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Densification Potential in Hong Kong Neighborhoods

ABSTRACT

As the global population is surging tremendously, urban densification has become an inevitable solution in urban planning to manage the density. While in Hong Kong, densification has also become a foundation of urban planning due to the mounting population; limited buildable lands and land sale policy. In addition, urban densification has been researched in addressing urban problems and bringing advantages in sustainability such as shortening travel distances, concentrating public services facilities and reducing resource depletion. However, urban densification has also been challenged of its adverse effects. Due to densely built environment, poor ventilation is particularly significant due to contributing to urban heat island effect. Therefore, it is compelling to study the densification potential in Hong Kong before further densification can take place in order to reduce issues and to control future densification. The presented research has taken on a novel approach to studying the densification potential of urban neighborhoods, based on quantitative urban planning data sets and qualitative computational fluid dynamic analysis. Based on the developed theoretical framework, the presented report summarizes the application of the framework by means of three case studies for evaluation and validation.
Densification Potential in Hong Kong Neighborhoods

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March 2015
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CHAPTER 1: INTRODUCTION

1.1 Background

The most compelling issue around the globe is the swelling population that is rapidly concentrating in urban areas. It is predicted by the UN that compared to 3.9 billion in 2014, by 2050, the urban population will tremendously increase to 6.3 billion, which results in approximately 60% of the world’s population living in urban areas (United Nations, 2014). Managing population density has become a pressing priority in urban areas as population surges. Urban densification, therefore, is the inevitable solution in urban planning in order to accommodate the increasing population in the urban areas (Bergsteinsson, 2014).

Sustainability has grown into another dominant issue on the urban development agenda worldwide. In fact, different urban forms have been researched for their potential to boost sustainability (Jenks and Dempsey, 2005). With the publication of the Brundtland report, ‘Our Common Future’, the notion of urban densification was firstly endorsed to achieve sustainable city (World Commission on Environment and Development, WCED, 1987). Since then, national and local authorities worldwide have been implementing densification in their urban planning (Bergsteinsson, 2014).

Jenks, Burton and William (1996) inspected the sustainability of the compact city in the book, ‘The compact Cities: A Sustainable Urban Form?’. Although the book did not draw an absolute conclusion of the compact city as a sustainable urban form, it had displayed the densification strategy in practice indeed addressing urban problems. Some of the advantages of densifying cities are shortening travel distances, intensifying and concentrating infrastructure and public facilities and reducing energy and resource depletion. (Jenks and Dempsey, 2005)

However, urban densification has also been challenged of its adverse effects. Most significantly, massive building forms and condensed building arrangements have lead to environmental issues such as air pollution and poor ventilation due to the canyon effect, etc. (Jenks, Burton and William, 1996)
Densification Potential in Hong Kong Neighborhoods

Concerning the issues of densification, numerous design criteria should be considered for a better high-density development. Densification involves a great deal of complexity requiring many considerations in implementation (Jenks, Burton and William, 1996).

In the context of Hong Kong, densification has become a foundation of urban planning due to the mounting population, limited buildable lands and land sale policy (Shelton, Karakiewicz and Kvan, 2011). However, several issues have been pointed out in this compact city. The most significant environmental issue of densification in Hong Kong is the poor ventilation resulting in poor air quality and urban heat island effect (Buildings Department, 2011), potentially affecting human health as experienced in the 1990s during SARS.

Therefore, the compelling need of urban planning in Hong Kong is to study the densification potential in Hong Kong before further densification can take place in order to reduce issues and to control future densification.

1.2 Purpose of Study

This thesis aims to evaluate the densification potential in Hong Kong neighborhoods.

The thesis will focus on exploring the densification in the context of Hong Kong. The densification potential of several Hong Kong neighborhoods will be studied.

The densification potential will be, firstly, determined with the density of the neighborhoods. The current density of the neighborhoods will be measured and calculated to find out the density saturation rate.

Second, due to the poor ventilation of dense urban zones, ventilation of the neighborhoods presents another determinant for the densification potential in this research. The ventilation pattern and airflow rate will be simulated and recorded.
Densification Potential in Hong Kong Neighborhoods

**Research Questions**

The main research question is:

**What are the densification potentials in Hong Kong neighborhoods?**

In order to address the main research question, the following questions have to be tackled first:

1. What is the current density in Hong Kong neighborhoods?
2. What is the maximum density permitted in these neighborhoods?
3. What is the ventilation condition in these neighborhoods?

These questions will be solved initially through literature research followed by data collection, where subsequently the main research question will be answered.

**1.3 Overall Structure**

The thesis is structured into 7 chapters as shown in Figure 1.1.

Chapter 1 “INTRODUCTION” introduces the background and purpose of the study in which research questions are raised.

Chapter 2 “LITERATURE REVIEW” will review the literature researched. This chapter will firstly introduce the urban densification by giving its definition, relevance and significance. By pointing out its issues, the design considerations applied to planning urban densification will be illustrated. It will then introduce the urban densification in the context of Hong Kong. The regulations and guidelines of Hong Kong in controlling urban density will be collected, reviewed and evaluated.

Chapter 3 “METHODOLOGY” will present the methodology of this research. The method of measuring density and ventilation of Hong Kong neighborhoods will be introduced with their underlying logic and software involved. Their limitations will be listed.

Chapter 4 “RESULT” will present the data collected from the Hong Kong neighborhoods.
Densification Potential in Hong Kong Neighborhoods

Chapter 5 “DISCUSSION” will discuss and interpret the findings. The data will be analyzed to find out the densification potential of Hong Kong neighborhoods.

Chapter 6 “CONCLUSION” will conclude by addressing the research questions.

Chapter 7 “FUTURE RESEARCH” will reflect on the thesis and expand onto future research in urban densification, urban planning and architectural design.

Flow Chart of the Research

Figure 1.1: Flow chart of the research
CHAPTER 2: LITERATURE REVIEW

2.1 Research on Urban Densification

2.1.1 Introduction to urban densification

**Definition of Urban Densification**

In this thesis, the central term of research is ‘urban densification’. Hence, for better understanding, a clear definition is required.

Urban densification is a term consisted of two words. According to *Oxford Dictionaries*, ‘Urban’ originates from ‘Latin urbanus’ in the early 17th century, referring to town or city. Densification means ‘to make (something) denser’ (Oxford Dictionaries, 2015). Yet, this definition does not express the complexity in association with ‘urban densification’.

According to ‘Cape Town: Densification Strategy’ (The Spatial Planning and Urban Design Department, Cape Town 2012), densification is defined as follows:

‘The increased use of space, both horizontally and vertically, within existing areas/properties and new developments, accompanied by an increased number of units and/or population threshold.’

To conclude, in this thesis, ‘Urban Densification’ means to increase the building and population density of existing built environments.

**Objectives of Urban Densification**

Literature: ‘Is urban densification a reachable goal?’

Bergsteinsson divided the objectives of urban densification into three aspects as followed:

**Densifying Existing Areas**

‘The most important objectives of urban densification relates to aim of creating a denser urban form (that is higher building density, referred to as people per hectare) between existing urban spaces of the city.’ (Fridrik Bergsteinsson, 2014, P.12)
Densification Potential in Hong Kong Neighborhoods

This explains that Densification is an urban growth to increase building and population density within the existing limits of the area of the city.

Renewing Industrial Areas

‘Urban densification can take many forms. It can take place on derelict industrial areas, also referred to as brownfield areas, through the demolition and recreation of existing areas or through optimizing existing spaces.’ (Fridrik Bergsteinsson, 2014, P.12)

Bergsteinsson clarifies that not only can densification increase building density and population threshold of the existing area, but can also improve and optimize the existing spaces through renewal.

Intensifying Mix Uses

‘Urban densification can also refer to aims of increasing the mix use of functions such as primary and secondary services as well as businesses.’ (Fridrik Bergsteinsson, 2014, P.12)

This further shows the complexity and diversity of urban densification by intensifying and mixing of functions in the existing areas.

First Promotion of Urban Densification

According to Bergsteinsson (2014), Urban densification was first put on the global agenda when the United Nations report, ‘Our Common Future’ was published in the 1987. The report promotes urban densification as a means of urban planning to achieve a more sustainable future (World Commission on Environment and Development, WCED, 1987). After the promotion of urban densification, national and local government worldwide have been applying densifying strategies to plan for a sustainable and compact city (Bergsteinsson, 2014).
CHAPTER 2: LITERATURE REVIEW

2.1.2 Reasons of Urban Densification

Figure 2.1: The world’s urban and rural populations, estimated for 1950-2014 and projected to 2050 (United Nation, 2014)

Rising Population

Since 2009, the world has turned to be more urban than rural when ‘the number (3.42 billion) of people living in urban areas had surpassed the numbers living in rural areas (3.41 billion)’ (United Nations, 2009). As shown in Figure 2.1, in 2014, the world’s urban population has tremendously increased to 3.9 billion. It is predicted that by 2050, 6.3 billion people (60% of world population) will live in urban settlements (United Nations, 2014).

Accommodating this enormous number of people has become the compelling need in cities across the world. It is logical, inevitable and consequential to increase the density of the existing areas of the cities. (Shelton, Karakiewicz and Kvan, 2011). Densification, therefore, has to take place so as to fit in this swelling population in the cities.

Sustainable Urban Form

After the endorsement of urban densification in the Brundland report, ‘Our Common Future’ in 1987, urban densification has been adopted to accomplish a sustainable city worldwide (World Commission on Environment and Development, WCED, 1987).
CHAPTER 2: LITERATURE REVIEW

2.1.2 Reasons of Urban Densification

Advantages of Urban Densification

Urban densification addresses urban problems in the three aspects of sustainability proposed by Rio +20 Conference, ‘The future we want’ (United Nations, 2014). They are environmentally, economical and social advantages as followed.

Environmental Significance:

Reduction on energy and resource consumption

Literature: ‘Urban densification: An innovation in sustainable urban policy?’

‘By creating higher densities it would be possible to support efficient infrastructure, create shorter distances between urban functions and thus all in all improve the energy efficiency of the urban area in the transport.’ (Anne Skovbro, 2001)
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As shown in Figure 2.2, the fuel consumption per people decreases as the urban density rises. The book, *The Compact City: A Sustainable Urban Form?* explained, one of the key advantages of urban densification in the sustainability stakes, is *its ability to reduce car dependency and fuel use, through its compactness and centre-to-periphery public transport corridors.* (Jenks, Burton and Williams, 1996)

Densification can save up the energy and resource depletion by short travel distance and intensive public transport system.

**Efficient and Viable Public Transportation**

Literature: High Urban Densities - A Solution for Our Cities?

*‘By concentrating a large number of people living or working in each area, it provides a large number of users for each unit length of the transport links.’*

(Fouchier and Merlin, 1994)

The high population in compact city sustains the construction and operation of transport system. In turn, an efficient and viable transportation system favors the densification by connecting the areas in the city (Fouchier and Merlin, 1994). In addition, effective public transportations lower dependency on automobile in the city, thus, reducing petrol consumption (Jenks, Burton and Williams, 1996).
CHAPTER 2: LITERATURE REVIEW

2.1.2 Reasons of Urban Densification

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<th>Rail</th>
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<td>131.7</td>
<td>8.6</td>
<td>12.3</td>
<td>4.3</td>
<td>18.2</td>
</tr>
<tr>
<td>15-29.99</td>
<td>152.6</td>
<td>105.4</td>
<td>9.6</td>
<td>10.2</td>
<td>6.6</td>
<td>20.6</td>
</tr>
<tr>
<td>30-49.99</td>
<td>143.2</td>
<td>100.4</td>
<td>9.9</td>
<td>10.8</td>
<td>6.4</td>
<td>15.5</td>
</tr>
<tr>
<td>50 and +</td>
<td>129.2</td>
<td>79.9</td>
<td>11.9</td>
<td>15.2</td>
<td>6.7</td>
<td>15.4</td>
</tr>
<tr>
<td>All areas</td>
<td>159.6</td>
<td>113.8</td>
<td>9.3</td>
<td>11.3</td>
<td>5.9</td>
<td>19.1</td>
</tr>
</tbody>
</table>

Table 2.1: Density and distance travelled per person per week mode (km) (Bergsteinsson, 2014)

**Short Travel Distance**

Table 2.1 shows the distance travelled per person per week. The higher density enables shorter travel distance by public transportation and encourages walking (Jenks, Burton and Williams, 1996). According to ‘High Urban Densities A Solution for Our Cities?’, under high-density development,

‘All activity points and places of residence are located at proximity to each other, both horizontally and vertically.’ (Fouchier and Merlin, 1994)

The book explained confined in a dense area, different uses are placed closely and piled vertically, shortening the travel distance. With short distance, it is more efficient for people to travel by foot. Hence, less reliance on the transportation reduces traffic problem. (Fouchier and Merlin, 1994)

**Preservation of valuable lands**

Literature: ‘Urban densification: An innovation in sustainable urban policy?’

‘Continued urban sprawl will lead to a continuing loss of land, and often valuable agricultural land.’ (Anne Skovbro, 2001)
CHAPTER 2: LITERATURE REVIEW

2.1.2 Reasons of Urban Densification

Skovbro (2001) explains when it comes to biodiversity; ‘large green areas outside the city are more valuable than many small green spots within the urban area’. Therefore, densification of urban areas can help preserve the natural habitats and agricultural lands.

Economic Significance:

Maximum Use of Civic Infrastructures

In each community, essential infrastructures must be provided including transport connections, water supply, drainage and sewage systems, electricity supply and utilities. The construction and maintenance of these infrastructures costs high investment of the government. High-density development fully utilizes the efficiency and capacity of these infrastructures (Fouchier and Merlin, 1994). Hence, densification of the city can make the most use of the civic infrastructures, making the investment on the service worthwhile.

Concentration of Specialized Services and Facilities

Literature: Asian Urbanization, A Hong Kong Casebook

‘There exist in a high density grouping the possibilities of economic opportunity and the specialization of services and facilities giving the economies of scale in business, manufacturing and the growth of so called quaternary services...’ (D. J. Dwyer, 1971)

Densification concentrates the limited specialized services and facilities to increase their utilization efficiency (D. J. Dwyer, 1971). On the other hand, it is much more expensive and wasteful to spread and build a lot of services and facilities in a smaller and sprawling development.

