Politecnico di Milano
Facoltà di Ingegneria Edile-Architettura
Master of Science in Architectural Engineering

RETHINKING SHANGHAI

Sustainable Intervention on the Suzhou Creek

Supervisor	Gabriele Masera	
Cosupervisor	Massimo Tadi	
Authors	Elham Del Zendeh	764759
	Siamak Kashfolayat	764619
	Mitzi Liszt Aguirre	766854

Academic Year 2012/2013

1. INTRODUCTION: SHANGHAI 10
1.1. CITY OF SHANGHAI 10
1.2. HISTORY OF SHANGHAI 14
1.3. DEVELOPMENT OF SHANGHAI 17
1.3.1. Development Strategies 17
1.3.2. Shanghai Urban Construction 18
1.3.3. Development of Pudong 19
1.4. ECONOMIC ASPECT OF PEOPLE'S LIVES 22
1.5. EXPO 2010 SHANGHAI CHINA 23
1.6. CITY ANALYSIS 26
1.6.1. Population Distribution 26
1.6.2. Shanghai Density 27
1.6.3. Historical Growth of Shanghai 30
1.6.4. Public Transportation of Shanghai 32
1.7. BRIEF OF THE COMPETITION 34
1.7.1. Project Description 34
1.7.2. Goals 34
1.7.3. Design Brief 35
1.7.4. Judging Criteria 36
1.7.5. Winners 36

2. URBAN 49
2.1. CHOOSING THE SITE 49
2.2. CHANGNING DISTRICT 52
2.3. ANALYSIS OF CHANGNING DISTRICT 56
2.3.1. Luxurious Apartment Buildings and Community for Overseas Residents 56
2.3.2. Historical Garden Houses are Popular 56
2.3.3. Top Quality Commercial Buildings for Foreign Enterprises 57
2.3.4. Excellent Information Service for Overseas Residents 58
2.3.5. Zhongshan Park Community: Place to Live, Work 59
2.3.6. Life in the District 61
2.3.7. Current Status of Overseas Residents in Changning District 62
2.4. WUSONG RIVER (SUZHOU CREEK) 64
2.4.1. Water environmental protection 67
2.4.2. Water transportation 70
2.5. SITE ANALYSIS 71
2.5.1. SWOT Analysis 83
2.5.2. Urban Design 84
2.6. CASE STUDIES 88
2.6.1. Leamouth Peninsula 88
2.6.2. Malacca Malaysia 89

3. CONCEPT 91
3.1. APPROACH TO THE OPTIONS FOR THE CONCEPT 91
3.2. MAIN CONCEPT 93
3.3. ANALYZING THE CONCEPT 95
3.3.1. 3D City 95
3.3.2. Green Pathways: Energy, Landscape and Connection 98
3.3.3. Water Treatment 98
3.4. MASTER PLAN 102

4. ARCHITECTURE 105
4.1. DIFFERENT TYPES OF RESIDENTIAL BUILDINGS IN SHANGHAI 105

4.1.1. New apartment mansion _____ *105*
4.1.2. Old apartment _____ *106*
4.1.3. Old garden villa _____ *107*
4.1.4. Townhouse _____ *108*
4.1.5. Independent lane house _____ *109*
4.1.6. Duplex house _____ *109*
4.1.7. Service apartment _____ *110*
4.1.8. Privatized public apartment _____ *110*
4.2. MODERN HOUSING CASE STUDIES IN SHANGHAI _____ 111
4.3. URBAN DESIGN STRATEGIES: _____ 115
4.4. SUZHOU CREEK _____ 117
4.4.1. Strategic Importance _____ *117*
4.4.2. Redevelopment and Future _____ *118*
4.5. VERNACULAR ARCHITECTURE: INNER COURTYARD _____ 121
4.6. WATER IN VERNACULAR ARCHITECTURE _____ 122
4.7. WATER IN MODERN ARCHITECTURE: CASE STUDY _____ 123
4.8. DESIGN PROCESS _____ 126
4.9. MATERIAL _____ 132
4.9.1. Terracotta Facade _____ *132*

5. TECHNOLOGICAL ANALYSIS _____ 134
5.1. ENERGY IN SHANGHAI _____ 134
5.1.1. Energy consumption and GHG emissions _____ *134*
5.1.2. Main Actions _____ *134*
5.1.3. General considerations: China, an energy consuming development _____ *135*
5.1.4. Residential _____ *136*
5.1.5. Policies _____ *138*
5.1.6. Plans and Objectives _____ *138*
5.1.7. Sectoral Policies _____ *139*
5.2. CLIMATE ANALYSIS _____ 141
5.3. CALCULATING HDD AND CDD: _____ 166
5.3.1. Heating/Cooling Set Point _____ *166*
5.3.2. HDD: Heating degree days _____ *167*
5.3.3. CDD: Cooling degree days _____ *168*
5.4. SOLAR RADIATION _____ 169
5.4.1. Overview of the current situation _____ *169*
5.5. GEOTHERMAL ENERGY _____ 170
5.5.1. Types of Geothermal Heat Pump Systems _____ *171*
5.6. CLIMATIC CONSIDERATIONS FOR THE DESIGN SOLUTIONS _____ 177
5.6.1. Region with cold winters and hot-humid summers _____ *177*
5.6.2. Priority of hot-humid summer conditions _____ *178*
5.7. ANALYSIS OF THE WALL AND FLOOR TYPES _____ 178
5.8. ECOTECT _____ 179
5.8.1. Ecotect Modeling and Renders _____ *179*
5.8.2. Daylight Factor Analysis _____ *183*
5.8.3. Solar Exposure Analysis: incident Solar Radiation _____ *195*
5.8.4. Thermal Analysis of U-shaped module _____ *200*
5.9. HVAC SYSTEM _____ 205
5.9.1. Introduction _____ *205*
5.9.2. Sources and Effects of Indoor Moisture _____ *205*
5.9.3. Indoor Air Quality _____ *206*
5.9.4. Occupant Comfort and Productivity _____ *206*

5.9.5. Types of Dehumidification ____ 207
5.9.6. Processes for Dehumidification ____ 207
5.9.7. Condensation on a Cold Coil ____ 207
5.9.8. Adsorption Using a Desiccant ____ 207
5.9.9. Hybrid Solar Air Conditioning ____ 208
5.9.10. How is humidity controlled with an AC system? ____ 209
5.10. SOLAR ENERGY SOLUTIONS ____ 210
5.10.1. Solar Lights ____ 210
5.10.2. Solar Electric (Photovoltaic) Systems ____ 210

6. STRUCTURE ____ 212
6.1. GENERAL DESCRIPTION ____ 212
6.2. MODELING PROCESS IN ETABS ____ 213
6.2.1. Structural Material ____ 213
6.2.2. Load cases and the mass source ____ 214
6.2.3. ETABS Structural Renders ____ 215
6.2.4. Loading ____ 217
6.3. STRUCTURAL ANALYSIS ____ 219
6.4. SUMMARY OF A BEAM DESIGN ____ 223
6.5. SUMMARY OF A COLUMN DESIGN ____ 224
6.6. DEFORMATION UNDER STATIC DEAD LOAD ____ 226
6.7. CHECKING THE DRIFT ____ 227
6.8. TYPES OF BEAMS AND COLUMNS ____ 227

7. INDEX AND TABLES ____ 236
7.1. BIBLIOGRAPHY ____ 236
7.2. LIST OF FIGURES ____ 238
7.3. LIST OF TABLES ____ 243

Abstract

Considering the urban analysis of the area, from the north our site is attached to the Creek and from south it is connected to Zhongshan Park. Since the site is surrounded by two important element supporting sustainability, we started to think about connecting them. We developed the idea of having moving water in the site, by thinking about the most profitable route for water in the area and also water treatment methods, which are applicable, extendable and economical in the area.

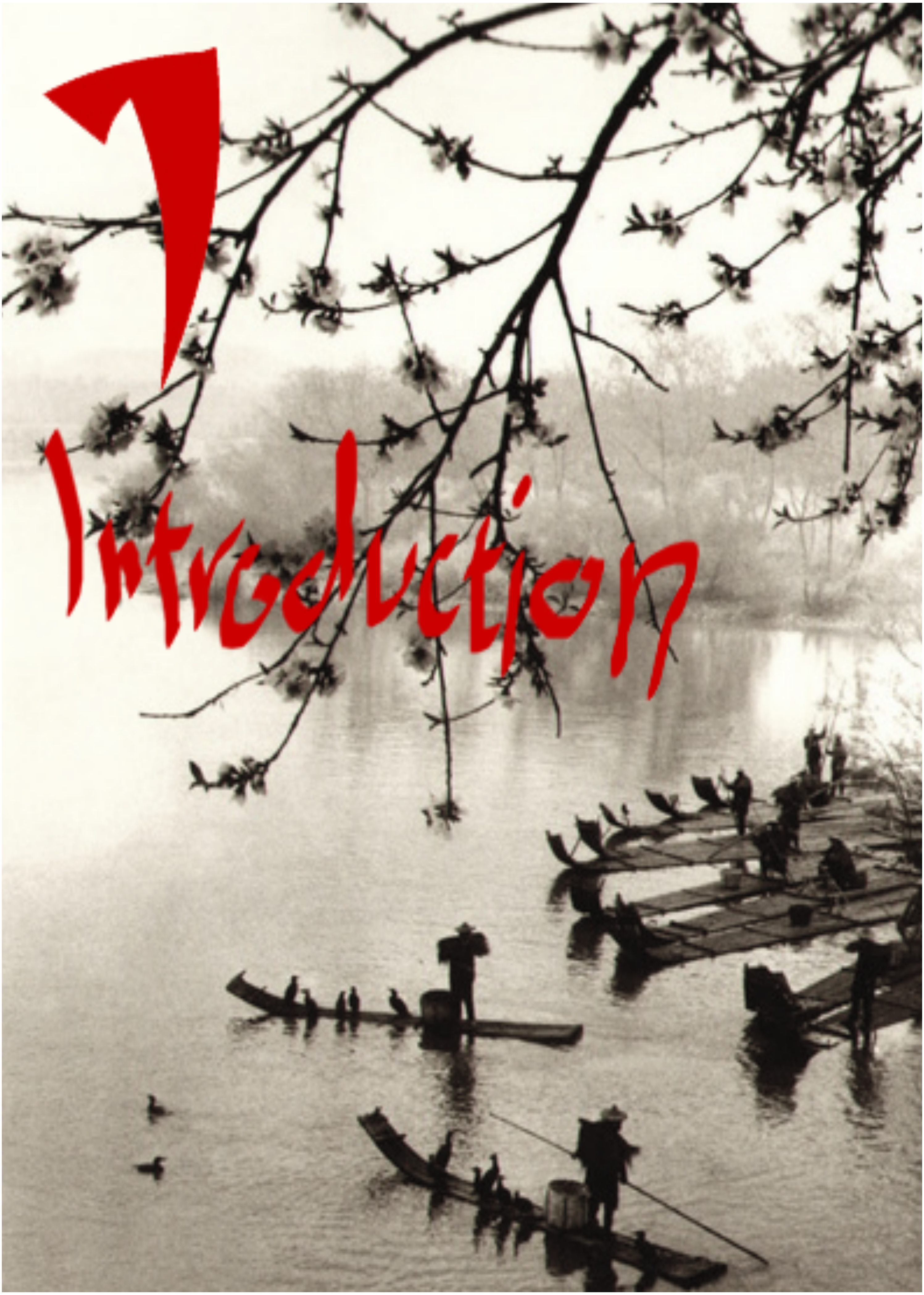
Shanghai had serious problems about water pollution. People used to suffer from the smell as well as the disturbing view of a polluted river a few years ago. The use of biological filters like Reed Bed filters is one of the traditional ways of water treatment. Having some changes in the design of the filters, they become economical and applicable to be used in other areas when it is necessary to have clean and odorless water.

Following our concept of movement, we designed flowing green areas in our site to show a stronger connection between the park and the creek. By using different levels of elevation we integrated the two main ideas of blue and green flow. To show the continuity of the concept in our area, we chose a focal point for our design, which is in the southern part, highlighted by a high-rise building. To provide required residential buildings and offices we are having some blocks, which are modular and possible to reach different heights according to the necessity.

The connection of the Creek and the park is a benefit with which we can develop a new way of thinking among the people of shanghai, by admiring the green areas and landscape design instead of designing high-rise buildings. Choosing and designing focal point to be a high-rise multi functional building to strengthen our landscape usage, and modular buildings in between, which supports the idea of movement and flow, and satisfies the required area for buildings, the concept is followed in a parallel way with the goals of the competition.

To strengthen the main concept, which is sustainability, all new systems of insulation and energy production are being used in different ways according to the functions of the buildings. The functions are chosen by studying the area completely to understand the needs in an area with the similar characteristics to the site, which brought us to the different zones in the buildings like sport-based zone, entertainment zone, cultural zone, and etc., which are all connected completely to the residential areas and to each other following the concept of connectivity and linearity, using the connecting walking pathways on the roof, in the building or pedestrian way in the site.

1 Introduction



1. Introduction: Shanghai

1.1. City of Shanghai

One of the four municipalities under the direct control of the Central Government of China, Shanghai (called Hu for a short time) is the largest industrial and commercial city in China and an internationally famous metropolis. According to the 2008 census, Shanghai has a residential population of 18.885 million, among whom 13.91 million people are in registered households.

