From Efficiency to Sufficiency

- Towards the Green High-rise Building

Master Thesis explanatory document supervisor

Professor Bin Su and Professor Dushko
TABLE OF CONTENTS

Abstract
1. Introduction
   1.1 Research question
   1.2 Aim
   1.3 Objectives
   1.4 Outline of project
2. Methodological Approach
3. Review of Current Knowledge
   3.1 Definitions
   3.2 International case study
4. Project Context
   4.1 Beijing CBD’s current situation and a future vision
   4.2 Site analysis
      4.2.1 Site location
      4.2.2 Site information
      4.2.3 Future development in Beijing CBD
      4.2.4 Site conclusion
5. Project Development
   5.1 Design strategy
   5.2 Brief
   5.3 Building programme
6. Design process
   6.1 Beijing current climate and lifestyle
      6.1.1 An analysis of Beijing climate main building energy consumption
      6.1.2 An analysis of current Beijing residential buildings
   6.2 Design concept
   6.3 Architectural idea
      6.3.1 An analysis of building interior spaces and the analysis of the street idea
      6.3.2 An analysis of building function
   6.4 The analysis of Chinese Code for Fire Protection Design of Tall Buildings
   6.5 Design development and outcome
      6.5.1 The design of apartments
      6.5.2 The design of commercial/cultural facilities
      6.5.3 The design of offices
      6.5.4 The of hotel
      6.5.5 Building location and urban solution
      6.5.6 Building envelope
      6.5.7 Building services analysis
      6.5.8 Building structure concept
7. Conclusion
   7.1 Critical appraisal of the finished work
8. Reference
Abstract

This project challenges the usual consumption of conception of the CBD as a cluster of HRSB. Instead of individual tall building, we have single building which acts as a vertical city. This building is 60 storeys high tower, with a rectangular floor plate of 150mx90m. The building volume is increased so as to provide more green and public spaces in the building itself. The distances between the different functions are decreased in order to reduce the travel time. The lifestyle has been changed by turning the horizontal traffic into the vertical building circulation. The single footprint leave large open spaces free on the ground level, and this allows the people of central Beijing to fully enjoy an abundance of green spaces.

It will not only to save land and reduce the social and economic problems by possible future demolitionment, and also provide a new lifestyle which is quite different to the traditional urban life. Residents could enjoy the convenience of the city and a truly low-carbon life. Residents could go to work just by walking, using lift or taking the convenient subway. People could enjoy the high-end art exhibition, shopping, dining and entertainment in the same place as they live; other occupants and overseas visitors could easily arrive there by taking trains from any city in China connected to more than a dozen subway lines in Beijing. People could take the subway directly from the commercial area in the basement, to their next destination after having finished shopping. Visitors would not even know what the building looks like from the outside. Private vehicles will be allowed, apart from 2,000 parking spaces for the hotel, the other 2000 are all commercial used parking spaces.

This building will integrate all of the relevant facilities, such as working, living, entertainment, retail and other needs of everyday life. The time saved from travel would indeed improve people's quality of life, while being both environmentally friendly and comfortable.

1. Introduction

1.1 Research question

How to design a mixed-use high-rise building so that it utilises widely applied technologies and resources efficiently, while ensuring that the occupants have good working and living condition?
1.2 Aim

The purpose of the project is to investigate through design a possible Green High-rise building form which can meet the requirement of a megacity’s rapid development and also achieve excellent human conditions.

1.3 Objectives

a. To ensure a good quality of urban life for people, by considering their needs, the building should:
   - Be comfortable, secure and healthy
   - Provide social space
   - Provide shopping, recreation, entertainment and cultural facilities
   - Be fair in allocation of space and good design
   - Provide visual delight

b. To design a sustainable and resilient high-rise building by pursuing the following 3 strategies:
   - To maximize land-saving
   - To minimize energy consumption
   - To utilize natural resources (such as solar, wind, light) efficiently

1.4 Outline of Project

Along with social development and population growth in recent decades, the number of megacities, cities with an estimated population of more than 10 million people has increased around the world. By the end of 2007, there were 19 megacities on Earth and their number will be increased in the next decade. Asian has eleven megacities, such as Tokyo, Osaka-Kobe, Shanghai and Beijing. Growth of the population will inevitably cause an increase in urban density. Just take Beijing, for instance, the multi-story residential buildings built in 1980’s within the 2nd Ring Road, which is the city boundary at that time, where demolished mostly. Even though the building life span is 70 years, their density was too low to suit the speed of urban development. Therefore, the effective building development in these megacities became more critical than ever before. Many issues should be observed, especially land limitation and

---

resource limitation. This is the main driver for this proposal. People expect an ever better quality of urban life and working and living environment, while wishing to reduce the consumption of resources.

In this project, I intend to investigate an appropriate way to design a mixed-use high-rise building in the Central Business District (CBD) of a megacity, dealing with the ecological and social issues. As Johann Eisele mentioned, ‘the high-rise is understood as a city within the city and thus makes an important contribution towards solving the structural and technical problems, as well as with regard to social problems and social responsibility.’

Ken Yeang stated in his book, *Reinventing The Skyscraper-A vertical Theory of Urban Design*, 'In response to the need for a sustainable future, the urban design for the new high-rise must address the limitation and constraints for our ecological environment.'

In some cases, sustainable design is seen as an ‘add-on’ technology. Many architects begin to perform a building with the basic ideas of function, form and cost, and only afterwards, they may consider the sustainability. They then add a design feature or technology which could be easily added on to reach the design requirement, such as a green roof or solar panels.

A truly ecological approach would include both spatial and climatic modelling. Any built structure causes a spatial displacement in its environment simply by existing, but it also alters the climate through its operation.

With an ecological approach, the designer must see the environment in which the designed system is to be located as more than just a spatial zone with physical, climatic and aesthetic features. Other environmental factors, such as topography, vegetation, natural hazards, energy and infrastructural systems, transportation and site access, for ecological design are especially influenced by the built form and in turn influence the operation of the built form.

Therefore, I propose to perform research based on sustainable design before the actual

---

design work starts, and form a proper programme to guide the whole design process by concerning those environmental factors.

2. Methodological Approach

This project used both ‘Research FOR Design’ and ‘Research BY Design’. These two approaches are not strictly separated; on the contrary, they are integrated and they influence each other a lot.

Research FOR Design

The project started with forming a proper sustainable programme regarding the local climate and urban development, based on research of the existing literatures and examples. Research FOR Design will be achieved by the following steps:

- To create a brief based on the client’s needs, and then generate an initial building programme according to this brief. The programme might be revised later for developing the project.
- To select a proper site according to the site criteria of the project
- To analyze and summarise the main features of the site
- To analyze the relevant issues:
  a. Optimisations with respect to sustainability, quality of life
  b. Energy consumption minimization and resource generation maximization (especially in lighting, heating and cooling)
  c. Assessment Methods:
     - official rating systems, such as LEED (United States), BREEAM (United Kingdom) and Green Star (Australia and New Zealand)
     - Other methods, such as ecological footprint or carbon rating.

Research BY Design

Design ideas and propositions were sketched, model and visualized digitally. To perform the Green high-rise building which were not only be sustainable, but also provide a new liveable and working place for the people. Research BY Design was instrumental both in discovery of new design possibilities, and in identifying the missing information to support the creative exploration in design. The process has the following steps:

- To collect and analyse the relevant data
- To study and analyse the related precedents
- To proposal tentative design solution
- To test and calibrate the design by computer simulation and physical modelling

3. Review of Current Knowledge

3.1 Definitions

Before the initial Green High-rise Building (GHRB) design starts, we need to have a general idea about what the GHRB is. It is hard to get an exact definition for GHRB worldwide. If we are trying to divide the GHRB into 2 parts which are Green Building (GB) and High-rise Building (HRB), the understanding of these 2 parts would still be various in different countries. To define the HRB, it is possible to find out the height requirements from the Building Code/Regulation in each country. There have been several Assessment Methods to evaluate the GB, such as LEED (US), BREEAM (UK) or Green Star (AU and NZ), etc.