Social Significance:

Mixed use

Literature: ‘Is urban densification a reachable goal?’
CHAPTER 2: LITERATURE REVIEW

2.1.2 Reasons of Urban Densification

‘By incorporating mix use of function it can potentially promote people’s use of greener modes of mobility and thereby reducing automobile dependency.’ (Fridrik Bergsteinsson, 2014, P.20)

With limited land, densification requires to pile up and mix different uses in a building and in a neighborhood. (Radovic, 2009) Applied to the context of Hong Kong, this would mean that mixing usages starts already within one building and then extends to the neighborhood. The question of a regulatory mix becomes very important.

Concentrated Public facilities

Jenks and Dempsey (2005) favor in densification because high concentration of people in high-density cities enables a closer proximity of diverse community, health, recreational, and other public services.

Diverse social life

Literature: ‘Urban densification: An innovation in sustainable urban policy?’

‘An essential part of the idea of urban densification, has been that this could lead to better urban districts, through creating more diverse social life, better local services due to the higher population densities, thus in general an urban lifestyle as known earlier in the century.’ (Anne Skovbro, 2001)

List of Advantages of Urban Densification

<table>
<thead>
<tr>
<th>Environmental</th>
<th>Economic</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduced energy and resource consumption</td>
<td>• Maximized use of infrastructure</td>
<td>• Mix use</td>
</tr>
<tr>
<td>• Short travel distance</td>
<td>• Concentrated infrastructure</td>
<td>• Concentrated public facilities</td>
</tr>
<tr>
<td>• Efficient and viable public transportation</td>
<td></td>
<td>• Diverse social life</td>
</tr>
<tr>
<td>• Preserve valuable lands</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2: List of advantages of urban densification
Urban densification also poses urban problems environmentally, economical and social as followed.

**Impact on Environmental Quality:**

**Poor Ventilation**

Jenks, Burton, Williams (1996) mentions the high-density building blocks can stifle the airflow, resulting in poor ventilation of the urban area.

**Street Canyon**

Besides, dense building blocks can also result in street canyon. According to ‘Sustainable Building Design Guidelines’ (Buildings Department of Hong Kong, 2011), ‘A street canyon is a canyon (a deep narrow valley) formed in a street between tall buildings on both sides.’ The street canyon is the main parameter influencing air ventilation between the buildings (Buildings Department, 2011).
CHAPTER 2: LITERATURE REVIEW

2.1.3 Issues of Urban Densification

Urban Heat Island Effect
The canyon effect traps the heat from sun radiation and urban exhaustion, raising the urban temperature (Jenks, Burton and Williams, 1996). Without the cooling by proper ventilation, urban heat island effect often happens at the compact city that the temperature of the urban area is higher than the surrounding rural areas (Fung, 2010). As shown in Figure 2.3, the temperature of high-density Kowloon Peninsula is higher than the surrounding at nighttime. This is an illustration of urban heat island effect that the heat is trapped inside the urban areas (Fung, 2010).

Air Pollution
According to ‘Urban densification: An innovation in sustainable urban policy?’ (Anne Skovbro, 2001), compacting city ‘causes increased traffic congestion, which leads to greater air pollution in urban areas.’ Besides, due to the poor ventilation of high-density built environment, the air pollutants stay and accumulate, further worsening the air quality (Jenks, Burton, Williams, 1996).

Economic Issues:

High Real Estate Values
Literature: ‘Asian Urbanization, A Hong Kong Casebook’

‘High intensity of land use brings such high real estate values as to begin to retard development.’ (D. J. Dwyer, 1971)

According to ‘Urban densification: An innovation in sustainable urban policy?’ (Anne Skovbro, 2001), urban densification ‘suffers more from the resulting high land prices.’ The valuable lands in a high-density area charge high premium from the developers. Therefore, the developers have to raise the real estate values to recover the premium and maximize profit. In turn, the high real estate value further elevates the land prices (Shelton, Karakiewicz and Kvan, 2011).
CHAPTER 2: LITERATURE REVIEW

2.1.3 Issues of Urban Densification

Social Issues:

Unwanted Social Contacts

According to ‘High Urban Densities A Solution for Our Cities?’ (Fouchier and Merlin, 1994), under congested conditions in compact cities, ‘People are forced by the practical physical conditions, in which they live and work, to be in contact with others with whom they have no need or desire to make contact.’ Involuntary contacts can result in social conflicts, breaking the harmony of the neighborhood (Fouchier and Merlin, 1994).

Deficiency of Facilities

Literature: ‘High Urban Densities A Solution for Our Cities?’

‘Under very congested conditions in which they have to suffer extremely keen competition for the use of facilities and spaces.’ (Fouchier and Merlin, 1994)

Moreover, insufficient land in dense areas stops building additional facilities even if resources are available. Lacking facilities further worsen the competition on use (Fouchier and Merlin, 1994).

Loss of Privacy

Literature: ‘High Urban Densities A Solution for Our Cities?’

‘Squeezing so many people so closely together, high-density development reduces privacy.’ (Fouchier and Merlin, 1994) Although this situation is less concerned in work places as frequent and close contacts favor in business, the residential areas requires a great deal of privacy (Fouchier and Merlin, 1994).

List of Issues of Urban Densification

<table>
<thead>
<tr>
<th>Environmental</th>
<th>Economic</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Poor ventilation</td>
<td>• High real estate values</td>
<td>• Unwanted social contacts</td>
</tr>
<tr>
<td>• Street Canyon</td>
<td></td>
<td>• Deficiency of facilities</td>
</tr>
<tr>
<td>• Urban heat island effect</td>
<td></td>
<td>• Loss of privacy</td>
</tr>
<tr>
<td>• Inadequate open space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.3: List of issues of urban densification
CHAPTER 2: LITERATURE REVIEW

2.1.4 Design Considerations of Urban Densification

After studying the issues of urban densification, design considerations should be made to minimize the problems while to maximize the advantages bought by densification.

Jenks and Dempsey (2005) suggest urban densification involves a great deal of complexity. During planning of the urban density, different considerations should be taken into account in order to minimize the issues bought by urban densification. These comprise physical setting, environmental quality, connectivity, public space and mixed use.

Physical Setting

Density Capacity

Literature: ‘The Compact City: A Sustainable Urban Form?’

‘Density capacity of a city should be limited by the authorities to prevent overcrowding and minimize its problems. Floor area ratio (FAR) is often employed as the density capacity of a site.’ (Jenks, Burton and Williams, 1996)

Each city requires its statutory regulations to control the density of the city. For example, in Hong Kong, there are Town planning Ordinance and Building ordinance to control the building density of the site, neighborhood and district (Shelton, Karakiewicz and Kvan, 2011).

Infrastructure Capacity

According to ‘High Urban Densities A Solution for Our Cities?’ (Fouchier and Merlin, 1994), ‘for every infrastructure system there is always an utilization threshold below which it is not cost-effective to provide the service.’ The threshold of necessary infrastructures should be analyzed to set the limitation of the population of the city.
CHAPTER 2: LITERATURE REVIEW

2.1.4 Design Considerations of Urban Densification

Environmental Quality:

Ventilation

In this thesis, ventilation study is employed to examine the density conditions of studied neighborhoods in order to study their densification potentials.

According to ‘The Compact City: A Sustainable Urban Form?’ (Jenks, Burton and Williams, 1996), ‘The air-flow and pollution dispersion are heavily driven by the 3-D geometry of the space.’

Site and Building Permeability

Literature: ‘Sustainable Building Design Guidelines’

‘For better urban air ventilation in a dense, hot-humid city, breezeways and air paths should be provided in order to allow effective air movements in the urban area to remove heat, gases and particulates and to improve the micro-climate of urban environment. Higher permeability can help improve air ventilation’ (Buildings Department, 2011)

There are several methods to achieve the permeability of building masses. Gaps can be created ‘between building blocks, between the podium and the building blocks built atop’, for instance, a void podium deck. Moreover, Setting building back from street, and within building blocks at various levels can also help increase site permeability (Buildings Department, 2011).

Therefore, in order to improve air ventilation and mitigate heat island effect, ventilation of the city should be studied to optimize the orientation, arrangement and form of buildings.

Other environmental considerations include study on daylight access, acoustic noise and energy consumption (Jenks, Burton and Williams, 1996).
CHAPTER 2: LITERATURE REVIEW

2.1.4 Design Considerations of Urban Densification

Connectivity:
Urban activities greatly rely on movement that is considerably influenced by the patterns and connections. In ‘Eco-Urbanity: Towards well-mannered built environments’ (Radovic, 2009), ‘Good connectivity promotes improved access to local facilities and free movement within and out of the city.’

Accessibility to public services and facilities
Radovic (2009) explains that closer proximity to public services and facilities can strengthen social interaction and improve efficiency of movement. High accessibility to public transport system especially, rail infrastructure can reduce vehicle emission and energy consumption (Radovic, 2009).

Walkability
Based on her observations of past American cities, Jane Jacobs (1961) advocates active street activities through having more route options and crossing points accomplished by more and shorter streets. With a complete network of walk path in the dense community can encourage people walking, reducing reliance on automobile. Therefore, when it comes to connectivity within a high-density city, accessibility to public services and facilities and walkability of the community should be considered in urban densification.

Other connectivity study includes proximity to places of employment (The Spatial Planning and Urban Design Department, Cape Town, 2012).
CHAPTER 2: LITERATURE REVIEW

2.1.4 Design Considerations of Urban Densification

Public Space:

Literature: ‘Eco-Urbanity: Towards well-mannered built environments’ (Radovic, 2009)

‘A high-quality public realm attracts people and activities, increases economic performance, encourages new forms of street activity, increases the pride of the community and improves the potential for social engagement and cultural activities.’

Radovic (2009) comments the urban densification often provides inadequate public space that is mainly ‘left-over space, poorly designed’. Jane Jacobs (1961) also advocates the importance of public space to activate street. Thus, it is essential to incorporate public space in planning for urban densification.

Mixed Use:

As said by ‘Eco-Urbanity: Towards well-mannered built environments’ (Radovic, 2009), ‘Mixed use is one of the cornerstones to healthy, vibrant and sustainable communities.’ Radovic (2009) discusses that putting different functions together can increase the viability of local businesses. By mixing different programs, the closer proximity can reduce dependency on cars and promote convenience.

However, Fouchier and Merlin (1994) points out mixed uses in congest area can lead to unwanted social contacts of different users, possibly resulting conflicts. Urban densification inevitably mixes different functions in an area. Therefore, the mixing of different uses should be studied of their nature and relationship and then carefully planned to minimize incompatible uses and unwanted social contacts.

Other design considerations of urban densification include cultural preference, housing affordability and health (Density Atlas, 2011).
CHAPTER 2: LITERATURE REVIEW

2.1.4 Design Considerations of Urban Densification

Design Considerations in this Research

In this research, site density and ventilation will be considered to examine the densification potential of Hong Kong neighborhoods.

First of all, measuring site density is essential because it can find out the saturation rate of density. The saturation rate can tell how much density could fit in the neighborhood whereby deducing the densification potential of the neighborhoods.

Second, ventilation is also an important consideration in densification to enhance environmental quality of the neighborhood. For environmental considerations, ventilation is studied over solar in this research because solar is not related to air quality and a shortage of solar does not pose risk to health. Plus, Building Ordinance in Hong Kong has already ensured buildings with access to enough daylight, but not ventilation. On the other hand, high-dense built environment does affect the ventilation whereby worsening the air quality and potentially spreading air-born diseases such as SARS as experienced in Hong Kong in 2003. Therefore, studying the current ventilation conditions of the neighborhoods would examine how dense can the buildings be built and assist the future urban planning.
CHAPTER 2: LITERATURE REVIEW

2.2 Hong Kong Context

2.2.1 Reasons of Urban Densification in Hong Kong

According to ‘The Making of Hong Kong: From Vertical to Volumetric’ (Shelton, Karakiewicz and Kvan, 2011), ‘the form of this city has been shaped fundamentally by a constant lack of developable land, very high land prices and an ever increasing population.’

Population

According to the Hong Kong Population Projection (2012), it predicts a vast growth of population from 7.1314 thousands to 8.469 thousands between 2012 and 2041. Urban densification, therefore, is an inevitably measures to accommodate this mounting population by offering more living and working space.

Topography

Expressed in High Urban Densities A Solution for Our Cities? (Fouchier and Merlin, 1994), ‘The mountainous terrain of the Territory has also restricted the amount of land available for residential development’. The lack of building land directs Hong Kong to employ urban densification. Besides, the investment on civic infrastructure and service in exploring the steep terrains is very high (Shelton, Karakiewicz and Kvan, 2011). The urban development, therefore, concentrates to compacting existing districts to fully utilize their infrastructure.

Land sell-off

As said by ‘Asian Urbanization, A Hong Kong Casebook’ (D. J. Dwyer, 1971), ‘In Hong Kong, where land values and government income from land sales have played an important part in the creation of total national income, the preservation of land values has in itself been an incentive to high density development.’ Due the significant role of leasing out land has played in Hong Kong government’s income, the annual land sell-off is controlled to achieve maximum price in land auction. Therefore, Hong Kong government, the landlord, maintains the high land values by preserving lands and developing the existing urban areas (Shelton, Karakiewicz and Kvan, 2011).
Densification Potential in Hong Kong Neighborhoods

CHAPTER 2: LITERATURE REVIEW

2.2.1 Reasons of Urban Densification in Hong Kong

Therefore, densification is the only way to deal with the surging population in the limited lands.

According to ‘Asian Urbanization, A Hong Kong Casebook’ (D. J. Dwyer, 1971), the compactness of Hong Kong has occurred ‘because of a system of lease revision, extracting high premiums but granting large permitted increases of volume on reconstruction.’ Having highest land price in the world, the developer tends to maximize the plot ratio to gain greatest profit to cover the high premium (Shelton, Karakiewicz and Kvan, 2011). This favors densification in Hong Kong.