Figure 1-1: Shanghai in the Map of China

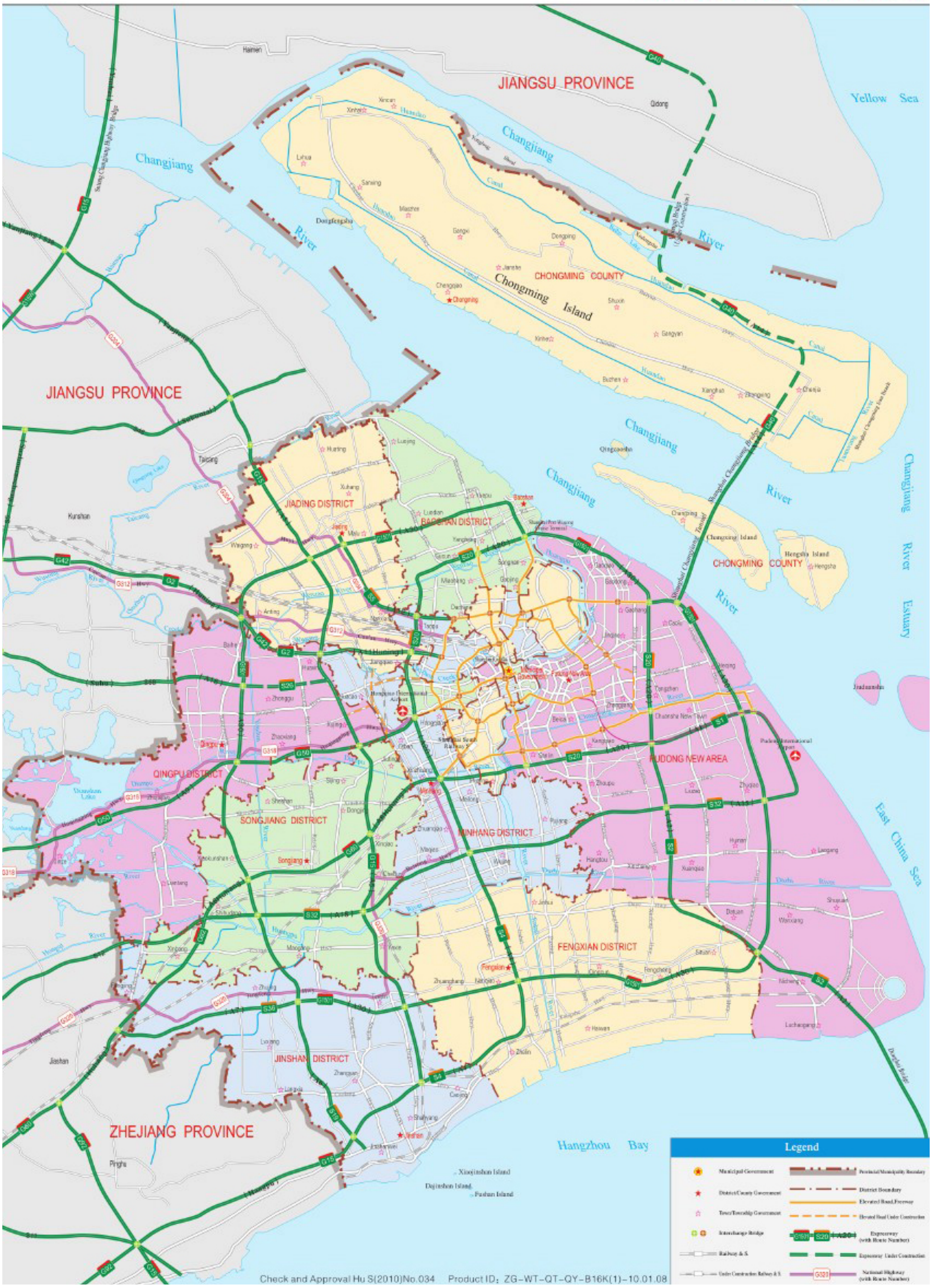


Figure 1-2: Maps of Shanghai City Center

Shanghai is a coastal city bordering on East China Sea, located at the south of Changjiang River Estuary and north of Hangzhou Bay. Jiangsu and Zhejiang Provinces are its neighboring provinces to the west. The geographical coordinates of the city are 31°14' north and 121°29’ east. It covers an area of 6,340.5 square kilometers, including 6,218.65 square kilometers of land, 1,107 square kilometers of water at Changjiang River Estuary and 376 square kilometers mud flats. There are 17 districts and a county under the municipality's jurisdiction, namely, Pudong New Area, Huangpu, Jing'an, Luwan, Xuhui, Hongkou, Zhabci, Yangpu, Champing, Putuo, Baoshan, Minhang, Jiading, Jinshan, Songjiang, Qingpu, Fengxian, and Chongming.

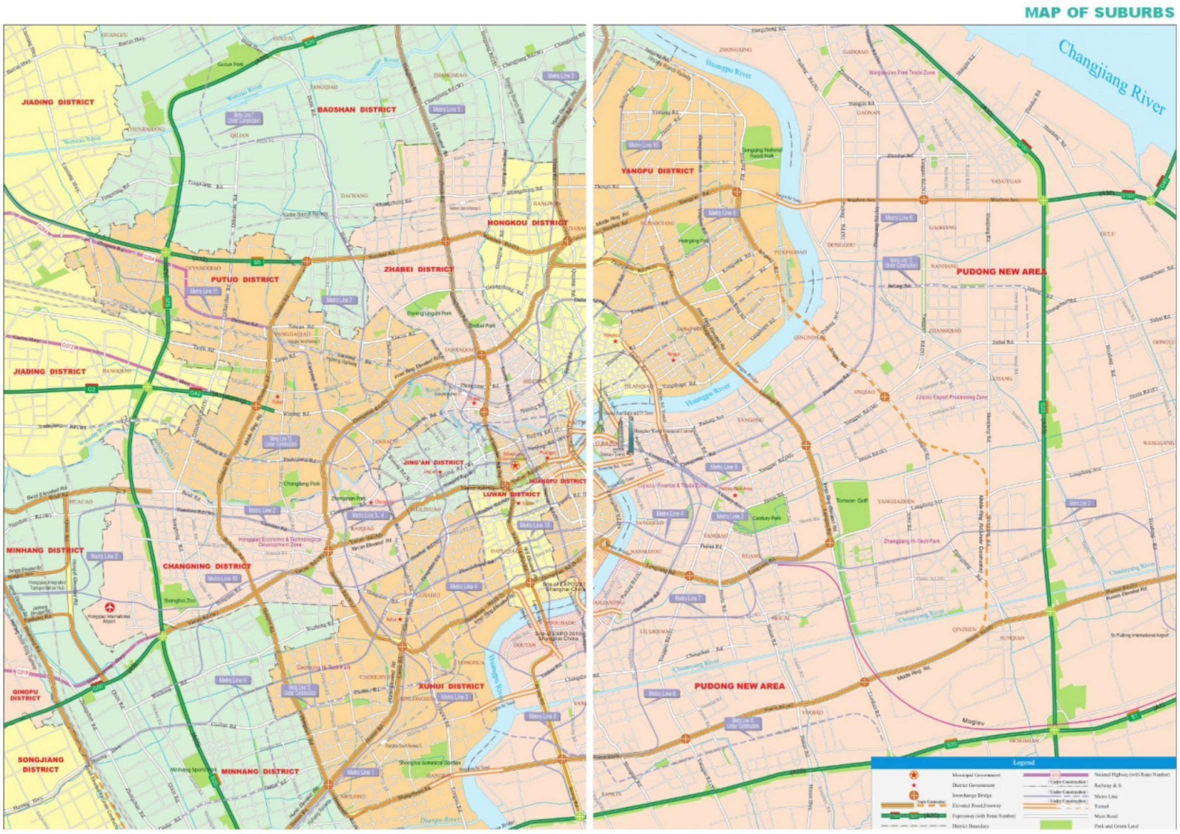


Figure 1-3: Map of Suburbs

Shanghai sits on the alluvial plain known as CHANGJIANG RIVER DELTA, whose foundation bed was formed in late Mesozoic Era about 70 million years ago. Changjiang River deposits large amounts of silt in its estuary, the accumulation of which resulted in a sand bank (called Gangshen) 6,000 to 7,000 years ago. Since that time, the coastline has been continuously extending eastward. It was not until the Tang Dynasty (618-907) that most parts of the modern-day Shanghai city area became dry land. In the Ming Dynasty (1308-1661), land emerged on the eastern bank of HUANGPU RIVER with a coastline which was more or less like that of today.

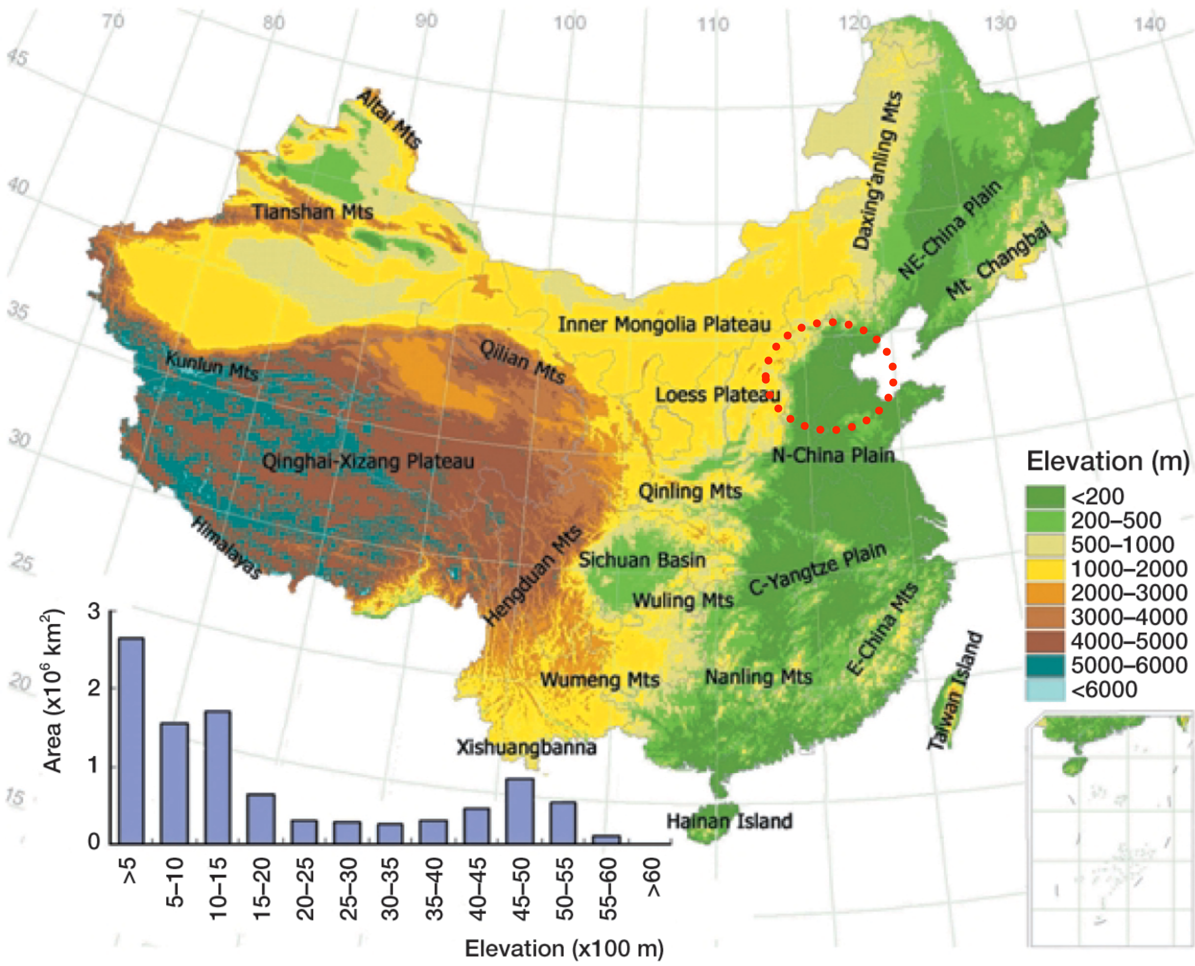


Figure 1-4: China Elevation Map

At Changjiang River Estuary in the north, there are three islands: Chongming, Changxing and Hengsha. The 1,267-square-kilometer CHONGMING ISLAND is the third largest island in China. In 1996, with a new island called Jiuduansha taking shape in the estuary, the number of islands under Shanghai's jurisdiction was 14.

Situated in the subtropical zone and the East Asian monsoon belt, Shanghai as a coastal city in medium latitudes has a mild and moist climate: it has plenty of rain and experiences four distinct seasons. It has an average annual temperature of 16.1 degrees Celsius, a yearly rainfall 1,164.5 millimeters and a frost-free period of 222 to 235 days per year. (Weather page)

Shanghai is interlaced with waterways. Huangpu River, the largest river in the area, has three major sources, namely, Xietang, Yuanxiejing and Damaogang. They join at Mishidu Ferry Crossing, Songjiang District, to form the main waterway. The main waterway is 82.5 kilometers long; it meanders through the city, joins WUSONG RIVER, and then enters the sea at Wusongkou. The 125-kilometer Wusong River rises in Guajingkou at Taihu Lake, 54 kilometers of whose overall length lies in Shanghai area. It joins Huangpu River at HUANGPU

PARK in the downtown area. The marshland in the west hosts most of the lakes of the city, among which DIANSHAN LAKE is the largest, covering 62 square kilometers.

Shanghai is located at the tip of the richly endowed Changjiang River Delta; Changjiang River Delta covers an area of over 1.8 million square kilometers, making up one fifth of China's total territory, where 440 million people live. This area abounds in natural resources and has a long-standing advanced economy, which provides Shanghai with a vast economically developed backyard. Situated in the middle of East China's coastline, Shanghai is a vital communications hub in the Western Pacific Region and an important gateway to the outside world. Situated at the crossroads of Changjiang River and the East China coastal economic belt, Shanghai is geographically privileged by having access to both the vast inland China and the international world.

1.2. History of Shanghai

About 6,000 stars ago, on the alluvial plain to the west of Gangshen lived Shanghai's ancestors. They labored, multiplied, and developed ancient cultures including the Majiabang Culture, the Songze Culture and the Liangzhu Culture. The Songze Culture dates from approximate 3,900 B.C.

During the reign of King Kaolie of the State of Chu (262-238 B.C.), the Shanghai area was part of the fief of Huang Xic, known as Lord of Chunshen, who was one of the four famous regional aristocrats of the late Warring States Period. It is said that Huang Xie dug the Huangpu River; therefore, the river is also called Shenpu, Chunshcnpu, ChunshcnRiver or Xiepu. One other commonly used nickname of the city Shenis also derived from that noble man. During the Jin Dynasty (265-420), the lower reaches of the ancient Wusong River were called Hudu. Hu was a bamboo-fishing device that the local people used as they caught fish to earn a living. Du refers to the rivers flowing to the sea. This is why Shanghai is commonly called Hu for short.

In 751, the tenth year of the Tianbao Period of the Tang Dynasty, Hinting County was established in today's Songjiang District, Huating County was a famous silk town, whose silk fabrics were sold at home and abroad. Qinglong Harbor was an important seaport in the area at that time. In 746, the fifth Year of the Tianbao Period of the Tang Dynasty, QINGLONG TOWN was founded in today's northeast section of Qingpu District on the southern bank of Songjiang River. By the early years of the Northern Song Dynasty, Qinglong Town had grown into a city where tens of thousands of families made their living. Millions of tons of sand brought by the sea tide silted up Wusong River. With the coastline moving eastward, Qinglong Town did not connect to the sea any longer, and ships could not reach Qinglong

Harbour through Hudu either. In the reign of Emperor Xiaozong of the Song Dynasty (1162-1189), ships altered their navigation routes to Huangpu River, the tributary on the southern bank of Wusong River. Shanghai began to replace Qinglong Town as the major port at Changjiang River Estuary.

