TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

DIPLOMARBEIT

Headquarter in Hangzhou – The Metropolitan Hybrid

ausgeführt zum Zwecke der Erlangung des akademischen Grades eines Diplom-Ingenieurs / Diplom-Ingenieurin unter der Leitung

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eingereicht an der Technischen Universität Wien
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Abstract

This thesis paper highlights the potential of transit and land-use integration as an inevitable step to achieve a sustainable urban development with emphasis on fast growing Asian cities, in specific Hangzhou. To answer major contemporary urban challenges related to the ongoing densification process of people's flows and functionality, this study proposes the vertical expansion in fast developing urban centers.

First, the literature review investigates the efficiency of pedestrian friendly circulations and leads from transit-oriented development towards hybrid vertical urban environment to counteract the up-to-date lack of the existing transportation modes. These changes of our built environment seamlessly intertwine the horizontal and vertical movement and revolutionizes the shape and form of cities.

Second, the comparative case study analyses different cases of TOD projects in Asia to identify the core lessons of the integration process summarized in a setup of key principles. The following case study of Qianjiang Century City (QCC) in Hangzhou is an in-depth analysis to examine its potential value for an infill project at center location.

The final thesis design project, which needs to be seen as an idealized but possible application, is an attempt to translate the theoretical approach of the thesis from strategy to tactic. Consequently, all three sections – literature review, case study and thesis design project – come together. In result, this thesis demands a significant reduction in vehicle ownership, while expanding the mass public transportation to provide superior pedestrian accessibility and short distances. Moreover, mixing-up functions in densified urban environments is crucial, however it is the open space that enables people to find an ideal balance between work, life and social activity. By implementing these essential amenities within the building people will use it throughout the day 24/7, resulting in – greater efficiency, economical activeness and environmental friendliness – urban sustainability.

Key Words: transit-oriented development (TOD), metropolitan hybrid, vertical city, sustainable development, pedestrian friendly infrastructure

Author's Declaration

I hereby declare that I am the sole author of this master thesis and that I have not used any sources other than those listed in the bibliography and identified as references. I further declare that I have not submitted this thesis to any other institution in order to obtain a degree.

Abstrakt

In dieser Masterarbeit wird das Potenzial der Transit- und Landnutzungsintegration als ein unvermeidlicher Schritt zur Erreichung einer nachhaltigen Stadtentwicklung mit Schwerpunkt auf schnell wachsenden asiatischen Städten, am Beispiel von Hangzhou, dargestellt. In dieser Studie wird die vertikale Expansion von schnell sich entwickelnden Stadtzentren vorgeschlagen, um den großen Herausforderungen der Gegenwart im Zusammenhang mit der fortschreitenden Verdichtung von Funktionen und Menschenströmen zu begegnen.
Die Literaturrecherche untersucht zunächst die Effizienz fußgängerfreundlicher Verkehrswege und führt von einer transitorientierten Entwicklung hin zu einer hybriden vertikalen städtischen Umgebung, um dem aktuellen Mangel an vorhandenen Verkehrsträgern entgegenzuwirken. Diese Veränderungen unserer gebauten Umwelt greifen nahtlos in die horizontale und vertikale Bewegung ein und revolutionieren die Form und Gestalt von Städten.
Zweitens analysiert die vergleichende Fallstudie verschiedene Fälle von TOD-Projekten in Asien, um die Kernlektionen des Integrationsprozesses zu identifizieren, die in einer Zusammenstellung von Schlüsselprinzipien zusammengefasst sind. Die folgende Fallstudie von Qianjiang Century City (QCC) in Hangzhou ist eine eingehende Analyse, um den potenziellen Wert für ein Infill-Projekt am zentralen Standort zu untersuchen.
Das endgültige Entwurfsprojekt, das als idealisierte, aber mögliche Anwendung angesehen werden muss, ist ein Versuch, den theoretischen Ansatz der Thesis von der Strategie in die Taktik zu übersetzen. Demnach kommen alle drei Abschnitte - Literaturrecherche, Fallstudie und Entwurfsprojekt - zusammen. Infolgedessen fordert diese Studie eine signifikante Reduzierung des privaten Fahrzeugbesitzes und gleichzeitig eine Ausweitung des öffentlichen Personennahverkehrs, um eine hervorragende Zugänglichkeit für Fußgänger und kurze Wege zu gewährleisten. Darüber hinaus ist die Vermischung von Funktionen in verdichteten städtischen Umgebungen von entscheidender Bedeutung. Es ist jedoch der öffentliche Raum, der es den Menschen ermöglicht, eine ideale Balance zwischen Arbeit, Leben und sozialer Aktivität zu finden. Durch die Implementierung dieser wesentlichen Einrichtungen wird das Gebäude den ganzen Tag rund um die Uhr genutzt, was zu mehr Effizienz, wirtschaftlicher Atraktivität, größerer Umweltfreundlichkeit, und nachhaltiger Stadtentwicklung führt.

Schlüsselwörter: Transit-oriented Development (TOD), Metropolitan Hybrid, vertikale Stadt, nachhaltige Stadtentwicklung, fußgängerfreundliche Infrastruktur

Acknowledge

I want to thank my parents for their tremendous support throughout my life in any situation. Furthermore, I want to thank Professor Sun Tongyu from Tongji University for his help during the whole process of my theoretical thesis and Ass.Prof. Mladen Jadric from TU Vienna who fostered me with my design project. I also have to thank numerous peers, especially my twin brother Clemens Neuber, Harvey Abrams and Erwin Ronacher.

While working on my thesis, I could count on experts from practical field of architecture and urban planning, notably some students from my Tongji Professor's office and I want to express my gratitude for their time and helpful inputs.

Finally, I want to thank Mr. Sun, Director of the Urban Planning Department of the QCC, Hangzhou for the set of information and data he exclusively provided to me.

Contents

List of Abbreviations

CBD	Central Business District
BRT	Bus Rapid Transit
FAR	Floor Area Ratio
GFA	Gross Floor Area
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HGH	Hangzhou (International Air Transport Association – Code)
HSR	High Speed Railway System
ICC	International Commerce Center (Hong Kong)
JTLU	Journal of Transport and Land Use
MILU	Multiple and Intensive Land-Use
MTR	Mass Transit Railway
NMT	Non-Motorized Transport
PT	Public Transport
QCC	Qianjiang Century City (CBD in Hangzhou)
SOHO	Small Office, Home Office
TDB	Transportation Demand Management
TJD	Transit Joint Development
TOD	Transit-Oriented Development
VC	Vertical City
VKT	Vehicle Kilometer Traveled

1 Introduction

1.1 Background

Transportation is becoming increasingly more important for our urban centers. Because of global population growth and rural-to-urban migration the cities of the future will have to move more people than ever before. Long driving distances caused by urban sprawl and worldwide motorization, which increases the number of travelers, will inevitably result in congestion or even a collapse of the transportation network.

“Sustainable cities will never appear if the transit system is not sustainable. Increasing energy consumption, extensive travel and poor natural resource management must be redirected. Urban sprawl and the need to commute great distances for work and shopping must be curbed” (Kazlauskiene, 2009, p. XXII).

Based upon this idea the way people move must be changed along with the shape and form of cities. The concentration of higher urban densities along mass transit routes is crucial. Simultaneously working on two issues, transportation and urban fabric, on both the regional and national levels, will be challenging. It will require the integration of transit systems with land-use in order to achieve the final goal of sustainable urban development. The problem of the cities of the future is that they are built upon the cities of the past. This makes the process of transit system and land-use integration, in the existing urban fabric, very complex.

“In almost all cities around the world, the integration of transit and land-use development is at top positions on the agenda of state and local governments, be it under the banner of ‘Transit-Oriented Development’” (TOD) as in North America and Australia, or without, as in the numerous railway station area development projects across Europe, Asia and South America.” (Curtis, Renne and Bertolini, 2009, p. 3). The seamless integration of this spatial development demands a long-term process and a lot of effort and money will be required to drive this process.

However, the implementation of transit-oriented development is considered the most promising tool. If done properly then transit and land-use integration will provide cities with a higher level of mobility and accessibility. This compact and mixed-use environment will be functional, dense, productive, livable and attractive for business, all at the same time, a very sustainable environment.

1.2 Research Scope and Purpose

The objective of this research is to highlight the potential of transit and land-use integration as an inevitable step for fast growing, developing countries toward achieving sustainable urban development. The focus in this study is on China. The Transit-oriented Development (TOD) model is used as the main tool to foster cross-sector integration. The interaction between the TOD and Transit Demand Management (TDM) makes the model far more effective in itself. However, in conjunction with land-use, cross-sector integration becomes the superior alternative to develop public transportation systems and a sustainable urban fabric.

This research analyzes different opportunities and challenges of integrated transit and land-use development designs that are needed to overcome the lack of today's traffic modes and therefore make the land-use more efficient. The process of how to integrate such designs is an essential component of this study. Different cases of TOD have been selected to learn from

their experience and to identify the core lessons of the integration process. A comparison leads to a setup of key principles and guidelines for future transit and urban developments.

The study also reviews several policies, regulations and measures affecting transit and land-use integration. It is important to consider the needs of disadvantaged and marginalized populations and improve their environment rather than displace them. If the designs for transit and land-use integration improve these conditions then such interventions can be considered successful contributors toward sustainable cities. Enacted policies, regulations and measures should be designed to reach the goal of urban sustainability as well as social equality.

The locations of TOD designs are, in many respects, superior residential communities. This study will lead to the logical conclusion that vertical expansion of the urban fabric is beneficial. Therefore, it is important to explore how to design compact, vertical developments that can meet the needs of future city dwellers.

Based upon the research and the collected data, the author will propose his own TOD vision for the CBD Hangzhou. This will contain an explanation of an appropriate TOD typology and TOD guidelines for CBD Hangzhou. The generated TOD Vision creates the groundwork for my further study and graduation project.

1.3 Research Questions

This research will attempt to answer two major questions:

- What are the most important factors needed to promote the combination of horizontal with vertical transportation infrastructure?

note: transit development = tool: TOD + TDM

The second question to be answered is:

- What strategies can be used to optimize the integration of the total walkable urban environment with the vertical development?

note: land-use development = tool: TOD + VC

1.4 Methods and Analysis

In order to assess which kind of strategies and indicators can be used to integrate an interface from horizontal to vertical traffic effectively, Transit-oriented development (TOD) model has been integrated. The research methods applied are: a literature review of the existing research, comparative study of different TOD prototypes, and case study of CBD Hangzhou and site surveys.

- Literature review of the existing research: How cities should grow in the future toward sustainability? What are the origins of transit-oriented development and what is the general idea behind the concept? Why promote transit and land-use integration? Which policies, regulations or measures support the implementation process? What makes China an ideal place for integrating transit-oriented developments.

- Comparative study: Because every city is different, then each TOD typology is not effective in every case. There is no “one-system approach”. Each city is unique with its own history and needs. Collecting, sharing and analyzing these variables would make future transit and land-use developments significantly more efficient.
- Case study of CBD Hangzhou: Research of the city, in particular the CBD area (Qianjiang Century City), and the different layers of (public) transportation. Furthermore, potential locations for transit and land-use integration must be analyzed.

(The analyzing methods employed will include a series of quantified interpretations which are illustrated by axonometric drawings with exact measures.)

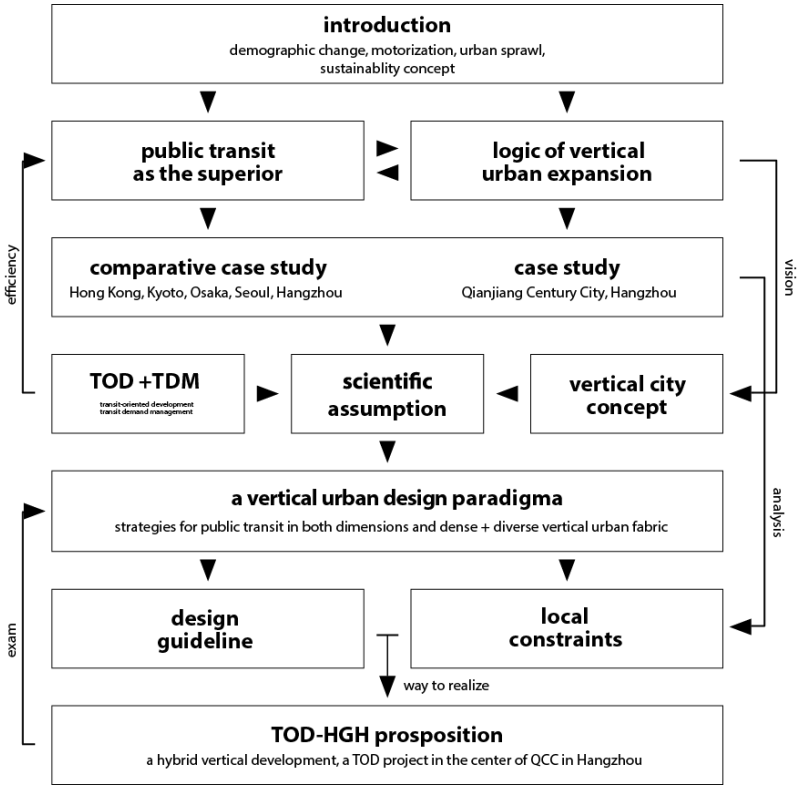


Figure 1 <framework of the thesis, source: done by author>

1.5 Delimitations

Due to the enormous range of the topic, there is always an attempt to support the focus of this research, which inevitably leads to certain things being left out.

Regarding the comparative case study, the full scope probably goes well beyond the scope of a master thesis, and therefore this research seeks to lay the groundwork for a potential PhD work.

1.6 Significance and Contribution

This research investigates and contributes to current transit and land-use integration efforts. Recommendations generated from the thesis provide valuable insights to transit and land-use developments and future urban sustainability. These contributions are of significant importance especially for fast growing and rapidly urbanizing developing countries, with emphasis on China's metropolitan area in this study.

The intention of this research is to improve the TOD model. Compact, mixed-use, bike-and pedestrian friendly communities can be created by well-designed TOD projects. More than just tall buildings, these integrated community designs can provide everything a city dweller would demand in their daily routine.

It is logical to see that vertical expansion of the urban fabric would be a benefit. However, most vertical developments fail to consider how the structure meets the ground and affects the surrounding urban context and street life. Disappointingly, this remains a common problem. Many tall buildings offer little to support an active pedestrian and social life at ground level or appropriate accessibility to public transportation. This is where transit and land-use integration is the most promising tool to combine the existing urban context with vertical development. Therefore, this research will both supplement the current efforts of transit and land-use integration, and also contribute to enhance the relationships between public transit and future urban sustainability in China.

The intent of this thesis is to explain how to solve the described problem of work in a conceptual form by generating a TOD vision and TOD guidelines based on the existing research and comparative case study on the example of CBD Hangzhou.

1.7 Outline of the Document

This research is divided into five parts. Chapter 1 introduces the thesis by outlining the sustainability challenge as the primary goal cities must face. It makes the case for evaluating the TOD model as a tool, with a focus on transit and land-use integration to implement vertical compact development into the existing urban fabric effectively. This part also describes the two central research questions, methods and analysis used, assumptions and limitations and the significant contribution of this research.

Chapter 2 conducts a review of the literature and the present status of TOD in urban design and contains four parts. The chapter begins with an introduction to the individual sustainability challenges that currently face cities. The main goal is to improve mobility and accessibility. Derived from these facts, this thesis provides an essential background for justifying the main focus of transit and land-use integration. The study highlights the origins of TOD theory, mentions different approaches and underlines the enormous potential of Chinese cities to implement TOD principles. The main focus is on the integration process which leads to the challenges, barriers, and constraints, and mentions some significant policies, regulations and measures. As the section continues, this literature review promotes the implementation of TOD development and compact vertical development to foster urban sustainability.

Chapter 3 begins with a framework on how the comparative case study is conducted. It continues by presenting exemplary cases of transit and land-use integration and examines the different TOD models on built prototypes. A summary of the lessons learned follows.

Chapter 4 also begins with a framework, focusing on the case study of CBD Hangzhou and how it is structured. The collected date about the city and TOD opportunities for a transit and land-use integration development are summarized in a TOD vision and guidelines.

Chapter 5 contains the thesis design project, the practical part of this research. The knowledge gained from the previous chapters will be implemented here, the case study being the basis, as the site is at the center of the CBD, Qianjiang Century City in Hangzhou.

The concluding chapter summarizes the research of the study and its contribution to the field. This thesis offers recommendations for the integration of transit and land-use development with highlighting some assumptions and limitations. The final statement will recommend further research in specific areas.

2 Survey of the Existing Research Field

2.1 Contemporary Challenges of the Urban Fabric

2.1.1 Demographic Change

- Global Population Growth

Foreboding declarations about contemporary urban trends pervade early 21st century academic political and journalistic discourse. Among the most widely recited is the claim that we now live in an 'urban era'. "Given that more than half the world's population is now living in cities – a number that is likely to reach 75 percent by 2050, while it was only 10 percent in 1900 – urban questions have become truly global ones, with significant consequences for the future of our planet" (Burdett *et al.*, 2007, p. 8). Globally, 54.6 percent of the world's population or 4.1 billion people were residing in urban settlements in 2016. It is projected that by 2030, 60 per cent of the world-wide population will reside in urban areas. Inherently, the biggest future demographic transformation is and will be in the cities and therefore make the city dwellers, the center of sustainable development (United Nations, 2017, p. 1).

Cities with more than 10 million inhabitants are classified as 'megacities'. Of the world's 31 megacities in 2016, 24 are located in the less developed regions. China alone was home to 6 megacities in 2016 and 3 more, Ho Chi Minh City, Viet Nam and Chungdu are projected to follow by 2030. Although megacities stand out as the more visible face of urbanization, half of the world's urban dwellers reside in settlements of less than 500,000 inhabitants. Between 2016 and 2030, the population in all city size classes is projected to increase, however in 2030, about a third of the urban population will live in cities with at least half a million inhabitants. In contrast only 12,5 percent lived in megacities in 2016 (United Nations, 2016).

Asia, despite its lower level of urbanization, is already home to 53 percent of the world's urban population. The most urbanized regions are Northern America (82 percent living in urban areas), Latin America (80 percent), and Europe (73 percent). In contrast, Africa and Asia remain mostly rural, with only 40 and 48 percent of their respective populations living in urban areas. However, Africa and Asia are currently urbanizing much faster than the other regions and are projected to become 56 and 64 percent urban, respectively, by 2050. The largest urban growth will take place in only three countries – India, China and Nigeria (UN-Habitat, 2016; United Nations, 2016). These facts of the progress of this future major transformation makes it legitimate to focus on China's urbanization and sustainable development process.

	2016			**2030**		
	Number of settlements	**Population (millions)**	**Percentage of world population**	**Number of settlements**	**Population (millions)**	**Percentage of world population**
Urban	…	4.034	54.5	…	5 058	60.0
10 million or more	31	500	6.8	41	730	8.7
5 to 10 million	45	308	4.2	63	434	5.2
1 to 5 million	436	861	11.6	558	1 128	13.4
500 000 to 1 million	551	380	5.1	731	509	6.0

Less than 500 000	…	1 985	26.8	…	2 257	26.8
Rural	…	3 371	45.5	…	3 367	40.0

Table 1 < world's population by size class of settlement, 2016 and 2030> source: (United Nations, 2016)

- Rural-to-Urban Migration in China

The main cause of this immense urban population increase is rural-to-urban migration. The Chinese government influences the pattern of urbanization through the 'Hukou' permanent residence registration system, land-sale policies, infrastructure investment and the incentives offered to local government officials. The decisive factors influencing rural-to-urban migration of people are more employment, education, and business opportunities, and higher standard of living. The number of floating population from rural to urban is increasing since 1979 and the speed of urbanization is extremely rapid. "In China's largest cities, for instance, it is often quoted that at least one out of every five persons is a migrant" (Wang and Xuejin, 1999). Certainly, this phenomenon will not diminish in the future decades and will further aggravate the situation. An eternal maintenance of the 'Hukou' system in its present form, generating invisible walls, and creating social class and inequality will not be possible and will additionally demand change.

To give an overview of the numbers, between 1979 and 2009 340 million people were attributable to net migration and urban reclassification. Until the middle of this century China is projected to add more than 292 million urban dwellers (United Nations, 2016). "This will require five million buildings … equivalent of ten cities the size of New York" (Neves, 2010, p. 28). China's population shift to the east and south coast is not only culminating in the big cities, like Shanghai, Beijing or Shenzhen, but even more importantly in the whole Chinese Metropolitan Area. Accommodating these large populations in urbanized regions will be a colossal challenge.

2.1.2 Commitment for Urban Sustainability

Besides the demographic changes another trend is receiving more and more attention in the recent debate about how our future cities should look. "As the world continues to urbanize, sustainable development is increasingly making its way up to the top of the agenda of several planning and urban design policies and regulations" (Al-Kodmany, 2012, p. 146). Due to the international commitment to achieve a sustainable world, a balanced development of the three main systems of environment, economy and society, no country or organization can escape the responsibility of making our cities a better place to live.

Originally the concept of sustainable development was coined by the United Nations World Commission on Environment and Development (WCED) in 1987 and was defined as a pattern of development that "meets the need of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 51). In 1997, when the 15th National Congress of the Communist Party of China took place, the republic identified sustainable development as a strategy that has to be implemented in the future modern construction. The rapid urbanization, motorization, and economic growth in China over the past three decades has resulted in alarming traffic congestion, energy consumption, urban sprawl and partly reversible environmental impacts (Peng, Sun and Lu, 2012, p. 36). It's going to be a long-term process, but it's now time for change. A sustainable city or metropolitan area should meet not only the demands of environment, economy, society, but also culture and politics, along with physical objectives, and ensure residents have equitable access to all services and facilities required, without depleting the resources of other places.

The concept is far more than the balance between environment, economy and society. It can be further divided in several pillars and requirements. Each individual point can significantly disturb the system. The theory of sustainability can be applied to different areas. To respond to the mentioned trends of demographic change and sustainable development, I want to expose the two main drivers that hold the key to China's urban sustainability. First – dense, compact and mixed-use vertical development to reform land-use efficiency. For Jane Jacobs "the first question, and she thinks by far the most important question, about planning cities is this: How can cities generate enough mixture among uses, enough diversity throughout enough of their territories, to sustain their own civilization? Beside residential and office, also retail trade, cultural facilities and entertainment need to be offered to satisfy all the inhabitants requirements" (Jacobs, 1961, p. 144). In this way, traveling distances are getting shorter which increases walkability, saves energy, time, and land and reduces emission of carbon. Second – despite China's recent efforts to increase motorization with 'cleaner' automobiles and construction of roads, the true potential lies in the public transportation network. Moreover, future interaction between urban planning and transportation planning, whether horizontal or/ and vertical, is essential to build better connected, smart grown cities. Given the monocentric form of Chinese cities, development density, concentration of employment in urban centers, and the continued urbanization process, there is a great opportunity for transit service development in China's Metropolis.

2.1.3 City's Dependent on Auto Mobility

There is a common consensus in the scientific community that today's automobile dependent urban development is the main trigger of the failure of achieving sustainable cities. In general, the car is a wonderful invention, that allows individuals to go anywhere at any time, day or night. However, the impact on urban development, transportation, environment and city dwellers are obvious. Today, developing countries with a high economic growth rate, China being in first place, follow the trend of increasing motorization and highway construction. The vicious circle begins with worldwide economic improvement, rising incomes make automobile ownership more affordable. As the highway systems improve in quality the public shifts from mass transit to private automobiles, making access to educational opportunities and offices from farther distances possible. Living in the green belt surrounding the cities, with more space than in the city centers, is attractive and more desirable for many wealthier people. However, the private car is sometimes the only option for transit. Thus the most sustainable form of transportation, non-motorized transit, is virtually impossible. The greater the number of city dwellers who follow this trend, not surprisingly returns in resulting urban sprawl and traffic congestion. Robert Cervero has aptly summarized this phenomenon in one sentence: "An automobile-oriented built form – marked by spread-out development, noncontiguous land uses, large city blocks that are unfriendly for pedestrians, and strip development – is an inevitable consequence of an automobile-dependent lifestyle" (Suzuki, Cervero and Iuchi, 2013, p. 29).

The development of suburban communities has been experienced mainly by Americans after World War II. European cities also developed outlying communities and suburbs in the late 20th century. The result is a city development with two faces that could not be more different. On the one side, there is the 'classical' city center; a compact high-density, mixed use, bike and pedestrian friendly development with organically evolved communities. On the other hand, the 'new suburbs' are sprawled, low-density, most residential, isolated, gated master planned communities that are absolutely dependent upon the automobile. The greater distance to the city center requires the highways to serve as a lifeline to urban activities, facilities and services. As result of the enormous increase of distances to cover, the vehicle kilometer

traveled (VKT) per person increases dramatically. In the transportation sector the VKT is used as a metric to measurement of sustainability and makes cities comparable (Cervero and Day, 2008b).

- Motorization in Developing Countries

Considering that motorization and income increase goes hand in hand with the source of the urban problem, this research utilizes the actual numbers of motorization in fast growing developing countries as indicator for income increase. In fact, the process goes through different stages. This means that the increasing number of motorcycles is ahead of the growing count of cars and trucks and therefore can be seen as an early indicator of changes in income levels, resulting in vehicle ownership.

Statistical data proves that, "the total number of motorcycles owned in China increases from 2.5 million (about 23 percent of total motorized vehicles in China) in 1987 to 50 million (about 70 percent) in 2002, and to 70 million (about 54 percent) in 2005" (National Bureau of Statistics, 2006). The fact that motorcycles only show the beginning of the motorization process, that the Chinese government is massively investing in highways and that the automobile industry produces many incentives to buy a car leads to the today's exponential increase in the number of motorized vehicles on Chinese streets. If China keeps going this way, it is projected to have more than 900 million motorcycles, cars and trucks in 2050, which is more than the total number of motor vehicles in the world of today. From a global perspective, 2.3 billion automobiles will be added between the years 2005 and 2050, highlighting that more than 80 percent of this increase will be spread over the streets and highways of developing countries (Chamon, Mauro and Okawa, 2008).

An alarming deterioration of global traffic conditions is the result of rapid motorization. Even during the worldwide recession between 2007 and 2010 a significant rise of the number of vehicles per 1000 people could be recorded. Numerous side effects of traffic such as stress, road rage, respiratory ailments from dirty air, and bodily injuries and deaths from traffic accidents are noticeable. In summary, all three pillars of the sustainability concept mentioned before are influenced by causing economic and environmental consequences as well as social concerns:

- Economic Consequences

The principle of how traffic affects the economy of a city is quite simple. Everything stands and falls with the further expansion of sprawling infrastructure. The greater the distances and the more motorized vehicles, the greater the volume of traffic congestion and the longer it takes to reach the respective destination. "Delays in the movement of people, goods, freight, and raw materials in and out of cities become a drag on economic productivity, reducing a city's competitiveness" (Suzuki, Cervero and Iuchi, 2013, p. 31). Moreover, with the increasing number of vehicles and travel distances comes the increase in consumption of energy and other resources, resulting in higher costs and irreparable pollution. The costs to provide public infrastructure and services for a given community in new suburbs is higher than to service the same community in a compact high-density or infill development (Al-Kodmany, 2012). Therefore, there is a strong association between urban density and energy consumption – denser cities simply consume less transport energy. This is where the two main drivers of this thesis – compact (vertical) development and public transit – are rooted.

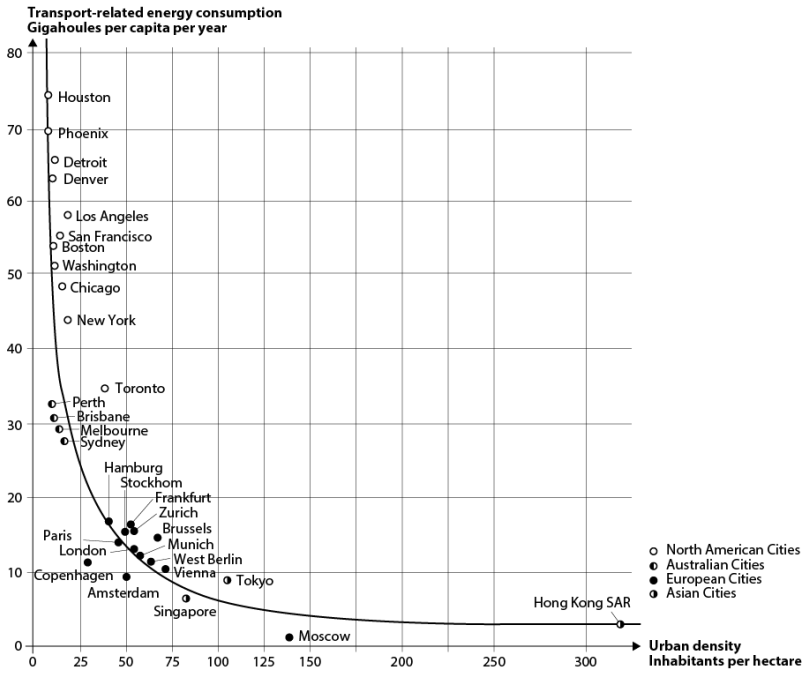


Figure 2 <Urban density and transport-related energy consumption, source: (Bournay, 2008) edited by author>

- Environmental Consequences

Since the outward expansion resulted in an increase in travel time, number of motorized vehicles and energy consumption, it is also responsible for the enormous increase of CO_2 emissions. Air pollution has a broader impact beyond the danger to humans like lung cancer or further diseases. The increase of carbon dioxide emissions has environmental consequences on a global scale that threatens to destabilize climates which then can cause rising sea levels, flooding, extreme heat waves and droughts. It is proven that one of the major contributors of global climate change is the transportation sector, which generates about one fourth of total emissions world-wide, with 18 percent coming from road transit (de Jong, 2016). It is projected that by 2050 the percentage of emissions caused by motorized vehicles will shoot up to one third of the total and will cause further environmental damage. In the following decades to come, China, followed by India, will account for the largest share of this increase, as the development process in these countries is correspondingly high. Besides, there is a noticeable correlation between urban density and CO_2 emission increase. Compact urban development not only demands less transportation and resources, it therefore also tends to have lower carbon emissions. This is confirmed in Hong Kong, which has the world's highest urban density while the CO_2 emissions, per capita, are at the world's lowest level (Guthrie, 2008).

- Social Concerns

Wealthier people, who can easily afford owning a car, are living in the city centers or highway-connected suburbs. Poor people are generally living in the slums or suburbs with little or no access to the city centers. This class division is created by the income difference, heavily influenced by the dominance of the automobile. The car is literally the 'key' to accessibility and consequently, people who cannot afford one have a limited opportunity to reach basic urban services, jobs, or educational opportunities in most cases.

As a result of income differences, the spent amount of money of travelling in percent is significant different even where transit services are available. A study already from 1993 found out that poor households spend as much as 20 percent of total income for

transportation, whereas wealthier families spend only 5 percent (Comez-Ibanez and Meyer, 1993). This discrepancy has continued to worsen over recent years, leading to a lack of money for basic things, such as food, shelter, health care, and education.

Spending money on transportation improvements is essential, however in most cities automobile-related investments, such as streets, highways and parking, spaces are the preferential choice. Low-income citizens, who do not own cars, are once again disadvantaged, as they are more reliant on public transport or non-motorized transit facilities, such as bikeways, which are, in fact, modes of relatively low cost. Only in recent years has there been reconsideration, especially in China.

It should be added that the more people that have to travel longer distances in the cities, the greater is the appearance of traffic congestion and the number of wasted travel-hours – 'time pollution'. These effects go beyond the class society. Finally, city dwellers have less time for working, studying, shopping, or socializing. However, it is the poor population spending much more time than other income groups on traveling from informal settlements on the urban periphery to city centers were jobs and other basic facilities are offered (Suzuki, Cervero and Iuchi, 2013, p. 33).

The final social concern to consider are the health effects of airborne pollutants and traffic accidents. It is claimed that everyone is exposed to the same environment. However, someone who is exposure to polluted air and aggressive motor vehicles every day while walking or cycling is a lot more at risk of long-term consequences than others. This is precisely what usually affects low-income residents.

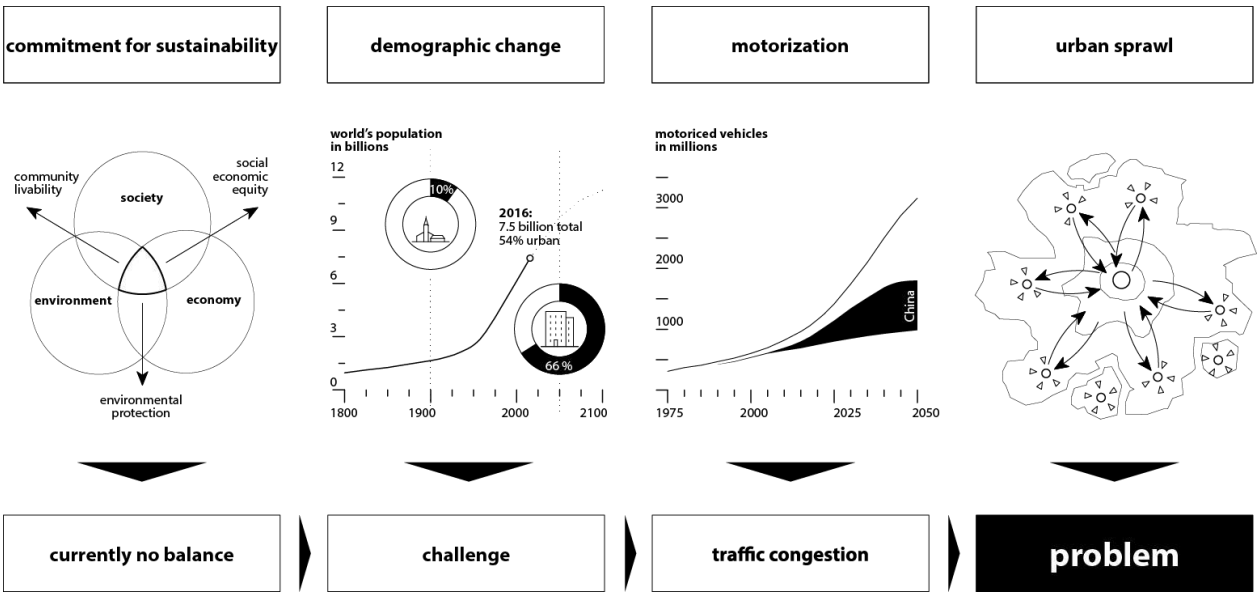


Figure 3 <problem summary: pillars for urban sustainability, demographic change, number of motorized vehicles in the world, 1975 – 2050, urban sprawl and decentralization, source: done by author>

2.1.4 Revitalization of Contemporary Urban Fabric

In one sentence, we need an inversion of 'transit', a city of short distances with a new level of mobility and accessibility, and an urban structure with integrated compact multi-functional 'land-use' developments. To reduce the VKT and to lower the requirement to use vehicles on a daily base is key for the design of the cities of the future. It must be considered as a whole. On the one hand, land-use demands transit and on the other transit supports land-use development.

As mentioned earlier, the traditional approach to meeting increased transport demand has been to provide additional road infrastructure, such as streets and highways. Although this approach has alleviated the problem of traffic congestion and the need for urban space in the short term, in the long term it has created the big problems of today's urban environments worldwide and solving them is the challenge of the 21st century. It has to be treated by 'what' sustainable urbanity can be achieved and 'how' it can be implemented in the existing urban fabric. Therefore, a new approach to tackling current transportation problems is required. The Institute for Material Flow (IfaS) from the University for applied Sciences Trier in Birkenfeld, Germany were inspired by the principles of sustainability and came up with the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) model, an alternative approach also known as **A-S-I** approach (Avoid/Reduce, Shift/Maintain, Improve), which focuses on the demand side and offers a more holistic approach for an overall sustainable transport system design. It seeks to achieve significant emission reductions, reduced energy consumption, less congestion, with the final objective to create more livable cities by promoting alternative mobility access (Heck *et al.*, 2015) and was, apart from the TOD concept, content of an UN Habitat talk given by Robert Cervero in 2014.

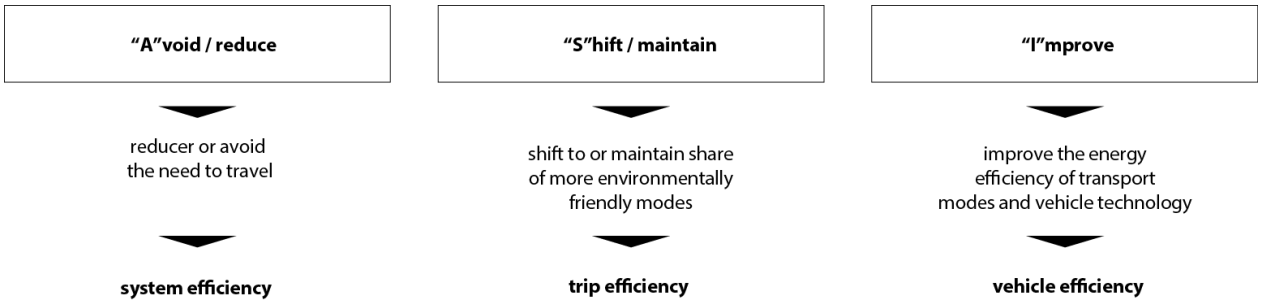


Figure 4 < A-S-I Approach (credit: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, source: (Heck *et al.*, 2015) edited by author >

- A…

Avoiding unnecessary travel and emissions, by referring to the need to improve the efficiency of transportation through integrated land-use developments and transport demand management. This could be achieved by lowering the distances between the facilities required by city dwellers through-out daily routine and reduce the number of cars in the inner cities. "The secret behind is to priories first pedestrian circulation followed by cycling, third public transport and as a least option cars" (Steffen and Baindl, 2008). Inherently, by reducing the need for mobility the urban development gets inclusive which affects the dwellers on a social aspect. Especially lower-income citizens are less disadvantaged when main facilities such as residential, office, shopping/retail and facilities for health care and education are within walking or cycling distance.

- S…

Shifting to more sustainable modes in order to improve trip efficiency. "A modal shift from the most energy consuming urban transport mode (i.e. cars) towards more environmentally friendly modes is highly desirable. In particular, the shift towards the following alternative modes" (Asian Development Bank, 2016) to an automobile independent sustainable system. First to non-motorized transport (NMT) such walking and cycling as they represent the most environmentally friendly options. Second, promoting public transport (PT) such as subway, BRT, LRT, etc. Although some PT modes also generates emissions, lower specific energy consumption per p-km and higher occupancy levels imply that the associated CO_2 emissions per p-km are lower compared to cars.

Figure 5 <Amount of space required to transport 60 people by bicycle, car and bus, credit: Press-Office of Münster, Germany>

- I…

Improving vehicle propulsion technologies and diversifying of alternative fuel and renewable resources as well as optimizing transport infrastructure. It pursues to improve the energy efficiency of transport modes by decreasing the demand of energy. Reducing the size of automobiles further degrease the energy consumption per VKT.
There is no doubt that the street network will remain until further notice their entitlement, since bus systems are the primary mode of public transportation. They are using the same streets as individual cars. The number of individual vehicles should not be unbalanced as they the compete with the same infrastructure capacity. For this reason, bus systems also started to fail when dwellers realized that if they have to wait for the public traffic, they might as well wait in their own cars that provided higher flexibility of timing and route (Belzer and Autler, 2002, p. 14). This in turn leads to bus system inefficiency and more traffic congestion. The current situation of many cities is the result.

Due to the upcoming trend of digitalization this study indicates the following point as it affects the demands of how people move or live significantly. One should not only think about the issues already identified but also those which could have an impact in the future.

- A…

Awareness of time. We now live in an era of internet and telecommunication where artificial intelligence becomes superior to humans and physical proximity is competing with connectivity. Joshua Cooper Ramo claims in his book ‘The Seventh Sense’ “the secret to power now is understanding our new age of networks” (Cooper, 2016) . There are different forms of connectivity and legitimately let us question if connection or location is more important. Forcibly, telecommunication influences urban form and how we provide the linkage in-between. For example, in many business fields, you can work from home, which makes the discussion about location almost irrelevant. Cooper claims in his book to look how the built environment is developing to improve links between people and communities, between public and private space, between districts and cities. It is more than integrating transit and land-use developments. “Best practice developments consider both the way that the digital and physical worlds interact and the way green space and built space can be linked. No development is an island, at least not if it has the ambition to succeed” (Cartledge and Cooper, 2016, p. 3).

In summary, achieving the goal of sustainable cities is not primarily about disadvantaging the current modes of mobility, but about creating a public transportation system and land-use development that is superior to the traditional approach. We need to encourage the use of public transit and creation of pedestrian friendly environments. City dwellers need the

provision of accessible and compact communities that are socially, environmentally, and economically sustainable (Cervero, Ferrell and Murphy, 2002). “By strategically increasing the number of dwelling units per acre, cities not only will go a long way toward meeting their sustainability objectives, but also will be competitive, resilient, and great places to live” (Murphy, Miller and Brandes, 2008).

This form of development is called compact, mixed-use, walking friendly development around transit stations or TRANSIT-ORIENTED DEVELOPMENT (TOD) (Peter Calthorpe, 1993).

2.2 Transit-Oriented Development

2.2.1 Origins of TOD

The car is since traffic congestion and urban collapse resulting of urban sprawl to handle urban demographic change the main indicator for the failure of urbanity and sustainability. The segregation of transit and urban planning in the late 18th century carries a considerable responsibility to it. However, back to the beginning of transit and land use integration. In the following chapter, I provide a historical background as well as different perspectives of Transit-Oriented Development.

- Transportation before the Automobile

In “The Time of the Trolley”, William D. Middleton describes how the electric street railway dominated municipal transportation between city and periphery until Henry Ford. At the turn of the 20th century, electric streetcar systems had appeared in many cities like New York and San Francisco, but also apart from the North America, contributing to the growth of suburbs in the decades to come. (Middleton, 1967). These electric street railways to the adjacent residential communities were usually designed by a single investor who built transit to provide a link between jobs in an urban center and housing at the periphery in order to add value to the residential development. “With typical features such as a transit depot and public space in the center of the neighborhood, small cottage-type houses, and a street pattern and scale that allowed convenient walking distances to transit, the early street suburbs were successful examples of pedestrian access to transit service that connects to downtown jobs and neighborhood services” (Cervero, 1993).

Inherently, in many cases, a small retail cluster has formed around a tram stop to serve commuters and residents alike. These small walkable business districts are to a certain extent the forerunners of the modern TOD, since they fulfill all the requirements of a dweller's daily routine and represent a good balance between place and node. The big difference, however, is that the tram has been added as a linkage between the suburbs and the city center to increase mobility and value capture. For this reason, the term ‘Development-Oriented Transit’ is much more appropriate to these developments.

- The Rise of the Highway

“However, the interdependence between housing, jobs, and transit inherent to the early streetcar suburbs was broken apart by the automobile. Starting in the 1930s, roads, including highways, became the preferred transportation infrastructure in America. Development was no longer dependent on transit, the link between transit and development was severed, and

developers got out of the business of building transportation systems" (Belzer and Autler, 2002, pp. 4–5).

- Transportation in the 2nd half of the 20th century

The post-World War II period saw the car along with the highway as the superior measure of transportation. It was an era of precipitous decline in public transit use and even the dismantlement and abandonment of many rail systems. The resulting problems have already been dealt with, but solving them will be the task of the 21st century and a long-term process.

Already in the early years of the 20th century, Huge Ferriss predicted the failure of the automobile and highway a hundred years ago and pointing out that the true potential relies in public transport in form of railways, not in the highways (Ferriss, 1929). However, the commerce and industries priorities were stronger than the commitment on building sustainability cities and therefore, the way for the rise of the automobile was a self-propelled one.

- The Change of Consciousness

Only since recent years when the impact inevitably led to a rethink, not only the understanding of transit planning has changed, but also the interaction with land-use planning is becoming increasingly important. Once predicted as the solution for sub-urbanism – because of traffic congestion, population growth and urban sprawl – the TOD concept today is the most promising regeneration tool for preventing our city centers of a collapse worldwide.

In 1993, Peter Calthorpe coined the term 'TOD' and came up with his idealistic concept of transit-oriented development in his announced book "The Next American Metropolis". However, he was not the first who promoted compact mixed-use and pedestrian friendly developments. Therefore, this literature review continues in the following part with the origins of transit-oriented development and contains a chronology of definitions and concepts of transit-oriented development, as they are the basis of actual transit and land-use developments. The outcome promotes China's metropolitan area as the ideal place for TOD integration projects.

2.2.2 Precursor of the TOD Model

- ‘Eixample’ – Iledfons Cèrdà, 1860

The realized development concept for Barcelona was the great contribution of the city planner, Cèrdà. In principle, it was a primary division into ‘traffic routes and ‘interstices’. The first serve as a public space for mobility, gathering, utilities (drinking water, sewerage, gas …), greening (over 100.000 street trees), lighting and urban furniture. The ‘gaps’ (blocks) are spaces (100 x 100 meter) for private life. Wide courtyards are lined on two sides of apartment blocks, in which all apartments without exception, receive natural sun light, fresh air and vitality as required by hygienists. This is the clear application of the will to ‘ruralize the urban and urbanize the rural’.

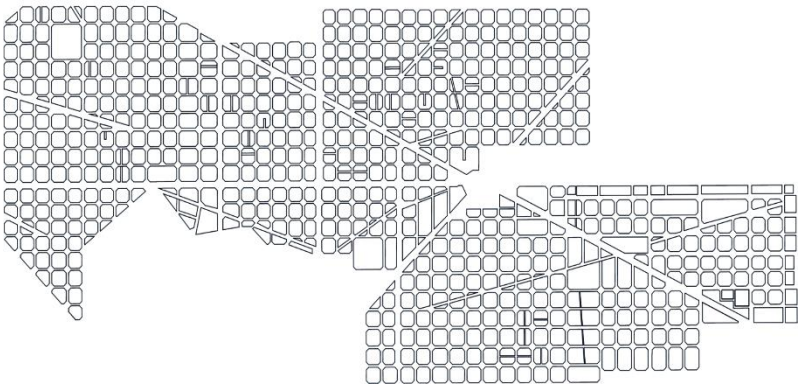


Figure 6 < Diagram of ‘Eixample’>

- ‘Garden City – Ebenezer Howard, 1894

With this concept, Ebenezer Howard already presented the concept of Development-Oriented Transit in 1894. He imagined 'Garden Cities' connected to each other by the central city through a strong transport network consisting mainly of interregional inter-municipal trains and streetcars. Attempts to combine the advantages of the city and the close access to nature.

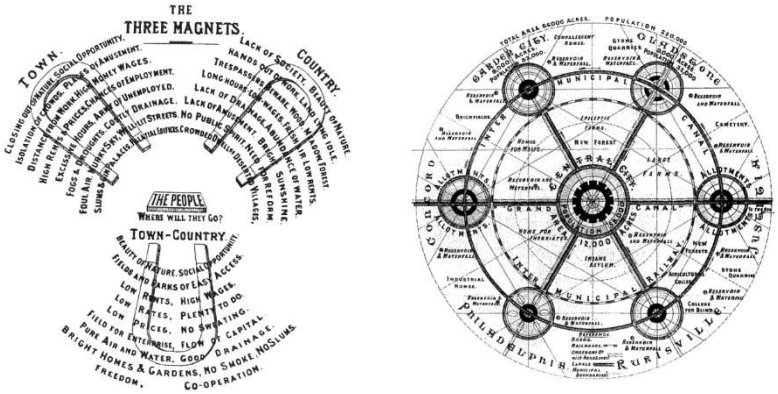


Figure 7 <The Three Magnets and Garden City (1902), Ebenezer Howard, source: (Howard, 1902)>

- ‘Pedestrian Pocket’ – Calthorpe Peter, 1989

Perter Calthorpe just published the Pedestrian Pocket four years before the TOD. The parallels are so obvious and the fact that the same author developed the two concepts allows the conclusion that it is the direct precursor. In short, the Pedestrian Pocket is “a simple cluster of housing, retail space and offices within a quarter-mile walking radius of a transit

system" (Calthorpe and Kelbaugh, 1989) with focus on higher density and quality public space that offer its heterogeneous population true pedestrian accessibility and a sense of place.

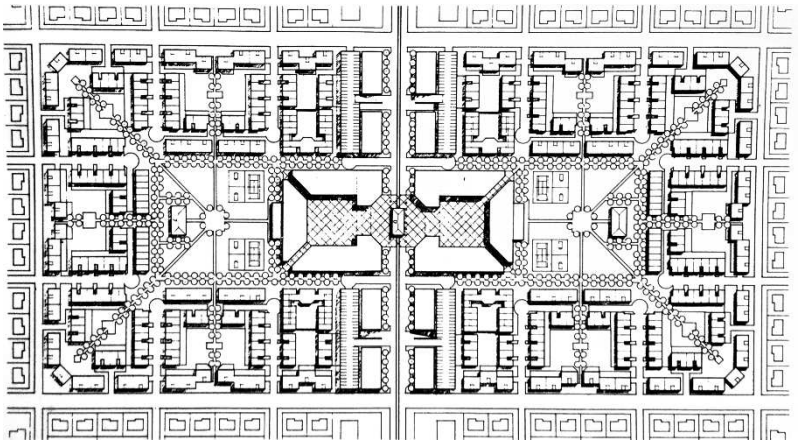


Figure 8 < Diagram of 'Pedestrian Pocket', source: (Calthorpe, 1993, p. 45)>

2.2.3 Challenges of Transit and Land-Use Integration

Cross-sector TOD integration, which involves both transit- and land use planning is truly complex. Complications are common in this process. This research attempts to address factors, which prevent TOD projects of being successful in the real world. The framework for the following list of major TOD barriers and their integration challenges is based on the research of the reviewed literature. In short, several researchers state that while many TOD concepts are based on great ideas, are well planned and built at the right locations, the true potential and benefits of TOD has not been exhausted in many built cases (Belzer and Autler, 2002, p. 3). The reality is far from the drawing board. The use of standard parking rations, an inappropriate mix of uses, caused by the dominant focus on economic success in the short term and the lack of residential or high function mix is still omnipresent and finally results in car oriented developments. In this section, the focus is on selected barriers of building future TOD projects. Some of them are not just related to TOD's, but can also be associated with dense urban infill projects in general. To significantly improve their outcome, it is of great importance to go beyond these limitations. Just building high density and providing transit infrastructure is barely enough. One has to step back and deal with the interaction of density, land-use mix, patterns of movement and transit systems as a whole.

In the process of facing the listed restrictions, future TOD projects may still not be as productive as projected, yet far superior to the earlier ones, and starting point for new approaches helping to further improve the understanding of cross-sector integration. In this context, Dena Belzer and Gerald Autler state: "If all the barriers to TOD were overcome, there would still be no guarantee of high-quality projects. However, if these challenges can be dealt with and overcome, it is likely that both the overall number and quality of such projects would be greatly increased"(Belzer and Autler, 2002, p. 19).

Based on the research of the transitional relationship between transit demand and land use offer, selected lacks of TOD integration have been analyzed in this study:

- Lack of a single definition:

There are several paradigms of coordination between urban planning and mass transit such as: Transit village, Transit-friendly Design, Satellite City, Pedestrian Pocket, Transit-supportive Development, Transit-Oriented Development (TOD), Transit Joint Development (TJD),

Compact City, City of short Distances, Interconnected Polycentrism, Suburban Hubs ... The period of emergence of most of those concepts and tools took place during the 1980s and 90s. The attempt of manifestation particularly took place in Australia, China, Europe, Japan, North and South America as well as South Korea. However, in the sense of the main objective, many ideas are quite similar, which were just named differently by their authors. In the course of globalization, several concepts were merged together to satisfy individual needs of land-use integration projects. Resulting from this, the network of definitions has made a clear separation of individual approaches very obscure.

The TOD concept is no exception. Nowadays, different TOD models with different interpretations or goals exist. They operate on very different scales and circumstances, concerning city centers as well as suburban areas; urban densification as well as city extension; and transit network expansion as well as new infrastructure implementation. There is not even an agreement about how big the radius of the directly involved urban structure of a TOD project is. In the discourse of TOD theory this is not a critical issue as it is believed that the radius is simply not a specific feature of TOD, however the range of one-quarter to half-quarter mile (about 400 to 800 meters) is quite common. The research of Erick Guerra, Robert Cervero and Daniel Tischler results that the radius of 400 and 800 meters work best when respectively predicting ridership as a function of jobs and residential units (Guerra, Cervero and Tischler, 2012).

At a later section of this literature review different, in particular TOD definitions are listed, the concepts analyzed, and the differences as well as similarities are made clear. This comprehensive comparison of TOD concepts and definitions leads to a literature based assessment of the potential of future TOD projects in China. This is possible because, despite the lack of a single definition, the TOD concept has been strongly promoted and co-developed in China since 2000 and therefore, pretends a certain direction for the TOD theory.

- No clarity on what makes a place successful for TOD:

As given apart in the introduction of this list, there is no clear statement as to which concept on paper can be implemented in the existing urban fabric in such a way that it is ultimately a success. Land-use elements such as urban density and mixed-use development are essential for making TOD projects work. However, only these do not guarantee sustainability or higher financial returns. The 24/7 passenger movement is of great importance for successful TOD, for retail and for commercial planning, and most TOD definitions lack of covering this issue (Hutchings, 2013). Shao-Ming Zhang promotes the importance of balanced factors and that no individual one can weigh greater than others. He evaluated in his dissertation, what factors increase the property values of TODs, the ridership of TODs and what the impact of other factors, including the household income level of the neighborhood around TODs and on the financial returns are (Zhang, 2005). However, for an overall success of sustainable urban development, further elements such as accessibility to transit stations, public space and other amenities, such as place making, need to be considered.

Another point of great concern is the range of different actors typically involved in TOD projects. These clusters of individual interests will never follow the same goals and will inevitably lead to disagreements. In general, the public sector, which in turn consists of different agencies, provides the infrastructure and ensures transit. The developer tries to realize a profit-oriented project, which in turn is controlled by the local government. In the case of most TOD projects, it is not uncommon for transit agencies to become property owners, or for developers to play a decisive role in shaping transit. Each of the further actors including transit riders, residents, neighbors, workers and visitors, has certain demands, which can be partly controversial, on the respective development. Accordingly, to the number of

entities, there are just as many interpretations, from which point a TOD project can be regarded as a success.

Actor	Possible Goals
Transit Agency	- Maximize monetary return on land - Maximize ridership - Capture value in the long term
Riders	- Create/maintain high level of parking - Improve transit service and station access - Increase mobility choices - Develop convenient mix of uses near station
Neighbours	- Maintain/increase property values - Minimize traffic impact - Increase mobility choices - Improve access to transit, service, jobs - Enhance neighborhood livability - Foster redevelopment
Local Government	- Maximize tax revenues - Foster economic vitality - Please constituents - Redevelop underutilized land
Federal Government	- Protect 'public interest' and set limits on how federally-funded investments can be used
Developer/Lender	- Maximize return on investment - Minimize risk, complexity - Ensure value in long term

Table 2 <Range of actors and goals involved in TOD projects> source: (Belzer and Autler, 2002, p. 19)

- Lack of support from market

Even though transit is considered by transit agencies and policy makers as a booster of land values, commercial rents, and development trends, it will not drive real estate investment alone. In theory, transit decreases the 'distance' to key locations, such as the city centers, and inherently improves the terms of time and cost. This efficiency advantage can be attractive to more users, which increases the demand and automatically makes the respective sites more valuable. Driven by tax revenue, the local government approves major construction projects, which in turn are beneficial to the developer. Given that, the more space can be sold at the same site, the larger is the total land value. However, this mechanism is much more complex and driven by several factors and not just transit. In view of the surrounding neighborhood, every potential site for a development stands in competition with each other. Real intensive market demand is a prerequisite for the success of a TOD, as is a good regional economic development or revitalization package which is typically worked out by the public sector. It should consist of well-planned transit investments as well as a range of supportive coordinating policies and economic incentives for future investments to foster TOD.

Other factors that lack support from the side of the market are driven by low expected profits or increased unpredictable risks. Neighborhoods with low-income residents as well as noticeable problems, such as crime, social issues or deteriorated physical conditions, as an example. However, it does not mean that only regions with wealthy inhabitants have the potential to pay off for TOD projects. It is the whole demographic composition that needs to be considered. For instance, a suburban style neighborhood consisting of detached houses also

will not be the first choice for real estate investors, as this area simply cannot produce the required density for a TOD.

To sum up this statement, many criteria are required to get in the focus of support of the market. Despite missing perfect basic conditions, a development placed in the right location can constitute as a key piece to an economic upswing to benefit the people living there and help to create another piece of sustainable urbanity.

- Lack of planning between node vs. place, between transit- vs. urban planning

While in transit planning 'nodes' (transit stations) are generated, in urban planning 'places' are created. The shortcoming is that the professions act independently and each one works for itself. Robert Cervero stated in 2014 during an UN Habitat talk that it is very important, that any investment in transportation, including public transportation be carefully integrated with urban land-use planning. It is pretty axiomatic, but it is so true that we do not hop to vehicles, trains, cars or buses, to be moving, we are going to places and it is places (of work residence, shopping, culture, …) that matter most. That is what we value and care most about our cities and not the process of necessarily getting to this place. Cities that have understood that have taken the first step into a sustainable future. A TOD should be a transit station, 'a place to be' not just a 'node to pass through'. This is called place making – places where people feel comfortable, where they want to be. "The role of transit in creating a link between individual places and the broader region means that transit-oriented development, unlike other forms of development, should explicitly perform a dual function as both a node within a larger regional or metropolitan system and a good place in its own right"(Bertolini and Spit, 1998).

The goal of a TOD to meet the requirements of a place as well as a node, leads to the matter that it affects the station design as well as the whole program of the development. From the large number of actors mentioned above, certain parties are more interested in a node as connector rather than in a place of actual quality. Without condemnation, it is usually the transit agencies that focus on the station as a node. The fact that they are alone responsible for making the agenda and regulations for such a project make the emergence of an imbalance in participation easy to understand. An eternal point of controversy is the car, the number of accessible roads and parking lots, which decisive shorten the development as a place. Transit agencies are under some compulsion to create enough parking space to strengthen the political and economic role of the station as a node in the wider regional environment, which in turn affects the composition of the station development as a place as well as the urban surroundings. TOD does quite the opposite. It calls for an alternative to car dependency, promotes walkability and the use of non-motorized (public) transit.

Given that China has a respective low motorization rate and therefore requires proportionally fewer parking lots at transit stations, in comparison to for instance the United States, space for pedestrian-friendly environment is created which finally strengthens the efficiency and the quality as a place as well as a node. This fact makes several cities in the metropolitan area of China the ideal starting point to integrate TOD projects as prototypes.

- Complex collaboration

As indicated in the previous paragraph, in many built projects the function as a node dominates and inevitably leads to the task of making the TOD work better as place in future projects. What makes a good place? Unfortunately, until the date of this research only a clear theoretical understanding of the factors that influence the outcome of TOD exists, however there are few guidelines for translating the TOD concept into concrete design propositions or plans for good places.

As typology, the TOD can only be defined as a concept and not as an actual physical type of form, which can be repeatedly applied in the same way at different locations. As Cervero summarized in his so called 5D's, a set of goals for successfully built environment: TOD rather combines high household and population density with an adequate mix of land-use in close proximity, an appropriate street pattern design, good destination accessibility to jobs as well as a walkable access to public transit. This results in a decrease of VKT and an increase in public transit trips, typical parameters that make the city more sustainable (Ewing and Cervero, 2010). However, there is still a lack of knowledge in designing appropriate density, mix of uses, transit stations as well as surrounding area accessibility. Changing parameters such as the scale and sphere of influence of such developments need to be considered to create sustainable places.

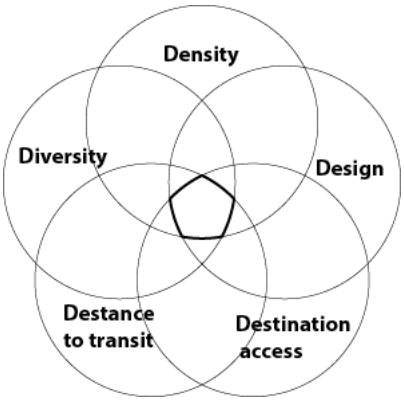


Figure 9 <5D's of the total built environment, source: (Ewing and Cervero, 2010) edited by author>

As a place and a node, a TOD is constrained to consist of all components of a city, packed closely together. In this way, it is a city in a city, however it is striving to be much more. The goal is to seamlessly integrate the TOD in the urban fabric to achieve absolute land-use efficiency, accessibility and mobility, rather than a self-acting architecture. The development attempts to interface among other things the transit system, station access routes (buses, taxis, cars, bicycles, and pedestrian infrastructure) as well as the walkable urban development, providing all amenities of different user groups requested throughout daily routine. The "TOD requires synergy among many different uses and functions, but this synergy is extremely difficult to achieve. As a result, TOD almost always involves more complexity, greater uncertainty, and higher cost than other forms of infill development" (Belzer and Autler, 2002, p. 24). This causes a common problem, because despite a good financing concept of the individual TOD components, in most cases there is little left to encourage the actual transition between node and place or simply viewed as secondary. The lack of existing place making inherently leads to the failure of the TOD. This happens if none of the actors involved feels responsible to take leadership on this aspect. TOD's are still seen as experiments, designed to drive the development of guidelines and regulations. Since no actor alone can achieve the complete agenda of a TOD project, it is the local government's responsibility to be involved in the planning and take control over these structural aspects. In most cases, they have to push transit agencies to redevelop the transit station design in order to set up the basis of interface functionality required for a successful TOD implementation.

- Lack of regional coordination at the metropolitan level

Decision-making needs, fiscal functions and other competencies are transferred from national government to the local governmental organizations, which coordinate land-use plans, infrastructure investments, and urban services at the metropolitan scale. This decentralization of power in diversified governmental units, acting at multiple

levels, is essential for an efficient administration of a country. However, it results in enormous complexity in the process of implementing new tasks on national level. The individual administrative zones are in strong political and economic competition with each other and the objectives of this heterogeneous array of actors are often conflicting. Focusing on the implementation of one's own interests influences the coordination of planning, investment and service delivery, ultimately leading to conflicts or at least to a delay.

Further constraints caused by the absence of coordination, regardless of the actors or lack of regulations are treated individually to make the whole construct of barriers, legacies and constraints legible at a glance.