Transportations

Highly developed transportations in Hong Kong support the urban densification. Multi-mode public transportations in Hong Kong including railways, buses and minibuses enable the viability of efficient movement and connection in the high-density urban areas (Shelton, Karakiewicz and Kvan, 2011).

Furthermore, the network of pedestrian trips in Hong Kong is complete to increase the speed and efficiency of movement (Fouchier and Merlin, 1994). Not only confined to the ground, the elevated walkway connects the high rises giving another route options for better efficiency (Shelton, Karakiewicz and Kvan, 2011). All these advances in transportations in Hong Kong favor the urban densification.

Building Regulations

According to Asian Urbanization, A Hong Kong Casebook (D. J. Dwyer, 1971), the compactness of Hong Kong has occurred ‘because of building regulations conceived to encourage maximum development of sites and changed over a short period of time to allow greater and greater volumetric development.’ The high plot ratio permitted in Hong Kong encourages developer to build dense and tall building for maximizing profits.
For controlling urban density, there are statutory regulations and non-statutory guidelines in Hong Kong. They are reviewed to find out how the urban density is controlled in Hong Kong.

Statutory Control:
There are two types of statutory regulations, namely the Town Planning Ordinance and Building Ordinance in Hong Kong, legally regulating the urban density and development of Hong Kong.

Town Planning Ordinance
Town Planning Ordinance prepared by the Town Planning Board aims ‘To promote the health, safety, convenience and general welfare of the community by making provision for the systematic preparation of plans and approval of plans for the lay-out of areas of Hong Kong’ (Town Planning Board, 1997).
CHAPTER 2: LITERATURE REVIEW

2.2.2 Related Regulations and Guidelines of Hong Kong

Outline Zoning Plan

‘The OZPs shows the proposed land-uses and major road systems of individual planning scheme areas in Hong Kong’ (Town Planning Board, 2008). A statutory plan is attached to each site to show its schedule of uses and explanatory statement on special requirements such as building set back, building separations, building height restriction and others. Therefore, the special requirements denoted in the OZPs shapes the building masses, heights, separations whereby controlling the building density and ventilation of the areas.

Building Ordinance

Building ordinance prepared by Buildings Department controls the development of building in Hong Kong. It states the permitted plot ratio and site coverage of a site to control the gross floor areas and the height of buildings. The plot ratio and site coverage of a site is determined by the use of building, building height permitted in OZPs or lease and class of site. (Buildings Department, 2012)

Building (Planning) Regulation Part IV

Furthermore, building ordinance regulates the lighting and ventilation of the building. By defining the size of openings and its light well, the buildings can be provided with better lighting and ventilation. The lighting and ventilation in the areas can also be controlled to minimize affects bought by adjacent buildings (Buildings Department, 2012).

Non-statutory Control:

Non-statutory control for urban density includes land lease and sustainable building design guideline. They propose methods that control urban density and promote sustainability in dense built environment.
CHAPTER 2: LITERATURE REVIEW

2.2.2 Related Regulations and Guidelines of Hong Kong

Land Lease

Lands in Hong Kong are leased by the Government. The land lease, a contract between the Government and the Landlord denotes the conditions of the site development. Conditions can consist of use of land, height limit, gross floor area, vehicular access and non-building area (Lands Department, 2005).

Sustainable Building Design Guideline (SBD Guidelines)

The objectives of SBD Guidelines (APP – 152) attached in Appendix A are ‘to achieve better air ventilation, enhance the environmental quality of our living space, particularly at pedestrian level, provide more greenery and mitigate the heat island effect’ (Buildings Department, 2011).
Densification Potential in Hong Kong Neighborhoods

CHAPTER 2: LITERATURE REVIEW

2.2.2 Related Regulations and Guidelines of Hong Kong

Three main building design elements: building separation, building set back and site coverage of greenery are employed to enhance the environmental sustainability of the urban area.

**Building Separation**

Buildings in large development sites need to be separated to prevent undesirable walling effect of ‘long buildings’ (Buildings Department, 2011). The building separation is divided vertically into three zones: low, middle and high height.

No pedestrian areas will be subject to excessive wind speeds and there are no stagnant areas not flushed by breezes’ (Buildings Department, 2011).

**Building Set Back**

Building abutting a narrow street less than 15m wide shall be set back so as to improve air ventilation especially at pedestrian level and mitigate deep street canyon effect. The flow of air volume should be allowed with ‘a minimum sectional area of 15m x 15m along the street’ (Buildings Department, 2011). The set back focuses on the structures at levels below 15m.
CHAPTER 2: LITERATURE REVIEW

2.2.2 Related Regulations and Guidelines of Hong Kong

Assessment Methods

Air Ventilation Assessments (AVAs) have been employed to study the air ventilation performance of the building to its surrounding. The Technical Circular of AVAs in Hong Kong is attached in Appendix B. There are three possible stages in AVAs: Expert Evaluation, Initial Study and Detailed Study. Expert Evaluation requires no analysis; Initial Study is typically done with Computational Fluid Dynamics (CFD) analysis; Detailed Study essentially requires a wind tunnel study. Figure 2.6 shows the sample projects done by Arup using CFD and wind tunnel study to study the ventilation in different districts.

In this research, Initial Study will be used because it is more efficient and less resource demanding. However, without using wind tunnel, the ventilation is less reliable due to the fact that wind is ever changing and affected by many factors such as topography and buildings far away. Therefore, 8 out of 16 wind directions, exceeding 75% of the annual wind of the site, will been use to study to obtain a more comprehensive and more accurate analysis.
CHAPTER 3: RESEARCH METHODOLOGY
This thesis is set out to evaluate the densification potential in Hong Kong neighborhoods.

3.1 Determinants:
In order to assess the densification potential, two determinants will be measured to examine the current density conditions. They are site density and ventilation.

3.1.1 Site Density
Reasons
In this thesis, the site density in Hong Kong neighborhoods will be measured. Measuring the site density can find out the saturation rate of density. The saturation rate can tell how much density could fit in the neighborhood whereby deducing the densification potential of the neighborhoods.

Underlying Logic
In each neighborhood, the current density and the density capacity of each site will be recorded. The current density of site is represented by the current plot ratio of the site while the density capacity of the site is the maximum plot ratio permitted of the site.

The current plot ratio and the maximum plot ratio permitted of all sites in the neighborhoods will be summed up respectively. The saturation rate of site density of the neighborhood will be the ratio of sum of current plot ratio to the maximum plot ratio permitted as followed:

\[
\text{Saturation Rate of Site Density of the neighborhood} = \frac{\text{Sum of Current Plot Ratio of All Sites}}{\text{Sum of maximum plot ratio permitted of all Sites}} \times 100\%
\]

Measurements
Three quantitative measurements of density: plot ratio, dwelling units and population are employed to study the site density in the neighborhood.
CHAPTER 3: RESEARCH METHODOLOGY

3.1.1 Site Density

Density Atlas (2011) explains these three are common measures of density, describing different aspects of density. For a better understanding of the density, the relationship of these three measurements will be analyzed in this thesis.

1. Plot Ratio

Definition

Plot ratio is the ratio of gross floor area to the site area.

![Diagram of plot ratio with FAR 1/9 (0.111) and FAR 9/9 (1.0)](image)

Figure 3. 1: Illustrations of plot ratio where Floor Area Ratio, FAR is same with plot ratio (Density Atlas, 2011)

Reasons

The plot ratio is measured to find out the site density. Having the plot ratio of each site in the neighborhoods, the saturation rate of density will be calculated.

Data

In each site in the neighborhoods, followings will be measured:

- Current plot ratio
- Maximum plot ratio permitted

According the Outline Zoning Plan, the sites are zoned into different land uses such as residential and commercial. The plot ratio of different uses will be measured to examine the density and the saturation rate of different uses.
CHAPTER 3: RESEARCH METHODOLOGY

3.1.1 Site Density

Measuring Methods

Current plot ratio of the site will be measured by estimating the plans of the existing buildings. Maximum plot ratio of the site will be found by looking into the Outline Zoning Plan and the Building Ordinance.

2. Dwelling Units

Reasons

Studying the dwelling unit aims to find out the residential density of the neighborhood. The ratio the dwelling unit to the site area examines the size of living space in the neighborhood.

![Illustration of different number of dwelling units in the same area](Density Atlas, 2011)

Data

In each residential site in the neighborhoods, the following will be measured:

- Number of dwelling units
- Ratio of dwelling units to the site area (DU/m²)

\[
\text{Ratio of Dwelling Units} = \frac{\text{Sum of Dwelling Units of the Site}}{\text{Site Area}}
\]

Measuring Methods

Number of dwelling units will be counted from the building plans.
CHAPTER 3: RESEARCH METHODOLOGY

3.1.1 Site Density

3. Population

Definition
Population means the number of people in a given area.

Reasons
Measuring the population of the residential site can also find out the residential density of the neighborhood. The ratio of population to the site area examines the crowdedness of the neighborhoods.

![Illustration of different population in the same area](Density Atlas, 2011)

Data
In each residential site in the neighborhoods, followings will be measured:

- Number of residence
- Ratio of population to the site area (POP/m²)

\[
\text{Ratio of Population} = \frac{\text{Sum of Population of the Site}}{\text{Site Area}}
\]

Measuring Methods
Number of residence will be estimated from the dwelling units mix and type of the building.
CHAPTER 3: RESEARCH METHODOLOGY

3.1.2 Ventilation Study

Reasons

In the literature review, one of the most compelling issues of urban densification is the poor ventilation causing urban heat island effect and potentially spread of air-born diseases such as SARS. Therefore, in this thesis, the current ventilation conditions of Hong Kong neighborhoods will be studied. The wind data produced, will examine the densification potential. Furthermore, studying the current ventilation conditions of the neighborhoods would assist the future urban planning to mitigate urban heat island effect.

Underlying Logic

Air Ventilation Assessments (AVAs) have been employed to study the ventilation performance of buildings and the surrounding. There are three possible stages in AVAs: Expert Evaluation, Initial Study and Detailed Study. Expert Evaluation requires no analysis; Initial Study is typically done with Computational Fluid Dynamics (CFD) analysis; Detailed Study essentially requires a wind tunnel study. In this research, the ventilation study will be an Initial Study. For Initial Study, 8 out of 16 wind directions, exceeding 75% of the annual wind of the site, will been use to study to obtain a more comprehensive and more accurate analysis.

CFD uses computer algorithms to precisely conduct numerical calculations. CFD simulates the interaction of fluids and gases with complex surfaces. In this thesis, the CFD software of choice is the wind tunnel tool in Autodesk Vasari.

Data

For each neighborhood, the following will be explored.

- Ventilation pattern of the low, middle and high zones.
CHAPTER 3: RESEARCH METHODOLOGY

3.1.2 Ventilation Study

Measuring Software

**Autodesk Revit** is used to build the digital 3D site models.

**Autodesk Vasari** is employed to run the ventilation analysis. The digital site model built in Autodesk Revit will be loaded into the wind tunnel tool in Vasari.

Wind Simulations

Wind data are provided by local weather stations and compiled in the weather data – database of Hong Kong. Autodesk is accessing the publicly available weather data and generate the wind rose diagram for easier interpretation and understanding. Wind rose diagram of each neighborhood location will be generated to shows the direction, frequency and speed of wind. After sitting the location of the neighborhood, the airflow of the site model will be simulated and analyzed to visualize the 2D ventilation pattern of different zones.
CHAPTER 3: RESEARCH METHODOLOGY

3.2 Limitations

1. Not only site density and ventilation, there are other parameters affecting the densification potential such as infrastructure capacity and connectivity.
2. The land-use and plot ratio of the site are subjected to change by Town Planning Board, Buildings Department and land lease.
3. Estimation of current plot ratio through measuring plans may pose inaccuracy to the result.
4. The population of residential buildings estimated by the dwelling mix and type may also imprecise.
5. The ventilation study only assesses the area of the neighborhoods. However, the buildings outside the neighborhoods, in fact, also affect ventilation. The scale of the computational site model greatly influences the result.

3.2 Neighborhoods Selection

The thesis will focus at exploring the densification in the context of Hong Kong. The densification potential of several Hong Kong neighborhoods will be studied. In this thesis, 3-5 neighborhoods will be studied.

In this thesis, the scale of examination will be at the neighborhood level, in between the urban and the building levels. The neighborhood level is defined as ‘a cluster of walkable blocks’ (Density Atlas, 2011) comprising certain public services and open space. The neighborhood level allows studying the urban density at a suitable scale that is large enough to study the different building densities of an area, yet being small enough to study the ventilation pattern at different levels of the area (Gracia, 2013).
CHAPTER 3: RESEARCH METHODOLOGY

3.1.2 Ventilation Study

Criteria of Choosing Neighborhoods

1. Urban Renewal Projects

According to Urban Renewal Authority, redevelopment has been implementing in Hong Kong. It aims to prevent urban decay and to improve the living conditions. A number of projects have been undertaking and proposing over Hong Kong districts. The districts include Kwun Tong, Sham Shui Po, Mong Kok, Yau Ma Tei, and Wan Chai et cetera. Hence, the neighborhoods studied in this thesis will be selected in these districts.

2. Close proximity to public transportation

In considering urban densification, proximity to public transportation is important for efficient travel and reducing energy consumption compared to private automobile. The most efficient and populated mode of transportation in Hong Kong is the MTR railways. A proximate area is usually a 500m-radius circle drawn from the MTR station (Shelton, Karakiewicz and Kvan, 2011). Therefore, the neighborhoods selected will be within the area serviced by MTR stations.

3. Mixed Use

Another design consideration in urban densification is the mixing different use for a socially vibrant community. The neighborhood studied, thus, will be diverse in mixing building types and uses. The different uses will be found out by looking into outline zoning plane where different areas are zoned into different uses.

4. Potential for Densification

The purpose of the research is to study the densification potential. Therefore, it is key that neighborhoods selected should have room for densification. It is difficult to tell the potential for densification based on observation. But, the areas mixed with old buildings and new development will be chosen to study its densification potential.
CHAPTER 4: RESULT

4.2.1 Introduction to Neighborhoods

Neighborhood 1: Sau Wa Fong, Wan Chai

Sau Wa Fong, located at Wan Chai, is a mixed use and vibrant neighborhood with a good network of footpath. The main reason of studying Sau Wa Fong is that this neighborhood has been planning to be redeveloped into the Hopewell Center III by the Urban Renewal Authority. This research aims to measure the current density and ventilation situation of this neighborhood in order to provide feedback and background information to the redevelopment.