Shanghai took its name from Shanghai Creek, a tributary of Wusong River During the Northern Song Dynasty, a township came into being on the west bank of the creek, and Shanghai Wu (an official body for collecting taxes on wine) was set up there until the Xining Period (1068-1077). During the reign of Emperor Duzong of the Southern Song Dynasty (1265-1174), Shanghai was upgraded to a marker town. With the establishment of a branch of Maritime Trade Office (Shi Be Si), Shanghai flourished into a prosperous seaport. In 1277, the 14th rear of Zhiyuan period of the Yuan Dynasty, Shanghai Maritime Trade Office was listed among the seven major authorities of its kind throughout the country.

In 1291, the 28th year of the Zhivuan Period of the Yuan Dynasty, Shanghai officially became a county, with a population of 300,000 to 350,000 in over 70,000 registered households. From then on, Shanghai experienced a period of rapid development. In the early years of the Ming Dynasty (1368), Shanghai had 114,300 registered households and a population of over 530,000. It became a populous township in the region south of Changjiang River.

The shipping industry is the other economic pillar of Shanghai County. In the middle of the Ming Dynasty, Shanghai gradually developed five mature shipping lines, including inland waterways shipping, Changjiang River shipping, coastal shipping, North China Sea shipping and South China Sea shipping. In 1685, the 24th Year of Emperor Kangxi's reign of the Qing Dynasty, the Qing Government opened a customs house (Jianghai Guan) in Huating Prefecture, giving a boost to the shipping industry. During the reign of Emperor Qianlong (1736-1795), there were ships from Japan, Korea, Vietnam and Thailand berthed in Shanghai Port. Shanghai became not only an export port whose cotton-cloth cargo handling volume ranked first throughout China, but also a transit center facilitating commerce between south China and north China.

Prior to the First Opium War, over 150 market towns prospered in the Shanghai area. In Shanghai County, merchants from Fujian and Guangdong sold imported goods in many shops. The development of a market economy paved the way for the emergence and prosperity of “Money Houses”. In the reigns of Emperors Qianlong and Jiaging of the Qing Dynasty (1736-1820), Shanghai's importance grew, and was noted as "a metropolitan city in the southeast, a busy port between rivers and scar”.

After Shanghai was opened as a trading port, foreign commodities and capital flowed in, which brought in advanced technologies and management knowledge, giving impetus to

Shanghai's development in domestic and foreign trade, finance, transportation, textiles and machinery industry. Foreign firms, shipping companies, banks, processing factories, printing houses, pharmaceutical factories, construction companies and public services were established in the city. With a quick growth of foreign trade, Shanghai became the major trade center of China, which in turn brought great opportunities for the development of shipping and shipbuilding industries as well as various harbor services. Enormous amounts of foreign financial capital ventured into Shanghai.

In the 1860s, Shanghai became a major base where officials of the Qing Government created their modern enterprises in the Westernization Movement. In 1865, Li Hongzhang set up KIANGNAN ARSENAL in Shanghai, which was the largest military enterprise in the country. He also founded CHINA MERCHANTS' STEAM NAVIGATION COMPANY (1872), SHANGHAI MACHINE WEAVING BUREAU (1878) and Shanghai Telegraph Office (1881). Merchants from Jiangsu and Zhejiang Provinces came to Shanghai and initiated national industries including textiles, papermaking, and machine manufacturing.

It was during this period that public services in the city sprang up. In 1865, the first gas plant in China began to supply gas to the concessions; in 1870, GREAT NORTHERN TELEGRAPH CO., Ltd, was established; in 1871, sea cables connecting Shanghai with trade centers all over the world were put into use; construction of truss bridges with steel girders supporting wooded carriage ways including Garden Bridge (today’s Waibaidu Bridge) over Suzhou Creek started in 1873; in 1876, the construction of SONGHU RAILWAY, the first railway in China, was completed; in 1881, British merchants' Shanghai Telephone Co. was founded; in 1882, the first electric power plant of China supplied electricity; in 1883, the first waterworks of China began its water supply. The development of public services quickened the modernization of Shanghai city.

After Shanghai was opened as a trading port, western culture and influence began to spread. Western missionaries in Shanghai erected churches, founded schools, and published newspapers and magazines. They preached their religion, and at the same time introduced modern western civilization.

Chinese people in Shanghai launched a tenacious struggle against the foreign powers and local feudal authorities that oppressed them. In response to the Wuchang Uprising in October 1911, revolutionists and trade associations in Shanghai announced the RECOVERY OF SHANGHAI on November 4. On January 1, 1912, the establishment of the Republic of China was declared in Nanjing.

On May7, 1927, Nanjing National Government defined Shanghai as a chartered city. The municipality proposed GREATER SHANGHAI PLAN to build a new city and its downtown area, from 1929 to 1935, with three phases of construction completed; municipal library museum, stadium, gymnasium, swimming pool and hospital were built. Main streets were paved around the downtown area. In 1937, when the Japanese invaded China, Greater Shanghai Plan was suspended.

After China's reform and opening, Shanghai grasped the opportunity of the development and opening of Pudong New Area, and made remarkable achievements in its modernization drive. Marching into the 21st century, Shanghai set itself ambitious goals and made initiatives to build the city into the "Four Centers", and carried forward the strategic targets of the "Four Leads". Shanghai, by hosting EXPO 2010, is entering a new phase of development in constructing a modern international metropolis. In 2008 Shanghai's GDP reached 1369.815 billion Yuan, about 10,529 US dollars per capita

1.3. Development of Shanghai

1.3.1. Development Strategies

Under the leadership of the CPC Central Committee and the State Council, Shanghai laid down its strategic positioning and development strategy for economic growth and social improvement of the city. This was such a gradual process that Shanghai defined its positioning from the original "Three Bases" of industry, technology and foreign trade, via a functional hub with both outward and inward economic radiation through the "One Lead, Three Centers" to the final "Four Centers".

In 1979, Shanghai proposed a plan to build the city into a base for advanced industry, advanced science and technology, and foreign trade. Shanghai achieved certain economic development in its adjustment.

In February 1985, the State Council made it clear that Shanghai should shoulder the responsibility of being a pioneer in the construction of the "Four Modernizations", and should spare no effort in building itself into a modern socialist city with proportionate industrial structure and advanced science and technology, which was open, multi-functional and highly civilized, In October 1986, the State Council identified Shanghai as one of the most important industrial bases of China, the largest port, an outstanding economic, scientific and technological, financial, information and cultural center, and one of the largest economies on the west coast of the Pacific

From the early1980s, the development of Pudong New Area was on the agenda On April 18, 1990, the CPC Central Committee and the State Council announced the DEVELOPMENT AND OPENING OF PUDONG, and entitled the area to favorable economic development policies. In October 1991, the 14th CPC Congress directed that "with the development and opening of Pudong as the leader, measures should be taken to further the reform in cities along Changjiang River; efforts should be made to build Shanghai into an international economic, financial, and trade center as soon as possible in order to spur economic growth in Changjiang River Delta and the whole Changjiang River", This was the start of Shanghai's national development strategy of "One Lead and Three Centers".

From 1991, Shanghai set about working out a new development plan. The State Council approved Shanghai Urban Comprehensive Planning (1999-2020), pointing out that in 2020 Shanghai is expected to be built into an international economic, financial and trade center: its status as an international economic metropolis should be primarily confirmed; and Shanghai's international shipping center should take shape. In 2001, the Fourth Session of the Eleventh Municipal People's Congress of Shanghai approved Outline of the Tenth Five-Year Plan for National Economic and Social Development in Shanghai. It pointed out that the 21st century would not only be a new development era for Shanghai to quicken its construction into an international economic, financial, trade and shipping center, but also be a new phase for it to confirm its status as a modern international metropolis, and to enhance the city's comprehensive competitiveness.

In 2006, President Hu Jintao, when taking part in discussions with the Shanghai delegation to the Fourth Session of the Tenth National People's Congress, demanded Shanghai to take the lead in transforming its economic growth model, enhancing its ability of self-innovation, furthering reform and opening, and establishing a harmonious socialist society, which is known as the "Four Leads". His words clarified the orientation of undertakings for Shanghai.

In 2009, the Fourth Session of the Ninth CPC Shanghai Committee made it clear that it was essential to further the implementation of the scientific outlook on development, adhere to the "Four Leads" orientation, stress the importance of enhancing the ability of self-innovation and optimizing the industrial structure, and spare no effort to make a new breakthrough in transforming the economic development model. The progress made in this stage to build a modern international socialist metropolis would lay a solid foundation for the achievement of the 2020goal.

1.3.2. Shanghai Urban Construction

In the 1990s, Shanghai started large-scale urban construction. A multidimensional municipal transportation network took shape. In addition to Hu Jia Expressway, the first expressway ever built in China, Shanghai successively constructed Xin Song Expressway, Hu Ning Expressway (Shanghai section), and Hu Hang Expressway (Shanghai section). At the end of 2009, the construction of CHANGJIANG TUNNEL-BRIDGE connecting the city area with Chongming and Changxing Islands was completed Shanghai Railway Bureau was in charge of 56.5 pairs of Electric Multiple Units (EMU) until the end of 2008. Jing Hu Express Railway, Hu Ning Railway, and Hu Hang Express Railway were under construction. Efforts were also made in building an international air transportation hub. By the end of 2007, Shanghai was connected with 97 cities in 41 countries and 82 Chinese cities via airlines: the two international airports, Pudong and Hongqiao, had four terminal buildings and five runways with the completion of YANGSHAN DEEP WATER PORT, the port of Shanghai was capable of handling the largest container ships and was one of the world largest cargo ports. Public services including GAS, electricity, water and PUBLIC TRANSPORTATION were optimized and improved. Various measures were taken to settle the housing problems. In terms of eco-protection, eco-environment construction programs were reinforced; Convergent Sewage Treatment Project and SUZHOU CREEK COMPREHENSIVE REHABILITATION PROJECT were launched. A multi-dimensional and all-round telecommunication network was established, which included satellite, short wave, optical fiber, microwave, coaxial cable and sea

In the three decades of reforming and opening, Shanghai finished the construction of series of architectural landmarks, such as ORIENTAL PEARL RADIO AND TV TOWER, SHANGHAI MUSEUM, YANGPU BRIDGE, SHANGHAI LIBRARY, SHANGHAI GRAND THEATER, JINMAO TOWER and SHANGHAI WORLD FINANCIAL CENTER. PEOPLE’S SQUARE, SHILIUPU, THE. BUND, and major shopping streets such as Nanjing Road, MIDDLE HUAIHAI ROAD, and North Sichuan Road, took on a completely new look.

1.3.3. Development of Pudong

In 1990s, by seizing the opportunity of the policy adoption of opening and developing Pudong, Shanghai's municipal government set up a leading group and development office, and established WAIGAOQIAO FREE TRADE ZONE, LUJIAZUI FINANCE AND TRADE ZONE, and Jinqiao Export Processing Zone. In two decades, Pudong has become a showcase of China's reform and opening.

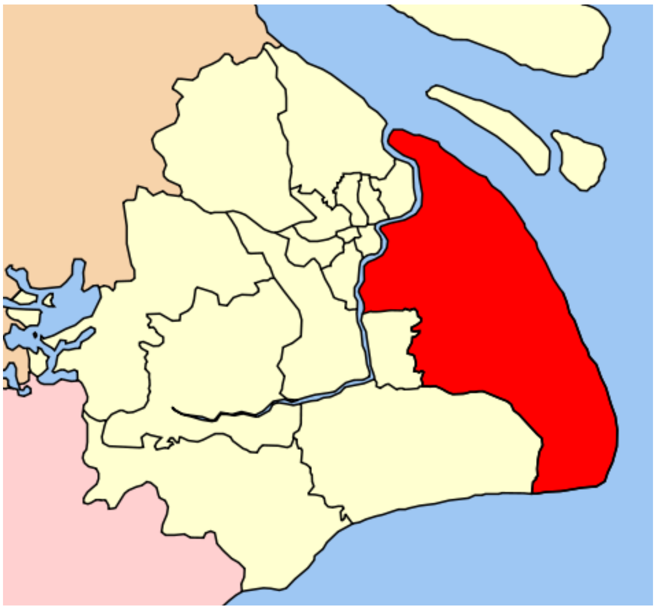


Figure 1-5: Pudong Location within Shanghai

Figure 1-6: Shanghai Pudong District Taken in September 1989

Entering the 21st century, SHANGHAI SCIENCE THECHNOLOGY MUSEUM, SHANGHAI NEW INTERNATIONAL EXPO CENTER (Phase I), and Shanghai International News Center were erected in Pudong New Area Since 2002, key construction projects such as PUDONG INTERNATIONAL AIRPORT, WAIGAOQIAO PORT AREA, and SHANGHAI INFORMATION PORT were finished; and the area's infrastructure network, through the construction of cross-river projects, RAIL TRANSIT and EXPRESSWAYS, has been greatly improved.

Figure 1-7: Shanghai Pudong District Taken in September 2006

With Pudong's development, its comprehensive economic strength has been enhanced enormously. Pudong GDP soared dramatically from 78.160 billion Yuan in 1990 to 315.099 billion Yuan in 2008, contributing 23 percent of the municipal GDP. The export volume reached 60.423 billion US dollars, 35.7percent of the city's total. In Lujiazui Finance and Trade Zone, 159 shopping and office buildings were erected; and 504 Chinese and foreign financial institutions settled here. Jinqiao Export Processing Zone became an attractive destination for corporate headquarters of both multinationals and domestic large enterprises; it hosts three major clusters of industrial research and development undertakings including telecommunication, automobiles and components, and automatic control, which generated an output value of 160.8 billion Yuan in 2008.Waigaoqiao Free Trade Zone achieved a customs closing of 8.96 square kilometers, and the total import-export volume reached 62.6 billion US dollars. There were 7,851 foreign-funded projects from 94 countries and regions; 127 enterprises among the world's top 500settled in the zone. ZHANGJIANG HI-TECH PARK established an integrated circuit industry base, 863 information security bases, a micro electron port, and a biopharmaceutical R&D base. Here settled 1,540 companies, whose patent applications amounted to 14,233, and 3,218 patents were issued.

In August 2009, Nanhui District was incorporated into Pudong New Area, enlarging Pudong to an area of 1,210 square kilometers, and creating a new engine for Shanghai's economic growth. In November of that year, Shanghai Disneyland Project was settled in Pudong.

