# Analysis on Urban Form and Evolution Mechanism of High-Density City: Case Study of Hong Kong

Yuan Zhang

*Abstract*—Along with large population and great demands for urban development, Hong Kong serves as a typical high-density city with multiple altitudes, advanced three-dimensional traffic system, rich city open space, etc. This paper contributes to analyzing its complex urban form and evolution mechanism from three aspects of view, separately as time, space and buildings. Taking both horizontal and vertical dimension into consideration, this paper provides a perspective to explore the fascinating process of growing and space folding in the urban form of high-density city, also as a research reference for related high-density urban design.

*Keywords*—Evolution mechanism, high-density city, Hong Kong, urban form.

## I. INTRODUCTION

HONG Kong is an international metropolis. Its urban form always impresses people tremendously with complex mountain terrain, abundant height variations, public open space, three-dimensional traffic systems. Convenience, openness and stereoscopic characteristics serve as the labels of this high – density city.

As the urban form of Hong Kong is closely organized from both horizontal and vertical dimensions, this paper regards it as a coherent organism, analyzing its complex form and evolution mechanism from three aspects of view, respectively as TIME, SPACE and BUILDINGS.



Fig. 1 Corridor of Pacific Place



Fig. 2 Pedestrian overpass

Yuan Zhang, is postgraduate student at Zhejiang University, Department of Architecture Design, 310058 Hangzhou, Zhejiang Province, China (phone: +8618768115357; e-mail: 694247721@qq.com).

## II. TIME

### A. Horizontal Expansion-from Possession Street to World War II

As Britain recovered its colonial dominion over Hong Kong, refugees crushed into the city. As consequence, its population instantly soared to 4000 people per hectare, turning into an extremely compressed city. In the early stage, movement of transportation lied mainly on walk and manpower tricycles. In later, mechanical power vehicle came into existence and with the factor of population and land density, they were usually in the form of multilayer. However, public transportation tools were not widely used at that time for the reason that they could only serve in flat areas for tourists while most roads were too steep and crowded to cross. Because shop houses were multistory and multifunctional, they became the only monotonous and popular pattern during the whole century. Meanwhile, a large number of illegal constructions occurred in the inner parts of the city with a trend of growth in the vertical dimension. At the same time, people in the urban fringe started to occupy common land at higher altitudes spontaneously, while houses still limited within two stories [1].
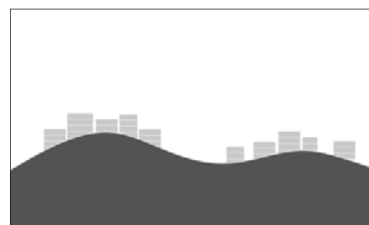


Fig. 3 Horizontal expansion-From Possession Street to World War II

### B. Vertical Expansion-Decades after World War II

Immediately after World War II, refugee tides constantly rushed into Hong Kong to such an extreme extent that population grew at the rate of 500000 people each year [2]. As a result of this, there was a sharp demand for public transportation and the system of that was greatly improved accordingly. The boundary of city was also greatly expanded with the construction of railways and tunnels. The application of elevators made the vertical movement inside buildings extremely convenient, contributing to large numbers of high rise buildings. During this period, half of the multistory buildings were pulled down with public apartment houses in the shape of H and plates taking its place. This type of buildings varied from 6~20 floors with both great height and mass. Though arrayed in sequence, few connections were among them and each scattered as isolated islands. As to the urban

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form, most streets still remained its narrow scale, while much higher buildings on both sides of it make people seem as if walking in the shadow of great valley.
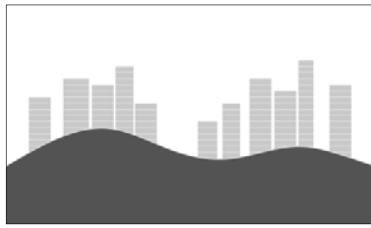