- Sector silo behavior and practices at the city level

This is not just about the one-sided elaboration of the regulations. In reality, transit agencies and urban planners are not even working together or try to balance their competencies to invent meaningful guidelines. In most cases, every profession has little idea of the other task area or why some processes work the way they do. In result, this makes the goal of a seamless interaction of urban and transit planning and the seamless integration of a TOD project even more challenging.

- Lack of strategically articulated densities which are potential TOD locations

In short, the more people live in the same amount of space and the more functions are integrated, the higher is the respective density and the better is the land-use efficiency. Logically, higher density requires an increased level of infrastructure. Therefore, future transit and land-use developments must be integrated precisely to support efficient and high-quality urban services while aiming to maintain good environmental conditions. 'Articulated densities' are urban developments with comparatively more people and features, than the average of the total city. These are, for instance, city centers, sub centers, or satellite cities. In car-oriented cities, these are usually the only small patches of city that are human-scale, workable, and overall sustainable. However, following the TOD concept and the promotion of public transit, entire corridors of this desirable urban development are possible. Each walkable perimeter of a public station represents an ideal location for integrating a TOD project which can be equated with an ‘articulated density’. Commonly, the lack of consideration of a location's economic value and achieving its appropriate density, prevents succeeding an efficient land use management. “Gross FAR in major Chinese cities does not vary sufficiently across the urban space because of uniformly regulated FAR values that suppress location premiums from being reflected in the price of land. This leads to the dearth of strategically located high density nodes” (Altaf and Shah, 2008, p. 3). Therefore, many large Chinese cities with a comparable high average population density, like Shanghai, Tianjin, or Zhengzhou retain a much lower FAR in total than for instance Hong Kong, Guangzhou, Tokyo, Singapore or Seoul.

Since the huge increase in urban population in fast-growing developing countries, especially in Africa and Asia, huge volumes of construction must be provided in an incredibly short time. For various reasons, governments, architects, and residents of most high-density cities in developing countries have a desire of spreading the city. Affected cities tend to prefer projects located in peripheral green fields to urban development in the city centers, because development of green fields is much faster and less expensive to construct (Burchell *et al.*, 2000). Due to the pressure of time and cost, and the sheer number of people moving to the cities in respect to the available space, this is the only choice to make. Further densification or additional growth in already built-up areas seems to be on such a high level almost impossible. This in turn causes irrevocable urban sprawl and despite allowing to build a

higher average FAR, the real important articulated densities lack of being constructed. Nevertheless, it is widely believed that this procedure is the only solution to face this challenge.

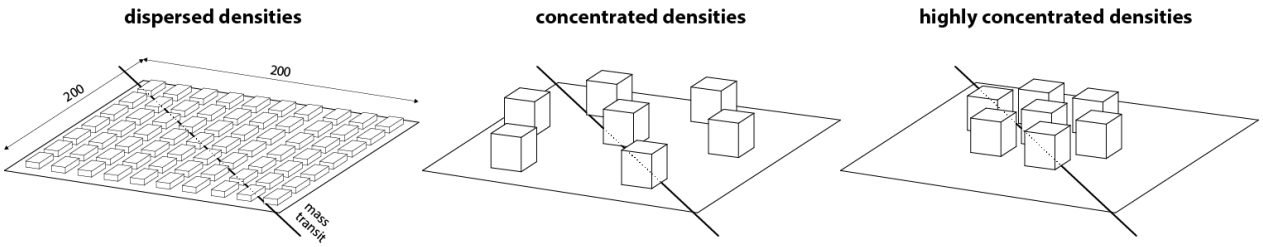


Figure 10 <efficiency of articulated vs average urban density, source: (OECD, 2012) edited by author>

- Lack of benefit for the TOD neighborhood

Most attention is taken by the 'real' TOD project, the transit station and further facilities to increase the land-use efficiency. The importance of density, function mixture affecting travel demand as well as the role of public transit in terms of shaping urban development has already made clear. In the neighborhood, there still remain lacks in design measures for making the pedestrian and non-motorized transit the predominant means of transportation.

Once inside the mass transit, whether subway or BRT, the speed and cost are quite optimized, however it is believed that almost half of the travel time is spent on walking from or to transit stations and waiting there. Waiting times can be considerably shortened by improvements in the public transport intervals. However, the true potential relies in the delinquent issues of walkability, safety, and accessibility of the neighborhood environment, which are caused by both, transit and land-use planning. This is where enormous potential still remains and the car is once again in the focus of inconvenience. Special attention during the TOD integration process must be paid on the improvement of quality of the surrounded squares and streets, which could serve as pedestrian corridors. This in turn attracts other people to these places and strengthens the entire TOD neighborhood. More people are walking, fewer cars are on the roads, efficiency is increasing - an important step towards urban sustainability would be done.

- Lack of opportunities of retro-fitting TOD projects

Before even thinking about constraints of national/local governments, either transit agencies or developers, have to identify the origins of the problem of urban sprawl. One reason why development toward transit and land-use integration in the existing urban context, so called brownfield sites, is so much more difficult than to build TOD projects on greenfield lots, is actually explained quite simple by existing private ownership and constant activity within urbanity.

In fact, most of the property around potential TOD areas is owned by private businesses or households. Therefore, the government or official actors barely have control over the urban development. However, they absolutely dominate the construction of transit, as soon as they insure the right of the way as well as the construction funds. In this sense, transit investments significantly affect the opportunities to provide good urban development and affect the increase of land values.

Another aspect making it more difficult to implement TOD projects on brownfield is that the redevelopment must be done beside the regular operation of the city. Nonetheless, it requires the demolition of assets, including still intact buildings as well as existing infrastructure. Before the construction of a large-scale urban regeneration development can begin, it already has a significant impact on the economic, social and environmental factors in the district

(Suzuki, Cervero and Iuchi, 2013, pp. 162–163). It demands confidence in the proactively effort of governments that a long-term investment, despite these risks and uncertainties, is worthwhile. Therefore, TOD developments require especially close collaboration by political authorities and private owners, which is unfortunately rarely the case.

- Fragmented land-use increases urban sprawl

Two selected reasons that cause this problem are, on the one hand, legislation and, on the other hand, the fact that construction sites closer to transit stations are more valuable than those further afield. In China, for instance in the periphery of Chengdu, national regulations limit land use developments to protect farmland, with the unintended consequence of fragmentation of the urban periphery, and incoherent development of relatively high-density clusters. Regulations that fail to strengthen agricultural lands outside and do not attract building urban development inside cities will only exacerbate the cities boundary fragmentation (Altaf and Shah, 2008).

Second, real estate developer's first goal is to make profit, but the high costs of available space close to mass transit makes it a business of high risk. Peripheral construction sites that are located in the extension of an existing transit corridor are preferred because they can be purchased relatively cheaply. After the construction of the developments, pressure is increased on the local government and transit agencies to connect the people living there with the necessary public transport and further amenities. If this is guaranteed, the value increases accordingly and the individual properties can be sold by far more, which increases the desired profit margin. As a result, less projects are built, at already potential plots which unnecessarily increases urban sprawl and further smooths out the transition from city to country.

- Financial constraints

The origin in this problem is not necessarily a result of a coordination failure. High realization costs due to the enormous complexity, amount of goals and constraints stated out above, and different funding schemes, are the original driver to develop the TOD concept. Resulting of an intensified mix of uses also the considerable number of different lenders and investors. Several real estate types, for instance rental or ownership create different parameters of financing, levels of risk or require different strategies to get the project finally financed. For a better assessment, this may require expertise and further knowledge from different professions, which will not only lead to time delays, but also to additional costs.

An interesting addition that had been noticed during the research concern the eight major barriers listed in ‘Transforming Cities with Transit’, which were drawn from existing case studies for probing the opportunities and challenges posed by integrated transit and urban developments. In the authors view, every city is its own TOD prototype developed out of a TOD typology. Every city has its own identity and therefore, there is no superior "one-approach system“ (Suzuki, Cervero and Iuchi, 2013). In 2010, Hiroaki Suzuki together with Arish Dastur, Sebastian Moffatt, Nanae Yabuki and Hinako Maruyama just did that – promoting a ‘one-approach system’, in the book “Eco2 Cities” (Suzuki et al., 2010). Given that Hiroaki Suzuki was involved in both publications suggests that this earlier attempt is rapidly outdated.

2.2.4 Definition of TOD and its Success

Worldwide requirements for transit- and urban planning have increased and significantly drove the research of methods to seamlessly connect public transit stations and their surrounding neighborhood. Inspiration was gained from the TOD based worldwide urban planning and management experience. However, what is the essence of TOD by definition? Does a definition exist from which all others are descended and what are the specific aims? A lack of a single definition or a specific set of goals for an ultimate success still remains. Recently, researchers have at least begun to categorize TOD projects.

To give an overview, this section deals with the foundation and definitions of the TOD concept, its guiding principles and the urge to translate the theory into reality by a performance-based approach. It gives answers of how to measure success, promotes a four-step strategy of how to integrate a TOD project and states that TOD alone will not enhance the full potential.

- Foundation of the TOD Concept

Practitioner-generated research on interaction between transit and land-use planning has been done for centuries. Concepts such as ‘Eixample’ and ‘Garden City’, which were developed by Iledfons Cèrdà in 1860 and Ebenezer Howard in 1898 respectively, are considered as trailblazing precursors. However, it was the American urban planner Peter Calthorpe who first coined the term 'TOD' in his book 'The Next American Metropolis' in 1993. The TOD model is based on the combination of several forerunner concepts and an evolution of his previous approach, the ‘Pedestrian Pocket’, from 1989. If one looks at the TOD theory for the first time, one might suspect its actual endeavor in suburbanization which fosters urban sprawl. On the contrary, the TOD model should be understood as a critique of the contemporary urban fabric and how the city continues to evolve. Up to the minute, the TOD is considered as the most promising tool for urban regeneration in the urban centers to integrate core projects to increase urban efficiency, accessibility and sustainability. It is a step closer, where urbanity gets treated as a collective of buildings, where efficient infrastructure becomes the superior connector of society, of livable conditions that strengthen the respective individual. Peter Calthorpe made clear that urban sprawl is bad whereas infill is good and states: “Infill and redevelopment should always be a central part of a region’s growth policy. It represents the best utilization of our existing infrastructure and the best opportunity to preserve open space” (Calthorpe, 1993, p. 31). When Peter Calthorpe came up with the TOD he provided the whole package of definitions, aims, guiding principles as well as case examples. It was the impetus for a worldwide research in transportation and urban planning, which endures to this day and in which the core essence has remained the same. Therefore, this section continues with the essence of TOD.

- The First-Hand Definition of TOD Theory

“A Transit-Oriented Development (TOD) is a mixed-use community within an average 2,000-foot (about 610 meters) walking distance of a transit stop and core commercial area. TODs mix residential, retail, office, open space, and public uses in a walkable environment, making it convenient for residents and employees to travel by transit, bicycle, foot, or car” (Calthorpe, 1993, p. 56).

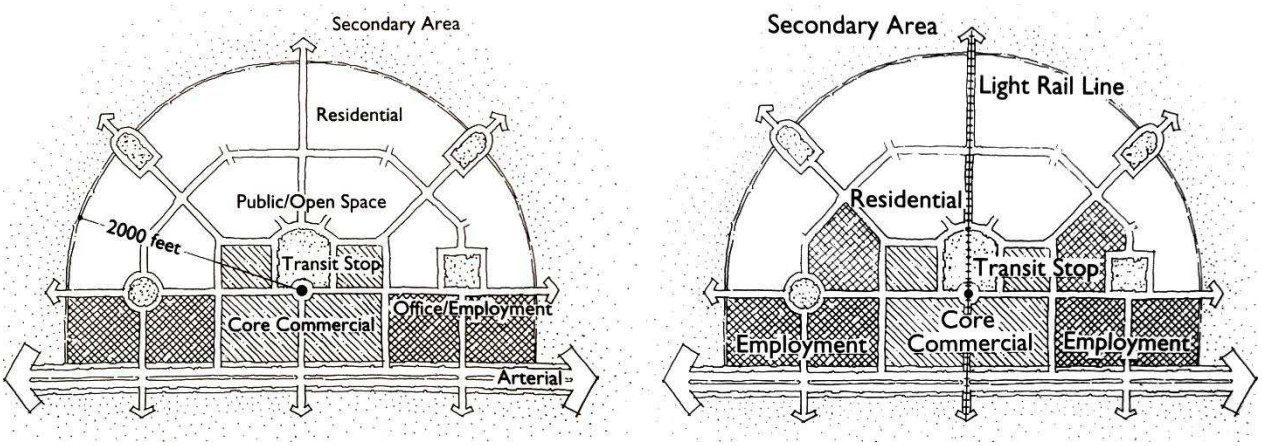


Figure 11 < Transient-Oriented Development (TOD) and Urban TOD, Peter Calthorpe (1993), source: (Calthorpe, 1993, pp. 56–57)>

Calthorpe argues that every TOD should include a minimum of convenience retail and local public office because in this way it is more likely that the public transit will be used for work if both components are combined. He also emphasizes that at least 10 percent of the entire TOD site and at least 10,000 square meters of retail space that is directly connected to the transit stop, are necessary to succeed. Additionally, he points out that residential areas should comprise a mix of residential types such as single-family, city, condominiums and apartments. In terms of public use, Calthorpe recommends placing parks, squares, green spaces, public buildings and utilities near the transit stop. From a more general perspective, Calthorpe made a distinction between the Urban TOD, the Neighborhood TOD which consist of different individual areas, uses or other parts which are made clear in detail. For instance, in an urban TOD, open space should contribute about 5-15 percent, the trade / employment center should be 30-70 percent, and housing should contribute about 20-60 percent, depending on the nature and design of the TOD. Despite contrasting percentage distributions of land-use of distinctive TOD types, the radius of 2000 feet (about 610 m) always stays the same. It is based on the consideration that this distance corresponds to a pleasant walk of about 10 minutes (Calthorpe, 1993).

- Guiding Principles:

The following 7 principles for building better cities were drawn from a TED talk, given by Peter Calthorpe in 2017:

- Preserve: preserve natural ecologies, agrarian landscapes and cultural heritage sites
- Mix: create mixed-use and mixed-income neighborhoods
- Walk: design walkable streets and human scale neighborhoods
- Bike: prioritize bicycle networks and auto-free streets
- Connect: increase density or road network, limit block size
- Ride: develop high quality transit including affordable BRT/MRT
- Focus: match density and mix to transit capacity

Compared to his original principles stated in ‘The Next American Metropolis’ the wording is a little different, but the essence of the statement is pretty much the same (Calthorpe, 1993, p. 43). He summarized, that the principles of TOD are to:

- Organize growth on a regional level to be compact transit-supportive
- Place commercial, housing, jobs, parks, and civic uses within walking distance of transit stops
- Create pedestrian-friendly street networks which directly connect local destinations;
- Provide a mix of housing types, densities, and costs
- Preserve sensitive habitat, riparian zones, and high quality open space
- Make public spaces the focus of building orientation and neighborhood activity
- Encourage infill and redevelopment along transit corridors within existing neighborhood

The creation of these principles was a long-term process and not invented by Peter Calthorpe alone. They request a return to the timeless goals of urbanism, which are based on the balance between society, economy and environment = sustainability. In this sense, it is the complete departure from the planning ideas that have shaped the urban design of the last century.

Despite today's lack of a single TOD definition with different goals and constraints, every approach of TOD is still rooted to the original one and follows the basic guiding principles.

- Selected directly quoted TOD Definitions of the global research:
- "Development within a specified geographical area around a transit station with a variety of land uses and a multiplicity of landowners" (Salvesen, 1996, p. 37).
- "A compact, mixed use community, centered around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more. The transit village extends roughly a quarter mile from a transit station, a distance that can be covered in about 5 minutes by foot. The centerpiece of the transit village is the transit station itself and the civic and public spaces that surround it. The transit station is what connects village residents to the rest of the region. The surrounding open space serves the important function of being a community gathering spot, a site for special events, and a place for celebrations (Bernick and Cervero, 1997, p. 5).
- "A mixed-use community that encourages people to live near transit services and to decrease their dependence on driving" (Still, 2002, p. 44).
- "A mixed-use residential or commercial area intended to maximize access to public transportation" (Holmes & Van Hemert, 2008, pp.4).
- "A mixed-use community extending for ¼ to ½ mile from a public transit station. The elements of this community include housing, retail, offices, civic uses, and open space; pedestrian-friendly infrastructure and amenities; higher densities than surrounding areas; and compact design (i.e., narrower streets, smaller building setbacks). TOD represents a neighborhood or a collection of developments and public amenities" (The Federal Transit Administration, 2014, pp. 1–2).

- Performance-based TOD Approach ≠ TOD Definition

To come up with a new TOD definition or theory that aims to structure urban growth on multiple levels – local level area around transit infrastructure, regional level, but also the entire metropolis – is one thing, but it is another to put it into reality. This direction was founded not least on the 5D's of the built environment or Robert Cervero – density, diversity, design, destination accessibility and distance to transit (Ewing and Cervero, 2010). In a performance based approach, it is essential to define a set of actions of various scales and natures that build up the actual TOD form. In this regard, Dittmar and Ohland state: "Organize growth on a regional level to be compact and transit-supportive; place commercial, housing, jobs, parks, and civic uses within walking distances of transit stops; create pedestrian-friendly street networks that directly connect local destinations; provide a mix of housing types, densities, and costs; preserve sensitive habitat, riparian zones, and high-quality open space; make public spaces the focus of building orientation and neighborhood activity" (Dittmar and Ohland, 2004, p. 43).

When implementing a theory, inevitably the central aspirations and goals which are of primary importance, take center stage. Aims to reduce automobile dependency, to limit land waste, to avoid single, function land-use, and to create good places, are also key elements of this research and foster the vision of infill TOD projects, that consider all spatial aspects of urban sustainability – society, economy and environment. “These transit-oriented developments have the potential to provide residents with improved quality of life and reduced household transportation expense while providing the region with stable mixed-income neighborhoods that reduce environmental impacts and provide real alternatives to traffic congestion” (Dittmar and Ohland, 2004, p. 2). For the collective sustainability is the major concern, but what matters most for the individual is the improvement of its ‘livability’. This has emerged during analysis in trying to quantify the TOD definition. The following are the five central objectives of the performance-based TOD definition (Belzer and Autler, 2002; Dittmar and Ohland, 2004; Renne and Ewing, 2013). Peter Calthorpe appreciated, this upcoming approach of the performance based TOD definition and states that this research “begins to provide answers to these challenges with more than mere assertions. … it clearly lays out the goals and means to accomplish a second generation of TOD” (Dittmar and Ohland, 2004, p. X). In this way, Dittmar and Ohland defined five major factors that affect the outcomes of any TOD project:

- Location Efficiency:

It is considered as the art of placing or reorganizing functions (residential, office, retail, culture, …) close to public transit as people are more likely to use it when it is in the within walkable distance. In time, residents of TOD areas rethink their habits and use public transit more (Lund, Cervero and Willson, 2004), which is the result of increased density, transit accessibility and pedestrian-oriented design (Poticha, 2004).

- A rich mix of choices:

This does not only apply to the transit station itself. The whole walkable neighborhood should offer multiple activities, various public spaces and affordable housing (Belzer and Autler, 2002). At its best, the walkable neighborhood meets all required daily-based needs of several user groups. This decreases car dependency and fosters pedestrian-oriented design and the use of public transit (Dittmar and Ohland, 2004).

- Value Capture:

The goal is to maximize the benefits of TOD for several stakeholders and realize its massive potential. By implementing transit-oriented and land-use integration projects well, it is not just about place-making, it is about economic improvement also. Researchers found out that, because of pedestrian friendly access and place-making design the ridership increases by approximately 20 percent. This, in turn, led to higher revenues and increased profits by about 25 percent. Improved accessibility to public transit makes residence more attractive, resulting in higher rental income and higher real estate selling prices. Therefore, in terms of social equality, up to 15 percent of subsidized housing in an TOD area is required to benefit even the less affluent (Cervero and Day, 2008b).

- Place Making:

Robert Cervero stated in a presentation published by the UN-Habitat in 2014 that it is all about creating "A place to be … not just to pass through". TOD is more than about establishing neighborhoods where people can get on and off a station. The best TODs are social hubs. They really become the center piece for urban regeneration, for building great quality communities. A big part of this is urban design – to soften people's perceptions of density so you can really get density high enough to make sure to have a very sustainable cost-effective form of transportation. It is what we call place-making places where people feel comfortable, where they want to be. In short, an essential key to 'place-making' is 'station access', which has been a high priority of creating new public transit stations since the year 2000. Since then, the quality of pedestrian-oriented environments, architectural integration and urban neighborhood have been significantly enhanced.

- The resolution of the tension between node and place:

Transit agencies create nodes/transit stations, whereas urban planning agencies design places and only if the synergy between them performs well can a TOD become a success (Walker, 2012, pp. 215–221). As the center building of a TOD, the transit station should be used 24/7, with no significant mass changes, no matter of peak or non-peak hour. By adding functions such as commercial, retail, culture and public spaces the node becomes a place to be. Ridership related to frequency, speed, regional context, and capacity is essential and makes any TOD project a success or failure (Poticha, 2004).

- Strategy of TOD success – the desired Outcomes of TOD

There is no overall agreement on what makes a TOD project successful. Besides the lack of no single definition, a set of parameters to measure the success of TOD projects is the greatest direct barrier of the TOD as urban model (Belzer and Autler, 2002). Research started to identify a variety of factors, to help transportation agencies make better decisions for creating successful TOD projects. Transit Agencies could then simply choose the most important factors and set the main emphasis goals that fit to the specific TOD project. Some of the factors are listed below. They are based on the author's research of literature and extended with references which were partly driven from the research of Avi Sharma, Kelly Strong and Mehmet E. Ozbek of the Colorado State University in 2017:

Factor of Success	Definition	Reference
Quality of walking to station quality	People should get motivated to reach the stations on foot, considering for example the length of the respective walk, or station accessibility. The same applies to non-motorized traffic (cycle paths), which requires just as good access, but also has to have a clear separation of vehicle traffic and pedestrian traffic.	(Dittmar and Ohland, 2004), (Renne and Wells, 2005), (Ewing *et al.*, 2013), (Bae, 2002), (Wey and Chiu, 2013)
Population/ Housing Density	It refers to the area covered by the station environment (different radii exist - this research follows the 400 and 800 meters radius)	(Renne and Wells, 2005), (Curtis, Renne and Bertolini, 2009), (Sung and Oh, 2011), (Calthorpe, 1993)
Number of shuttle and bus services provided from transit station	The point is that the station acts as a transport nodal point, which opens up different places	(Dittmar and Ohland, 2004), (Belzer and Autler, 2002), (Messenger and Ewing, 1996)
Positive government intervention	Government support of the TOD project, potentially with funding or assisting regulations	(Curtis, Renne and Bertolini, 2009), (Leach, 2004)
Number of mixed-use structures	Multi functionality or hybridity rather than monotone purpose (e.g., residential, commercial, industrial, etc.)	(Cervero and Radisch, 1996), (Tumlin and Millard-Ball, 2003), (Renne and Wells, 2005), (Bae, 2002), (Freilich, 1998)
Improved landscape/ streetscape and park spaces	Availability of or planned green spaces	(Cervero, 2004), (Lund, Cervero and Willson, 2004), (Jacobson and Forsyth, 2008), (Calthorpe, 1993), (Dittmar and Ohland, 2004), (Cervero, 2004),
Subsidized housing units	Mixed-income (and potentially subsidized) housing units for all income classes to live in the TOD neighborhood	(Calthorpe, 1993), (Belzer and Autler, 2002), (Suzuki, Cervero and Iuchi, 2013)
Number of convenience/ service retail planned	Refers to the success or availability of these functions	(Calthorpe, 1993), (Boarnet and Compin, 1999), (Cervero and Day, 2008b)
Planned new/ improved cultural/ artistic institution	Includes the access or availability of cultural/ artistic institutions	(Nelson, Nile and Hibshoosh, 2001), (Dunphy and Porter, 2006)
Household disposable income	It refers to the TOD neighborhood incomes (different radii exist - this research follows the 400 and 800 meters radius)	(Cervero and Day, 2008b), (Cervero and Day, 2008a), (Mu and de Jong, 2012), (Hess and Lombardi, 2004)
Community support/public perception	How the project is received by the residents within the existing context	(Belzer and Autler, 2002), (Renne and Wells, 2005)
Parking supplies on site	The availability of parking is required, but the correct dimensioning is the question	(Renne and Wells, 2005), (Tumlin and Millard-Ball, 2003)
Property taxes	New Taxes might drive government for approving such TOD projects	(Boarnet and Crane, 1998)

Table 3 < list of factors to measure the success of TOD projects source: (Sharma, Strong and Ozbek, 2017, p. 16) edited by author>

Renne J. and Wells J. once analyzed a list of factors which was found in their literature review. They evaluated various indicators of the impacts of TOD projects and provided the results of their survey by grouping the factors into four sections of outcomes. These could

then be used to determine a strategy to measure the success of individual TOD projects (Renne and Wells, 2005):

- Travel Behavior
    - Vehicle Kilometers Traveled (VKT), which is considered as one of the most important indicator (Suzuki, Cervero and Iuchi, 2013)
    - Mode split
    - Frequency of public transit usage
    - Resident commuting time
    - Frequency of headways
    - Vehicles ownership
- Local Economy
    - Number of jobs by type
    - Vacancy rate
    - Home ownership vs. rental
    - Weekly hosing expenses
    - Property value increase (with regard to: before and after TOD implementation)
- Natural Environment
    - Transport energy consumption (computed)
    - CO_2 emissions (computed)
    - Park space
    - Percent of land cover as green space in the TOD area
    - Percent of land cover as trees
- Built Environment
    - Population and housing density
    - Street quality
    - Quality of public spaces
    - Parking inventory
    - Pedestrian accessibility

In this sense, it is a method for a prospective or retrospective analysis of success to help make advanced decisions for future TOD projects. Any TOD's project minimum requirements are a moderate/high density and mixed-use pedestrian-oriented development within walking distance of public transit, however for Peter Calthorpe the most essential goal of TOD is to make places more accessible (Calthorpe, 1993).

- Procedure of Transit and Land-use integration

Suzuki, Cervero and Iuchi promote a four-step strategy to do it right, regardless that each city is different and a "one-approach system" will not work. It is an all-compassing framework of key tasks considering numerous factors from the list above. In short, it is a guideline for successful TOD integration projects (Suzuki, Cervero and Iuchi, 2013):

- Have clear vision:

The first step should be the elaboration of a strategic perspective and enabling institutional and regulatory framework on the metropolitan level. The creation of a supportive institutional and government environment is essential to remove restrictive regulations and set appropriate prices on land. Transit is a means to help to create desirable patterns of urban growth, not the other way around. Therefore, the focus should be on parallel process of short-term mobility objectives and long-term sustainable urban fabric goals.

- Have a plan and place of how to grow:

The second section refers to the city-level planning approach and spotlights the correlation between transit and land-use planning. Urban form with an average density (congruent to urban sprawl) will not work as it doesn't support mass transit, which requires articulated densities at transit stations as well as higher densities along transit-served corridors. 'Transforming Cities with Transit' summarizes this in a short quote: 'mass transit needs mass' (Suzuki, Cervero and Iuchi, 2013, p. 173). In this way, a supportive urban environment to leverage TOD projects can be created.

- Promote the implementation of transit-oriented development:

Scaling the focus to the 500-meter radius raises some specific questions which need to be answered individually. Each city has its unique context and therefore creates its own prototype of TOD. The combination of the transit demand management and the TOD is the ultimate goal to implement a successful infill project. These pioneer projects create new communities which by regulation should foster inclusive cities and avoid crippling urban poverty or deprivation.

- Elaborate a beneficial financing scheme:

Investment and public transport are the main triggers for achieving the desired urban form. Goals such as sustainable financing through value enhancement play a major role here. Regulations create the basis for vertical growth rather than horizontal expansion. This, in turn, increases the value capture, which is the most promising tax tool available for generating new revenue. In this regard, Hong Kong is probably the best example.

During the whole process of transit and land-use integration projects all levels need to be considered. It goes from the 'macro scale', metropolitan area, to the 'micro scale', the within walkable neighborhood of a transit station, including the different centralities between 'city-center station' to 'new-town station'. Regarding several transportation tools from slow, rapid or express (Walker, 2012, p. 64), a differentiation between 'high-level means of transportation', HSR, BRT, MRT or subway, and 'low-level means of transportation', Bus, LRT, bike lines, can be made. However, everything always refers to the pedestrian and daily life circle as the superior position, aiming urban sustainability.

- Potential of TOD & TDM (Transportation Demand Management) as entity:

In short, TDM can be considered as the "software" that significantly affects the integration process and potential success of the TOD project, the actual "hardware". This literature review already addressed both, first, the demand of public transit and the promotion of non-motorized transportation modes, and second, Transit Oriented Development as physical design. The combination of TOD and TDM is defined as the strategic linkages between urban

locations with different land uses and functions through high-quality transit services, including linkages between social housing and public transport.

- Résumé of Definitions of Transit and Land-use Development

Considering all the difficulties and complexity that come along with this model, this research still promotes the TOD as the urban regeneration tool of choice. Due to the variety of different cities, there is simply no need for a single definition, 'the set of goals for an ultimate success' or 'the strategy of integration'. In general, the guiding principles and goals remain the same at every TOD project and inherently makes them comparable at some points. The TOD is not an urban form it is rather the strategy of how to design urban form. Accordingly, the question arises on where and in which metropolitan areas it makes sense the effort to integrate transit and land-use integration projects to operate. This research promotes China as an ideal playground to just do that, and therefore the next section is an in-depth analysis of China's ability to fully exploit the potential of TOD.

2.2.5 China's Cities and the TOD Theory

When in 1993 Peter Calthorpe coined the abbreviation 'TOD' in his book "The Next American Metropolis" he advocated a fundamental change in constructing the patterns of buildings and defined a new direction in planning (Calthorpe, 1993). Since then, the concept of transit-oriented development had great worldwide success. The occurrence during the last decades of rapid urbanization and the demand of forward-looking transportation systems requires new planning approaches. In this regard, China is currently expanding the construction of a metropolitan network, the High-Speed Railway system (HSR network) aiming to improve the interconnection of the cities. Apart from that, China is investing heavily in the public transportation sector and non-motorized transport (NMT) systems. It is creating simultaneously dozens of subway/Mass Transit Railway (MRT) and Bus Rapid Transit (BRT) networks all around the country, reinforced in the big cities. Moreover, China is realizing a system of close-knit patterns consisting of separated lanes, sidewalks and plazas for (public) bikes and pedestrians to increase accessibility, mobility, walkability and ridership.

Figure 12 <China's parent public transport system – the HSR network, source: (Dai, 2015) edited by author>

Based on the reviewed literature, this thesis proves that some Chinese cities are 'real' TOD typologies and that the TOD concept as part of the theoretical discourse of architecture has led to the emergence of a strong interaction between (public) transit and urban planning. The accessible information of Jean-Francois Doulet, Aurelien Delpirou and Telanay published in the 'The Journal of Transport and Land Use' (JTLU) among others builds up the starting point of this section and highlights current key trends in China (Doulet, Delpirou and Delaunay, 2017).

- What makes China an Ideal TOD Place?

The interplay of several factors such as constant effort for positive change, large-scale public investment and policies, its inherently long-term effects and the fact that China is a fast-developing country that hosts a significant percentage of the world's population opens the possibility of implementing TOD principles in China's metropolitan area. In this way, the world-wide challenges of demographic change, automobile dependency and urban sprawl, explained in detail in the first chapter of this review, privilege China as a unique test area for verifying that the TOD concept as theory leads to sustainable cities in reality. Considering this evidence, numerous researchers come to the conclusion that China has a 'golden opportunity' these days (Zhang and Lin, 2011, p. 11) to create a linkage between transit and land-use developments in a sustainable way which is inseparably connected to the TOD concept. Chosen statements that underlie this opinion are listed:

- China is in the midst of a long-lasting process of change, with no end in sight, or full exploitation of China's potential for TOD integration: "Opportunities for creating sustainable city forms through bundling land development and railway investments in large Chinese cities are quite substantial and largely untapped" (Cervero and Day,

2008b, p. 315).

- To find an overall strategy that fits the need to overcome the major and future challenges of Chinese cities is a big concern and it is strongly assumed that the TOD concept has this potential:" Major cities in China are extending rail transit into the urban periphery to counter urban growth and suburbanization that are automobile-driven and automobile-dependent. In the meantime, transit-oriented development (TOD) has been adopted widely in Chinese cities" (Pan, Shen and Zhang, 2009, p. 95).
- Despite China's ambition, the TOD concept needs to be implemented today rather than tomorrow, in order to effectively fight the basic indicators of the failure of the city such as increasing car ownership and use, urban sprawl and spatial segregation of functions and activities:" This is the critical time when we need to fight a battle against upcoming and highly possible auto-dependency in urban China. It is now or never" (Zhang and Lin, 2011, p. 6).
- The TOD concept was founded on American expertise and has been publicized world-wide. Inherently it is TOD principles have particular influence on Chinese academic discourse and professional spheres. However, it would be inaccurate to say that the TOD concept is merely copied. In some way, the matrix and philosophy got adopted and implemented in China's urban fabric in a unique approach. America's and China's metropolitan areas are different and so are the challenges:" Urban planners in China typically adopt the TOD concept in the planning of new neighborhoods, at least in their own interpretation" (Bruce, 2012, p. 23).
- Especially in Asia, TOD principles were applied early in many urban development strategies and therefore a unique portfolio of different TOD typologies can be drawn. Some existing "best case practices", such as Seoul, Taipei, Singapore, Tokyo, Guangzhou and above all Hong Kong, can be taken as role models and serve for further inspiration and progress: "Since there is limited research on this topic in a Chinese context, many researchers look to Hong Kong as a benchmark for a successful TOD strategy, given, for example the similar culture and problems with population growth" (Bruce, 2012, p. 8).

As conclusion of these statements, the claim that China is really the 'country where everything is possible' in terms of the TOD concept is truly justified. Undisputedly, the extensive construction of road infrastructure and the motorization have been the primary responses in guiding the very high rate of land development since the last two decades (Zegras, 2010) in Asia. The culture of China's extensive urban development and the realization of major projects (Yang and Gakenheimer, 2007) are causing sprawled urban and regional development and therefore, it has to be questioned to what extent Chinese cities are car depended today. Some researchers, particularly American, are trying to highlight some parallels between North America's rapid suburbanization in the 1960s and China's urban development over the last 20 years (Calthorpe, 2012). However, others represent a contrary attitude, as the contextual parameters are not comparable at all (Campanella, 2008; Chen, 2010). In Fact, some Chinese cities already fulfill several elementary objectives of the TOD concept – the density of Chinese cities is very high; the vast majority of urban fabric are

superblocks. Looking at them individually, they can be seen as autarkic narrative cells, which contain a whole community and consist of still walkable distances; besides massive motorization, the car use in respect to the enormous population of China still remains quite low; the public transit system in general, from a metropolitan as well as a city level or regional perspective appears relatively abundant and is more than ever in the focus of transit and urban planning.

- Potential of TOD in China

Notably, China is publishing a significant amount of literature on TOD since the turn of the millennium in English. Additionally, various academic fields in China's theoretical discourse deal with this topic and produce numerous TOD approaches and interpretations to achieve goal-oriented results in real projects. The reason for multiple outcomes can have several factors:

- One fundamental criterion of TOD is the inseparably linked dual nature of TOD consisting of both a concept and a set of operational practices. This resulted in an increase of both various theoretical articles, which analyze the relevance and challenges of implementing the TOD concept in China's urban fabric, and case studies of actual projects to explore the conditions and logistics during the implementation process. Theoretical articles are mostly done on the higher levels, national and metropolitan, and are rather conceptual and executed for territorial economic or regional planning reasons. The direct effects of public transit on land-use (Yang and Gakenheimer, 2007) and on the balance of urban sustainability in general are here of major concern. Case studies, however, scale down to the neighborhood level, the actual architecture of the TOD project, and face questions such as residential densification, placing public spaces around transit hubs or providing daily needs within walkable distance (Bruce, 2012).
- Reasoning that the different academic disciplines use distinctive methods and ways of working also creates contrasting approaches and conclusions. Regarding the Chinese TOD research, disciplines such as urban planning, transportation management, territorial economics, political science, public sociology among others could be involved.
- Plenty of Articles on China exist, however most researchers specialize in certain areas of TOD and do not treat the full scale of the analysis of TOD. Already Peter Calthorpe addressed that the cohere implementation between transit and urban planning can only be successful when managing its whole complexity, the local level (TOD neighborhood), city level and even the whole metropolitan area (of China in this research). One team who did exactly that with emphasis on Asian cities, an overall theoretical TOD approach as well as in depth case studies on multiple levels, was Hiroaki Suzuki, Robert Cervero and Kanako Iuchi with 'Transforming Cities with Transit' in 2013 (Suzuki, Cervero and Iuchi, 2013).
- Additionally, for decades the subway has been researched as the central transport

mode in most Chinese articles and TOD projects. On the contrary, the field of public transportation in China is very broad. Various public transportation systems, besides the subway, are already operating and include: High-Speed Railway system (metropolitan), Bus Rapid Transit (notably in Guangzhou) or future streetcar systems. Besides China puts an extensive effort on non-motorized transport modes and in combination with the effort in public transportation it is likely to affect the automobile dependency in the long term.

To summarize, China is heavily expanding its transit networks and land-use development which includes the construction of new TOD projects. At the same time, enormous theoretical research is being conducted around the whole TOD topic. This dual process forms the basis for scientific articles that advance the future of theoretical discourse, as well as already completed projects. Finally, the implementation of TOD principles leads to a new perspective of the urban context which simultaneously fosters a sustainable, dense and diverse urban environment.

Interim Theoretical Research Point

Up to this point of the research, the focus was on the first major research question of this thesis – 'What are the most important factors needed to promote the combination of horizontal with vertical transportation infrastructure?' First, the demand for this endeavor was delivered and analyzed in detail. However, this ambition affects both, the way people move and live within the urban context. Therefore, a tool that operates intersecting between transit and land-use planning was needed. Transit-oriented Development promotes this cross-sector integration and provides the whole set to create articulated densities at key spots of transit stations. In this way, the resulting urban form creates the ideal interface on a conceptual level. Shown in an equation:

TDM + TOD => Cross-Sector Integration between Transit and Land-Use Planning

In order to get even closer to the goal of urban sustainability, this research goes a step further and promotes an absolute densification of the urban context at these identified key spots. Moreover, it follows the logic of vertical expansion and all its counterparts that go along with it. This requires vertical structures that are both, hybrid urban spaces and mass infrastructure, which will be seamlessly connected to the public transit as well as the TOD neighborhood by the generated interface. This finally leads to the following equation:

(TDM + TOD) + Vertical Land-Use => Sustainable Cities

2.3 The Metropolitan Hybrid

2.3.1 Thinking Architecture as 3-Dimensional Organism

The pursuit of density inevitably leads to a height increase and the main task is the improvement of continuity of urban communities and public places in both planes, horizontal and vertical. The key aspect to achieve the appropriate function layout of the future urban fabric is to provide the appropriate tools and strategies to generate the 3D city. Major lessons in terms of compact human scale urban- and transit planning can be drawn from the TOD theory as it promotes articulated densities at the macroscale of the metropolis. This second literature chapter goes down from the urban planning to the architecture scale. In this context, the building typology that stands for articulated densities within the city is the tall building, but not in the classical sense. In extreme, this research promotes an extending 'bend' of urbanity from horizontal to the vertical interfaced by a TOD development. The strive of satisfying the requirements of different user groups and life cycles in a central location leads to an enormous complexity and size of urban structure, ultimately leading to a new typology, the Vertical City.

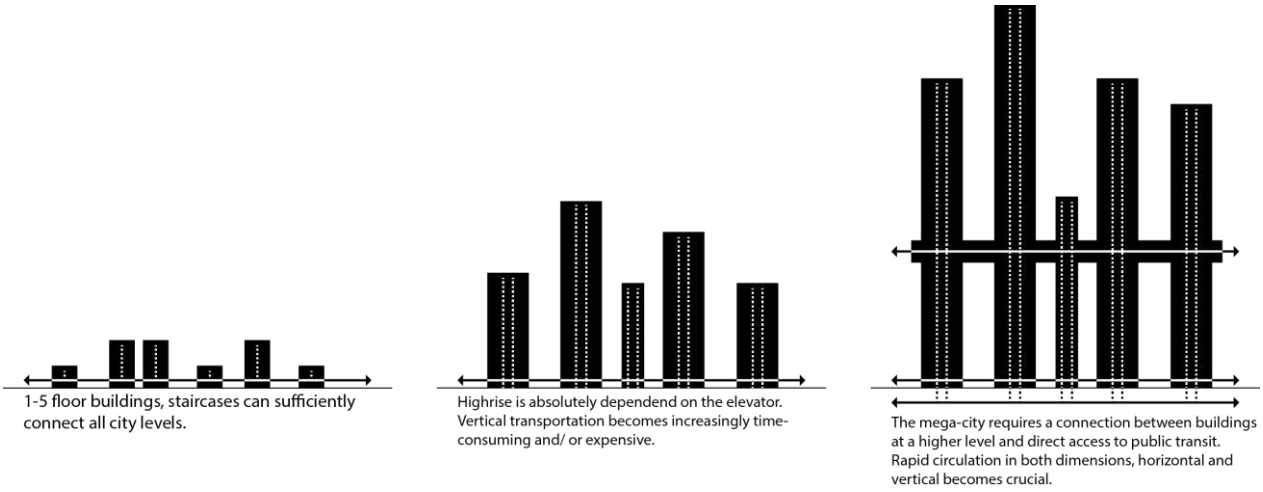


Figure 13 <process of the 3D city, credit: (design-boom, Willy Wonka Elevator (2019)) edited by author>

This section analyzes why hybrid cities are so crucial and how they can empower the community on a social level. The conclusion to reach the sustainable city is, despite criticism of the tall building, the vertical expansion. In particular, the Vertical City approach by Kenneth King is included and the most important components – circulation, open space and 24/7 scenario – that make up this type are analyzed.

2.3.2 Hybrid Urban Form and Logic of Vertical Expansion

- From Hybrid Entity to Metropolis to Metropolitan Area

The concept of hybrid or mixing up different functions is not new at all. It is actually going back to the original form of architecture, of creating communities. "Throughout history, density, the value of land and the overlapping of functions have been inherently linked" (Fernández Per *et al.*, 2014, p. 12). In the ancient times, city-states developed borders and walls in order to defend and define the distinction between the civilized and the wild (Nijenhuis, 1994, p. 14). At that time, the most important forms of transit for most people and transportation of goods had been on foot. Therefore, daily life circle requirements, mentioning

housing or working, were placed in the same spots, nearby or even stacked on top of each other, with little or even no distinctions between buildings, rooms or functions. Because of the 'fixed' sized city form, space is limited, and any expansion or construction requires further merging and overlapping and thus increased density. Consequently, during the process of growing cities, adding functions fostered the ambition of infill to use any space available. This resulted in cities acting like urban organisms which constantly changed and evolved over time and truly became 'Hybrid Entities'. This makes the origin of the concept of hybridization from genetics and the reference to cross breeding of different species comprehensible. At some point these entities collapsed for several reasons. Massive street construction led to massive increase of mobilization and innovations in new weapon technology made the city wall obsolete, the foundation that led to the urban hybrids. Constantly more people moved into the cities, which eventually led to quarters outside the former city walls where land was much easier to afford. The consequence was urban sprawl and the merging of expanding city-states to one urban structure finally created a new type, the modern 'Metropolis'. In the 19th century, the industrial age and the invention of the car led to a revolution of mobility and changed the way of planning cities, completely, almost to the contrary of the philosophy of hybrid. The separation of functions such as living, working, shopping and manufacturing went so far that each function has its own city zone assigned. The process of urban sprawl eventually led to cities and metropolises expanding to the point where 'city' and 'country' merged to a single 'Metropolitan Area'.

- The Hybrid Building as Vertical City Typology

The process of concentrating functions and activities into a structure, into a hybrid urban form, is ubiquitous in many current projects worldwide, especially in China. In this way, the pressure on the expectations of architecture increases and has the capacity to "distend and warp a pure building type" (Fenton, 1985, p. 1). In the design process of hybrid buildings, the type fades into the background, while the actual individual program of functions in a specific location is of the utmost importance. It is mass data analysis that provides the basis for the layout, as each construction site requires a new concept of how to mix the functions in respective of activating the development, its uses and surrounding neighborhood, and therefore, cannot be reused elsewhere. Resulting from this, hybrid buildings lack a unique building type and were just grouped under the term 'mixed-use'. However, Joseph Fenton brought up the argument that they could not be grouped into the same building type due to their significant differences. In 1985, he came up with a catalogue and classified three hybrid building types based on the analysis of projects built in America's Metropolis:

- Fabric Hybrid: These hybrid buildings are volumetric infill of the city's gridded fabric.
- Graft Hybrid: Each program gets expressed by the result form of the hybrid building.
- Monolith Hybrid: Programmatic elements being subsumed into a continuous envelope.

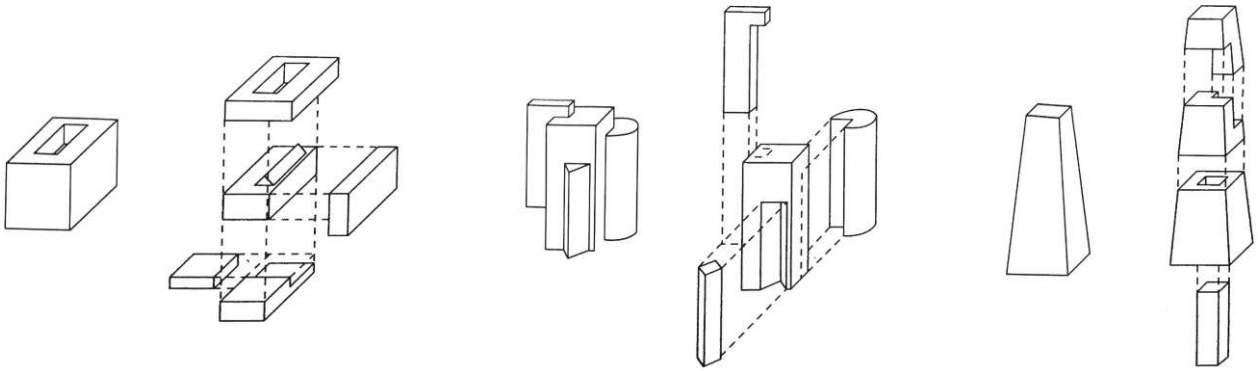


Figure 14 <Joseph Fenton's Catalogue of Hybrid Building Typologies (left: fabric hybrid, center: graft hybrid, right: monolith hybrid), source: (Fenton, 1985)>

Additionally, Fenton argued that only if the individual functions within the program relate to each other and start to share intensities, can it be considered as hybrid building. For example, the early attempts of combining different functions into one structure, such as the Ponte Vecchio from 1245 (which consists of the elements of residential houses and a bridge) can only be considered as mixed-use. However, in the 19th century certain conditions and the way of thinking architecture have changed fundamentally. At that time cities were booming and land values in city centers shot up to an immeasurable degree. In combination, some technological inventions, such as the practical usable elevator of Elisha Otis in 1853, or groundbreaking innovations, such as structural steel or reinforced concrete, finally led to the 'Logic of Vertical Expansion' of the urban fabric and to a new form of development – the era of the 'Skyscraper'. Derived from these new possibilities, the regulations of construction volume and thus floor space were maximally exploited purely for economic reasons in order to achieve high financial returns despite enormous land values. This often-speculative approach of building tall buildings eventually led to miscalculations. Out of necessity it came to the combination of uses, functions and entire programs, which was a great success and the starting point of the rise of the 'Hybrid Building'. This emergence of urban organisms, full of activities, at center locations within American metropolises took place in the late 19th century and allowed a glimpse of the next level of hybrid urbanity within the metropolitan area. However, with the turn of the century and the emergence of modernism, a radical rethinking took place. Functions, uses and activities got separated into individual buildings or even districts, rather than attempting to understand the full complexity of life. In 1919, this approach manifested itself with the regulations of the New York Zoning Resolution which dealt with hybrid buildings. Basically the regulations limited the mixing of functionally impartible uses within the buildings and required new tall building interpretations to fit the regulations (Fenton, 1985, pp. 5–7). Consequently, the basis for further development of hybrid skyscrapers, high-density city center as an organism and the creation of communities was withheld. On the large scale, modernism had an impact on transit and urban planning, not only on America's metropolitan area but worldwide, to an unprecedented extent and eventually led to an imbalance where economy stood above society and environment. The failure of modernism was predictable and overcoming it the ultimate goal. The criticism of the predominant building types is to be answered by the ambition of developing and testing innovative programs. This is the basis of postmodernism's strategy appealing to a renaissance of multifunctional layouts and a new understanding of transit and land-use. The main driver of the creation of unprecedented diversity of innovative approaches is the poststructuralist thinking which allows different coexisting or interrelating concepts. The breakup of the interdependency between program and envelope is since then the main focus of various professions. In 1978, Rem Koolhaas published Delirious New York, which he described as a "retroactive manifesto for Manhattan" (Koolhaas, 1978, p. 9) and an attempt to get away from

modernism. The book is about Manhattan's 'Culture of Congestion' relating to the hyper-density, its complex system of parks, its city grid and its use of in-between-space. Rem Koolhaas praised the American skyscraper for the incredible efficiency with which, through the horizontal autonomy of its floor plates, it managed to combine divergent metropolitan programs in close proximity. The freedom afforded by its plan libre made possible any programmatic occupation, without mortgaging any future use through a too specific design. However, Koolhaas claims that the Lower Manhattan of New York simply works better as it considers more aspects of the whole spectrum of life, whereas the American skyscraper simply lacks in providing residents functional and housing spaces within the limited space available. Moreover, each of the stacked level acts like a two-dimensional individual having barely no relation to the underlying or overlying in most cases. Once, classified in Joseph Fenton's catalogue as 'Monolith Hybrid', due to its external expression, the Downtown Athletic Club, built in 1930 in New York by Starrett and van Vleck, actually completely contradicts this modernism image of high-rise. The fluid program consists of sporting activities on the lower floors, such as squash courts, swimming pools, a gym, even a golf course, and upon ascending there are floors for lounges, roof gardens, dining halls and bedrooms. Koolhaas states that "in the Downtown Athletic Club the Skyscraper is used as a Constructivist Social Condenser: machine to generate and intensify desirable forms" (Koolhaas, 1978, p. 152) of human intercourse, almost leading to the belief that this particular Skyscraper is some sort of a paradise. Not the functions which lead to independent types should be separated like in modernist thinking, rather than the segregation of appearance and performance is determined. There is an upcoming tendency to apply program as a source for the re-evaluation of requirements and use, pushing for a level of indeterminacy and creating overlays and juxtaposition of spaces. This way of creating architecture encourages the focus on the section and three-dimensional modelling, which challenges the vertical separation afforded by the economy of stacking floor plates on top of each other in order to link spaces and cross pollinate program over several levels (Fernández Per *et al.*, 2014, p. 18). Upon this, the question of how far this approach could go and if it is possible to put the whole spectrum of a cosmopolitan's life into one vertical structure arises, leading straight to the mantra of 'bigness developed by Rem Koolhaas. "Bigness no longer needs the city: it competes with the city; it represents the city; it pre-empts the city; or, better still, it is the city. If urbanism generates potential and architecture exploits it, Bigness enlists the generosity of urbanism against the meanness of architecture. Bigness = urbanism vs architecture" (Koolhaas and Mau, 1998, p. 515). This is the rehabilitation of the skyscraper, as well as the hybrid building and abandons the idea of implementing the Vertical City as extension of the city, folding back urbanity, as the ultimate step to create compact generic human scaled cities. In addition to the theoretical approach, Rem Koolhaas has also developed various taxonomies and city models since his student days, such as 'Exodus' (1972), which was an "intense/devastating but positive... architectural warfare against undesirable conditions", a mega structure that cuts through London and spreads out into the suburbs of the capital consisting of various different programs even intersecting each other in many parts (Schaik and Máčel, 2005, pp. 237–253). A first realized experiment of Rem Koolhaas' paradigm was the Seattle Public Library in Washington State, completed in 2004, where terms such as 'living room' or 'chamber room' remind of the social condenser. Different in scale, but in a very impressive way it shows that the culture of congestion brings together public and functional space, and provides a true amenity for the whole city based on a methodological well thought program. Koolhaas's entire work is shaped by this advent and triggered a worldwide rethink. Some experiments may remain utopias, but they are an incredible attempt of creating something new and reaching for the next step of sustainable cities. In 1996, he proposed together with his studio, Office of Metropolitan Architecture (OMA) the 'Hyperbuilding', a self-contained city for 120.000 inhabitants with housing, education, culture, welfare, medical facilities, amusement,

industry, retail and was supposed to be built on the banks of the Chao Phraya River in Bangkok, Thailand. A preceded hypothetical architectural project was the Sky City 1000 developed by Takenaka Corporation, for 135.000 inhabitants. Apart from this, Sky City 1000 is mentioned, because in 2014 Takenaka Corporation in partnership with Pelli Clark Pelli completed Abeno Harukas, in Osaka, which is considered as one of the first true Vertical City (Because of this relationship, Abeno Harukas is treated in detail in the comparative case study of this research). A Skyscraper can be the best amenity, with the most advanced program, however will still fail if the people cannot easily get there and actually use it. Reasoning from this, transit questions, meaning the vertical movement, get more and more essential to answers. Again, Rem Koolhaas once again gives progressive answers with his unbuilt competition project, La Defense, in 2004. The site was at center location in Paris right next to the Grand Arc de la Fraternite and was ideal for connecting people. His approach was the replacement of sprawl, with an idealized bigness structure or infrastructure. In this way, he deals with the criticism of the vertical city that it is acting as an autonomy city in the city. La Defense demonstrates how such a structure should involve the surrounding neighborhood by including a public transit, retail and other functions to really help create a community.

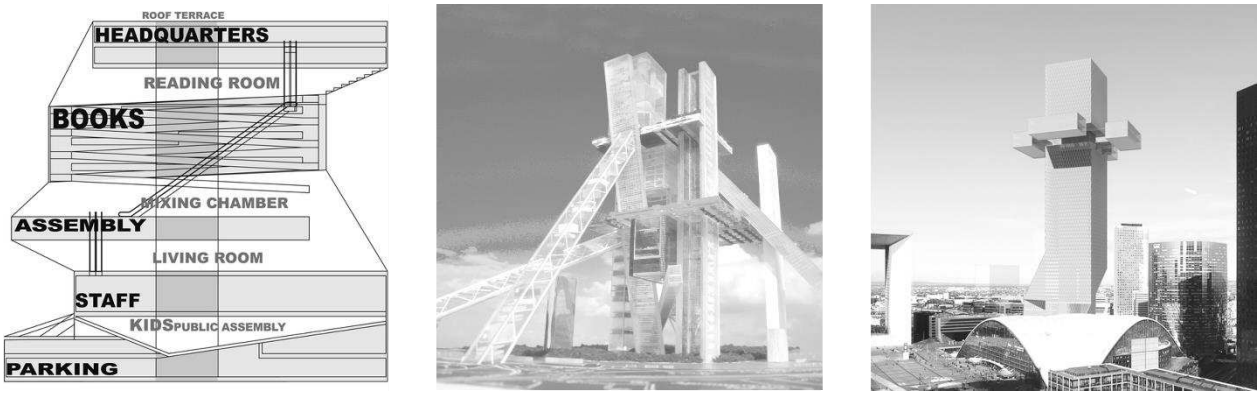


Figure 15 <Seattle Public Library, The Hyper Building, La Defense, source: (www.oma.eu, accessed 2019)>

Because of the rising number of economic and political benefits of hybrid development the interest has significantly gained in such kind of real estate. Especially in Asia, particularly China, the construction boom has no end and creates through unprecedented construction projects, new ways to create sustainable urbanity from the lessons learned. Studios worldwide create a pool of approaches that show different strategies for solving the urgent problems.

- Characteristics and Personality of Hybrids

In 'This is Hybrid', Steven Hall promotes the following potential aspects to characterize the positive future path of Hybrid types in creation of inspiring and active new urban spaces: 21st century cities as incubators; Public Space Information; Programmatic Juxtapositions; Living/ Working/ Recreating and Cultural Social Condensers; Dynamics of Section; Super Green Architecture; Freedom of New Concepts. Javier Mozas grouped and summarized the main characteristics and defined themes of the hybrid being very clearly in his Article: Mixed uses. A historical overview, Low-rise Mixed-used Buildings (Fernández Per *et al.*, 2014, pp. 8, 38–41):

- Personality: The personality of the hybrid appreciates complexity, diversity and varied programs providing several uses and activities. Each hybrid is a unique concept, with no settled blueprint, always trying to take advantages of its multiple, even apparently contradictory functionalities. Hybrid buildings need to further experiment with innovative relations of uses, in a not too serious way, to provide unplanned parts as the

principal for future flexibility.

- Sociability: The ideal hybrid feeds off the union of public and private spheres. The intimacy of private life and the sociability of public life finds a matrix for development in the hybrid building. The quality of porosity increases accessibility of hybrids between, the city and the private use of its facilities throughout 24/7 which is not controlled by private or public pace.
- Form: Since the break with modernism, the building is separated into appearance (by its form) and performance (by its functions), which can be in an explicit or implicit relationship. The first case tends to fragmentation, the second to integration. In contrast, a generic hybrid is a building-container that attempts to create a habitat undifferentiated from the diversity of functions grouped inside.
- Typology: Each hybrid has an individual function layout and therefore will always refuse categorization. However, its primitives, which have not yet reached full integration potential among merging together its functions, can be separated into a set of typologies.
- Processes: mixing of uses; combining public and private development in property- and land development; mixing structural materials (concrete and steel); mixing construction methods (dry assembled elements with wet joints, prefabrication and traditional assembly methods), combining management (individual and communal multi-property).
- Programs: The essence of a hybrid is the mixture of uses to providing a system of activities which let any individual feel the benefits. The multiple interconnected programs make them true urban organisms, which work best when housing both planned as well as unplanned activities.
- Density: Dense environments with land use restrictions set the basic requirement for hybrid buildings encouraging the use-overlapping and multi-functional development to improve living conditions and revitalize the surrounding neighborhood.
- Scale: “Hybrids have a super-building, super-block, megastructure or building-as-a-city nature. Hybrids are associated with a certain form of grandeur, splendor, and gigantism, as mixing requires size and superposition. The scaling of a hybrid and its relationship to the environment is measured by the juxtaposition of program sections. In vertical hybrids, functions are complemented by overlaying and in horizontal hybrids by topping” (Fernández Per *et al.*, 2014, p. 41).
- City: By definition the hybrid includes the perspective, insertion into the grid, dialogue with other urban landmarks and interrelationships with the surrounding public space. The fact of not clearly arranged transition between architecture and urban planning requires individual implementation strategies.

- Critique of the Skyscraper still remains

What makes it a Sustainable Urban Form and where is its future potential hiding?

- Ken Yeang: “At the outset, we should be clear that the skyscraper is not an ecological building type. In fact, it is one of the most un-ecological of all building types” (Yeang, 2002, p. 84). But he also stated “ unless an alternative equivalent built form presents itself that can economically and physically be a more viable solution to the intensification of our cities land use (as a consequence of urban growth), then tall buildings will remain with us for a while” (Yeang, 2002, p. I).
- Christopher Alexander in his 21st Pattern – Four Story Limit: “There is abundant evidence to show that high buildings make people crazy. High buildings have no genuine advantages, except in speculative gains for banks and land owners. They are not cheaper, they do not create open space, they destroy townscape, they destroy social life … they damage light and air and view” (Alexander, 1977, p. 114).
- Jan Gehl, who coined the term ‘People-Oriented Cities’, is not critical about skyscrapers per se, but about how they interact with the city and highlights that what matters most is the life between the buildings (public open space) and how it is used (Gehl, 2011). He always fosters sensitivity to ask what a building can do for the city and vice versa. The city, regardless of height nor expansion, is for the people and should therefore strengthen the human scale and the people's social interaction to become truly sustainable (Gehl, 2010).
- Jane Jacobs illustrates in “The Death and Life of Great American Cities” different conditions for city diversity, how declines occur and how cities could regenerate. For her, the human scale and pedestrian level are at heart of attention. Diversity of functions of the urban fabric creates a much better mix of classes and, by nature, better working communities. Essential to make this happen is the in between space – sidewalks, parks and other public open space facilities. In order for these to work, "it takes again a wide functional mixture of users to populate and enliven a neighborhood park through the day" (Jacobs, 1961, p. 99).

Carol Willis gives away three options in advent of massive population growth, rapid urbanization, and international commitment to a prospective sustainable world: 1. horizontal overcrowding, 2. urban sprawl and 3. vertical expansion. She views vertical expansion as the prevailing choice (CTBUH, 2010). In order to respond to the legitimate criticism and implement the issues raised must change the type and placement of the skyscraper, but not necessarily its existence. Generally, it is about two things – human scale and diversity. To strive for People-oriented cities (skyscrapers), the pedestrian is the superior study participant and so the entire infrastructure must be laid out to direct the transportation according to this aspect. Second, the lack of public open spaces must be overcome. Diversity, does not consist only of residential, commercial and retail functions but most importantly of a place where people can meet. As mentioned above, several classes of people come along with different functions and the connector of creating social communities, public open space, is missing in many cities (skyscrapers). Regarding high rise buildings, questions of public and private, and

how to implement these spaces into the developments layout consequently arise. To achieve the best accessibility possible both points, human scale and diversity, must be seamlessly integrated and connected. Today the infrastructure of a skyscraper consists of a sophisticated system of elevators and lobbies. Similar to the TOD theory of Luca Bertolini, these lobbies are good nodes but lack in place value. Consequently, by adding public open space (with different themes and aims) within the developments these structures are able to provide all the cutting-edge amenities a city dweller could ask for throughout daily routine. To give an example of someone trying to give answers, WOHA in collaboration with the writer and photographer Patrick Bingham-Hall, came up in their book "Garden City Mega City" with various mini-city projects and proposals as prototypes for energy-efficient vertical landscapes with sky villages and sky parks (Bingham-Hall and WOHA (Firm), 2016, p. V). This manifesto for the in between space will fulfill the approach of the Skyscraper. Despite higher quantity of urban fabric than ever before, the improved diversity and focus on human scale provides the potential for 'the most sustainable articulated urban densities placed in the city centers. In this way, the folding back of urbanity aiming to embank urban sprawl and all the consequences that come with it, the vertical city concept becomes a significant tool for the future metropolis. All sustainability factors: society-economy-environment profit from it, increase accessibility, connectivity and livability. These hybrids bring people together regardless of class or age and at the same time include the genetic of the 'urban organism'. They are social active and are not only economic oriented real estate machines but also true 'social condensers'.