Figure 1-8: Fast Growing Shanghai from 1990 to 2010

Figure 1-9: Pudong Skylight at Night

1.4. Economic aspect of People's Lives

Since the reform and opening, people's incomes have grown continuously, the average annual wage increasing from 716 Yuan in 1978 to 2,917 Yuan in 1990. The average annual income of farmers in the rural areas was 281yuanin 1978 and 1,665 Yuan in 1990. According to statics at the end of 2008, the annual per capita disposal income of urban households was 29,700 Yuan, and that of rural households was 11,400 Yuan. The city’s household savings deposits increased from 1.812 billion Yuan in 1978 to 1208.366 billion Yuan in 1990. Market supplies have been increasingly enriched: Shanghai launched a "shopping basket program" in 1988, and with the efforts made in about 20years, supplies of Shanghai groceries achieved a transformation from shortage and lack of choice to abundance stressing quality and nutrition.

In the 21st century, household consumption patterns have changed from meeting basic needs to seeking case and comfort High-level consumption such as leisure pleasure, healthcare; education and culture have increased greatly in the percentage of total household consumption.

1.5. EXPO 2010 Shanghai China

On December 3, 2002, the 132nd convention of the Bureau of International Expositions granted Shanghai the chance to host EXPO 2010. Shanghai spent eight years in planning and constructing EXPO Site and pavilions. By May 2010, the construction of EXPO BOULEVARD, CHINA PAVILION, THEME PAVILIONS, EXPO CENTER, EXPO CULTURE CENTER, and various temporary pavilions were completed. The EXPO has put many eco-friendly low-carbon technologies into application, embodying its theme of "Better City, Better Life”. The EXPO opened on May 1, 2010, and closed on October 31, 2010, offered a 184-day show on the site.

History granted favors to Shanghai in the past, and the new century has given the city new opportunities for development. Shanghai is marching forward, quickening its step to achieve the "Four Leads", and sparing no effort to realize the great goal of the "Four Centers".

Figure 1-10: Shanghai EXPO area before the construction

Figure 1-11: Shanghai EXPO Master Plan

Figure 1-12: Polish Pavilion in Shanghai EXPO 2010

1.6. City Analysis

1.6.1. Population Distribution

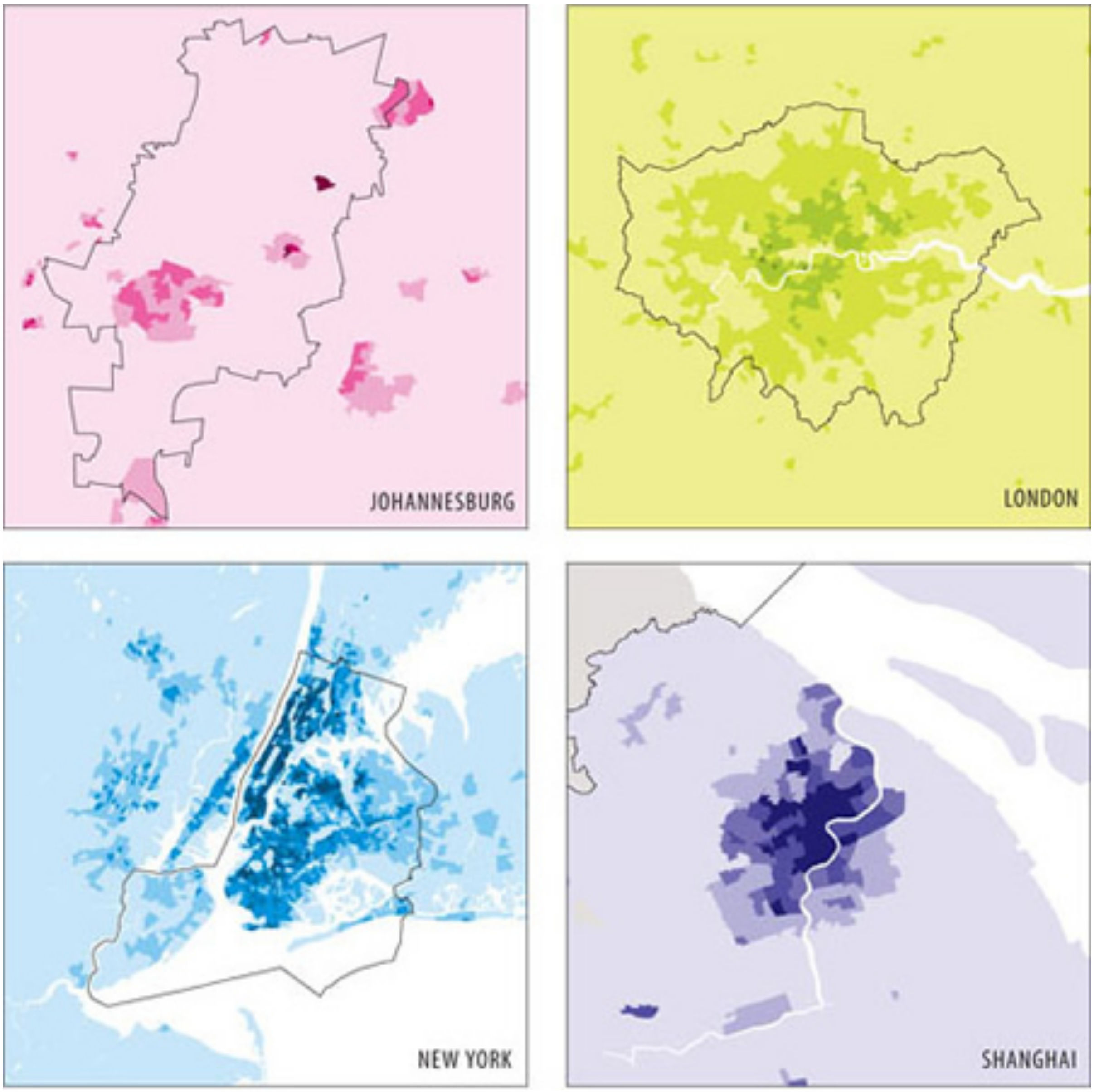


Figure 1-13: Comparison among three other cities in terms of population distribution shows that Shanghai is a mono-center city growing to be a poly-center city.

1.6.2. Shanghai Density

Figure 1-14: Map of Shanghai

By the end of 2008, however, the city's permanent residents had grown to 13.9104 million, or 1% of China's population. The population of long-term residents reached 18.8846 million, including 5.1742 million from other parts of the country. On average, the city had 2,978 long-term residents per square kilometer of land. By making a comparison between our District, Changning District and Pudong New Area we can understand the feeling of density in our area, which is medium to high.

Table 1: Population and Population Density (year-end of 2008)[1]

District/County	Population	Population Density (person/sqkm)
Changning District	66.83	17,449
Pudong New Area	305.70	5,738

Here comes the definition of a mega city. A megacity is usually defined as a metropolitan area with a total population in excess of 10 million people.[2]

[1] Governmental webpage of Shanghai, http://www.shanghai.gov.cn
[2] "How Big Can Cities Get?" *New Scientist Magazine*, 17 June 2006, page 41.

Table 2: All agglomerations of the world with a population of 1 million inhabitants or more at the reference date 2012-10-01 [3]

Rank	Name	English Name	Country	Population	Remark
1	Tōkyō	Tokyo	Japan	34,600,000	incl. Yokohama, Kawasaki, Saitama
2	Guangzhou	Canton	China	26,100,000	Northern Pearl River Delta incl. Dongguan, Foshan, Jiangmen, Zhongshan
3	Jakarta	Jakarta	Indonesia	25,600,000	incl. Bekasi, Bogor, Depok, Tangerang, Tangerang Selatan
3	Shanghai	Shanghai	China	25,600,000	incl. Suzhou
5	Seoul	Seoul	Korea (South)	25,500,000	incl. Bucheon, Goyang, Incheon, Seongnam, Suweon
6	Ciudad de México	Mexico City	Mexico	23,400,000	incl. Nezahualcóyotl, Ecatepec, Naucalpan
6	Delhi	Delhi	India	23,400,000	incl. Faridabad, Ghaziabad, Gurgaon
8	Karāchi	Karachi	Pakistan	21,900,000	
9	Manila	Manila	Philippines	21,700,000	incl. Kalookan, Quezon City
10	New York	New York	United States of America	21,500,000	incl. Bridgeport, Newark, New Haven

[3] (1999) (http://maps.google.com) (Shanghai - Heaven for Foreign Employees, 2003) (Digital Changning) (Brinkhoff)*HomasBrinkhoff: The Principal Agglomerations of the World, http://www.citypopulation.de*

Working on a site in a Mega City has differences than a normal site, we need to look for the new problems, which are more probable to happen than normal areas, and try to cure these problems. Problems like, traffic, transportation, water, air and sound pollution, and housing are the main problems. A profound city and site analysis is needed to identify most of the problems and choose the ones related to our concept. We start our urban analysis by analyzing the city first, the district then and the site in the end.