In Germany, ‘High-rises are buildings in which the floor of at least one occupied room is more than 22m above the natural or a prescribed ground level’. High-rise buildings (HRBs) have been defined as buildings exceeding specified heights (which can vary between 13m and 50m) in other countries’ building laws. In China, the HRB is defined in Code for Fire Protection Design of Tall Building as being a building which is more than 24m. It is, therefore, difficult to generalise regarding how HRBs are defined in international legislation. Because there are different safety criteria, such as the dictates of fire protection and the effective use of fire escapes, to define the HRB in different locations around the world.

Nor is it possible to explain GB in a few words. ‘Being ‘green’ means different things to different people; there is no single right answer. When business and government talk of being ‘green’ they mean being ‘sustainable’. For them, it’s about changing the way they do business. For individuals, being ‘green’ is about making informed decisions, lessoning negative impacts, and moving toward a more sustainable lifestyle.’

After the site location has been decided, it is possible to make a proper definition for the GHRB if we conclude the above different understanding of GB and the local HRB

---

7 Ibid., p11
requirement. The GHRB for this project which is located in China will be defined as a building which is more than 24m tall and would start the design process with sustainable principles from the very beginning.

Several international Assessment Methods have got a different focus on their applications.

a. LEED (Leadership in Energy and Environmental Design) is a rapidly growing green building system. Through this tool they aim to encourage and accelerate global adoption of sustainable green building and development practices through “the creation and implementation of universally understood and accepted standards, tools and performance criteria” (LEED website).

LEED was created to:

• Define “green building” by establishing a common standard of measurement
• Promote integrated, whole-building design practices
• Recognise environmental leadership in the building industry
• Stimulate green competition
• Raise consumer awareness of green building benefits
• Validate achievement through third party review
• Contribute to a growing green building knowledge base.

b. Building Research Establishment Environmental Assessment Method (BREEAM) was developed to assess the environmental performance of both new and existing buildings. It is now the world’s most widely used assessment tool. Since its launch in 1990, BREEAM has been increasingly accepted in the UK construction and property sectors as offering best practice in environmental design and management.

BREEAM offers a range of benefits, from environmental to financial including:

• Compliance with environmental requirements
• Environmental improvement: in support of a wider corporate strategy or as a standalone contribution
• Occupant benefits: to create a better place for people to work and live
• Marketing: as a selling point to potential tenants or customers
• Financial: to achieve higher rental incomes and increased building efficiency
• Best practice: to provide a thorough checklist or tool for comparing buildings
• Client request: responding to the requirements of users.

c. Green Star was based on the LEED and BREEAM schemes. It is widely used in Australia, and has also been applied in the New Zealand context in the past, in the absence of a New Zealand-specific tool. The Green Star scheme is voluntary and offers a suite of tools, including office design, office existing and office as built.

The stated objectives that the Green Star tool aims to achieve are to:
• Establish a common rating tool
• Set a standard of measurement for green buildings
• Promote integrated, whole-building design
• Recognise environmental leadership
• Identify building life-cycle impacts
• Raise awareness of green building benefits. 9

Although the details requirements of these international Assessment Methods are different, but the overall aim is to determine the building energy-efficient levels by accounting how many assessment requirements have been met. However, the annual report by LEED shows that most of the buildings which have met the assessment requirements are not able to save as much energy as expected during the latter running process.

So if the sustainable building design is just simply based on those requirements of international Assessment Methods, then afterwards, the results may be quite different with the original ideas.

3.2 International case study

There are hundreds of GHRB around the world during last 20 years, and the following 5 good examples are really interesting and can be related to the current project.

The Bahrain World Trade Centre (BWTC) in Manama (Kingdom of Bahrain) is the world’s first building to integrate large-scale wind turbines, together with numerous energy reducing and recovery systems. The inspiration for the 42-story twin towers originated from regional ‘Wind Towers’ and their ability to funnel wind. To increase the function of the

turbines, the sail-shaped building on either side harnesses the breeze in driving them forward. Three wind turbines are expected to provide 10-15% of the BWTC’s total power consumption. The construction cost for the turbines was approximately 3% of the total construction cost. (Figure 1)

The office block at 21 Queen St in Auckland (New Zealand) is the most eco-friendly office building in New Zealand. This redevelopment project of the 1970s-built office tower has created a striking glass-clad, light and transparent building on one of the best sites in Auckland’s CBD. The redevelopment was based on reusing the structure of the existing 14 floor building. Demolition of most of the old 14-storey building left just the concrete slabs, the central core and the columns standing. Combined with high performance glazing ensuring plenty of natural light, a chilled beam air-conditioning system, water recycling and a special area for recycled rainwater, the building has the highest score for a five star green rated property in New Zealand, which is rewarded by New Zealand Green Building Council and five Star Green Star NZ Certified Rating (score 60-74) signifies 'New Zealand Excellence'. ANZO(AMP NZ Office Trust)’s chief executive Rob Lang said ‘Because of the building’s sustainable strategies, electricity usage is projected to be less than half of existing Auckland CBD offices and water consumption is about 30 per cent less than comparable properties.’ (Figure 2)
The Pearl River Tower in Guangzhou (China) is a 309-meter tower; its sculpted body directs wind to a pair of openings at its mechanical floors, where travelling winds push turbines which generate energy for the building. The design for Pearl River Tower weaves together a number of highly innovative technologies (such as Wind Turbines, High-Performance Building Envelope and Radiant Cooling/Chilled Beams with Displacement Ventilation), which work together to significantly reduce the amount of energy required to operate the building’s infrastructure and promote the highest levels of human comfort and indoor air quality.¹⁴ (Figure 3)

Linked Hybrid in Beijing (China) is the pedestrian-oriented 66m building complex, sited adjacent to old city wall of Beijing, it aims to counter the current privatized urban developments in China by creating a new twenty-first century porous urban space, inviting and open to the public from every side. Filmic urban public space; around, over and through multifaceted spatial layers, as well as the many passages through the project, make the Linked Hybrid an "open city within a city". The project promotes interactive relations and encourages encounters in the public spaces that vary from commercial, residential, and educational to recreational. The entire complex is a three-dimensional urban space in which buildings on the ground, under the ground and over the ground are fused together.¹⁵ The project incorporates numerous sustainable design features, but goes far beyond its technical green features, to tackle the much broader issue of social-urban sustainability itself, and it points the way to the future.¹⁶ (Figure 4)

---


Roppongi Hills Mori Tower (Japan) is a 54-story skyscraper located in the Roppongi Hills, and completed in 2003. It is currently the fifth-tallest building in Tokyo at 238 meters. The tower is a mixed-use facility that is used for retail and office space. The lower floors serve as retail stores and restaurants. The Roppongi Hills project is the largest-scale redevelopment in Japan. The concepts are "Culture City" and "Vertical Garden City" with green areas created by integrating small plots of land, and also building high and compact on the combined site. To actively work on energy conservation, energy saving systems are installed. The offices are located on the 8th to 48th floors, and boast a floor area of approximately 4,500sqm of rental room area per floor, the most spacious in Japan for a super-high rise building. The rooftop deck (the Sky Deck) is open to the general public and there are cultural and educational facilities on the upper floors, including the Mori Art Museum, Tokyo City View (the observation deck), the Roppongi Hills Club and Academyhills. Visitors are provided with views of the city at Tokyo City View on the 52nd floor and an open-air roof deck on the 54th floor. Roppongi Hills Mori Tower provides an attractive sightseeing spot and has become a symbol of a “Tokyo cultural centre.” This project has created a safe and comfortable pedestrian space by developing Metro Hat and linking it directly to Roppongi Station on the subway via an underground passage. The lake and green areas from the Mori Mansion that was on the site before the redevelopment have been preserved, and parks and plazas have been developed, making half of the site open space, thus creating a city space rich in greenery and water. (Figure 5)