Fig. 4 Vertical Expansion-Decades after World War II

### C. Three-Dimensional City: Since 1980

During this period, the population growth has slowed down but on the whole it still remains high-density. As a result of this, high speed transportation such as railways, elevated roads and airports has developed quickly, which further expanded the boundary of city. Drastically increased loads of traffic has badly burdened original road systems and two more new types of transportation were developed vertically as elevated roads upward and underground traffic downward [3]. Buildings with the form of 'base and tower' have taken the leading place. Arrays of them connect with each other. In the meantime, forms of base also have experienced great changes with platforms, balconies and mass overhead coming into existence. Some of them even join with the space of corridors as a whole body. In this time, horizontally, the urban form of Hong Kong has turned into a much more open relationship between buildings and urban space than before with bases and overhead platforms brought great release to ground space. Also developments of high speed traffic have strengthened the connections between building nodes, which ask for fine organization of business formats. In the vertical dimension, elevators have closely connect elevated level, ground level and underground level together, leading to a half open space relationship with city hilly areas. The expansion of vertical dimension also requires great organization of business formats inside buildings vertically.
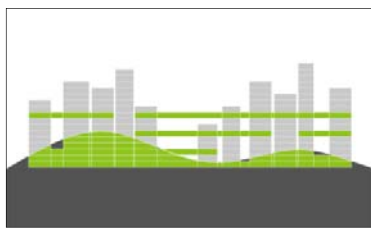


Fig. 5 Three-dimensional City-Since 1980

### D. Summary along Timeline

Taking all three phases together, a clear timeline turns into sight, which reveals a fabric growing process from horizontal to vertical and finally to three-dimensional as shown in Figs. 6-9.
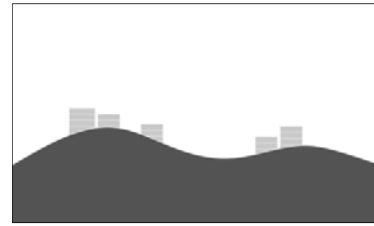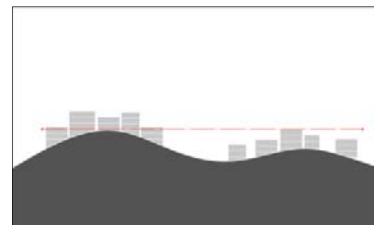


Fig. 6 Early stage



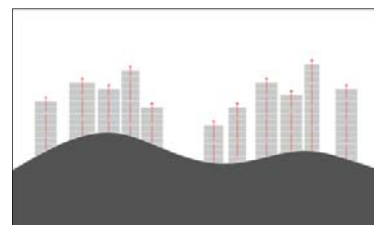Fig. 7 Horizontal expansion-From Possession Street to World War II



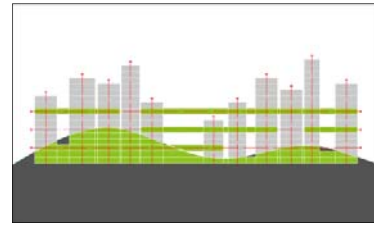Fig. 8 Vertical Expansion-Decades after World War II



Fig. 9 Three-dimensional City-Since 1980

## III. SPACE

From the point of space, this paper illustrates the evolution mechanism of three-dimensional space composition by analogy with the manipulation of folding networks.

### A. Folding Networks

Along with the timeline, history shows that after the industrial revolution, mechanical power vehicle has been widely used. Traffic system, working as a physical entity that supports the movement of people, has been playing the important role of skeleton in the structure of urban form. For this skeleton structure, abstracts can be drawn as follows. Firstly, traffic lines alternatively join different building joints together. As a result of this, nodes at the same altitude compose a planar network, while nodes varying at different altitudes form a folded three-dimensional network with the conjunction of stairs, escalators in urban space and elevators inside buildings, which is very similar to the interesting process of tridimensional paper-cut. Ultimately, several folding networks