Figure 1-15: Air Pollution in Shanghai

1.6.3. Historical Growth of Shanghai

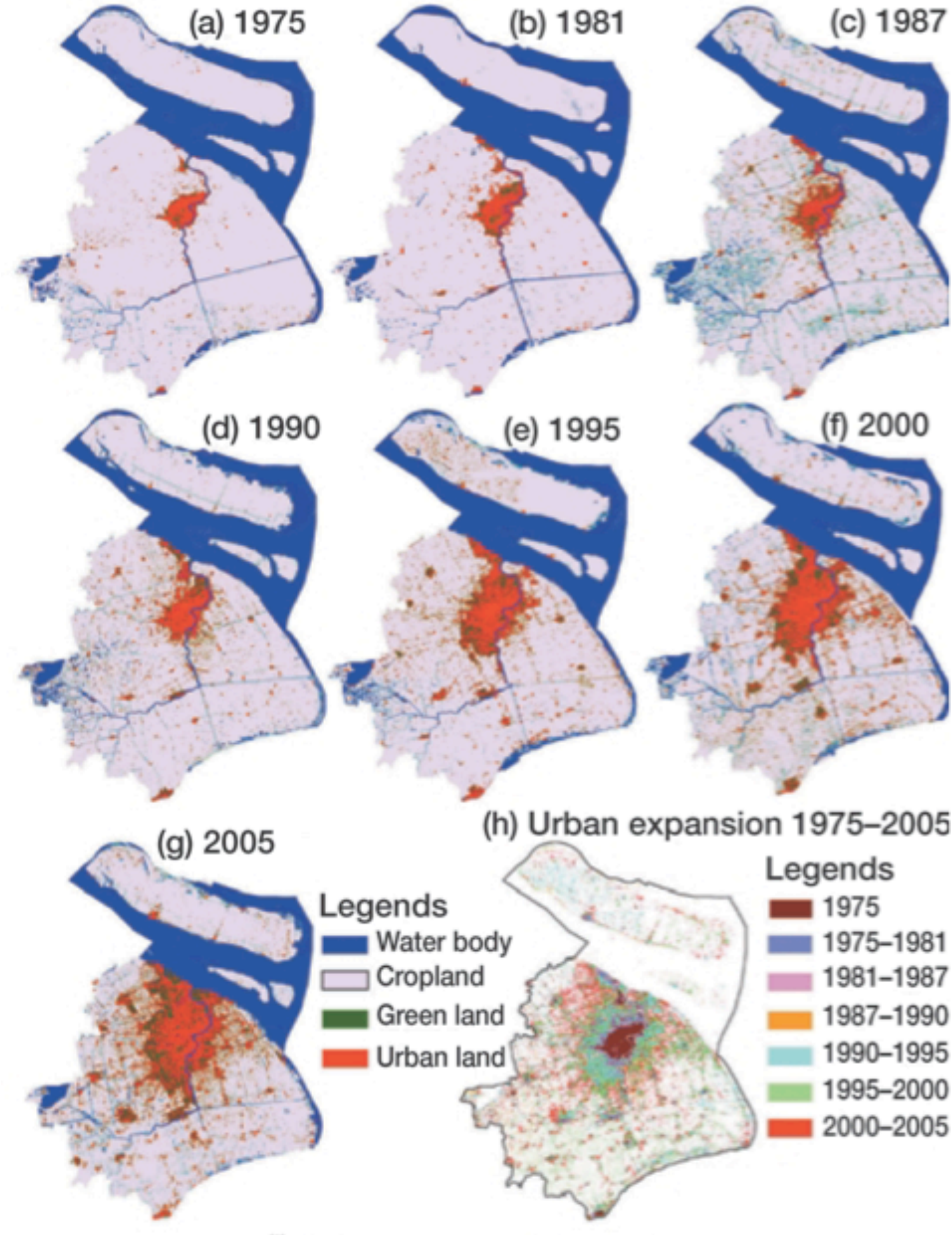


Figure 1-16: Shanghai City Growth

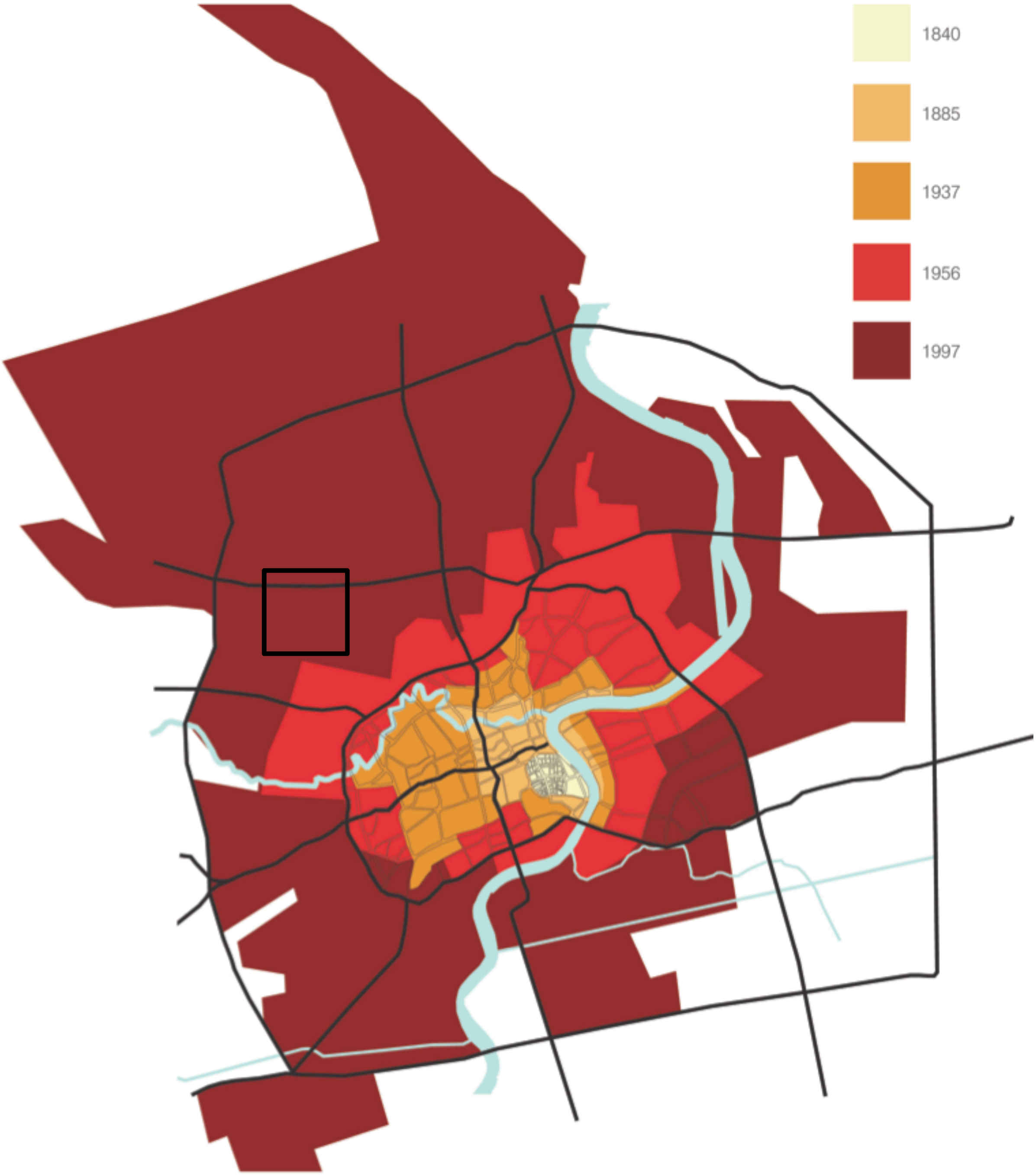


Figure 1-17: Shanghai City Growth

1.6.4. Public Transportation of Shanghai

Shanghai has about 1 million cars, but this number is rapidly growing. Shanghai has 13 subway lines in 2012. Lines 2, 3, and 4 are the ones passing our site in a stop called Zhongshan Park which is located in the south of our site. According to some surveys, Shanghai is being called the Kingdom of the bicycle because the number of bicycles per 100 households in 1995 was 190 bikes and in 2008 was 113 bikes. Also because of the existence of two main rivers and the canals, water transportation is also one of the main means of transportation mainly for moving cargos.

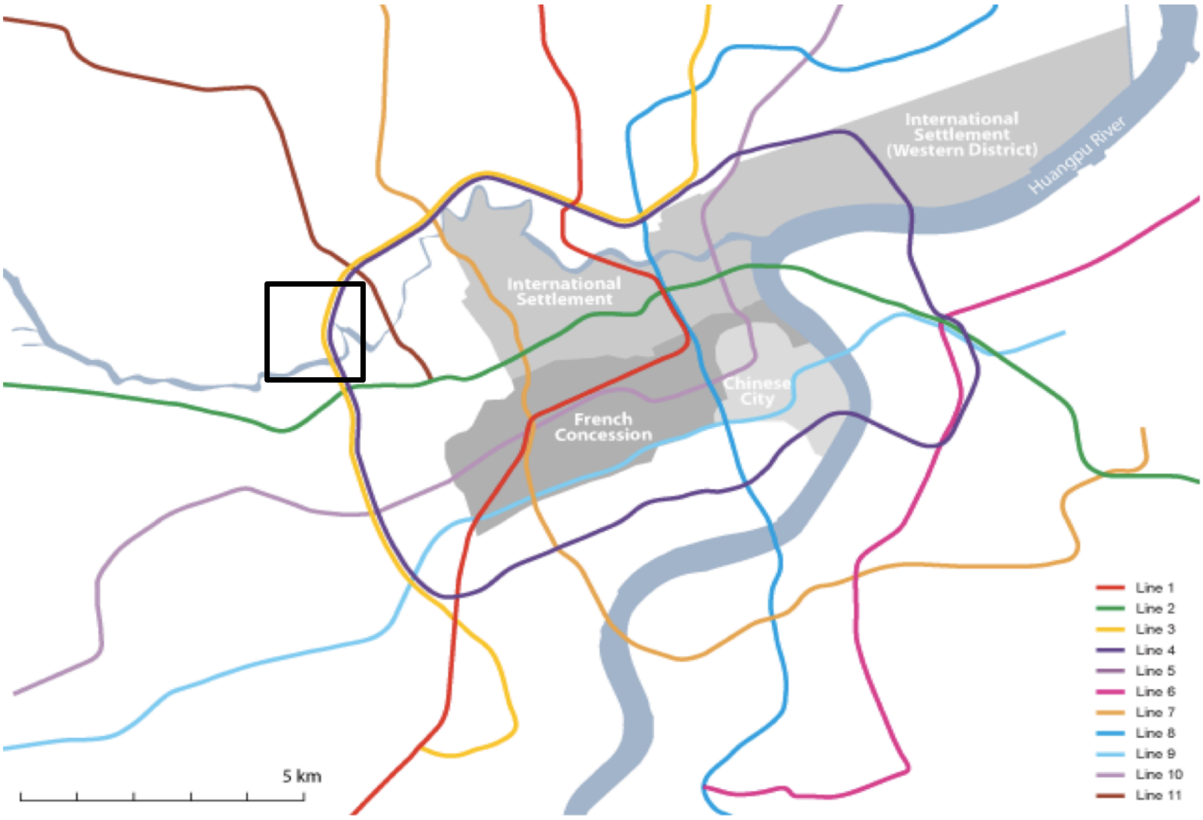


Figure 1-18: Subway Map of Shanghai in the City Scale

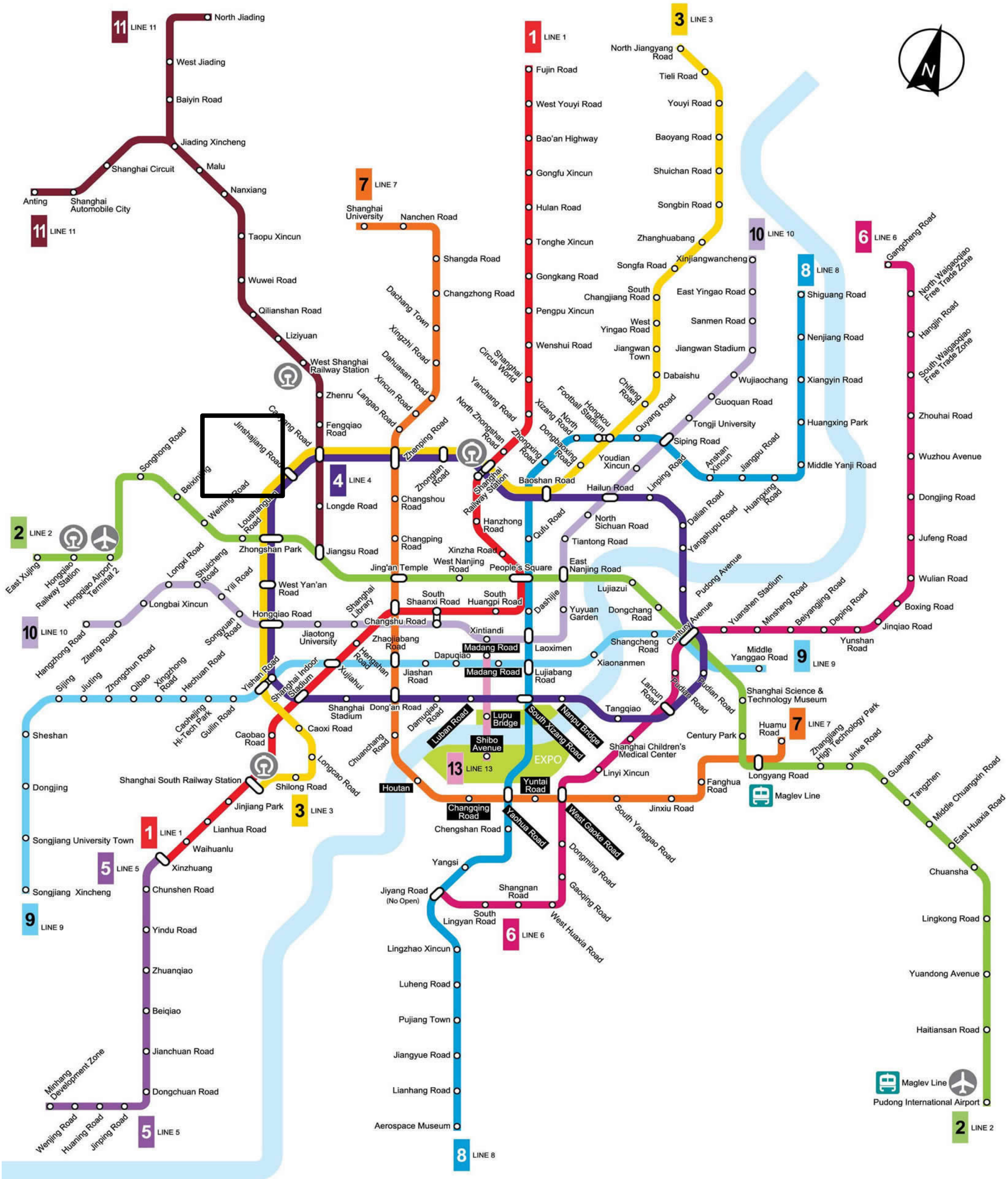


Figure 1-19: Subway Map of Shanghai

1.7. Brief of the Competition

1.7.1. Project Description

The project is based on a competition called “Re thinking Shanghai”. According to the demands of the competition, the location of the selected site can be anywhere along the Suzhou creek as long as it is within Shanghai, which will be selected by the participants of the competition. The project must occupy at least 150,000 square meters of land and contain residential, office, and commercial functions. Moreover, the ratio and size of the programmatic elements is up to the competitor. The project must also maximize green areas on the site.

Figure 1-20: Old map of Shanghai

1.7.2. Goals

- Further and expand a dialog about Green thinking in Asia.
- Design a visionary proposal for a Sustainable Architectural intervention along the Suzhou Creek in Shanghai.
- Concepts move beyond the ordinary and address issues such as: alternate power generation, passive Solar, cleaning air and water pollution, pollution neutralization concepts, and the use of innovative materials and geometries.

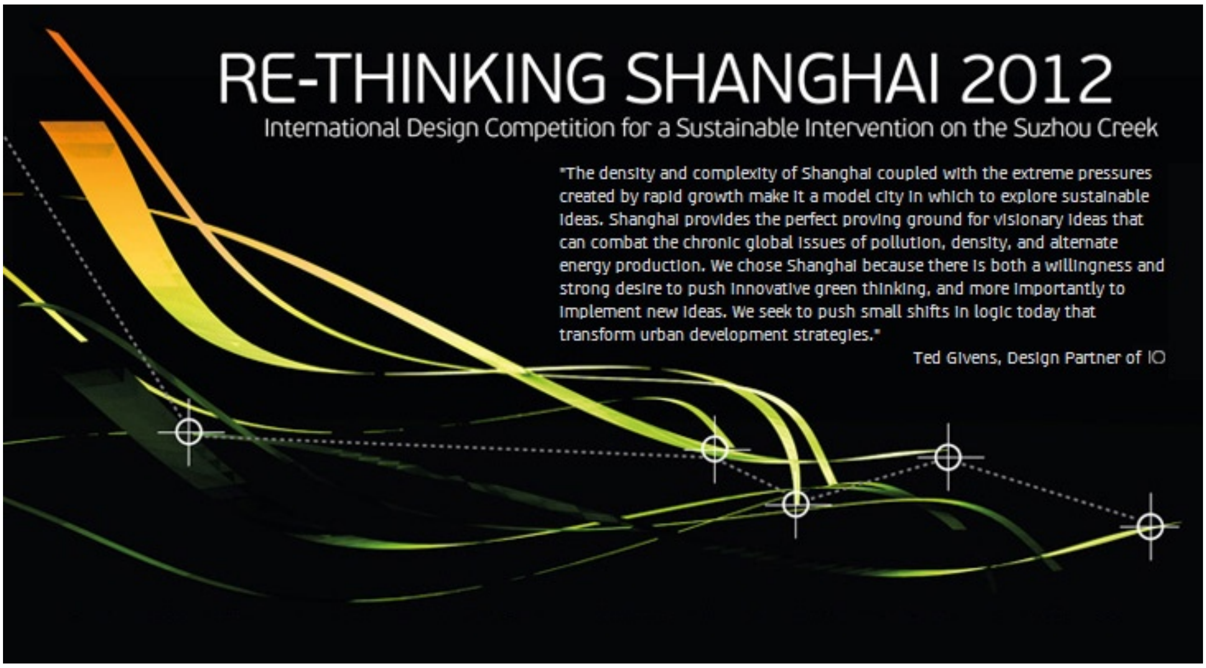


Figure 1-21: Competition Introduction Poster

1.7.3. Design Brief 4

This design competition is open to all students, architectural professionals, and artists. The competition aims to further and expand a dialog about green thinking in Asia. The competition site is located in Shanghai, China.

The aim of the competition is to design a visionary proposal for a sustainable architectural intervention along the Suzhou Creek in Shanghai. The location of the site selected can be anywhere along the Suzhou creek as long as it is within Shanghai. The project must occupy at least 150,000 square meters of land and contain residential, office, and commercial functions.

The ratio and size of the programmatic elements is up to the competitor. The project must also maximize green areas on the site. We are looking for concepts that move beyond the ordinary and address issues such as power generation, cleaning air and water pollution, and the use of innovative materials and geometries.