Another reason to examine Sau Wa Fong is its potential for densification. Currently, Sau Wa Fong is a rare residential neighborhood in Wan Chai having a relatively low density of building including many low-rise tenement houses. There are total 18 plots in the neighborhood.
CHAPTER 4: RESULT

4.2.1 Introduction to Neighborhoods

Neighborhood 2: Kam Wa Street, Shau Kei Wan

Kam Wa Street, located in Shau Kei Wan, is an old and vibrant neighborhood with two walkable streets. The walkable streets, Kam Wa Street and Tai Tak Street are used for street market and act as a network of footpath to connect the neighborhood.

The main reason to examine Kam Wa Street is that Shau Kei Wan is one of the key redeveloping districts by the Urban Renewal Authority. Presently, Kam Wa Street is a residential neighborhood with a relatively low building density in Shau Kei Wan having many low-rise row houses. There are total 10 plots in the neighborhood.
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Densification Potential in Hong Kong Neighborhoods

CHAPTER 4: RESULT

4.2.1 Introduction to Neighborhoods

Neighborhood 3: Tsuen Hing Path, Tsuen Wan

Tsuen Hing Path is a vibrant and distinct neighborhood in Tsuen Wan. The network of footpath composed of Tsuen Hing Path, On Wing Street and Cheong Tai Street is used as outdoor dinning areas and public spaces for the social activity of the neighborhood. The area is a famous food street with international cuisines.

The main reason to study Tsuen Hing Path is that Tsuen Wan is the only redeveloping district in New Territories by the Urban Renewal Authority. Currently, Tsuen Hing Path is now a residential neighborhood with a relatively low building density in Tsuen Wan including several low-rise tenement houses. There are total 11 plots in the neighborhood.
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 1: Sau Wa Fong, Wan Chai

1. Plot Ratio

<table>
<thead>
<tr>
<th>Plot</th>
<th>Site Area (m²)</th>
<th>Class of Site</th>
<th>Maximum Plot Ratio</th>
<th>Current Plot Ratio</th>
<th>Saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Domestic</td>
<td>Non-dom.</td>
<td>Domestic</td>
</tr>
<tr>
<td>A</td>
<td>229</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>110</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>227</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>223</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>109</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>72</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>107</td>
<td>A</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>473</td>
<td>A</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>455</td>
<td>A</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>448</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>303</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>380</td>
<td>B</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>224</td>
<td>A</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>96</td>
<td>B</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>172</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>62</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>125</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1: Plot ratios of each plot in Sau Wa Fong neighborhood
## Densification Potential in Hong Kong Neighborhoods

### Table 4.2: Calculation of plot ratios of Sau Wa Fong neighborhood

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total site area of the plots in the neighborhood</strong></td>
<td>229 + 110 + 227 + 223 + 109 + 72 + 107 + 473 + 455 + 448 + 303 + 380 + 224 + 96 + 172 + 62 + 125 + 139</td>
</tr>
<tr>
<td><strong>Total Maximum Gross Floor Area of the plots in the neighborhood</strong></td>
<td>229<em>9 + 110</em>8 + 227<em>15 + 223</em>8 + 109<em>8 + 72</em>8 + 107<em>5 + 473</em>5 + 455<em>5 + 448</em>9 + 303<em>9 + 380</em>5 + 224<em>5 + 196</em>5 + 72<em>8 + 62</em>8 + 125<em>8 + 139</em>8</td>
</tr>
<tr>
<td><strong>Maximum Plot Ratio Permitted of the neighborhood</strong></td>
<td>29743 / 3954</td>
</tr>
<tr>
<td><strong>Total current Gross Floor Area of the plots in the neighborhood</strong></td>
<td>229 * 6.1 + 110 * 4.2 + 227 * 14.9 + 223 * 4.5 + 109 * 4.2 + 72 * 4.2 + 107 * 4.2 + 473 * 3.96 + 455 * 4.6 + 448 * 9 + 303 * 9 + 380 * 4.5 + 224 * 5 + 196 * 4.2 + 72 * 6.527 + 62 * 2 + 125 * 2 + 139 * 4.149</td>
</tr>
<tr>
<td><strong>Current Plot Ratio of the neighborhood</strong></td>
<td>23253 / 3954</td>
</tr>
<tr>
<td><strong>Saturation rate of site density of the neighborhood</strong></td>
<td>Sum of Current Plot Ratio of All Plots / Sum of maximum plot ratio permitted of all Plots × 100%</td>
</tr>
</tbody>
</table>
4.2.1 Site Density

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

2. Dwelling Units

<table>
<thead>
<tr>
<th>Plot</th>
<th>Unit Sizes / floor (UFA)</th>
<th>No. of Units / floor</th>
<th>No. of Floors</th>
<th>Total No. of Units</th>
<th>Total No. of Units to Site Area (DU/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>573; 646 sqft</td>
<td>2</td>
<td>9</td>
<td>2 * 9 = 18</td>
<td>18 / 229 = 0.0786</td>
</tr>
<tr>
<td>B</td>
<td>396; 389 sqft</td>
<td>2</td>
<td>5</td>
<td>2 * 5 = 10</td>
<td>10 / 110 = 0.0909</td>
</tr>
<tr>
<td>C</td>
<td>(Office)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>280; 290; 300; 280 sqft</td>
<td>4</td>
<td>7</td>
<td>4 * 7 = 28</td>
<td>28 / 223 = 0.125</td>
</tr>
<tr>
<td>E</td>
<td>387; 367</td>
<td>2</td>
<td>4</td>
<td>2 * 4 = 8</td>
<td>8 / 109 = 0.0734</td>
</tr>
<tr>
<td>F</td>
<td>78; 20; 57; 64; 107 sqf</td>
<td>5</td>
<td>7</td>
<td>5 * 7 = 35</td>
<td>35 / 72 = 0.486</td>
</tr>
<tr>
<td>G</td>
<td>1-4/F: 914; 5/F: 428 sqf</td>
<td>1</td>
<td>5</td>
<td>1 * 5 = 5</td>
<td>5 / 107 = 0.0467</td>
</tr>
<tr>
<td>H</td>
<td>275 * 2; 330; 285; 265; 280; 270; 260</td>
<td>8</td>
<td>5</td>
<td>8 * 5 = 40</td>
<td>40 / 473 = 0.0846</td>
</tr>
<tr>
<td>I</td>
<td>268; 277 * 4; 269 sqft</td>
<td>6</td>
<td>7</td>
<td>6 * 7 = 42</td>
<td>42 / 455 = 0.0923</td>
</tr>
<tr>
<td>J</td>
<td>21.98 * 2; 18.44 * 2 sqm</td>
<td>4</td>
<td>25</td>
<td>4 * 25 = 100</td>
<td>100 / 448 = 0.223</td>
</tr>
<tr>
<td>K</td>
<td>20; 21; 21</td>
<td>3</td>
<td>24</td>
<td>3 * 24 = 72</td>
<td>72 / 303 = 0.237</td>
</tr>
<tr>
<td>L</td>
<td>282; 261; 261; 251; 246; 238</td>
<td>6</td>
<td>5</td>
<td>6 * 5 = 30</td>
<td>30 / 380 = 0.0789</td>
</tr>
<tr>
<td>M</td>
<td>29 * 2</td>
<td>2</td>
<td>11</td>
<td>2 * 11 = 22</td>
<td>22 / 224 = 0.0982</td>
</tr>
<tr>
<td>N</td>
<td>G/F: 382; 1-5/F: 356 sqft</td>
<td>1</td>
<td>6</td>
<td>1 * 6 = 6</td>
<td>6 / 96 = 0.0625</td>
</tr>
<tr>
<td>O</td>
<td>14.78 * 2 sqm</td>
<td>2</td>
<td>16</td>
<td>2 * 16 = 32</td>
<td>32 / 172 = 0.186</td>
</tr>
<tr>
<td>P</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1 / 62 = 0.0161</td>
</tr>
<tr>
<td>Q</td>
<td>441; 251 sqft</td>
<td>2</td>
<td>2</td>
<td>2 * 2 = 4</td>
<td>4 / 125 = 0.032</td>
</tr>
<tr>
<td>R</td>
<td>230; 210 sqft</td>
<td>2</td>
<td>6</td>
<td>2 * 6 = 12</td>
<td>12 / 139 = 0.0863</td>
</tr>
</tbody>
</table>

Table 4.3: Dwelling units of each plot in Sau Wa Fong neighborhood

Total dwelling units of the neighborhood

\[= 18 + 10 + 28 + 8 + 35 + 5 + 40 + 42 + 100 + 72 + 30 + 22 + 6 + 32 + 1 + 4 + 12\]
\[= 465\]

Ratio of dwelling units to site area of the neighborhood

\[= \text{Total Dwelling Units of the Neighborhood} / \text{Site Area}\]
\[= 465 / 3954\]
\[= 0.118 \text{ DU/m}^2\]

Table 4.4: Calculation of dwelling units of Sau Wa Fong neighborhood
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

3. Population

<table>
<thead>
<tr>
<th>Plot</th>
<th>No. of People / Unit (people)</th>
<th>No. of People / floor</th>
<th>No. of Floors</th>
<th>Total No. of People</th>
<th>Population to Site Area (POP/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17; 19</td>
<td>36</td>
<td>9</td>
<td>36 * 9 = 324</td>
<td>324 / 229 = 1.41</td>
</tr>
<tr>
<td>B</td>
<td>6 * 2</td>
<td>12</td>
<td>5</td>
<td>12 * 5 = 60</td>
<td>60 / 110 = 0.545</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>D</td>
<td>8, 9, 9, 8</td>
<td>34</td>
<td>7</td>
<td>34 * 7 = 238</td>
<td>238 / 223 = 1.07</td>
</tr>
<tr>
<td>E</td>
<td>6 * 2</td>
<td>12</td>
<td>4</td>
<td>12 * 4 = 48</td>
<td>48 / 109 = 0.440</td>
</tr>
<tr>
<td>F</td>
<td>2, 1, 2, 2, 3</td>
<td>10</td>
<td>7</td>
<td>10 * 7 = 70</td>
<td>70 / 72 = 0.972</td>
</tr>
<tr>
<td>G</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>8 * 5 = 40</td>
<td>40 / 107 = 0.374</td>
</tr>
<tr>
<td>H</td>
<td>6; 6; 7; 6; 6 * 4</td>
<td>49</td>
<td>5</td>
<td>49 * 5(floors) = 245</td>
<td>245 / 473 = 0.518</td>
</tr>
<tr>
<td>I</td>
<td>8 * 6</td>
<td>48</td>
<td>7</td>
<td>48 * 7 = 336</td>
<td>336 / 455 = 0.738</td>
</tr>
<tr>
<td>J</td>
<td>3 * 4</td>
<td>12</td>
<td>25</td>
<td>12 * 25 = 300</td>
<td>300 / 448 = 0.670</td>
</tr>
<tr>
<td>K</td>
<td>3 * 3</td>
<td>9</td>
<td>24</td>
<td>9 * 24 = 216</td>
<td>216 / 303 = 0.713</td>
</tr>
<tr>
<td>L</td>
<td>8; 7 * 5</td>
<td>43</td>
<td>5</td>
<td>43 * 5 = 215</td>
<td>215 / 380 = 0.566</td>
</tr>
<tr>
<td>M</td>
<td>4</td>
<td>7</td>
<td>11</td>
<td>7 * 11 = 77</td>
<td>77 / 224 = 0.344</td>
</tr>
<tr>
<td>N</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>10 * 6 = 60</td>
<td>60 / 96 = 0.625</td>
</tr>
<tr>
<td>O</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>8 * 16 = 128</td>
<td>128 / 172 = 0.744</td>
</tr>
<tr>
<td>P</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>7 / 62 = 0.113</td>
</tr>
<tr>
<td>Q</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4 * 2 = 8</td>
<td>8 / 125 = 0.064</td>
</tr>
<tr>
<td>R</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6 * 6 = 36</td>
<td>36 / 139 = 0.259</td>
</tr>
</tbody>
</table>

Table 4. 5: Population of each plot in Sau Wa Fong neighborhood

Total Population of the Neighborhood:

\[- 324 + 60 + 238 + 48 + 70 + 40 + 245 + 336 + 300 + 216 + 215 + 77 + 60 + 128 + 7 + 8 + 36\]

\[= 2408\]

**Ratio of population to site area of the neighborhood**

\[= \text{Total Population of the Neighborhood} / \text{Site Area}\]

\[= 2408 / 3954\]

\[= 0.609 \text{ POP/m}^2\]

Table 4. 6: Calculation of population of Sau Wa Fong neighborhood

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CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 2: Kam Wa Street, Shau Kei Wan