4. Project Context

Asia’s cities have experienced explosive growth rates during the past few decades with the onset of economic growth. The HRBs began to spring up like mushrooms in Asia’s cities. The site location of this project will be in Beijing -- the capital of China and also one of the biggest cities in Asia. The rapid development of both the economy and urbanization in Beijing is faster than in other competitive cities. Due to these fast developments, the Beijing municipal government paid more attention to sustainable urban planning and design, also approving the Beijing CBD eastward expansion in May 2009. The eastward expansion will

---

almost double the original CBD size and the initial idea from the government is to build high performance and sustainable low carbon top-level ‘Business Office’.\textsuperscript{19}

4.1 Beijing CBD’s current situation and a future vision

The current CBD area, centred at the China World Trade Centre area in the Chaoyang District, is home to a variety of corporate regional headquarters, shopping precincts, and high-end housing. The Beijing CBD was approved by the State Council, China’s central government, in 1993 as a vital part of the Beijing Urban Master Plan 1991–2010. Under the Beijing CBD Regulatory Plan of 1998, a 3.99 square-kilometre (sq km) area is designated as the Beijing CBD, bounded by Dongdaqiao Lu on the west, Xi Dawang Lu on the east, the Tonghui River on the South and Chaoyang Lu on its north.\textsuperscript{20}

Before the CBD plan was approved, this area was for industrial use. From the 1950s to 1960s, the Chaoyang District became the main location of Beijing’s industrial base, chemical, automobile, machinery and other traditional industries are gathered round here. At that time, the CBD area was a collection of many large factories which now longer exist. Famous factories like the First Machine Tool factory, the Second Dye factory and the Snow refrigerator factory were all located in today’s CBD area. The people who lived in this area were mainly industrial workers, and the vehicles which went through this area were large cargo trucks. After 7 pm every day, a dead silence falls here. Because of the industrial waste and water pollution, Tonghui River-Beijing’s ancient canal was plagued by contaminated water and the surface was covered by sick floater. From the 1980s, some institutes of foreign affairs began to enter the Chaoyang District and The China World Trade Centre has been built, both of these would be treated as significant steps in the CBD development. Since then, a growing number of large multinational companies, international agencies and foreign investment enterprises have settled in Chaoyang District.\textsuperscript{21}

Until now, Beijing CBD has hosted more than 15,000 firms and financial institutions. And the pollution of Tonghui River has been settled by the Beijing Water Authority, it has

become the backyard garden of the CBD. Beijing has kept up the unstoppable development speed in the past years, but it has also created a multitude of problems for the city. Beijing is known for its smog as well as the frequent "power-saving" programmes instituted by the government. Citizens of Beijing as well as tourists frequently complain about the quality of the water supply and the cost of basic services such as electricity and natural gas. To reduce air pollution, a number of major industries have been ordered to reduce emissions or leave the city.22 According to the future subway planning, there will be two additional railways across under this expansion area in 2015.

The government has arranged a public design competition for this CBD eastward expansion (Figure 6). The world's leading architects have participated in the design competition and completed seven preliminary CBD expansion designs including SOM Architect and KPF Architect from the US, and ADPi Company from France. This project will take one of the sites from the SOM Master Plan (first place honours of the competition) (Figure 7).23

![Figure 6](image6.png) ![Figure 7](image7.png)

4.2 Site analysis

4.2.1 Site location

The selected site is located inside the Beijing CBD expansion area, which is currently bounded by Jintaixi Lu on the west, Xi Dawang Lu on the east, Chaoyang Lu on the South and Renmin Daily Press on its north (Figure 8-9). The site is quite close to the future transfer subway station of the two additional railways. The site is situated at the boundary of the east

---

expansion area, which is also nearby the existing CBD, so it takes around 5 minutes to walk from the site to the new CCTV (China Central Television) Headquarters building. The final site area and plan is shown in Chapter 6.3.3.

![Figure 8](image1.png)  ![Figure 9](image2.png)

### 4.2.2 Site information

The site is currently used as Xiaozhuang Community. In this 275,000sqm (27.5 ha) mixed-use site, as well as except the residential buildings, there are some other commercial buildings like Chaoyang Hotel, Chaoyangqu Cultural Centre, Chaoyang District Library Xinhua Bookstore and Renmin Daily press. The Capital University of Economics and Business is at the opposite side of the Chaoyang Lu.

There is one single-story house; all others are multi-storey residential buildings (Figure 10). The height of the commercial buildings is usually as the same as the residential buildings. The present residents, is around 7000 people in total (2112 households), who are lived in this place for decades since the founding of the country. They are quite enjoy the life in this busy area, even the traffic jam was still be a problem, but apart from this, the place that they are lived in have all kinds of shops which can be reached in 10-15mins by walk, and that makes life there more easier.

### 4.2.3 Future development in Beijing CBD

According to the proposed government plan released in Oct. 2009, a 3 sq km expansion, along the Chaoyang North Road, and the east of Tonghui River to expand to the East Fourth Ring Road, will be completed in the next six to eight years.\(^{24}\) It will accomplish its goals of 7

---

million square meters total construction, 100 billion RMB (around US$ 15 billion) of social investment, and creating 15 million jobs. The CBD development also proposed the strategic concept of building a "low-carbon CBD" for the first time, making it a national demonstration zone of low-carbon economic development. A Low-Carbon Economy is a concept that refers to an economy which has a minimal output of greenhouse gas emissions into the biosphere, but specifically refers to the greenhouse gas carbon dioxide. Recently, most scientific and public opinion has come to the conclusion there is such an accumulation of greenhouse gas (especially CO₂) in the atmosphere due to anthropogenic causes that the climate is changing. The over-concentration of these gases is producing global warming that affects long-term climate, with negative impacts on humanity in the foreseeable future. Globally implemented Low-Carbon Economy is therefore proposed as a means of avoiding a catastrophic climate change, and as a precursor to an ideal, zero carbon society and renewable energy economy.²⁵

After the expansion, the CBD core area will provide global services to Global Fortune 500 enterprises with the knowledge of advanced finance and insurance, cultural, media, and related services. Apart from a “Business Office”, the CBD core area is also an organic life space with cultural amusements and shopping centres.²⁶ Meanwhile, 75% of the existing multi-story residential buildings will be demolished, and be replaced by additional 20% high-grade office buildings (mainly used as the headquarters of big companies) of the existing office buildings. In which means that the rate of these high-grade office buildings will become around 50% of the future CBD. The government will settle the existing residents in the suburban – Gaobeidian area which located around the 5th Ring Road (Figure 11).

demolished and replaced by several high-rise office buildings around 200m tall. The western side, which is the existing CBD, will keep its original commercial and residential buildings. The two additional underground railways will cross each other in this area, one will connect the northern and western parts of Beijing, the other will travel through the western and eastern sides of Beijing.

If Beijing keeps its current pace of development in next decades, the SOM Master Plan (Figure 12) will be suited to the CBD development requirements. But China is unlike developed countries in Europe or North America, their development is at a regular pace. From the 60 years development in China after World War II people can see that the pace of development is unpredictable. Even for the Chinese people, the pace of social development is incredible fast. There are no relative development strategies and models that China could use. The social development in China is a process of exploration: no one can predict what China will look like in the decades to come. In order to reduce such a phenomenon, those buildings built 10-20 years ago need to be demolished due to their low density. So what we can do now is to leave reserved spaces as much as possible, to provide the maximum possibility for the future development and save more resources.