- Application of the Social Condenser Philosophy to Hybrids

This research describes different types of hybrids (2.3.2 Hybrid Urban Form and Logic of Vertical Expansion) and ends up in the previous section with a new term – "social condenser". The question of whether the social condenser is a hybrid can be answered with yes, but not in the opposite direction. The following only defines a very basic distinction:

- Hybrid = Function mix to maximizing economic factors and financial returns. In most cases, the sustainability factors are not balanced. Consequently, it is not defined if the individual functions work side by side or with each other.
- Social Condenser = Different functions enter into a symbiosis with each other containing a varied program for public and private. The main focus is more on efficient circulation, how to connect and exchange, and on the ambition to humanize. This makes the social condenser a far more sustainable and thus more desirable type of hybrid.

2.3.3 Visions and Utopian Urbanism of the 19/20 Century

The following high-density concepts (ordered by publication date) promote the combination of transit and land-use. Most of them were published in the 19th and the first three decades of the 20th century. This kind of master planning was aiming to exhaust both potentials: the benefits of industrialization and modernism but also the awareness of sustainability that all endeavors are for the people and not for the buildings. Interestingly, many of the later urban problems were already considered at the time and some of them are still not resolved. Therefore, some of these concepts or aspects of them have lost none of their relevance:

- Moses King:
    - King's Dreams of New York 1908 and
    - King's Views of New York 1911, 1912.

King's futuristic drawings of canyon-like streets show multiple layers of different transit systems and pedestrian walkways or better bridges: streetcars, bus lines, rail tracks, pedestrian sidewalks and even zeppelins in the air (Axelrod, 2009, p. 143).

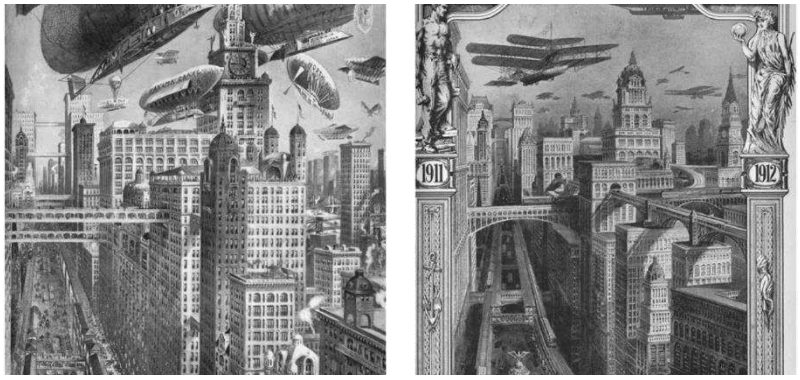


Figure 16 <King's Drams of New York (1908) and King's Views of New York (1911, 1912), Moses King, source: (Axelrod, 2009, p. 143)>

- Harvey Wiley Corbett:
    - City of the Future, 1913

With this drawing, Corbett imagines the New York road infrastructure as an innovative multi-layered usage system (Corbett, 1913). In „Different Levels for Foot, Wheel and Rail" Corbett describes how to divide the means of transportation in three rational divisions through a process of double or triple decking streets to maximize the continuity of movement. He suggests to set the wheel traffic on the present street level, put the rail traffic, subway, underground and lift the foot traffic one or two stories above street level. In this context, Corbett came up with traffic studies, which were illustrated by Hugh Ferriss (Corbett, 1924).

    - The Wonderful City You May Live to See, 1925

In this proposal Corbett gave precise suggestions about how the transportation infrastructure should be organised. He divided the means of transportation into four levels. The street level was for pedestrians, the first and second basement were reserved for slow and fast motor traffic respectively and at the very bottom electric trains. Additionally, Corbett did not believe in decentralization of the cities and stacked several urban functions into skyscrapers. He believed that "buildings half mile high and 4 – deck streets may solve congestion problems" (Corbett, 1925).

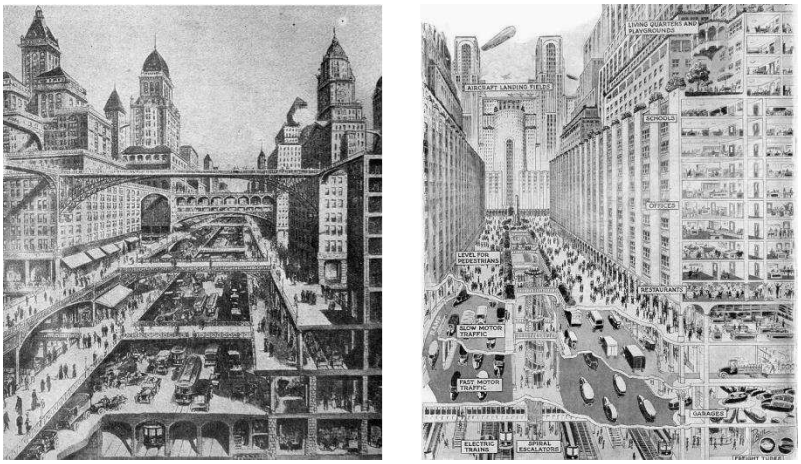


Figure 17 <City of the Future (1913) and The Wonderful city You May Live to See (1925), Harvey Wiley Corbett, source: (Corbett, 1925)>

- Le Corbusier, Ville Radieuse, 1924

This concept of an ideal city ('The Tower in the Garden') was to bring open space and light to high-density housing typologies in order to improve the future city dweller's lifestyle and create a better society. The radical and strict urban pattern, dominated by order, symmetry and standardization separated the city into function 'districts' combined by an effective means of transportation. The principles of this concept had an enormous influence on the urban planning of modernism (Le Corbusier, 1933).

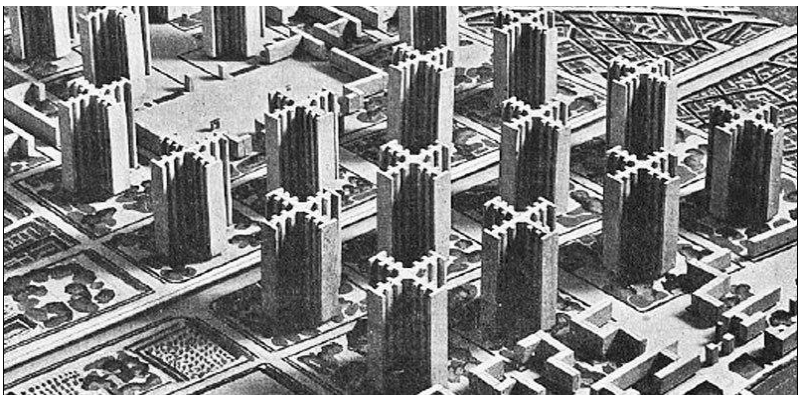


Figure 18 <Ville Radieuse (1924), Le Corbusier, source: (Le Corbusier, 1933)>

- Ludwig Hilberseimer, Vertical City, 1927

This concept was a response to Le Corbusier's approach, Ville Radieuse. The project, which was supposed to be located in Berlin, was a theoretical attempt to simplify the transportation and sanitation problems of the modern city. Hilberseimer distanced his approach from cities like Chicago or New York, because he considered these them as the mere product of real estate speculation (Hilberseimer, 1978).

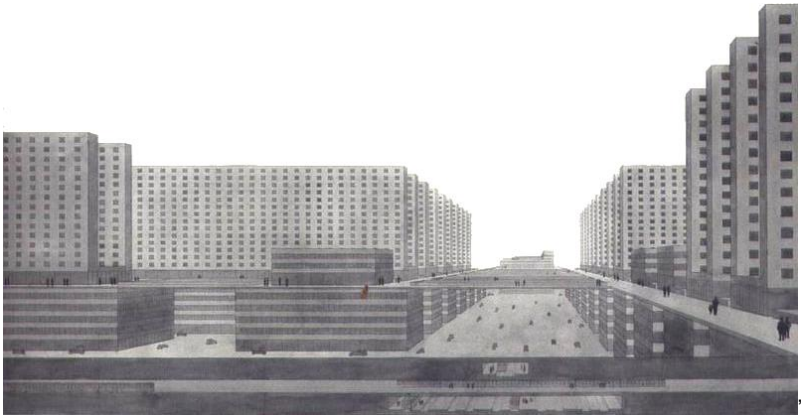


Figure 19 <Vertical City (1927), Ludwig Hilberseimer, source: (Hilberseimer, 1978)>

- Hugh Ferriss, The Metropolis of Tomorrow, New York City, 1929

As architect and poet, Ferriss explored the psychological condition of modern urban live. As mentioned above (2.2.1 Transportation in the 2nd half of the 20th century) he already predicted the car dependency and its accompanying issues in "The metropolis of Tomorrow 1929". Ferries specialized in creating architectural renderings, influencing an entire generation architects and urban planners (Ferriss, 1929).

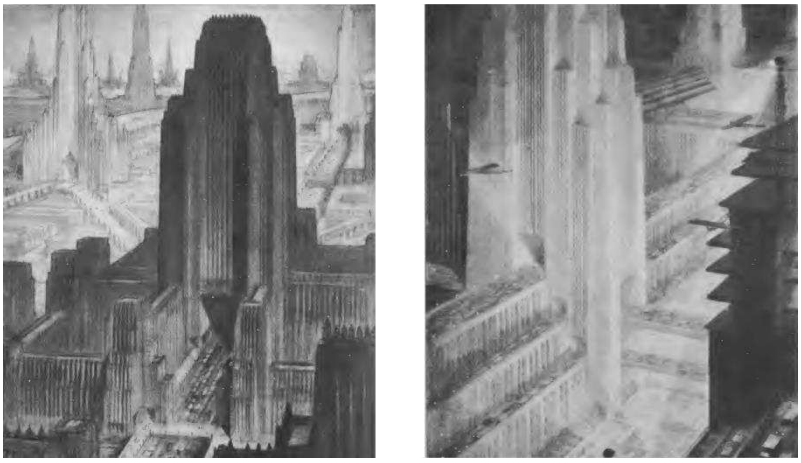


Figure 20 <the Metropolis of Tomorrow (1929), Hugh Ferriss, source: (Ferriss, 1929)>

- Arata Isozaki, Clusters in the Air, Shinjuku neighborhood, Tokyo, 1960-1962

Isozaki's concept 'Clusters in the Air' clearly shows the approach of metabolism. The urban fabric consists of central 'trunks' which contain circulation and service facilities, and the 'leaves', residential units. The term metabolism refers to the essential exchange between material, energy, organism and the outside world. Metabolists believe that the laws of form and function that have hitherto prevailed in the design of cities are no longer sufficient. The future demands of culture and society require the inclusion of the laws of space and of continuous functional change.

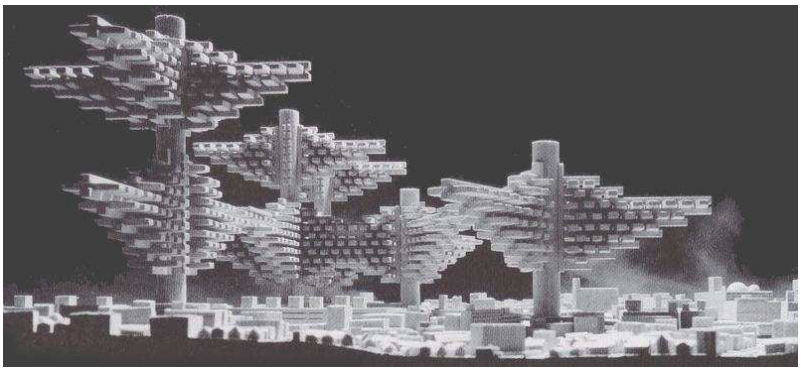


Figure 21 <Clusters in the Air (1960-1962), source: (Arata Isozaki & Associates)>

- Tsukiji District, Kenzo Tange, 1963, Tokyo Bay

With the Tsukiji plan, Kenzo Tange ”provided a three-dimensional realization of the linear Plan of Tokyo of 1960, which formed a city-within-a-city occupying Tokyo Bay” (Bingham-Hall and WOHA (Firm), 2016, pp. 52–55). The concept is based upon the idea to introduce a new physical order in Tokyo that would accommodate the city's ongoing urban sprawl and foster its internal regeneration (Tange, 1961). In the redevelopment Plan of the Tsukiji district proposal Kenzo Tange manifested his metabolism approach.

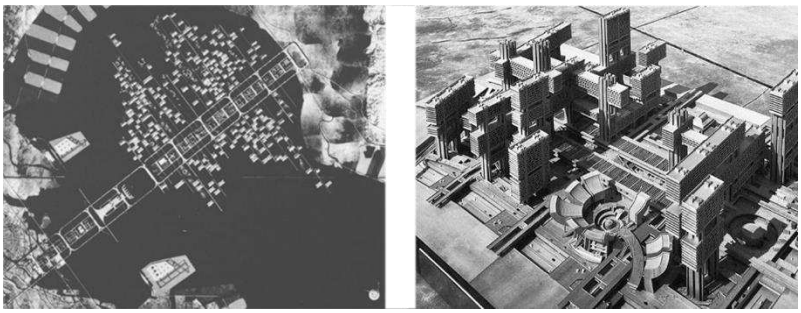


Figure 22 <Tsukiji Plan (1960) and Redevelopment Plan (1963), source: (Kenzo Tange)>

- Transferring these Approaches to Vertical Urbanism

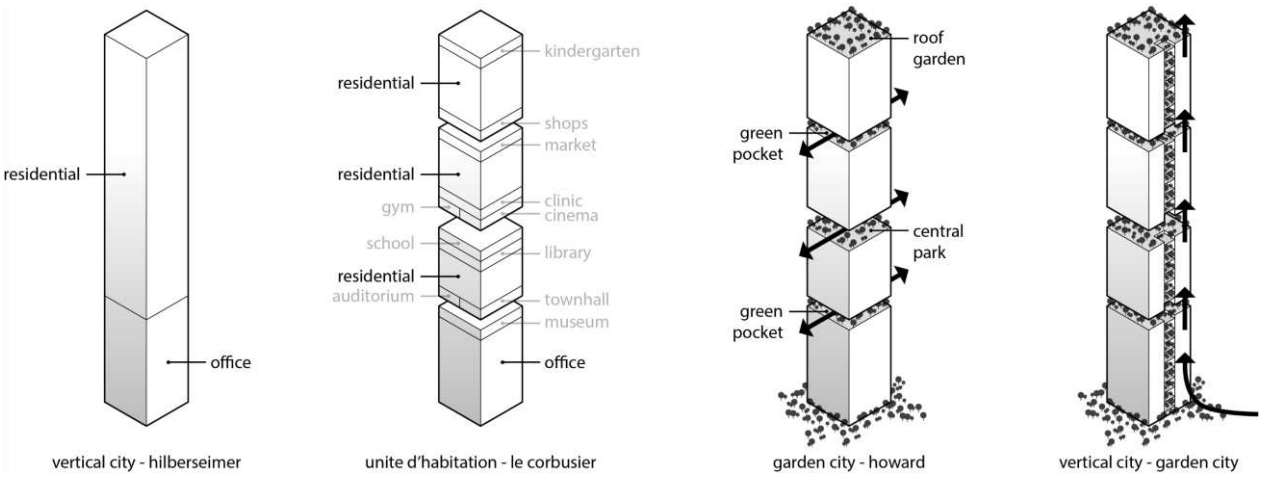


Figure 23 <the tower diagrams: transferring approaches to vertical urbanism, source: done by author>

- China's Urban Fabric today vs. America's Urban Fabric around 1900

"The innumerable variations of Le Corbusier's template have become the suburbs of Asian mega cities" (Bingham-Hall and WOHA (Firm), 2016, p. 72). Following from this, America's cities built up the same conditions during times of modernism as in China's metropolis today – are the mistakes really repeated? Like the authors of "Garden City Mega City", this research agrees with the view that this statement alone is not tenable. Undoubtedly, Ville Radieuse and the suburbs of Asian megacities resemble each other in some points in terms of infrastructural and economical thinking of high-density urban space not least because of the enormous generic volume of construction, which must be provided in China. However, American culture is in absolute contrast to Chinese culture. The Asian society reveres the family and has always lived from a spontaneous conviviality on all levels of private and public life, which overlap in some way. In some way, it is the traditional Chinese "community spirit and street life of the of the premodern low rise cities need to be reinstated to the increasingly vertical landscape" (Bingham-Hall and WOHA (Firm), 2016, pp. 71–73) to be fully sustainable.

The earth would run out of resources and collapse if the mistakes of the last century are repeated. Looking back, many of mankind's greatest achievements would not be possible without these 'mistakes'. The side effects and long-term developments were mostly incalculable and therefore they could only be considered as 'mistakes if they were repeated in the future. One hundred years ago, the American metropolis boomed, despite the enmity of crowding and industrialization and therefore, living in the green suburbs was the privileged choice if financially sustainable. A similar rethinking takes place in the Asian metropolis in recent years as an increasing number of cosmopolitans are reaching for nature and open space. Fulfilling this requires other ways than America did in the last century. Instead of people moving into the green, the green, in whatever form, has to be brought back to the city. Once again it is the folding back and stacking upward of urbanity that holds the key for urban sustainability. In this way, city dwellers can combine the desire to live beautifully and homogeneously without further urban sprawl to prevent the environment to create a kind of an eco-environment (Bingham-Hall and WOHA (Firm), 2016, p. 39).

In summary, the visions mentioned above (and many others), which once contributed to overcoming the modernism, still serve today as a guide to the future path for the further development of the city.

2.3.4 Supertall Hybrid - the Vertical City Concept

Since prehistoric times humankind has had the ambition to reach the sky. According to the legend of the Tower of Babel, the will to reach heaven through human-made towers has led to a tangle of different languages and the scattering of humans around the globe. However, this could not stop the endeavor to continue with success and ever new heights were reached, such as the Cheops-Pyramide in Cairo with a height of 139 meters which was built thousands of years ago. At least since the turn of the 19th century the skyscraper celebrated its breakthrough and has since become indispensable in the urban fabric worldwide. The technologies have been getting better and eventually only the sky is the limit. This raises not so much the question of 'how' but 'why' building vertical urban structures.

In 1956, Frank Lloyd Wright proposed Illinois Sky-City, a one-mile high (or 1.600 meter) tower. In some way Frank Lloyd Wright's vision became true. Regarding the current highest building in the world, the Burj Khalifa, as well as the Jeddah Tower which is currently under construction (both by Adrian Smith + Gordon Gill Architecture), the silhouettes look pretty similar to the sketches of the 20th century from a general design perspective. However, there

is still a lack of reaching the proposed height. Until today construction achievement in height is around half a mile.

To answer why we should be building urbanity vertical, new models of the future metropolis and the reinvigoration of community are at heart of this research section. The Vertical City Concept, as a potential solution to the major urban challenges, which are analyzed in '2.1 Contemporary Challenges of the Urban Fabric', supports a manifesto of sustainable urbanity. Per definition, every building 300 meters or higher is classified as 'supertall'. The term 'hybrid', the logic of building vertically rather than horizontally and the necessity to humanize are explained in detail in the previous section. By building upwards the function mix of residential and office area, open space and all the cutting-edge amenities of modern daily needs, the structure becomes a city within a city. Accordingly, the small footprint automatically leads to the notion of the 'Vertical City'.

This part of the research is about evaluating the characteristics of a 'Vertical City' in order to define this approach in more detail. Among many concepts for specific locations the Vertical City approach of Kenneth King provides a vision, a general concept and layout, and different schemes for different requirements or locations. Finally, he analyses the upcoming building components and topics that may not be dealt with in typical skyscrapers. Besides, Kenneth King's approach strives for a height of one mile (or 1.600 meters) and therefore, fits even better into this research. During this procedure several issues of the Vertical City get explained or eliminated and lead to the conclusion that the Vertical City is certainly a promising tool.

- Vertical City: a solution for sustainable living, by Kenneth King:

King presents a rationalized approach to a hypothetical Vertical City. Like in the TOD theory, King also states that there is no single solution and therefore analysed numerous bedroom and live/work communities and their density/composition worldwide. The main objective is "to test whether a Vertical City construct offers a viable solution to curtailing haphazard and unsustainable urban expansion and suburbanization, in both developed countries and developing countries around the word" (King and Wong, 2015, p. 513). In general King's case study is separated into bedroom and live/work communities, which propose a Vertical City for a population of approximately 100.000 and 200.000 respectively. The main focus in this research relies in the live/work community as this approach takes the social and cultural aspects more serious. Whether horizontal or vertical city, areas must be provided where people can congregate, get daily-required goods, talk to each other and know their neighbours (King and Wong, 2015, pp. 503–519).

General Dimensions:

- Height: 1.600 meters (1 mile)
- Foot print: 800 x 800 meters (0,5 x 0,5 miles) or 10 x10 squared Manhattan blocks (each: 80 x 80 meters)

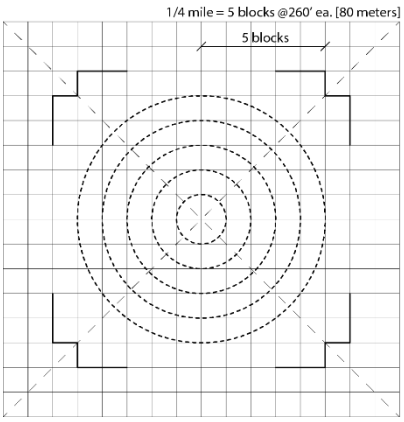


Figure 24 <maximum size (as applied to a new self-sustaining live/work community, source: (King and Wong, 2015, p. 510) edited by author>

These restrictions were decided because in that area people can get from one place to another within 15 minutes of comfortable walking. This compact way of living will result in a car-free urban fabric and only take away 1,5 percent of land. The other 98,5 percent can be used for open space, farming, ponds for fishes or other occupancy.

Components of King's Vertical City Scheme's:

- Podium (function = city center):
  Number of stories: 6 – 10 and organized within a 24 meter grid.
  Included functions: entrance to sky lobbies, retail/ shopping, schools, theatres, museums, auditoria, exhibition and convention halls, sport arenas, clean industries, …
  The Podium is also the element that touches the ground and, if done well, it also revives the bond with nature.
  - upper levels: exclusively for pedestrian and bicycles
  - lower level (function = transportation hub): public transit, vehicle use and parking slots, storage and service facilities
- Towers Scheme I:
  Number of stories: 80 – 400
  Included functions: residential (including serviced apartments and SOHO)
- Towers Scheme II:
  Primary use is to support the towers of Scheme I.
  Included functions: mixed use, hotels or office occupancy
- Sky Lobby (function = transportation hub and village center):
  Distance: every 100 stories
  Included functions: open space enhances the environment and the inhabitants' overall quality of life. In terms of function, there are apparent parallels to the podium.
  Both, the 'Podium' and the 'Sky Lobby' need be good 'Places' and 'Nodes'. In this respect, the TOD theory can be applied here and support the idea that it is not limited to the horizontal City.
  - Connectors:
    Bridges that link several sky lobbies of different towers to comprehensive

'Village Squares'.

- Enclosed Parts:
  Included functions: shops for the daily basis

- Circulation & Infrastructure:
  - Pedestrian: General movement is by foot and bicycle. If people can get from one place to another within 15 minutes, there is no need to have cars.
  - Elevators: The internal circulation consists of shuttles that go from the podium to the individual sky lobbies where people can transfer to local elevators (rope-less elevators).
  - Rapid Transit: HSR systems connect the Vertical Cities and Horizontal Cities in a matter of hours or even less.
  - Car: It can be used but to avoid any kind of restrictions they should not be the main means of transportation.
  - Resource Management: the layout of the VC makes it quite simple to sort the garbage out and recycle. A number of garbage chutes.
- Costs: It is admitted that the construction costs are massive and difficult to keep track. However, comparing the costs (including site preparation, installation of infrastructure, street furniture, utilities and services) of a Vertical city and a new suburban area consisting of detached houses it becomes unambiguous that the Vertical City is superior in this respect. With the Vertical City's tiny footprint of only 1,5 percent, land costs are reduced to a fraction which in contrast make up a sizable share of the overall costs of the horizontal city (Al-Kodmany, 2012; King and Wong, 2015).

Quad-Wing Scheme/ Live-Work Community:

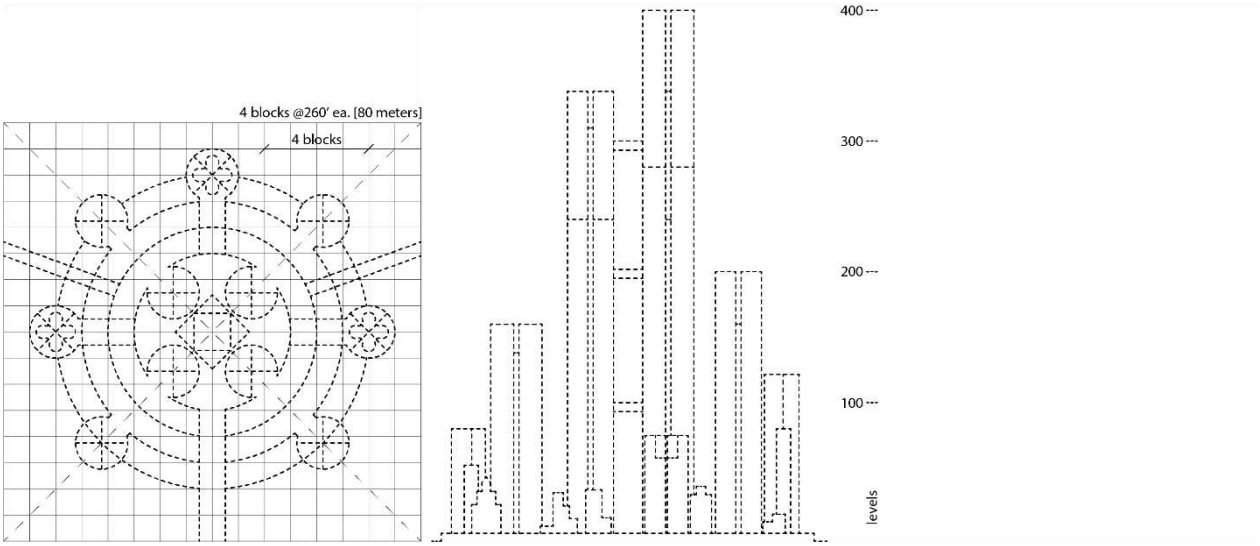


Figure 25 <Quad-Wing Scheme/ Live-Work Community, source: (King and Wong, 2015, p. 537) edited by author>

- Basic example:
  - Area per person: 70 m^2
  - Residential building area: 14 million m^2
  - Tower area per floor: 5.220 m^2
  - Number of floors required: 2.700
  - Number of towers required: 11
  - Height of towers: 100 to 400 stories
- Alternative example:
  - Area per person: 46,5 m^2
  - Residential building area: 9,3 million m^2
  - Tower area per floor: 5.220 m^2
  - Number of floors required: 1.800
  - Number of towers required: 11
  - Height of towers: 180 to 300 stories

These numbers can be used to compare the Vertical City concept with the examples from the comparative case study (3 Best Case Practices in Asia). Scaling down the 'alternative' may inspire the following 'Thesis Design Project (QCC, HGH).

2.3.5 Design Strategies & Fundamental Components

As Tschumi once said, “Form follows Fiction”, this research is convinced that in the 21st century the building type of the vertical city will be established in the metropolis. New fundamental components will be implemented into these metropolitan hybrids regarding the following topics – circulation, (public) open space and a 24/7 scenario.

- Circulation in both Directions

In 1854, the invention of the elevator changed the way we live and since then the principle of a cabin in a shaft on one rope, which is moving up and down did not change over the last 165 years. Today elevators are the ‘spine’ of people transportation in every building. In spite of ever lager, denser and higher cites an even better urban mobility is being sought. In 2003, the ‘TWIN’ elevator changed the industry. Two cabins that operate independently in one shaft reduces the elevator footprint and is able to transport 30% more people. However, apart from the resulting limitations, also other concepts that strive to increase transportation capacity, such as the double-decker elevator, to increase the speed of elevators or to reduce the core area by organizing hoist way structure will not lead to a long-term solution by today’s tall building ambitions.

The tall buildings discrepancy relays in the matter that increasing the building height requires more space for elevators and inherently results in less usable space, which reduces the building’s economic viability. The challenge of transportation relies in the conflict to balance the ‘highest building efficiency’ and ‘highest traffic performance’ possible. The more usable space in respect to the total area the more ‘efficient’ is the building. As a result, as few elevators as possible are implemented to minimize the elevator footprint. In contrast, the claim is to provide the best possible transport performance for optimal passenger and material transportation. In order to minimize waiting times and times to the destination, as many elevators as possible are aimed for (Schöllkopf, 2016, p. 4).

Due to the massive increase of tall buildings since 2000 new concepts in the fields of transportation and architecture are in demand to provide the highest level of availability, efficiency, flexibility and safety to guarantee a well-being atmosphere for everybody. The following two transportation concepts were chosen because they are not only the latest and innovative, but also already available technology:

- MULTI (vertical and horizontal transportation in vertical cities)

ThyssenKrupp came up with a revolutionary idea that has been triggered a new era for the elevator. Their approach is a rope less transportation system that moves not only vertical but also sideways. Originally, the concept idea was released to public in Nov 2014 and only a year later they presented their operating one to three mock up in Gijon, Spain. With the 246 meter high test tower in Rottweil, Germany, ThyssenKrupp has proven the feasibility of the concept in a one to one prototype. The ‘Eastside Tower Project’ in Berlin with an expected completion date in 2021 is considered to be the first building where the new system will be applied.

Unless conventional elevators, the next generation of vertical transportation system completely operates without any cables. The approach is based on a circulating system, similar to the paternoster and is therefore able to provide a cabin every 15 to 30 seconds. MULTI is a shaft-changing system with multiple cabins operating in a shaft-loop. Horizontal links between several loops or to a horizontal track is possible at exchanger levels. The system is designed in a way that 16 – 20 cabins can operate in the entire shaft-loop at a height of 300 meters. To guarantee a safe operation ThyssenKrupp implemented high-level collision

prevention and other safety features. Despite, the cabin relatively low speed of up to 7 meters per second in respect to high-speed elevators, MULTI has not only far more advantages than conventional elevators, but is also much more human (Schöllkopf, 2016, p. 13).

This transportation approach is superior to the conventional elevator and the following facts stand for itself. First, MULTI increases capacity by 50 percent and reduces the elevator footprint within a building by half. Second, up to 75 percent reduction in peak power consumption could be achieved. Third, the system is easily scalable with no restriction or limit in height. Fourth, MULTI eliminates many limitations in constructing new innovative building design concepts, for instance the vertical city (Schöllkopf and Mueller, 2016). Additionally, "a rope-less system can grow with the building in sections and provide the final elevator group functionality and speeds" (Jetter and Gerstenmeyer, 2015, p. 110). Furthermore, cabin cars can be added or removed seamlessly to adapt to changing demand.

- ACCEL (faster horizontal transportation in vertical cities)

In fact, walkways already exist, however this system brings horizontal transportation of continuous high speed to the next level. This walkway combines smooth speed changes from 0,65 to 2 meters per second, has a capacity of up to 7.300 passengers per hour and the highest safety requirements for horizontal passenger transportation. A set of modules provides total lengths between 100 to 500 meters and therefore perfectly closes the gap between moving walks and public transit stations with an average distance of smaller than 250 and higher than 800 meters respectively. In this way, ACCEL functions as a 'feeder' that connects buildings, conference center, event areas, airport terminals or simply increases the effective range of metro stations which can attract additional 30 percent more passengers. The developers even thought about using existing facility space in certain metro tunnels to relieve the subway. Since many passengers only drive individual stations, ACCEL, which could be installed directly above the metro in the same tunnel, is a potential choice. In summary, ACCEL enhance the people flow significantly and improves connectivity and transit times with medium cost (Schöllkopf, 2016, pp. 30–38).

- Traffic Concept for Super and Mega Tall Buildings

With the implementation of MULTI, ACCEL and other innovative transport systems, the following movement scenario of a vertical city can be set up. The aim is to link building and public space with transportation hubs to improve access and people flow. In this context, the synergy between place and node and its importance can be revealed. The traffic concepts for super and mega tall high-rise can be divided into two levels.

The first level of transit contains the public transit with long distance train and bus. Additionally, the pedestrian is the superior means of transportation and receives the best possible accessibility. The local traffic links are the vital points as they interface horizontal and vertical movement.

The second level of transit consists of a long distance vertical transportation system, MULTI. The cabin cars only stop at the exchanger levels - basement, podium and sky lobbies. They are circulating in a shaft-loop and therefore, are able to bring people continuously up and down, comparable to the horizontal public transit with stations. The floors between the MULTI stops are operated by the respective sky lobby with conventional elevators. Because the delivery units do not go through the entire building, they get stacked and save usable space. As MULTI, ACCEL among others also operate horizontally, sky bridges can be included in the traffic concept.

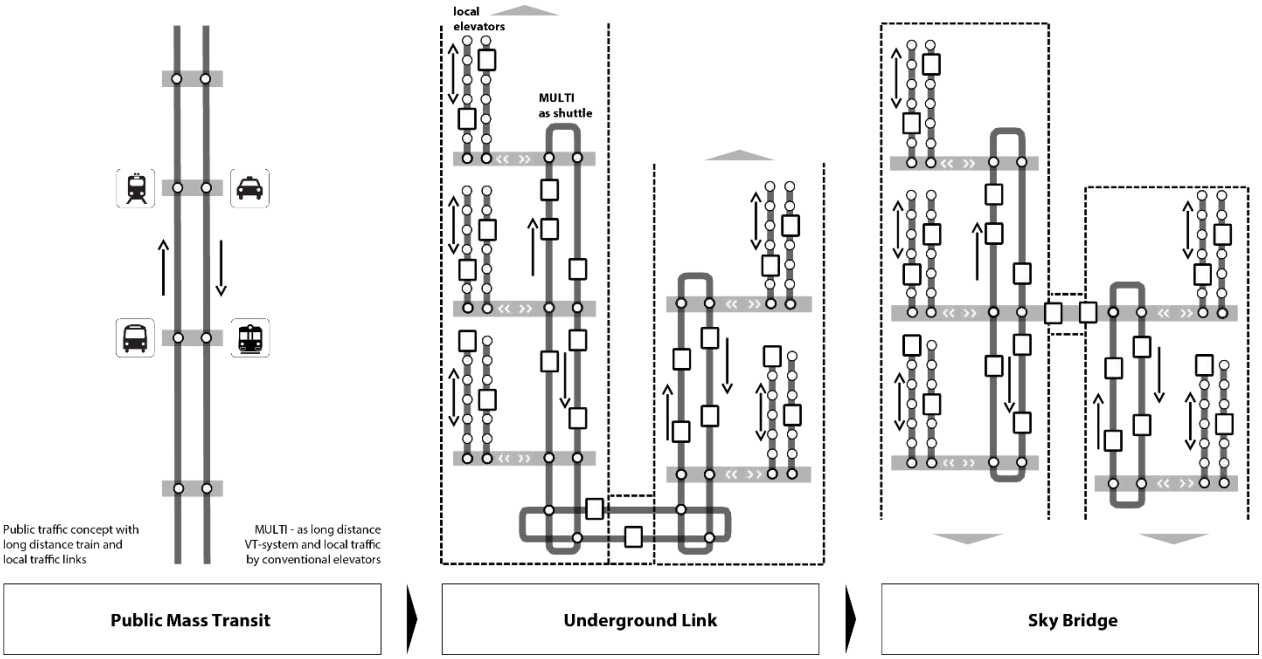


Figure 26 <Traffic Concept for Super- and Mega High Rise, source: (Schöllkopf, 2016, pp. 27, 29) edited by author>

- (Public) Open Space, the Sky Village

In many cases, parks and plazas are placed in front or on top of the podium roof of tall buildings. However, the lack of sufficient place making and the high density of city centers requires lifting the 'open space' as key function up and include it as integrative part of the building envelope. To create a community and not just another tall building, which includes a vertically stacked mixed-use program, the vertical city needs to be a place for people. There must be space in which people can meet and interact. The ideal place to do so is the sky lobby, because people concentrate there for transport-technical reasons anyway. It can be much more than just a transportation hub where people pass through. Whether a sky lobby of a single tower or multiple ones connected by sky bridges, in interaction with open space, it would become a new typology, the sky village, which functions as true community center. "When sky courts are integrated into broader movement strategies via skyways, podium, decks or sky bridges, it can lead to greater social integration through pedestrian permeability – from the fabric of the city, through the tower and beyond" (Parker and Wood, 2013, p. 129). The broad horizontal expanse of large sky lobbies means, "sky parks can incorporate a considerable diversity of planting and facilities. Within their circumscribed and easily maintained environments, the elevated parkland can accommodate groves of trees with jogging tracks, watercourses and swimming pools, sporting venues, and allotment farming, performance spaces, cafes, and restaurants ... just as large city parks always have" (Bingham-Hall and WOHA (Firm), 2016, p. 122).

- Defining the typology of open space in the sky and its characteristics

Besides the observatory, Jason Pomeroy, distinguishes among three different open space typologies: the roof top garden "a landscaped environment built on the roof"; the sky court "an open or enclosed landscaped open space that can be dispersed through the higher levels of the urban habitat or tall building"; and the sky garden, an enclosure "created by the void space being bordered by other buildings within the immediate urban context, or formed by its own internal facades", respectively (Pomeroy, 2014, p. 41). Even more important than the typology is the meaningful implementation of these places and the decision on their function to make each building respond to the genius of its environment. This requires accurate

analysis on what these spaces could provide at those unique places. As with the research of TOD and Vertical City, the one typology or definition does not exist and has to be adapted every time. The three pillars of sustainability help to develop the best possible approach for each open space in the sky. Jason Pomeroy indicates the society, environmental and economic issues and presents the individual characteristics in analytical diagrams:

“Besides a great community potential, the social viability of open space in the sky does have restrictions. In general, open space on the ground tends to be governed by public interests and permit a spontaneity and freedom movement, speech and action. However, sky court and sky garden tend to be governed by private interests. Those who can afford to pay for a view will enjoy a panoramic skyline; those who will not or cannot will be excluded by their own choice or economic circumstances” (Pomeroy, 2012). From the developers perspective this might be comprehensible, but in this respect, for social reasons, it is the policy’s duty to counteract and to grant everyone access to it to a certain extent.

Natural light and ventilation are essential for any organism. The open space in the sky functions as an environmental filter that stays in contrast to the rest of urbanity and has multiple potential usages for different user groups. Despite high-density urban environments vertical cities need to “engage with nature ... gardens, watercourses, birdlife, views, and fresh air” (Bingham-Hall and WOHA (Firm), 2016, p. 46). By increasing the quantification of greenery at horizontal, diagonal and vertical surfaces, the bio diversity within the urban habitat is enhanced. Regardless of whether these spaces are nature or manmade scenes, studies (Ulrich, 1981, 1986) have shown that the mental health of people is significantly improved and thus the psycho-physiological well-being is improved (Pomeroy, 2014, pp. 52–71).

Besides social and environmental aspects, implementing a source of amenity within the building could also have benefits from an economic perspective. "They can be a useful source of convenience, recreation and amenity that can negate the need to travel groundwards for the grocery run, gymnasium visit or relaxation in open space" (Pomeroy, 2014, p. 65). In order to drive profitable trade and generate income, a critical mass of social and recreational activities has to be created that is freed from the conventional attitude of the ground level, thus increasing the number of visitors to the building and sky villages.

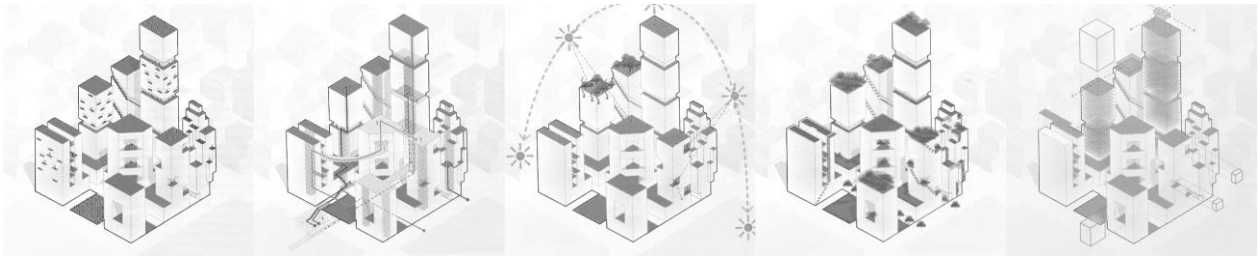


Figure 27 <analytical diagram of open space in the sky: as a social space, as a transitional space, as an environmental filter, as a bio-diversity enhancer, as an income generator, source: (Pomeroy, 2014, pp. 47–67)>

Accordingly, open space of the vertical city is implemented at the podium, as already common in tall buildings today, and the sky villages in first place. The functions of the floors between the sky villages indicate how public or how private the room should be and what uses should implement according to the user groups:

- Residential Sky Villages:
  schools, kindergartens, private parks, gardens, pools, sport facilities, super markets and other shops for daily use …

- Commercial Sky Villages:
  bars, restaurants, café, squares, convention halls, public parks, auditoria's …
- Visitor Sky Villages: bars, restaurants, café, observatories, theatres, museums, exhibitions, public parks, sport facilities, squares, retail and shopping …

It is notable, that there is a certain intersection among certain sky villages with each other. This may be an issue for bringing together the different user groups, despite ensuring security and privacy. This requires a very fine balance because it involves very complex relations and finally yet importantly, each person has a different sensation.

- Urban Farming

King suggests farming in the surroundings of the Vertical City. However, this would be only possible if the vertical is placed in a rural setting. In theory, 98 percent could then be used for farming. However, this research is placing the VC within the city to fold the city back and avoid future urban sprawl. Shipping food from distant places causes not only damage to the food, but also increases the costs because of transportation. King's idea is actually a step backwards rather a return to a much more sustainable system that existed in the first cities. If the climate allows it, the food should be grown and produced in the surrounding area. Due to the small footprint of the Vertical City, compared to the Horizontal City, there is now plenty of room for it. However, this research aims to avoid future urban sprawl and thus provides the vertical city for the city center (King and Wong, 2015). The only option would be that urban farming becomes part of the vertical city, which Ken Yeang, for example, has already implemented in his vertical research on tall buildings (Yeang, 2002).

- 24/7 Scenario – The city never sleeps

In modernism, the segregation of urban functions was propagated, which led to sleep cities, the suburbs, and to working cities, the city centers. Without reiterating the resulting problems, each district is used logically a maximum of 50 percent of the day. By symbiotic interaction of different functions at well selected spots, a much higher efficiency can be achieved. In the best case, these are used around the clock 7 days a week, which requires an extremely complex and at the same time balanced usage program between transportation, open space and facilities. Ben van Berkel describes these urban developments as places "of confluence, a hub for business conduct and a new destination for visitors and residents alike; an 'all-in-one' destination for working, living and leisure in a highly sustainable environment" (www.unstudio.com, accessed: 2018).

Due to the strong dependencies of people, culture, macro scale, surrounding urban environment and many more, in '5. Thesis Design Project (QCC, HGH)' this research deals with the question of how to optimize the goal of a 24/7 scenario in reality on the basis of a specific construction site.

Final Theoretical Research Point

In summary, the first step: TDM + TOD => Cross-Sector Integration between transit and land-use planning, sets the basis for placing integration projects – articulated densities – at centrally located key nodes of transportation. While land-use is all about scale, transit is about volume. It generates the interface from the horizontal metropolis to the vertical city or the merger of TOD and vertical development into a single entity. The 'Interim Theoretical Research Point' ends with the demand for vertical structures that are both hybrid urban spaces and mass infrastructure. This is summarized in the equation:

(TDM + TOD) + Vertical Land-use => Sustainable Cities

The main target of the second part of this literature review is to answer the second major research question of this thesis – 'What strategies can be used to optimize the integration of the total walkable urban environment and the vertical development?' People, with all demands and needs and human scale as a pedestrian is the starting point to form a community in any urban context. To a certain extent efficiency can be increased through diversification and densification, meaning vertical expansion of hybrid urban form. On the basis of the Vertical City concept, three components were extracted that maximize accessibility, life quality and usability:

- Circulation in both Dimensions (horizontal and vertical)
- (Public) Open Space, the Sky Village
- 24/7 Scenario – The city never sleeps

In total, start point is the focus on the metropolis scale down to the neighbourhood, the TOD tool. These interfaces set great potential for Hybrid urban form leading to the logic of vertical expansion, to the Vertical City Concept as a solution for sustainable living.

2.4 Comments to the Literature Review

Finally, the three sections – Contemporary Challenges of the Urban Fabric, Transit-Oriented Development and The Metropolitan Hybrid come together. The first gives the background and problem this thesis faces and the second two use a model or tool each to answer it based on the two major research questions. After answering, each one of them there is an interim- and final theoretical research point that briefly summarizes the outcome of the respective part.

The TOD might be one of the most politically reasonable and economically viable development types going forward, being able to support China's aim to achieve a sustainable metropolitan area. This path calls for a major focus on public transport, pedestrian systems and vertical development. China has had great success, but still has to be careful not to repeat the mistakes of modernity and to rely on itself and its individual circumstances. Aggravating is added that time is short.

The research of the Vertical City Concept, which concludes from the logic of vertical expansion, gives answers of how to layout such urban structures, what the differences to typical skyscrapers are and which components and strategies are essential to implement to be successful. Most importantly, Vertical Cities are not about building infinitely high, they are about creating good places for people. Public open space accessible to anyone would be desirable, noting that this brings with it some challenges.

The justification with the contention of the two topics can be explained by the strong synergy, which gets verified more and more in the course of this literature review. The combination of the disciplines Architecture, Urban Planning and Transit Planning, which vary between the macro scale (metropolis), city scale and micro scale (neighborhood), is necessary to make these integration projects a success. By understanding different relationships of different levels, the understanding of the whole can be provided.

3 Best Case Practices in Asia

3.1 Framework of the Comparative Case Study

- Purpose of this Method

This comparative case study was preceded by an intensive literature research and examines the two-way dynamic between vertical hybrid developments and their surrounding urban fabric. First, the integration and connectivity by means of horizontal and vertical infrastructure (including its interface), and second, the functional layout within super-tall towers are at heart of this research. Accessibility improvements provoked by transit infrastructure encourages urban densification and accordingly its diversification. If done well, this will further lead to increasingly sustainable urban form and travel behavior, especially in fast developing countries such as China. A series of contemporary 'vertical hybrids' of different scales and building typologies were reviewed from different countries worldwide. This provided an opportunity to consider whether a country's social, economic, political or cultural differences affected the outcome of tall and super-tall structures in its built form, accessibility, size or use. In addition, it was evaluated whether the different building typologies had any common traits that could help formulate the successful generic 'vertical city'.

- Research Questions

As summarized in the previous paragraph this comparative case study is referenced to the main research questions of this research: First, what are the most important factors used to promote the combination of horizontal with vertical transportation infrastructure? Second, what strategies were used to optimize the integration of the walkable surrounding urban context and the compact vertical development?

- Chosen Case Typologies

Built in Asia, the five selected cases, in some way, are an expression of the fundamental principles of design, each in a different location, market and political atmosphere (3 Cases were completed between 2014 - 2017, 1 is being further developed).

- Tower-Cluster on Podium – Kowloon Station Development:

Building a podium as the base of a tower is a common practice to anchor a structure and connect it emphatically to the surrounded urban context on ground level. This offers the integration of various functions and therefore inevitably fosters mixed use buildings. Nevertheless, to fit the 21st century's requirements the 'podium tower' as concept needs to be updated. In the case of the Kowloon Station, the podium is so massive that the architects segmented it to provide an appropriate circulation system.

- Horizontal Skyscraper – Kyoto JR Main Station:

Lessons in researching a vertical theory can be learned from the aircraft carrier or 'sea scraper', considering it as a total city with a multitude of urban amenities within it (Yeang, 2002). Steven Hall's 'Horizontal Skyscraper' in Shenzhen (2009), which often gets contrasted with the Empire State Building in New York, floats over the landscape and incorporates a great deal of strategies in order to guarantee sustainability in attempt to overcome the sense of

guilt over its gigantism (Fernández Per *et al.*, 2014). In this regard, this approach has also been included in research.

- Supertall Compact City – Abeno Harukas:

This concept goes far beyond the term 'mixed use skyscraper'. Converting the possibilities inherent in the innumerable encounters in 'compact cities' into effects is the key. Architectural elements such as three dimensional routes affording various choices, networks of voids, and three-dimensional networks of greenery, are fundamentally crucial (Tetsuo and Masaomi, 2015). Following this approach, Abeno Harukas not only raises new questions but also gives answers.

- Supertall Vertical City – Lotte World Tower:

The 'vertical city' created in response to the present worldwide urban conditions as a solution is an even further developed concept that can offer the diversity and experimental qualities typically only found in linear, horizontal urban centers (von Klemperer, 2018). Lotte World Tower is one of the most advanced and updated projects worldwide of this approach and sets a new bar for the paradigm of the vertical city.

- Twin Towers – Hangzhou Raffle City:

One of the oldest visual, aesthetic and functional used characteristics in architecture is symmetry. Commonly, the composition of self-similar objects or 'twins' can be analyzed as one complex unit. Inevitably, questions of the in-between-space and place-making arise. Most known 'twin towers' are the World Trade Center in New York (by Minoru Yamasaki) and the Petronas Towers, in Kuala Lumpur (by César Pelli). In the case of the Raffle City in Hangzhou the twins are joined by an interconnecting 10-story podium.

- Template for each Case Study

The individual project analysis is limited to the actual case development and the urban surrounding context within the 400m/ 800m radius. The framework of each case is partly consistent with the categories set by Renne, and Wells (Renne and Wells, 2005): travel behavior, local economy, built environment, and is then further advanced to fit this research. Site visits were conducted to all chosen cases, attempting to expand the perspective on the respective transit infrastructures, hybrid vertical developments and surrounding neighborhoods.

- Framework of the Cross-Case Study Comparison

The assessment criteria, comprising both qualitative and quantitative questions based on the conducted literature review and case studies. The selected categories form a matrix to compare and contrast the selected cases, and to detect a strategy to measure its actual success. The '5D's of the built environment' and the '7 principles of TOD' of Ewing and Cervero (Ewing and Cervero, 2010), and Peter Calthorpe (Calthorpe, 1993) respectively were included. This cross case study comparison finalizes in the 'node place diagram' by Luca Bertolini and the '3-v approach' (Salat and Ollivier, 2017), a '3-centrality system' of the values of node, place and market potential, by Serge Salat and Gerald Ollivier (Roth *et al.*, 2012). The research course as well as the outcome is a non-linear process, going back and forth between literature review, case study, analysis and research framework. The drawn lessons in the concluding paragraph of this section will help to propose guidelines that are

used as a reference to design recommendations for a prototype in Qianjiang Century City, Hangzhou.

comparison (5D's + further extension)	**results by methodology**	**conclusion** (interplay of value indexes)
▪ density ▪ diversity ▪ design ▪ distance to transit ▪ Destination access ▪ circulation ▪ public space ▪ 24/7 scenario	▪ node value index ▪ place value index ▪ market potential value index	▪ place/ node diagram – Bertolini ▪ 3-v approach diagram – Salat and Olivier ▪ learned lessons and recommendations

Table 4 <cross-case study comparison framework>

- Limitations

Cities are always in progression and the collected numbers and facts only represent one specific time slot. Therefore, provided information might not be fully meaningful in comparison or might be slightly different from the actual figures.

Kowloon Union Square

3.2 Case 1: Kowloon Union Square (Hong Kong SAR)

Figure 28 <impression image of the respective case on the previous page; source: done by author>

client – Kowloon Station Development client – International Commerce Center (ICC)	MTR Corporation Sun Hung Kai Properties Limited
address – ICC	1 Austin Road West, Kowloon, HK SAR
in operation – Kowloon Station (MRT) completion – Kowloon Station Development completion – ICC	1998 2009 (overall 2015) 2010
architect – Kowloon Station Development architect – ICC	Farrells & Partners Kohn Pedersen Fox Associates
structural engineer – ICC	Arup

Table 5 <general Information of the respective Case>

TRAVEL BEHAVIOUR			
public transit system	name of line/route	distance to transit (*)	references
MRT	Airport Express Tung Chung Line	0 (part of the podium at center location)	MTR Corporation, 2018
bus	8, 11, 203 E, 215P, 215X, 259 B, 261 B, 270P, 281 A, 296 D	0 (part of the podium at center location)	MTR Corporation, 2018
minibus	26, 26A, 74, 74S, 77M	300	td.gov.hk, 2018
closest transit station		Kowloon Union Square	
centrality of the station		'fork'– 'transit village'	(Roth *et al.*, 2012)
closeness centrality of the station (average of the closeness centrality index of 'distance' and 'time')		0,36	watch: 3.7 – distance to transit
degree of centrality		high degree: 2 major interchanges, 15 bus routes	
betweenness centrality (number of transit lines at this node)		17	
intermodal diversity (amount transit systems)		3	(Roth *et al.*, 2012)
daily ridership (amount of people passing the station within 24h)		110.000 passengers per 24 hours	MTR Corporation, 2018
vehicle ownership in Hong Kong		7,46 cars per 100 population	Trsp. Dept. HK, td.gov.hk, 2018

Table 6 <Data of the 'Travel Behavior' of the respective case>

(*) is the direct distance from the center of the union square to the respective transit system station (m).

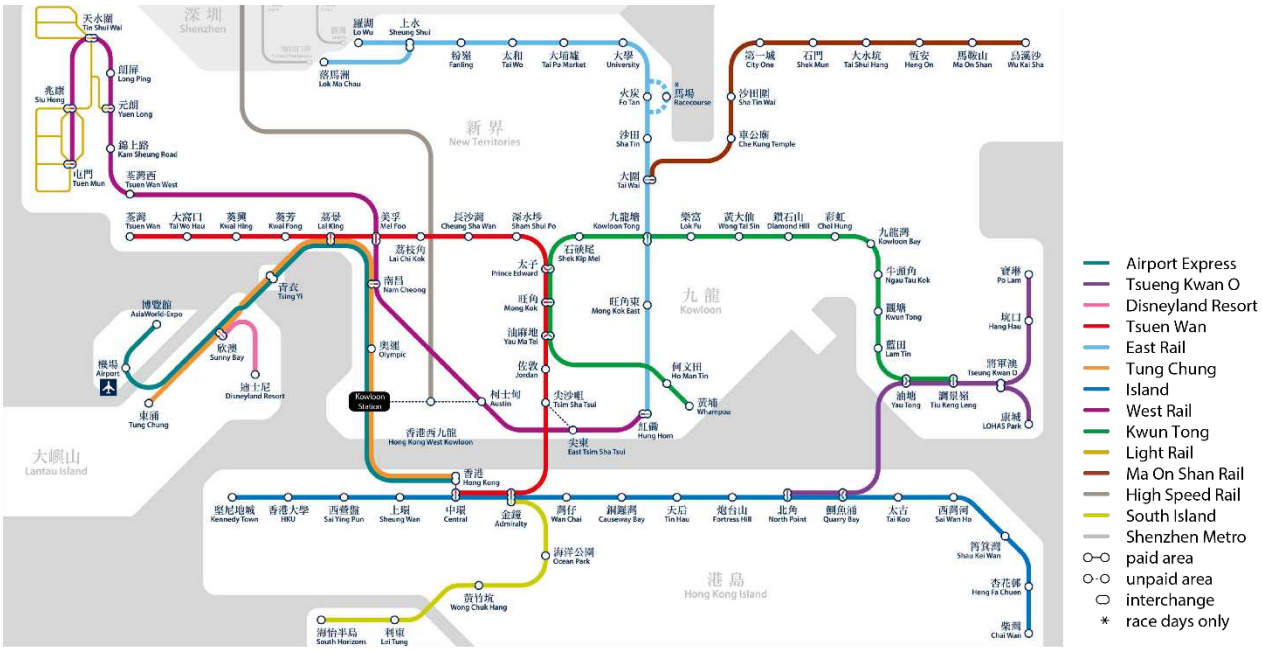


Figure 29 <map of the transit system of Hong Kong – the respective case is highlighted to clarify its position and importance within the metropolitan area, source: (mtr.com.hk, accessed 2019) edited by author>

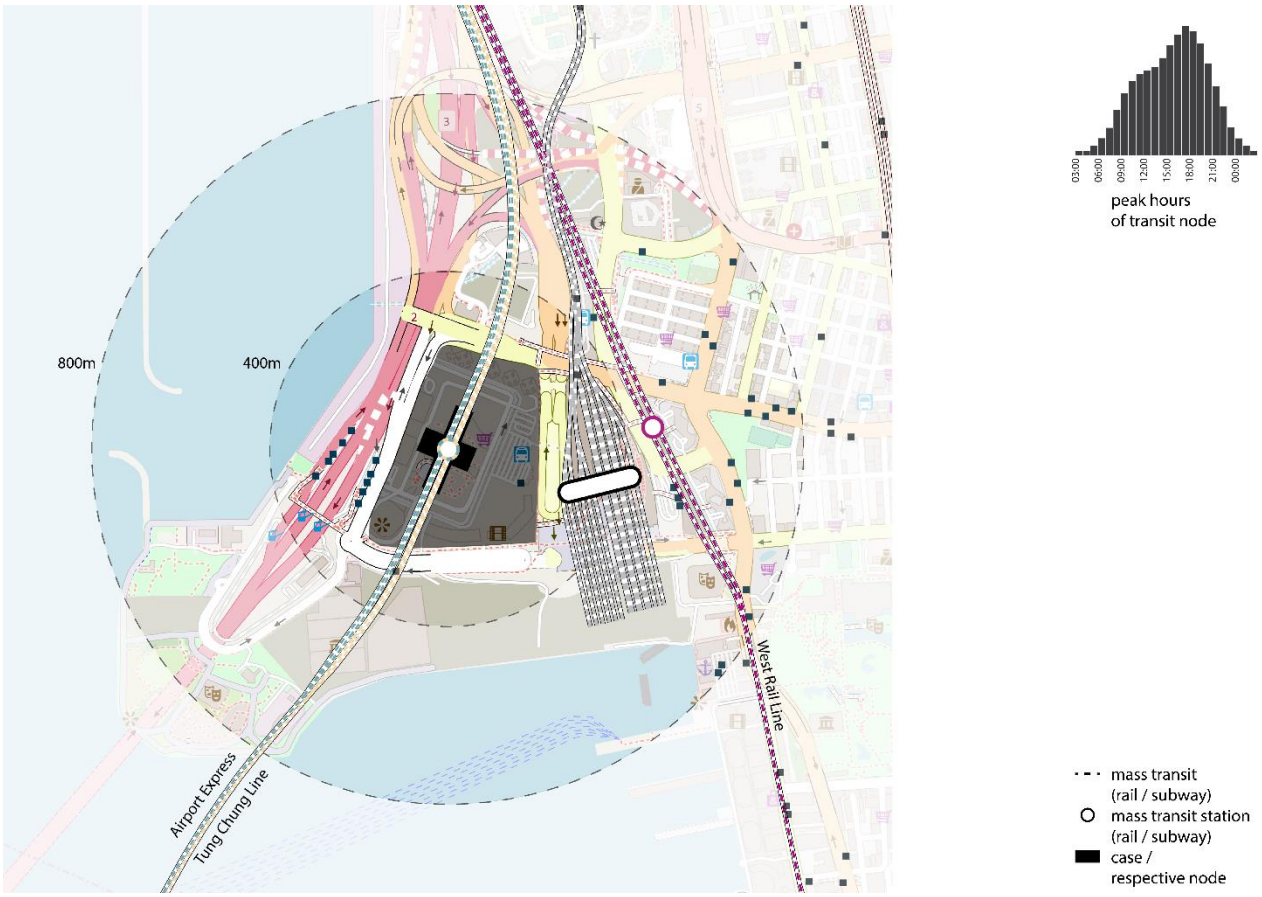


Figure 30 <Kowloon Station: 400- and 800-meter radius is highlighted; its distribution of usage changes over 24 hours (public transit, road system, pedestrian/bike (non-motorized) infrastructure), source: (openstreetmap.com, googlemaps.com) done by author>

LOCAL ECONOMY		
GDP per capita Nominal – Hong Kong SAR	48.829 US$	statisticstimes.com, 2018
economical active – Yau Tsim Mong District	26.724 workers per km^2 (total: 186.800 employees)	Census and Statistics Department – HK, 2017
property value	28.570 US$ per m^2	globalpropertyguide.com 2018
rental prices	75 US$ per m^2 per month	globalpropertyguide.com 2018

Table 7 <Data of the 'LOCAL ECONOMY' of the respective case>

BUILT ENVIRONMENT		
LEVEL I LAND USE OF THE SURROUNDING NEIGHBORHOOD (400m and 800 m radius ≠ circular)		
district area – Yau Tsim Mong	6.99 km^2	CTBUH, 2018
population density – Yau Tsim Mong district	47.726 inhabitants per km^2 (total 333.600 population)	Census and Statistics Department – HK, 2017
dominant zoned land uses	residential, business area	

Table 8 <Data of the 'Built Environment' of the respective case – Level I>

LEVEL II LAYOUT OF THE ACTUAL CASE		
total site area	135.417 m^2	Farrells, 2009
dimensions of site	369 m • 503m	Farrells, 2009
built up area (GFA) – total built up area (GFA) – Kowloon Station Development built up area (GFA) – ICC	1,09 mio m^2 (underground included: 1.679.552 m^2) 111. 480 m^2 274.064 m^2	 Farrells, 2009 CTBUH, 2018
number of towers	22 (18 residential tower)	Farrells, 2009
land-use functions – total land-use functions – ICC	hotel, office, retail, residential, hotel, office	Farrells, 2009 CTBUH, 2018
open space – Kowloon Station Development observatory – ICC	min. 1.7 ha (union square on podium-roof) 2.323m^2 (height: 388 m)	Farrells, 2009 CTBUH, 2018
number of automobile parking spaces – total number of automobile parking spaces – ICC	6.590 1.7000	Farrells, 2009 CTBUH, 2018
supporting facilities	franchised buses, minibuses, taxis, and private coaches	Farrells, 2009
number of levels of the towers	range 35-110	Farrells, 2009
level above ground – ICC	118	CTBUH, 2018
level below ground – ICC	4	CTBUH, 2018
number of elevators – ICC	83	skyscrapercenter. com, 2018
height – ICC	484 m	CTBUH, 2018

Table 9 <Data of the 'Built Behavior' of the respective case – Level II>

Figure 31 <composition of the primary intended uses of the respective case (in %), credit: Courtesy Stefan AI, done by author>

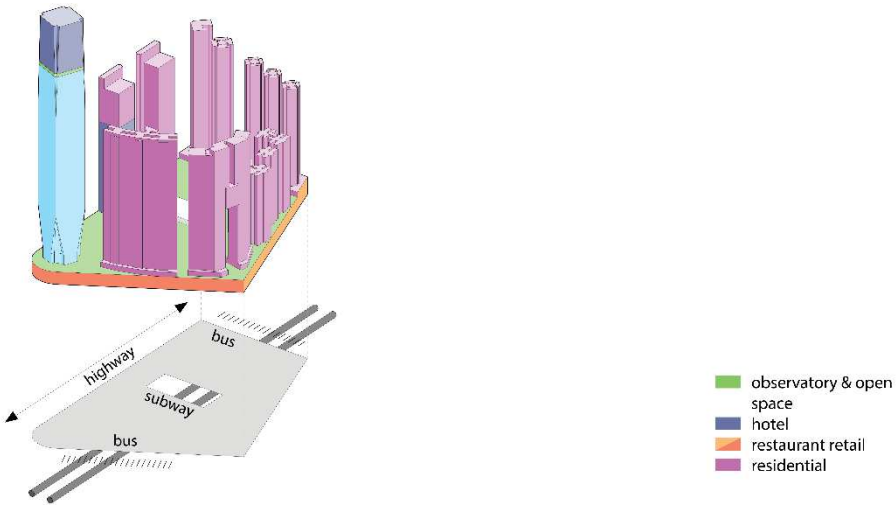


Figure 32 <illustrations of the different layers/ elements/ horizontal to vertical infrastructure of the project (3D), source: done by author>

SECTION - FROM HORIZONTAL TO VERTICAL

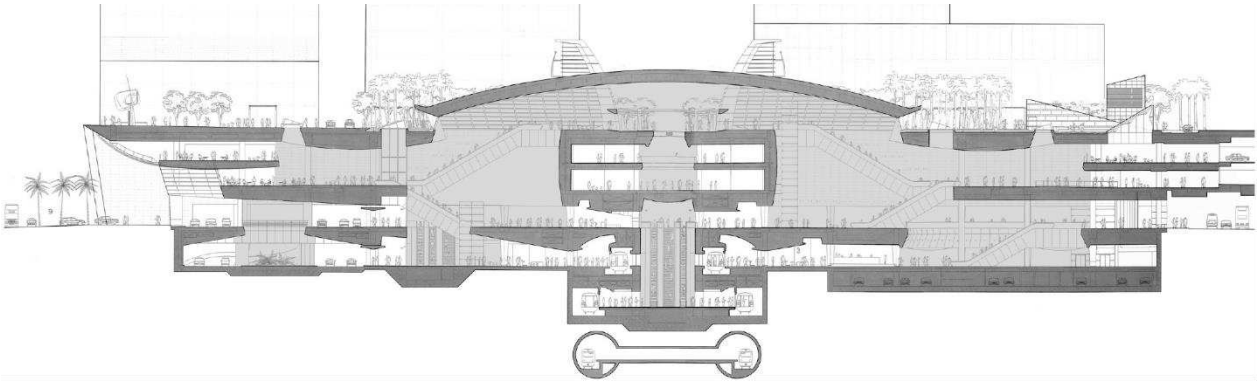


Figure 33 <section through the whole podiums project – the interface from horizontal to vertical transportation, source: (International Journal of High-Rise Buildings, Charlie Qiuli Xue and Cong Sun) edited by author>

FURTHER INFORMATION

The Kowloon Station Development (Farrells) is considered as one of the largest multiple and intensive land use (MILU) transit-oriented developments worldwide. Until completion in 2010, it took nine construction phases by Hong Kong's Mass Transit Railway Corporation (MTRC) and includes an integrated transit station in the basement, which is the focal point of the development and a multi-floor shopping mall. The green roof of the podium is the entrance level of the various towers with residential, office, and hotel programming, including the International Commerce Center (ICC) Building – the tallest tower in Hong Kong, Harbor-side, the Arch, the Sorrento Towers, the Waterfront Towers and the Cullinan Towers (Al-Kodmany, 2017, pp. 206–215). The system of closed-circulation routes for vehicles and pedestrians creates a coherent relationship between the private properties and the public realm by connecting multiple layers. In facing the challenges of TOD in the context of super-tall skyscrapers, there is also some criticism of its closed nature. In fact, this megastructure, which acts a bit like a self-sufficient city island, is well connected by public transit and car, however can only be accessed by foot via bridges, which are comparable to bypasses, and therefore truly lack of pedestrian accessibility. However, this needs to be relativized a bit because the entire surrounding context is currently, July 2018, under construction. "Whether it is positive or negative for the city remains to be seen, but one thing is certain: a building of such scale and density is rarely seen in other cities of the world" (Xue, Zhai and Roberts, 2010, p. 15).