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like this overlap with each other, leading to a system composed of networks. A single network can never work in this way. Also, it is not hard to see that horizontal organization of function takes the leading place macroscopically on the scale of urban form and vertical organization influences more specifically when it comes to the function organization inside buildings. It is worth mentioning that nodes at different altitudes can be marked with different colors. Warmer colors represent higher levels and colder colors represent lower levels. Therefore, nodes with the same color are at the same altitude and a gradient color means variation of different altitudes. This manipulation means that a complex three-dimensional network can be illustrated in the form of two dimensions, through which mechanism is both easily and clearly revealed how a three-dimensional city is horizontally well organized.
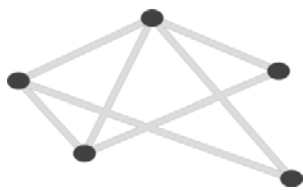


Fig. 10 Nodes at the same altitude composes a planar network
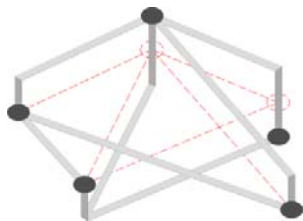


Fig. 11 Nodes at different altitudes connect with each other by stairs, escalators in urban space and elevators inside buildings
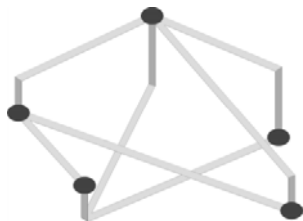


Fig. 12 Nodes at different altitudes form a folded three-dimensional network dimensional, similar to tridimensional paper-cut
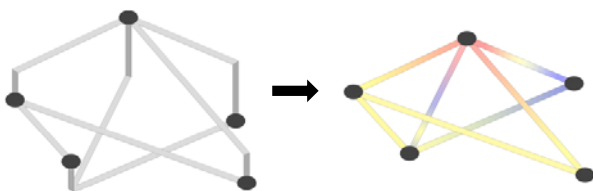


Fig. 13 Mark nodes at different altitudes with different colors

*B. Folding Networks as a Strategy against High Population Density*

During the stage of vertical expansion, blind increase of building height has only relieved slightly the space need of people who move at a low speed. The conflict that how people with such a high density move efficiently in city space still remains unsolved. A relatively isolated state is formed between the enclosed vertical towers, like ends of branches hanging around the main trunk city space, while tremendous load of traffic still confined on the limited ground floor.

With the structure of folding network, traffic load of ground floor is separated according to speed and people. Shared on underground level, ground level and elevated level, great burden of traffic is resolved and the maximum efficiency of different means of transportation has been brought into play, which also increased the order of the network. Much to our interest, when the surface layer is separated into multiple layers, like the process of fermenting lasagna, a lot of void space starts to pop out from the original urban space. Combined with the design of overhead space and sinking squares, urban space and building space are greatly opened and fused [4].
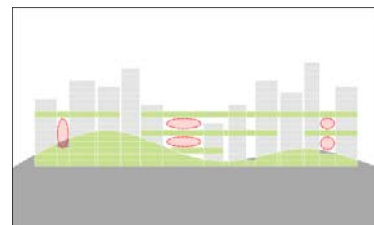


Fig. 14 Void space pops out from the original urban space when the surface layer is separated into multiple layers
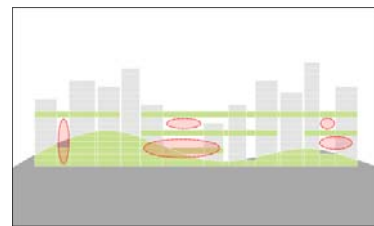


Fig. 15 Combined with the design of overhead space and sinking squares, urban space and building space are greatly opened and fused

*C. Folding Networks as a Strategy against Complexity and Regeneration*

As a physical support system with great efficiency and complexity, logic and order are very important to Hong Kong's regeneration. If we see this process from the view of folding network, urban renewal is much like a surgery. Tissues no longer fit or necrotic are cut away and new joints of buildings, serving as mediators are inserted into the folding network. Designers selectively connect these mediators with the original nodes through the skeleton of traffic. A new connection with the original urban organization thus is created. Once these building nodes are well organized with attractive space, streams of people, like fresh blood, will soon bring vitality to this nascent tissue.