Therefore, in order to save more land and resources, this project on the selected site will discover another way of developing the site on the proposed SOM Master Plan. To test whether the multiple functions could be built together for achieving the land-saving idea.

Figure 12

4.2.4 Site conclusion

Traffic is a serious problem in Beijing, especially in the CBD(Figure 13). Because of the limitation of the residential buildings in the CBD area, most of the people who work there
take 1-2 hours to drive their cars or take public transport to go to work. There is no doubt that public transportation especially subway is the best way to solve the traffic problem in a high-density area. Currently, there are only two subway lines passing through the CBD area, which is not enough to transfer the huge number of working people. Buses can be caught almost every 5 minutes in most of the places during the rush hour, which is enough to transfer the people, but there are also many people driving their private car or taking a taxi to go to work. Finally, the big amount of private cars and the public transport (buses and taxis) are all stacked together. Therefore, the limitations of the residential buildings and the traffic jams have become the main problems we faced in this project. If that can be solved properly, the business value and improved living environment of people in this area will be achieved. It can also be a possible solution for sustainable development in Beijing.

5. Project Development

5.1 Design strategy

Through an analysis of people’s current working and living situation in the CBD, the design will try to figure out the most suitable building layout to fulfil the requirements of the people and urban development. There will then be an answer to the question of whether the existing residents should be settled outside Beijing CBD for the better business/economy growth and also to solve the city’s traffic problem.

5.2 Brief

There are two main points which have formed the brief of the CBD east expansion, and which is also the goal of this design exploration, as follows,

a. Low-carbon
b. Organic life space with cultural amusements and shopping centres

The initial purpose of Low-carbon is to reduce the carbon dioxide (CO₂) emission in the CBD area. This has two aspects: one is to reduce the CO₂ emission by cutting down energy consumption; another is to release oxygen as much as possible. The green coverage is in direct ratio to the amount of oxygen released, which means that it could also be possible to achieve the land-saving goal by increasing the green coverage and decreasing the building footprint.

The different kinds of cultural and commercial facilities could be combined with other
functions to achieve the idea of the organic life space with cultural amusements and shopping centres. The building functions will be various. It will be just like a small town organised in a building, including apartment, office, hotel, restaurants, supermarkets, library, gym, conference centre, post office, police station, banks, gardens, medical facilities, recreation facilities, kindergarten and all kinds of retail, so that people could reach almost everything they want and without going out of the building.

Replacing the existing households in the CBD is not the primary objective from the local government. These people are expected to move out of the CBD to the suburbs. But the existing residents disagreed, because they are used to living in this place and they do not want to live far from the city. If the government could not provide an acceptable proposal for where they could live and have a better life, the CBD east expansion will be stopped. It is intended not only to build a new community in the suburb, but also a huge amount of infrastructure will be built underground, which will cost around 20% of the total construction fee. If the existing households could move back to the CBD, green fields in the suburbs will be saved as well as the infrastructure. It seems to have worked very well by combining all the functions into several mixed-use HRBs, but the footprint has not been of concern. How about some other building form or to make them into one? It should be clear that one building is better than several building for reducing the footprint area. But it is going to have to be a quite different building form and may be in a big volume.

Roppongi Hills Mori Tower building has cultural, commercial and office functions, but the important thing is that it present a possibility that the HRB still works very well, not only providing the working spaces and retails, but also as a cultural centre to be attractive to citizens and tourists.

5.3 Building programme

As a research project, no specific requirements have been given, such as building capacity or Gross Floor Area (GFA). Thus, the building programme will be discovered according to logical analysis and calculated based on the Chinese Building Code of Practice.

This mixed-use HRB will include two kinds of people, the people who lived here and the people who work in the building. To encourage the people to take public transportation, it is recommended that an additional subway station be built in this project. The building will be
directly connected to the underground subway station, which is also be the main strategy for solving the traffic problem in Beijing, and the subway will be the main mode of travel for these people. Therefore, the building capacity will depend on the maximum passenger capacity of the subway. If we chose a normal 4-carriage subway to calculate the capacity, which could accommodated 318-410 persons per carriage, and it is running in every 5 minutes in rush hour (12 subways per hour), the capacity will be calculated as following,

\[400 \text{ (persons) } \times 4 \text{ (carriages) } \times 12 = 18,200 \text{ people}\]

So the number of people who live or work in the building should be less than 18,200.

The people who lived or worked in the building will be around 7,000 persons (the existing residences). Therefore, 18,200 should be treated as the maximum capacity of the people who will work in the building. Based on the Beijing practical figures, the large-scale shopping mall (see Chapter 6.5.2) will have around 2,000 staff, a five-star hotel (see Chapter 6.5.4) will have around 1,000 staff, and then the office workers will be 15,200 persons at maximum (18,200-2,000-1,000 = 15,200). Based on the building capacity, the total GFA will be 659,000sqm which is calculated based on the Chinese Building Code of Practice as follows,

- Residents GFA: \( 7,000 \times 25\text{sqm} = 175,000\text{sqm} \) (according to 25-30sqm/person)
- Office GFA: \( 15,200 \times 20\text{sqm} = 304,000\text{sqm} \) (according to 10-20sqm/person)
- Commercial GFA: \( 120,000\text{sqm} \) (as mentioned in Chapter 6.5.2)
- Hotel GFA: \( 60,000\text{sqm} \) (as mentioned in Chapter 6.5.4)
- Total GFA: \( 659,000\text{sqm} \)

All these above functions will be mixed on each floor, which means that functions like residential and office have daylight requirements would be arranged around the building outer part, while the commercial will stay at the inner part of the building.

6. Design process

6.1 Beijing current climate and lifestyle

6.1.1 An analysis of Beijing climate and main building energy consumption

Twenty years ago, Beijing had four distinct seasons. Because of the rapid urban development and pollution, the four seasons are changed so that summer and winter have
become longer, while spring and autumn becomes shorter.\textsuperscript{27} Generally, spring and autumn were good seasons in Beijing, with a comfortable temperature and humidity, high temperature in summer and low temperature with the strong cold wind in winter. But now, the only good season is autumn, ‘Spring is less pleasant - lots of wind and dust (northwesterly winds blow in masses of fine loess from Mongolia). The winter climate is due to Siberian air masses that move southward across the Mongolian Plateau, and then it's an ice box outside.’\textsuperscript{28} The summer became high temperature (sometimes, it can reach 40\degree C) with high humidity, and people described this season are felt like taking a sauna. These climate changes made people spend more time indoors. A normal person who works at an office in Beijing for instance spends 2-3 hours outside a day, which includes the travelling time from home to work and back, apart from these hours, the rest of the time is spent at inside, whether for work or entertainment. Even sometimes at the weekend, people will still stay at home or take some indoor activities instead of playing in the bad outdoor environment. It may be the reason why the indoor activities are more popular in Beijing.

By contrast, Auckland or some European cities like Copenhagen or Amsterdam have all got a comfortable outdoor environment. There is neither cold, strong wind in winter nor high humidity in summer, and the nice spring and autumn are still lasting longer than in Beijing. Even in Madrid, which is on the same latitude as Beijing, it just had cold winter (the temperatures at night frequently drop to 0\degree C) without the strong wind and hot summer (the temperature can reach 40\degree C) without the high humidity. People living in these cities have no reason to hide behind a wall. There are a lot of things people can do outside in the sunny day, even just walking alone the beach or lying on the grass, but is just a dream for the people living in Beijing. And that may be the reason there are so many tourists visiting those cities in different seasons.