1. Plot Ratio

<table>
<thead>
<tr>
<th>Plot</th>
<th>Site Area (m²)</th>
<th>Class of Site</th>
<th>Maximum Plot Ratio</th>
<th>Current Plot Ratio</th>
<th>Saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Domestic</td>
<td>Non-dom.</td>
<td>Domestic</td>
</tr>
<tr>
<td>A</td>
<td>362</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>8.4719</td>
</tr>
<tr>
<td>B</td>
<td>455</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>8.506</td>
</tr>
<tr>
<td>C</td>
<td>177</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>4.9079</td>
</tr>
<tr>
<td>D</td>
<td>261</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>E</td>
<td>87.8</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>179</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>3.848</td>
</tr>
<tr>
<td>G</td>
<td>611</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>H</td>
<td>494</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>8.5107</td>
</tr>
<tr>
<td>I</td>
<td>278</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>8.1525</td>
</tr>
<tr>
<td>J</td>
<td>216</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Table 4. 7: Plot ratios of each plot in Kam Wa Street neighborhood

| Total site area of the plots in the neighborhood |
| = 362 + 455 + 177 + 261 + 87.8 + 179 + 611 + 494 + 278 + 216 |
| = 3121 |

| Total Maximum Gross Floor Area of the plots in the neighborhood |
| = 362 * 9 + 455 * 9 + 177 * 9 + 261 * 8 + 87.8 * 8 + 179 * 9 + 611 * 15 + 494 * 9 + 278 * 9 + 216 * 9 |
| = 31404 |

| Maximum Plot Ratio Permitted of the neighborhood |
| = 31404 / 3121 |

| = 10.06 |

| Total current Gross Floor Area of the plots in the neighborhood |
| = 362 * 9 + 455 * 9 + 177 * 6.881 + 261 * 4.5 + 87.8 * 4 + 179 * 4.553 + 611 * 15 + 494 * 9 + 278 * 9 + 216 * 3.7 |
| = 28507 |

| Current Plot Ratio of the neighborhood |
| = 27823 / 3121 |

| = 8.92 |

| Saturation rate of site density of the neighborhood |
| = Sum of Current Plot Ratio of All Plots / Sum of maximum plot ratio permitted of all Plots × 100% |
| = 8.92 / 10.06 * 100% |

| = 88.6 % |

Table 4. 8: Calculation of plot ratios of Kam Wa Street neighborhood
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

2. Dwelling Units

<table>
<thead>
<tr>
<th>Plot</th>
<th>Unit Sizes / floor (UFA)</th>
<th>No. of Units / floor</th>
<th>No. of Floors</th>
<th>Total No. of Units</th>
<th>Total No. of Units to Site Area (DU/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>22.36 * 3 sqm</td>
<td>3</td>
<td>24</td>
<td>3 * 24 = 72</td>
<td>72 / 362 = 0.199</td>
</tr>
<tr>
<td>B</td>
<td>16.5; 17.6 * 2; 16.7; 12.1 sqm</td>
<td>5</td>
<td>23</td>
<td>5 * 23 = 115</td>
<td>115 / 455 = 0.253</td>
</tr>
<tr>
<td>C</td>
<td>238; 284 sqft</td>
<td>2</td>
<td>9</td>
<td>2 * 9 = 18</td>
<td>18 / 177 = 0.102</td>
</tr>
<tr>
<td>D</td>
<td>417 * 2; 211.5 *2 sqft</td>
<td>4</td>
<td>9</td>
<td>4 * 9 = 36</td>
<td>36 / 261 = 0.138</td>
</tr>
<tr>
<td>E</td>
<td>10.6 * 2 sqm</td>
<td>2</td>
<td>5</td>
<td>2 * 5 = 10</td>
<td>10 / 87.8 = 0.114</td>
</tr>
<tr>
<td>F</td>
<td>269; 267; 179; 240 sqft</td>
<td>4</td>
<td>5</td>
<td>4 * 5 = 20</td>
<td>20 / 179 = 0.112</td>
</tr>
<tr>
<td>G</td>
<td>- (Factory)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H</td>
<td>20; 19; 19; 19 sqm</td>
<td>5</td>
<td>24</td>
<td>5 * 24 = 120</td>
<td>120 / 494 = 0.243</td>
</tr>
<tr>
<td>I</td>
<td>24 *2 sqm</td>
<td>2</td>
<td>25</td>
<td>2 * 25 = 50</td>
<td>50 / 278 = 0.180</td>
</tr>
<tr>
<td>J</td>
<td>1430 sqft</td>
<td>1</td>
<td>6</td>
<td>1 * 6 = 6</td>
<td>6 / 216 = 0.0278</td>
</tr>
</tbody>
</table>

Table 4.9: Dwelling units of each plot in Kam Wa Street neighborhood

Total dwelling units of the neighborhood

= 72 + 115 + 18 + 36 + 10 + 20 + 120 + 50 + 6

= 447

Ratio of dwelling units to site area of the neighborhood

= Total Dwelling Units of the Neighborhood / Site Area

= 447 / 3121

= 0.143 DU/m²

Table 4.10: Calculation of dwelling units of Kam Wa Street neighborhood
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

3. Population

<table>
<thead>
<tr>
<th>Plot</th>
<th>No. of People / Unit (people)</th>
<th>No. of People / floor</th>
<th>No. of Floors</th>
<th>Total No. of People</th>
<th>Population to Site Area (POP/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>15</td>
<td>24</td>
<td>15 * 24 = 360</td>
<td>360 / 362 = 0.994</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>10</td>
<td>23</td>
<td>10 * 23 = 230</td>
<td>230 / 455 = 0.505</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>6 * 9 = 54</td>
<td>54 / 177 = 0.305</td>
</tr>
<tr>
<td>D</td>
<td>12 * 2; 9 * 2</td>
<td>42</td>
<td>9</td>
<td>42 * 9 = 378</td>
<td>378 / 261 = 1.45</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4 * 5 = 20</td>
<td>20 / 87.8 = 0.228</td>
</tr>
<tr>
<td>F</td>
<td>8 * 2; 5, 7</td>
<td>28</td>
<td>5</td>
<td>28 * 5 = 140</td>
<td>140 / 179 = 0.782</td>
</tr>
<tr>
<td>G</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H</td>
<td>3 * 5</td>
<td>15</td>
<td>24</td>
<td>15 * 24 = 360</td>
<td>360 / 494 = 0.729</td>
</tr>
<tr>
<td>I</td>
<td>3 * 2</td>
<td>6</td>
<td>25</td>
<td>6 * 25 = 150</td>
<td>150 / 278 = 0.540</td>
</tr>
<tr>
<td>J</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>8 * 6 = 48</td>
<td>48 / 216 = 0.222</td>
</tr>
</tbody>
</table>

Table 4. 11: Population of each plot in Kam Wa Street neighborhood

Total Population of the Neighborhood:

\[= 360 + 230 + 54 + 378 + 20 + 140 + 360 + 150 + 48\]

\[= 1740\]

Ratio of population to site area of the neighborhood

\[= \frac{\text{Total Population of the Neighborhood}}{\text{Site Area}}\]

\[= \frac{1740}{3121}\]

\[= 0.558 \text{ POP/m²}\]

Table 4. 12: Calculation of population of Kam Wa Street neighborhood
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 3: Tsuen Hing Path, Tsuen Wan

1. Plot Ratio

<table>
<thead>
<tr>
<th>Plot</th>
<th>Site Area</th>
<th>Class of Site</th>
<th>Maximum Plot Ratio</th>
<th>Current Plot Ratio</th>
<th>Saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>604</td>
<td>C</td>
<td>10</td>
<td>15</td>
<td>8.052 / 10 = 80%</td>
</tr>
<tr>
<td>B</td>
<td>446</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>5.95 / 9 = 66%</td>
</tr>
<tr>
<td>C</td>
<td>446</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>7.79 / 9 = 86%</td>
</tr>
<tr>
<td>D</td>
<td>595</td>
<td>C</td>
<td>10</td>
<td>15</td>
<td>8.67 / 10 = 87%</td>
</tr>
<tr>
<td>E</td>
<td>409</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>3.12 / 8 = 39%</td>
</tr>
<tr>
<td>F</td>
<td>204</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>7 / 8 = 88%</td>
</tr>
<tr>
<td>G</td>
<td>418</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>7.229 / 8 = 91%</td>
</tr>
<tr>
<td>H</td>
<td>186</td>
<td>B</td>
<td>9</td>
<td>15</td>
<td>3.761 / 9 = 42%</td>
</tr>
<tr>
<td>I</td>
<td>194</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>3.295 / 8 = 41%</td>
</tr>
<tr>
<td>J</td>
<td>209</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>3.274 / 8 = 41%</td>
</tr>
<tr>
<td>K</td>
<td>209</td>
<td>A</td>
<td>8</td>
<td>15</td>
<td>3.27 / 8 = 41%</td>
</tr>
</tbody>
</table>

Table 4.13: Plot ratios of each plot in Tsuen Hing Path neighborhood

Total site area of the plots in the neighborhood

\[
= 604 + 446 + 446 + 595 + 409 + 204 + 418 + 186 + 194 + 209 + 209
\]

= 3920

Total Maximum Gross Floor Area of the plots in the neighborhood

\[
= 604 \times 10 + 446 \times 9 + 446 \times 9 + 595 \times 10 + 409 \times 8 + 204 \times 8 + 418 \times 8 + 186 \times 9 + 194 \times 8 + 209 \times 8 + 209 \times 8
\]

= 35254

Maximum Plot Ratio Permitted of the neighborhood

\[
= \frac{35254}{3920}
\]

= 8.99

Total current Gross Floor Area of the plots in the neighborhood

\[
= 604 \times 10 + 446 \times 9 + 446 \times 9 + 595 \times 10 + 409 \times 8 + 204 \times 8 + 418 \times 8 + 186 \times 9 + 194 \times 8 + 209 \times 8 + 209 \times 8 + 4.212 + 209 \times 4.27
\]

= 31401

Current Plot Ratio of the neighborhood

\[
= \frac{31401}{3920}
\]

= 8.01

Saturation rate of site density of the neighborhood

\[
= \frac{Sum \ of \ Current \ Plot \ Ratio \ of \ All \ Plots}{Sum \ of \ maximum \ plot \ ratio \ permitted \ of \ all \ Plots} \times 100\%
\]

= 8.01 / 8.99 \times 100\%

= 89.1%

Table 4.14: Calculation of plot ratios of Tsuen Hing Path neighborhood
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

2. Dwelling Unit

<table>
<thead>
<tr>
<th>Plot</th>
<th>Unit Sizes / floor (UFA)</th>
<th>No. of Units / floor</th>
<th>No. of Floors</th>
<th>Total No. of Units</th>
<th>Total No. of Units to Site Area (DU/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>274 * 2; 256 * 2; 277 * 2 sqft</td>
<td>6</td>
<td>22</td>
<td>6 * 22 = 132</td>
<td>131 / 604 = 0.217</td>
</tr>
<tr>
<td>B</td>
<td>251 * 2; 318 * 2 sqft</td>
<td>4</td>
<td>16</td>
<td>4 * 14 + 2 * 2 = 60</td>
<td>60 / 446 = 0.135</td>
</tr>
<tr>
<td>C</td>
<td>388 * 2; 279 * 2 sqft</td>
<td>4</td>
<td>18</td>
<td>4 * 18 = 72</td>
<td>72 / 446 = 0.161</td>
</tr>
<tr>
<td>D</td>
<td>257 * 2; 333 * 2; 327 *2 sqft</td>
<td>6</td>
<td>18</td>
<td>6 * 18 = 108</td>
<td>108 / 595 = 0.182</td>
</tr>
<tr>
<td>E</td>
<td>273 * 2; 272 sqft</td>
<td>3</td>
<td>21</td>
<td>3 * 21 = 63</td>
<td>63 / 409 = 0.154</td>
</tr>
<tr>
<td>F</td>
<td>330; 313; 319 sqft</td>
<td>3</td>
<td>5</td>
<td>3 * 5 = 15</td>
<td>15 / 204 = 0.0735</td>
</tr>
<tr>
<td>G</td>
<td>218 * 2; 297 * 2 sqft</td>
<td>4</td>
<td>19</td>
<td>4 * 19 = 76</td>
<td>76 / 418 = 0.182</td>
</tr>
<tr>
<td>H</td>
<td>282; 230; 232; 216 sqft</td>
<td>4</td>
<td>5</td>
<td>4 * 5 = 20</td>
<td>20 / 186 = 0.108</td>
</tr>
<tr>
<td>I</td>
<td>329; 297 * 2 sqft</td>
<td>3</td>
<td>5</td>
<td>3 * 5 = 15</td>
<td>15 / 194 = 0.0773</td>
</tr>
<tr>
<td>J</td>
<td>370; 375; 318 sqft</td>
<td>3</td>
<td>5</td>
<td>3 * 5 = 15</td>
<td>15 / 209 = 0.0718</td>
</tr>
<tr>
<td>K</td>
<td>349; 355; 305 sqft</td>
<td>3</td>
<td>5</td>
<td>3 * 5 = 15</td>
<td>15 / 209 = 0.0718</td>
</tr>
</tbody>
</table>

Table 4.15: Dwelling units of each plot in Tsuen Hing Path neighborhood

Total dwelling units of the neighborhood

\[= 132 + 60 + 72 + 108 + 63 + 15 + 76 + 20 + 15 + 15 + 15\]

\[= 591\]

Ratio of dwelling units to site area of the neighborhood

\[= \frac{591}{3920} \]

\[= 0.151 \text{ DU/m}^2\]

Table 4.16: Calculation of dwelling units of Tsuen Hing Path neighborhood
CHAPTER 4: RESULT

4.2.1 Site Density

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

3. Population

<table>
<thead>
<tr>
<th>Plot</th>
<th>No. of People / Unit (people)</th>
<th>No. of People / floor</th>
<th>No. of Floors</th>
<th>Total No. of People</th>
<th>Population to Site Area (POP/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3 * 6</td>
<td>18</td>
<td>22</td>
<td>18 * 22 = 396</td>
<td>396 / 604 = 0.656</td>
</tr>
<tr>
<td>B</td>
<td>6 * 2; 7 * 2</td>
<td>26</td>
<td>16</td>
<td>26 * 16 = 416</td>
<td>416 / 446 = 0.933</td>
</tr>
<tr>
<td>C</td>
<td>12 * 2; 8 * 2</td>
<td>40</td>
<td>18</td>
<td>40 * 18 = 720</td>
<td>720 / 446 = 1.64</td>
</tr>
<tr>
<td>D</td>
<td>3 * 2; 4 * 4</td>
<td>22</td>
<td>18</td>
<td>22 * 18 = 396</td>
<td>396 / 595 = 0.666</td>
</tr>
<tr>
<td>E</td>
<td>3 * 3</td>
<td>9</td>
<td>21</td>
<td>9 * 21 = 189</td>
<td>189 / 409 = 0.462</td>
</tr>
<tr>
<td>F</td>
<td>4 * 3</td>
<td>12</td>
<td>5</td>
<td>12 * 5 = 60</td>
<td>60 / 204 = 0.294</td>
</tr>
<tr>
<td>G</td>
<td>3 * 4</td>
<td>12</td>
<td>19</td>
<td>12 * 19 = 228</td>
<td>228 / 418 = 0.545</td>
</tr>
<tr>
<td>H</td>
<td>3 * 4</td>
<td>12</td>
<td>5</td>
<td>12 * 5 = 60</td>
<td>60 / 186 = 0.323</td>
</tr>
<tr>
<td>I</td>
<td>3 * 3</td>
<td>9</td>
<td>5</td>
<td>9 * 5 = 45</td>
<td>45 / 194 = 0.232</td>
</tr>
<tr>
<td>J</td>
<td>4 * 3</td>
<td>12</td>
<td>5</td>
<td>12 * 5 = 60</td>
<td>60 / 209 = 0.287</td>
</tr>
<tr>
<td>K</td>
<td>4 * 3</td>
<td>12</td>
<td>5</td>
<td>12 * 5 = 60</td>
<td>60 / 209 = 0.287</td>
</tr>
</tbody>
</table>

Table 4. 17: Population of each plot in Tsuen Hing Path neighborhood

Total Population of the Neighborhood:

\[ = 396 + 416 + 720 + 396 + 189 + 60 + 228 + 60 + 45 + 60 + 60 \]
\[ = 2630 \]

Ratio of population to site area of the neighborhood

\[ = \frac{\text{Total Population of the Neighborhood}}{\text{Site Area}} \]
\[ = \frac{2630}{3920} \]
\[ = 0.671 \text{ POP/m}² \]

Table 4. 18: Calculation of population of Tsuen Hing Path neighborhood
CHAPTER 4: RESULT

4.2.2 Ventilation Study

Neighborhood 1: Sau Wa Fong, Wan Chai

1. Wind Rose

![Wind rose diagram of Sau Wa Fong](image)

Figure 4.4: Wind rose diagram of Sau Wa Fong

8 out of 16 wind directions have been studied, including N, NNE, NE, ENE, E, ESE, S and SSW. This set of direction exceeds 75% of the annual wind of the site.