---

[4] (10+ competition)

Figure 1-22: Competition Introduction Poster

1.7.4. Judging Criteria[5]

- Quality of Design
- Originality of Thinking
- Cultural/Contextual Response
- Strength of Urban Integration
- Sustainable Concepts (possible ideas relating to alternate power generation, passive solar, pollution neutralization concepts, advanced materials)

1.7.5. Winners[6]

1.7.5.1. 1st Prize Winner

Jan Karasek, Ondrej Dusek, Lukas Makovsky, Jana Brankova - Czech Republic

Can a city river become more than a mere vista? Doing embankments "European-style" is wrong for Chinese cities. Promenades and green belts all the way along the riverbank do not bring any considerable value to the place. Think about Chinese cities - they are well known for their living public space. People are not afraid to use and exploit their surrounding - indeed this is often given by necessities, but over the years it has become a way of live. It is one often unseen yet wanted in many cities across the globe. So let the River become another busy city street! It is vast open space in the middle of dense city. But it can become vast public space. Such that allows you to use it in a way the streets and roads cannot be: It can serve travel and transportation, but it is the program itself that can also be transported. The river can become a plug-in city in its own way! Thus we can reverse the city to place where people stay, while the program comes to them. Here it is the program that can come to its user, not the other way around. One can stay at his neighborhood and have a market under his windows in the

[5] (10+ competition)
[6] (10+ competition)

morning, festival at noon and an entertainment district at night. And you will not be limited by selection - the public space is open to anyone willing to offer his services. We propose a city that changes in time and place, a city that is always perceived differently. Traditional long-lasting connections are broken and new temporal are created - such that form only when they are convenient: A new flexible neighborhood is born.

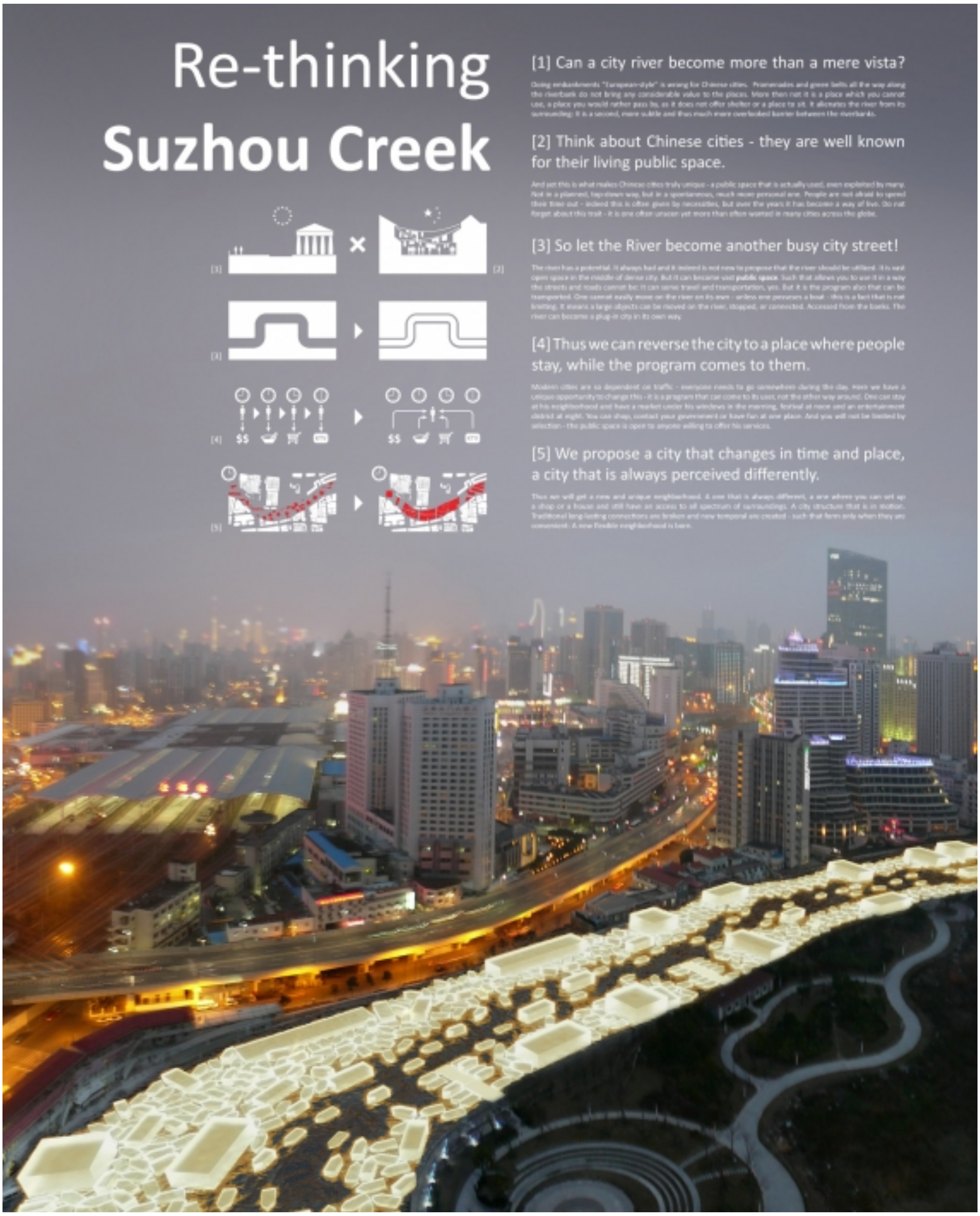


Figure 1-23: Competition 1st Prize Winner's Poster

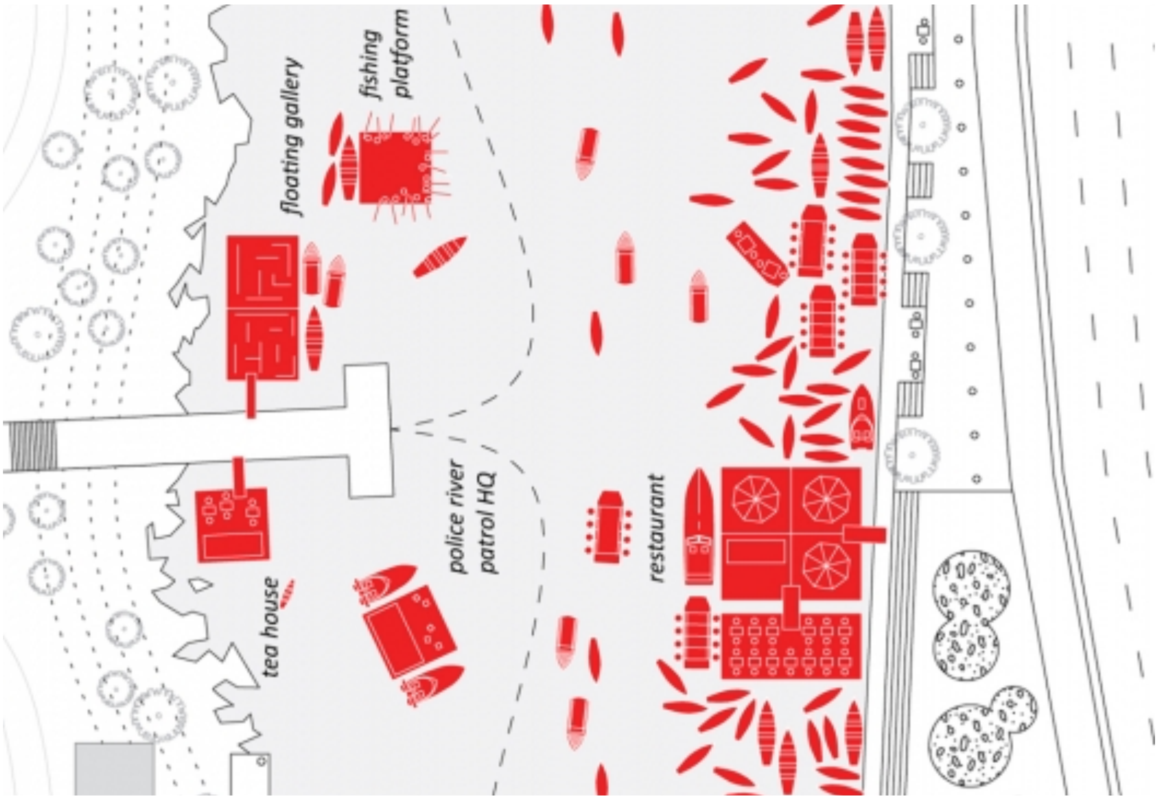


Figure 1-24: Competition 1st Prize Winner's Poster

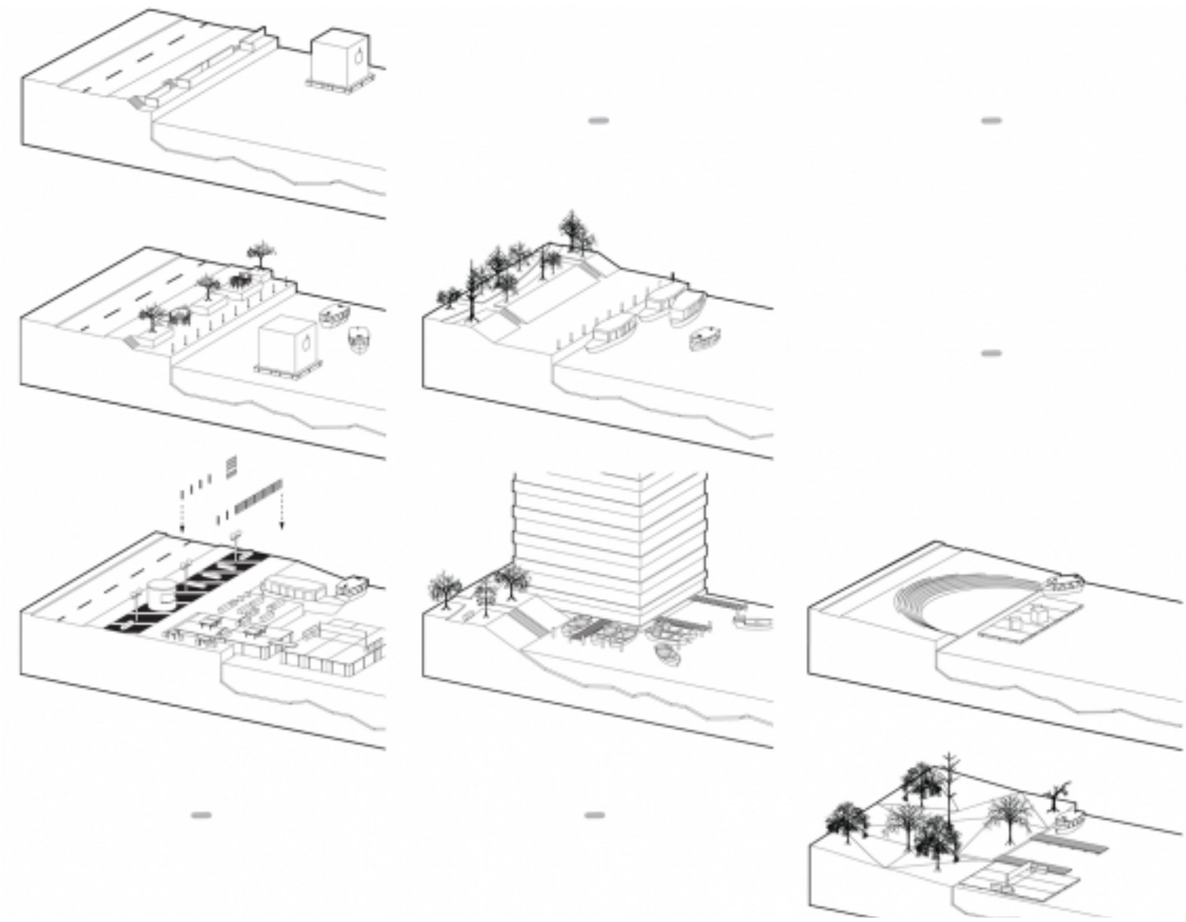


Figure 1-25: Competition 1st Prize Winner's Poster

1.7.5.2. 2nd Prize Winner

Fok Chun Wing, Chan Chun Ho, Chen Yiping, Fung King Him Daniel – China

The irregular formation of functions and mobile urban spaces in our opinion, TRUE SUSTAINABILITY can only be achieved if forms are flexible enough to service the changing needs of users throughout the different times of a day, or even throughout the different periods of a generation. Often we see stationary structures being built around the city due to increasing demands etc. These structures will have an economic life, and once the demand is gone, these structures will become redundant. Construction waste is thus created and this is not EFFICIENT use of resources! Our system consists of four hierarchical modules. The "Boat" is the standard mode of providing functions and activities along the water edge. The "Platform" supplements the Boat in creating unique spaces; it also functions as a mobile recharge station for boats. These two modules are mobilized, thus enabling them to change, group or cluster together anywhere along the creek to cater for the changing needs of users throughout the day. The "Edge" is the formalized means of enabling pedestrian users to connect with the boats and platforms; it also functions as a stationary recharge station for boats and platforms. The "Shipyard" enables the retrofitting of boats and platforms, and thus enabling them to be recycled and changed according to the demands of users throughout different periods of a generation. The boats and platforms utilize electricity for mobilization. We envisage that these two modules would be able to service themselves; however if needed they can connect with the edge or shipyard for recharging. With our hierarchical system, functions are no longer restricted to stationary structures. Time is forever moving, and so should function and from! The combination of the different modules will enable UNIQUE functions and spaces specific to a certain times created depending on the changing conditions of users. Suzhou Creek was once filled with boats providing goods and services along the waterways; let's reintroduce this historical culture back into modern Shanghai TODAY! We envisaged that our system would enhance the cultural, environmental and economic sustainability of Shanghai. Let's make Shanghai the avant-garde model of sustainability.