Besides, opposite Victoria harbor, the Two International Finance Center (IFC) is located at the adjacent station and has a strong visual relationship to the ICC.

Kyoto JR Main Station

3.3 Case 2: Kyoto JR Main Station (Kyoto, Japan)

Figure 34 <impression image of the respective case on the previous page; source: done by author>

client	Kyoto Municipal Transportation Bureau
address	Higashishiokoji Kamadonocho, Shimogyo Ward
completion – 'new' Kyoto Station Building	1997 (Original Kyoto Station: 1877; Second Kyoto Station: 1914; Third Kyoto Station: 1952)
architect	Hiroshi Hara

Table 10 <general Information of the respective Case>

TRAVEL BEHAVIOUR			
public transit system	name of line/route	distance to transit (*) closeness centrality	references
railway	JR Tokaido Shinkansen Tōkaidō-Mainline Nara Line San'in Main Line Kosei-Line Kyōto-Line	0 -100 (depending on the gate, however still within the case development)	kyotostation.com, 2018
subway	Karasuma-Line	0 (part of the case)	kyotostation.com, 2018
bus	E1, E2, F1, F2, F3, G1, G2, G3, H1, H2, H3, H4, H5, H6, H7	80	kyotostation.com, 2018
bus terminal	A1, A2, A3, B1, B2, B3, C1, C2, C3, C4, C5, C6, D1, D2, D3, JR1, JR2, JR3	80	kyotostation.com, 2018
closest transit station		Kyoto JR Main Station	
centrality of the station		'core'	(Roth *et al.*, 2012)
closeness centrality of the station (average of the closeness centrality index of 'distance' and 'time')		1	watch: 3.7 – distance to transit
degree of centrality		high degree: 6 major interchanges, 33 bus routes	
betweenness centrality (number of transit lines at this node)		39	
intermodal diversity (amount of transit systems)		4	(Roth *et al.*, 2012)
daily ridership (amount of people passing the station within 24h)		JR West Part: 200.426 passengers per 24hours Subway Station: 123.360 passengers per 24 hours	kyotostation.com, 2018
vehicle ownership in Kyoto		38,53 per 100 population (1.003.776 automobiles)	Ministry of Land, Infrastructure, Transport and Tourism, stats-japan.com, 2017

Table 11 <Data of the 'Travel Behavior' of the respective case>

(*) is the direct distance from the entrance hall to the respective transit system station (m).

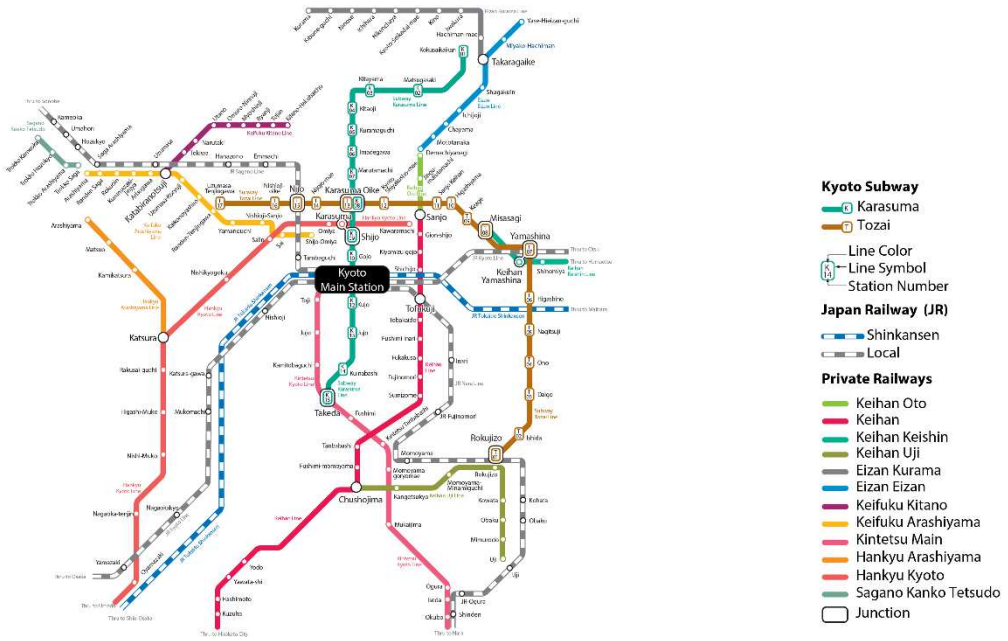


Figure 35 <map of the transit system of Kyoto – the respective case is highlighted to clarify its position and importance within the metropolitan area, source: (discoverkyoto.com, accessed 2019) edited by author>

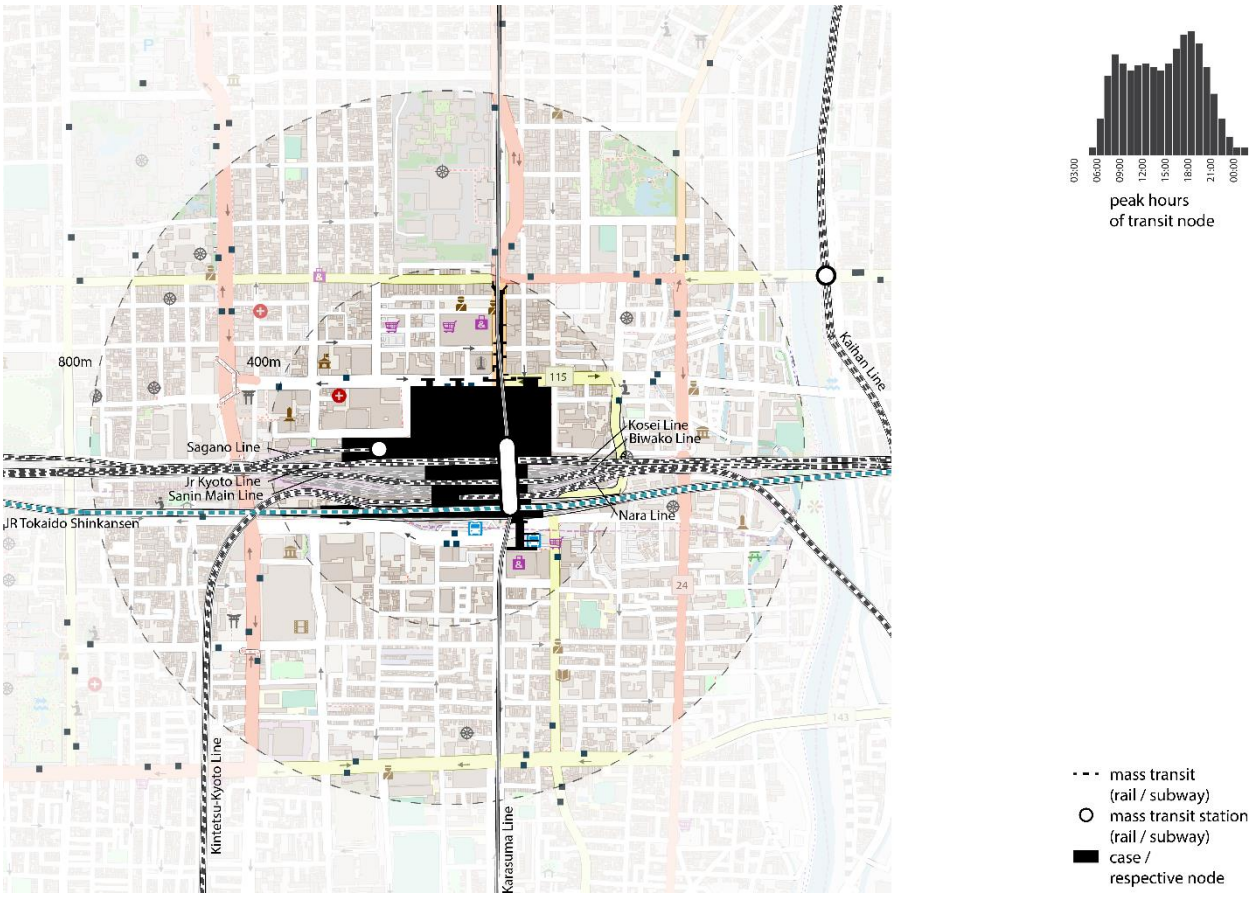


Figure 36 <Kyoto Main Station: 400- and 800-meter radius is highlighted; its distribution of usage changes over 24 hours (public transit, road system, pedestrian/bike (non-motorized) infrastructure). source: (openstreetmap.com, googlemaps.com) done by author >

LOCAL ECONOMY		
GDP per capita Nominal – Japan	40.849 US$	statisticstimes.com, 2018
economical active – Kyoto	1.500 workers per km^2 (total: 1242107 employees)	Japan External Trade Organization, jetro.go.jp/en/invest/region/kyoto.html, 2018
property value	4.837,80 US$ per m^2	numbeo.com/property-investment/in/Kyoto, 2018
rental prices	18 US$ per m^2 per month	numbeo.com/property-investment/in/Kyoto, 2018

Table 12 <Data of the 'LOCAL ECONOMY' of the respective case>

BUILT ENVIRONMENT		
LEVEL I LAND USE OF THE SURROUNDING NEIGHBORHOOD (400m and 800 m radius ≠ circular)		
population density	1772 inhabitants per km^2 (total: 1466937 population)	city.kyoto.jp, 2018
dominant zoned land uses	residential, business area	

Table 13 <Data of the 'Built Environment' of the respective case – Level I>

LEVEL II LAYOUT OF THE ACTUAL CASE		
total site area	108.000 m^2	
dimensions of site	470 m • 230 m	
built up area	237.689 m^2	kyotostation.com, 2018
land-use functions (primary intended uses)	hotel, theater, museum, retail, restaurants, clinic	
open space (Sky Garden)	3.400 m^2 (height: 70 m)	
number of automobile parking spaces – Kyoto Railway Station Hachijyokuchi Parking Sakura Building (5 minutes to walk)	208 1125	kyotostation.com/kyoto-station-map, 2018 kyotostation.com/aeon-mall-kyoto, 2018
integrated transit station	Kyoto JR Main Station	
supporting facilities	taxi stand, bike parking-slots	
level above ground	12	kyotostation.com, 2018
level below ground	3	kyotostation.com, 2018
number of elevators (station related)	9	kyotostation.com/kyoto-station-map, 2018
height	70 m	kyotostation.com, 2018

Table 14 <Data of the 'Built Behavior' of the respective case – Level II>

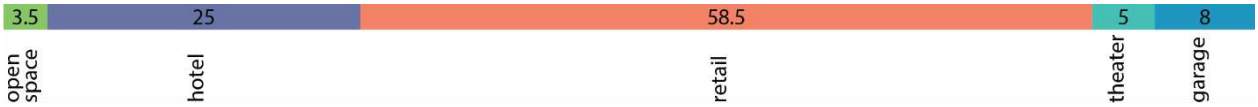


Figure 37 <composition of the primary intended uses of the respective case (in %), source: done by author>

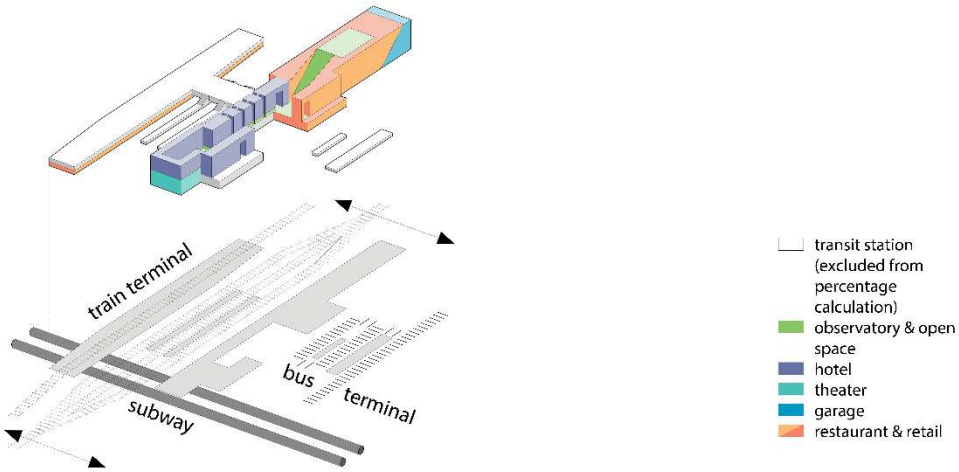


Figure 38 <illustrations of the different layers/ elements/ horizontal to vertical infrastructure of the project (3D), source: done by author>

FURTHER INFORMATION

Kyoto JR Main Station is a major transportation hub and with a length of almost 500 meters one of Japan's biggest buildings consisting of various functions including numerous shops, restaurants, a hotel, a museum and other facilities. The current Kyoto Station Building was one of the commemorative projects marking the 1200th anniversary of Kyoto's foundation as capital. An international architecture competition, which took place in 1997, finally led to the current station building by Hiroshi Hara. Its focal area is the gigantic entrance hall, also known as 'cathedral of technology'. The Kyoto JR Central Station is located in the center of this urban structure and therefore of the utmost importance (www.kyotostation.com, 2018).


Abeno Harukas

3.4 Case 3: Abeno Harukas (Osaka, Japan)

Figure 39 <impression image of the respective case on the previous page, source: done by author>

client	Kintetsu Corporation
address	1-1-43 Abenosuji, Abeno-ku
completion	2014
architect	Clark Pelli Clark architects
structural engineer	Takenaka Corporation

Table 15 <general Information of the respective Case>

TRAVEL BEHAVIOUR			
public transit system	name of line/route	distance to transit (*) closeness centrality	references
railway	Osaka Loop Line Hanwa Line Yamatoji Line	145	osakametro.co.jp, 2018; westjr.co.jp, 2018
subway	Midosuji Line Tanimachi Line	65	osakametro.co.jp, 2018; westjr.co.jp, 2018
tram	Uemachi Line	90	Hankai.co.jp, 2018
bus	12, 13, 22, 30, 62, 67, 63, 64, 1, 5, 6, 48, 52, 80, 62, 62A, 62B, Abeno-Uehommachi Loop-line, airport bus (ITM), airport bus (KIX), express buses	65	osakametro.co.jp, 2018
closest transit stations		JR Tennoji Station, Kintetsu Osaka Abenobashi Station	
centrality of the station		'core' (metro system under construction)	(Roth *et al.*, 2012)
closeness centrality of the station (average of the closeness centrality index of 'distance' and 'time')		0,35	watch: 3.7 – distance to transit
degree centrality		high degree: 5 major interchanges, 1 tram, 20 (+) bus routes	
betweenness centrality (number of transit lines at this node)		26 (+)	
intermodal diversity (amount of transit systems)		4	(Roth *et al.*, 2012)
daily ridership (amount of people passing the station within 24h)		73.000 passengers (+ 34.000 visitors), total: 107.000 people per 24 hours	abeno.project-takenaka.com, 2018
vehicle ownership in Osaka		31,35 per 100 population (total: 2.768.886 cars)	Ministry of Land, Infrastructure, Transport and Tourism, stats-japan.com, 2017

Table 16 <Data of the 'Travel Behavior' of the respective case>

(*) is the direct distance from the entrance hall, the cathedral of technology, to the respective transit system station (m).

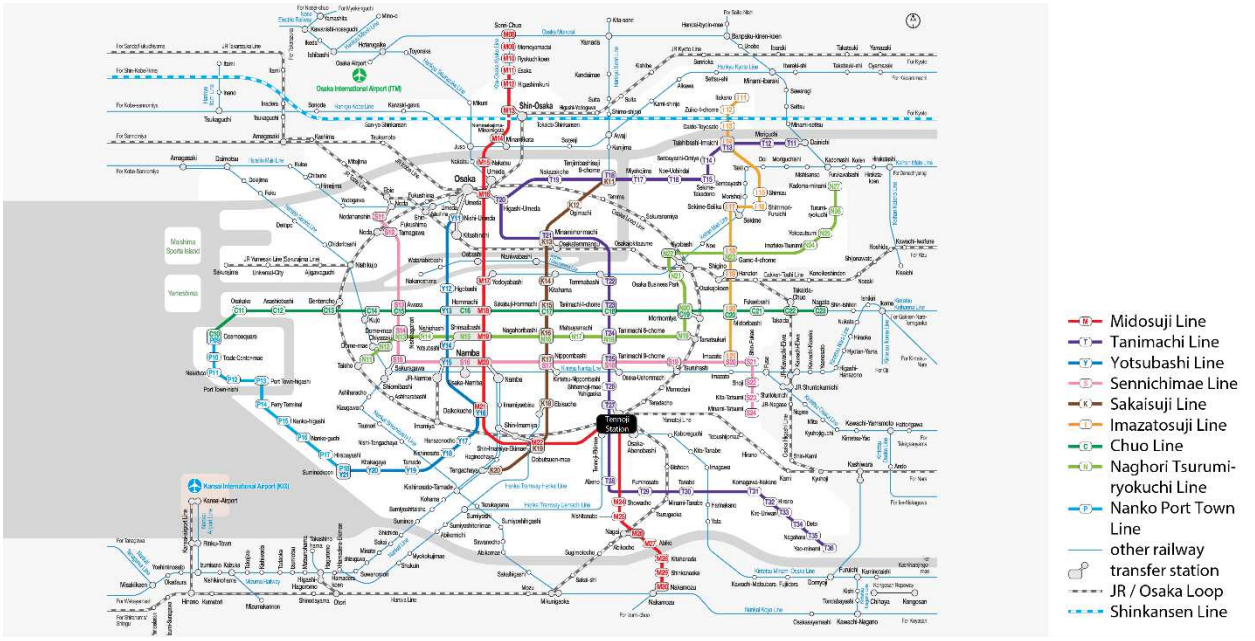


Figure 40 <map of the transit system of Osaka – the respective case is highlighted to clarify its position and importance within the metropolitan area, source: (osake-info.jp, accessed 2019) edited by author>

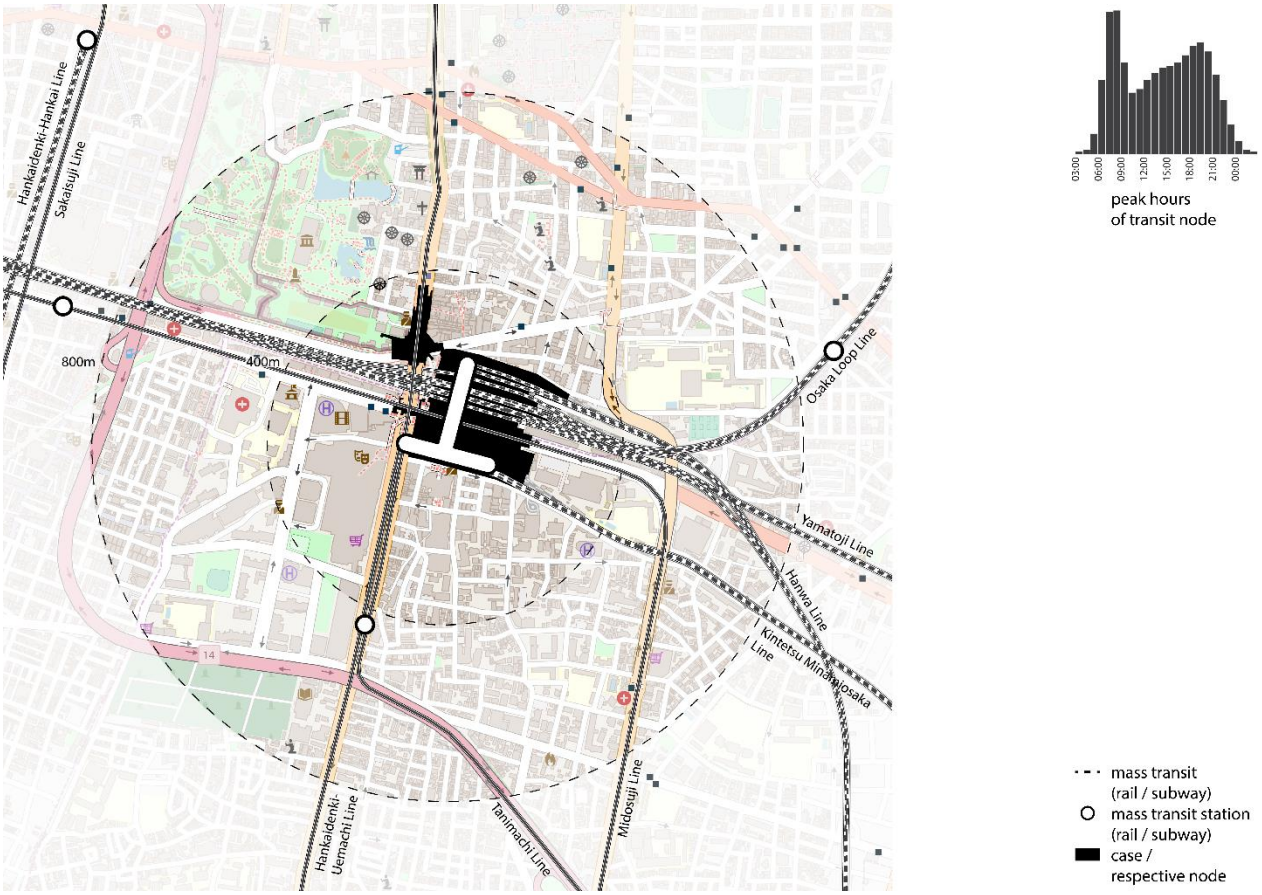


Figure 41 <Tennoji Station: 400- and 800-meter radius is highlighted; its distribution of usage changes over 24 hours (public transit, road system, pedestrian/bike (non-motorized) infrastructure), source: (openstreetmap.com, googlemaps.com) done by author >

LOCAL ECONOMY		
GDP per capita Nominal – Japan	40.849 $	statisticstimes.com, 2018
economical active	4974 workers per km^2 (total: 1,120,195 employees)	o-bic.net/e/profile/, 2018
property value	4.617,90 per m^2	expat.com/forum/ viewtopic.php?id =628267, 2018
rental prices	21 US$ per m^2 per month	expat.com/forum/ viewtopic.php?id =628267, 2018

Table 17 <Data of the 'LOCAL ECONOMY' of the respective case>

BUILT ENVIRONMENT		
LEVEL I LAND USE OF THE SURROUNDING NEIGHBORHOOD (400m and 800 m radius ≠ circular)		
population density	12.215 inhabitants per km^2 (total: 2.713.157 population)	stat.go.jp, 2018
dominant zoned land uses	residential, business, retail area	

Table 18 <Data of the 'Built Environment' of the respective case – Level I>

LEVEL II LAYOUT OF THE ACTUAL CASE		
total site area	28.700 m^2	abeno.project-takenaka.com, 2018
dimensions of site	300 m • 96 m	
built up area (total floor area)	306.000 m^2 (tower: 212.000 m^2 existing building: 94.000 m^2)	CTBUH, 2015
land-use functions (primary intended uses)	hotel, office, retail, university, theater, museum, hospital	
open space – 5 sky courts observatory height	total: 8.752 m^2 287,6 m	(Pomeroy, 2014, p. 146)
number of automobile parking spaces	190	CTBUH, 2015
integrated transit stations	JR Tennoji Station, Kintetsu Osaka Abenobashi Station	
supporting facilities	taxi places, bike parking	
level above ground	60	CTBUH, 2015
level below ground	5	CTBUH, 2015
number of elevators	56	CTBUH, 2015
height	300 m	CTBUH, 2015

Table 19 <Data of the 'Built Behavior' of the respective case – Level II>

Figure 42 <composition of the primary intended uses of the respective case in percent, source: (Tetsuo and Masaomi, 2015) done by author>

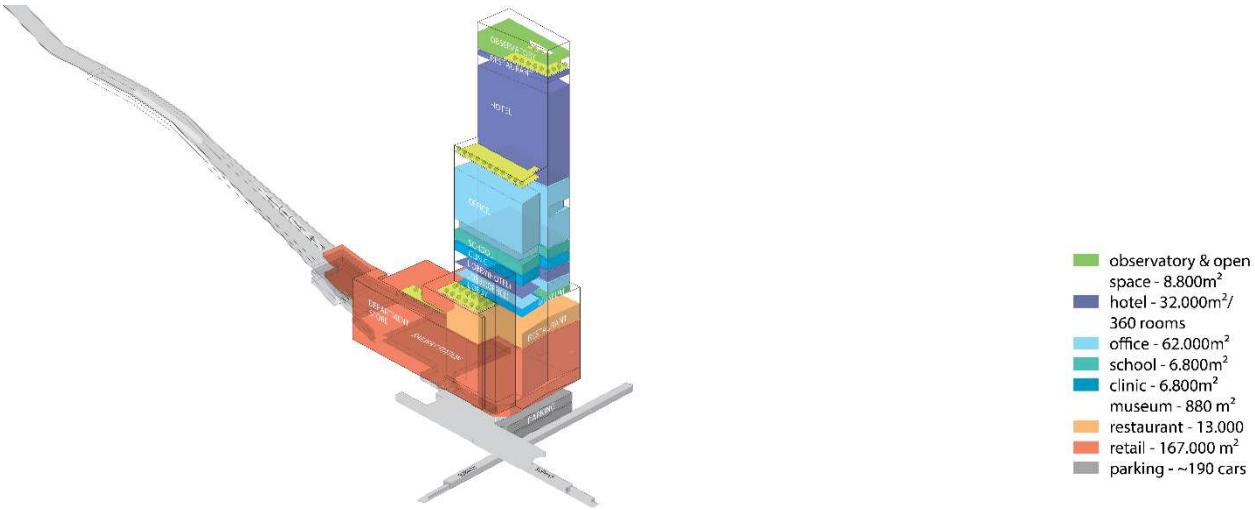


Figure 43 <illustrations of the different layers/ elements/ horizontal to vertical infrastructure of the project (3D), source: (CTBUH, 2015) edited by author>

FURTHER INFORMATION

At a height of 300 meters, it is Japans highest and only super-tall tower. The building was not designed as a single building but as a city and as a multifaceted urban gem with all the cutting-edge amenities, it can be truly considered as ‘compact city’. It's high-density complex range of functions includes a department store, an art museum, offices, a hotel, a clinic, an institute and an observatory. Additionally, this urban program is placed on top of a transit station consisting of railway, subway, tram and bus connections. With its three-dimensional circulation, network of voids and greenery, structural engineering concepts and its sensitive approach of dealing with energy consumption in various fields it is really an extraordinary piece of architecture. ‘Harukas’ is an old Japanese expression meaning ‘to brighten, to clear up’. As its namesake suggests, ‘Abeno Harukas’ embodies the exhalation of clear sweeping. The complex’s wide array of facilities and amenities answers every need and is the future of multifunctional urban space in the sky (abenoharukas-300.jp, 2018).


Lotte World Tower

3.5 Case 4: Lotte World Tower (Seoul, South Korea)

Figure 44 <impression image of the respective case on the previous page; source: (floornature.de, accessed: 2019)>

client	Lotte Property
address	300 Olympic-ro, Jamsil 6(yuk)-dong, Songpa-gu
completion	2017
architect	Kohn Pederson Fox Associates
structural engineer	Leslie E. Robertson Associates

Table 20 <general Information of the respective Case>

TRAVEL BEHAVIOUR			
public transit system	name of line/ route	distance to transit (*) closeness centrality	references
subway	line 2, 8	100	odsay.com, 2018
bus	302, 303, 320, 2311, 2412, 32, 101, 116, 500-1, 500-1A, 1000, 1000-1, 1001, 1003, 1007, 1009, 1115-6, 1680, 8002, 8012, G1300, M2316, M2323, 30-3, 30-5, 341, 3216, 3313, 3315, 3411, 3414, 4319, 30-1, 70, 3319, 3413, M5333	90	odsay.com, 2018
closest transit station		Jamsil Station (or Songpa-gu Office Station)	
centrality of the station		'core'	(Roth *et al.*, 2012)
closeness centrality of the station		0,07	watch: 3.7 – distance to transit
degree of centrality		high degree: 2 major interchanges, 37 bus routes	
betweenness centrality (number of transit lines at this node)		39	
Intermodal diversity (amount of transit systems)		2	(Roth *et al.*, 2012)
daily ridership (amount of people passing the station within 24h)		120.000 passengers per 24 hours	english.chosun.com, 2018
vehicle ownership in Seoul		33,8 cars per 100 population	statista.com, 2016

Table 21 <Data of the 'Travel Behavior' of the respective case>

(*) is the direct distance from the entrance hall of the Lotte World Tower to the respective transit system station (m).

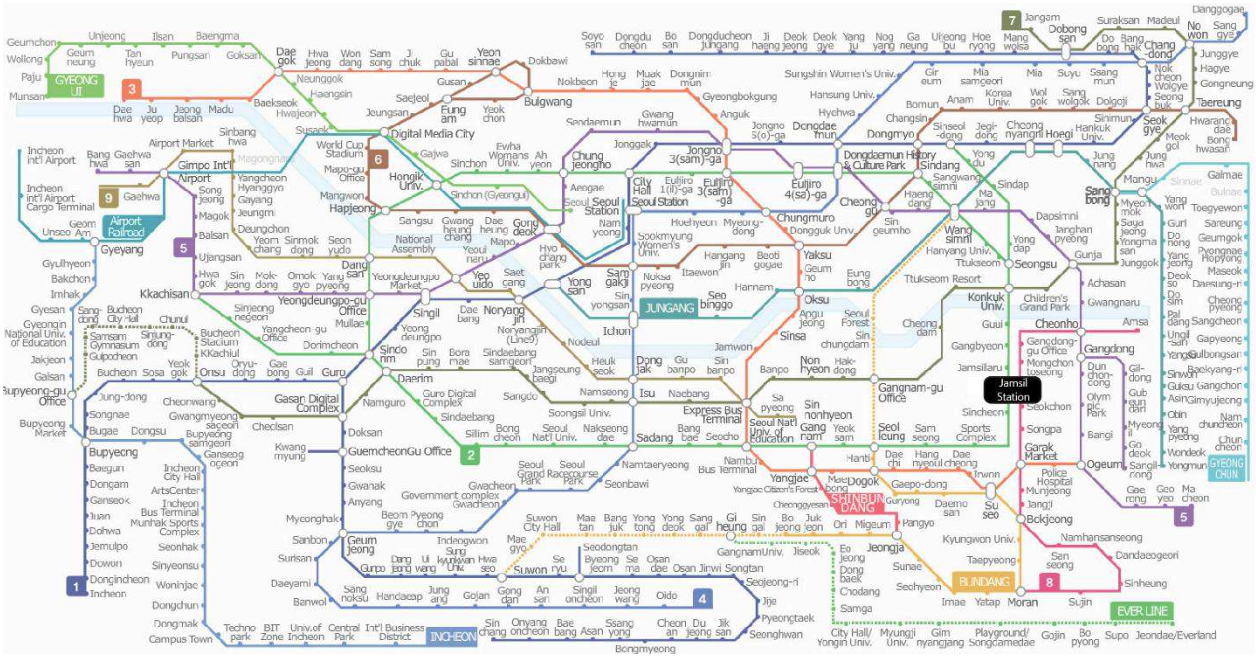


Figure 45 <map of the transit system of Seoul – the respective case is highlighted to clarify its position and importance within the metropolitan area, source: (seoulsublet.com, accessed 2019) edited by author>

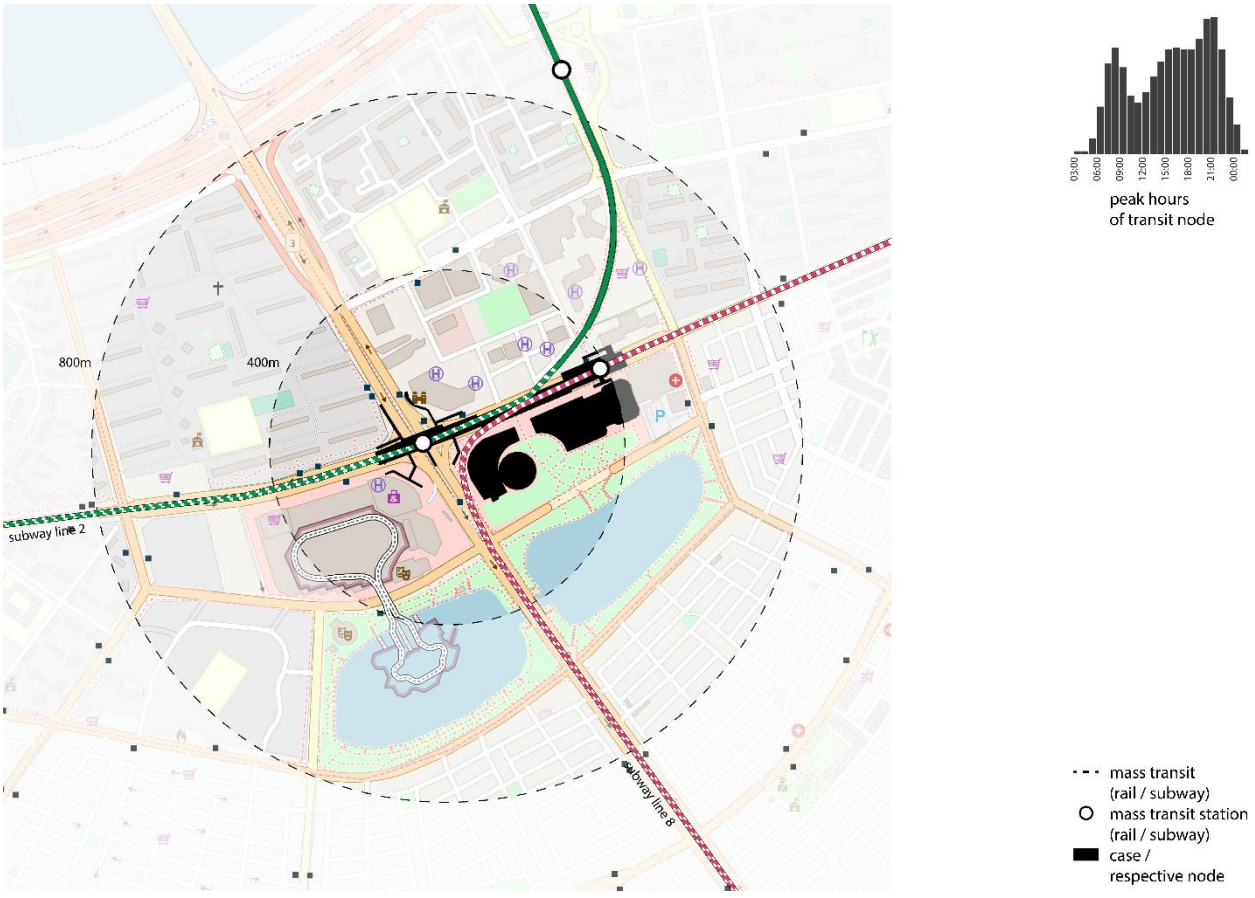


Figure 46 <Jamsil Station: 400- and 800-meter radius is highlighted; its distribution of usage changes over 24 hours (public transit, road system, pedestrian/bike (non-motorized) infrastructure), source: (openstreetmap.com, googlemaps.com) done by author >

LOCAL ECONOMY		
GDP per capita Nominal – South Korea	32.775 $	statisticstimes.com, 2018
economical active	8.946 workers per km^2 (total: 5.416.600 employees)	xinhuanet.com/english/2018-08/17/c_137397809.htm, 2018
property value	14.111,84 US$ per m^2	numbeo.com/property-investment/in/Seoul, 2018
rental prices	17 US$ per m^2 per month	numbeo.com/property-investment/in/Seoul, 2018

Table 22 <Data of the 'LOCAL ECONOMY' of the respective case>

BUILT ENVIRONMENT		
LEVEL I LAND USE OF THE SURROUNDING NEIGHBORHOOD (400m and 800 m radius ≠ circular)		
population density	17.005 inhabitants per km^2 (total: 10.297.000 population)	english.seoul.go.kr, 2016
dominant zoned land uses	residential area	

Table 23 <Data of the 'Built Environment' of the respective case – Level I>

LEVEL II LAYOUT OF THE ACTUAL CASE		
total site area	87.182,8 m^2	CTBUH, 2018
dimensions of site	356 m • 225 m	
built up area	810.988 m2	CTBUH, 2018
land-use functions (primary intended uses)	hotel, residential, office, retail, museum (aquarium), concert hall	
4 sky courts observatory height	total: 7.195 m^2 497,6 m	(Pomeroy, 2014, p. 134)
number of automobile parking spaces	2100	lotteworld.com, 2018
supporting facilities	taxi	
level above ground	123	CTBUH, 2018
level below ground	6	CTBUH, 2018
number of elevators	58	CTBUH, 2018
height	555 m	CTBUH, 2018

Table 24 <Data of the 'Built Behavior' of the respective case – Level II>

Figure 47 < composition of the primary intended uses of the respective case in percent, source: done by author>

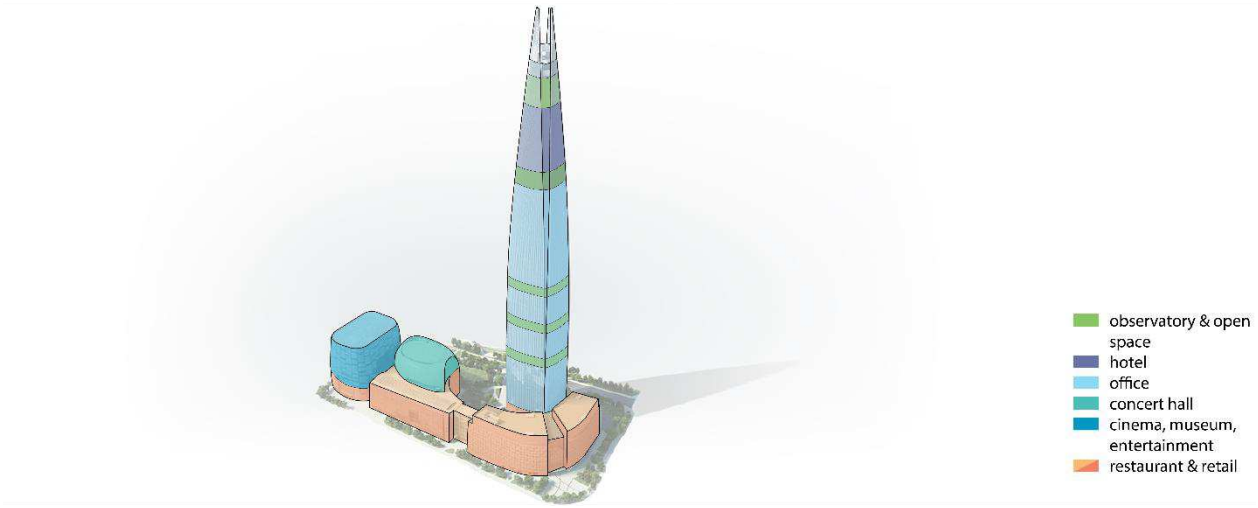


Figure 48 <illustrations of the different layers/ elements/ horizontal to vertical infrastructure of the project (3D), source: done by author>

SECTIONS – FROM HORIZONTAL TO VERTICAL

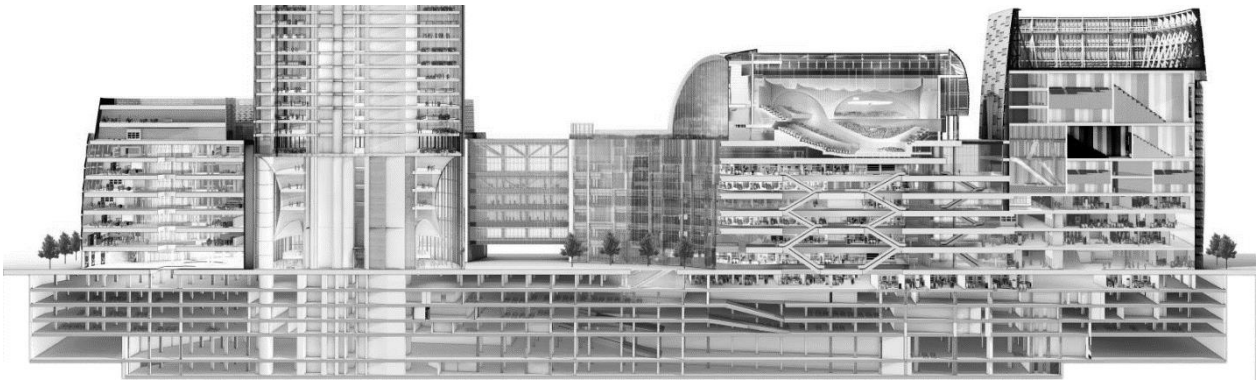


Figure 49 <section through the whole podiums project – the interface from horizontal to vertical transportation, credit: KPF edited by author>

FURTHER INFORMATION

Multi-program complexes are emerging as the standard development model. Kohn Pederson Fox Associates was instrumental in the development of the new generation of mixed-use projects that embrace a further hybridization of program. In 2016 KPF completed the CTF Finance Center located in Guangzhou, China, at a height of 530 meters. The iconic Lotte Tower in Seoul, Korea, is another upgrade of complexity. Its program stacks the complete range of functions of a city on a total of 123 floors or 555 meters and introduces a new paradigm of urban density – the 'vertical city' as built typology. The layout promotes fluid circulation, constant visual and physical connections between programs, dual lobbies as amenities and shared spaces, retail and hotel blended with workspace, and much more.

Raffle City

3.6 Case 5: Raffle City (Hangzhou, China)

Figure 50 <impression image of the respective case on the previous page; source: done by author>

client	CaptialLand Limited China
address	No. 228, Xinye Road, Jiangan District
completion	2017
architect	UnStudio
structural engineer	Arup

Table 25 <general Information of the respective Case>

TRAVEL BEHAVIOUR			
public transit system	name of line/ route	distance to transit (*) closeness centrality	references
subway	line 4	185	maps.google.cn, 2018
BRT/bus	9, 106, 105, 133, 156, 176, 71	150	maps.google.cn, 2018
closest transit station		Jiangjin Road	
centrality of the station		'core'	(Roth *et al.*, 2012)
closeness centrality of the station		0,06	watch: 3.7 – distance to transit
degree of centrality		pleasant degree: 1 major interchange, 7 bus routes	
betweenness centrality (number of transit lines at this node)		8	
intermodal diversity (amount of transit systems)		2	(Roth *et al.*, 2012)
daily ridership (amount of people passing the station within 24h)		21.000 passengers per 24 hours	
vehicle ownership in Hangzhou		23 cars per 100 population (total: 2.140.000 cars)	Statistics Bureau of Hangzhou 2012

Table 26 <Data of the 'Travel Behavior' of the respective case>

(*) is the direct distance from the entrance hall to the respective transit system station (m).

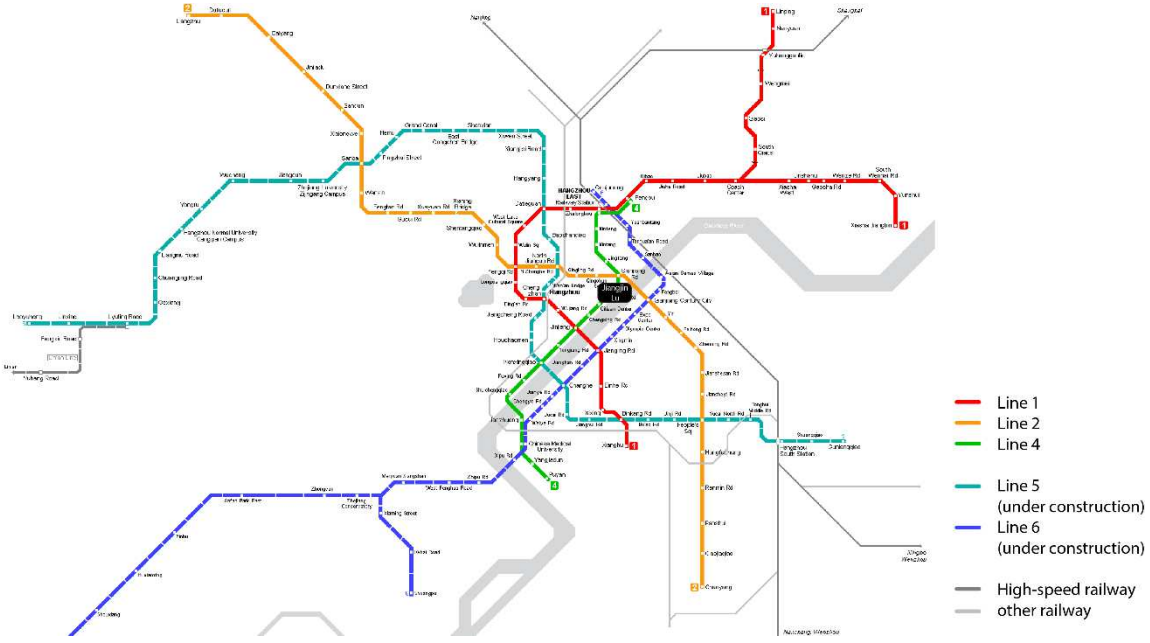


Figure 51 <map of the transit system of Hong Kong – the respective case is highlighted to clarify its position and importance within the metropolitan area, source: (urbanrail.net, accessed 2019) edited by author>

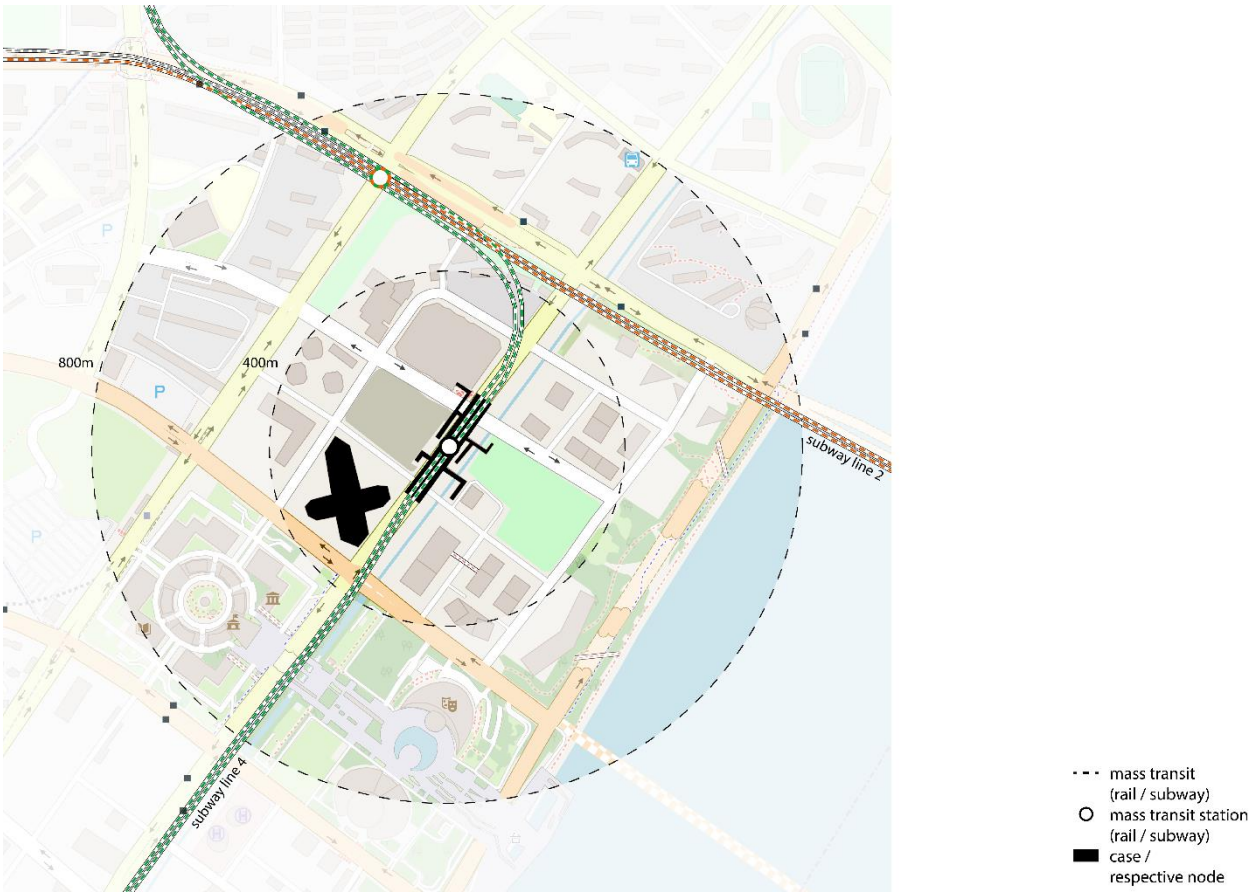


Figure 52 <Jiangjin Road: 400- and 800-meter radius highlighted; its distribution of usage changes over 24 hours (public transit, road system, pedestrian/bike (non-motorized) infrastructure), source: (openstreetmap.com, googlemaps.com) done by author >

LOCAL ECONOMY		
GDP per capita Nominal – China	10.088 US$	statisticstimes.com, 2018
economical active in Hangzhou	3.356 workers per km^2 (total: 4.765.239 employees)	statista.com, 2016
property value	6.784,94 US$ per m^2	numbeo.com/property-investment/in/Hangzhou, 2018
rental prices	10,12 US$ per m^2 per month	numbeo.com/property-investment/in/Hangzhou, 2018

Table 27 <Data of the 'LOCAL ECONOMY' of the respective case>

BUILT ENVIRONMENT		
LEVEL I LAND USE OF THE SURROUNDING NEIGHBORHOOD (400m and 800 m radius ≠ circular)		
population density – Xiaoshan district	6.470,8 inhabitants per km^2 (total: 9.188.000 inhabitants)	statista.com, 2016
dominant zoned land uses	business area	

Table 28 <Data of the 'Built Environment' of the respective case – Level I>

LEVEL II LAYOUT OF THE ACTUAL CASE		
total site area	51.700 m^2	
dimensions of site	235 m • 220 m	
built up area – tower I	187.119 m^2	CTBUH, 2018

built up area – podium total built up area	116.000 m^2 393.000 m^2	CTBUH, 2018 CTBUH, 2018
land-use functions (primary intended uses) – tower I land-use functions (primary intended uses) – tower II	SOHO, serviced apartments, office, retail, hotel, office,	CTBUH, 2018 CTBUH, 2018
open space – roof gardening podium roof gardening height	5.058,4 m^2 32,5 m	
number of automobile parking spaces	490	unstudio.com, 2018
supporting facilities	taxi places, bike parking	
level above ground – tower I level above ground – tower II	61 59	CTBUH, 2018 CTBUH, 2018
level below ground	2	CTBUH, 2018
number of elevators – tower I number of elevators – tower II number of elevators – total	30 18 48	CTBUH, 2018 CTBUH, 2018 CTBUH, 2018
height	257,6 m	unstudio.com, 2018

Table 29 <Data of the 'Built Behavior' of the respective case – Level II>

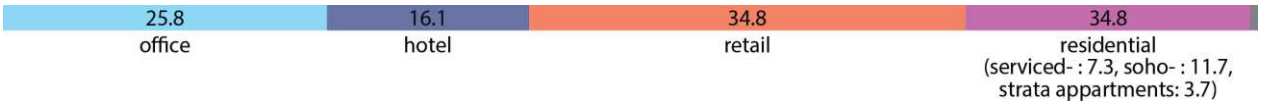


Figure 53 <composition of the primary intended uses of the respective case in percent, source: (unstudio.com, 2019) done by author>

Figure 54 <illustrations of the different layers/ elements/ horizontal to vertical infrastructure of the project (3D), source: UNstudio edited by author >

SECTIONS – FROM HORIZONTAL TO VERTICAL

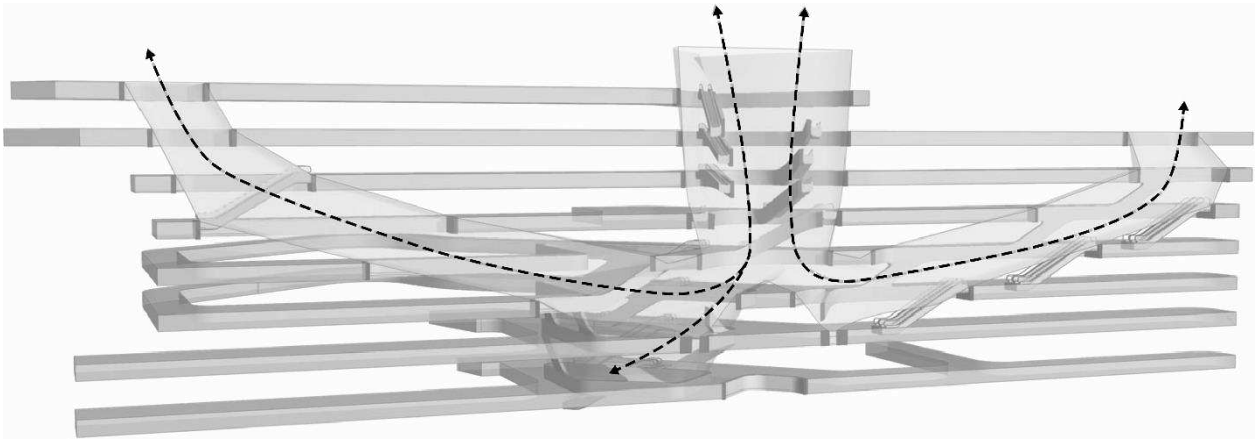


Figure 55 < section through the whole podiums project – the interface from horizontal to vertical transportation, credit: UNstudio, edited by author>

FURTHER INFORMATION

"Raffles City Hangzhou will be a point of confluence, a hub for business conduct and a new destination for visitors and residents alike; an 'all-in-one' destination for working, living and leisure in a highly sustainable environment" – Ben van Berkel (unstudio.com, accessed: 2018).

It is rich mix of functions provides a concept of a 24/7 scenario. With a height of 258 meters it is not "super-tall", but if looking at the two twin towers as a unit of 516 meters, it results in the advantage that the circulation must be designed only for the half.

3.7 Cross Case Study Comparison

Each individual fact's reference is given in the respective case study above. To simplify the following tables some facts are rounded:

- **DENSITY** *node: Cervero's 5D's = household/population density*

Level I:

On the district/city scale level, factors such as – population density, employment density, density of cars and market value generated by the density at that respective location – are the major indicators to measure density:

	Hong Kong SAR	**Kyoto, Japan**	**Osaka, Japan**	**Seoul, Korea**	**Hangzhou China (*)**
population density (x 1000 per km^2)	47,7	1,8	12,2	17	6,5
economical active (x 1000 per km^2)	26,7	1,5	5	8,9	3.4
vehicle ownership (per 100 people)	7,5	38,5	31,4	33,8	23
property value (1m^2 in US$ x1000)	28,6	4.8	4,6	14,1	6,8
rental prices (1m^2 in US$)	75	18	21	17	11
growth potential index (**)	0,95	0,8	0,7	0,7	0,6

Table 30 <population/ density comparison table>

(*) given that the city Hangzhou is in progress of a complete redevelopment and not finished yet, individual facts/information might not be fully meaningful.

(**) was adopted by evaluating (open street map, google maps) in how far one can further develop/ densify the urban fabric.

Deductions drawn from 'density level I':

Even though Hong Kong has by far the highest population density, the vehicle ownership is only a fraction compared to the other cases. This is a good indicator that Hong Kong's MRT system is a superior means of transportation and only a low percentage of dwellers are depended upon their own vehicles.

Level II:

On the development scale level, factors such as floor area ratio, highest physical elevation, passenger volume and the number of parking spaces are the major indicators to measure density:

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
passenger volume at closest node (x 1000 people)	110	324	107	120	21
daily ridership index (*)	0,339	1	0,33	0,37	0,065

built up area / site area (x 1000 m²) = FAR	1.090 / 135 = 8 (8,1)	238 / 108 = 2 (2,2)	306 / 29 = 11 (10,6)	811 / 87 = 9 (9,3)	393 / 52 = 8 (7,6)
highest elevation (in m)	484	70	300	555	257,6
parking spaces	6590	208	190	2100	490

Table 31 <development density – comparison table>

(*) in analogy to passenger volume at closest transit node by using the following formula:

$$dri = passenger\ volume_{(respective\ case)} / passenger\ volume_{(highest\ passenger\ volume)}$$

Deductions drawn from 'density level II':

Despite the fact that all cases, except of Raffle City Hangzhou, are major transportation hubs Kyoto JR Main Station and Abeno Harukas only have around 200 parking slots. However, these figures are misleading as car parks are located in the immediate vicinity of the respective cases. Apart from that, Kowloon Union Square has by far the highest built up area. This indicates that the people in charge of the development have seen an enormous potential for a TOD development at that location.

- **DIVERSITY** *node: Cervero's 5D's = land use mix; entropy*

Level I: land-use functions of 400/ 800 m radius

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
office	✓	✓	✓		✓
residential	✓	✓	✓	✓	✓
retail			✓		
total number of functions	2	2	3	1	1

Table 32 <existing function level I overview – comparison table>

Deductions drawn from 'diversity level I':

Abeno Harukas is located at the boundary of the public transportation core (Roth *et al.*, 2012) which indicates the potential of dealing with several urban functions. On the other side of the spectrum, Lotte World tower is located in a mostly residential area right at the most dominant plot. This is a good indicator that this center building should further inject momentum into the development of the region and accelerate promotion of Seoul in the long term.