2. 2D Wind Pattern

Low Zone (10m):

![2D Wind Pattern at low zone of Sau Wa Fong at different wind direction](image)

Figure 4.5: 2D Wind Pattern at low zone of Sau Wa Fong at different wind direction
CHAPTER 4: RESULT

4.2.2 Ventilation Study

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

Medium Zone (30m):

High Zone (60m):

Figure 4. 6: 2D Wind Pattern at medium zone and high zone of Sau Wa Fong at different wind direction
CHAPTER 4: RESULT

4.2.2 Ventilation Study

Neighborhood 2: Kam Wa Street, Shau Kei Wan

1. Wind Rose

8 out of 16 wind directions have been studied, including N, NNE, NE, ENE, E, ESE, S and SSW. This set of direction exceeds 75% of the annual wind of the site.

2. 2D Wind Pattern

Low Zone (10m):

Figure 4. 7: Wind rose diagram of Kam Wa Street

Figure 4. 8: 2D Wind Pattern at low zone of Kam Wa Street at different wind direction
CHAPTER 4: RESULT

4.2.2 Ventilation Study

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

Medium Zone (30m):

High Zone (60m):

Figure 4.9: 2D Wind Pattern at medium zone and high zone of Kam Wa Street at different wind direction
CHAPTER 4: RESULT

4.2.2 Ventilation Study

Neighborhood 3: Tsuen Hing Path, Tsuen Wan

1. Wind Rose

8 out of 16 wind directions have been studied, including N, NNE, NE, ENE, E, ESE, S and SSW. This set of direction exceeds 75% of the annual wind of the site.

2. 2D Wind Pattern

Low Zone (10m):
CHAPTER 4: RESULT

4.2.2 Ventilation Study

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

Medium Zone (30m):

High Zone (60m):

Figure 4.12: 2D Wind Pattern at medium zone and high zone of Tsuen Hing Path at different wind direction
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 1: Sau Wa Fong, Wan Chai

1. Plot Ratio (PR)

As shown in Figure 5.1, plot C, J, K and M (colored in red) have reached the maximum plot ratio (PR). It is because these plots have been redeveloped and maximized their PRs into high-rise residential towers. Moreover, the saturation rates of PR of plot G, H, I, L, N and O (colored in orange) are high ranging from 80% to 90%. The reason is that they have been redeveloped long time ago before their PRs have been revised and further increased to the maximum today. Furthermore, the saturation rates of PR of plot A, B, D, E, F and R (colored in yellow) are medium varying from 50% - 70%. These plots have remained at old low-rise shop tenement houses. For P and Q (colored in blue), their saturation rate is lowest at 25% because they are only singular house built with low PR.

To sum up shortly, 14 out of 18 plots have room to increase their PR to further densify the neighborhood.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

2. Dwelling Units (DU)

As shown in Figure 5.2, the dwelling unit (DU) ratio of plot F (colored in red) is highest with 0.5DU/m². Although it is a low-rise tenement house, it has a highest ratio of DU to site area. It is because that its site area is too small, giving a high ratio. For plot J, K and O (colored in orange), their DU ratios are high at 0.2DU/m² because they are high-rise tower providing a large number of DU. For plot A, B, D, E, H, I, L, M, N and R (colored in yellow), their DU ratios are medium at 0.06 - 0.1DU/m² because they are low-rise tenement house affording a small amount of DU. For plot G, P and Q (colored in blue), their DU ratios are lowest at 0.02 to 0.05DU/m² because plot G provides one DU per floor while plot P and Q are singular houses with only one DU. As a pure commercial building, Plot C is not applicable in counting dwelling units.

To sum up, the DU ratio tells the number of household and the size of living area. In general, there is a wide range of different sizes of living area in this neighborhood.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

3. Population (POP)

As shown in Figure 5.3, the population (POP) ratios of plot A, D and F (colored in red) are highest at 1.0 – 1.4POP/m² because they are low-rise tenement houses lived with a very large-sized family (around 9 people) in each flat. It implies that their living areas are extremely compact. For plot I, J, K, L, N and O (colored in orange), their POP ratios are high at 0.6 – 0.7POP/m² because plot I, L and N are low-rise tenement houses lived with a large-sized family (around 6 people) in each flat while plot J, K and O are high-rise tower providing a large number of small flats where each flat lived with a small-sized family (around 3 to 4 people). For plot B, E, G, H, M and R (colored in yellow), their POP ratios are medium at 0.3 – 0.5POP/m² because they are low-rise tenement houses lived with a medium-sized family (around 4-5 people) in each flat. It implies that their living areas are less compact. For plot P and Q (colored in blue), their POP ratios are very low at 0.06 – 0.1POP/m² because they are singular family houses lived with only one large-sized family (around 6). It means that their living areas are uncrowded and comfortable.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 2: Kam Wa Street, Shau Kei Wan

1. Plot Ratio

As shown in Figure 5.4, plot A, B, G, H and I (colored in red) have reached the maximum plot ratio (PR). It is because these plots have been redeveloped and maximized their PRs into high-rise residential towers. Moreover, the saturation rates of PR of plot C (colored in orange) are high at 77%. The reason is that they have been redeveloped long time ago before their PRs have been revised and further increased to the maximum today. Furthermore, the saturation rates of PR of plot D, E, F and J (colored in yellow) are medium varying from 41% - 56%. These plots have remained at old low-rise shop tenement houses.

To sum up shortly, there are 5 out of 10 plots have room to increase their PR to further densify the neighborhood.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

2. Dwelling Units

As shown in Figure 5.5, the dwelling unit (DU) ratio of plot B (colored in red) is highest with 0.3DU/m² because it is a high-rise tower providing a very large number of DU due to 4 flats per floor. For plot A, H and I (colored in orange), their DU ratios are high at 0.1 - 0.2DU/m² because they are high-rise tower providing a large number of DU. For plot C, D, E and F (colored in yellow), their DU ratios are medium at 0.1DU/m² because they are low-rise tenement house offering a small amount of DU. For plot J (colored in blue), its DU ratio is lowest at 0.03 to DU/m² because it affords only one DU per floor. As a pure industrial building, Plot G is not applicable in counting dwelling units.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

3. Population

As shown in Figure 5.6, the population (POP) ratios of plot A and D (colored in red) are highest at 1.0 and 1.5POP/m$^2$ because plot D is low-rise tenement houses lived with a very large-sized family (around 9 people) in each flat while plot A is a high-rise tower also lived with a very large family (around 5 people). It implies that their living areas are extremely compact. For plot B, F, H and I (colored in orange), their POP ratios are high at 0.5 – 0.8POP/m$^2$ because plot F is a low-rise tenement house lived with a large-sized family (around 7 to 8 people) in each flat while plot B, I and H are high-rise tower providing a large number of small flats where each flat lived with a small-sized family (around 3 people). For plot C, E and J (colored in yellow), their POP ratios are medium at 0.3 – 0.5POP/m$^2$ because they are low-rise tenement houses lived with a medium-sized family (around 4-5 people) in each flat. It implies that their living areas are less compact.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 3: Tsuen Hing Path, Tsuen Wan

1. Plot Ratio

As shown in Figure 5.7, plot A, B, C, D, E and G (colored in red) have reached the maximum plot ratio (PR). It is because these plots have been redeveloped and maximized their PRs into high-rise residential towers. Furthermore, the saturation rates of PR of plot F, H, I, J and K (colored in yellow) are medium varying from 51% - 54%. These plots have remained at old low-rise shop tenement houses.

To sum up shortly, there are 5 out of 11 plots that can increase their PR to further densify the neighborhood.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

2. Dwelling Units

As shown in Figure 5.8, the dwelling unit (DU) ratios of plot A, B, C, D, E and G (colored in orange) are high at 0.2DU/m² because they are high-rise tower providing a large number of DU. For plot F, H, I, J and K (colored in yellow), their DU ratios are also medium at 0.07 - 0.1DU/m² because they are low-rise tenement house affording a small amount of DU.

To sum up shortly, there are many two type of dwelling unit in this neighborhood. They are flats from tenement houses and high-rise residential towers.
CHAPTER 5: DISCUSSION

5.1 Site Density

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

3. Population

As shown in Figure 5.9, the population (POP) ratio of plot C (colored in red) is highest at 1.6POP/m² because it is a high-rise tower lived with a very large family (around 8 to 12 people) in each flat. It implies that their living areas are extremely compact. For plot A, B, C, D, E and G (colored in orange), their POP ratios are high at 0.5 – 0.9POP/m² because they are high-rise tower providing a large number of small flats where each flat lived with a small-sized family (around 3 to 4 people). For plot F, H, I, J and K (colored in yellow), their POP ratios are medium at 0.2 – 0.3POP/m² because they are low-rise tenement houses lived with a medium-sized family (around 4-5 people) in each flat. It implies that their living areas are less compact.
CHAPTER 5: DISCUSSION

5.1 Site Density

Summary and Comparison of Neighborhoods

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>Current PR</th>
<th>PR Saturation Rate (%)</th>
<th>Domestic Unit (DU/m²)</th>
<th>Population (POP/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sau Wa Fong, Wan Chai</td>
<td>5.88</td>
<td>77</td>
<td>0.12</td>
<td>0.61</td>
</tr>
<tr>
<td>Kam Wa Street, Shau Kei Wan</td>
<td>8.92</td>
<td>89</td>
<td>0.14</td>
<td>0.56</td>
</tr>
<tr>
<td>Tsuen Hing Path, Tsuen Wan</td>
<td>8.01</td>
<td>89</td>
<td>0.15</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Table 5.1: Comparison of site density of the three neighborhoods studied

Site Density Conditions and Implications

Sau Wa Fong, Wan Chai:
This neighborhood has low current plot ratio at 5.88, lower than other two neighborhoods with low domestic unit and medium population. Therefore, due to a large number of low-rise tenement houses, Sau Wa Fong is a neighborhood with least building density and less population compactness.

Kam Wa Street, Shau Kei Wan:
This neighborhood has high current plot ratio at 8.92, highest compared to other two neighborhoods with low domestic unit and population. Therefore, Kam Wa Street is a neighborhood may seem dense because of half plots of high-rise towers. However, the population living in the neighborhood is relatively low, resulting in a less crowded environment. Besides, its dwelling units are medium in size, leading to a more comfortable living area per person.

Tsuen Hing Street, Tsuen Wan:
This neighborhood has high current plot ratio at 8.01, in between two neighborhoods with higher domestic unit and population. Therefore, Tsuen Hing Street is a
Densification Potential in Hong Kong Neighborhoods

neighborhood is dense because of the high-rise towers providing a large population and dwelling units.

Densification Potential

The PR saturation rate of Sau Wa Fong neighborhood is lower at 77% where 11 out of 18 plots have not yet maximized their PR. They are mainly old low-rise tenement houses. Moreover, the PR saturation rates of Kam Wa Street neighborhood and Tsuen Hing Path neighborhood are higher both at 89%. For Kam Wa Street neighborhood, 5 out 10 plots are below their maximum PR. For Tsuen Hing Path neighborhood, 5 out 11 plots have not yet reached their full PR. As a result, Sau Wa Fong possesses the highest densification potential in term of site density.
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 1: Sau Wa Fong, Wan Chai

E and SSW (NNE for Tsuen Hing Path neighborhood) directions have been chosen to discuss, firstly, because they are occupying the high percentage of annual wind availability. Secondly, E (NNE for Tsuen Hing Path neighborhood) and SSW are the winter and summer prevailing wind directions of the neighborhoods. Thirdly, the ventilation patterns generated in these two directions represent the notably worse scenarios that need to be tackled before further densify the neighborhoods.

Low Zone

![Diagram of wind patterns at low zone](image)

**Figure 5.10: Wind pattern diagrams of E and SSW wind directions at low zone of Sau Wa Fong neighborhood**

Interpretation and Implication

For the E wind direction as shown in the left of Figure 5.10, the main road is well ventilated. However, wind (green arrow) cannot ventilate into the neighborhood due to the walling effect of dense row blocks (green dashed line). The wind (black arrow) also cannot ventilate into the neighborhood because of the two dense blocks (black dashed line). For the SSW wind direction as shown in the right of Figure 5.10, wind (green arrow) cannot ventilate into the neighborhood due to the street canyon of close blocks (green dashed line).
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

![Site map showing designs to improve ventilation in low zone of Sau Wa Fong neighborhood](image)

Suggestion (as shown in Figure 5.11)
For the E wind direction, a breezeway should be created in plot M (red color) for better ventilation into the neighborhood.