Unlike those planar cities that are constrained by the single form of ground transportation, multiple choices are provided by Hong Kong's traffic skeleton. Accordingly, new relationship between new tissues and city space is full of flexibility and

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creativity. From this point of view, folding networks not only solve the conflicts of high density population, also provides sustainable support for urban renewal and transformation.

## IV. BUILDINGS

Folding network, acting as load entities for motion, only composes the skeleton streamline of the city. What really attract people are activities that connect building nodes together, such as function and space. They do constitute the flesh and blood of the whole city.

### A. Function Organization

Good function distribution and format organization can form good synergy relation in local tissues. Investigations of Building Complex like IFC International Financial Center, Pacific Plaza, Langham Place, APM, and Festival Walk are made to demonstrate and analyze their organization of function from two angles of horizontal and vertical respectively.

TABLE I
HORIZONTAL FUNCTION ORGANIZATION

| Building Complex | Horizontal Function Organization | Specifications |
|---|---|---|
| IFC | shopping centers, offices, hotels, hotel apartments, parks | The function system composition is good; the office is now Hong Kong's second high-rise; shopping centers and hotels positioning high-end; large area roof park open to the public. |
| Pacific Plaza | shopping centers, offices, hotels, hotel apartments, parks | The function system is good; shopping centers are representative; hotels and office buildings with good view; mid-level park easily accessible. |
| Langham Place | shopping centers, offices, hotels, parks | Located in downtown Mong Kok; tense land resources; office buildings and hotels as the main; shopping center oriented to all kinds of people, with original streamlined organization and distinctive theme. |
| APM | shopping centers, offices, parks | Located in the suburbs; shopping centers and office buildings as the main; shopping centers with AM and PM themes, rich in features. |
| Festival walk | shopping centers, offices, traffic | Located in the suburbs; shopping centers as the main, offices as a supplement; also served as traffic transfer station. |
| Telford Plaza | shopping centers, residence, parks, underground traffic | Located in the suburbs; large residence as the main; shopping centers positioning at surrounding residents living; parks easily accessible. |

Taking both location and tale into consideration, it is easy to find that the building complex has certain regularity in the layout of the horizontal function:

1) **Shopping centers**: Need to consider the accessibility of people, generally arranged in the vicinity of the traffic transfer station. Different shopping centers have different market positions. General community shopping center aims at retail consumption, those at the city center is relatively balanced and even high-end positioning, shopping centers located in suburban (such as APM, another city) are combined with original themes and entertainment to attract tourists.

2) **Hotels**: Hotels and business volumes are linked or completely separated by corridors. In order to take full advantage of land commercial value, current approach tends to integrate them together, such as the IFC International Finance Center Four Seasons Hotels.

3) **Residence**: Except such a large building complex like Telford relying greatly on community, the form of pure apartments is not common in commercial construction groups, because the floating balcony will affect the appearance of the beautiful facade. As a result, hotel apartments have been widely used.

4) **Offices**: High-end positioning. Centralized layout. Suitable for intensive land use.

5) **Parks**: When land use and location conditions allow, many city complexes use their own roofs or surrounding mountain terrains to set up parks, providing visitors with green open space. Merged with urban space, construction groups and city space form a good relationship of density.

In a word, functional organization between commercial buildings needs to coordinate the commercial, hotels, residence, office buildings and other relationships between different formats at the same time according to the site conditions. Traffic system is effectively connected, elastically interacted with city space, thus forming a harmonious whole [5].

Due to the fact that traffic of different elevation levels mostly depends on the vertical traffic inside buildings, organization of vertical formats in building counts a great deal. In my investigations of several well-known urban complexes, a certain regularity of vertical distribution appears in accordance with lease capacity, the ability to attract passengers, as well as site conditions:

TABLE II
ORGANIZATION OF VERTICAL FORMAT IN HONG KONG CITY COMPLEX

| Floor | Format type | Specifications |
|---|---|---|
| MTR,B1,B2,LG, G,UG,LB | Retail category, Catering category | Supermarket; Department store; Food Plaza. |
| 1-9F | Retail category, Catering category, Service class | Clothing, jewelry, cosmetics (lower floors); Banks, convenience stores, etc (lower floors); Leisure catering (spread on all floors). |
| 10-12F | Entertainment, Catering category | Cinema, skating rink; General catering. |
| Upper than12F | Catering category | Middle and high grade Restaurants. |

1) **Retail category**: *Clothing, jewelry, cosmetics*: High rental capacity, good image, easy to attract impulsive consumers, and scattered in the vicinity of the first floor. *Home furnishing, sports and other professional stores*: Generally scattered in the form of scattered upward. *Supermarkets*: Weak lease capacity, certain site requirements, usually distributed underground.