Certainly, the longer people spend on indoor activities, the more energy consumption there will be. There is an analysis of several kinds of commercial buildings energy consumption in Beijing showing that lighting is taking around 8\%-14\% of the total building

energy consumption, and the heating and cooling are taking around 50%-60%. In contrast, the energy consumption of a commercial building in Auckland shows that the lighting is taking around 10% of the total building energy consumption and heating and cooling are taking more than 30%. (Figure 14)

The energy consumption of lighting is almost equal between the two cities, but the energy consumption for heating and cooling is quite different. That is because Beijing has hot summers and cold winters, but Auckland does not.

So it is obvious that the building energy consumption difference between the two cities is the result of the climate difference. The climate cannot be changed in a short time, but a reduction in the building energy consumption of heating and cooling can be achieved. This is the important sustainable issue which should be focused on in Beijing, because that is taking almost half of the entire building energy consumption.

6.1.2 An analysis of current Beijing residential buildings

There are basically two kind of basic residential HRB type in Beijing: slab-type and tower type (Figure 15). These two types have something in common in that they both have a core in the middle of the building for serving the units around the corridor and transitional spaces. The core and the corridor occupy almost 10%-14% of the floor area (Figure 16). These types of buildings were widely built in Beijing, because the residential units are designed at the periphery of each floor and the transitional spaces are compassed by them, so that the natural light and natural ventilation can be used efficiently.

However, there are still some limitations of those building types. The depth of the unit is normally less than 10-12m, because if the depth is too much, the effective usage of the natural light and ventilation will drop. Also the number in the household should not be too

---

30 BAI Xue-lian, SUN Chun-wu, GUO Lin-wen WANG Hong-wei,Journal of Chongqing University, Vol.31 No.6 Jun, 2008, p638
31 Nigel isaace, Bees investigates commercial building energy and water use, Build June/July 2009, p40
much for the reason of noise and safety. Due to the limitations of unit depth and the household number, the floor area in the residential building will not be too big.

The residential buildings built in China could last at least 70 years. The residential buildings which will be demolished in the Beijing CBD area could be used for another 40 years. The reason for demolishing them is because they are in low density and could not fit the CBD development speed. Beijing’s urban expansion is unstoppable. If we take the city’s new boundary, the 6th Ring Road for instance, its perimeter is 256km which means it takes at least 2 hours to drive around it at a speed of 120km/per hour. The urban expansion and the building density rise will directly cause an increase in the building energy consumption.

Therefore, the traffic problem and the building energy consumption mentioned in the Chapter 4.2.4 and Chapter 6.1.1 will become the main questions for the design, which are how to reduce the energy consumption of heating and cooling in high density buildings and the traffic pressure in Beijing CBD.

In accordance with the above analysis and building programme, the main focuses in the design will be to discover the multiple functions in a big mass.

6.2 Design concept

The design concept is sustainable. This project will be a revolutionary design, which intends to contain the people and city’s function, to discover a possible way for solving the traffic problem, to reduce building energy consumption and to save land.

6.3 Architectural idea

The project will focus on the interior space design and circulation, and also intends to present an extremely different building to overthrow the traditional understanding of indoor
spaces.

6.3.1 An analysis of building interior spaces and the analysis of the street idea

The huge amount of people and various functions in the same building make designing this building more like town planning. Organizing the circulation in the town and the interior spaces will be the challenge of this project. So the analysis of the following precedent is a must.

The most famous example of the ideal city is Filarete's plan of Sforzinda. That's the first ideal city plan of the Renaissance (1400-1600). Although it was never built, Sforzinda served as an inspiration for many future city plans. (Figure 17)

The birth of this architectural ideal city caused an end of the organic life of cities in Europe. The regular geometry, straight streets with strong perspective of cities and new ideal towns represent the power of the early capitalism and central state 32

Figure 17

Analysis of old cities’ traffic solutions in the western and eastern countries might provide some universal features. We can take some existing well-known old cities in Europe to analyse, such as Amsterdam in Netherlands (Figure 18) and Copenhagen in Denmark (Figure 19), and also some of China's old cities, such as Zhouzhuang in Zhejiang Provence (Figure 20) and the Old Town of Lijiang in Yunnan Provence (Figure 21).

There are some common features in these old cities. The main streets of these old cities are wider, and there always have some small plazas or green spaces in the middle of the street. The multiple functional spaces in the old cities were connected by a number of secondary streets or lanes to the main street. All the streets are presented in the same style, but they also have some differences in detail. The 2-4 stories buildings are built along the streets, part of them being used as apartment and the rest of them in commercial use. Even the street elevation looks different, but they are still kept in the same style. Looking at the street view, it is not just a straight line, instead, the buildings seem to be arranged randomly, making people feel comfortable. These cities have been maintained in good conditions and parts of them have been turned into pedestrianised streets. Tourists will inevitably come to visit these places which are containing the city’s culture.

If interior spaces could perform the layout as analysed above with same proportion between streets and buildings, there is no doubt that these old cities could be reproduced within a certain envelope.

This will not only solve the layout problem of multiple functions and circulation, but also achieve good business value at the same time. That is because people are coming here not just for their original functions, but even more to visit the building as a show case of the old city. The interior space could perform some famous places which people maybe not easy or unable to visit. This idea is to bring a kind of fresh feelings and to excite the people, either the entire street or details, that will make people feel very different though the first step people walked into the building. There are also some good examples about how to bring the outdoor spaces into the building, such as *The Venetian Las Vegas Hotel Casino*, in United States or
Shunxing Old Teahouse, in China.

The Venetian Las Vegas Hotel Casino (Figure 22-23) is located on the historic site of the Sands Hotel on the Las Vegas Strip. This Italian themed resort is a classy luxurious Las Vegas gem with such a wide variety of shopping, entertainment and dining. When guests enter into this over the top hotel, they will truly feel as if they have been transported to Italy. With the ceilings painted like the Sistine Chapel and the fabulous old world frescos that decorate the walls, guests will be in a world of complete visual overload. The Grand Canal Shoppes feature such chic boutiques as Jimmy Choo, Dooney & Burke, Mikimoto and St. John Sport along cobblestone walkways. The Artisti Dell Arte - classically trained singers, actors and musicians from all over the world - perform beneath the sky of the Grand Canal's St. Mark's Square. And people could catch a ride on authentic Italian gondolas navigated by an opera-singing gondolier.

Shunxing Old Teahouse (Figure 24-25) is located on the third floor of the Chengdu

---

International Convention and Exhibition Centre. It is one of the most famous teahouses in China, with more than 3,000sqm floor area. The interior design was copied from the ancient architectural style of the Ming and Qing Dynasties, which also included the wall carving, window decorations, wood carvings, furniture and tea sets. It was represent Chinese tea and the tea culture, as China's national characteristics tea culture museum.

These examples could be a successful approach to this project, which is to bring outdoor spaces into a building, arranging the interior spaces with multiple functions such as commercial, cultural and residential.

Therefore, the design of the building circulation could use the same way that these old cities did, to organise the functions by streets. Because the proposition and the style of the streets are coming from those old cities, they could well manage the building circulation and delighted people by the various change of landscape.

Figure 26

To form the street feeling in the building, first of all the proportions must be studied. The proportion between the main street and the site is around 9%-12%(Figure 26), which is almost the same with the proportion of the residential unit and transitional space above mentioned and to take one of them -- Copenhagen as an example, the ratio of the main street between long side and short side is about 1:0.5, the minimum length of the long side is 100 meters and 50 meters for the short side.

6.3.2 An analysis of building function

As mentioned above, there will be 4 kinds of building functions: apartment, commercial/cultural, office and hotel. The location of these functions will be decided by their requirements in the building, the following analyses are based on the Chinese Code and
Apartments, as the habitable space, will require direct daylight and natural ventilation. Thus they will be distributed in the most lateral of the building, and the depth of the unit will be between 10 to 12m to efficiently use the daylight (the analysis is shown in a later chapter). The commercial and cultural faculties will be surrounded by the apartments, that is due to their uniform light and Heating Ventilation Air Conditioning (HVAC) system requirements (the analysis is shown in a later chapter).