Level II: land-use function layout of the actual case developments

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
hotel	✓	✓	✓	✓	✓
office	✓		✓	✓	✓
residential	✓			✓	✓ (*)
retail	✓	✓	✓	✓	✓
concert hall		✓	✓	✓	
museum		✓	✓	✓	
university			✓		
clinic		✓	✓		
observatory	✓	✓	✓	✓	✓

total number of functions	5	6	8	7	5-6 (*)
tourism (**)	2	4	5	5	2
economy (**)	4	3	4	4	4
education (**)		3	4	2	
completion	2010 (2015)	1997	2014	2017	2017

Table 33 <existing function level II overview – comparison table>

(*) Regarding this specific case, 'residential' further includes SOHO and serviced apartments.

(**) The functions above can be grouped into tourism, economy, education (functions might be part of more than one category):

- tourism: hotel, concert hall, museum, observatory
- economy: hotel, office, residential, retail, clinic
- education: concert hall, museum, university, clinic

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
land use diversity index (*)	0,6 (2; 5)	0,7 (2, 6)	0,95 (3, 8)	0,75 (1, 7)	0,65 (1, 6)
intermodal diversity index (**)	0,75 (3)	1 (4)	1 (4)	0,5 (2)	0,5 (2)

Table 34 <land use diversity index – comparison table>

(*) the index is based on the evaluation of both function diversity tables, 'level I' (dominant zoned land uses) and 'level II' (land use functions). In analogy to land use diversity index calculation by using the following formula (referring to the cases, the function layouts of level II were rated twice as important as those of level I):

$$ludi = (level\ I + (2 \times level\ II)) / 20$$

(**) in analogy to intermodal diversity by using the following formula:

$$idi_{(diversity)} = intermodal\ diversity_{(respective\ case)} / intermodal\ diversity_{(highest\ passenger\ volume)}$$

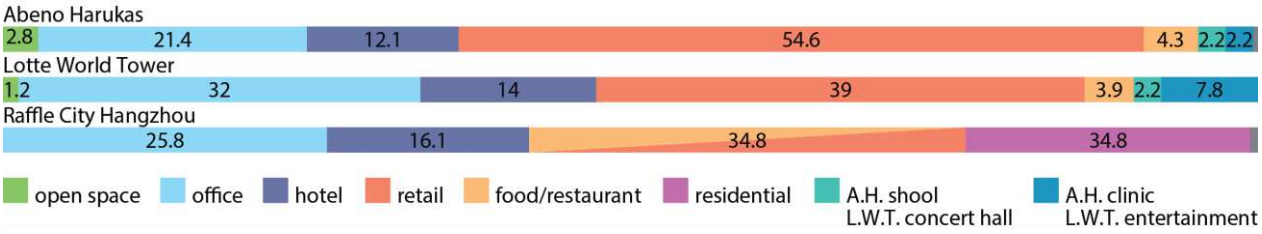


Figure 56 <comparison diagram: function layout distribution in percent of Abeno Harukas, Lotte World Tower and Raffle City Hangzhou (because of its topicality), source: done by author>

Deductions drawn from 'diversity level II':

Abeno Harukas followed by Lotte World Tower include the most functions. If comparing the different land use index with the final completion dates of the respective cases, an increase of the amount of functions within the development is noticeable. This is a good indicator that the demand and expectation on upcoming projects is rising and inherently drives the development's complexity. This once again legitimizes the effort in the theory of the vertical city.

- **DESIGN** *node: Cervero's 5D's = intersection/ street density*

	Kowloon Union Square	Kyoto JR Main Station	Abeno Harukas	Lotte World Tower	Raffle City Hangzhou
intersection (*)	1	1	2	2	3
high ways	1 (West Harbor Crossing)	1 (Gojo Dori)	1 (Hanshin No. 14 Matsubara)	1 (Olympic-daero)	1 (Quishi Expressway)
highway section (**)	68,5 12	44 8	25 4	48 8	26 6
street density – main roads (m)	250	580	610	560	470
main roads section (**)	24 4	26,5 4	40 4 (+2 for tram)	51 10 (+2 for bus)	54 8
street density – minor roads (m)	60	73	76	157	235
minor roads (**)	11,5 1	7 1	7	9	28
intersection density index (***)	0,74	0,514	0,328	0,199	0,17
number of parking slots	6590	208	190	2100	490
block size (m)	400 x 400	70 x 40	75 x 135	530 x 420	430 x 430
walkability degree (****)	4	1	3	2	2

Table 35 <street design and walkability – comparison table>

(*) priority vector for relevance of intersection (with emphasis in car traffic) at the respective case within the urban context. In case of doubt, an average value was calculated or related to the closest situation: 1 = greatest importance; 2 = great importance; 3 = less importance; 4 = low importance

case 1: between Hong Kong and Hong Kong island (= one out of three existing harbor crossings)

case 2: is 'the intersection point' of Kyoto regarding movement

case 3: between Abiko-suji and Abeno-suji Road

case 4: Olympic-ro and Sangpa-daero

case 5: Wujiang Road and Qingchun Road, which intersect with the Qiushi Expressway and surround together with the Qiantang River the New Town Shangquan District. The Raffle City of Hangzhou is placed right at center location.

(**) 1. total width (m); 2. total number of roadways

(***) the index is based on the evaluation of the street density of main and minor roads. In analogy to intersection density index calculation by using the following formula:

$$idi_{(design)} = ((1 / \text{minor street density}) + 2 \times (\text{main street density})) \times 20$$

(****) Priority vector for factors in walkability make an evaluation possible (the value refers to the pedestrian mobility of the surrounded urban area, considering different user-groups):

1 = very good; 2 = good; 3 = inadequate; 4 = insufficient

Deductions drawn from 'design':

Because of the special location at the riverside, Raffle City Hangzhou has access to three intersections which have smaller highway sections than the average of the other cases. In contrast, Kowloon Union Square is connected to only one intersection with a wide width, but to one out of three existing harbor crossings in Hong Kong which strengthens this node significantly. Despite a relatively small block size in the surroundings of Kyoto JR Main Station and Abeno Harukas, Kyoto JR Main Station has in comparison the best walkability degree while Abeno Harukas lacks in this evaluation. This is a good indicator that the pedestrian layer is much better integrated into the transportation network of Kyoto.

- **LOCAL ECONOMY**

	Hong Kong SAR	**Kyoto, Japan**	**Osaka, Japan**	**Seoul, Korea**	**Hangzhou China**
population density index	1 (47.726)	0,04 (1.772)	0,26 (12.215)	0,36 (17.005)	0,14 (6.471)
job density index	1 (26.724)	0,06 (1.500)	0,19 (4.974)	0,34 (8.946)	0,13 (3.356)

- **DISTANCE TO TRANSIT** *node: Cervero's 5D's = distance to closest transit stop*

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
distance to major transit station (m, min) (*)	0 ~ 3	50 ~ 3-5	65 ~ 2-4	100 ~ 3-5	185 ~ 4-6
distance/ travel time to city center (km, min) (**)	2,2/ ~ 12 mtr.com.hk, 20018	1/ 1 basically, at center location	3-5/ 15-20 adjacent to the city center	13/ 40 rome2rio.com, 2018	7,6/ 25-30 maps.google.at, 2018
distance/ travel time to CBD (m, min) (**)	2,2/ ~ 12 International Finance Center (IFC)	1/ 1 basically, at that location	7,5/ ~ 30 Umeda in Kita-ku	8/ ~ 25 Gangnam Business District (GBD)	6/ ~ 30 Qianjiang Century City (QCC)
closeness centrality index$_{(time)}$ (***)	0,222 (0,5)	1 (2,25)	0,189 (0,425)	0,140 (0,315)	0,120 (0,27)
closeness centrality index$_{(distance)}$ (***)	0,495 (1,001)	1 (2,020)	0,503 (1,016)	0,005 (0,0010)	0,003 (0,006)
mean closeness centrality	0,359	1	0,346	0,0725	0,0615

Table 36 <distance overview – comparison table>

(*) distance from flat or working place to the next major transit station, considering the use of elevators and stairs.

(**) the chosen locomotion system is the public transport system

(***) in analogy to closeness centrality calculation by using the following formula:

$cci_{(time)}$ = (1 / travel time to major transit stations in minutes) + (1 / travel time to city center in minutes) + (1 / travel time to CBD in minutes)

in analogy to closeness centrality calculation by using the following formula:

$cci_{(distance)}$ = (1 / distance to major transit stations in meter) + (1 / distance to city center in meter) + (1 / distance to CBD in minutes in meter)

Deductions drawn from 'distance to transit':

Kyoto JR Main Station has by far the best closeness centrality index, whether regarding time nor distance. Already from the city level perspective, there is only one place where to estimate the case's location. This is a good indicator that this case is the superior node of transportation of Kyoto.

- **DESTINATION ACCESS** *node: Cervero's 5D's = job-accessibility by car*

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
directly linkage to public transit	✓	✓	✓	✓	
station linked or within case (*)	1	1	1	2	3
number of main accesses on ground level	3	12	10	13	14
Daily ridership (x 1000)	0,89 (110)	1 (123,36)	0,87 (107)	0,97 (120)	0,17 (21)
accessibility degree (**)	3	1	1	2	2
betweenness centrality index (***)	0,436 (17)	1 (39)	0,667 (26)	1 (39)	0,205 (8)

Table 37 <destination access overview – comparison table>

(*) 1 = station within case; 2 = station linked to station (underground); 3 = no direct linkage

(**) Priority vector for factors in accessibility makes an evaluation possible (the value is determined by the evaluation of the relationship 1: linkage between transit station and vertical case development; relationship 2: linkage between transit station and case development, and the walkable/ bike-able surrounded urban area, considering different user groups):

1 = very good; 2 = good; 3 = inadequate; 4 = insufficient

(***) total number of transit lines at this node

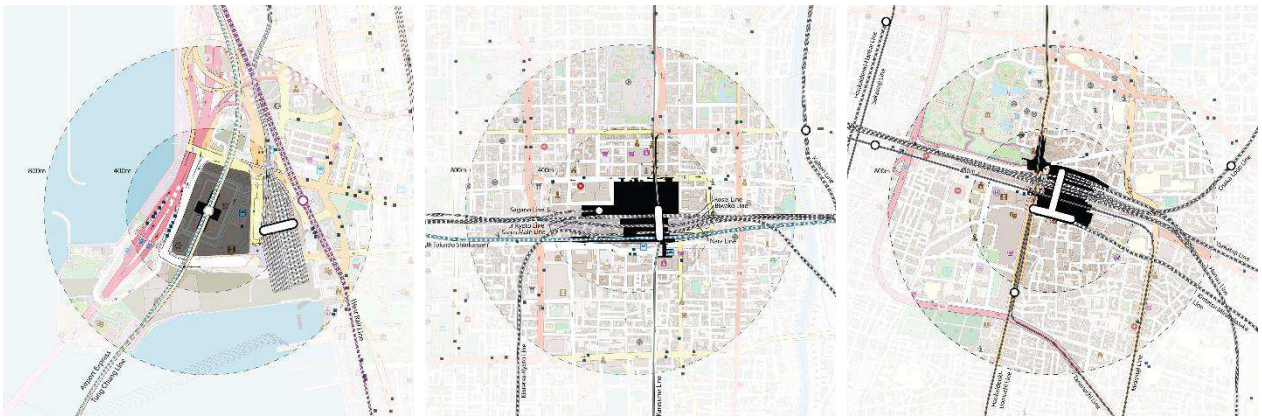


Figure 57 <comparison diagram: the TOD core and the distance to transit (400/ 800 meter radius) is highlighted of left: Kowloon Union Square, center: Abeno Harukas and right: Kyoto Main Station (these three were selected as they represent the best closeness centrality and provide the best accessibility to the respective case), source: done by author>

This 'destination access' section is the cross-paragraph of the following three points, and the relation between accessibility and connectivity (Further detailed information can be found in the literature review above):

- circulation: the movement in horizontal and vertical direction
- public space: like the plazas of ancient times
- 24/7 scenario: a strategy to make it work

Deductions drawn from 'destination access':

Apparently, Raffle City Hangzhou is the only case which does not provide a direct linkage to the public transit network, however has the highest number of main access on ground level. This is an indicator that the architects of UN Studio really thought about how to attract people walking into the building and not just passing by. All cases, except of Raffle City Hangzhou have a very high betweenness centrality index, however Kyoto JR Main Station and Lotte World Tower are with a total number of 39 transit lines at the respective nodes on another level and prove of being absolute vital points.

- **CIRCULATION** *node: the infrastructure whether horizontal or vertical within the case*

	Kowloon Union Square	Kyoto JR Main Station	Abeno Harukas	Lotte World Tower	Raffle City Hangzhou
number of elevators	83	9	56	58	48
number of lobbies (*)	2	0	5	4	0
number of floors of podium (**)	4	12	13	8	8
wayfinding degree (***)	3	2	1	1	1

Table 38 <circulation overview – comparison table>

(*) in the future, the so-called 'lobbies' will become hubs, key places that serve as social viable places and key nodes of the circulating transportation infrastructure. As node, it is where the transition from horizontal to vertical traffic on multiple levels and the blending of

different groups, each requiring different route guidance depending on their actual purpose (user groups, service delivery, takes place. All this together, including the increasingly important safety requirements, these are extremely complex entities.

(**) indicator for evaluating how much space is (semi-) public.

(***) priority vector for factors in circulation make an evaluation possible (the value refers to the relation between the factors of movement and legibility. It is the evaluation of how different user groups (businessman, resident, visitor) get an impression of the building's whole infrastructure/ function layout and how obvious it is to find the right way.):

1 = very good; 2 = good; 3 = inadequate; 4 = insufficient

In order to evaluate a meaningful statement about the circulation, several values from other sections, such as 'number of design', 'distance to transit' and 'destination access', must also be included.

Deductions drawn from 'circulation':

Even though Kyoto JR Main Station has an extension of over 500 meters it is only 70-meter-high (the effective height is even lower). This makes the low number of elevators and the lack of a lobby fully meaningful. The fact that Abeno Harukas and Lotte World Tower have 5 and 4 lobbies respectively indicates that these buildings deal with several user groups and therefore also have a complex internal infrastructure. This is also a good indicator that people use this building throughout the day and not just during working hours.

- **PUBLIC SPACE**

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
total space (x 1000 m^2)	17	3,4	8,8	7,2	5,1
number of lobbies (*)	2	0	5	4	0
distribution (semi-) public/ private	1/ 1	0/ 0	3/ 2	1/ 3	0/ 0
continuity and enclosure degree (**)	2	3	1	1	2

Table 39 <public space overview – comparison table>

(*) in future, the so-called 'lobbies' will become hubs, key places that serve as social viable places and key nodes of the circulating transportation infrastructure. As place, it functions like the plazas since ancient times. Organized in the function layout of vertical development they are acting as central platforms to meet and be to foster socializing and therefore, become true amenities as a result.

(**) Priority vector for factors in public space make an evaluation possible (the value refers to facade continuity and sense of enclosure to help create open spaces, within developments, for social interaction and support the coding of public, private or semi-public spaces. Invigorating public spaces with active frontages can further increase activity, encourage co-presence and aid security.):

1 = very good; 2 = good; 3 = inadequate; 4 = insufficient

Deductions drawn from 'public space':

Abeno Harukas and Lotte World tower provide the greatest amount of open space for different user groups within the development. This is once again a good indicator that the demand and expectation on upcoming projects is rising and inherently drives the development's complexity but also livability.

- **24/7 SCENARIO**

	Kowloon Union Square	**Kyoto JR Main Station**	**Abeno Harukas**	**Lotte World Tower**	**Raffle City Hangzhou**
existence of a 24/ 7 concept (*)			✓	✓	✓
operating hours (during week) – public transit system (**)	17,75 (05:53 - 00:52) (mtr.com.hk, 2018)	18 (05:30 - 23:30) (kyotostation.com, 2018)	19 (05:00 - 24:00) (mapa-metro.com, 2018)	18.5 (05:30 - 24:00) (kias.re.kr, 2018)	18 (06:00 - 24:00) (mapa-metro.com, 2018)
opening hours – retail (may vary by business) (**)	11 (10:00 - 21:00) (elementshk.com, 2018)	12,5 (08:30 - 21:00) (kyotostation.com, 2018)	12 (10:00 - 22:00) (osaka-info.jp, 2018)	11,5 (10:30 - 22:00) (lwt.co.kr, 2018)	24 (00:00 - 24:00) (capitaland.com, 2018)
opening hours – observatory (**)	11 (10:00 - 21:00) sky100.com.hk, 2018)	18 (05:30 - 23:30) (kyotostation.com, 2018)	12 (09:00 - 22:00) (abenoharukas-300.jp, 2018)	13 (10:00 - 23:00) lotteworld.com, 2018)	
% of opening hours: - public transit - retail - observatory	 74 46 46	 75 52 75	 79 50 50	 77 48 54	 75 100
24/ 7 scenario degree (***)	3 (0,55)	2 (0,66)	2 (0,6)	2 (0,6)	1 (0,92)

Table 40 <24/7 scenario overview – comparison diagram>

(*) this only refers to the case development

(**) number of hours that are open

(***) priority vector for factors in 24/7 scenario make an evaluation possible (the value refers to how urban life happens. The success of a development lies in its ability to foster its local and regional integration in the city and beyond provide throughout the whole day, 24/ 7, a wide range of offer. This is vital to respond the daily demands of different user-groups, such as businessman, resident, visitor.):

1 (0,8-1) = very good; 2 (0,6 – 0,8) = good; 3 (0,5 – 0,6) = inadequate; 4 (0,0 – 0,4) = insufficient

Deductions drawn from '24/ 7 scenario':

Only if the building's usage goes beyond the typical working hours it will be fully efficient and economically active. The matter that Raffle City Hangzhou is the only case that provides a '24/7' scenario highlights great potential to be duplicated in future projects.

- **RESULTS BY METHODOLOGY**

Individual categories of 'travel behavior', 'local economy' and 'built environment' were contrasted above but what makes the cases as a 'node' or/ and a 'place' successful and where is the most potential left? The '3-v approach' (Salat and Ollivier, 2017), a '3-centrality system', of the values of node, place and market potential (Roth *et al.*, 2012), provides an overall comparison overview. To follow this approach and to evaluate the main value indexes, several sub-indexes were identified. The collected data of the case studies and the cross case comparison set up the basis for the evaluation. Basically, it is the extension of Luca Bertolini's 'node place diagram', a two-axis figure, which is additionally conducted to complete this comparative case study (Bertolini and Spit, 1998).

value index	node	place	market potential
sub-index	▪ closeness centrality ▪ betweenness centrality ▪ daily ridership ▪ intermodal diversity	▪ intersection ▪ land-use diversity (*)	▪ population density ▪ economical active ▪ growth potential

Table 41 <overview of the sub-indexes of node, place and market potential value used for the following 'place node' and the '3-value approach' diagram>

node value index:

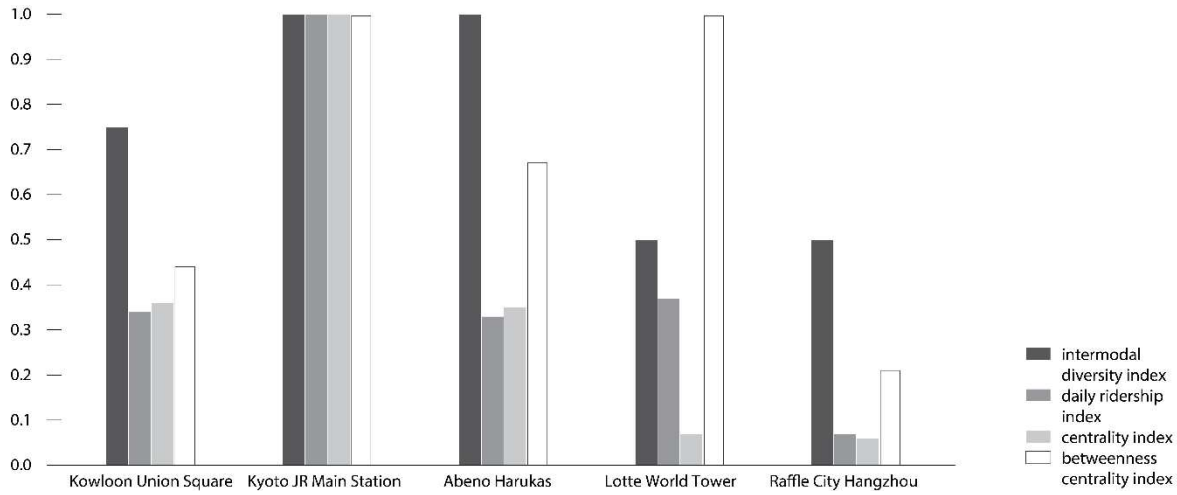


Figure 58 <comparison of the node value sub-indexes (intermodal diversity index, daily ridership index, centrality index (is the mean of $cci_{(time)}$ *and* $cci_{(distance)}$), and betweenness centrality index) reveals imbalances in connectivity, reference: (Salat and Ollivier, 2017, p. 199) done by author>

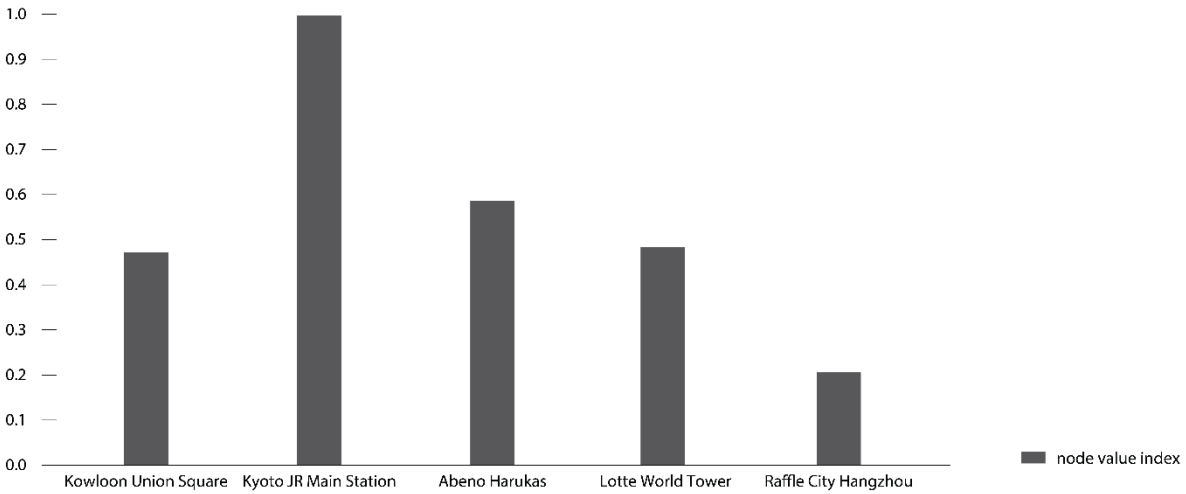


Figure 59 <resulting comparison diagram of the node value indexes of the five cases (calculated from the mean of all respective sub-indexes shown in the previous figure), reference: (Salat and Ollivier, 2017, p. 200), done by author>

place value index:

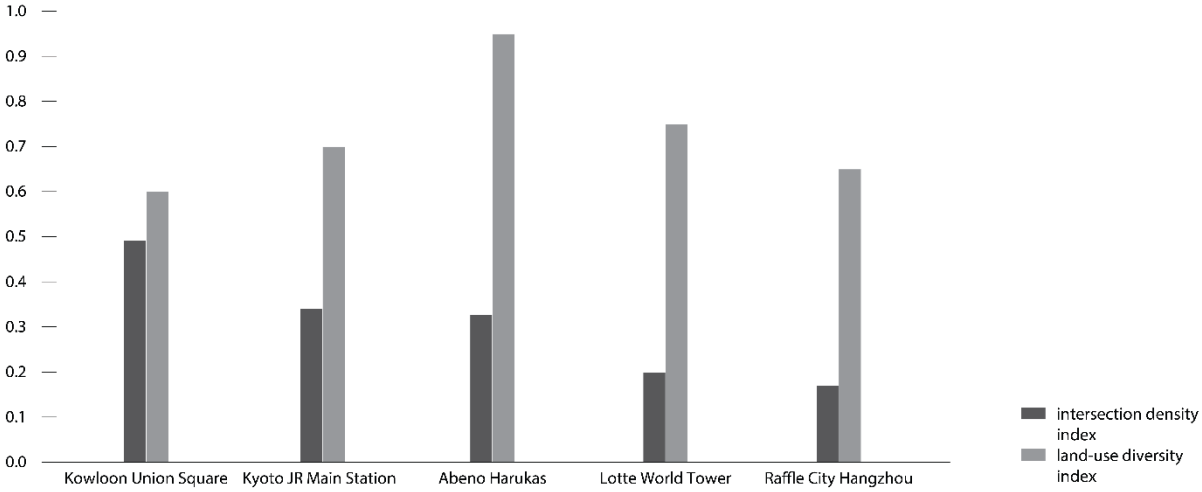


Figure 60 <comparison of the place value sub-indexes (intersection density index and land-use diversity index), reference: (Salat and Ollivier, 2017, p. 205) done by author>

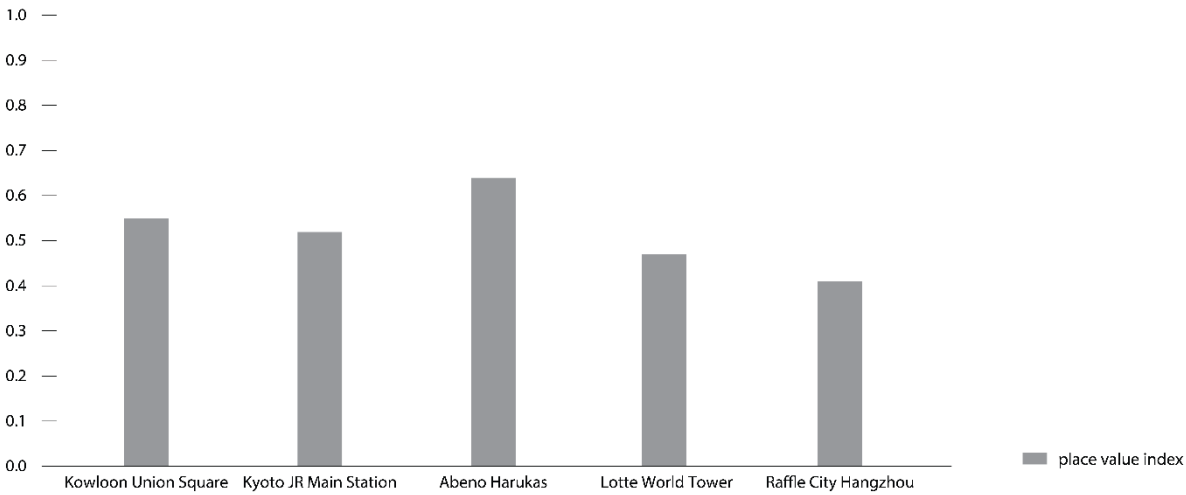


Figure 61 <resulting comparison diagram of the place value indexes of the five cases (calculated from the mean of all respective sub-indexes shown in the previous figure), reference: (Salat and Ollivier, 2017, p. 205) done by author>

market potential value index:

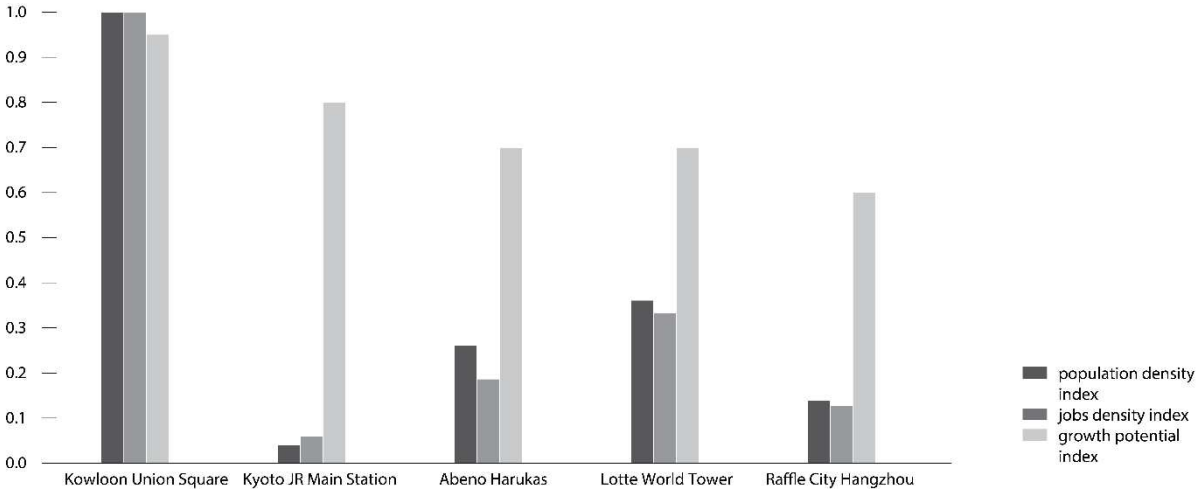


Figure 62 <comparison of the market potential sub-indexes (population density index, jobs density index, growth potential index), reference: (Salat and Ollivier, 2017, p. 209) done by author>

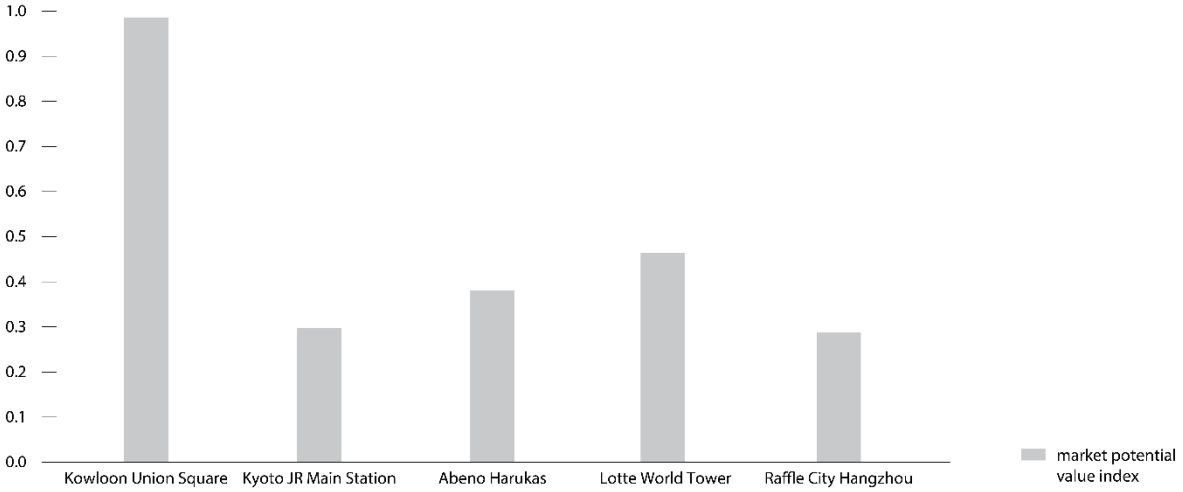


Figure 63 <resulting comparison diagram of the market potential value indexes of the five cases (calculated from the mean of all respective sub-indexes shown in the previous figure), reference: (Salat and Ollivier, 2017, p. 209) done by author>

Interplay of node, place and market potential value:

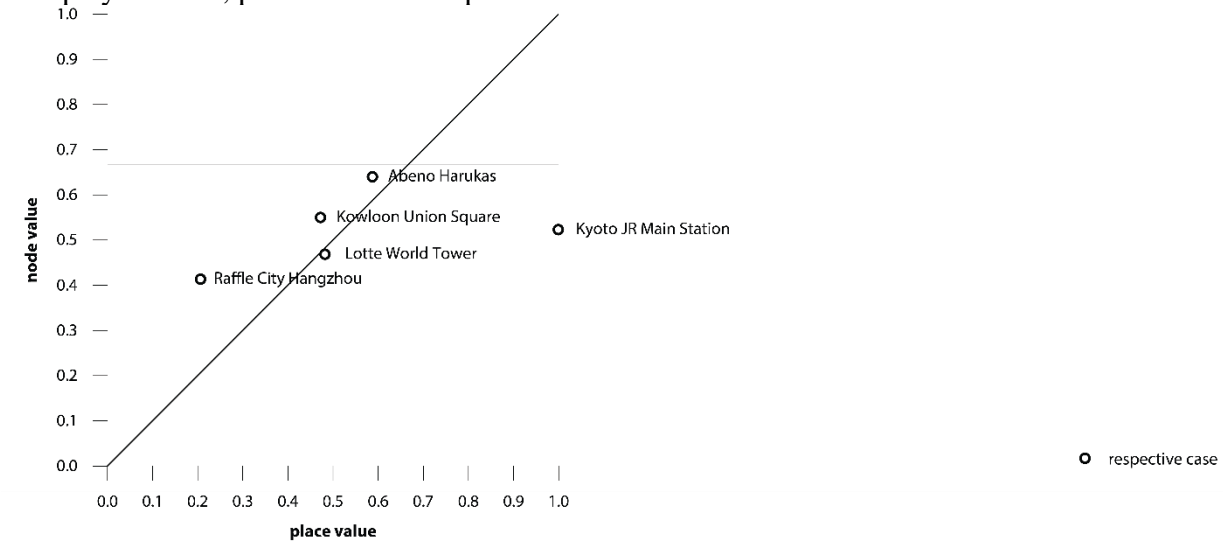


Figure 64 <relationship between node and place values – Bertolini's node place model, 1998, reference: (Salat and Ollivier, 2017, p. 2010) done by author>

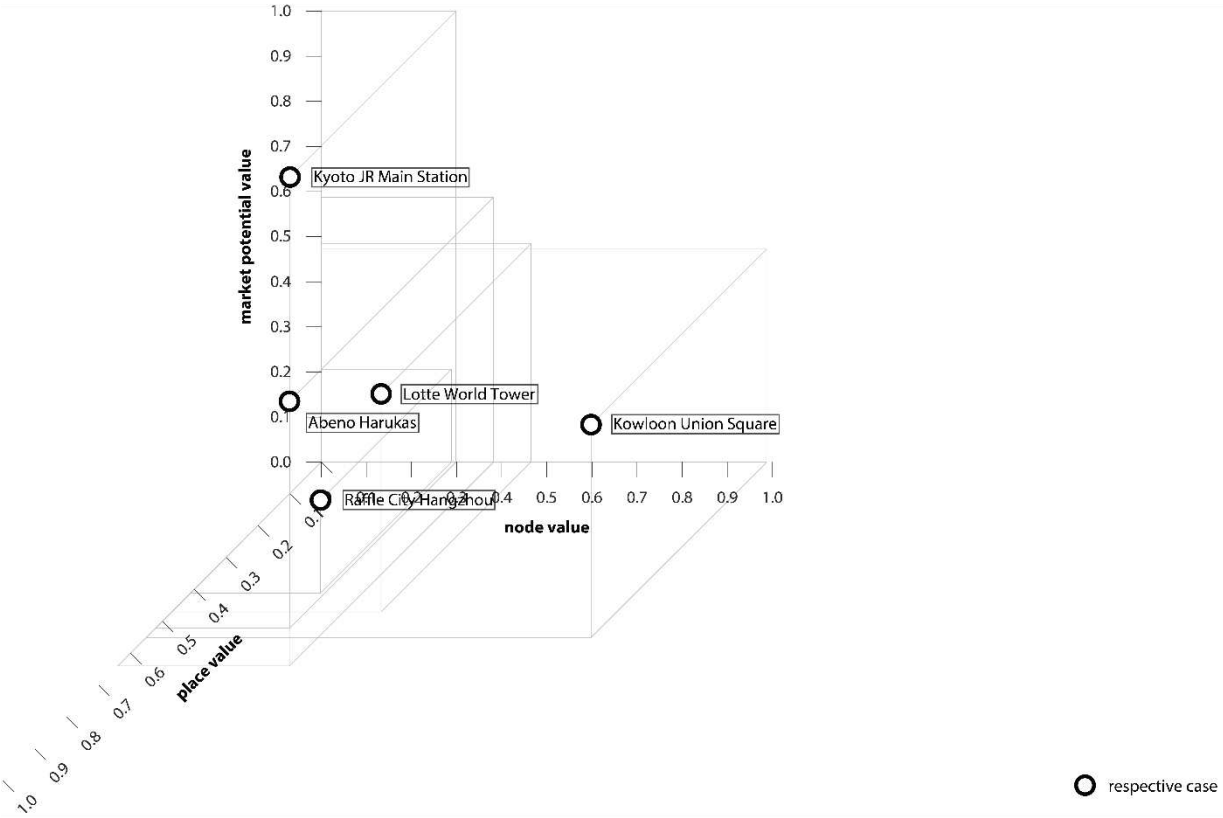


Figure 65 <synchronization of node, place and market potential value - the 3-value approach of Salat and Olivier, reference: (Salat and Ollivier, 2017, p. 7), done by author>

- **DEDUCTIONS DRAWN FROM 'RESULTS BY METHODOLOGY'**

By extracting the outcome of the diagrams that follow Bertolini's node place model and the 3-value approach of Salat and Olivier, Salat and Olivier give three specific strategies for value clusters (Salat and Olivier, 2017 pp. 51-52). Following from this:

- Kyoto Main Station is a highly connective hub with concentrated urban fabric in the surroundings (and a strong market potential value). This fosters further transformation.
- Kowloon Union Square, Abeno Harukas and Lotte World Tower are core transfer stations with concentrated urban fabric in the surroundings (and emerging market potential value). This fosters further intensification.
- Raffle City Hangzhou is a Single Line Station with concentrated urban fabric in the surroundings (and limited market potential value). This fosters further infill.

In general, these assumptions seem comprehensible, despite each evaluation of node, place and market potential value faces restrictions:

- node value: This value could be extended by taking the pedestrian accessibility between street level, urban fabric and transit station/ hub into account (walkability degree and accessibility degree).
  For instance: Kowloon Union Square and its criticized closed nature.
- place value: This value could be extended by first, distinguishing between public and private amenities and not only focusing on the function diversification and second, taking the 24/7 scenario into account. Good places are where people from any user group can meet throughout the day.
  For instance: Raffle City Hangzhou is the only case that provides a true 24/7 scenario. Lotte World Tower provides multiple open space lobbies; however, they are only semi-public as they are only for specific user groups or only accessible after buying a ticket to the observatory. In contrast, Kowloon Union Square provides a respectable park on the podium roof for everybody.
- market potential value: The evaluation of the growth potential of a specific development with an individual layout at a distinct location at a certain time is quite complex, time consuming and requires a big amount of data. In this regard, only an estimate was made in this comparative case study, which may well differ from the actual situation.

To sum up, the final figures of the diagrams that follow Bertolini's node place model and the value approach of Salat and Olivier give a sufficient first impression image and can be used to select specific cases for further investigation and analyses of the individual values/ potentials. Based on the final result of this comparative case study comparison, it would be limited to Abeno Harukas, Lotte World Tower and Raffle City Hangzhou for further analysis.

- **NOTE**

The following (worldwide) projects were also reviewed for this research section:

- Super-High-Level Competition Plan for South Bank District of Melbourne, 2018 (concept) – Blue Sky Group
- The Interlace, Singapure, 2013 – Ole Shereen
- Sliced Porosity, Chengdu, 2012 – Steven Hall
- Chongqing Chaotianmen, Chengdu, 2018 – Mosche Safdie
- Skyville, Singapore, 2015 – WOHA
- Shanghai Tower, 2015 – SOM
- Hudson Yards, New York, 2025 – Diller Scofidio + Renfro
- Yongsan International Business District Block H, 2012 (concept) – KPF
- Cadre City, Guangzhou, 2014 (concept) – Atkins
- Wangchao Center, Hangzhou, 2021 – SOM
- Guangzhou Finance Centre (CTF), Guangzhou Zhujiang New Town, 2016 – KPF

3.8 Conclusion of the Comparative Case Study

The following observations were drawn from the collected key findings of the conducted case studies, the cross case study comparison and the evaluated results by methodology. It should act as a trigger for thinking for the design of hybrid super-tall buildings at center locations in the future.

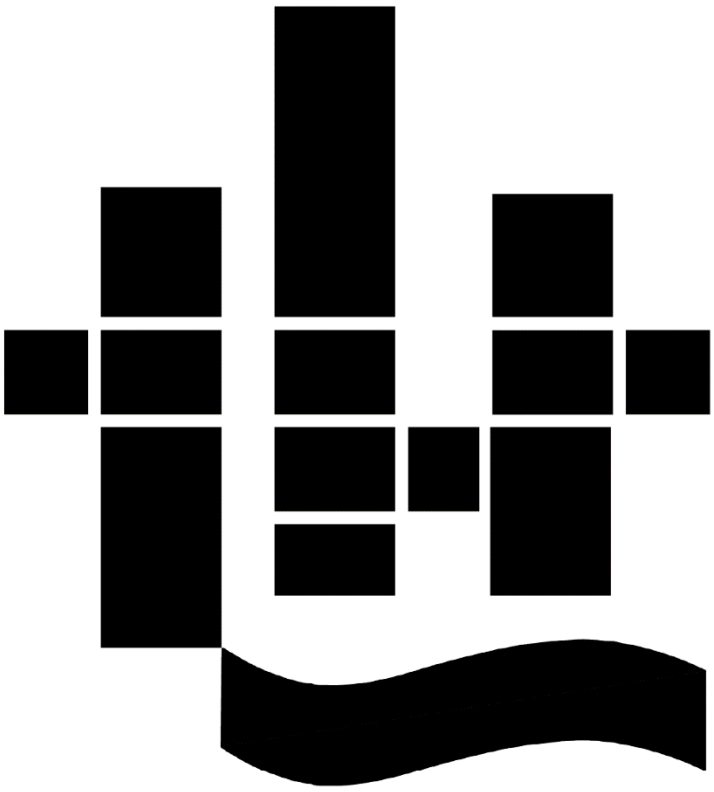
- Lessons drawn from Cross Case Study Comparison

These concluding facts are given as a list of recommendations to use it later as a tool to provide a set of guidelines. Therefore, it helps to foster the development of the following thesis design project and its potential impact and success. In this way, the given recommendations get tested if the given explanations are the only perception or should be expanded by other perspectives, which would require a further contention with regard to the literature review, case studies, analysis and research framework:

- Urban Fabric is more efficient and sustainable if the vehicle ownership is as small as possible and the public transit the superior means of transportation. The higher the population density the higher the overall effectiveness and success – as long as the maximum utilization of the public transport network is not completely exhausted, otherwise collapse at peak times (3.7 – Density, Level I).
- Despite point one, a certain percentage or certain user groups use the car. Enough parking slots need to be provided within the development or immediate vicinity. It's not about banishing individual means of transportation, but finding the right proportions for that specific location. To justify the effort of a project / investment, the built-up area must always be maximized (3.7 – Density, Level II).
- A TOD project can combine various urban functions of the surrounding urban

environment or be built in a mono-functional area in order to inject momentum into the development of the region (3.7 – Diversity, Level I)

- Demand and expectation of upcoming projects is rising and inherently drives the development complexity. The trend is to combine and coordinate more functions within one project. This legitimizes the effort of developing the theory of the vertical city (3.7 – Diversity, Level II).
- A project works only if it is for the people and in the right scale. Major importance is to integrate the pedestrian layer into the transportation infrastructure at its best to result in a high walkability degree (3.7 – Design).
- People will only use Public Transit if it's right next to them. The distance to public transit needs to be minimized and the closeness centrality maximized (3.7 – Distance to Transit)
- It's all about accessibility, how to attract people walking into the building and not just passing by (3.7 – Destination Access).
- The more user groups the more complex (lobbies, number of elevators, public-private) is the internal infrastructure. However, this makes people use the building throughout the whole day more likely due to its additional amenities and not just during working hours, which significantly increases efficiency (3.7 Circulation).
- Public Open Space (pockets or rooftops) within the development is a key function to increase the livability. Different public and private spheres make various user groups benefit from it (3.7 Open Space)
- Only if the building's usage goes beyond the typical working hours it will be fully efficient and economically active – the ideal scenario would be a 24/7 usage (3.7 24/7 Scenario).



Qianjiang Century City

4 Analysis Research of Qianjiang Century City (QCC, Hangzhou)

4.1 Framework of the Case Study

- Purpose

The following case study is an in-depth examination of Hangzhou, in specific of the 'new' CBD area – Qianjiang Century City. In contrast to the comparative case study above, which analyses and compares already realized TOD projects and vertical hybrid developments, this research part evaluates the potential value for an infill project – a center terminal building, a compact vertical city – placed at center location. In this regard, it is the preparation for the thesis project of practical work.

- Clarification of the key evaluation questions

How to upgrade the city development by more mobility and accessibility and how to integrate such an infill development? What is the actual potential of a TOD project in Hangzhou? What impact could it cause on the city (architecture and public transportation), and even more importantly, what effect does such a structure have on the community, on the people living in it and with it? It particularly pays attention on the integration process, as infill development, in the existing CBD area of Hangzhou. The resulting positive and negative aspects, and implications are of major interest to measure the potential project's success and value.

- Definition of the type of case that will be included and how the case study process will be conducted

In some way, it is a two-sided – transit- and urban planning – research which starts from a metropolitan perspective, goes down to the city level and the 800- and 400-meters radius approach (the typical TOD radius that are used). This research finally ends up by examining the actual chosen site for a huge infill TOD project at the Yingfeng lu station (subway line 2).

- Definition of how evidence will be collected, analyzed and synthesized within and across cases and how to conduct the study.

Considerable material used for this case study is available on web pages, in articles and reports about the respective case. A first impression of the site location, CBD Hangzhou, was already gained in August 2017 during the workshop 'Eco Community Urban Design Workshop' in Hangzhou for the Chinese Games in 2022. In 2018, further experience of the CBD area was gained by participating in the international competition "Conceptual Architecture and Landscape Design on the International Zone of 2022 Asian Games Athlete Village (Hangzhou)".

In addition to this, further multi-day site visits were done in July and August 2018 to evaluate the current existing transit and urban planning conditions in person and collect further data of the site and surroundings. The highlight of this trips was a meeting with Mr. Sun, Director of die Urban Planning Department of the Qianjiang Century City (QCC), Hangzhou.

Note: the following information is based on the Hangzhou City, Qianjiang City Core Area Unit Control Detailed Planning Revision of April 2018 (Tongji University, 2018). The

document is provided by the Planning Bureaux of Hangzhou, in its received form written in Chinese and not officially published.

4.2 Background and Overview

- Location and Planning Scope:

The area of focus is the Qianjiang Century City (QCC), which is located in the central part of Xiaoshan District, Hangzhou, with a great view to Jianggan district across the Qiantang River, where the ancient town center of Hangzhou is also located. Basically, QCC (CBD Hangzhou) is limited by the Qiantang River in the West, by a landscape park belt with a railway high-line in the East, by the Asian Games Village (2022) to the Minxiang Road in the North and by the Jinji Road in the South. Accessibility by the public transport is ensured by metro line 2, metro line 6, and the new metro line X that pass through this area. The development plan envisages that QCC area, which covers 614.20 km^2 in total, becomes the 'new center' of Hangzhou after completion (expected in 2022).

- Preparation and Background:

The main driver of Hangzhou's intense development are the Asian Games, which will be held in Hangzhou in the northern part of the QCC in 2022. Such major events will further inject momentum into the development of the region and accelerate promotion of Hangzhou in the long term. The core unit of QQC and the current downtown area of Hangzhou generate an "urban cross-river axis". It is basically bounded by the Second Qianjiang Bridge and the Third Qianjiang Bridge. Jianggan district, north-west of Qiantang River, is largely saturated. However, QCC, on the south-east side, provides more land and potential to further develop. In this regard, the location and direction of expansion on the city level are given. To a big advantage, the infrastructure of QCC is predominantly completed and has high-level development conditions and foundation. The financial business function of QCC's core business and the degree of agglomeration far exceeded the expectations. Already today QCC has become a vital "new center" of Hangzhou.

Figure 66 <left: Hangzhou and the New Center (consisting of Qianjiang New Center and Qianjiang Century City) and right: Qianjiang Century City, source: google-maps, done by author>

- Major Units of QCC:

(0) North Part: The Asian Village will be built on a 3.46 m^2 planning area. The very dense urban network efficiently integrates multifunctional integration development with innovative industries, cultural experience, leisure and entertainment for athletes, visitors

and people living or working at this place.

(1) Core Unit of QCC: The functions of public, financial, trade, information, commerce, exhibition, tourism, and residence are combined to play the role of the central business district.

(2) Southern Part (Aobo Unit): Major buildings of this area are the two stadiums, the exhibition center and the State International Expo Center, the main venue of the G20 summit in 2016, which had a major impact on the development of QCC.

(3) Green Belt/ Ring: The element creates a harmonic boundary all around QCC, not a barrier, but a place that stands in contrast to the dense urbanity, is freely accessible to everyone 24/7 and rich in water environment and greening resources.

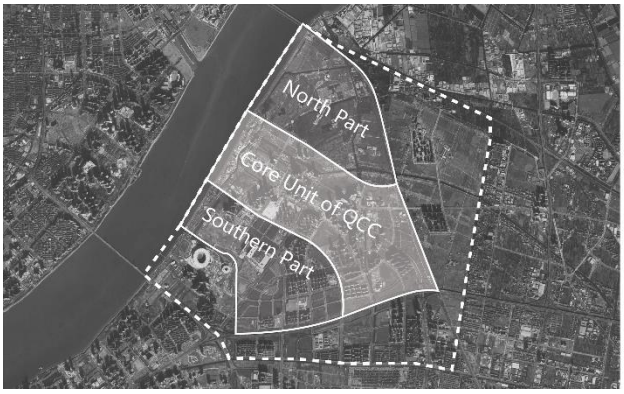


Figure 67 <the Major Units of the Qianjiang Century City, source: google-maps, done by author >

4.3 Status Analysis and Evaluation of the Core Unit of QCC

- Demographic Status of the Core Unit of QCC:

There are currently 9 residential communities within the planning area, of which Fengbei Jiayuan and Lierjiajiao are resettlement communities. Apart from that, also some residential buildings exist, especially in the south and east of QCC. The current population (April 2018) is about 12,600 and is expected to rise to a total of 32,000 inhabitants.
The plan predicts 2.464 Kindergarten students, 4.928 primary students and 2.464 junior high school students in the Core Unit of QCC. According to the 35, 45 and 50 students in each class, 82, 110 and 49 classes are required respectively and are already partially constructed.

- Land-use status of the Core Unit of QCC:

Serial number	Land name			Land code	Area (hm^2)	proportion(%)
1	**Construction land**			H	379.56	61.80
	among them	Urban and rural residential construction land		H1	355.17	57.83
		among them	Urban construction land	H11	349.04	56.83
			Village construction land	H14	6.13	1.00
		Regional transportation facilities		H2	24.39	3.97
		among them	Railway land	H21	20.00	3.26
			Road land	H22	4.39	0.71
2	**Non-construction land**			E	227.93	37.11
	among them	Water		E1	42.07	6.85
		Agricultural and forestry land		E2	185.86	30.26
3	total				614.20	100

Table 42 <overview of urban and rural land use of the Core Unit of QCC, source: (Tongji University, 2018)>

Serial number	Land code		Name	Land area (hm2)	proportion (%)
1	**Residential land**			62.45	17.89
	R	R21	Residential land	58.98	16.90
		R22	Service facility land	0.56	0.16
		R2/B1/B2	Residential mixed land	2.91	0.83
2	**Public administration and public service facilities**			12.89	3.69
	A	A3	Educational research land	12.89	3.69
3	Commercial service facility land			86.83	24.88
	B	B1	Commercial land (Industry)	1.16	0.33
		B2	Commercial land (Business)	23.50	6.73
		B1/B2	Industry and Business commercial mixed land	62.17	17.81
4	**Road traffic land**			124.74	35.74
	S	S1	Road land	124.74	35.74
5	**Utility land**			4.15	1.19
	U	U1	Supply facility land	2.29	0.66
		U2	Environmental facility land	0.26	0.07
		U3	Safety facility land	1.60	0.46
6	**Green land and Plaza**			57.98	16.61
	G	G1	Park green space	41.67	11.94
		G2	Protective green space	1.06	0.30
		G3	Plaza	15.25	4.37
7	**total urban construction land (H11)**			349.04	100

Table 43 <composition of urban construction land of the Core Unit of QCC, source: (Tongji University, 2018)>

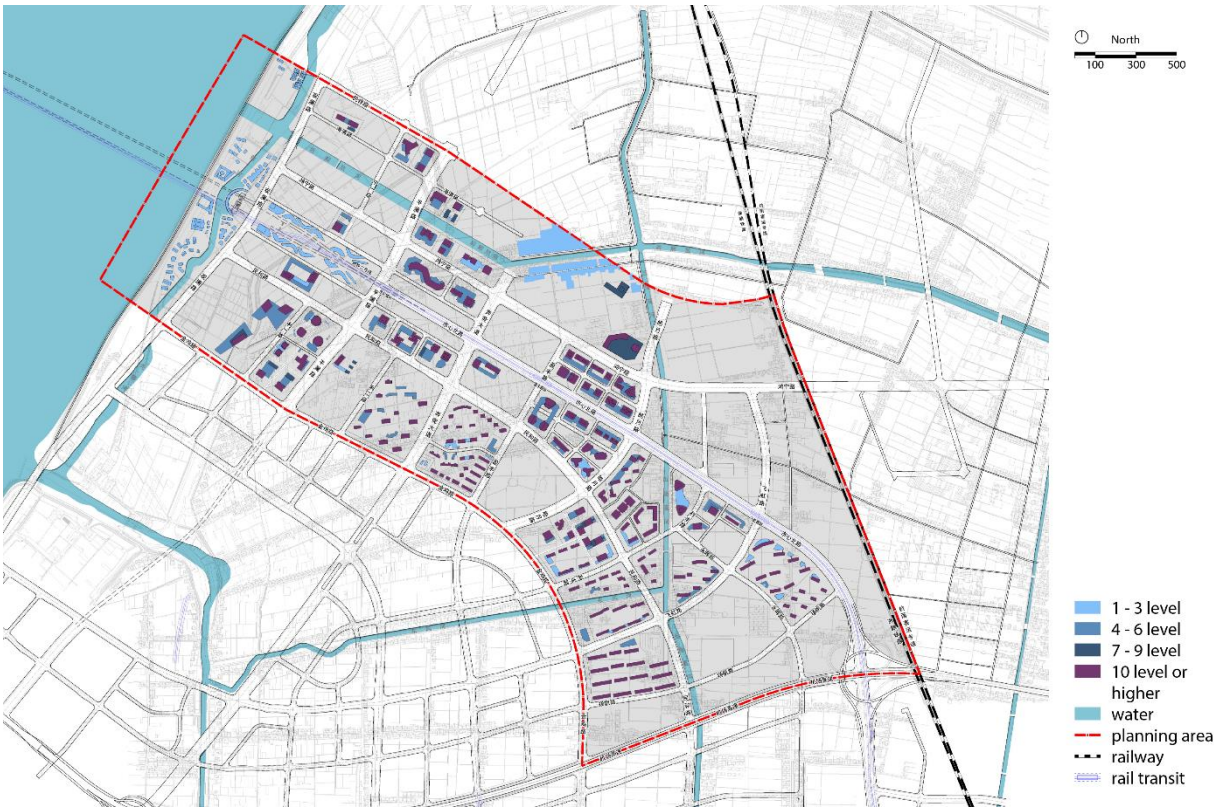


Figure 68 <Height distribution of the urban fabric of the Core Unit of QCC, source: (Tongji University, 2018, p. 54) edited by author>

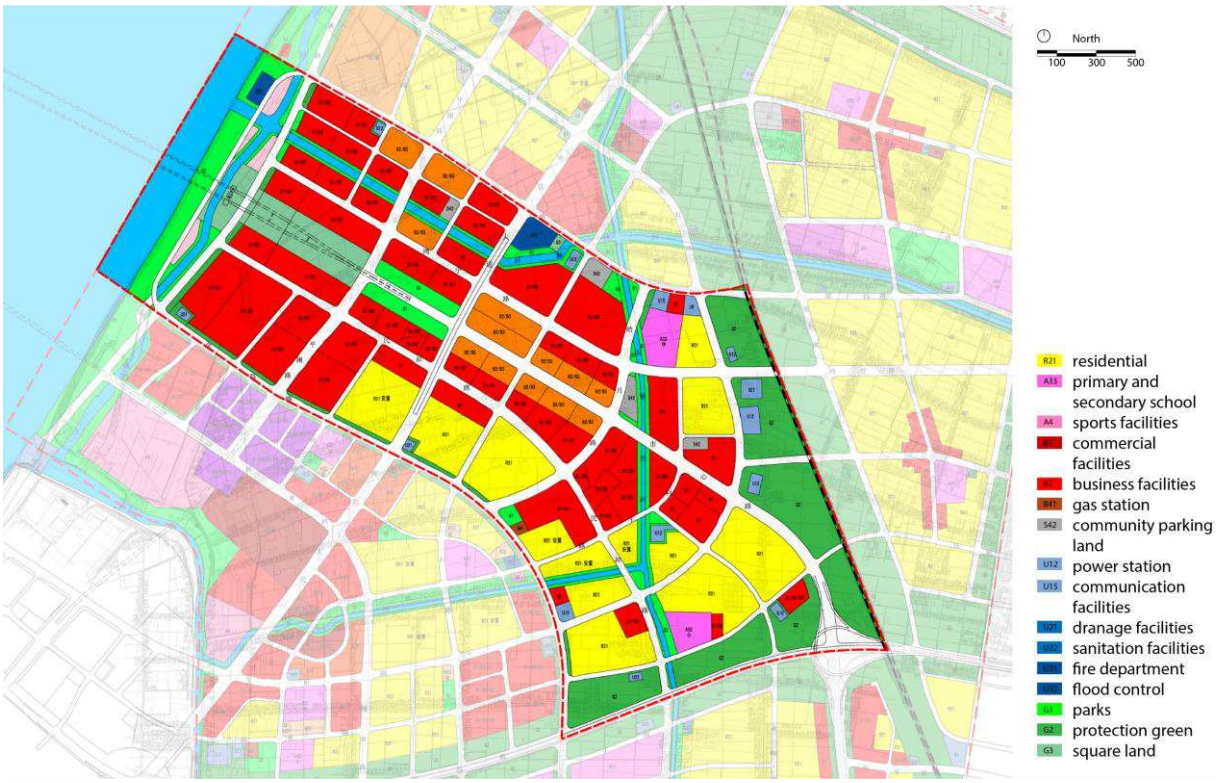


Figure 69 <Land use diagram of the Core Unit of QCC, source: (Tongji University, 2018, p. 55) edited by author>

- Infrastructure Status of the Core Unit of QCC

- regional traffic analysis:

In the central section of the Yangtze River development, road traffic on both sides of the Qiantang River must strongly support the development of cross-strait integration. In the urban inner roads, it is necessary to consider that the transit roads do not cut the city under the condition of retaining mobility.

- road system ideology:

Guided by the needs of urban development, the district will be greatly developed and prospered by adjusting the road network layout in the core area of Century City, strengthening urban functions and optimizing urban forms. The aim is to ensure road transport services that meet diversified transport demands in terms of quality and quantity, maintain the dynamic balance between supply and demand and guarantee high reliability. This will be facilitated by a multi-level road network with high efficiency, complete functional structure and reasonable grading is constructed to achieve stratified and diversion, internal and external combing, incremental coordination and stock efficiency.

- road system planning:

It is planned to further improve the structure of the road system and form a hierarchical network of trunk roads, secondary trunk roads and branch roads. The road traffic planning in the core area of Century City is based on the principle of optimizing external traffic, separating cross-border traffic, and narrow streets in the district. The Planning Bureaux of Hangzhou plans to form a “six vertical and five horizontal” urban trunk road network framework and a “narrow street secret road” branch road network.