For the SSW wind direction, breezeways should be created between plot A and B; in plot D; in plot K (red colors) to allow airflow. Plot F should be deleted to allow airflow. Plot J and I (red line) should be set back to mitigate the deep street canyon and increase airflow.
CHAPTER 5: DISCUSSION

5.3 Ventilation Study

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

Medium Zone

High Zone

Interpretation and Implication

For the E and SSW wind direction as shown in the left of Figure 5.12 and the left of Figure 5.13, wind (green arrow) is hindered due to the walling effect of tall towers (green dashed line).
CHAPTER 5: DISCUSSION

5.4 Ventilation Study

Neighborhood 1: Sau Wa Fong, Wan Chai (continued)

Figure 5.14: Elevations of designing openings in medium and high zones

Figure 5.15: Site map showing designs to improve ventilation in medium and high zones of Sau Wa Fong

Suggestion

As shown in Figure 5.14, all towers should be opened up, for example, as a sky garden at the medium zone and high zone to allow cross ventilation through the buildings. Furthermore, Figure 5.14 indicates opening at the low zone to create breezeway (as shown in Figure 5.11). As shown in Figure 5.15, it is suggested that some plots (red dashed line) should be merged together to build a single tower with larger footprint instead of few towers with small footprints. The existing plots are too small to create closely placed buildings, leading to walling effect. Nevertheless, merging small plots into a larger plot can allow more space for building separation and set back whereby creating more breezeway and reducing deep street canyon effect.
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 2: Kam Wa Street, Shau Kei Wan

Low Zone

![Wind pattern diagrams of E and SSW wind directions at low zone of Kam Wa Street neighborhood](image)

**Interpretation and Implication**

For the E wind direction as shown in the left of Figure 5.16 the main roads (horizontal) are well ventilated. However, the roads (vertical) cannot be ventilated due to the sharp angle of the building corners (green dashed line) to the wind direction. Another reason is the wall effect of the dense row blocks (black dashed line). For the SSW wind direction as shown in the right of Figure 5.16, the poor ventilation at horizontal roads is caused by sharp building corners (green dashed line).
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

Figure 5. 17: Site map showing designs to improve ventilation in low zone of Kam Wa Street neighborhood

Suggestion (as shown in Figure 5.17)

For the E wind direction, the corners of plot C and plot H should be softened up to create a breezeway (red colors) to encourage air flowing into the vertical roads.

For the SSW wind direction, the corners of plot A and plot I should be round up to crafting a breezeway to encourage air flowing into the vertical roads.
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

Medium Zone

![Wind pattern diagrams of E and SSW wind directions at medium zone of Kam Wa Street](image)

High Zone

![Wind pattern diagrams of E and SSW wind directions at high zone of Kam Wa Street](image)

Interpretation and Implication

For the E and SSW wind direction as shown Figure 5.18 and Figure 5.19, wind (green arrow) is blocked because of the walling effect of tall towers (green dashed line).
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 2: Kam Wa Street, Shau Kei Wan (continued)

As shown in Figure 5.14, the towers should be tunnelled out at the medium zone and high zone, for example, as a sky garden to assist cross ventilation through the buildings.

As shown in Figure 5.20, red dashed lines suggest merging the existing plots into larger plots. A larger plot can build a singular tower with larger footprint instead of a row of block. As a result, this affords more space for building separation and set back, creating more and larger breezeway and reducing deep street canyon effect.
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 3: Tsuen Hing Path, Tsuen Wan

Low Zone

Figure 5.21: Wind pattern diagrams of NNE and SSW wind directions at low zone of Tsuen Hing Path

Interpretation and Implication

For the NNE wind direction as shown in the left of Figure 5.21, wind (green arrow) reduces velocity due to the street canyon of close blocks (green dashed line). The poor ventilation (black arrow) is caused by sharp building corners (black dashed line). For the SSW wind direction as shown in the right of Figure 5.21, wind (green arrow) also significantly slows down due to the street canyon of close blocks (marked in green dashed line).
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

Suggestion (as shown in Figure 5.22)

For the NNE wind direction, the corner of plot D should be softened up to create a breezeway (red colors) to encourage airflow (blue arrow). The blocks in plots highlighted in red lines should be set back to mitigate the deep street canyon and increase airflow.

For the SSW wind direction, the blocks in plots highlighted in red lines should be also set back to reduce the deep street canyon effect.
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

Medium Zone

High Zone

Interpretation and Implication

For the NNE and SSW wind direction as shown in Figure 5.23 and Figure 5.24, wind (green arrow) cannot flow through due to the walling effect of tall towers (green dashed line).
CHAPTER 5: DISCUSSION

5.2 Ventilation Study

Neighborhood 3: Tsuen Hing Path, Tsuen Wan (continued)

As shown in Figure 5.14, the towers should be hollowed out, for example, as a sky garden at the medium zone and high zone to facilitate cross ventilation through the towers.

As shown in Figure 5.25, merging plots (red dashed line) is suggested for better organization and ventilation. A larger plot can build a singular tower with larger footprint instead of a row of block. Therefore, more space can be used for building separation and set back whereby creating breezeway and reducing deep street canyon effect.
CHAPTER 6: CONCLUSION

The purpose of this chapter is to address the main research question.

**What are the densification potentials in Hong Kong neighborhoods?**

In order to answer this question, the current site density and maximum site density of the neighborhoods have been researched. Besides, the ventilation conditions of the neighborhoods have also been analyzed.

Three neighborhoods in Hong Kong have been studied including Sau Wan Fong in Wan Chai, Kam Wa Street in Shau Kei Wan and Tsuen Hing Path in Tsuen Wan.

In each neighborhood, the site density including plot ratio, dwelling units and population has been collected through researching in Building Records Access and Viewing On-line (BRAVO). The result has proved that all three neighborhoods have potential for densification since their plot ratios have not yet maximized. Among the three, Sau Wa Fong has the greatest potential for densification due to the lowest saturation rate of plot ratio, and low dwelling units and population.

For the ventilation study, the wind patterns of low, medium and high zone have been generated using Wind Tunnel in Vasari. However, as mentioned by Mr Christopher Lee from Arup, there are no strict rules on how dense a building or neighborhood can be to allow proper ventilation. The ventilation study in this research aims to record and analyze the current conditions to give feedback to improve for future densification. By studying the current ventilation conditions, the densification can be better managed and designed to mitigate the street canyon effect and poor ventilation of the neighborhood whereby minimize the urban heat island effect to the urban environment.

As an initial study of Air Ventilation Assessments (AVAs), 8 out of 16 wind directions have been employed, exceeding 75% of the annual wind of the neighborhood. The result has found out that, generally, the ventilation at low zone is especially poor due to the deep street canyon effect and walling effect of row blocks.
Densification Potential in Hong Kong Neighborhoods

while ventilation at medium and high zones is mainly affected by the wall effect of tall towers. In the low zone, buildings have been suggested to set back and separated to create breezeways and to reduce street canyon. The dimension of each breezeways and set back in different plots and neighborhoods varies according to the ventilation situation. In the medium and high zones, advises have been made to merge some plots to provide more space for set back and separation. Creating sky garden have been also recommended at desired locations to enhance airflow in the neighborhoods. These suggestions aim to improve the current ventilation situations in the neighborhoods. After fixing the ventilation situations, the density of the neighborhood can further increased by building higher.

To conclude, three neighborhoods have great potential for densification in term of plot ratio. However, when it comes to ventilation study, three neighborhoods have proved to have less desirable ventilation, particularly at low zone. As suggested in discussion including building separation, set back and merging plots, these measures should be taken for each neighborhood to improve its ventilation condition for future densification.
CHAPTER 7: FUTURE RESEARCH

The ventilation study in this research takes reference to the Initial Study in Air Ventilation Assessments (AVAs). Computational Fluid Dynamic (CFD) has been employed as a tool to study the ventilation pattern in the neighborhoods. Only 8 out of 16 wind directions, exceeding 75% of the annual wind of the site, have been considered. For future research, Detailed Study in AVAs should be used for more accurate and quantitative study with more consideration on the urban impact. Detailed Study uses wind tunnel as tool and accounts for all 16-wind directions to obtain a more comprehensive set of data.

To deal with the ventilation problem in the neighborhoods, different measures should be researched. Projects with innovative ventilation strategies can be studied. A set of guideline can then be produced to improve ventilation in term of site design and building design.

In this research, site density and ventilation study have been considered to examine the densification potential of the neighborhoods. However, there are other considerations for densification including infrastructure capacity, connectivity, solar effect, social activity, public space and use mix (as discussed in the Chapter 2.1.4). Therefore, the neighborhoods studied can be further examined in these aspects to examine their densification potential more comprehensively.

When it comes to studying infrastructure capacity, threshold of necessary infrastructure, for example, public transportations should be investigated to set a limitation of the population of the neighborhood. For connectivity study, Space Syntax should be employed to examine accessibility to public services and facilities and walkability of neighborhoods.
REFERENCES

**Book**

**Research**

**Website**
Housing, Planning and Lands Bureau, (2006), “Air Ventilation Assessments”, [online], Available:
Densification Potential in Hong Kong Neighborhoods


Figure

Figure 2.1:

Figure 2.2:

Figure 2.3:

Figure 2.4:

Figure 2.5:

Figure 2.6:

Figure 3.1-3:

Table

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Table 2.1:
Fridrik Bergsteinsson. (2014), “Is urban densification a reachable goal?”, [online], Available:
Sustainable Building Design Guideline


This practice note promulgates guidelines on building design which will enhance the quality and sustainability of the built environment in Hong Kong. These guidelines are the Sustainable Building Design Guidelines (SBD Guidelines) referred to in Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers (PNAP) APP-151, the compliance with which the Building Authority (BA) will take into account, where applicable, as a pre-requisite in exempting or disregarding green and amenity features and non-mandatory / non-essential plant rooms and services from gross floor area and/or site coverage calculations (GFA concessions) for new building developments. Terminology and definitions of terms used in the SBD Guidelines are listed in Appendix A.

Objectives

2. In the SBD Guidelines, 3 key building design elements to enhance the environmental sustainability of our living space are identified. They are building separation, building set back and site coverage of greenery. The objectives are to achieve better air ventilation, enhance the environmental quality of our living space, particularly at pedestrian level, provide more greenery and mitigate the heat island effect.

Application of the SBD Guidelines

3. It is recognized that compliance with the SBD Guidelines on building separation, building set back and site coverage of greenery may have been imposed in the lease conditions of new land sale sites or lease modifications or land exchanges or private treaty grants, or incorporated in some planning proposals submitted to the Town Planning Board or imposed as conditions in the planning approvals. During building plan submission stage, the BA will take into account the compliance with the SBD Guidelines, where applicable, when granting GFA concessions in new building developments. Further details on the prerequisites for granting GFA concessions are set out in PNAP APP-151.

Building Separation

4. In order to improve air ventilation, enhance the environmental quality at pedestrian level and mitigate heat island effect arising from the undesirable walling effect of “long buildings”, buildings in large development sites should be separated by intervening spaces.
5. Subject to paragraphs 8 to 11 below and the detailed requirements in Appendix B, for sites that are two hectares or above, or for sites that are less than two hectares and proposed with any building or any group of buildings having a continuous projected façade length\(^1\) (Lp) of 60m or above, buildings thereon shall comply with the building separation requirement such that:

(a) the individual Lp of any building or any group of buildings that abuts a street\(^2\) shall not exceed the maximum permissible Lp;

(b) when projected onto the chosen projection planes, the separating distance between the projected façade(s) of the building(s) and the site boundaries or the centreline of adjoining streets shall not be less than 7.5m; and the permeability\(^3\) (P) of the buildings on one projection plane shall not be less than 20% and onto the other projection plane shall not be less than 20%, 25% or 33.3\(^4\)%\(^5\), depending on the site area and the height of the tallest building, in accordance with Table 1.

<table>
<thead>
<tr>
<th>Height(^5) (H) of the tallest building</th>
<th>Permeability (P) of Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site area &lt; 20,000 m(^2) and with building(s) of Lp ≥ 60m long</td>
<td>Site area ≥ 20,000 m(^2) (regardless of the length of buildings)</td>
</tr>
<tr>
<td>H ≤ 60m</td>
<td>20%; 20%</td>
</tr>
<tr>
<td>H &gt; 60m</td>
<td>20%; 20%</td>
</tr>
</tbody>
</table>

Table 1 - Minimum permeability (P) of buildings.

6. Detailed requirements and method of measurement are given in Appendix B. A sample case is given in Appendix C. Any covered areas providing permeability of the buildings will be accountable for GFA and/or site coverage, except where exempted or disregarded if they satisfy the requirements stipulated in the relevant PNAP or Joint Practice Notes (JPN).

7. Subject to paragraphs 8 to 11 below, the building separation requirement shall be met in each of the following assessment zones:

- **Vertical division**
  - Low Zone: 0 – 20m
  - Middle Zone: 20 – 60m
  - High Zone: Above 60m

---

\(^1\) See Appendix A for definition and Figures 2 and 3 of Appendix B for illustration

\(^2\) Street has the same meaning as that given in Regulation 18A(3)(a)(i) & (ii) of the Building (Planning) Regulations (B(P)R).

\(^3\) See Appendix A for definition.

\(^4\) The plane with the higher permeability should preferably be set perpendicular to the summer prevailing wind direction with plus or minus 30 degree flexibility or existing street pattern. At the present stage, characteristic natural wind availability data of the site may be simulated using wind tunnel and topographical models and/or computer simulations as appropriate.

\(^5\) Height of a building has the same meaning as that given in B(P)R23(1).
APPENDIX A

Sustainable Building Design Guideline (continued)

8. The building separation requirement at the low zone may be waived if:
   (a) the site coverage for the building(s) including any podium above ground level does not exceed 60%, 62.5% or 65% of the area of the site for a Class A, Class B or Class C site\(^5\) respectively; and
   (b) the full height of the building(s) is set back from the site boundary abutting on a street; the total frontage of such set back is not less than 50% of the length of the site boundary that abuts on a street and not less than 10m long or the full frontage for site with frontage less than 10m in length; and the total area of such set back(s) is not less than 15% of the area of the site.