Figure 1-26: Competition 2nd Prize Winner's Poster

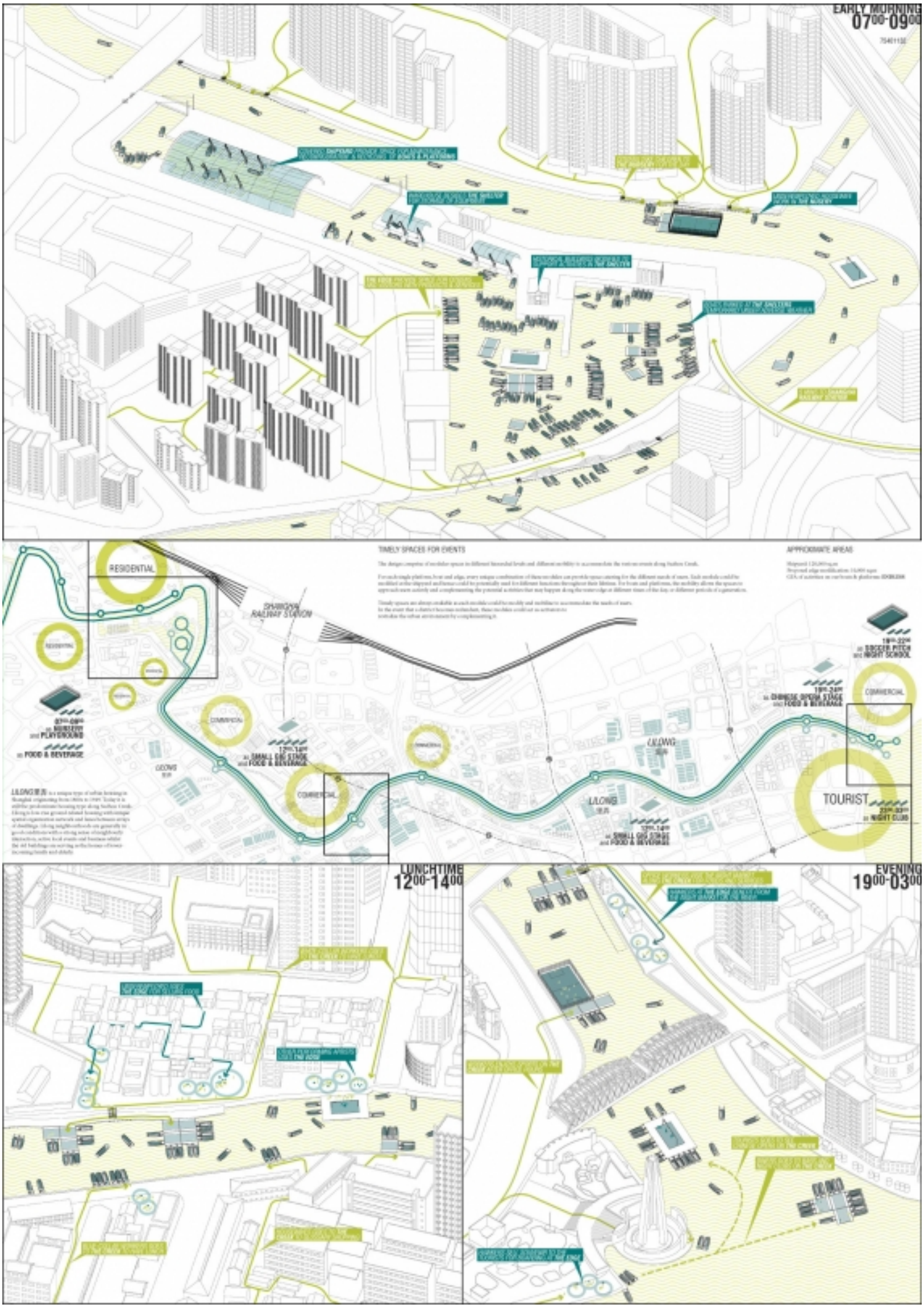


Figure 1-27: Competition 2nd Prize Winner's Poster

Figure 1-28: Competition 2nd Prize Winner's Poster

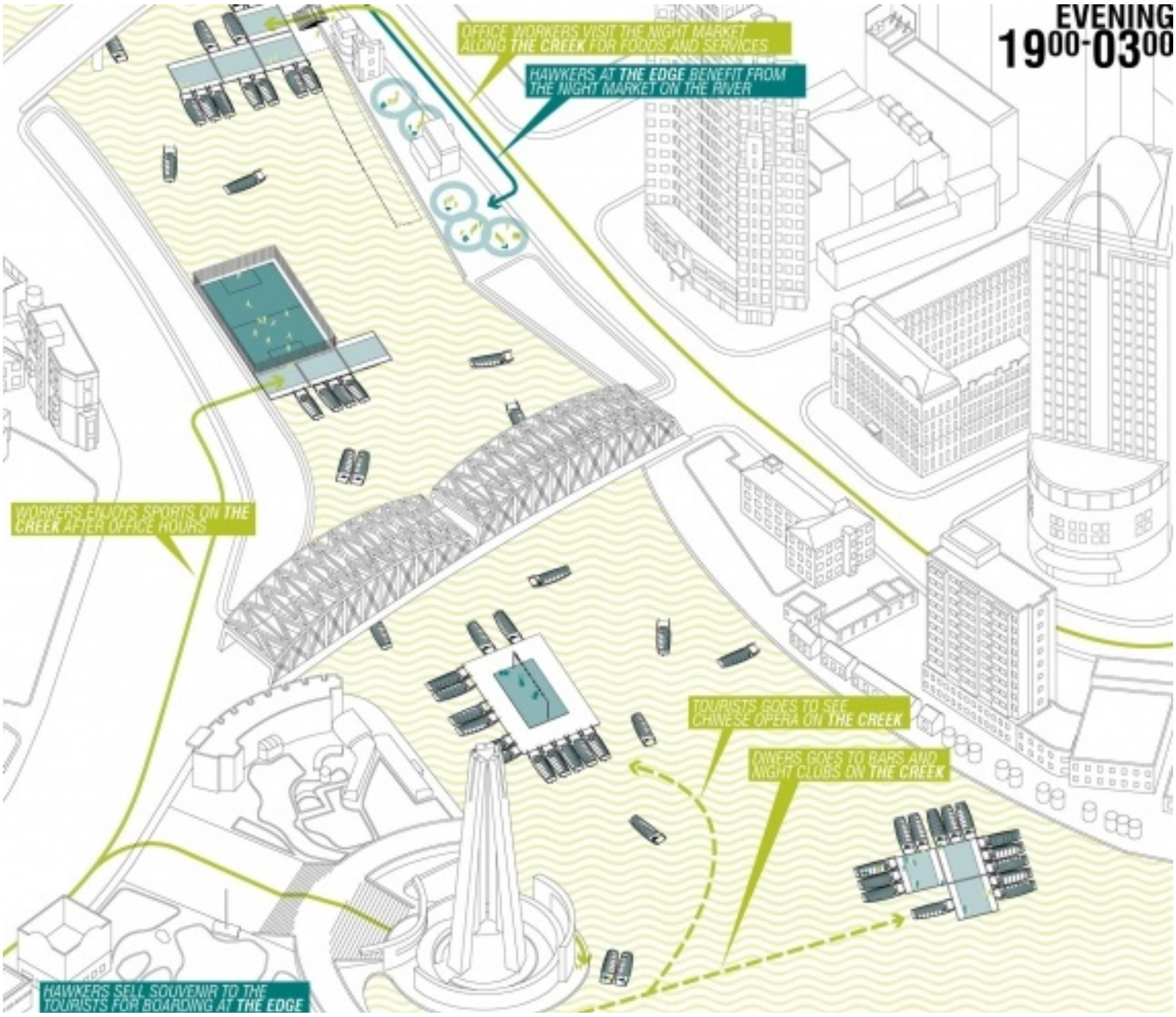


Figure 1-29: Competition 2nd Prize Winner's Poster

1.7.5.3. 3rd Prize Winner

Zhang Zhiyang, Liu Chunyao – China

Current situation:

1. Lack of groundwater since 1860, people in Shanghai started to exploit underground water; Shanghai has drilled for so much water that land in the center of the city has sunk 1.7m. Facing the problem of both land subsidence and sea level rise, shanghai will be submerged in seawater.

2. Lack of municipal water Although Shanghai has rich water resources, after considering both upstream water and local water pollution, we consider shanghai as a typical city of lacking quality water

3. Adequate rainfall Shanghai's average annual rainfall in recent 5 years is 1178.2 mm, north of tropical monsoon climate, adequate rainfall, and three pluvial per year.

4. Suzhou River's high water level Suzhou River's water level rises quickly during pluvial,

the construction of the dams costs a lot, and sometimes water can reach the street level.

Strategies based on the situation, we want to build a water project, to rebalance the distribution of water. We collect and purify rainwater and water in Suzhou River for daily water supply in the community, and injecting the recycled water underground at the same time. We can balance the amount of rainwater, underground water and river water. The rebalance and the co-ordination of the three can reduce the disasters. Moreover, we use the organic matter obtained by filtering water to develop farm, wetland, and to cultivate green alga. The flora contributes to our "clean air zones". The energy provided by green hydraulic generator is utilized by the community. The Future Influence:

1. To recovery supplement groundwater resources, thus solving the problem of land subsidence.

2. To purify Suzhou River and provide sufficient water supply for the city.

3. To ease the pressure of the flood controlling and we can lower the water level of Suzhou River.

4. To solve the high-density and high-population urban planning problems by forming a self-sufficiency and multi-function community.

5. To use the vertical eco-system to form "Clean air zones".

6. Wetlands along the river and Vertical Park provide public space for citizens.

7. Reorganize the special sceneries and form a new symbol of Shanghai.

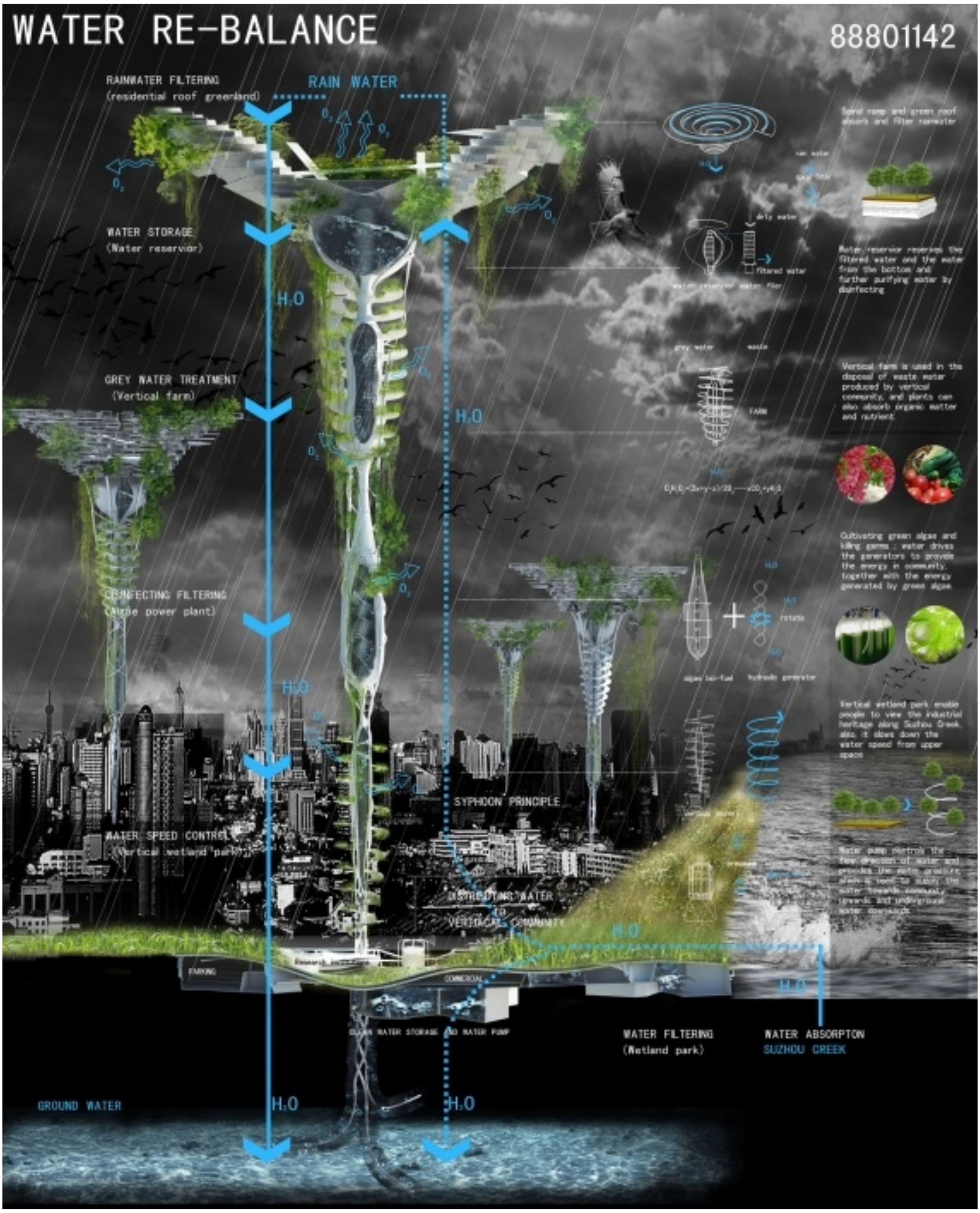


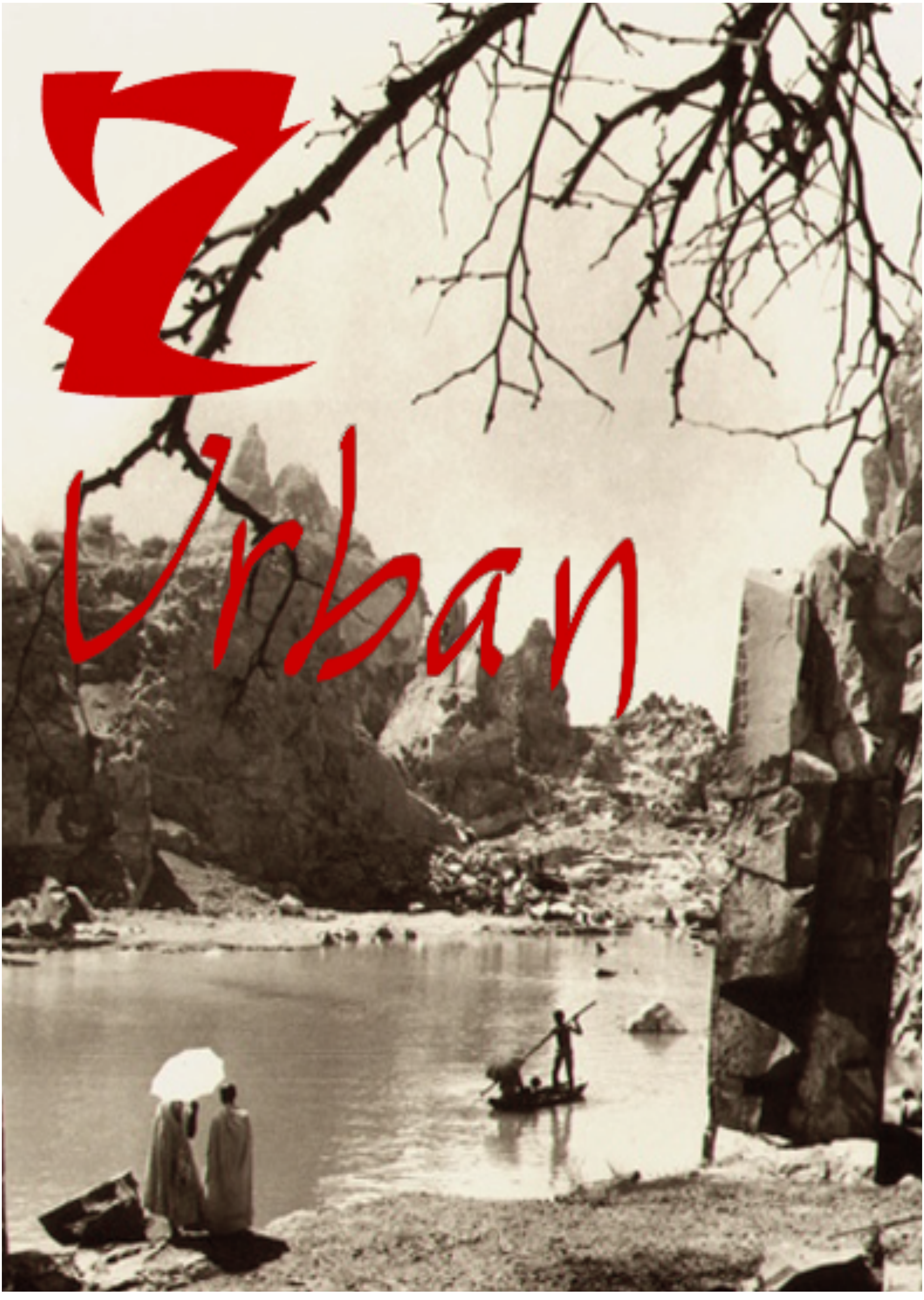
Figure 1-30: Competition 3rd Prize Winner's Poster

Figure 1-31: Competition 3rd Prize Winner's Poster

Figure 1-32: Competition 3rd Prize Winner's Poster

__Figure 1-33: Competition 3rd Prize Winner's Poster__

__Figure 1-34: Competition 3rd Prize Winner's Poster__


7
Urban

2. Urban

2.1. Choosing the Site

Figure 2-1: Map of Shanghai

Our site is located in Changning District, in the west of downtown Shanghai, which name is derived from Changning Road that runs through the district. Our site abuts Suzhou Creek to the north, east and west, and Zhongshan Park to the south. By choosing this site we can get the benefit of being close to water and also a park by which we can have a good approach toward our concept that we explain later in this document.