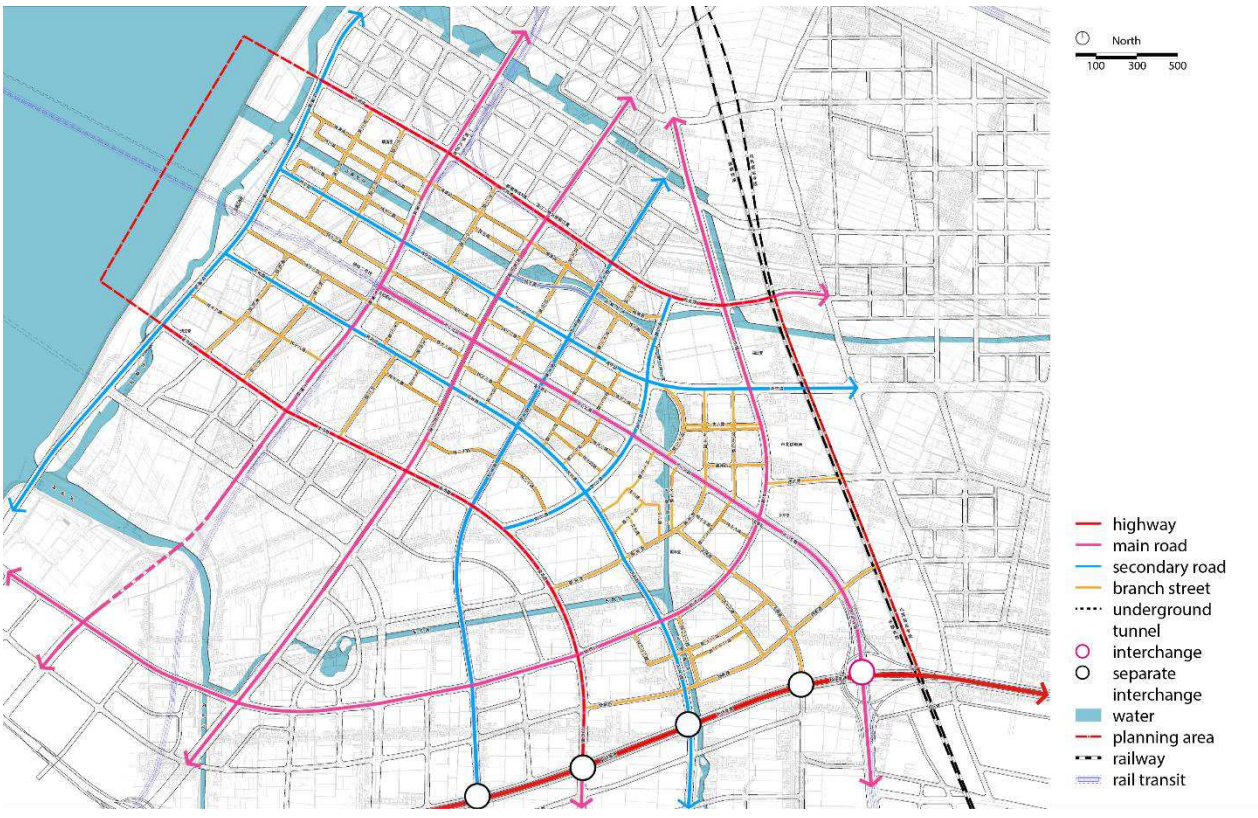


Figure 70 <hierarchy of the road traffic system of QCC, source: (Tongji University, 2018, p. 68) edited by author>

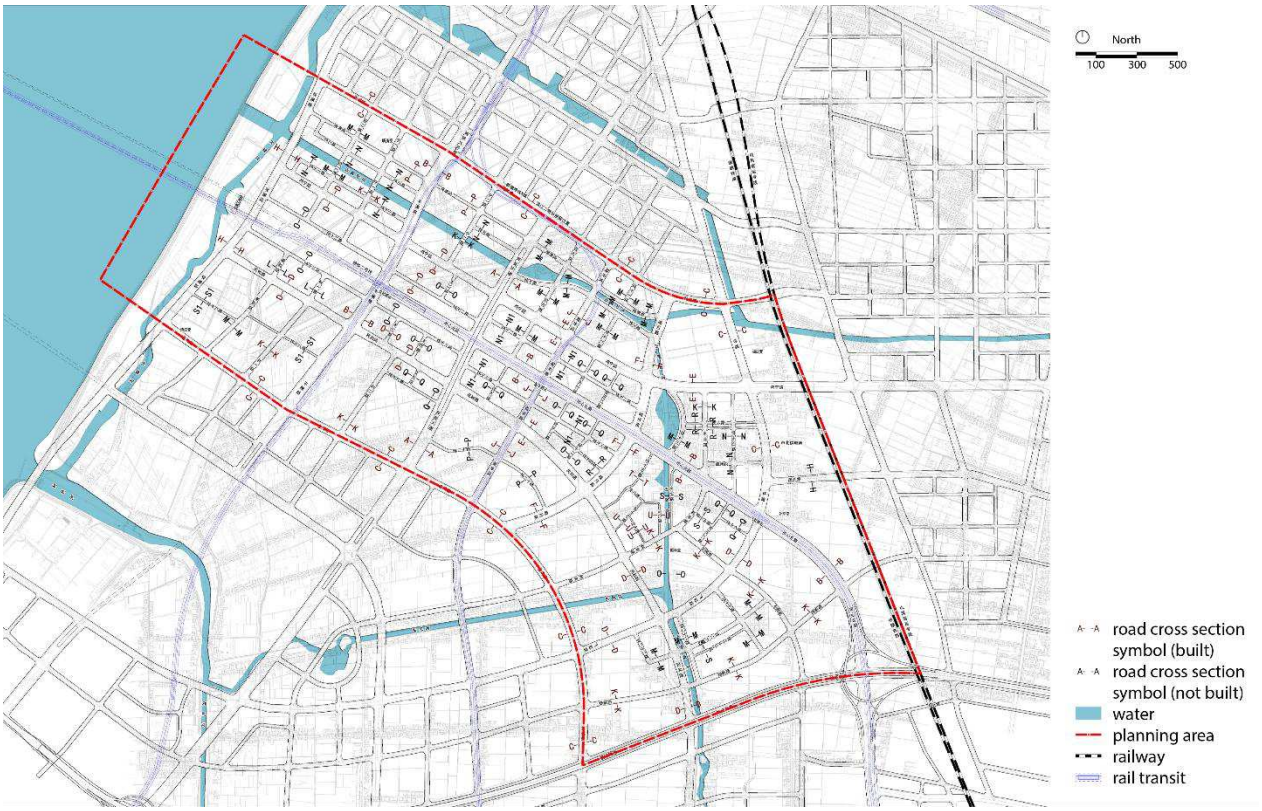


Figure 71 <overview of the street sections of QCC, source: (Tongji University, 2018, p. 69) edited by author>

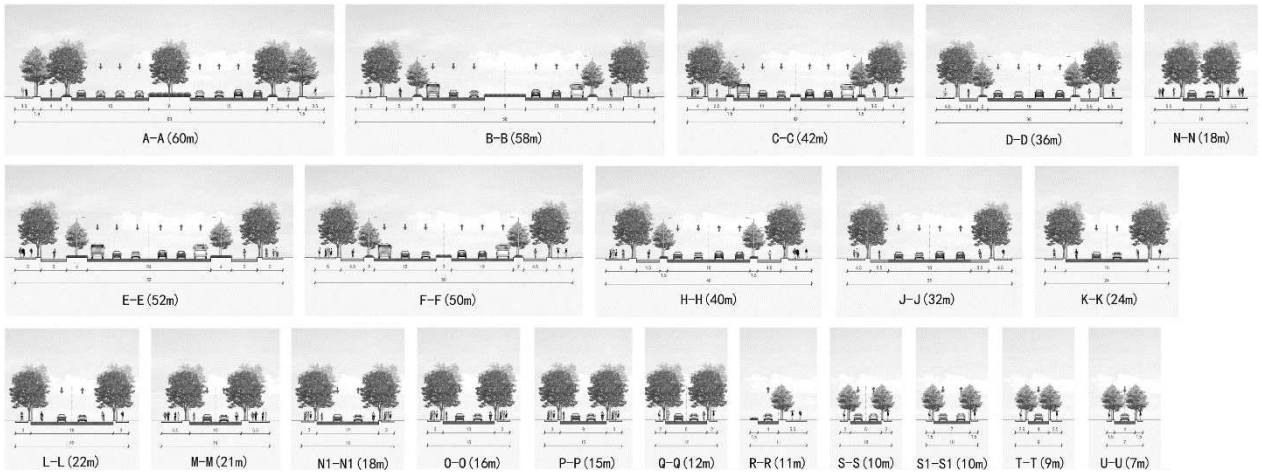


Figure 72 <street sections of QCC, as location reference watch previous figure, source: (Tongji University, 2018, p. 70) edited by author>

- Public Transportation Status of the Core Unit of QCC

- subway and rail transit (network):

The Plan is to build three subway lines, Line 2, Line 6 and X Line, and set up Century City Subway Station, Yingfeng Lu Subway Station, Feihong Road Subway Station and Binjiang Second Road Subway Station, a total of 4 stations within the Core Unit of QCC (Line 2 and line 6 are already realized).

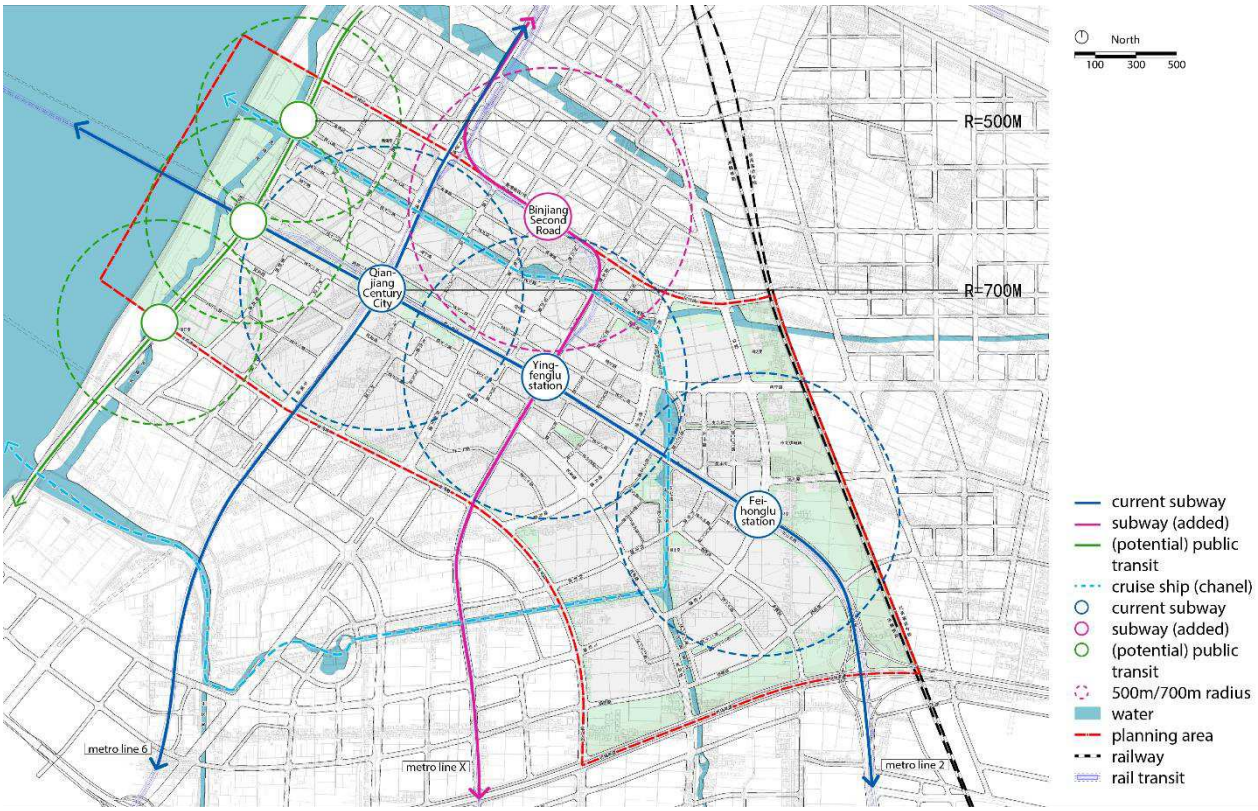


Figure 73 <public transportation: subway and rail transit, (Tongji University, 2018, p. 71), edited by author>

- regular bus (network):

The bus stop is set up according to the requirement of 100 percent service radius coverage of 100 meters. The main and secondary trunk roads should be arranged with bus stop-way stations as required, while the bus hubs are combined with the subway stations. In total, 10 bus lanes (and 23 stations) will operate within the Core Unit of QCC.

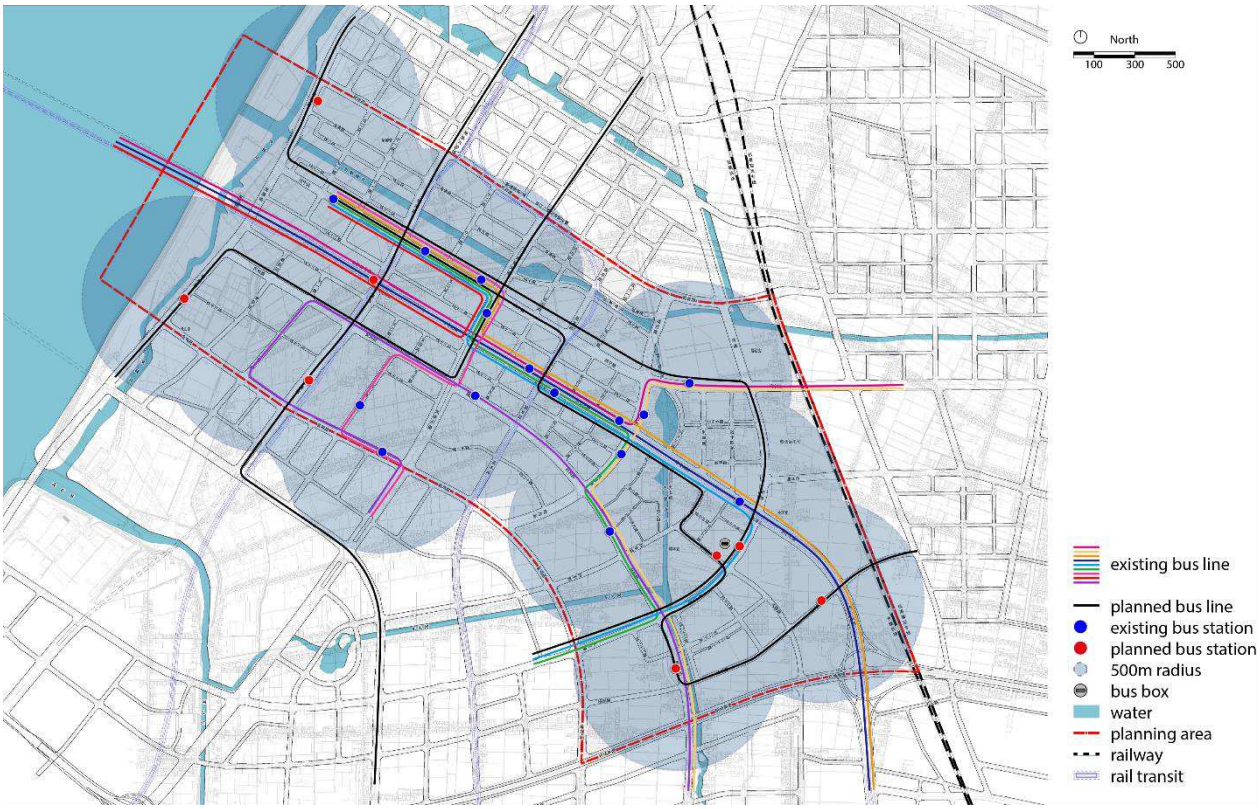


Figure 74 <public transportation: bus system, (Tongji University, 2018, p. 72) edited by author>

- taxi station (points):

It is planned to set up a number of taxi waiting stations (waiting points) in combination with the public transportation hubs, large shopping malls, hospitals and primary/ secondary education facilities. The waiting stations comprise an average of 3 to 5 berths, but not more than 10 berths.

- slow system (pedestrian network):

To set up a three dimensional, complete pedestrian network, waterfront/greening space, transit stations, and open space squares need to be integrated well. Elements such as bicycle lanes and walkable paths strengthen this approach at the level of the pedestrian. The system covers the areas along the Qiantang River, the Houfang River, the Wubaozhi River and the Pioneer river land and further strengthens the greening network.

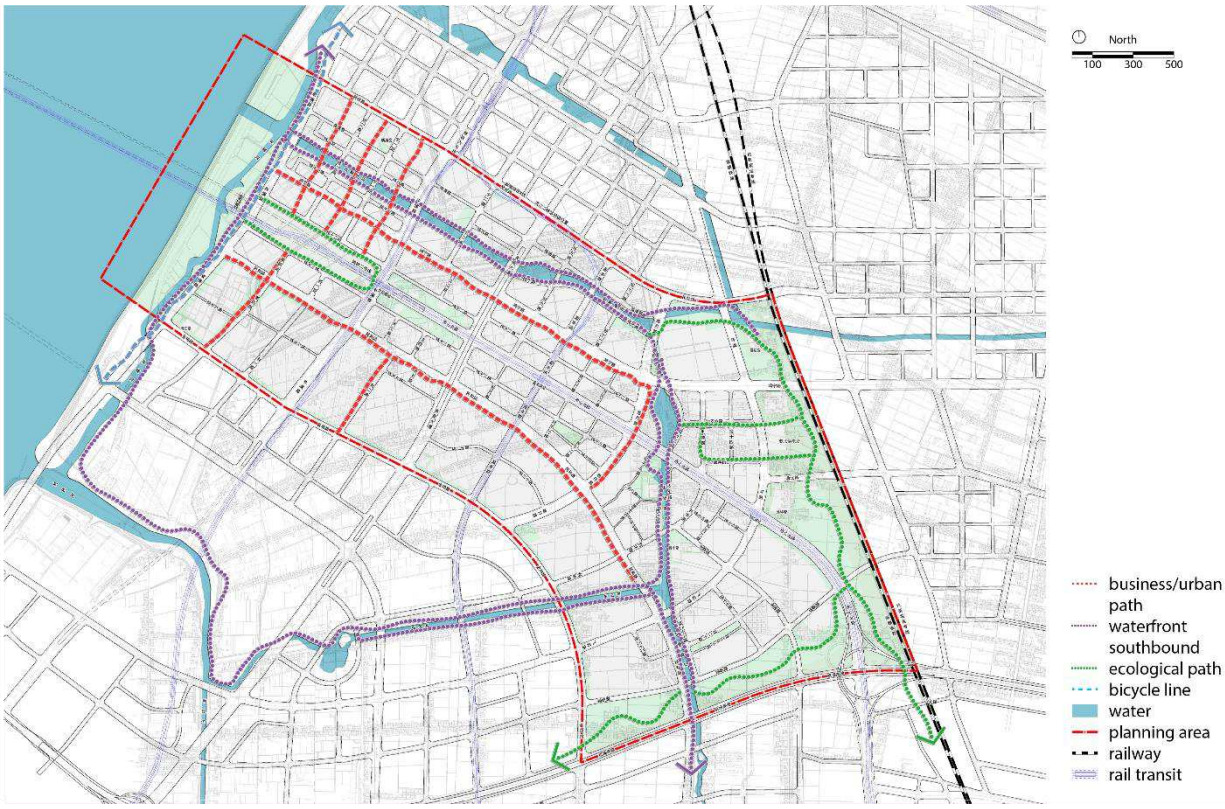


Figure 75 <slow system: bike lines and pedestrian paths, (Tongji University, 2018, p. 73) edited by author>

- Open Space Status (Greenland and Plaza System) of Core Unit of QCC

- layout of the open space of the Core Unit of QCC:

The whole Greenland and Plaza concept consists of the green ring, a landscape structure of multiple axes and multiple nodes. This approach constitutes the basic skeleton of the urban landscape. The total green land and plazas area of the Core Unit of QCC cover 57.98 hm^2 or 16.61 percent of the total urban construction land. This results in a per capita park green space index of 11.6 m^2 per inhabitant.

- Principles and Targets of QCC's Open Space:

(1) The principle of ecological harmony combines the strict protection of the waterfront landscape greening and the design of key landscape nodes.

(2) Construction of an urban network with greening on both sides of the main roads to set up a number of ecological green corridors.

(3) Strengthening the creation of green spaces for recreational activities to optimize the urban living environment.

(4) The natural geographical conditions of the water system and urban green space system get fully exploited to pursue the principle of ecological priority and to meet the requirements of sustainable development.

(5) Actively combination of railways and roads with the river system and greening network to follow the "garden city" strategies.

(6) To maximize the potential land use, the principle of "ecological priority" leads to pocket and rooftop parks. The multiple-level green space system will further improve the urban

environment characteristics.

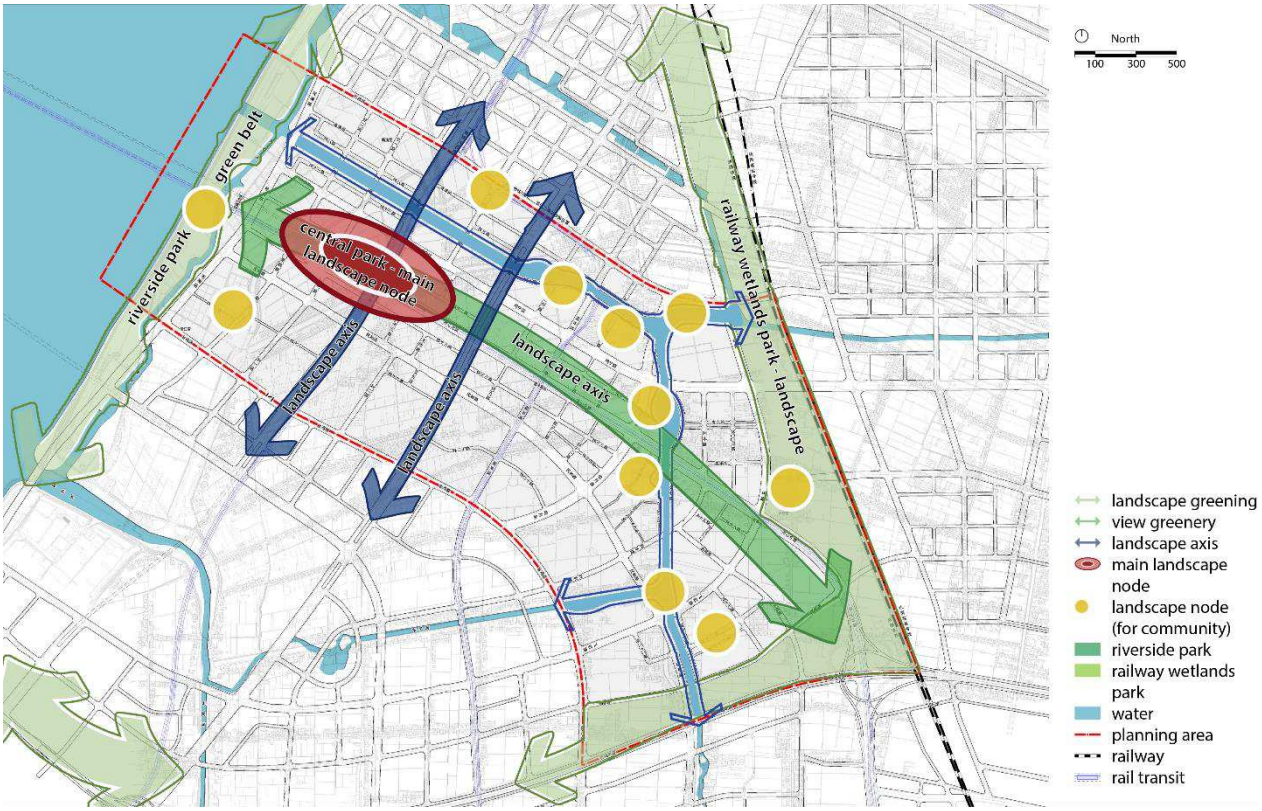


Figure 76 <greenland and plaza system: multiple-axis and multiple-nodes, source: (Tongji University, 2018, pp. 60–61) edited by author>

- Underground Space Utilization Plan Status of Core Unit of QCC:

- Layout and Function of Underground Space:

(1) Underground commercial development, including functions such as catering, retail and entertainment, and will be mainly concentrated in the core are of QCC. The comprehensive combination of underground commercial space and subway sites of 2-3 stories is in planning at the Century City Station and Yingfeng Lu Station. This effort makes these spots potential TOD nodes.

(2) Underground garage with 1-3 floors will be created on all mixed use, residential and commercial plots to fit the people's requirements.

(3) To improve accessibility, the underground spaces between various small blocks can be connected or co-constructed if needed.

- The principles of underground space:

(1) The principle of intensive and efficient development strives for functional compounding, value commercialization, development flexibility to achieve intensive and efficient development of underground space and ensure sustainable land use.

(2) The principle of coordination between above ground and underground space demands that underground space is part of urban space and not less of value. Therefore, planning must fully consider the functional relationship between above ground and underground.

(3) The principle of government-led and public-private collaborative construction states that

the government and the enterprise share the building functions of the underground space: The government is leading the construction of backbone infrastructure (such as subways, underground roads, underground municipal facilities, etc.). The market focuses on the comprehensive construction within the plot and the network improvement of the communication channels between the plots.

(4) The principle of development intensity states that all plots should be developed underground no more than 3 layers. If development requires more than 3 layers a credible argument must be provided. Drawn from this, the total available underground area is 281.14 hm^2. This could result in about 8.4 million m^2 of underground space if the maximum theoretical supply of three layers would be exhausted.

(5) The principle of lighting comfort states that underground parking space should make full use of natural lighting and ventilation if possible. When conditions permit to encourage the use of landscape techniques to enhance the quality of underground space. For instance, set up sinking plazas to provide access to natural lighting and fresh air, and maintain visual connection with the ground level.

(6) The principle of readability states that underground space areas, nodes, channels, etc. should be highly identifiable, with good sense of direction, with not too many signs, and high accessibility.

- Guidelines resulting from Status Analysis

- Plot Control Guidelines:

(1) Control indicators: First, prescriptive indicators: Land use boundaries, land use properties, land area, floor area ratio, green space rate, motor vehicle entrance and exit orientation, and necessary public service facilities and municipal facilities. Second guiding indicators: building density, height, limit, residential population capacity, land compatibility, site design guidelines, architectural form, volume, style, color requirements and so on.

(2) Set-back and Block-model: The borders of the plots, the section layout of the road and the spacing between the buildings need to be strictly controlled according to the "morphological control plan". (watch figures of 'Public Space Planning Control Guidelines")

- Public Space Planning Control Guidelines:

(1) Composition of Public Space: The public space consists of streets (including sidewalks), parks, plazas, and open sections within the borders of development plots (including building demarcation public spaces and street corner plazas). Public space must be open to the public 24 hours unconditionally.

(2) Basic Element of Open Space: The main focus is on both sides of the street (including space between the motorway and the building interface). It should be dominated by hard paving surfaces (hard-paving rate ≥ 70 percent) in combination with urban furniture, street lights, service facilities and small landscape greening facilitate pedestrian access and residence. This further improves the efficiency of the greening environment. The long side

of continuous landscape greening should not exceed 10 meters to avoid the street being separated from the buildings along the street (figure 18-1).

(3) Public Space Interface Element: The area of windows, doors should be more than 60 percent in order to ensure the people's interaction.

First, the street interface should be continuous, ≥ 70 percent (figure 18-2).

Second, when setting back the building, the depth should not exceed 3 meters, the net height should not exceed 5 meters (this area is not included in the FAR-calculation), and must be open to the sidewalk ≥ 60 percent. The line rate of the riding section should be 100 percent (figure 18-3).

Third, if a street corner square is set, the area of opening (windows and doors) should account more than 60 percent (figure 18-4).

Forth, a non-continuous opening section of the bottom layer of the building shall not exceed 20 meters in length. Building volume should be filled in potential upper floors. The line rate of the building should be 100 percent (figure 18-5).

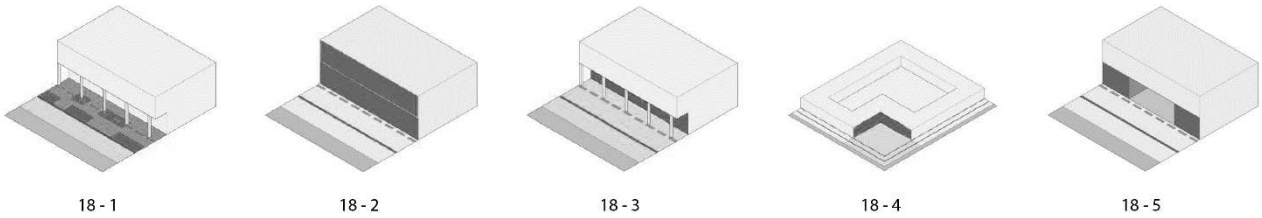


Figure 77 <schematic diagram of public space guidelines of QCC, source: (Tongji University, 2018, pp. 37, 38) edited by author>

(4) Demarcation of Public Space: Along the red line of the building's bottom floor public space is provided. No walls or obstacles will be implemented to ensure the people's interaction between the street and urban fabric. A balcony (or bridge) is allowed to enrich the street facade however must be set above 10 meters of the ground. The projected area does not exceed the total area of the demarcation space. 30 percent are not included in the FAR-calculation (Figure 18-6).

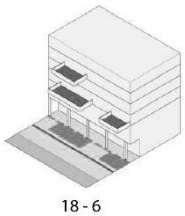


Figure 78 <schematic diagram of the demarcation of space of QCC, source: (Tongji University, 2018, p. 38) edited by author>

4.4 Site of the Thesis Design Project: at Yingfeng Lu Station

- Level 0: subway station – Yingfeng Lu Station

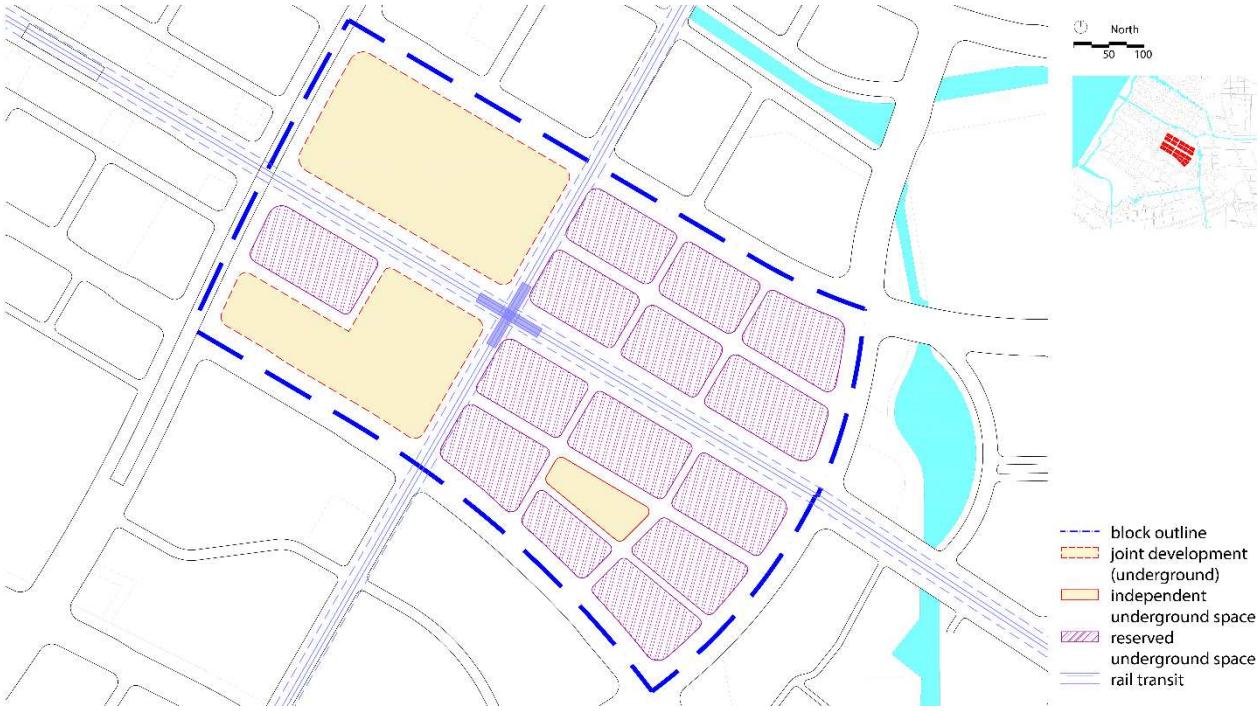


Figure 79 <Yingfeng Lu Station (Beneath the surface 1-2 levels): layout, existing situation, potential for integrating subway line X, source: (Tongji University, 2018, p. 105) edited by author>

- Level I: pedestrian level (of the whole block)

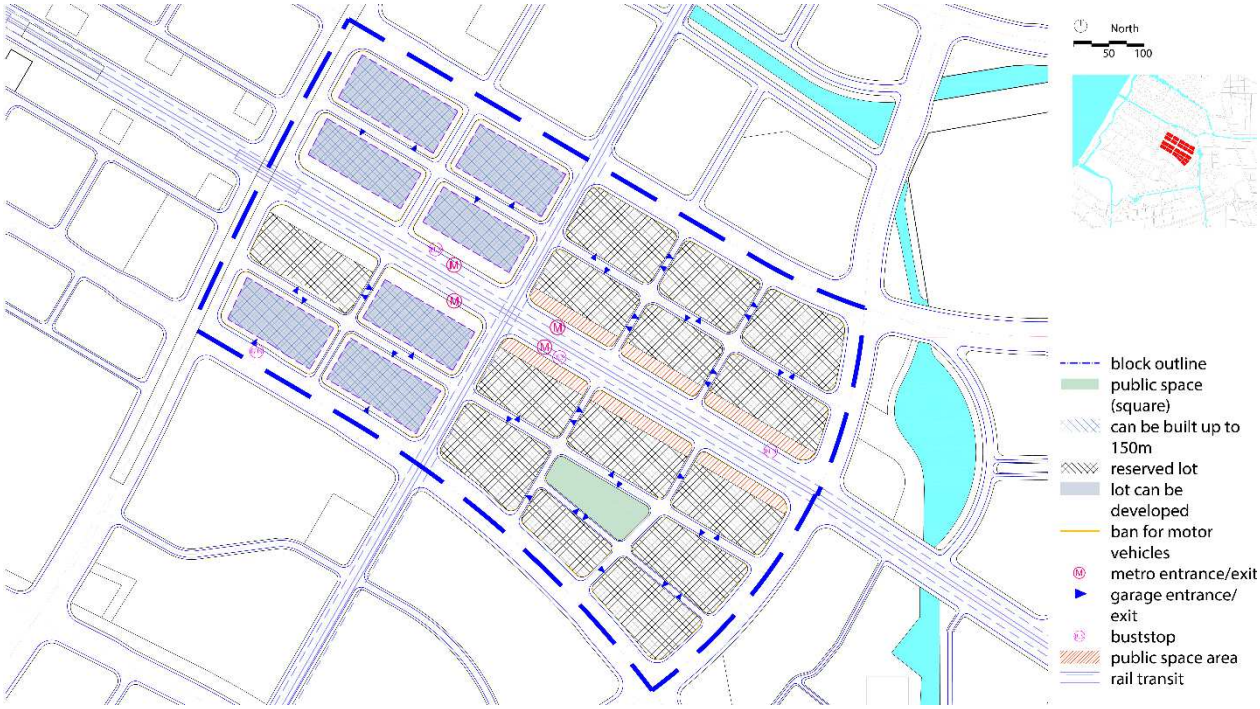


Figure 80 <Yingfeng Lu Station at the pedestrian level, source: (Tongji University, 2018, p. 104), edited by author>

- Level II: development level (everything existing above pedestrian level)

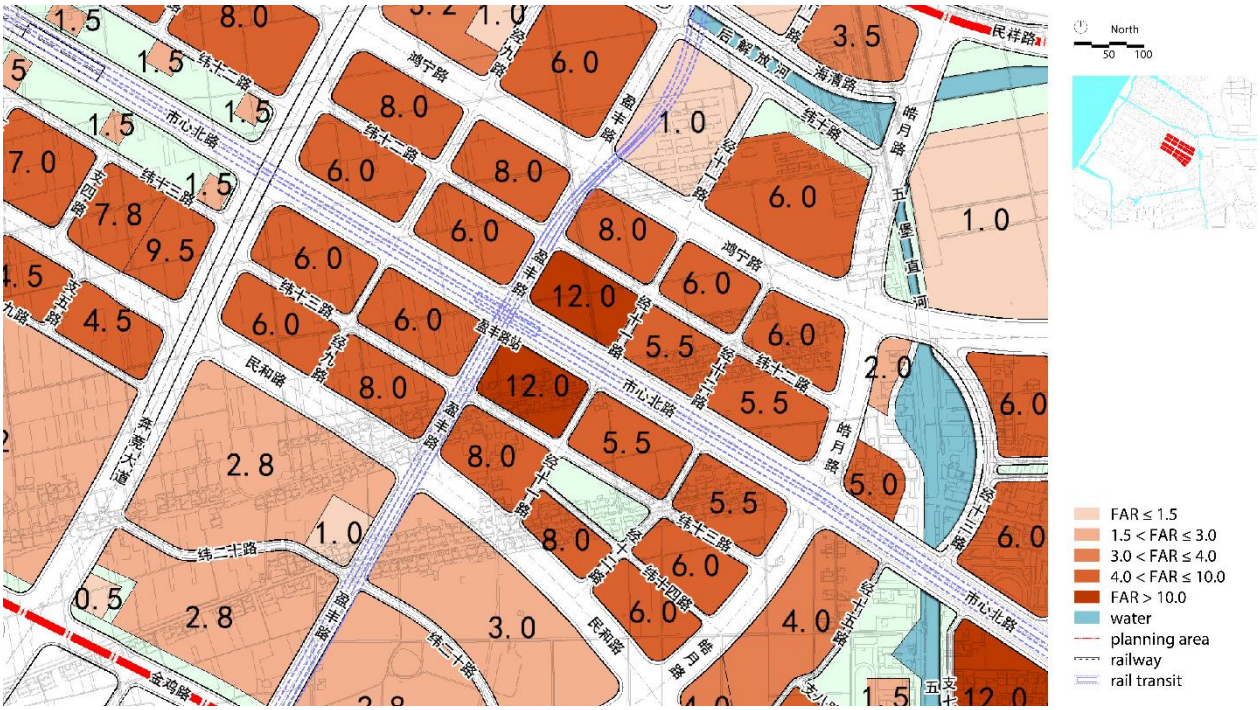


Figure 81 <map of FAR of the Core Unit of QCC (max height = 300 meters), source: (Tongji University, 2018, p. 63) edited by author>

4.5 Conclusion of the Examination

The first thing to note is that at the time that this case study was conducted, the Qianjiang Century city was not yet fully developed. However, some conclusions can already be made which ultimately lead to the conclusion that the chosen building site at Yingfeng lu transfer station has a great potential for an integration project.

- The city is due to become the center of attention in China because of the upcoming events. This favors the planning of large investments and construction projects.
- Like typical CBD areas the main emphasis is on providing maximum office space. In contrast with residential areas this may not be fully balanced at the moment.
- The road network, which consists of main and side streets, is well developed and offers maximum safety by separating the different user groups (cars/ trucks, bicycles/ motorcycles and pedestrians). A resulting issue, however, is the lack of walkability due to the extremely wide street sections.
- After completion of subway line X, the Qianjiang Century City provides a well developed public transportation system which also connects the people with ancient Hangzhou located on the other side of Qiantang river. Car dependency is thereby reduced.
- The green belt is a huge amenity for the whole area and makes nature a direct experience for everyone. It serves for recreation and is thus in direct contrast to the city. The green axes that extend through the area loosen up the city structure a bit and create good places that benefit the people living and working in the direct environment.

Thesis Design Project

5 Thesis Design Project (QCC, HGH)

5.1 Vision for CBD Hangzhou

Figure 82 <impression image of the site of the thesis design project – Yingfeng Lu Station (on the previous page); source: done by author>

Note: The following illustrations are without exception done by the author. Photographs that are not made by the author are referenced.

The main objective is to create a center transit and land-use integration development; a Vertical City; a pedestrian friendly high-rise cluster supporting the whole CBD area (QCC). Healthy living and collaborative working environments promote productivity and innovation and create a sense of community for the users! Moreover, flexible dynamic spaces enhance user's wellbeing and encourage redirection of their focus.

Cross-Sector Integration between transit and land-use planning, sets the basis for placing this integration project – articulated density – at a centrally located key node of transportation (Yingfeng Lu Station). This generates the interface from the horizontal metropolis to the vertical city and merges the TOD and the vertical development into a single entity. At its best, this vertical structure is both, a hybrid urban place and a mass infrastructure node that is based on human scale and promotes urban life.

During the process of designing this project, five main emphasis were extracted on the basis of the theoretical approach and case study ("Comments of the Literature Review" and "Conclusion of the Comparative Case Study"), to maximize its potential success:

- Public Transit
- Accessibility and Readability
- Circulation in both Dimensions (horizontal and vertical)
- (Public) Open Space, the Sky Village
- 24/7 Scenario – The city never sleeps

In the following step, the basic idea for the thesis project and its conception is presented:

- implemented set of amenities:
- open space: public connector, relaxing, regenerative, life balance
- office: flexible, co-everything, networked, efficient, fun, serviced, convenient
- residence: quality, serviced, sophisticated, comfortable
- geriatrics & clinic: social awareness, quality, serviced, comfortable, homely, healthy
- retail: enjoy-full, experience driven, trendy, healthy, active
- art & convention: culture, networked, innovation, technology, social awareness, creative, entrepreneurship
- hotel: sensible, experience driven, upscale, creative, enjoying, relaxing

- a place for all people:
- workers
- residents
- visitors

- young and old people

Figure 83 <from top to bottom: the whole set of amenities is access able to all user groups>

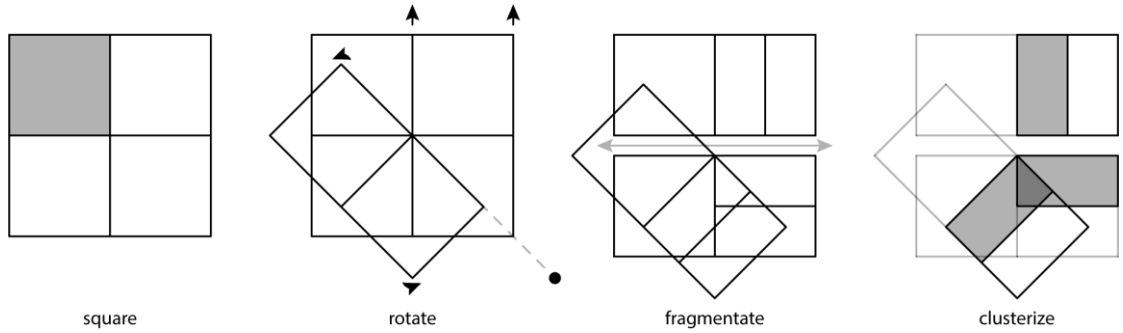
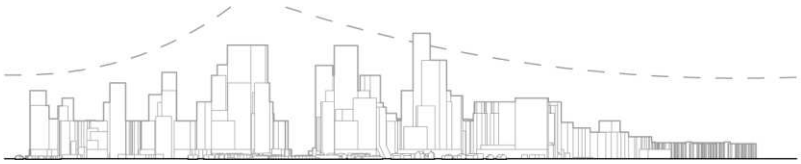


Figure 84 <conceptional layout of the thesis design project>

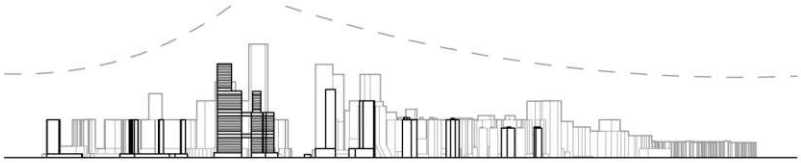
This development of the thesis design project goes beyond the traditional mixed-use tower by creating a synergistic balance between living, working and playing.

One can sympathize the individual focus of each respective step:

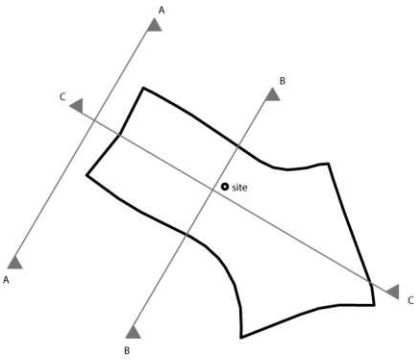
- square: define open public space
- rotate: orientation to public transit
- fragmentate: mix and add functions
- clusterize: create articulated densities (office/hotel, residential and clinic/geriatrics)



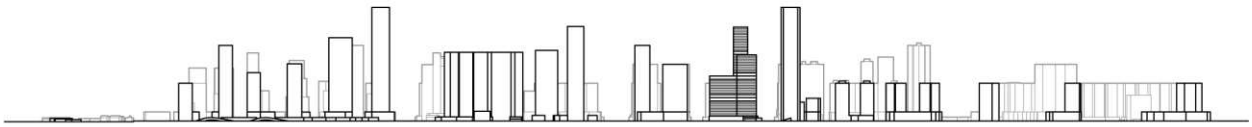
A-A: waterfront silhouette



B-B: section I



overview



C-C: section II

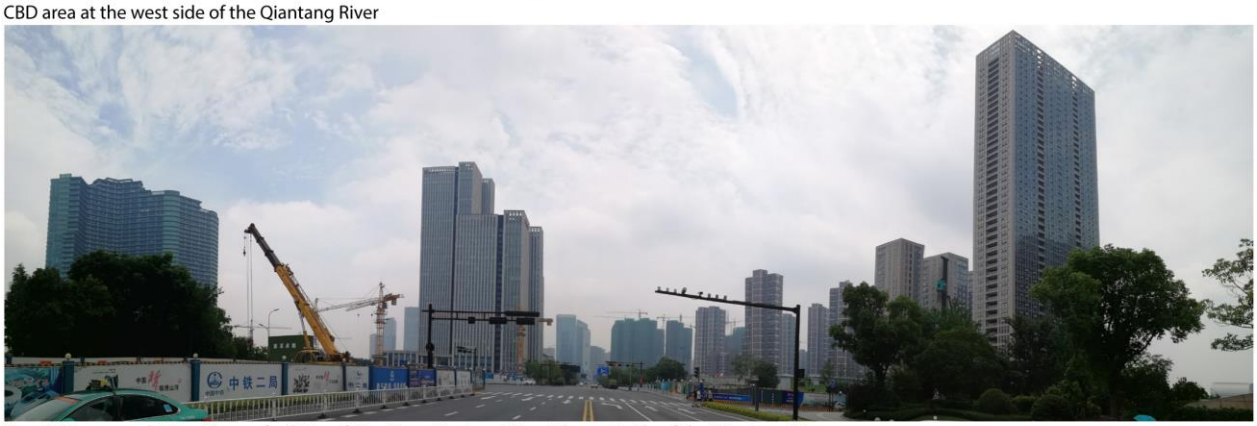
Figure 85 <masterplan, silhouette and sections>

The Project has a strategic location within the CBD area of QCC and the adjoining cities of Hangzhou. The mixed-use project acts as a hub between the different cultural, environmental, and creative zones.

cultural context of Hangzhou - ancient city center

environmental context of Hangzhou - West Lake and Qiantang River

CBD area at the west side of the Qiantang River



New CBD area and Asian Games facilities of Qianjiang Century City at the east side of the Qiantang River

from top to bottom – cultural context: www.dailymail.co.uk; environmental context, CBD area and New CBD area: done by author

Figure 86 <urban context of Hangzhou>

Figure 87 <masterplan of QCC>

view from the main Avenue of QCC to the south-east

view from the main Avenue of QCC to the north-west

view at the west corner of the site of the thesis design project

view of the site of the thesis design project (status 2018)

Figure 88 <impressions and images of the chosen site of the thesis design project, source: done by author>

5.2 Programmatic Design Concept

- Proposal of a Vertical City Concept

As with the traditional city, which is constituted of buildings of different use and typology, the high-rise building embraces different functions within a vertical structure. The art is to create authenticity for each individual program within a bigger ensemble to strike the balance between the complementing elements while maintaining their legibility for the user. At a certain scale the building offers all amenities urbanity could do. This is were a building becomes a city full of urban life within the metropolis.

This section includes:

- eyes to/from the city
- general program organization: functions
- plot organization: overview of podium and towers
- masterplan: considering the whole superblock
- GFA calculation: including all sorts of data of the thesis design project
- creating a pedestrian friendly address
- creating a multi-level open public space accessible by foot, car and public transportation:
  interface of the project's horizontal and vertical transportation
- (vertical) circulation
- relations
- sky gardens and amenities (pocket I, II, III)
- 24/7 scenario: considering the whole life cycle of a fictive person that could live there

- eyes to/from the city

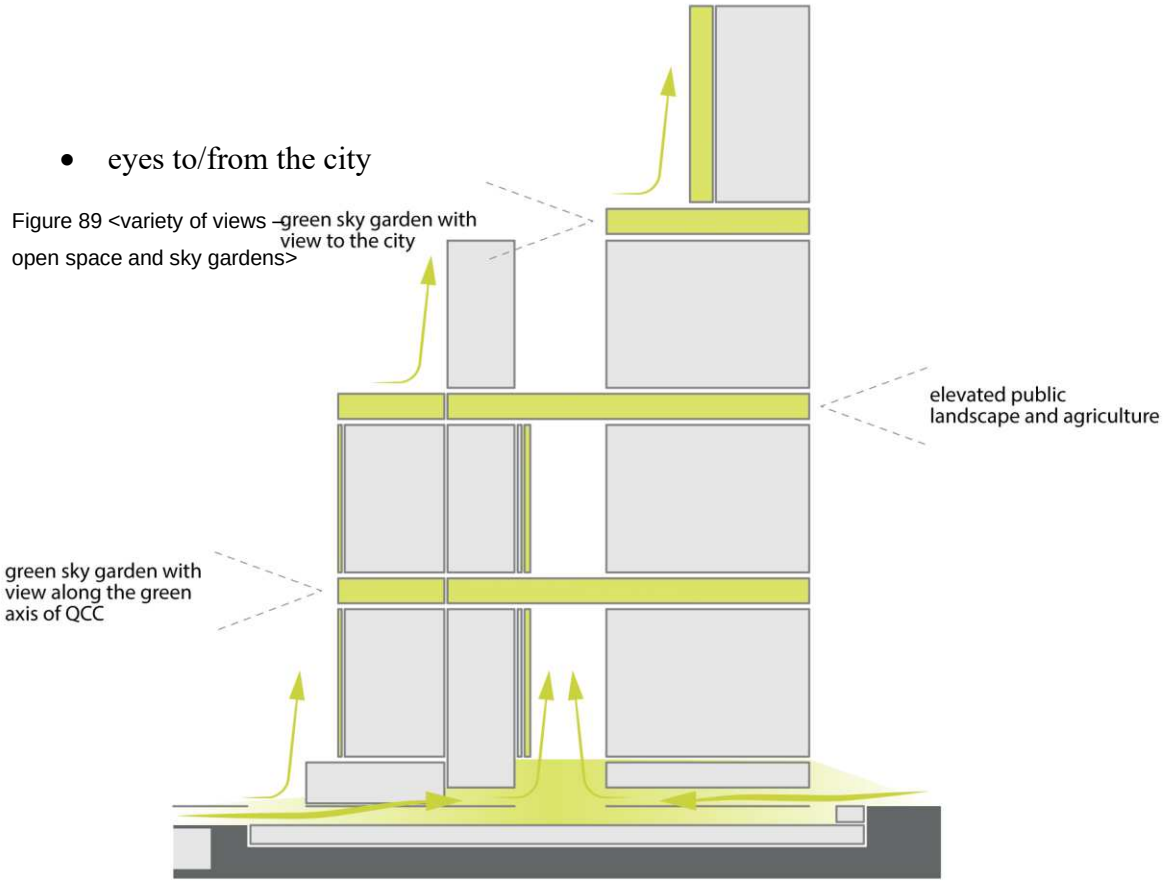


Figure 89 <variety of views – open space and sky gardens>

The three interconnected towers offer varying views making them unique for each resident, worker or visitor. Opening the ground floor to the neighborhood will create high quality public space.

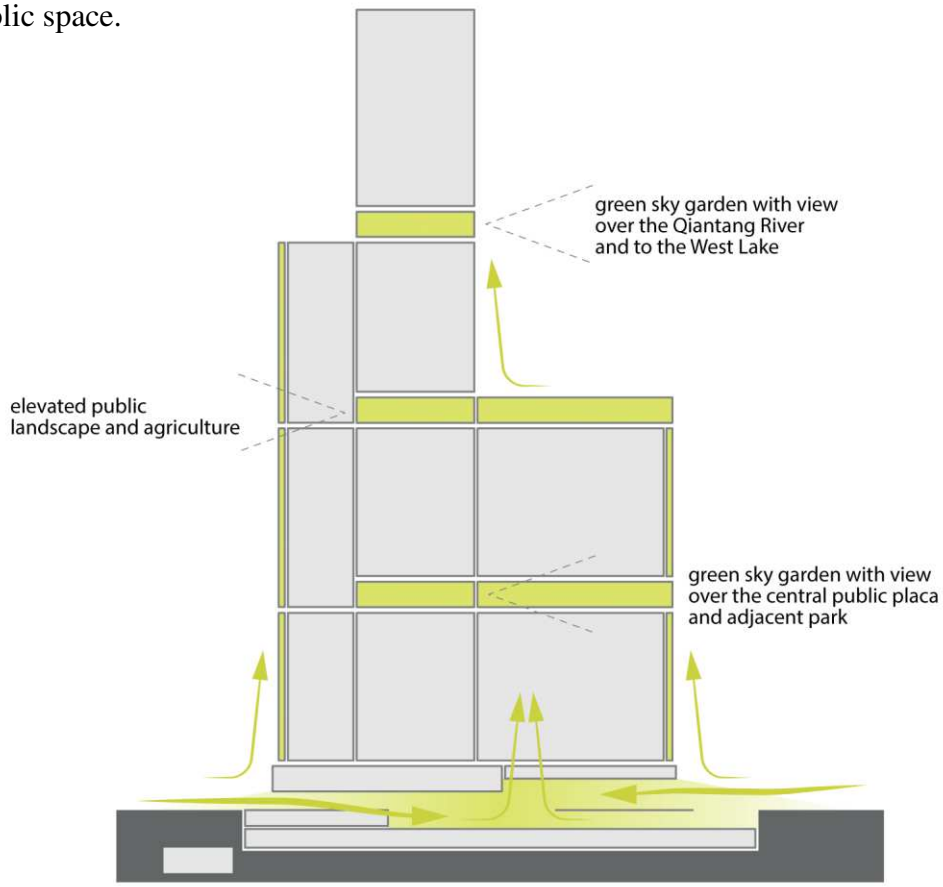
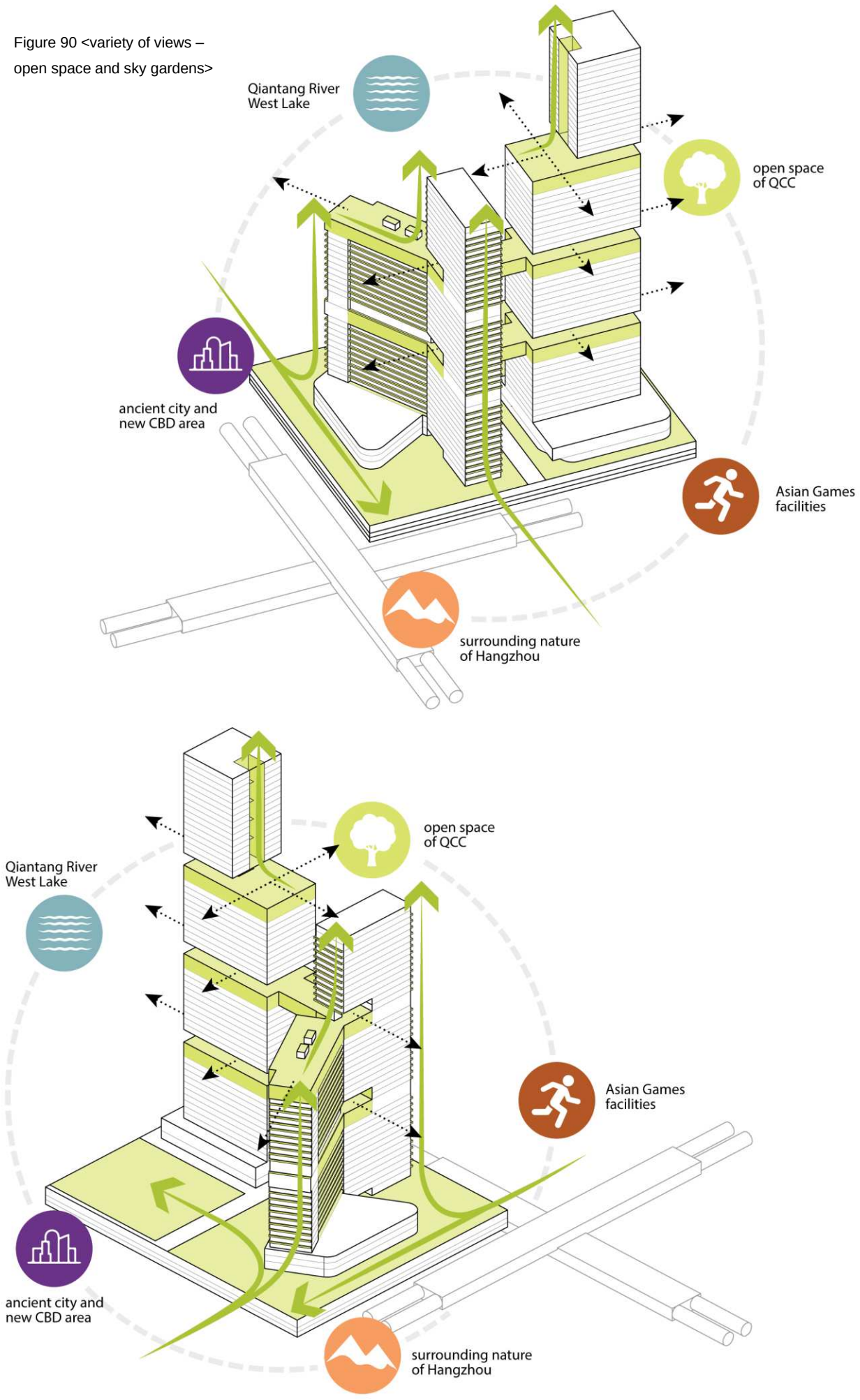
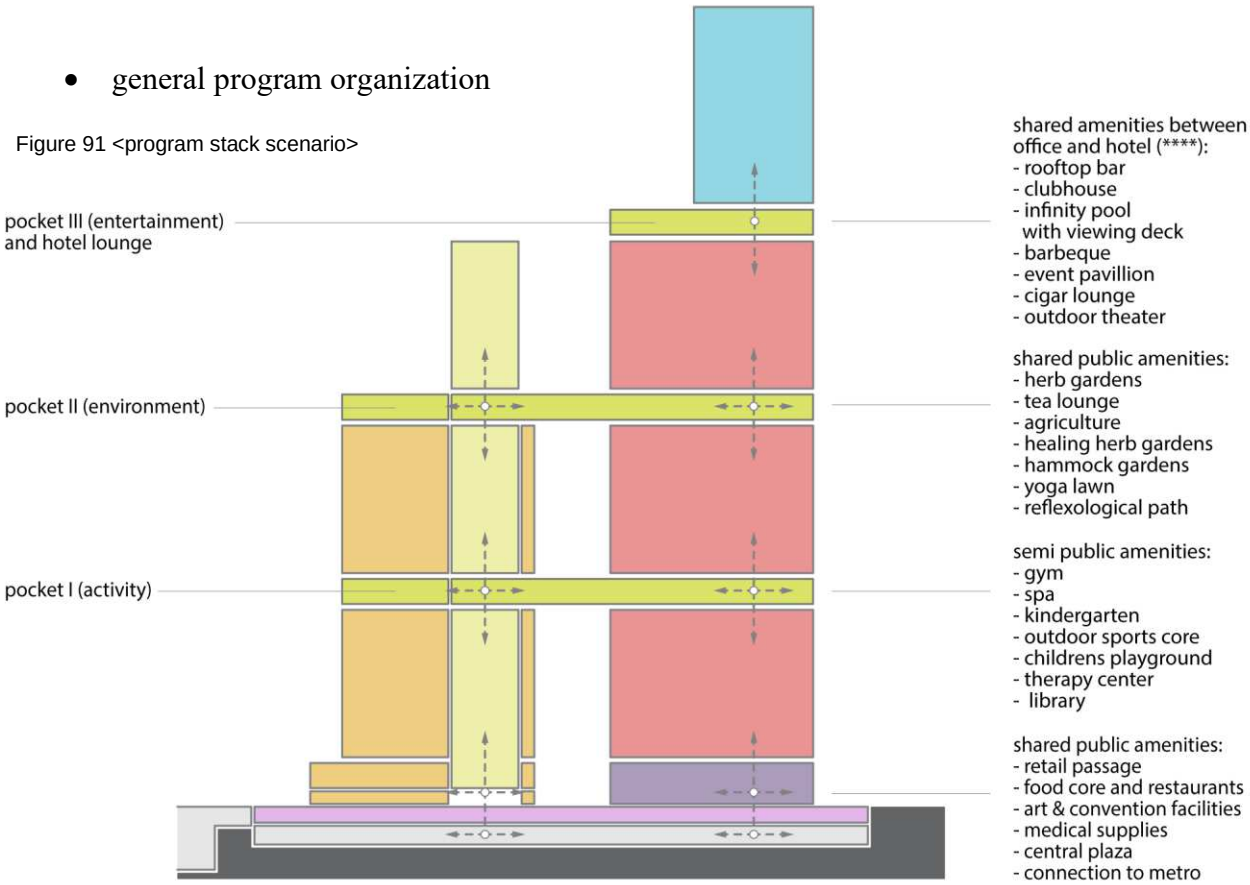