The offices and hotel will be arranged on the separate floors apart from the above functions depend on their needs and economic benefits. According to government requests, the new offices in the CBD area should be designed mostly as the Chinese headquarters of the world's leading companies. There are no specific daylight and natural ventilation requirements on the office floors, but a HVAC system is required for the built environment. Regarding the high-grade request of the office floors, they will need to have a better view than the above mentioned functions, so the offices will be placed above the apartment/commercial floors. (the analysis is shown in a later chapter)

Hotel guest rooms had the same daylight requirements as the apartments had and the HVAC system is also required, as with the office floors. Because of their view and management requirements, the hotel will be located at the top of the building to obtain the best view. The top floor could also be an attractive place for visitors, such as the top floor on Auckland Sky Tower and Shanghai World Financial Centre. (the analysis is shown in a later chapter)

Therefore, the order from the building's top to ground will be hotel, office, apartment and commercial/cultural. To minimise lighting energy consumption, the building's long side will face north and south, so as to use daylight effectively and save on a part of the heating energy consumption.

According to the above analysis and concerning the interior street proportion, the typical building floor plan is as shown in (Figure 27). The minimum building typical floor
area will be 132m x 82m = 10,824sqm, and the building height will be 659,000sqm/10,824sqm = 60 floors, which is around 200m.

6.4 The analysis of Chinese Code for Fire Protection Design of Tall Buildings

Due to the strict fire requirements for HRB design in China, it is necessary to study the relevant requirements from Code for Fire Protection Design of Tall Buildings (CFDTB) before the design development. According to the requirements from CFDTB, the design of HRB must meet the following requirements for fire evacuation and fire section:

1. Refuge floor: the refuge floor will be applied in every 15 floors, if the height of the building is more than 100m, which also can be used as services floor.

2. Fire exit and fire section: the building must fulfil the following requirements, if its height is more than 50m and contains the functions such as hotel, office or library,
   a. Each Fire section under 2000sqm will be closed by fire doors, and have at least 2 exits.
   b. Each Fire section under 1400sqm will be closed by fire doors, and have at least 1 exit. The 2 fire sections can be combined, that is, two of the Fire sections less than 2800sqm will be closed by fire doors in each fire section, have at least 2 exits.
   c. Distance between the building main entry door to the fire exit:
      · For office: >20m
      · For hotel/exhibition space: >30m
      · For apartment: >40m

6.5 Design development and outcome

6.5.1 The design of apartment

For the street idea, the three levels of the unit will be treated as a group and the street will also be three levels tall. Thus, the residents could have both different views at the same time, the HRB outside view and the multi-storey building, walking street view. There are two kinds of existing typical unit layouts as mentioned in Chapter6.1.2. The layout in Figure 28 is more suitable for the apartment design comparing with others, because each apartment in this building requires both an interior street view and outdoor landscape view, and it will also have
further reform possibility. Residents could either choose to live in one of the units as designed, or to buy two or more units and join them as according to their needs. The existing households will be settled in 30 floors with the above mentioned unit layout.

In China, land ownership is belongs to the nation, people only have the right to use it. The property rights for the residential buildings is 70 years, for office and apartment complexes it is 50 years, so in the residential part of building will be designed as an apartment in accordance with the design requirements. According to Chinese *Design Code for Residential Buildings*, the main difference between residential and apartment in China is as following,

1. Property right: Residential is 70 years and apartment 50 years.

2. Orientation: Apartment buildings have no orientation requirements, but residential has.

3. Installation: The kitchen in residential buildings must install the gas pipeline for cooking, but the apartment has no such a requirement.

---

**Figure 28**

**Figure 29**

### 6.5.2 The design of commercial/cultural facilities

There are many large-scale shopping malls in Beijing, Oriental Plaza shopping mall and SOLANA lifestyle shopping park being two of the most popular shopping destinations in the capital for locals and visitors alike.

Oriental Plaza shopping mall (Figure 29) is situated in the heart of Beijing, and occupies a total area of 120,000sqm - one of the largest commercial complexes in Asia. It comprises six themed shopping malls, offering world-class shopping, dining and
entertainment facilities. Oriental Plaza shopping mall has a direct connection with the underground subway, which is very convenient for locals and visitors.

SOLANA lifestyle shopping park (Figure 30) has built 150,000sqm of luxury buildings on 130,000sqm of valuable land. It is like a small town from Europe and perfectly integrates the culture of commerce with the beauties of nature, carrying forward the innovative spirit and showing endless surprises. The 19 two to three-story Euro-style buildings are built around charming landscapes. The Euro-style building with original taste and flavour, the suitable street and the spacious shopping environment bring consumers a suitable, charming and attractive open shopping place and produce an illusion that people are in romantic and elegant Europe rather than crowded Beijing.

Although the forms of these two shopping malls are different, one is a traditional indoor commercial street, another is an outdoor shopping street, but they have also got something in common, both of them are integrated with various functional spaces and comprised the rich landscape, such as, central square, courtyard, atrium and lanes.

Their luxury layout and interesting landscape bring a comfortable shopping environment to the consumers, so that people are willing to stay in the shopping mall as long as possible for shopping or entertainment, and this also increase their commercial value.

Both of them have used very little natural resources. The shopping street in Oriental Plaza shopping mall hold the huge indoor spaces, so it will rely on artificial lighting and

---

HVAC system mostly during the day and night. This also enable people to ignore the time and to focus their attention on shopping and entertainment. Even SOLANA lifestyle shopping park has an outdoor shopping street, but to compare the floor plan between it and Oriental Plaza shopping mall (Figure 31), the size of the commercial spaces along the shopping street layout are quite similar, the only difference is that one has the indoor street and the other is outdoor. It is obvious that the artificial lighting and HVAC system will also be used to serve this big commercial space in the same way as the traditional shopping mall did. The above successful commercial example shows that the huge commercial spaces will basically rely on artificial lighting and HVAC system to meet their technical service requirements.

Therefore, the commercial/cultural spaces in this building will also use this practical technical service approach. For creating a street feeling and harmonious indoor environment, the commercial/cultural spaces will keep the same height as the apartment, 9m with two stories (4.5m/floor). The layout of these spaces will be arranged loosely and combined with the landscape, such as central square, courtyard, atrium and lanes, to form a comfortable old city street in the building (Figure 32-33).

6.5.3 The design of offices

Due to the fact that the office spaces will be designed as the headquarters of Global Fortune 500 enterprises, China World Trade Centre and China Central Place and which already served a numbers of Global Fortune 500 enterprises may be seen as the successful examples to be studied.

Both of these HROBs are located in the CBD area. China World Trade Centre (CWTC) is the top upmarket commercial mixed-use development in China. CWTC has contributed significantly to the development of China’s top-quality service industry and facilitated the
enhancement of an investment environment in Beijing as well as foreign trade and economic cooperation. The 37-storey twin office, China World Offices (CWO) 1 & CWO 2, already have some of Global Fortune 500 enterprises as their clients, such as Apple, FedEx, American Express, UBS, Hess, HSBC Holdings, Ford Motor, etc. (Figure 34)

The China Central Place (CCP) Office Buildings facing Chang ’An Avenue at an angle of 45 degrees were designed by KPF Architectural Design Office with the style of purity, simplicity and brightness. The offices have spacious views and natural lighting and the buildings are full of commemorative significance. The present clients include Global Fortune 500 enterprises such as Deutsche Bank, Marriott Asia Pacific Management., SAP (Beijing) Software System, Itochu (China), Johnson & Johnson Services, etc. Some of the headquarters required much bigger floor areas, such as Johnson and Johnson have rented 6 levels, from Level 14 to Level 19. (Figure 35)

![Figure 34](image.png) ![Figure 35](image.png)

Therefore, the design of the office spaces in this project will be mainly divided into large spaces based on the bigger space requirements of Global Fortune 500 enterprises to meet the flexible space demands of these companies. The fire escape staircases and elevators will be distributed evenly, providing the space rearrangement possibility for smaller companies. (Figure 36)

6.5.4 The design of hotel

Hyatt Hotels Corporation as a leading international operator of hotels, the design

---

requirements of their hotel rooms can be seen as a reference for this project, such as Grand Hyatt Shanghai and Grand Hyatt Beijing. Their GFA are around 50,000-60,000.

