that embraces such massive issues as global warming, climate change and rising sea-levels (Shelton, 2011).



Left: Fig.9. Dim Sum – Identical Stacking Baskets – Towers of Separated Single Food Types – Vertical Culinary Zoning (Shelton, 2011)
Right: Fig.10. Typical Hong Kong Towers Connection (Shelton, 2011)

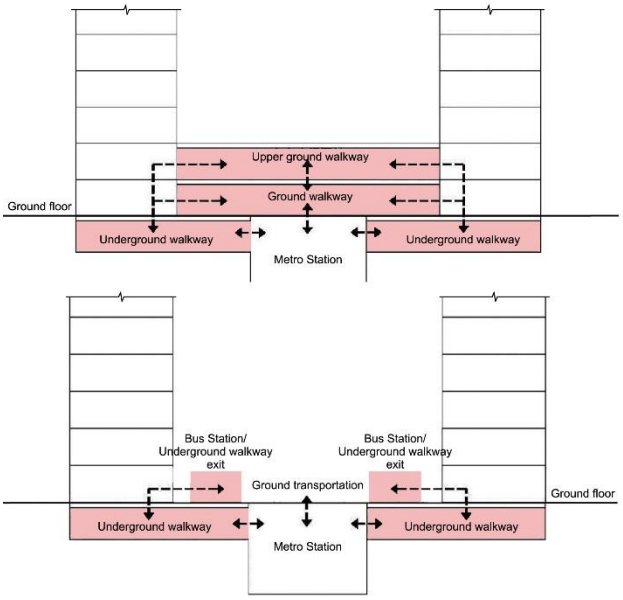


Fig.11. Multi-level Connections in Tsim Sha Tsui

Some scholars wonder that volumetric urban space lead to more resources loss and micro-climate changes, however, the volumetric urban space in Hong Kong has been helping encourage public transporting and reduce dependence on the automobile. Compare with other high-dense cities, Hong Kong uses more renewable energy sources and keeps a relatively low level of green

island effect.

Through the volumetric study of Tsim Sha Tsui district, we conclude four elements encourage a volumetric urban space generation:

- Compactness
- Space proximity
- Verticality
- Intensive mixed uses

Hong Kong's volumetric pattern dives by economic demands and highly developed construction technology as well. Besides the four architectural elements above, economic background and environment tolerance are also essential factors for a volumetric city. Hong Kong is a strong city without any doubt. How about other high-dense cities, can they become volumetric as Hong Kong? Or is Hong Kong the only city that suitable for volumetric development? For instance, Hanoi, Vietnam is another high-dense city with compact urban form and concentrated population (Fig.12). It has the necessary conditions like compactness, intensively mixed uses as volumetric required. Hanoi and other high-dense cities with similar population scale as Hong Kong have a potential to become volumetric but they still need a long time.

Fig.12. Compact Neighbourhoods (Wang, et al., 2015).

5. Conclusion

Through an understanding of the volumetric conception, the paper explores the characteristics of a mature volumetric urban space by redefining ground, exploring movement modes, and analysing layered functions. Although volumetric is a consequence of various factors including topography, economic foundation, society, and cultural background, etc., this paper assigns the research scope in high population density with multi-level morphology. The volumetric study in Tsim Sha Tsui district is divided into three parts: high-dense situation analysis; multi-level morphology investigation; and building forms research. In these respects, we evaluate the volumetric urban space of Tsim Sha Tsui and argue necessary elements of generating a volumetric city, and then discuss the potential of creating volumetric in other high-dense cities. In the further study, how to create a universal volumetric model for the multi-level morphology of high-dense cities to release population pressure should be discussed deeply.

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