Figure 90 <variety of views – open space and sky gardens>



- general program organization

Figure 91 <program stack scenario>



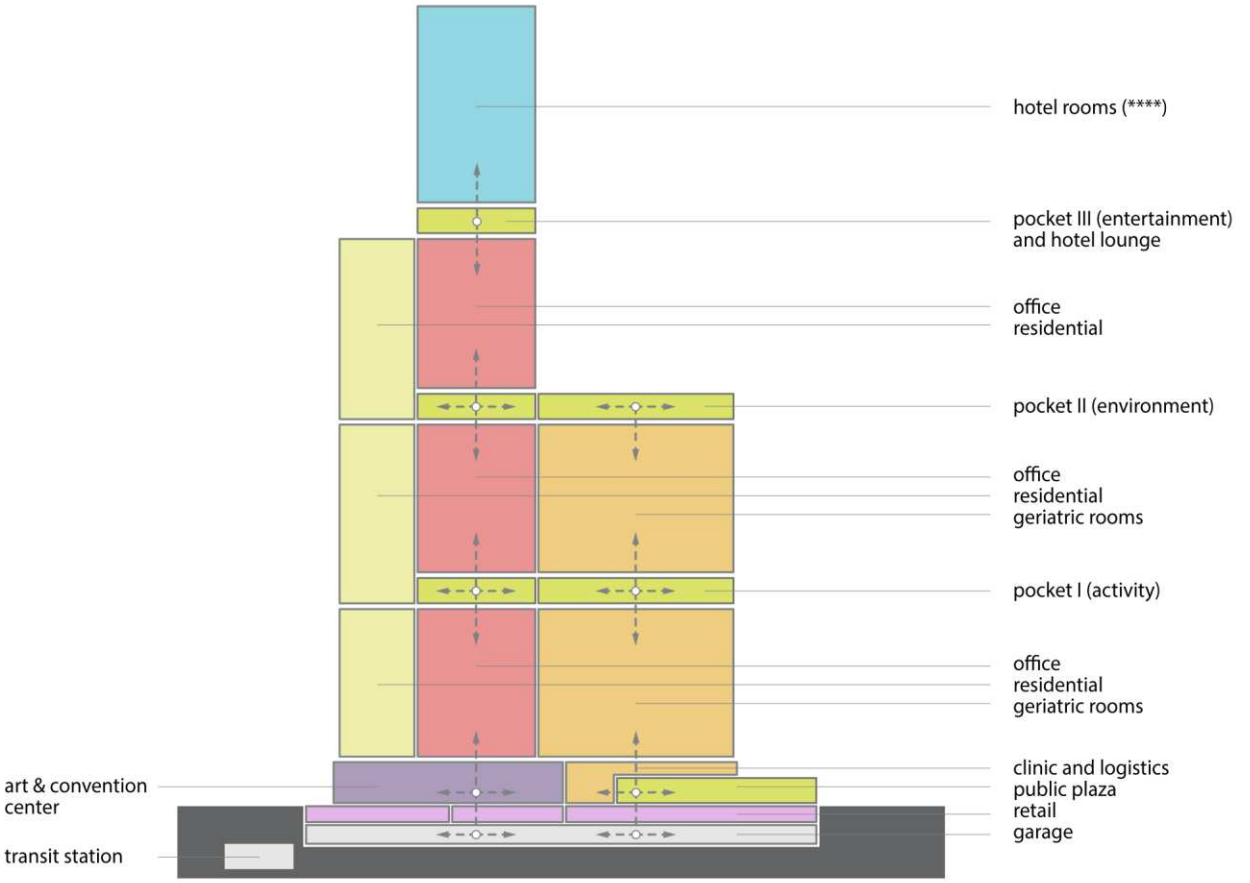


Figure 92 <program stack scenario>

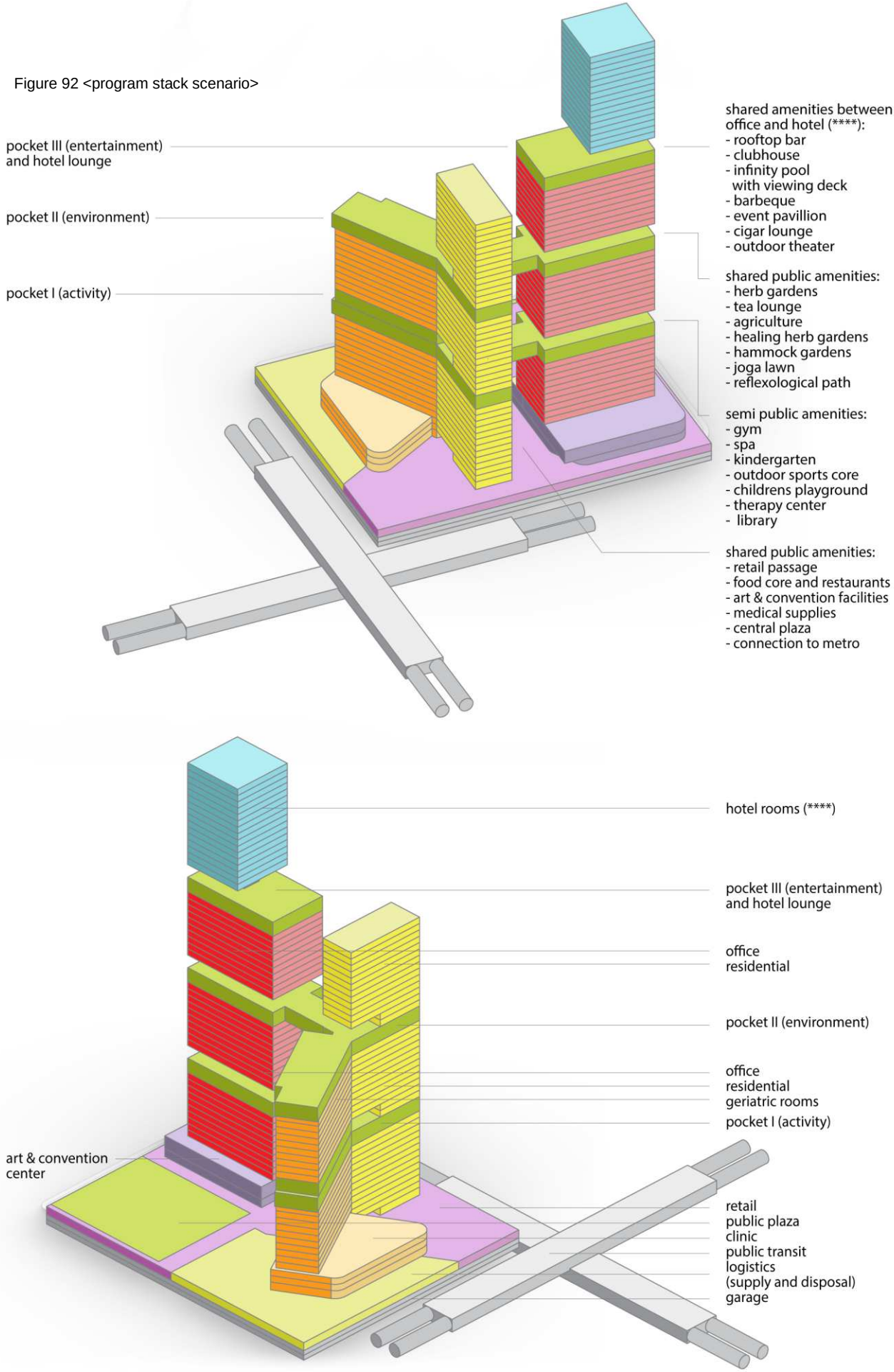
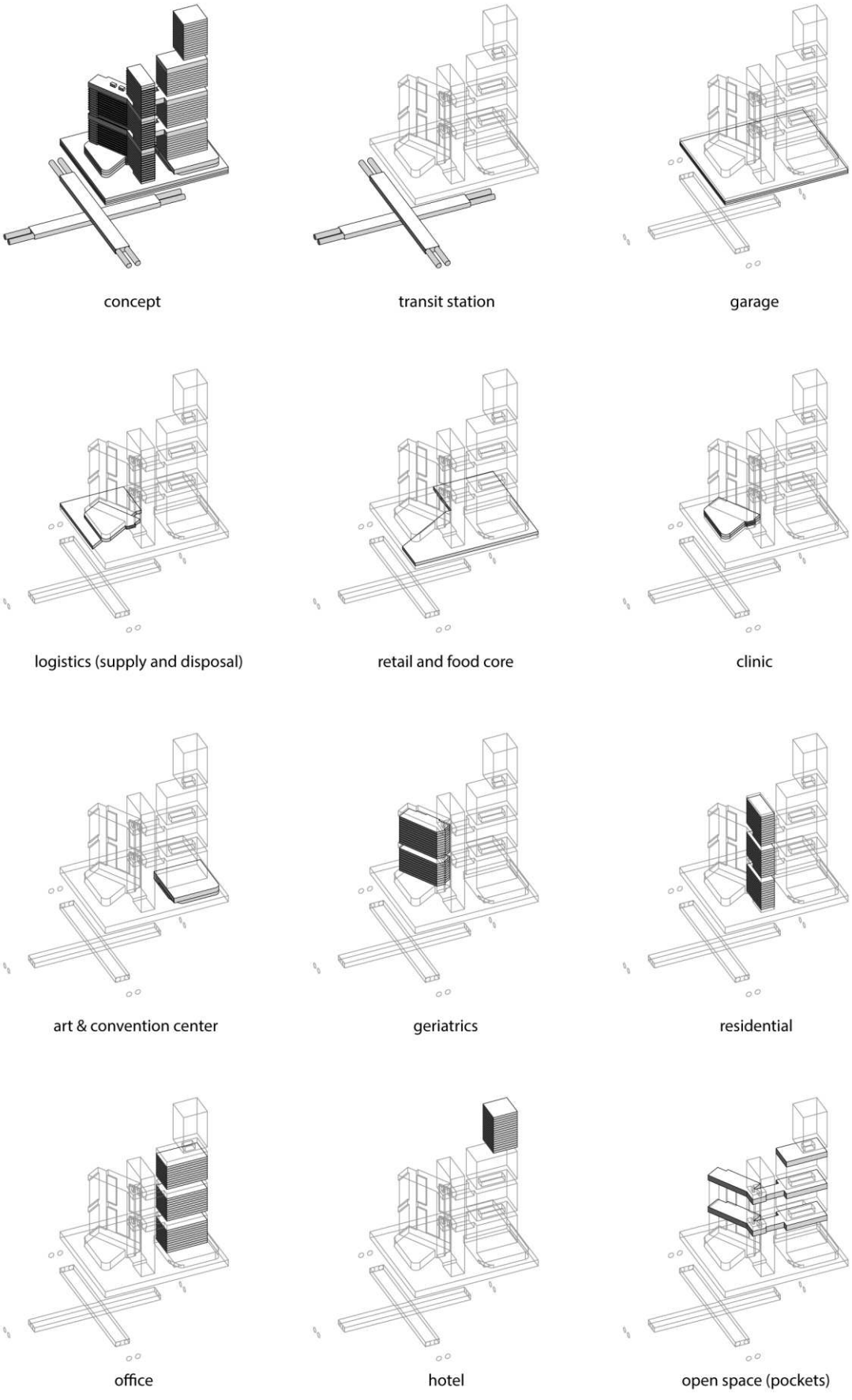
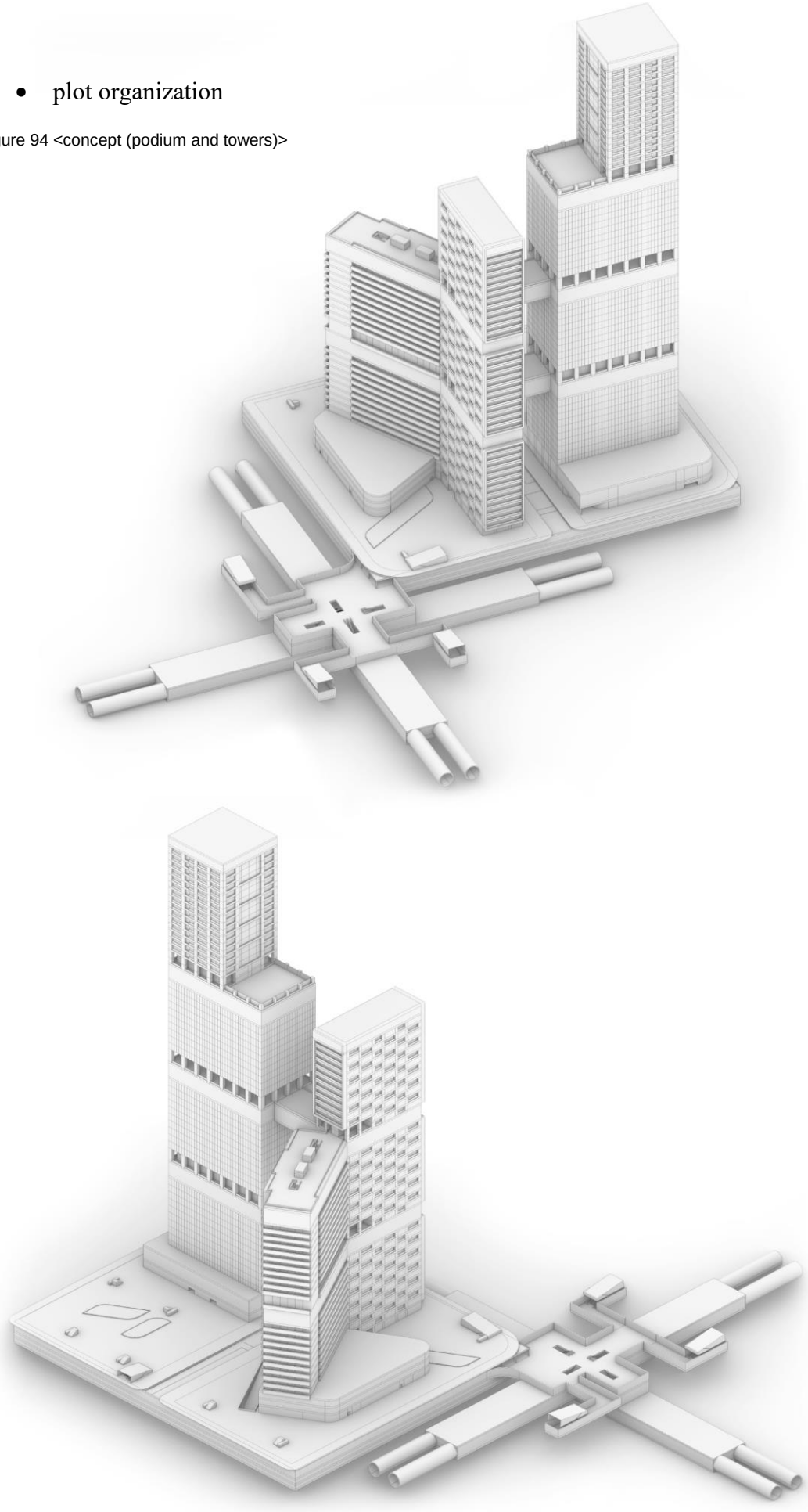


Figure 93 <function matrix of the concept>



- plot organization

Figure 94 <concept (podium and towers)>



- masterplan of the whole superblock

Figure 95 <masterplan of the superblock>

Figure 96 <function layout distribution in percent of the respective superblock in QCC, Hangzhou>

The neighborhood of the thesis design project lacks of urban life. Office space is of strong dominance while other major amenities are completely missing. There are effective green avenues that strive for a green image, however there is no consciousness of a center of QCC where people can come together for public gathering.

- masterplan with highlighted building site of the thesis design project

Figure 97 <masterplan with highlighted building site of the thesis design project>

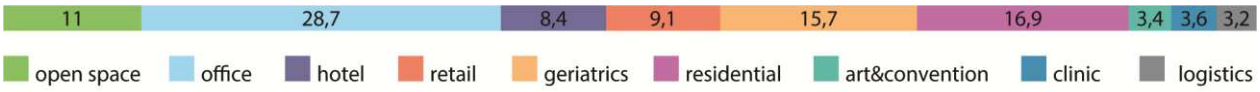


Figure 98 <function layout distribution in percent of the thesis design project in QCC, Hangzhou>

Based on the deductions on the left side, and the findings of the literature review and the case study (“Comments to the Literature Review” and "Conclusion of the Examination" respectively), an attempt is made to compensate for the shortcomings mentioned and to promote urban life. As a result, the above attached percentage distribution of the function layout was determined. It represents the cross section of a functioning city and thus forms the center for various user groups. By using this sustainable strategy, the neighborhood promotes the Vertical City as starting point for the urban success of the imbedded surrounding.

- numbers and data

site area	31.789,8 m² (north part: 15.742,4 m² south part: 16.047,4 m²)
FAR	7,2
total GFA (watch detailed calculation below)	228.639,4 m²
building coverage	10.738,6 m² (north part: 5.483 m² south part: 5.255,4 m²) (podium: 10.242,4 m² towers: 5.558,6 m²)
total building coverage	33,8 %
towers	17,5 %
podium	32,2 %

Table 44 <masterplan data of the project>

- GFA calculation

	floors	**m²**
office	30 (x 2.424,5 m²)	72.735 m²
hotel (270 rooms)	15 (x 1.422,8 m²)	21.342 m²
residential (376 flats with 498 double beds)	38 (22 x 1.143,2 m² + 11 x 1.183,4 m² + 4 x 842,1 m²)	42.679,2 m²
geriatrics (480 rooms with 620 beds)	20 x 1990,8 m²	39.816 m²
retail	1	23.035,2 m²
open space	5	total: 27.863,9 m² at ground: 13.419,8 m² within development: 14.444,1 m²
clinic	3	9.041 m²
art and convention center	2	8.510,8 m²
logistics	1	2.737 m²
supply and disposal, and emergency area for ambulance vehicles)	1	5.286,7 m²
garage and MEP of basement	3	66.923,7 m²

basement	3	95.245,5 m²
parking spaces	1338	

total area (basement, podium and towers)	323.884,9 m²

office efficiency	82,3 %

Table 45 <GFA calculation>

- creating a pedestrian friendly address

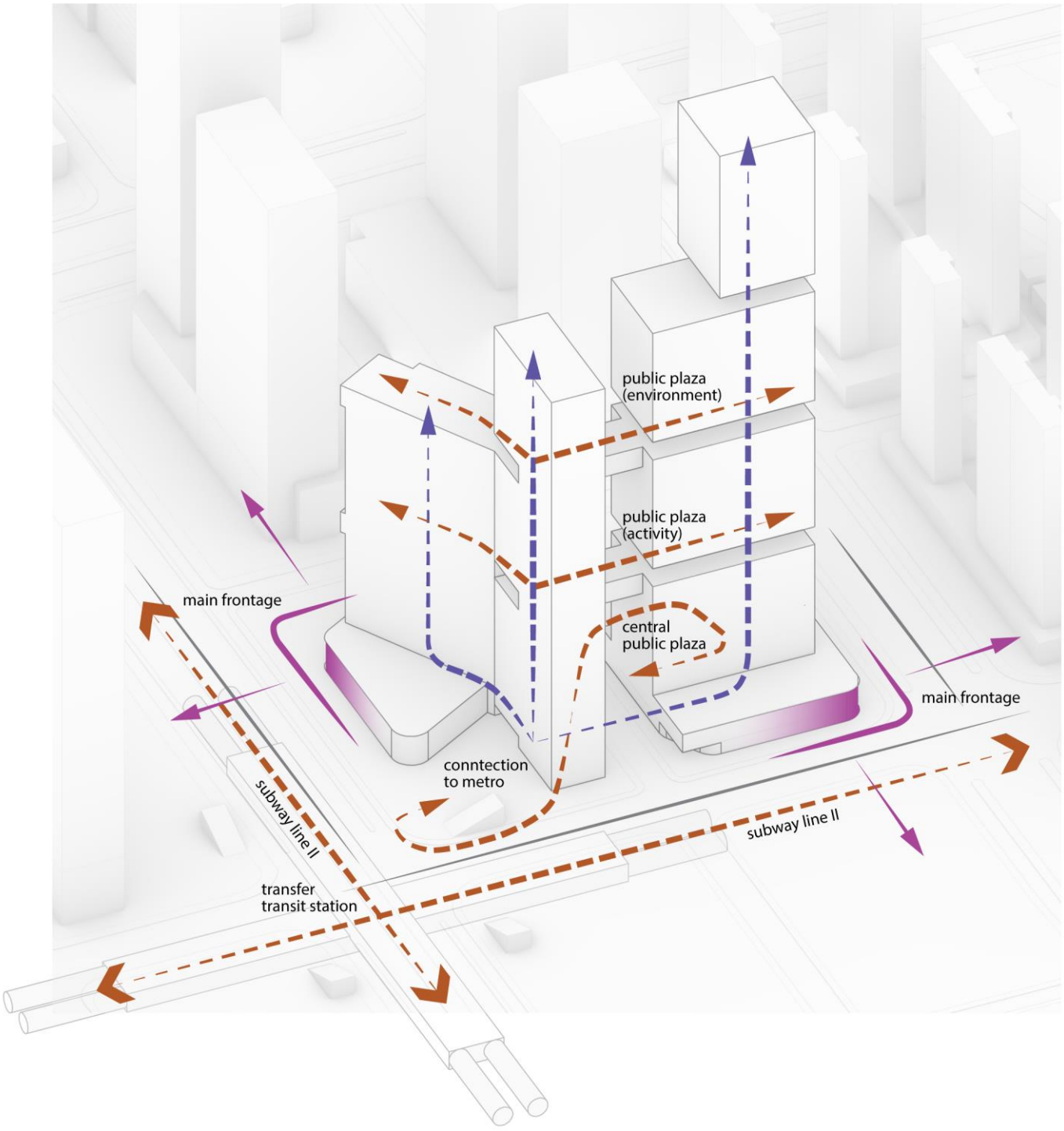


Figure 99 <accessibility (connection to metro and bus station, public plaza and to the pockets)>

In order to improve the people's flow throughout the project, the façade and the inner layout of the different building parts clarify its functionality. The introduction of several routes for the different user groups enables everyone to get from each point on site to any other by the fastest possible way. The sky-bridges of this route system serve with its public open space functionality as the all-embracing key elements that cannot be run past.

- creating a multi-level open public space accessible by foot, car and public transportation

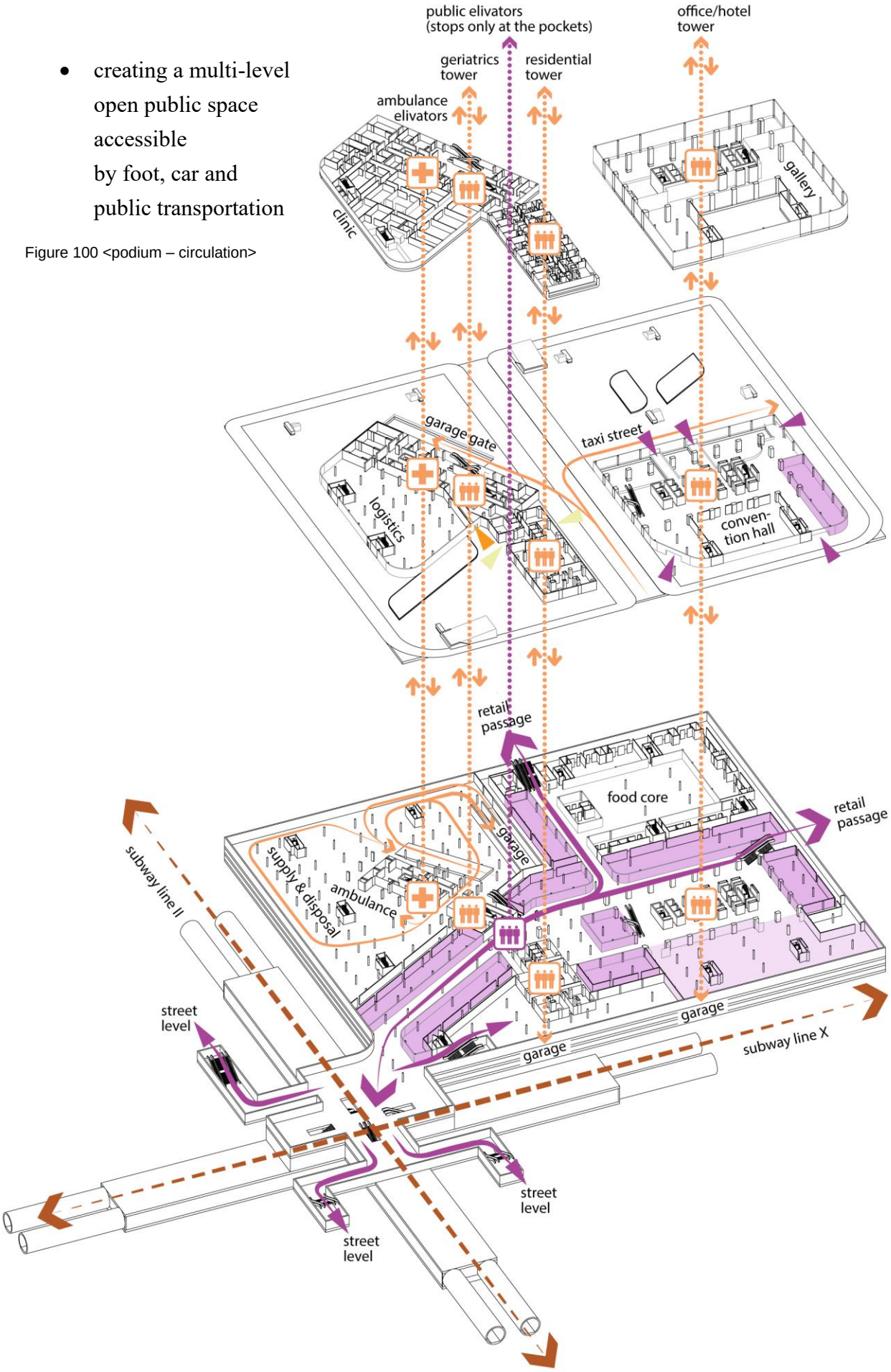


Figure 100 <podium – circulation>

- (vertical) circulation

The lobbies, which are highlighted in dark grey, are not just transitional spaces where people can change from the shuttle elevator to the local elevator, but they offer programmed places and operate as key nodes throughout the high-rise building inviting people to linger. This vertical city strategy is fundamentally different from the often repeated monotonous single-use structure of typical skyscrapers. Disposing the tower into several blocks of private units also enables the integration of public space by ensuring security standards at all time.

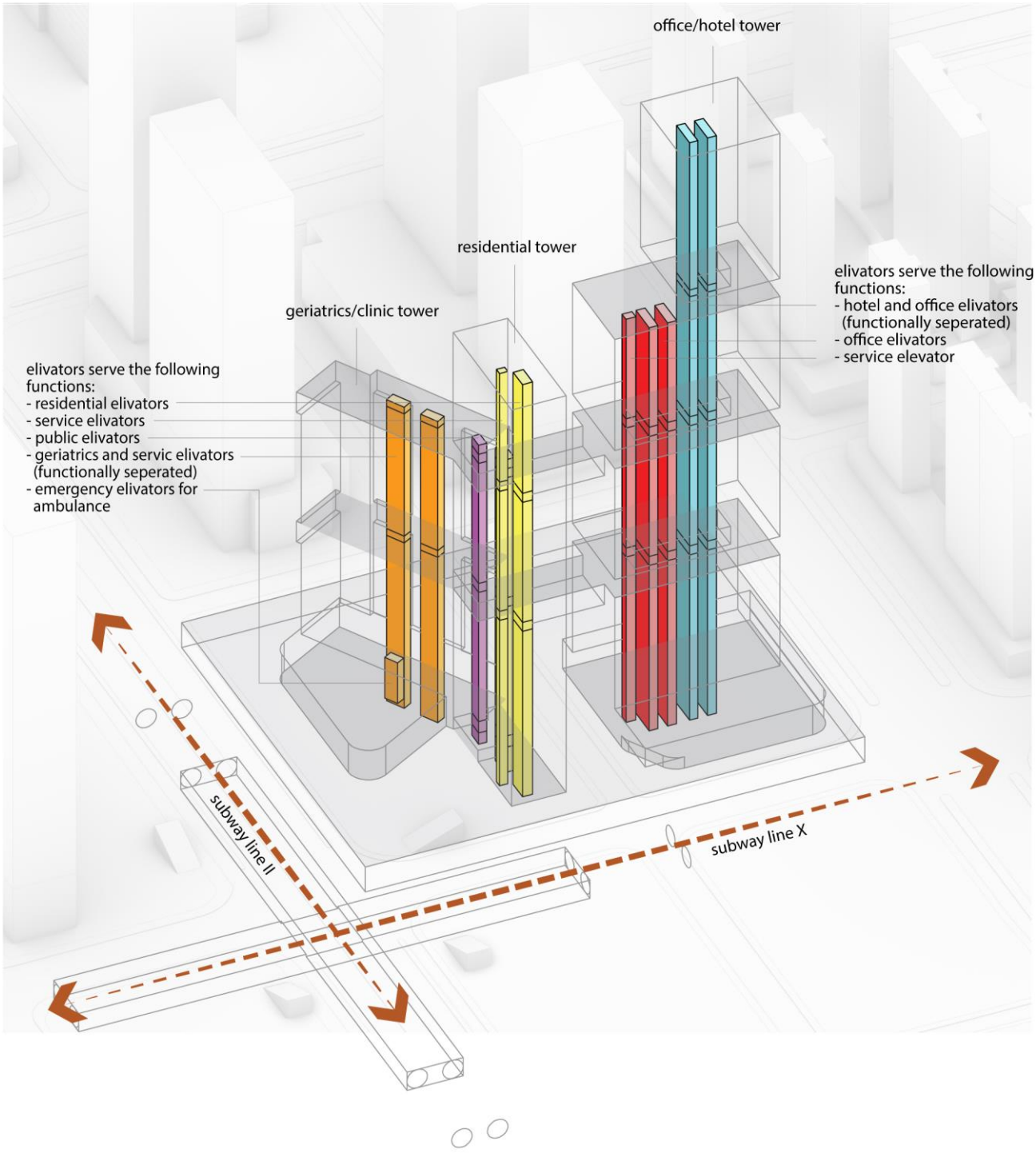


Figure 101 <general vertical circulation strategy>

number of elevator shafts	total: 27
number of elevator shafts residence tower	total: 9 3: B3 – F26 3: B3 – F1, F14, F26 – F36 1 (service elevators): B3 – F36 2 (public elevators): B1, F14, F26
number of elevators shafts office/hotel tower	total shafts: 13 5: B3 – F26 4: B3 – F1, F14, F26 – F36 2: B3 – F1, F14 – F15, F26, 3: F26 – F36 1 (service elevator): B3 – F25
number of elevators geriatrics/clinic tower	total shafts: 6 2: B3- F25 2: B3 – F26 2 (ambulance elevators): B1, F1

Table 46 <vertical circulation data of the project>

- relations

In order to create urban life, all criteria of the building's context need to be considered. During the design process a distinction between the following relationships was made:

- relationship between interior and exterior:

The connection to the surrounding neighborhood is crucial. A sophisticated system of axes and squares creates visual links and, in addition to the function-coordinated facades, increases the differentiation (readability) of inside and outside.

- relationship between different levels:

Traditionally, urban life took place on one level or units with one use. When stacking whole units, the relationship between public floors (sky gardens) with each other and with the ground itself becomes automatically crucial.

- sky gardens and amenities
- pocket I: activity

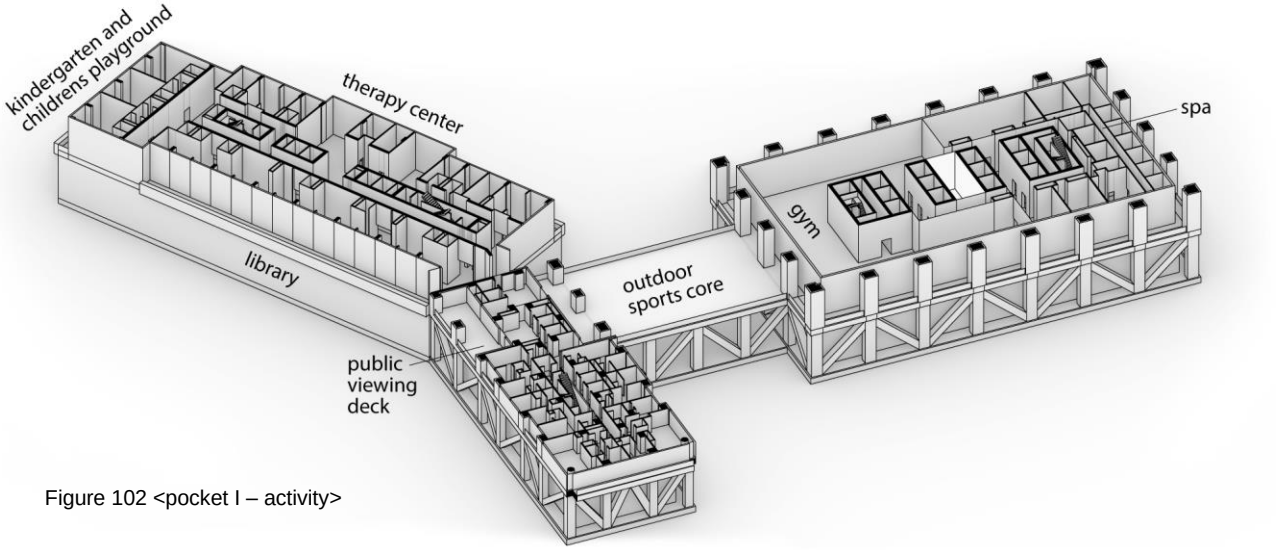


Figure 102 <pocket I – activity>

- pocket II: environment

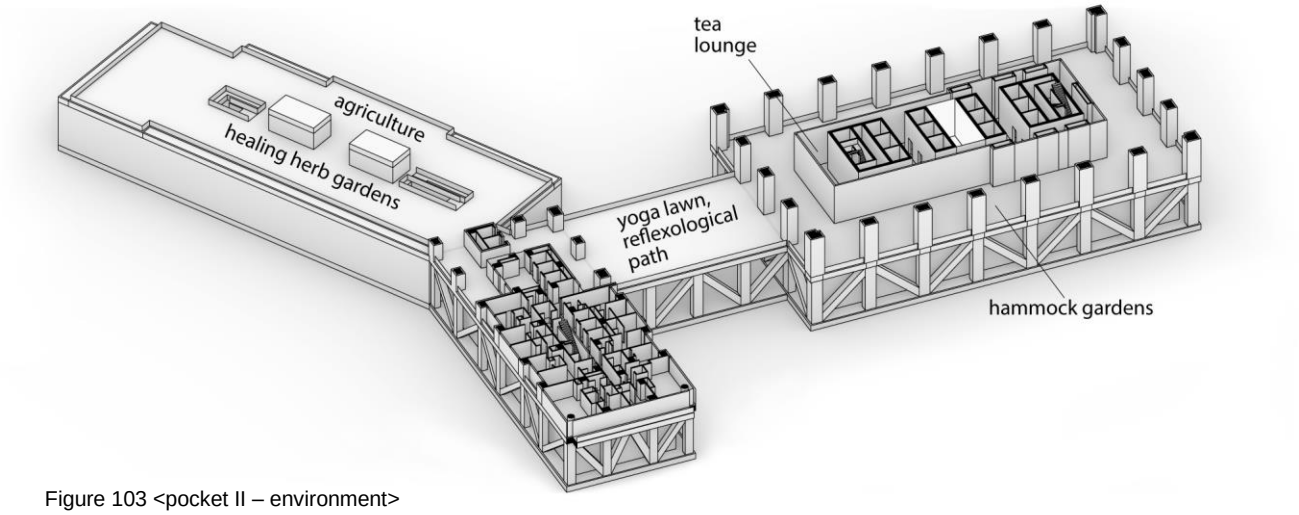


Figure 103 <pocket II – environment>

agriculture | healing herb garden | reflexological path | yoga lawn | hammock garden

from left to right – agriculture: www.domusweb. it; herb garden: www.inhabitat.com, reflexological path: www.timescolonist.com; yoga lawn: www.breckcreate.org; hammock garden: www.tripadvisor.com

Figure 104 <amenities of pocket II – environment>

These interfaces (podium and sky gardens) set great potential for the hybrid urban form, which is leading to the logic of vertical expansion. This in turn makes the Vertical City concept a solution for sustainable living. Implementing these amenities is not just making it more user-friendly for the people, but a strategy that creates a whole ecosystem and ultimately reduces the impact on the environment.

- Pocket III: entertainment, clubhouse and hotel lounge

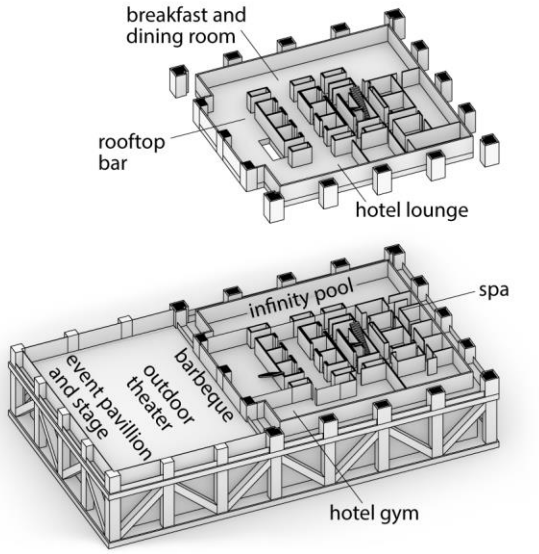


Figure 105 <Pocket III – entertainment, clubhouse and hotel lounge>

- 24/7 scenario

The impression of the network of possibilities within the development is verified in the following example. It is assumed that the person lives and works in the respective building, has a child and the grand parents live in the geriatrics:

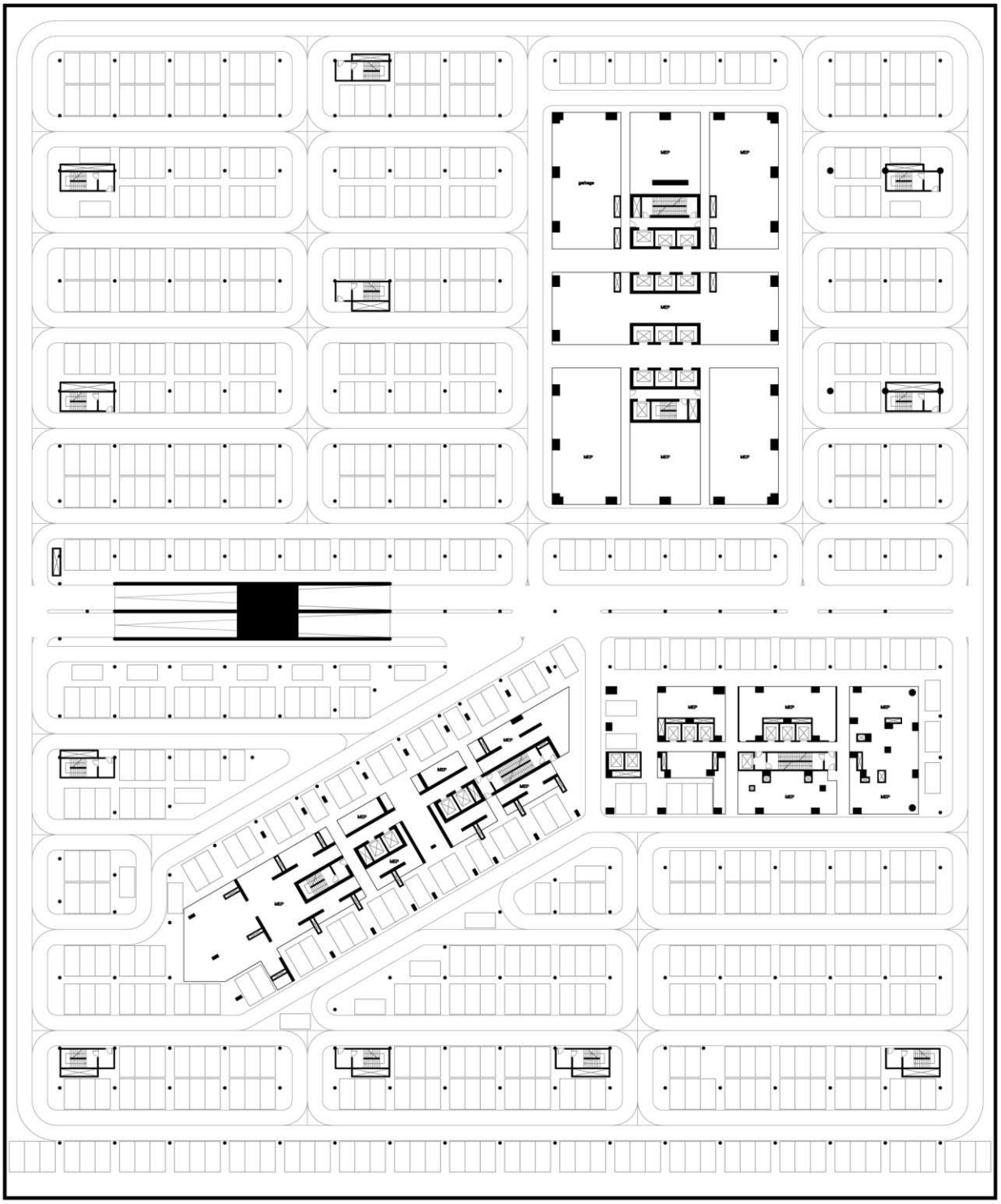
from left to right – morning workout: www.shutterstock.com; breakfast: www.no35.com; kindergarten: www.stocksy.com; working: www.sherryblairinstitute.com, shopping: www.freepik.com; spa: www.carsonhotspringresort.com; geriatrics: aginginplace.com, dinner: www.pxhere.com; drinks: www.weinkenner.de; late night party: www.alfaenlinea.com

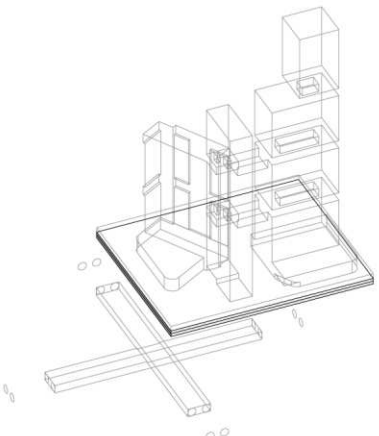
Figure 106 <example of a 24/7 scenario of an inhabitant of the thesis design project>

5.3 Formal Design Concept

This section includes:

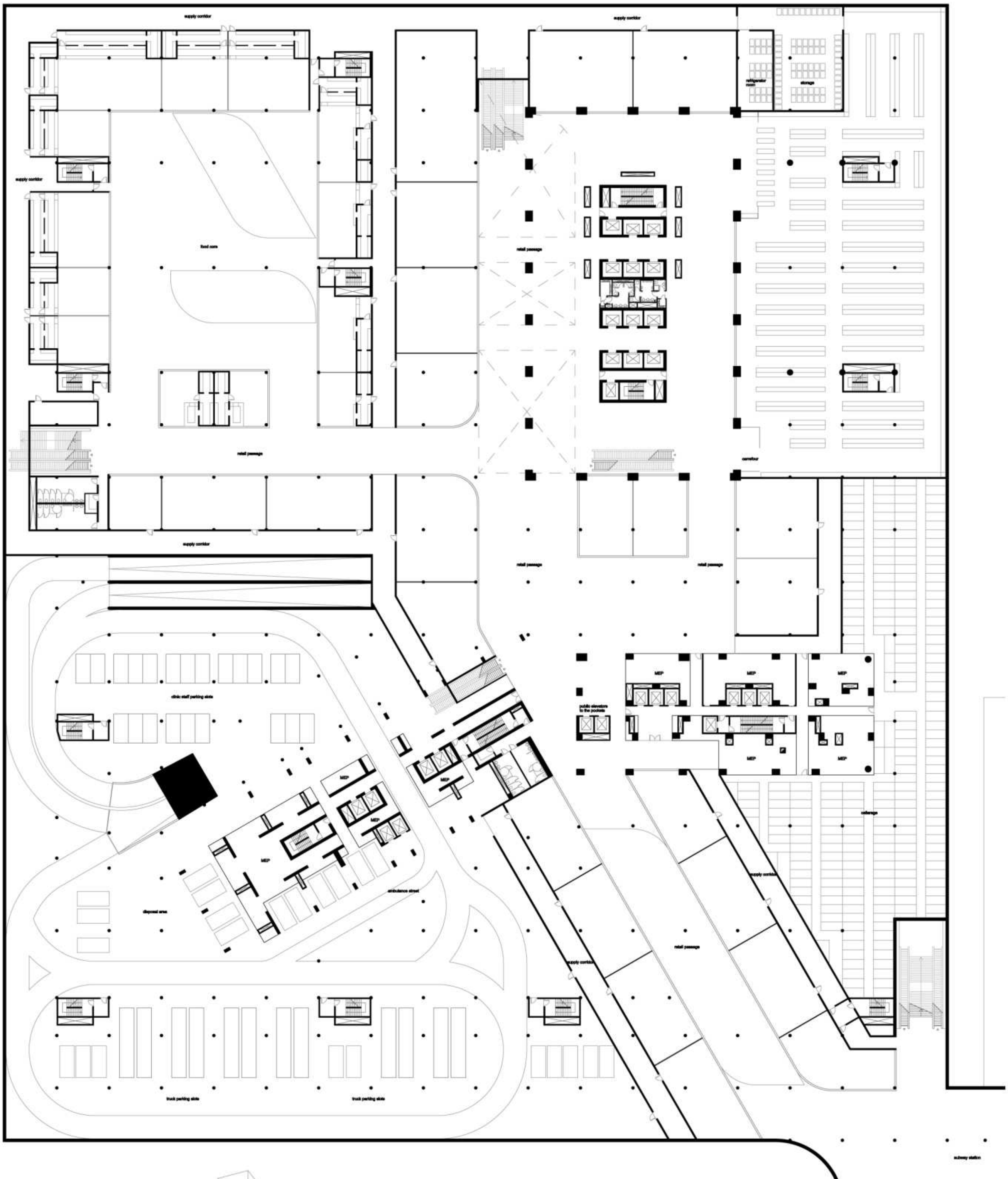
- floorplans: podium and towers
- elevations
- sections
- structural concept
- detail – 1:20





- floorplans: PODIUM
  scale 1:1000

Figure 107 <B3-B2 (garage)>



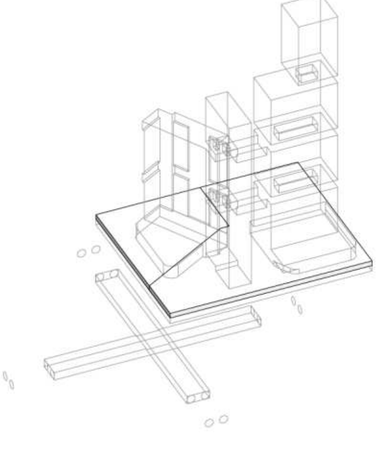
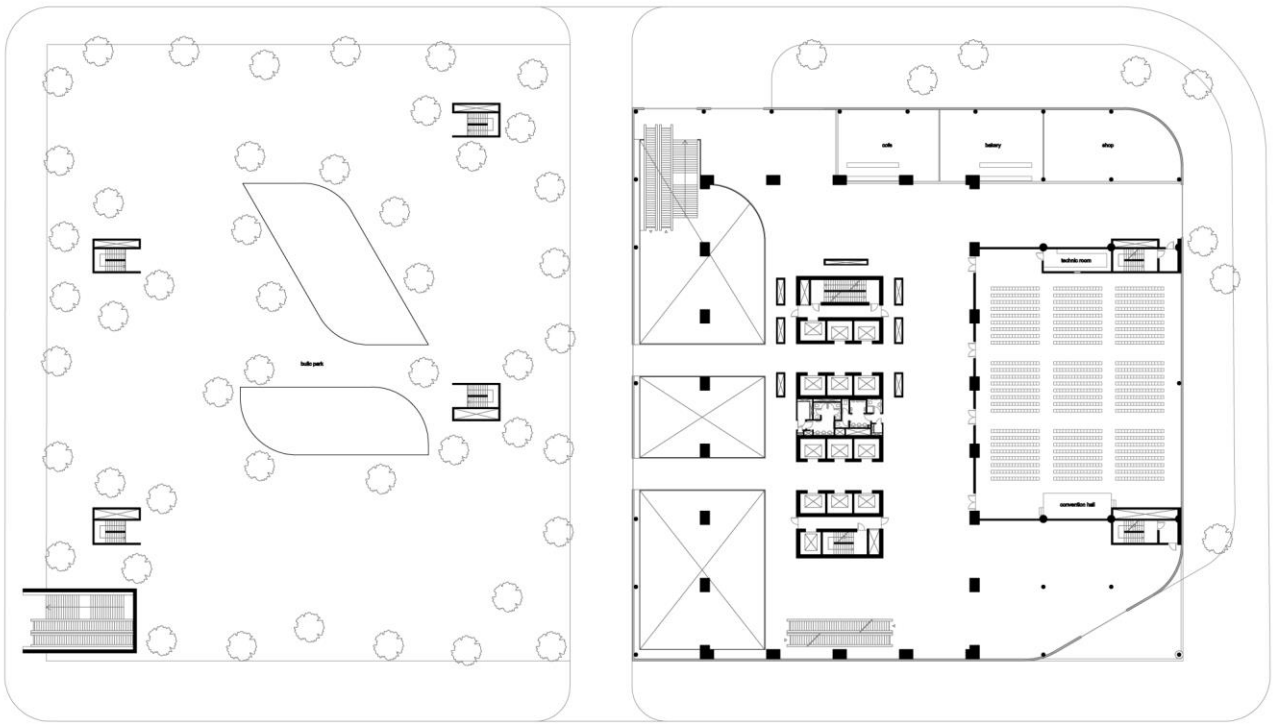
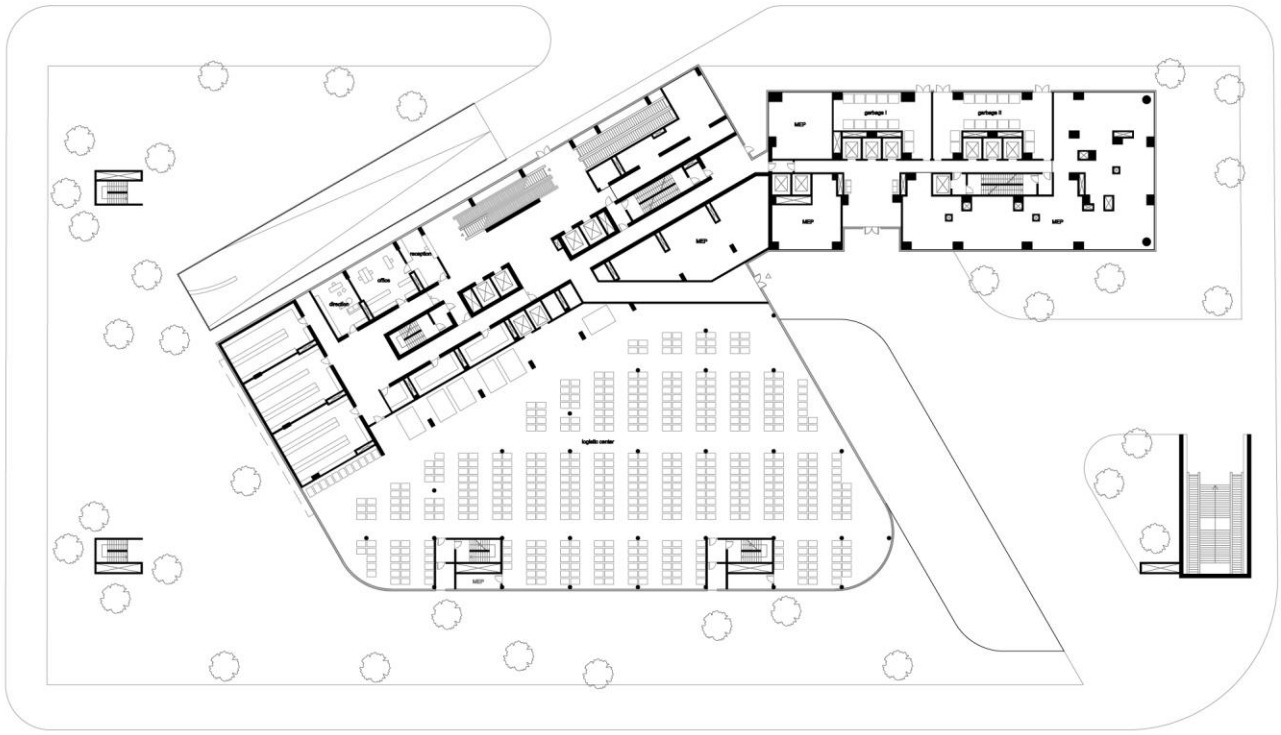


Figure 108 <B1 (retail passage, food core, supply and disposal, ambulance entrance)>





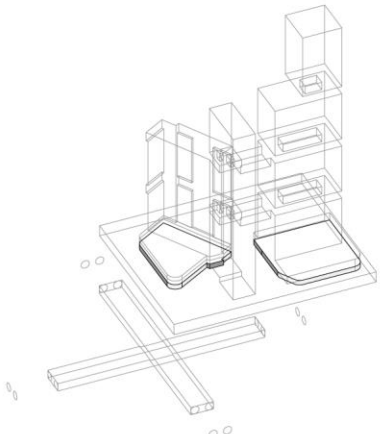


Figure 109 <ground floor (convention hall, entrance lobby, logistics, public plaza)>

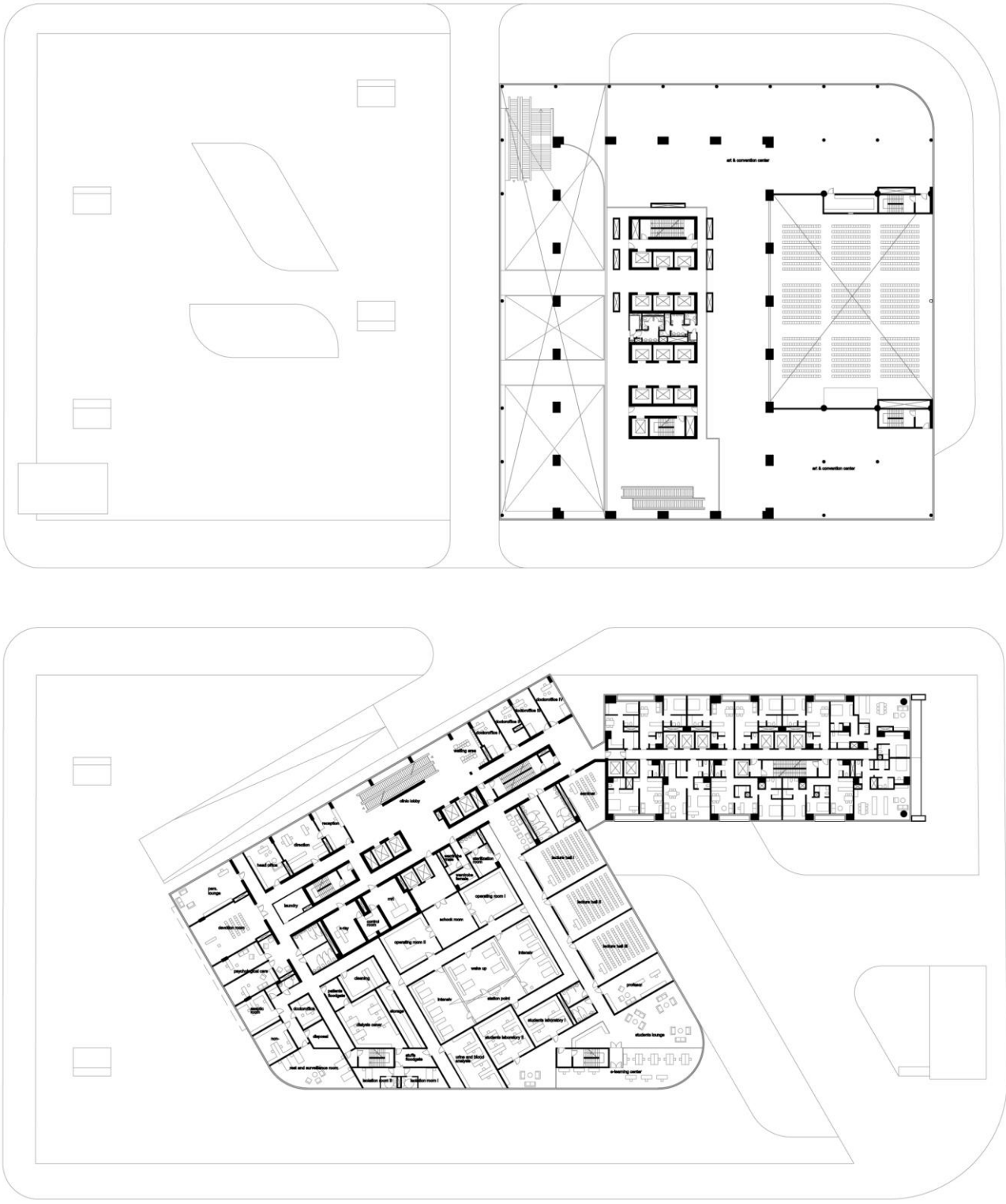


Figure 110 <F1-F2 (clinic, art & convention center)>

- floorplans: TOWERS

Figure 111 <F3-12;15-24 (office, residential, geriatrics)>

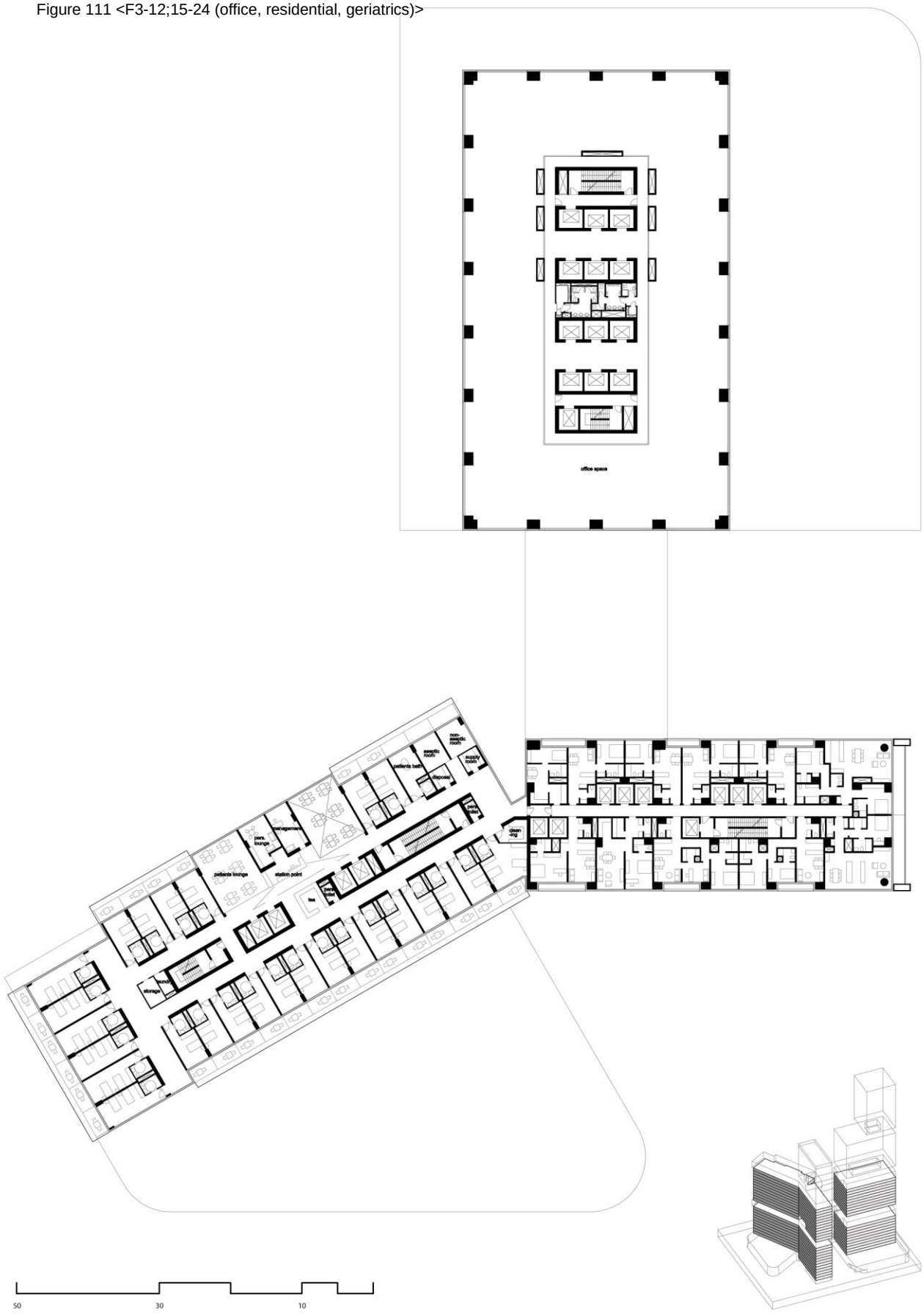


Figure 112 <F14: pocket I (activity)>

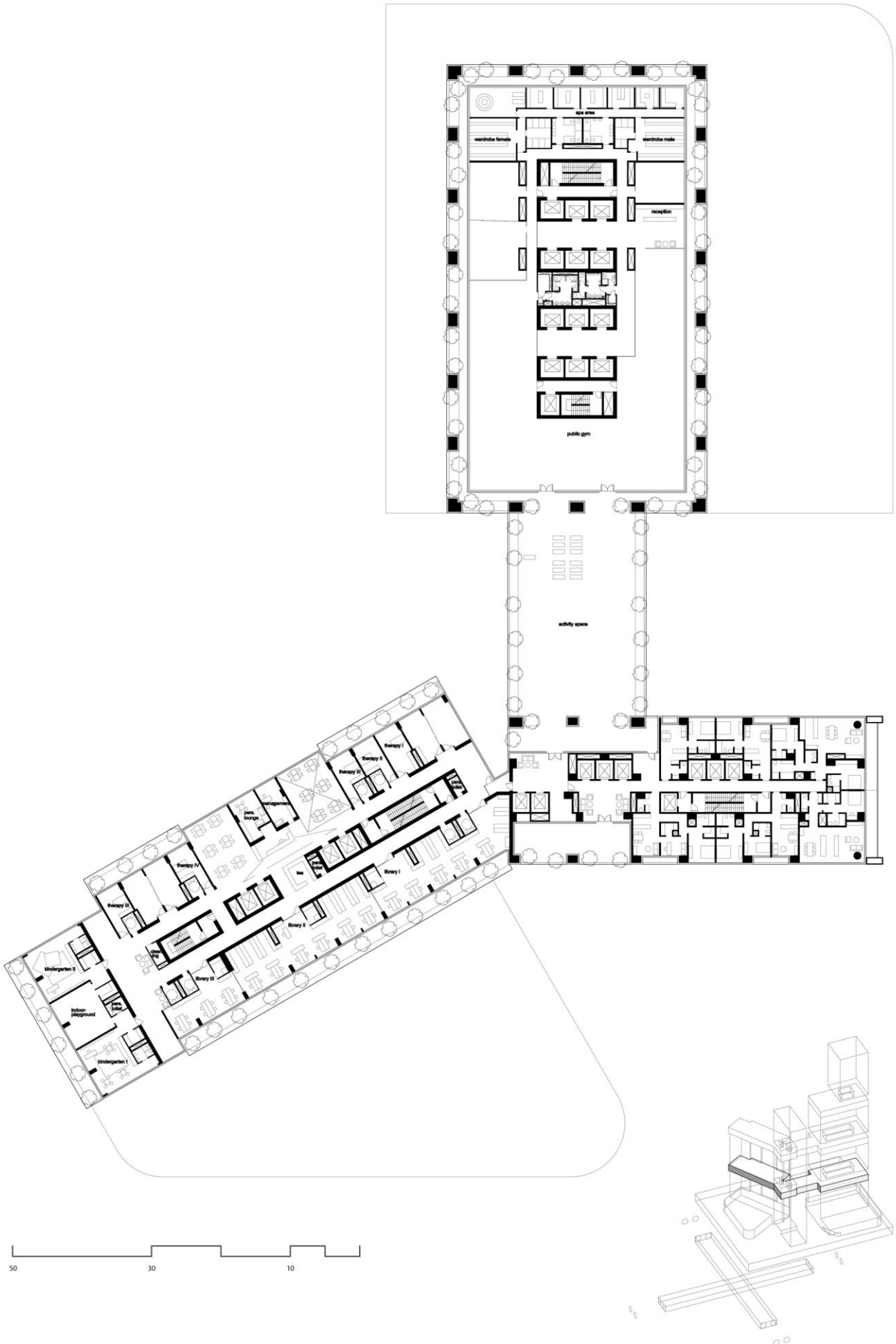


Figure 113 <F25: pocket II (environment)>

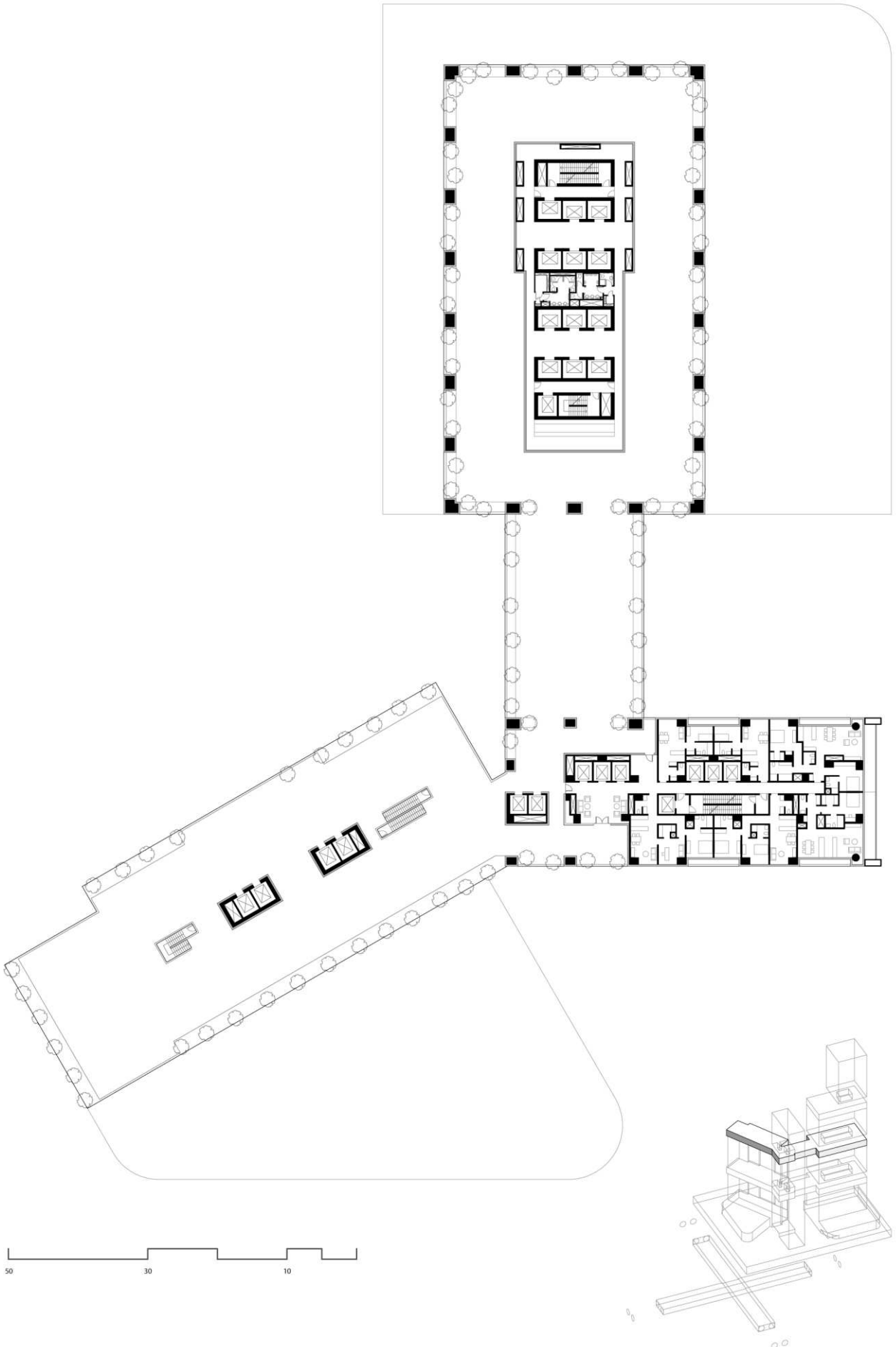
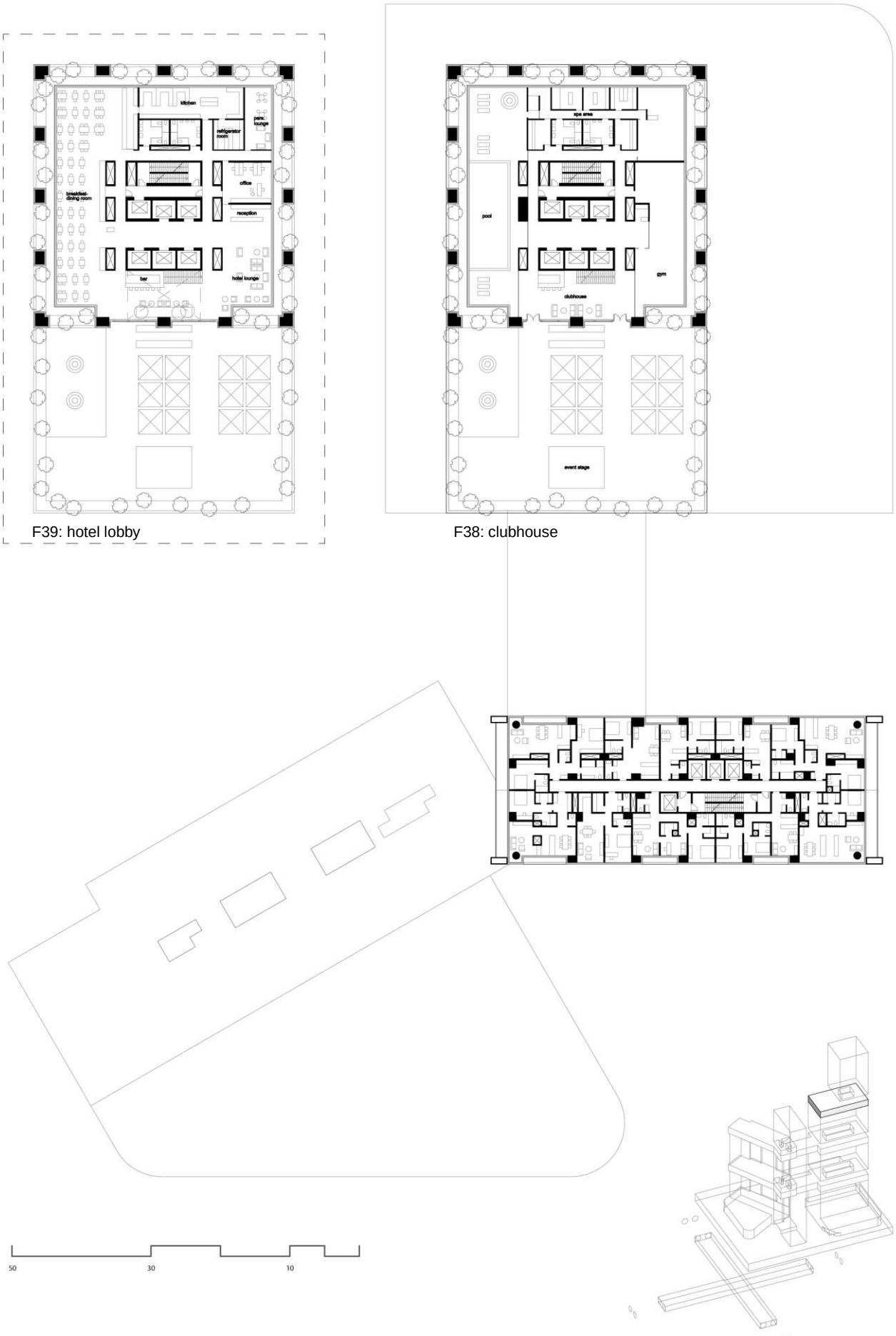