Grand Hyatt Shanghai hotel is one of the 'highest hotels in the world', occupying the 53rd to 87th floors of the Jin Mao Tower building. There are 555 Rooms and Suites, two Ballrooms and Business and 11 Multi-functional Meeting Rooms in the hotel, with 1000 parking spaces in the basement.40

Grand Hyatt Beijing hotel is part of the Oriental Plaza commercial complex and provides direct access to the adjacent shopping mall. Grand Hyatt Beijing hotel is also home to award-winning restaurants Made in China and Noble Court. Leisure facilities include Club Oasis Spa and a resort-style indoor pool. There are 825 Rooms and Suites, Grand Ballroom for up to 700 guests and Business and Meeting Facilities in the hotel, with 2000 parking spaces in the basement.41

The basic guest room layout in these hotels is designed by considering the view and daylight, a corridor in the middle link both sides of the guest room. The big spaces in the hotel, such as the dining hall, ballroom and the conference centre, are designed separate from the guest room area, but the guests can be easily reached by some transitional spaces. Running these functions will not affect the guests living environment.

Therefore, the hotel located on the top part of the building will take circulation between the guest rooms and service facilities into account. To maximize the different views of the hotel and taking the social value into account, the top level will have a public view platform for guests and visitors, and that will provide more commercial value for the hotel. (Figure 37)

6.5.5 Building location and urban solution


The building’s location on the site will be decided by its relationship with the site context. As the main roads are located on the east and south side along the site boundary, so the two site entries (based on the Chinese *Code for Design Civil Buildings*, at least two site entries should be designed) will be placed on these two sides. The site in this project is chosen from the SOM Master Plan, so the site context will be based on their proposed Master Plan as well. In the SOM Master Plan, there are high-rise office buildings (HROB) and 30m tall commercial buildings along these main roads. The most prominent HROBs cluster around this area is a 400m tall HROB together with four others of 200m each, with a central culture plaza in the middle of them (Figure 38). They are located close to the southeast corner of the site.

Because the building in this project is a mixed-use HRB which also combined with cultural facilities, so this building will be more appropriately placed at the southeast corner of the site, which is close to the central culture plaza and also able to join the HROBs cluster. Therefore, the rest of the site has been released, which means, the site area will be refined to fit the building. To study the site coverage of the CCTV Headquarter which is just 1km from the building might provide a solution for the site area, the calculations as followed,

\[
\text{CCTV footprint} = 25,600\text{sqm}, \quad \text{CCTV site area} = 100,000\text{sqm} \quad \text{42}
\]

\[
\text{CCTV site coverage} = \frac{\text{footprint}}{\text{site area}} = \frac{25,600\text{sqm}}{100,000\text{sqm}} = 25.6\%
\]

\[
\text{The site area in this project} = \frac{\text{footprint}}{\text{site coverage}} = \frac{12,240\text{sqm}}{0.256} = 47,813 \text{sqm}
\]

Finally, the proper site area in this project will be around 47,813sqm, which is less than 18% (47,813sqm/275,000sqm= 17.4%) of the original site area (Figure 39). Thus, the northwest of the original site will be released, and its can seen as a show piece in the CBD presenting the sustainable idea of land-saving. There are some successful solutions for land

---

like this, such as Central Park in Manhattan, New York and Lujiazui Central Green in Pudong, Shanghai.

Central Park is a public green space and park in the heart of Manhattan in New York City (Figure 40). The park was not a part of the plan at the beginning. Andrew Jackson Downing began to publicize the city's need for a public park in 1844. A stylish place for open-air driving was felt to be needed by many influential New Yorkers, and in 1853 the New York legislature designated a 700-acre (280 ha) area. And now, with approximately twenty-five million visitors each year, it is the most visited urban park in the United States. 43

![Figure 40](image1.jpg) ![Figure 41](image2.jpg)

The Lujiazui Central Park, with 100,000sqm area, is located in Pudong, Shanghai (Figure 41). The park neighboured by the well-known Shanghai World Financial Centre and Jin Mao Tower. The Central Park is covered by 65,000sqm of an all-the-year-round-green-type turf, and a man-made lake of 8600sqm which resembles a map of the Pudong New Area in the centre of the park. The magnolia shaped pathway and the lake look like the city emblem of Shanghai. 44

6.5.6 Building envelope

The people in this building will be fully integrated into urban life, all the necessary facilities can be reached in the vertical connected functional space of the building. In fact, the building can be seen as a vertical town, and its envelope will be treated as the wall of this town. Therefore, the design of the façade will use the wall concept. Beijing as the capital city of six dynasties still has many places where the Ancient City Wall remains, the most famous

one is the Great Wall.

To consider the large amount of the daylight requirements in this building and its overall performance, the entire building will be covered by a double skin façade system. The double skin façade is essentially a pair of glass “skins” separated by an air corridor.

Sunshading devices are located between the two skins. The double skin façade consists of a main double-glazed skin of insulating glass with a second single-glazed skin placed outside. The air space between the two layers of glazing becomes part of the HVAC system. The heated “used” air between the glazing layers is extracted through the cavity by means of fans and thereby tempers the inner layer of glazing while the outer layer of glass reduces heat transmission losses. Shading devices are mounted within the cavity. Windows on the interior façade can sometimes be opened, while ventilation openings in the outer skin moderate temperature extremes within the façade.45 (Figure 42)

6.5.7 Building services analysis

Despite the fact that building volume is around 3 or 4 times bigger than the ordinary office building, the building services will be the same, using normal technical installations, there are no special requirements for this building. That is also one of the sustainable aspects, saving the high cost of the unnecessary new technology.

**HVAC system** – The building will need to have a HVAC system. Full services request for the office building and hotel, but mainly providing heating and cooling for the apartments and to provide the general ventilation for the commercial/cultural area. And the Building integrated photovoltaic (BIPV) technology will be applied at the outside skin of curtain wall, which will connect to the HVAC system to generate part of the energy for the building. (see Chapter 7.1).