9. For buildings that are served by surrounding pedestrian networks at an elevated level rather than at grade, justification may be made to demonstrate that the air ventilation performance for the building portion below such raised pedestrian level will not cause any material concerns to any sensitive users in general. Subject to the special circumstances of each case, the BA may exempt the portion of building below such raised pedestrian level from the building separation requirement.

10. The building separation requirement is not applicable to domestic developments comprising buildings of height not exceeding 15 meters or not more than four storeys. For sites comprising buildings with mixed uses and/or varying building heights, domestic buildings of height not exceeding 15 meters or not more than four storeys can be disregarded in the building separation assessment, provided that these domestic buildings are not connected to the other buildings.

11. It is recognized that certain buildings with special functional requirements in building length and/or bulk e.g. infrastructural facilities, transport terminus, sports and civic facilities, may not be able to comply with the building separation requirements. The BA may consider exempting such special facilities from the building separation requirement if the following compensatory measures are provided:
   (a) According to the methodology and requirements as stipulated under the category of Microclimate Around Buildings (S8) of the BEAM Plus\(^7\) certification, an Air Ventilation Assessment (AVA) by wind tunnel or Computational Fluid Dynamics (CFD) has been conducted to demonstrate that the optimal design option has been selected in comparing with different design options; and either one of the following three requirements under the aforesaid category of the BEAM Plus certification has also been complied with and all results of which are considered acceptable by the BA;
      (i) On wind amplification / stagnant air – demonstrating that no pedestrian areas will be subject to excessive wind speeds and there are no stagnant areas not flushed by breezes;
      (ii) …

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\(^5\) Site classification has the same meaning as that given in B(P)R18A

Sustainable Building Design Guideline (continued)

(ii) On elevated temperatures – providing shade; or
(iii) On elevated temperatures – providing high emissivity roofing material or vegetation roof.

(b) Building features such as additional building set back, stepped profile of the podium from the adjoining streets and communal podium garden to separate the podium from the tower above and to promote air flow at pedestrian level, etc. have been considered in the assessment described in item (a) above and incorporated in the optimal option, where appropriate; and

(c) Building separation requirement is fully complied with for other buildings on the same site or other parts of the building that are located above such special facilities, where applicable.

Building Set Back

12 In order to improve air ventilation, enhance the environmental quality at pedestrian level and mitigate deep street canyon effect, buildings abutting a narrow street less than 15m wide shall be set back.

13 Building set back should allow the flow of air volume with a minimum sectional area of 15m x 15m along the street. Where the level of the street varies, the minimum sectional area of set back shall follow the profile of the street. Subject to paragraphs 15 and 16 below, a building abutting on any narrow street less than 15m wide should be set back to comply with one of the following requirements:

(a) No part of the building, up to a level of 15m above the street level, shall be within 7.5m from the centreline of the street as shown in figure 1 of Appendix D; or

(b) Where a communal podium garden is provided, the building abutting on the street shall comply with the following requirements:

(i) no part of the building, up to a level of 15m above the street level, shall protrude above the 45 degrees inclined plane, the base of which is placed at street level at the boundary line of the lot on the opposite side of the street as shown in figures 2 and 3 of Appendix D; and

(ii) such communal podium garden shall comply with the height, openness, size and greenery area requirements as stipulated in paragraph 1(d) of Appendix A to JPN1, to enhance air flow to reach the street.

14. In determining the compliance with the set back requirement, the BA may take into account the following factors where applicable:

/(a) …/
APPENDIX A

Sustainable Building Design Guideline (continued)

(a) Structures at levels higher than 15m above the street level may be allowed to project over the set back area. The set back area at ground level under the footprint of such structures may be exempted from GFA calculation if it is designated as common areas accessible by all occupants of the building and without any commercial activities. Where the covered area is not designated as common areas but complies with the height and width requirements as stipulated in paragraph 6 of PNAP APP-19, the covered area may not be accountable for GFA;

(b) Minor projecting features as described in paragraph 3(a) and (d) to (g) of PNAP APP-19; signboards projecting not more than 600mm from the external walls and at a clear height of not less than 2.5m above the street level; and single storey footbridges that are open on both sides and provided with perforated railing, may be permitted within the set back area. If the set back area is uncovered, a canopy that complies with the projection and height limits stipulated in Regulation 10 of the B(P)R may also be permitted. For the covered areas under the canopy, the criteria for exemption from GFA or not being accountable for GFA as stipulated in item (a) above are also applicable;

(c) Structural columns supporting the tower above may be permitted within the set back area provided that any resultant clear space between the columns and/or between the column and other parts of the building is not less than 3m and, where the building is set back in accordance with paragraph 13(a) above, the minimum sectional area for building set back shall not be less than 112.5 m² (i.e. the same as the required building set back sectional area of 7.5m x 15m);

(d) Subject to item (f) below, the set back area should be properly landscaped and/or paved, and be open and without any permanent building structures other than landscaped features, perforated balustrades, perforated boundary walls and/or structural columns as described in item (c) above;

(e) There will be satisfactory arrangements for the management and maintenance of the set back area and any resultant flat roofs and covered areas; and

(f) The part of the set back area that forms the means of escape from or access to the building shall be properly paved, unobstructed and lead directly to a street.

15. Where the set back of the building in accordance with paragraph 13(a) above will result in a set back area of more than 15% of the area of the site, requirement for building set back may be relaxed if the following compensatory measures are provided:-

(a) Full height and full frontage set back of the building from the site boundary abutting on the narrow street(s) by an area which is not less than 15% of the area of the site; and

/b (b) …

The set back area shall be so designed to provide high degree of visual connectivity and openness fronting the street
Sustainable Building Design Guideline (continued)

(b) For small sites not exceeding 1,000 m², greenery should be provided at the pedestrian zone such that the greenery area is not less than 50% of the setback area. For other sites, site coverage of greenery to be provided at the pedestrian zone should be increased by 5% of the area of the site in addition to the respective requirements as stated in paragraph 18 below. For the avoidance of doubt, the required total greenery areas as stated in paragraph 18 below remains the same and all greenery areas shall comply with the requirements in paragraph 19 below.

16. Taking into account the genuine need to improve air ventilation at pedestrian level, development sites meeting the following criteria may be exempted from whole or parts of the building set back requirement:

(a) Where the height of the building is less than 2 times the mean width of the street; or

(b) Where there are special constraint rendering the building set back requirement undesirable and that other parts of the proposed building not affected by the special constraints will comply with the building set back requirements.

17. For the avoidance of doubt, non-building area and set back area required under the OZP or lease conditions, area dedicated for public passage or surrendered for street widening at street level under B(P)R 22 and set back area provided under PNAP APP-132 facing the subject narrow street may form part or whole of the set back area required under this PNAP provided that the criteria as stated in paragraphs 13 to 15 above are complied with where applicable.

Site Coverage of Greenery

18. In order to improve the environmental quality of the urban space, particularly at the pedestrian level and to mitigate the heat island effect, new building developments with site areas of 1,000 m² or more, shall be provided with greenery areas at the pedestrian zone, communal podium roof / flat roof / main roof, slope and retaining structure, where appropriate, to meet the minimum site coverage of greenery as specified in Table 2 below.

<table>
<thead>
<tr>
<th>Site Area (A)</th>
<th>Minimum Site Coverage of Greenery (i.e. percentage of greenery area over site area)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pedestrian zone</td>
</tr>
<tr>
<td>1,000 m² ≤ A&lt; 20,000 m²</td>
<td>10%</td>
</tr>
<tr>
<td>A ≥ 20,000 m²</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 2 Site coverage of greenery requirement

19. In determining the compliance with the greenery requirement, the BA may take into account the following factors where applicable:

/(a) …

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9 Under this criterion, height of the building is measured from the mean level of the street on which the building abuts to the mean height of the roof over the highest usable floor space in the building. 
10 See Appendix A for definitions.
Densification Potential in Hong Kong Neighborhoods

APPENDIX B

Air Ventilation Assessments


Annex A

Technical Guide for Air Ventilation Assessment for Developments in Hong Kong

1. This Technical Guide assists project proponent to undertake Air Ventilation Assessment (AVA) to assess the impacts of the proposal on the pedestrian wind environment. The assessment should follow this Technical Guide as far as possible and a report should be submitted to the proponent departments / bureaux or authorities on the assessment findings.

2. Every site is different. The assessor is strongly advised to approach the assessment intellectually and discretionally taking into account different site conditions. Working with experienced practising wind engineers throughout the assessment process is strongly recommended.

Indicator

3. Wind Velocity Ratio (VR) should be used as an indicator of wind performance for the AVA. It indicates how much of the wind availability of a location could be experienced and enjoyed by pedestrians on ground taking into account the surrounding buildings and topography and the proposed development. Given the general weak wind conditions in Hong Kong, the higher the wind velocity ratio, the less likely would be the impact of the proposed development on the wind availability.

4. Wind VR is defined as $V_p/V_{\infty}$ (V pedestrian/V infinity). $V_{\infty}$ captures the wind velocity at the top of the wind boundary layer (typically assumed to be around 400 m to 600 m above city centre, or at a height wind is unaffected by the urban roughness below). $V_{\infty}$ is taken as the wind availability of the site. $V_p$ captures the wind velocity at the pedestrian level (2 m above ground) after taking into account the effects of buildings and urban features.

Expert Evaluation / Initial Study / Detailed Study

5. It is always useful and cost effective for the assessor to conduct an early round of Expert Evaluation. This provides a qualitative assessment to the design and/or design options and facilitates the identification of
Densification Potential in Hong Kong Neighborhoods

APPENDIX B

Air Ventilation Assessments (continued)

problems and issues. The Expert Evaluation is particularly useful for large sites and/or sites with specific and unique wind features, issues, concerns and problems. The following tasks may be achieved with Expert Evaluation:

(a) Identifies good design features.

(b) Identifies obvious problem areas and propose some mitigation measures.

(c) Defines “focuses” and methodologies of the Initial and/or Detailed studies.

(d) Determines if further study should be staged into Initial Study and Detailed Study, or Detailed Study alone.

6. In exercising expert knowledge and experience, the assessor should refer to the “Urban Design Guidelines”, Chapter 11 of the Hong Kong Planning Standards and Guidelines downloadable from the Planning Department’s (PlanD) website at http://www.pland.gov.hk.

7. The Expert Evaluation could lead to an Initial Study or directly to a Detailed Study depending on the nature of the development. The Initial Study will refine and substantiate the Expert Evaluation. The following tasks may be achieved with the Initial Study:

(a) Initially assesses the characteristics of the wind availability (Vw) of the site.

(b) Gives a general pattern and a rough quantitative estimate of wind performance at the pedestrian level reported using Wind VR.

(c) Further refines the understanding (good design features and problem areas) of the Expert Evaluation.

(d) Further defines the “focuses”, methodologies and scope of work of the Detailed Study.

8. It is sometimes necessary to reiterate the Initial Study so as to refine the design and/or design options.
9. With or without the Initial Study, the **Detailed Study** concludes the AVA. With the Detailed Study, the assessor could accurately and “quantitatively” compare designs so that a better one could be selected. Detailed Study is essential for more complex sites and developments, and where key air ventilation concerns have been reviewed and identified in the Expert Evaluation / Initial Study. The following tasks may be achieved with the Detailed Study:

   (a) To assess the characteristics of the wind availability \( (V_{\infty}) \) of the site in detail.

   (b) To report all VR of test points. To report Site VR (SVR) and Local VR (LVR) when appropriate (as outlined in paras 27 to 30). To report, if any, wind gust problems.

   (c) To provide a summary of how the identified problems, if any, have been resolved.

### Site Wind Availability Data

10. It is necessary to account for the characteristics of the natural wind availability of the site. As far as possible, the design should utilize and optimize the natural wind.

11. For the Expert Evaluation, it is advisable to make reference to the Hong Kong Observatory Waglan Island wind data, as well as reasonable wind data of nearby weather stations. Expertly interpreted, it is possible to qualitatively estimate the prevailing wind directions and magnitudes of the site necessary for the evaluation.

12. For the Initial Study, it is necessary to be more precise. Either “simulated” site wind data, or “experimental” site wind data, as described in paras 13 and 15 below, respectively, could be used.

13. Using appropriate mathematical models (e.g. MM5 and CALMET), it is possible to simulate and estimate the site wind availability data \( (V_{\infty}) \). For the Expert Evaluation and Initial Study, project proponent may refer to the preliminary set of simulated “Site Wind Availability Data” \( (V_{\infty}) \) available at PlanD’s website.
Air Ventilation Assessments (continued)

14. For the Detailed Study, it is necessary to be even more precise. “Experimental” site wind data, as described in para 15 below, should be used.

15. Using large scale topographical model (typically 1:2000 to 1:4000) tested in a boundary layer wind tunnel, more precise wind availability and characteristics information in terms of wind rose, wind profile(s) and wind turbulence intensity profile(s) of the site could be obtained. Hong Kong Observatory Waglan Island wind data should be referenced to for the experimental study.

Tools

16. Wind tunnel is recommended for both the Initial and the Detailed Studies, and most particularly for the Detailed Study. The conduct of the wind tunnel test should comply, as far as practicable, with established international best practices, such as, but not be limited to:

   (a) Manuals and Reports on Engineering Practice No. 67 : Wind Tunnel Studies of Buildings and Structures, Virginia 1999 issued by American Society of Civil Engineers.


17. Computational Fluid Dynamics (CFD) may be used with caution, it is more likely admissible for the Initial Studies. There is no internationally recognized guideline or standard for using CFD in outdoor urban scale studies. The onus is on the assessor to demonstrate that the tool used is “fit for the purpose”.

18. Should the assessor wish to use other forms of tool for the assessment not described above, the onus is on the proponent to demonstrate that the tool to be employed is “fit for the purpose”. The scientific suitability, as well as the practical merits of the tool to be used must be demonstrated.