2) **Entertainment**: *Cinema:* Tai Koo Plaza cinema is set on the lower floor, and some urban complexes locate cinemas above retail floors taking into account the regular flow of passengers, also the relatively quiet nature of this activity. *Ice rink skating*: As ice skating asks for certain requirements for the site, so generally arranged on the ground floor or the top floor. *Playground*: Generally

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placed on the top floor. Most interestingly, the West Kowloon center built a roller coaster in the atrium, decorating the monotonous atrium space as well as attracting upward flow of passengers.



Fig. 16 Roller coaster at atrium top of West Kowloon Central

3) **Catering category**: *Large food plaza:* Although the lease capacity is weak, it is very attractive to passengers and generally located on higher floors, or even the top floor. *Leisure Catering:* Currently, many new urban complexes (such as APM, etc.) also noted the need to combine centralization with decentralization. Coffee bars, snacks, desserts and other leisure food are also scattered on various floors.

4) **Service class**: *Banks, convenience stores, salons, pharmacies*: Service formats are less profitable and tend to form a service area, which is more common on lower floors. In some of the urban complexes with higher floors (such as Tai Koo Square), they are also vertically distributed.

What is worth noting is that, unlike many large cities that we are familiar with, the underground transportation system in Hong Kong is well developed. In general, the underground space in large cities is at most 2~3 floors, while most of them in Hong Kong is up to 5~6 floors [6]. Combined with the table, it is easy to figure out that the business format of underground commercial needs better organization according to streamlines. In the vicinity of rail traffic or relatively closed underground parts, supermarkets, department stores and service class should take the leading place. Sublevels near the surface are merged with upper floors or urban space by sinking squares, walking corridors and void space. They not only break the closed state underground, but also bring floods of passengers into the complexes, which is appropriate for retail formats.

*B. Space Design*

Urban complexes in Hong Kong usually have a large number of stories. In order to increase the interest of interior space, quite a lot attempts have been made in the design of vertical void space [7]. Meanwhile, the atrium space develops transverse connections with urban walking space, corridors, and squares through space overhead and unfolding interfaces. Boundaries of cities and buildings are gradually blurred, turning into flourishing flesh and blood of the city [8], [9]. Among them, ingenuity theme decorations, such as ladder, screen, rotary gallery display their own unique charm.

TABLE III
TYPICAL SPACE DESIGN OF URBAN COMPLEXES

| Building Complex | Vertical dimension | Horizontal dimension | Space theme decoration |
|---|---|---|---|
| Pacific Place | Take use of multi-story atrium space to integrate the passenger flow of underground, ground and upper floors. | Atrium directly connected with the subway station. Give way to the urban space using the Pacific square. Escalators connect with urban sidewalks and the mid-level green park, attracting a lot of passengers. | As a result of the concession in urban space, the entire atrium space enjoys a large design scale with soft curves, forming a theme style combined with distribution, leisure and green urban public land. |
| Langham Place | Core atrium sixty meters high, combined with affiliated ones, whose spread solves the problem of uneven lighting in high-rise commercial buildings. The 15 stories atrium is equipped with two of the territory's longest 'Stairway', directly from the first floor to the fifth floor. | Less horizontal connections with urban space due to the reasons of scale. | The shape of the exceedingly high staircase and the digital canopy at the top of the atrium form the attractive theme. |
| Festival walk | Five stories height leads to a five layer multi core atrium. | The atrium is directly connected with the Kowloon Tong MTR station, introducing a large number of passenger flows. | Planar form: curved corridors run through polygonal, oval, multi core atrium. Curved corridors indicate motion while polygon and ellipse indicate rest. The stainless steel staircase is arranged in a streamlined shape, catering to the natural design theme 'glacier'. |
| Mega Box | A semicircular side atrium in the profile covers 4F~11F, while the wedge-shaped one covers 10F~16F. Three cross layer high speed escalators are connected with 1F~5F, 5F~8F and 8F~10F respectively. | Ground level is two stories overhead. 10F~16F atrium serves as the entrance space to greet the passenger flows at 10F. Huge opening of the facade forms a strong visual association with the urban space. | The shape of side atrium is bold and dynamic. The semi-circular section of the atrium creates a strong central theme through the large scale circular LED screen and a cross floor escalator. |