**Lighting Design** – The lighting design is based on research results. According to the Standard for Daylighting Design of Buildings in China, the illumination requirement for

---

interior transitional spaces is half of the habitable room illumination requirement, and the ratio between side window area and floor area is 1:12, which means 1sqm window area could serve for 12sqm floor area. Those lanes which link the side window with the main street are 2m width by 9m (3 stories) height, which can provide daylight for the interior main street. Based on the above requirements, the light design for the streets will be:

The lighted street area (floor area) = side window area x 12 - the floor area of lanes

=2x9x12-(2x10)

=196sqm

One side of the lighted street length = (the lighted street area/street width-lane width)/2

=(196/6-2)/2

=15.3m

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Full cut-off</th>
<th>Semi-cut-off</th>
<th>Non-cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layout</td>
<td>Height (H)</td>
<td>Distance (S)</td>
<td>Height (H)</td>
</tr>
<tr>
<td>Type a</td>
<td>H≥Weff S≤3H</td>
<td>H≥1.2Weff S≤3.5H</td>
<td>H≥1.4Weff S≤4H</td>
</tr>
<tr>
<td>Type b</td>
<td>H≥0.7Weff S≤3H</td>
<td>H≥0.8Weff S≤3.5H</td>
<td>H≥0.9Weff S≤4H</td>
</tr>
<tr>
<td>Type c</td>
<td>H≥0.5Weff S≤3H</td>
<td>H≥0.6Weff S≤3.5H</td>
<td>H≥0.7Weff S≤4H</td>
</tr>
</tbody>
</table>

Weff = efficient lighting width(m)

Figure 43

Figure 44

Figure 45 a

Figure 45 b
Therefore, according to the above calculation, as shown in the diagram (Figure 43), without artificial lighting, the light which is provided by the side window could meet the daylight requirement for the main street between the apartment and the commercial facilities. In the evening, the lighting will use the same method as the outdoor street lighting by lamp. However, the indoor lighting energy consumption of the lamp will still be less than the outdoor spaces, because there are more indoor light reflections than outside. According to the Chinese Standard for Lighting Design of Urban Road, the design of the lamp should meet the requirements in Figure 44. To take lamp design in the old cities as the reference, the height of the lamp will be about 4.5m (the same height as the shop’s ground level) and the lamp will be placed 13.5m part. (Figure 45a-b)

The lamp distance = the lamp height x 3  
= 4.5mx3 (Figure 44)  
= 13.5m

The lighting for the secondary street, which link the main street with commercial interior spaces, will partly use light pipe technology to provide daylight (Figure 46). The rest of the spaces which cannot be reached by daylight will use artificial light, similar to that used for the main street night lighting. Even there are some of the interior spaces will rely on the artificial light, but to compare with the corridor which is fully reliant on artificial light in the shopping mall, the lighting energy consumption will still be less than usual.

6.5.8 Building structure concept

Structural investigation is particularly important as the design proposes to build above a large-scale building. Currently, no same structure scale has been built in the world. So the structure of this building will be based on the research of relevant literature to discover the solution. According to the building height, the structure has been chosen as exterior structural system using ‘steel framed tube’ (Figure 47) and interior structural system using ‘concrete shear wall with steel rigid frame’\(^{46}\). (Figure 48)

\(^{46}\) Mir M.Ali & Kyoung Sun Moon, Structural Developments in Tall Buildings, Architectural Science Review Volume 50.3, Published by University of Sydney. 2007, p211
7. Conclusion

7.1 Critical appraisal of the finished work

This project will be assessed based on the objectives stated in the Research question (see Chapter 1.1), these objectives were the quality of life for the residents and employees and resource efficiency and sufficiency.

The quality of life for all occupants mainly depend on how successful is the idea of the internal streets. A general criticism is that an indoor street will never be the same as an outdoor street and will only be a corridor, no matter how wide it is, or what it looks like. The reason is the people on an indoor street will never feel the natural air and sunlight directly, or see the natural features, so the street will only be an artificial space, it will not be able to keep the people to stay longer.

However, if this indoor environment could delight the people with the good design of internal facade and good lighting, it would then be more suitable than the outdoor spaces, especially in Beijing. Through the analysis of the climate between Beijing and some big cities in Europe (see Chapter 6.1.1), the climate in Beijing is quite different to that in European cities. Perhaps hard to imagine for those people who haven’t been to Beijing, people in Beijing would spend much more time in interior spaces because of the bad weather (see Chapter 6.1.1). Therefore, to design a comfortable indoor environment for the people will be the most practical thing in Beijing.

The street within the building is designed based on an analysis of the pedestrianised street in Europe and China, and it will be quite different with the corridor concept. Generally,
the width of the corridor is 1.5 to 2m, which is almost like the width of the lanes in this building. The lanes are connected to the main street (see Chapter 6.5.7), and they separate groups of 4 or more apartments. The purpose of these lanes is not for the circulation, but mainly for allowing the daylight into the interior street.

Based on well documented popularity of places like *The Venetian Las Vegas Hotel Casin* and the *Shunxing Old Teahouse* (see Chapter 6.3.1), we know that their artificial interior spaces do delight people, make them comfortable, wish to stay longer and even come again.

Internal streets are also safer, they reduce crime. Because the building no longer serves a single function, most of the time, there are people on the street, just like the outdoor street. If there is some criminal even taking place in the building, the criminal will find it is hard to escape than in the ordinary community. Because the street in the building is like a semi-public space, even when the criminal is out of a functional space, they will still be inside the building instead of public space, and that will be make it harder for them to escape. Thus, the people can feel safer either living or working in this place.

The stated objective of achieving high level of resource efficiency and sufficiency is achieved through three strategies:

1. Transport energy reduction
2. Passive heating/cooling energy conservation
3. Active generation and harvesting

This large-scale building would save a large amount of resources for infrastructure and energy transmission, because the existing residents have remained in the city instead of transferring to the suburbs. The existing traffic problems in Beijing will be settled down and switched to being the building’s vertical circulation. To reduce the traffic demand is another contribution to reducing the city's energy consumption.

The building will minimise its energy demand due to unusually bulky volume, providing it with an enormous thermal inertia, and almost minimal area/circumference ratio. And then the building will optimise its use of energy by mixing the commercial and office spaces, which demand a large amount of energy during the day, and apartments which demand less energy during the day. Thus, it will not be a busy place during the day and an
empty building during the night. Basically, the resident will be at home between 6pm to 8am, and the people who work here will stay between 9am to 5pm.

In sum, the main energy saving of building energy consumption is the 50%-60% heating and cooling. Because multiple functions have been wrapped in an overall envelope, they are able to save more energy. That is because the heat exchange by conduction between the building and the ambient air is decreased. Smaller surface / volume ratios (building content / building surface) are better for conservation of indoor heat (Figure 49)\textsuperscript{47}. Some calculations show that, while in houses more than 90% of the cooling load is due to weather factors, in large buildings the same effects amount to less than 60%. Therefore, as the building's volume is bigger than the ordinary building, so the external surface area will be equally shared with each building functions, which will be smaller than in the ordinary building. This applies especially to the commercial spaces, as they have been completely wrapped in by the apartments. Thus, it will keep the basic constant temperature, regardless of the climate changes outside whether hot or cold, it will not have any impact on the inside temperature. So the commercial HVAC system will only be used as a normal ventilation system. Meanwhile, the heating and cooling energy consumption will be greatly reduced. Therefore, the main building energy consumption has been saved to a large extent, so that the building could achieve the original intention of sustainable design.

The lighting energy consumption will be reduced by efficient use of daylight by the lanes (and with energy saving installation).

The main active generation feature of the building is BIPV technology which have been applied over the outside skin of the south facade (150x200m=30,000sqm).

\textsuperscript{47} Olgyay, Victor, \textit{Design with climate}, Princeton University Press 1962, p91
8. Reference

21. ‘Beijing CBD expansion to focus on low-carbon design’,
22. ‘Beijing CBD to widen east area’,
27. Nigel isaacce, Bees investigates commercial building energy and water use, Build June/July 2009, p40
29. ‘THE ARCHITECTURAL IDEAL CITY IN THE ITALIAN RENAISSANCE’,
30. ‘Venetian Las Vegas Hotel Resort and Casino’,
31. ‘The Venetian Resort’,
32. ‘Oriental Plaza shopping mall’,
33. ‘SOLANA lifestyle shopping park’,
37. ‘Grand Hyatt Shanghai hotel’,
39. ‘China Central Television (CCTV) Headquarters, China’,
41. ‘Lujiazui-Shanghai Pudong Landmarks’,
42. ‘Glass architecture: is it sustainable?’,
43. Mir M.Ali & Kyoung Sun Moon, Structural Developments in Tall Buildings, Architectural Science Review Volume 50.3. Published by University of Sydney. 2007, p211
44. Olgyay, Victor, Design with climate, Princeton University Press 1962, p91