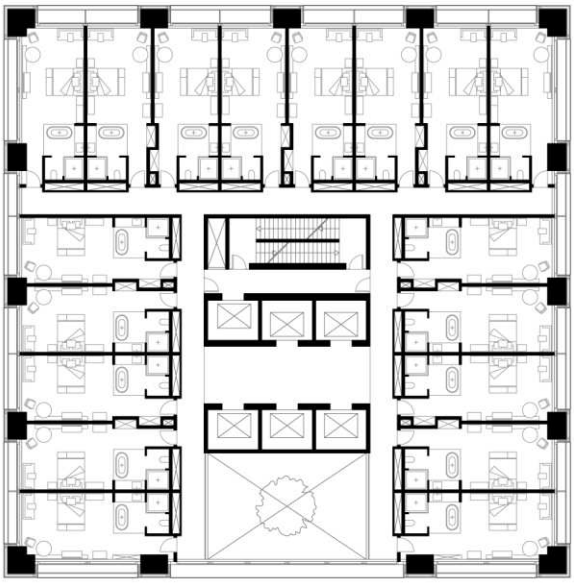
Figure 114 <F38-39: pocket III (clubhouse, hotel lobby)>



F39: hotel lobby

F38: clubhouse

Figure 115 <F40-55: hotel floor>



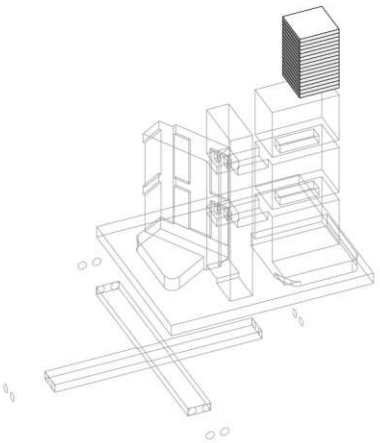
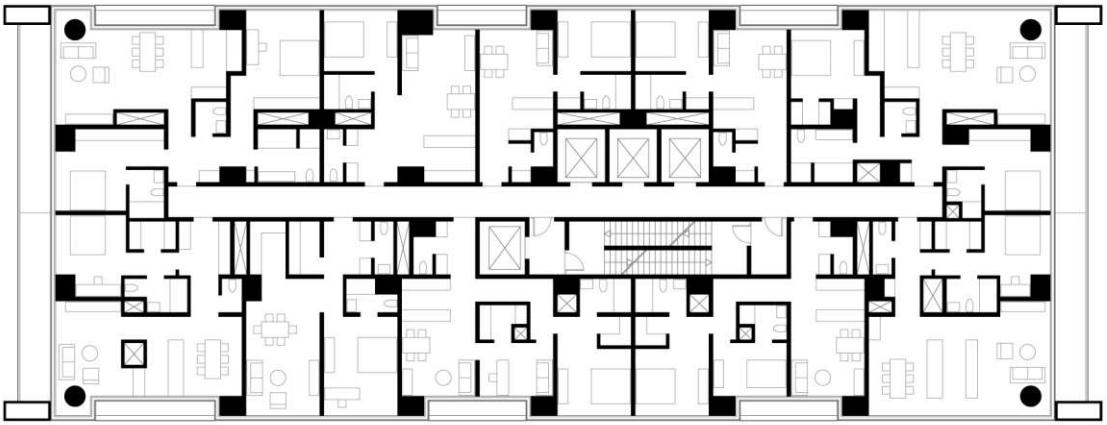


Figure 116 <F27-36: residential floor>



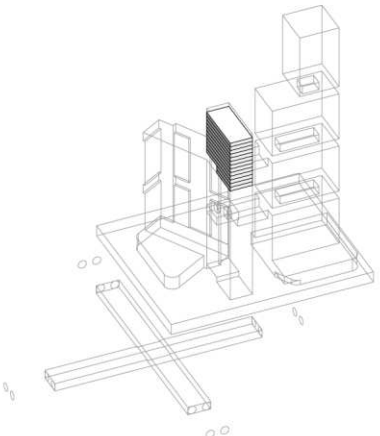
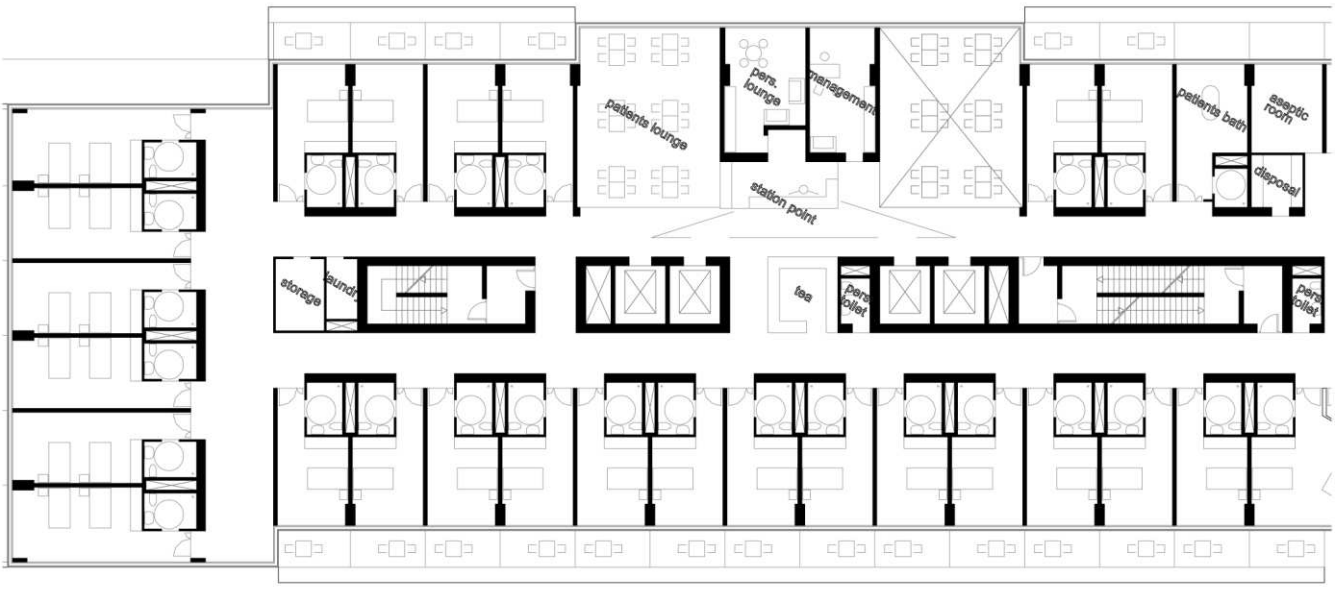
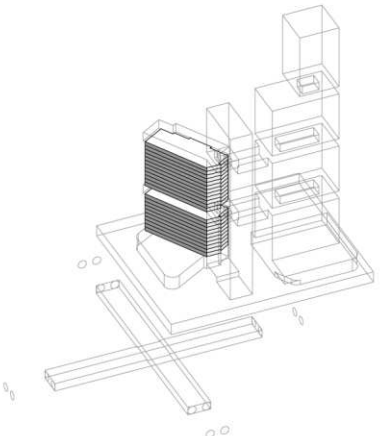


Figure 117 <F3-12;15-24: geriatrics floor>





- elevations scale 1:1000

Figure 118 <north>

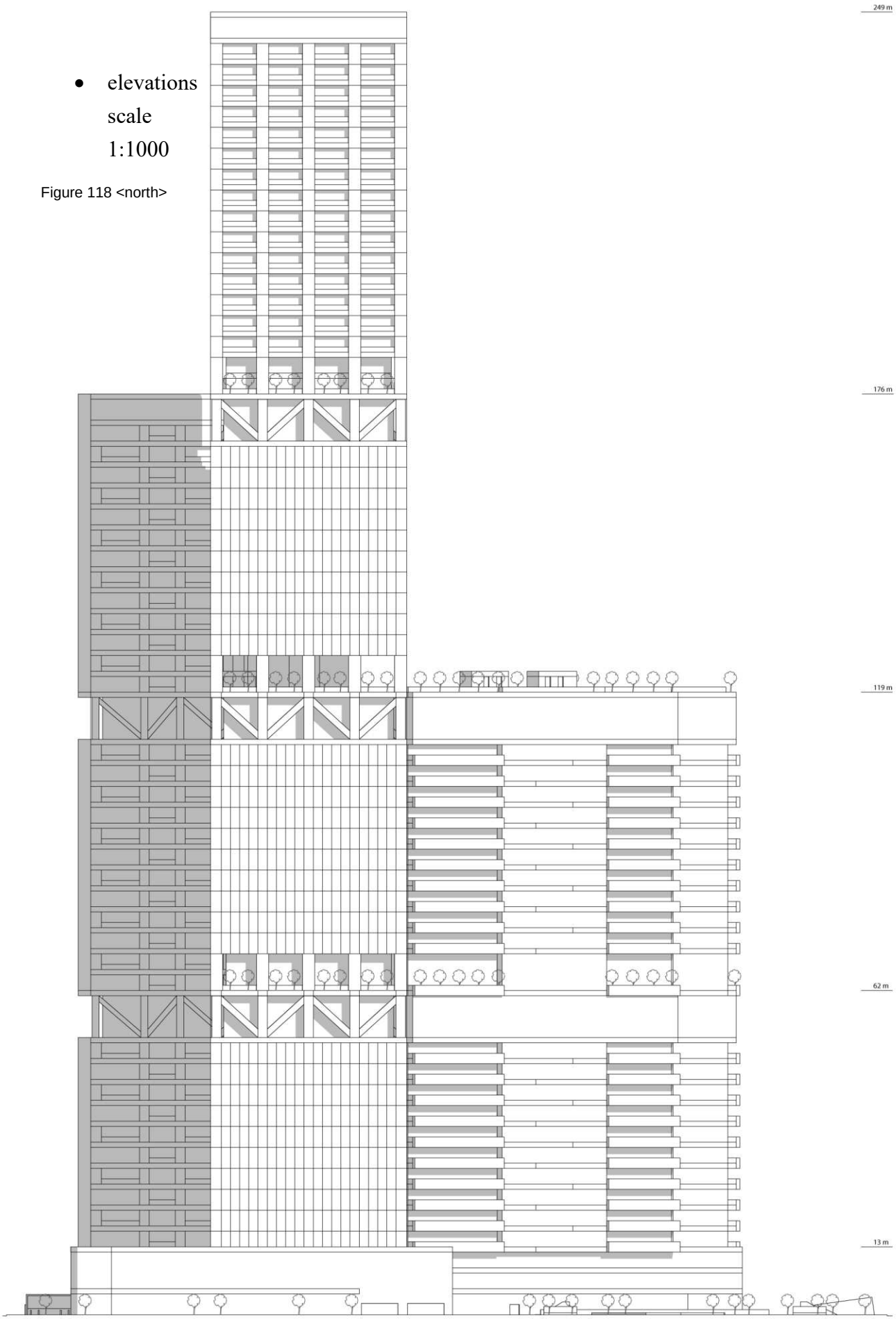


Figure 119 <south>

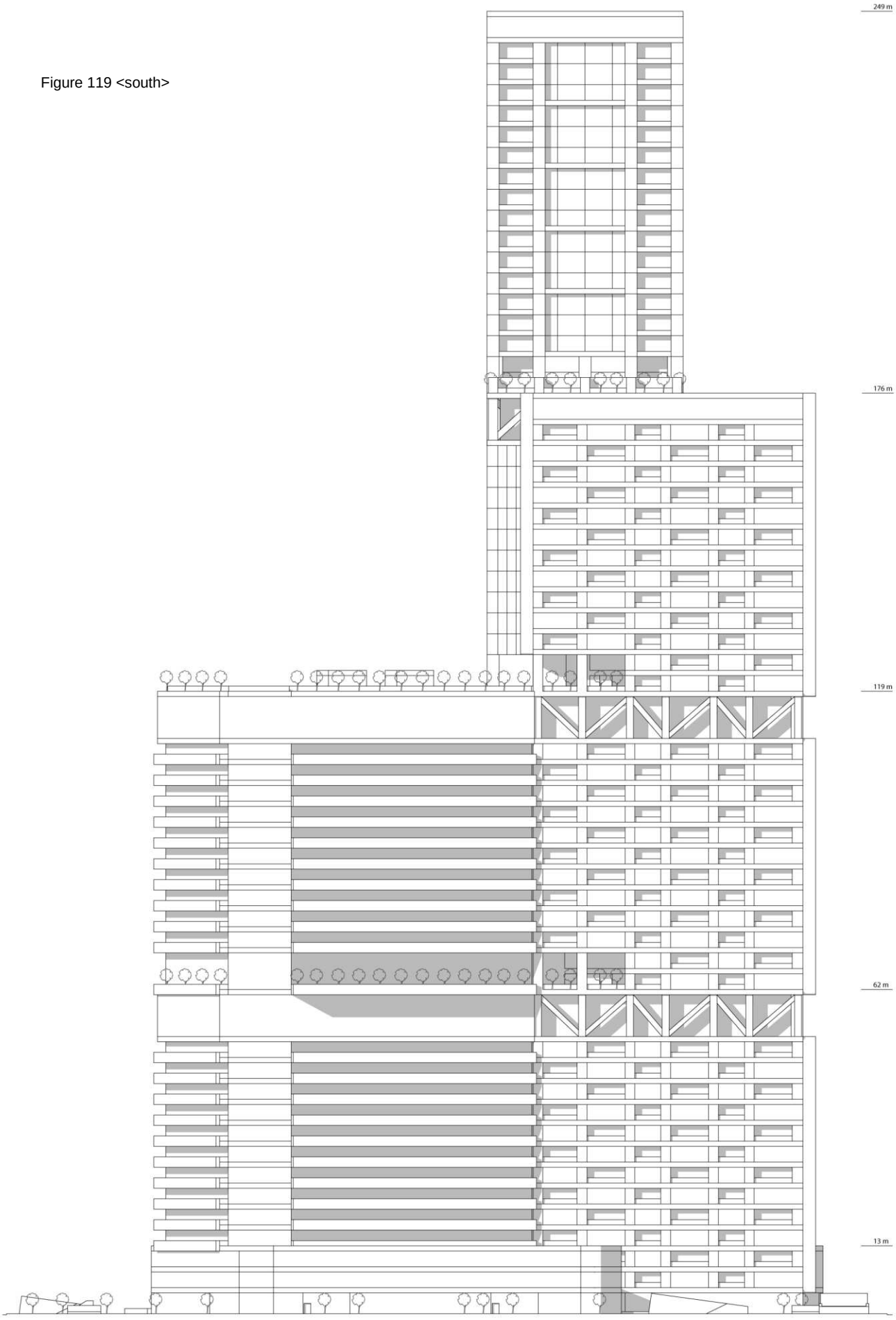


Figure 120 <east>

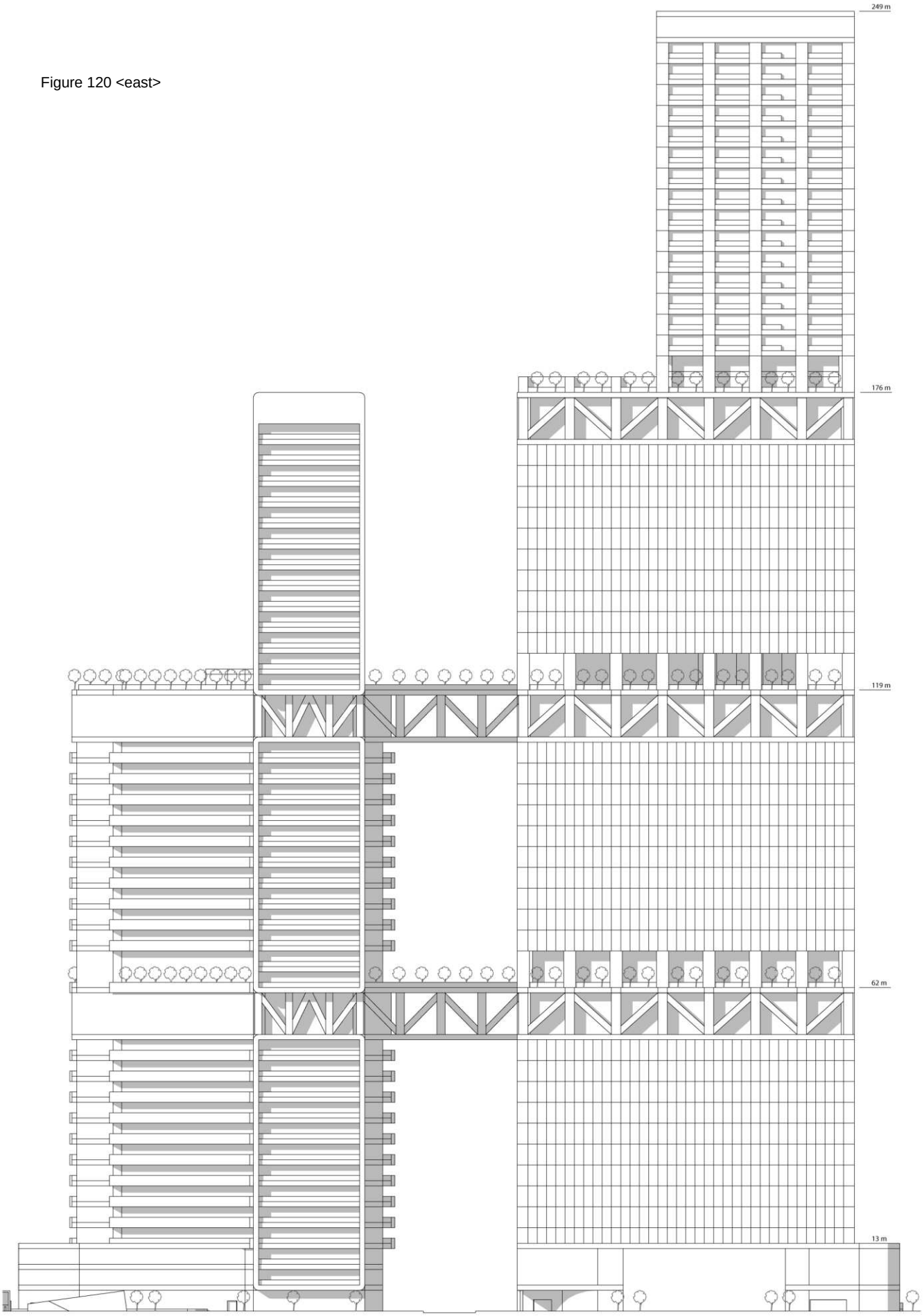
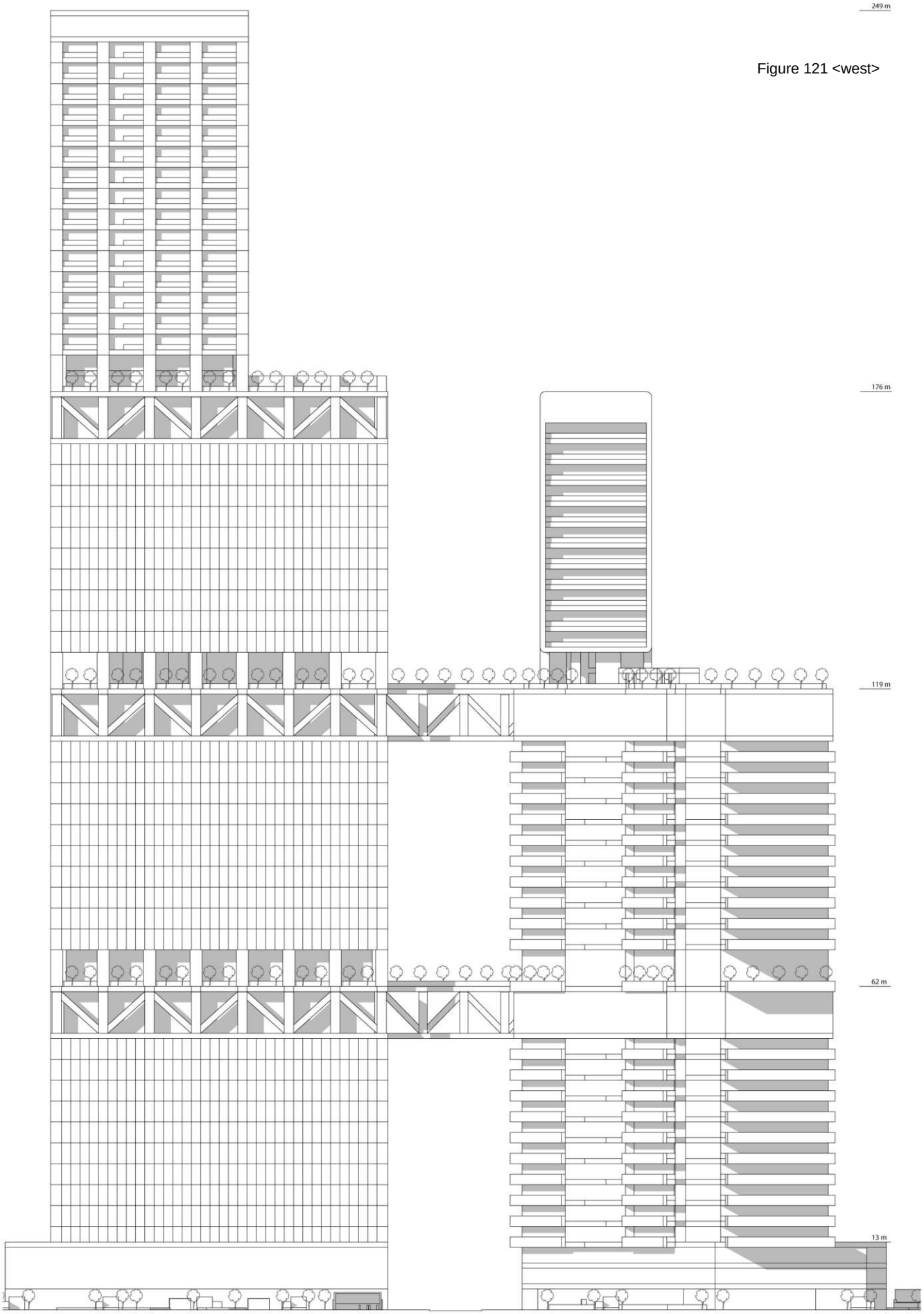


Figure 121 <west>



- sections

Figure 122 <section I>

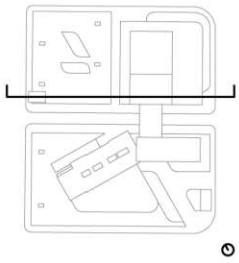


Figure 123 <section II>

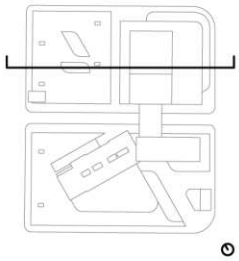
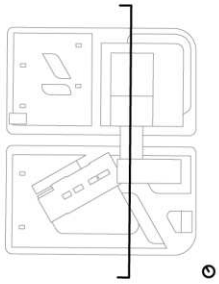
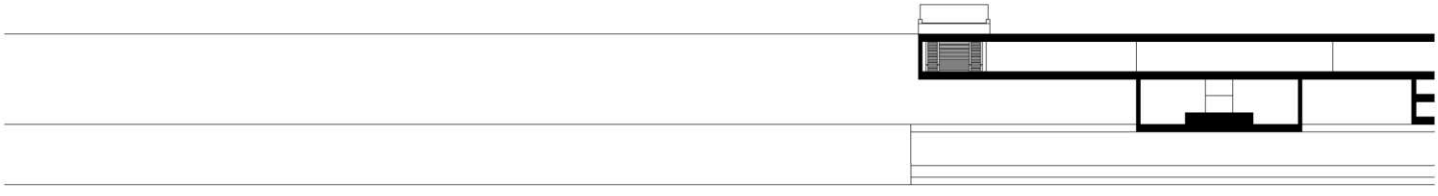


Figure 124 <section III>





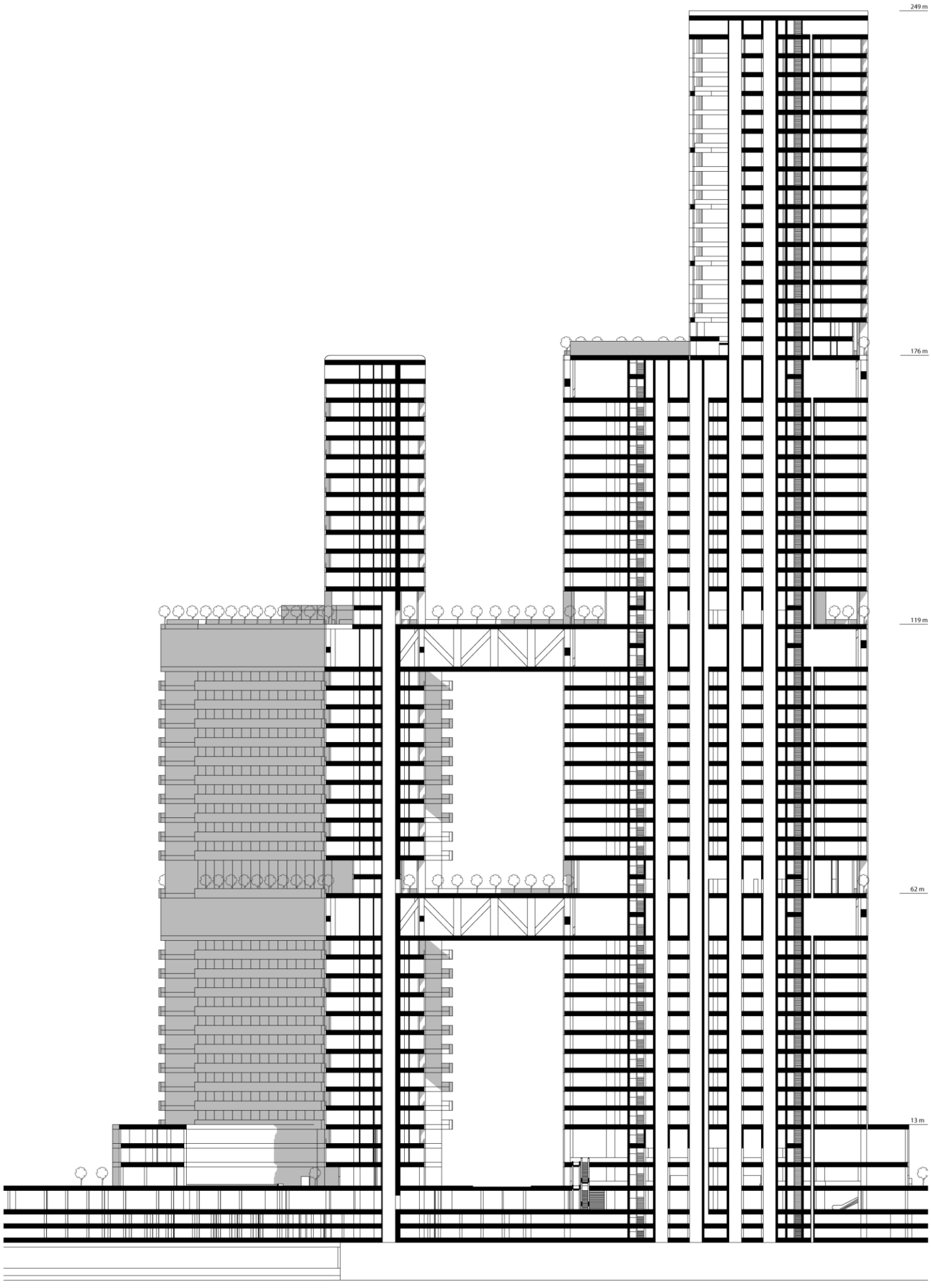
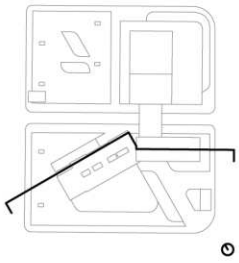
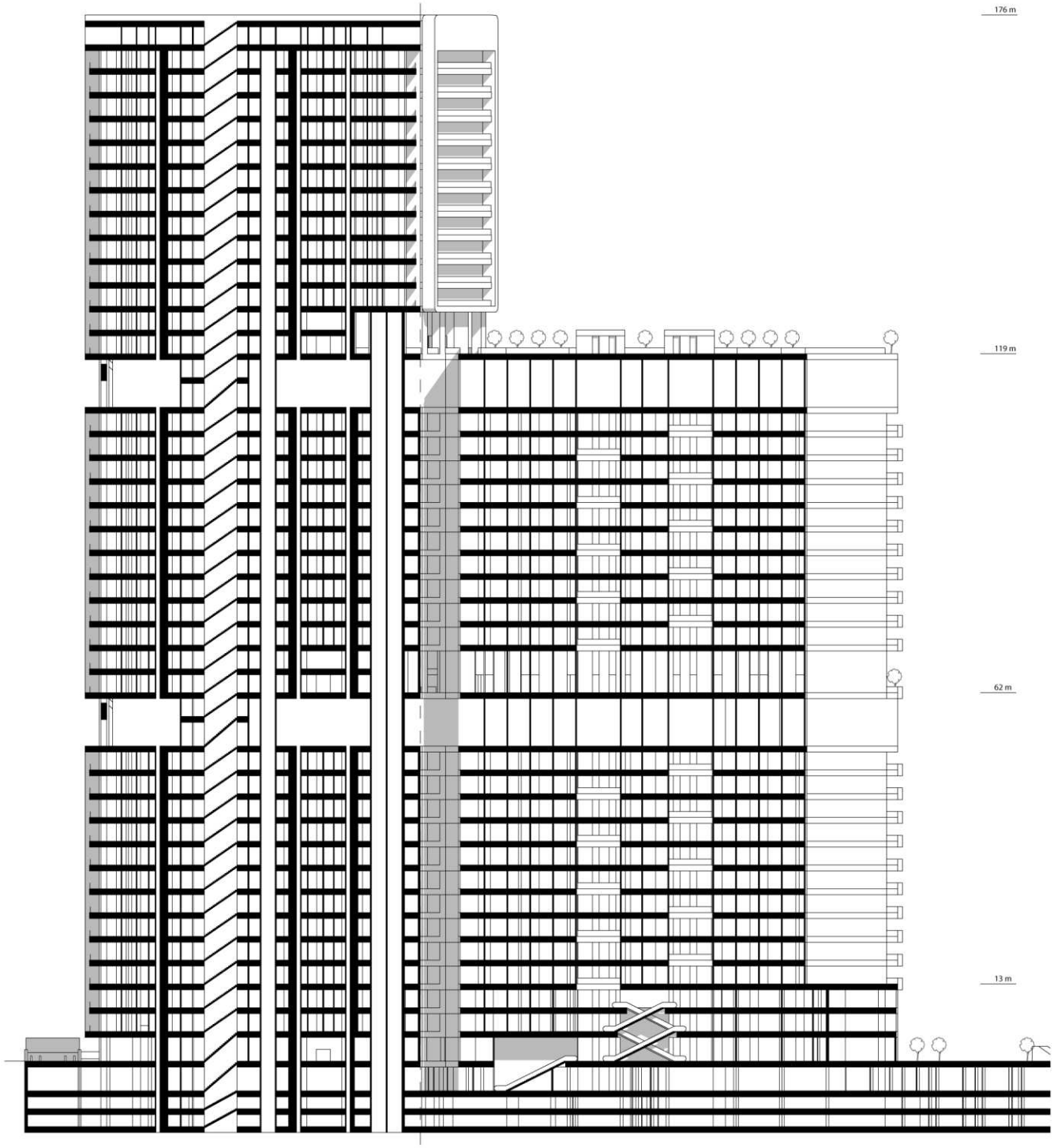

249 m
176 m
119 m
62 m
13 m

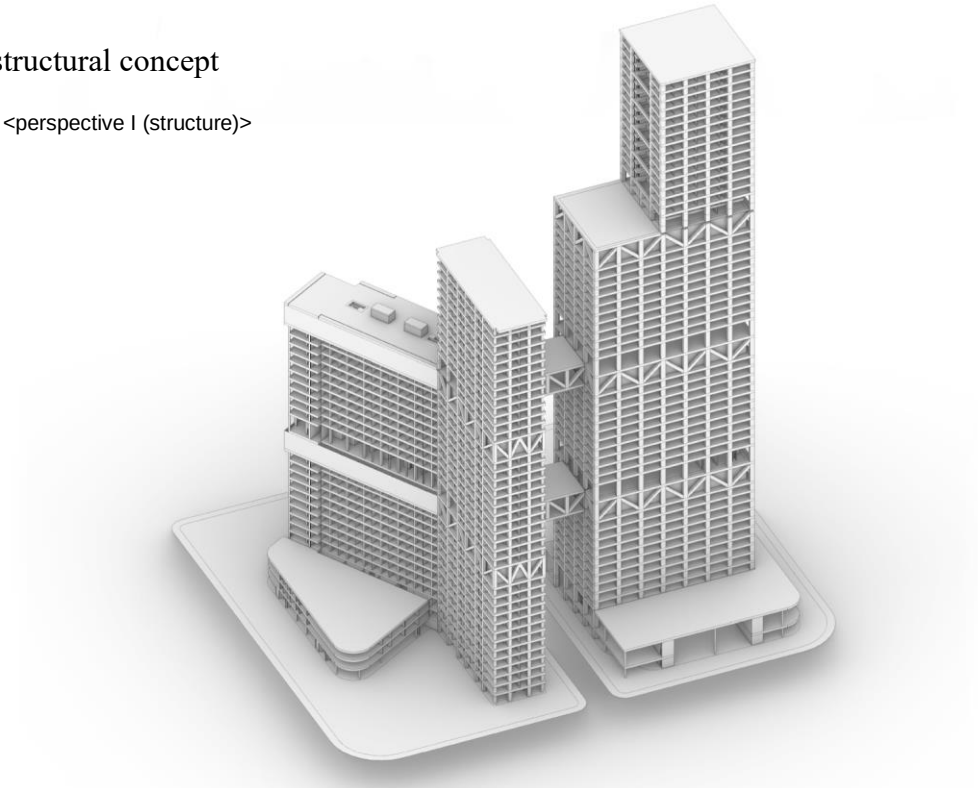
Figure 125 <section IV>





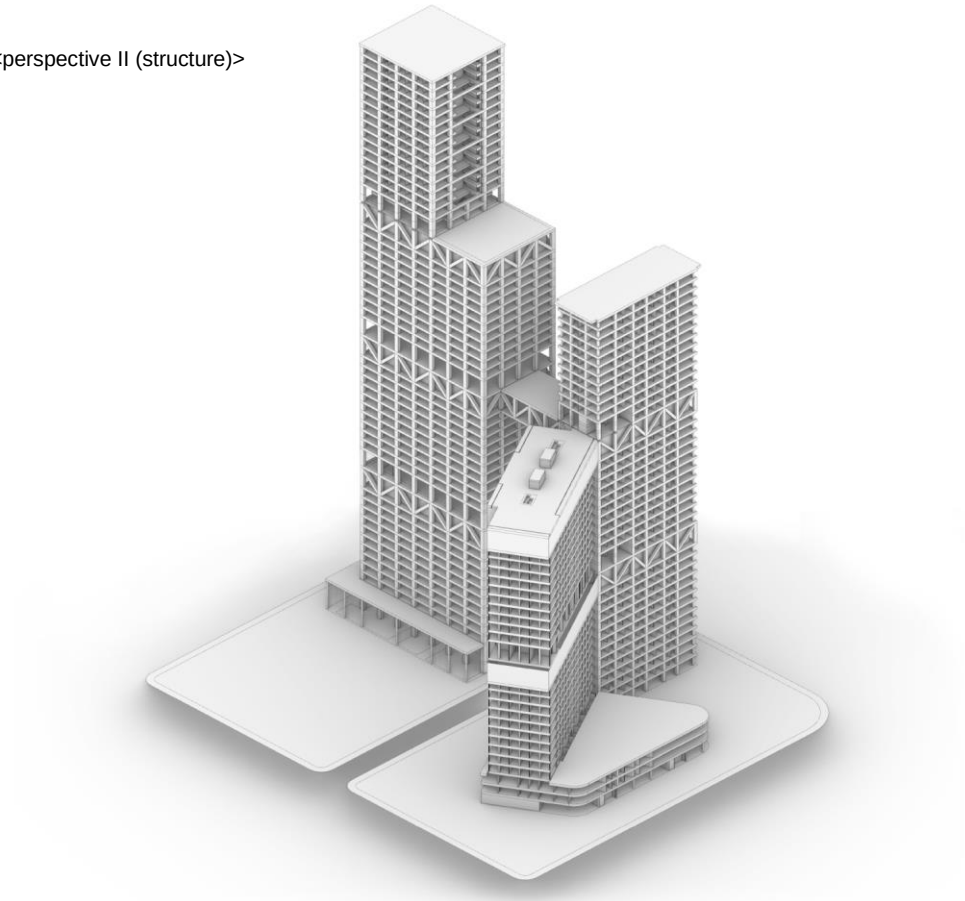
- structural concept

Figure 126 <perspective I (structure)>



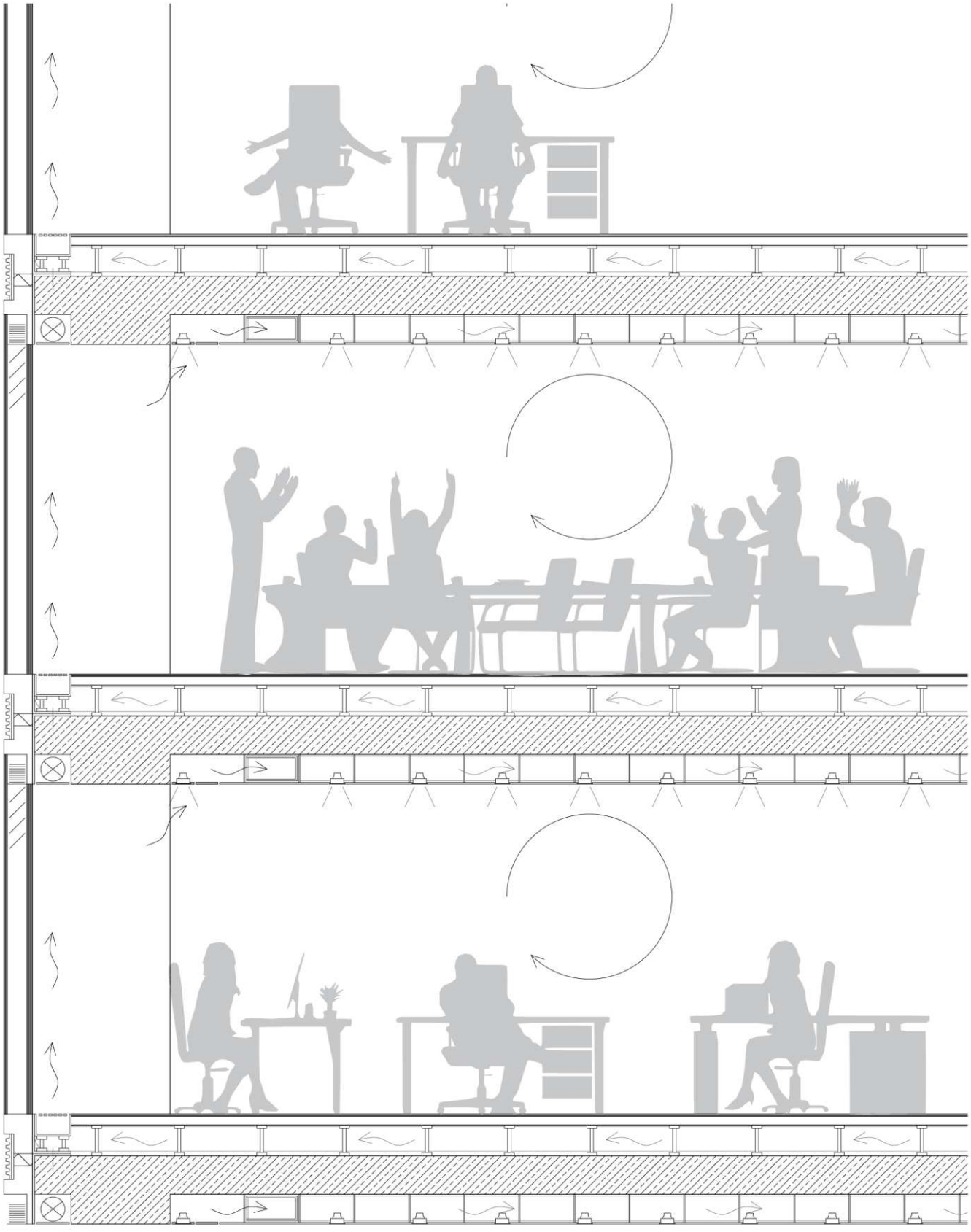
In general, the geriatrics tower follows a conventional structure strategy with sheer walls, reinforced concrete core walls and supporting pillows. In contrast, a super pillow structure is used at the residential and office/hotel tower. The belt truss is used as a transfer truss, enabling the elimination of the bridges at the sky gardens. To compensate possible stresses, the bridges are only rigidly fixed on one side.

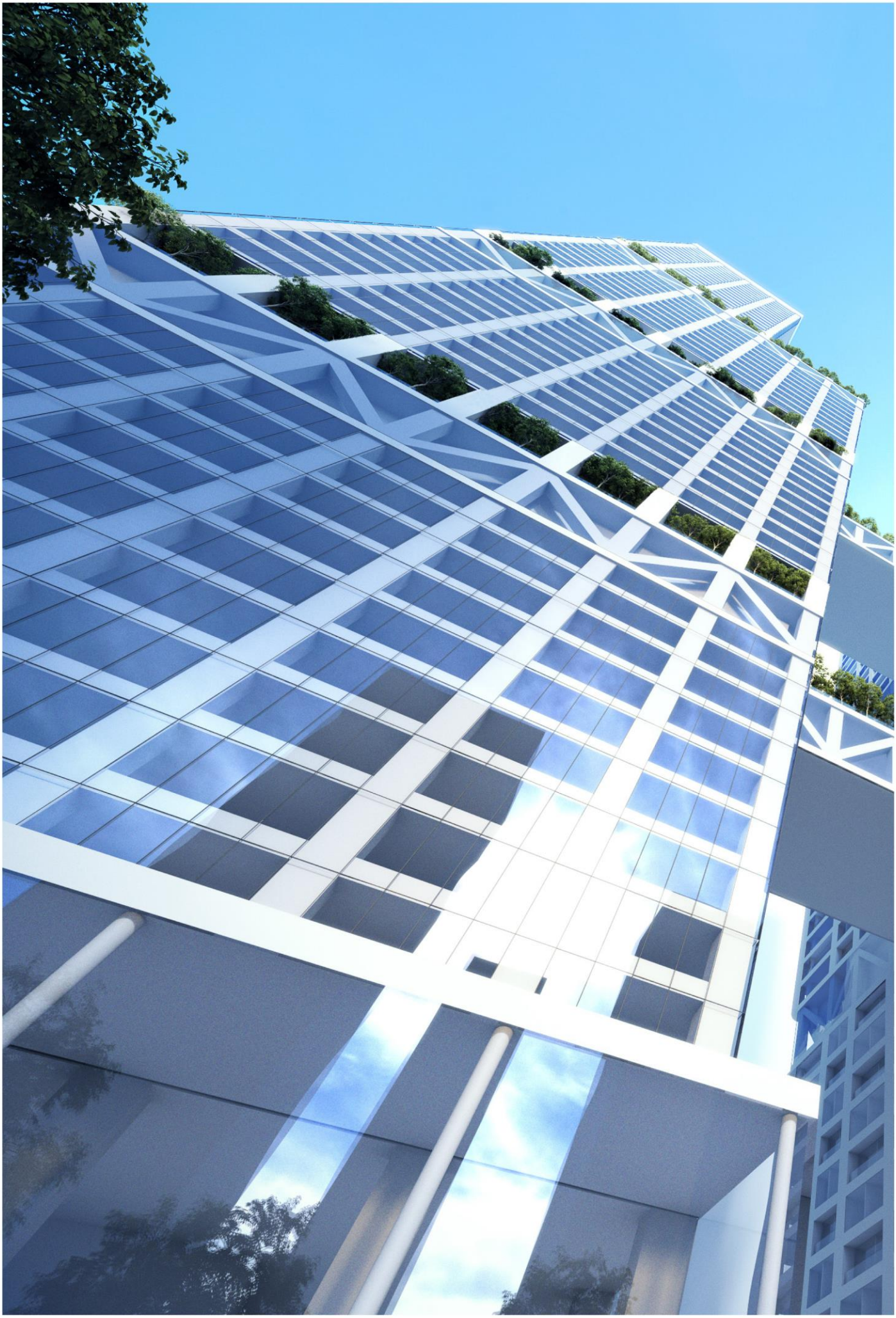
Figure 127 <perspective II (structure)>



- detail – 1:20

Figure 128 <section detail of the facades>





5.4 Visualizations

Figure 129 <rendering I: impression perspective>

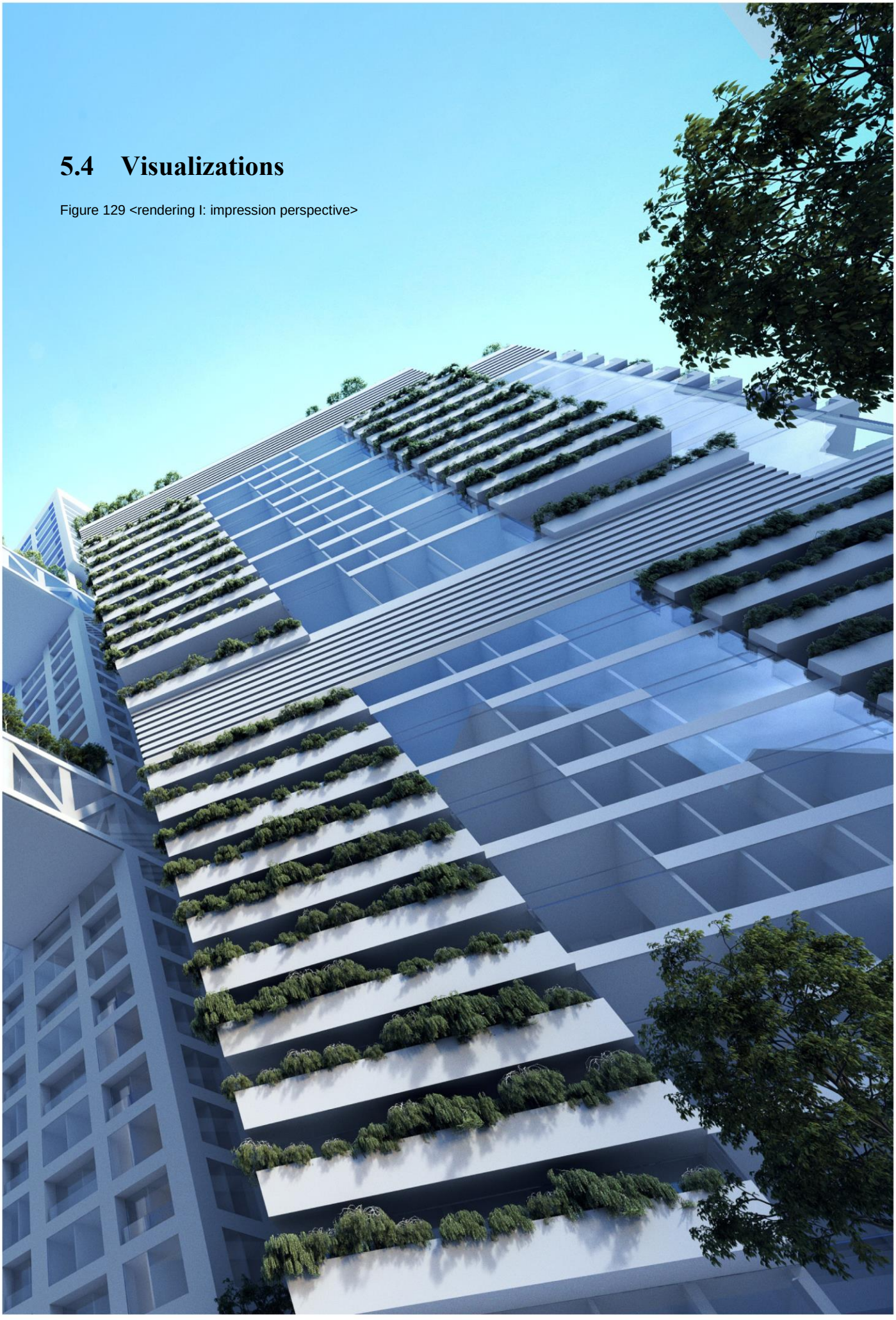


Figure 130 <rendering II: bird’s view>

Figure 131 <rendering III: pocket II – environment>

In the respective illustration "rendering III" the public park with its gardens, paths and quiet places stands in the foreground. Although situated on a high-rise roof, one really has the impression to be at ground level in the nature. The impressive view into the distance makes the scenario unique and reveals that one is part of a Vertical City.

Figure 132 <rendering IV: pocket II – environment>

Figure 133 <rendering V: west perspective>

Figure 134 <rendering VI: north west perspective>

6 Conclusion

6.1 Summary of Research

In a strong growing agglomeration like Hangzhou, any new building has to reach beyond the pure functional approach for generations to come. Future proof means to supersede this: by being flexible, adaptable and programmable. The organization of the podium and sky gardens allows for synergy of retail, leisure and work. What users can do and experience in these spaces can change with their demands, it is not bound to any typology and essentially can grow over time. At the same time, these spaces can facilitate what has become a worldwide trend: collaboration, co-working in co-creation.

Application of the findings of the theoretical approach (which are formulated in the "Comments of the Literature Review", the "Conclusion of the Comparative Case Study" and the "Conclusion of the Examination) on the project:

- Public Transit

What's the problem in the public transportation and what is the strategy to overcome?

As a rule, the public transit and urban fabric are planned separately and in most cases are not seamlessly connected. If there is a linkage, today, it usually has a complex access and it is preferably used purely for shopping. In the future, merging public transit and land-use planning will make these connections much more effective, since they are integrated into the overall concept right from the start. Following this design approach, in addition to shopping, further functions and amenities can be implemented, such as in the thesis design project: retail, a food core, a multi-level pedestrian passage, an art and convention center, an ambulance base/ clinic, several lift lobbies, where the public elevators that link to the sky gardens are situated in central location. Despite this complex program, the floor plan design follows a clear layout which automatically points the user in the right direction. Due to this pleasant connection to the transfer station, people of the development use public transit more frequently and more likely than other means of transportation. This inevitably further promotes the movement of the pedestrian.

- Accessibility

How do people (user groups) get to know how to enter (the direction)?

To guarantee valuable urban life, a good relation between interior and exterior is necessary for the success of the project. In regard of the thesis design project, first a distinction must be made between the following transportation modes: pedestrian, public transit, car, bus, truck, ambulance as they access the development differently. As pedestrian there are two options, by foot or by public transit. By foot is insured by a continuous retail passage below ground that can be entered from each side of the lot from street level. The public transit core is connecting four lots including the one of the thesis design project. By that, the already mentioned retail passage that leads towards this core is the all-embracing entrance to the development and consequently the lobby for the public to enter the elevators that bring people to the sky gardens.

To provide best readability possible, all vehicles enter the development at one entrance. To ensure the fastest possible access, ambulance vehicles stop in the first floor below ground, just like buses and trucks, in order to keep transportation roots efficient. Private cars are accommodated to the second and third floor below ground.

- Circulation in both directions (horizontal and vertical)

How to layout the relationship between different levels in multiple directions?

Traditionally, pedestrian activity within buildings just takes place at the ground level, while elevators are in charge of the vertical movement. Over time, density increased, new heights were reached and therefore, it is required to provide urban life on several levels. As a result, typical skyscrapers implement multiple sky lobbies, where people exchange between shuttle elevators and local elevators. However, they only act as nodes. Today the driving force of upcoming projects is first, to implement open space and other amenities at these levels to create urban places in the sky and second, to upgrade the vertical infrastructure to a 3-dimensional transportation system. The thesis design project attempts to even go beyond this layout. On the ground floor, it offers a multi-level pedestrian system, whereby particular lobbies transport different user groups in vertical direction for security and private law reasons. Each of the integrated (semi) public sky gardens has an individual theme and pursues different goals through its program. In addition, the individual towers are connected at the exact height of the sky gardens, which eventually forms a collective of high-rise buildings to one unit, a Vertical City. The introduction of several routes for the different user groups enables everyone to get from each point on site to any other by the fastest possible way. The sky-bridges of this route system serve as horizontal links with its public open space functionality and as the all-embracing key elements that cannot be run past.

- (Public) Open Space

How to organize open space within vertical structures?

In regard of the thesis design project, the podium and the sky gardens are organized in a flexible and open manner. They become the most public asset of the development. Here the character and identity are the most exposed and people from the neighborhood are invited to become part of this City Center Hub. The organization of public and private spaces link to the urban fabric; the terraces are at a threshold between the various functions and visible sustainable features. This project includes:

- Podium: central plaza
- Public sky garden of pocket I: full of physical activities
- Public sky garden of pocket II: agriculture, gardens, parks and places to relax
- Semipublic sky garden of pocket III: clubhouse, outdoor event stage and hotel lounge

- Functionality - 24/7 Scenario

How to achieve usage of vertical development throughout the day (24h)?

In the past, the single use of high-rise buildings dominated and resulted in an average usage of not more than 12 hours a day. By blending the functions hotel, residential, office and retail, this can be extended. However, the full potential has not been exploited yet. Only if the entire set of functions and amenities of a city has been established a usage of 24 hours can be achieved. This is what the thesis design project tries to verify. The organization of the podium and the sky gardens allows a synergy of retail, leisure and work. What users can do and experience in these spaces can change with their demands. It is not bound to any typology and in essence it can grow over time.

- Final Statement

In the long run, the synergy of working, living and spending leisure time has its own cycles and users engage with each other in various ways. Shaping communal areas with different qualities allows all people a functional, visual and social cohesion. The way the project is positioned at Yingfeng Lu Station at the main avenue of QCC stands out as a prototypical architecture that sets the direction for the future.

6.2 Direction for further Study

As clarified in the delimitations, some sections, especially from the theoretical approach, try to lay the foundations for a potential PhD work. In addition, massive amount of research is being done and experimental architecture currently under construction worldwide. In order to strive knowledge from their outcome and success, a continuation of this study is crucial and of great personal interest. This study focuses in particular on the three-dimensional infrastructure and functional organization of a vertical city. The future research question will be how to not only bring people together, satisfy their needs through the implementation of amenities and create urban life, but how to build a holistic strategy for a vertical city as an entire eco-system which has no negative impact on the environment at all (In short, how to go beyond sustainability).

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List of Figures

List of Tables