Fig. 17 Atrium in Pacific Plaza

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Fig. 18 The atrium of Pacific square leading to the City Park



Fig. 19 Sculpture in Langham Place atrium



Fig. 20 Territory's longest 'Stairway' in Langham Place atrium



Fig. 21 Atrium of Festival Walk connected with the Kowloon Tong
MTR station



Fig. 22 'Glacier' theme atrium of Festival Walk



Fig. 23 Atrium in Mega Box

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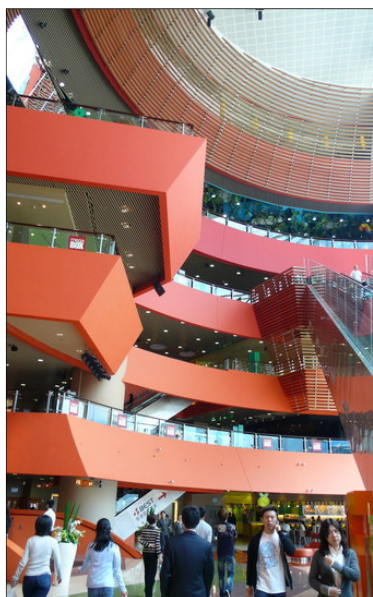International Journal of Urban and Civil Engineering
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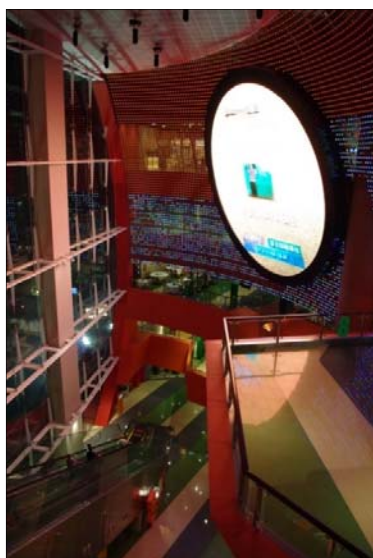Fig. 24 Shape of side atrium is bold and dynamic



Fig. 25 Large scale circular LED screen and a cross floor escalator in the atrium of Mega Box

From cases above, we can see the importance of atrium space of urban complexes, which mainly solves the contradiction of several aspects: coordination and organization of the complex vertical and horizontal transportation networks; interaction with urban space; design theme of interior space and organization of streamline. These cases make good use of their own terrain, techniques and other characteristics, creating a variety of flexible and rich internal space inside urban complexes of Hong Kong [10].

## V.conclusion

From the point of time, this paper reveals that Hong Kong has experienced a fabric growth process from horizontal dimension to vertical dimension, and eventually into the fulfilled pattern of three-dimensional city; also explains how does the factor of history works on the change of material form.

From the point of space, this paper illustrates the evolution mechanism of three-dimensional space composition by analogy with the manipulation of folding networks.

From the perspective of buildings, analysis of function and space inside those buildings serving as important nodes of folding networks is laid out to demonstrate its great advance, creativity and efficiency in the design of a high-density city.

In summary, given the complex urban form of Hong Kong, this article provides a profound perspective to explore the dialectical and subtle relationship during its growing and weaving process both macroscopically and microscopically. Based on which, new insight and exploration of urban design and renewal can be figured out, creating a much more comfortable, efficient and sustainable residential environment of high-density city.

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