Figure 2-2: Selected Site

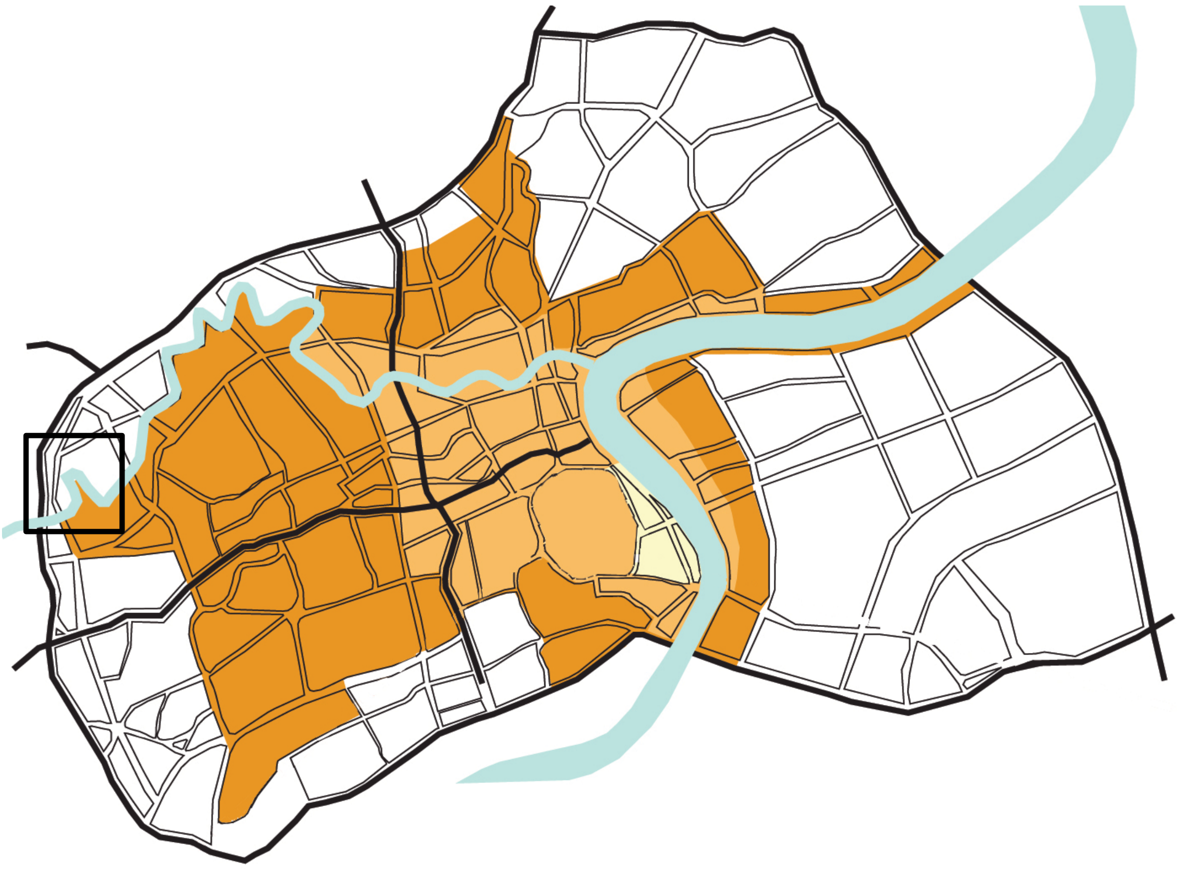


Figure 2-3: Map of Shanghai

Figure 2-4: Selected Area

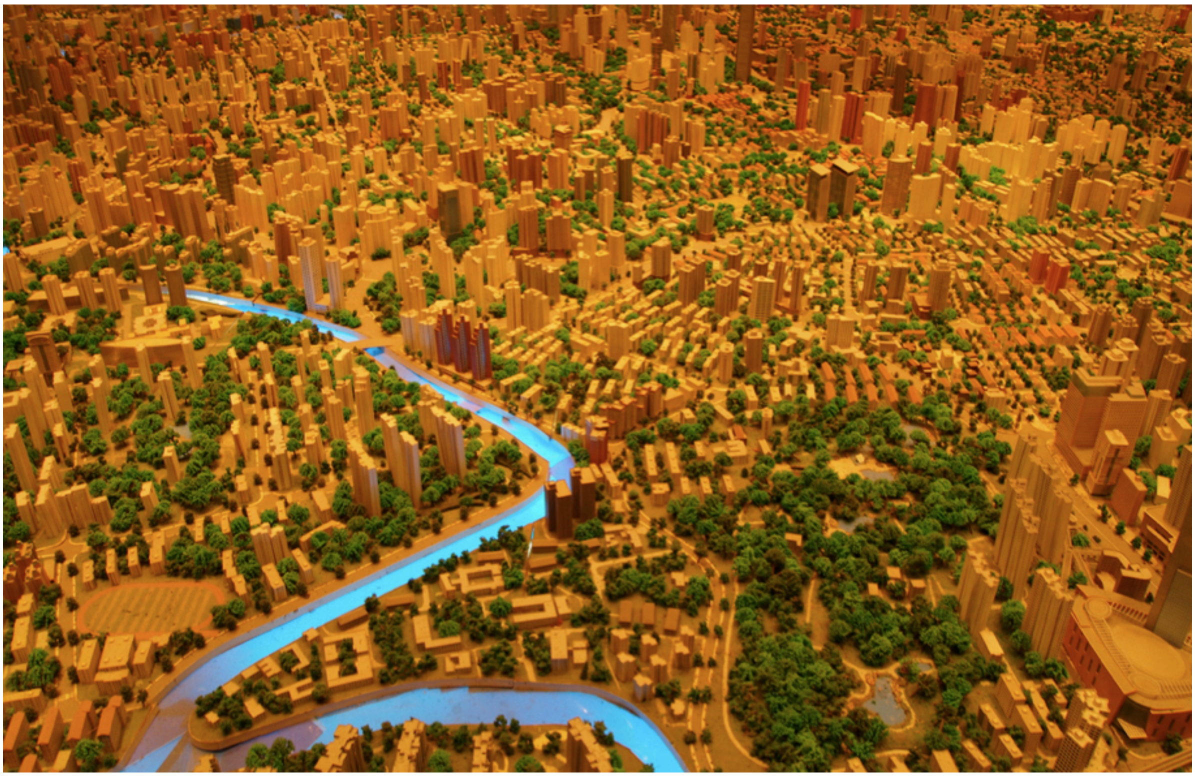


Figure 2-5: : Physical Model of the Site from Shanghai Urban Planning Exhibition Center

2.2. Changning District

Located in the west of downtown Shanghai, Changning District derives its name from Changning Road, which runs through the district. It abuts Jing'an District and Xuhui District to the east, Minhang District to the west and south, and Putuo District to the north across Suzhou Creek. With 10 sub-districts, it covers an area of 37.19 square kilometers. In 2008, there were 212,600 households and a registered population of 613,700 in the district. In the Ming and Qing Dynasties, the district was under the jurisdiction of Fahua Town, Shanghai County. In 1928, it became Fahua District after being incorporated into the Chartered City of Shanghai. It assumed its current name in 1947. The years between 1950 and 1994 witnessed several alterations to its administrative divisions. Beixinjing Town, Xinjing Township and some villages of Hongqiao Township were merged into Changning District, and they have remained part of the district ever since.

Figure 2-6: Map of Changning District

Foreign-related elements are the most notable features of the quick economic development of the district. HONGQIA0 ECONOMIC AND TECHNOLOGICAL DEVELOPMENT ZONE is the only zone of its kind nationwide. It is home to mainly foreign-related businesses, trade and tertiary industry firms, and the only development zone with a consulate. In the vicinity of the development zone is one of the areas with the largest number of foreign business buildings and hotels in Shanghai. Quite a few of the global top 500 enterprises, well-known multinational corporations and leading domestic corporations have set up regional headquarters or branches in this area. Among them are Dell, Accenture, LG, Eaton, Toyota, Sumitomo Rubber, CSPC, SPX Corporation, LOTTE, Unilever, Wanxiang Resources and five of the top ten enterprises in the global tire industry. With the support of Hongqiao Economic and Technological Development Zone, the district's professional services, MICE industry, modern logistics and the information service industry have boomed. As part of building a "Digital Changning", information and consulting services have been fully developed as "key industries".

Three key digital projects—National 863 Program of high-performance broadband information network, the fourth-generation mobile communications, and Shanghai Multimedia Public Service Platform—have been launched in Changning. Shanghai Multimedia Park, the first of its kind in Shanghai, is located in Changning District. It brings together many key domestic and foreign enterprises in the fields of motion pictures and animation and broadband multimedia applications, as well as multimedia exhibitions and demonstration. It has been classified by the Ministry of Science and Technology and the Ministry of Culture as a National Digital Media Technology Industrialization Base and a National Cultural Industry Demonstration Base.

The district boasts six five-star hotels—Pacific Hotel, HONG QIA0 STATE GUEST Hotel, Marriott Hotel, Renaissance Yangtze Hotel, Xijiao State Guest Hotel and Xingguo Hotel—and six four-star hotels. Yihe Longbai Hotel, Rainbow Hotel, Silver Star Hotel, Galaxy Hotel, World field Convention Hotel and Renton Hotel. It has 47 other star rated hotels as well as 66travel agencies, such as Shanghai Spring International Travel Service. In 2008, 2,139 new companies were set up in the district with a combined registered capital of 8,217 million Yuan. Also in 2008agreements were signed for foreign investment worth 524 million US dollars. Gross regional product in 2008 was 44.811 billion Yuan, with an added value of 25.673 billion Yuan, a year-on-year increase of 11.2 percent. Fiscal revenue for the district in 2008 stood at 5.267 billion Yuan.

Figure 2-7: Some Hotels in Changning District

The district boasts abundant scientific and technological resources as well as thriving scientific, technological, cultural and educational institutions. There are several scientific research institutions, such as CAS's Shanghai Institute of Microsystem and Information Technology and SHANGHAI INSTITUTE OF CERAMICS, Shanghai Institute of Biological Products of China National Biotech Group, 809 Institute of China Aerospace Science and Technology Corporation, Shanghai Bao steel Construction Design Institute and Shanghai Institute of Rubber Products: 5 full-time institutions of higher learning: DONGHUA UNIVERSITY, EAST CHINA UNIVERSITY OF POLITICAL SCIENCE AND LAW, Shanghai University of Engineering Science, Shanghai Institute of Foreign Trade, and Antai College of Economics Management; 28 secondary school including SHANGHAI No.3 GIRLS' HIGH SCHOOL and Yan'an High School; and 65 other schools of various types. The district has many major cultural and sports facilities, providing a wide variety of leisure activities for the residents. There are well-known artistic organizations including SHANGHAI SONG AND DANCE. ENSEMBLE, SHANGHAI BALLET, SHANGHAI CHINESE ORCHESTRA, and Shanghai Light Music Orchestra; modern cultural and sports facilities such as LIU HAISU ART MUSEUM, SHANGHAI OIL PAINTING AND SCULPTURE INSTITUTE, Hongqiao International Library (also known as "Window of China" Shanghai Reading Center), Shanghai International Gymnastics Center, Xianxia Tennis Center; and some large exhibition centers for exhibitions, international conferences, new product demonstrations, symposia and banquets.

Figure 2-8: Educational-Cultural Examples in Changning District

The district provides a pleasant living and ecological environment. Its large green areas, such as Hongqiao Central Garden, Huashan Green Land, Kaiqiao Green Land and Xinjing Park, cover 32.5 percent of the district, which puts Changning in first place among Shanghai's downtown districts in terms of its integrated environmental index. Gubei New Area, built to complement Hongqiao Economic and Technological Development Zone, is one of the largest foreign-related and up-market residential areas in Shanghai. Along Hongqiao Road and around Xijiao State Guest Hotel are more than 1,600 villas, which constitute one of the historical and cultural preservation areas of Shanghai. Occupied by one third of the consulates and so percent of the diplomats in Shanghai, the area is largely a community for expatriates.

Convenient transportation is another outstanding feature of Changning District. HONGQIA0 INTERNATIONAL AIRPORT, one of the "aerial gateways" linking Shanghai to the world, is situated in the southeast of the district: Inner Ring Elevated Road, Middle Ring Road, and Outer Ring Expressway run through the district from cast to west; S20 Expressway in the western part of the district joins the G2, G92/ G6o and S5Expressways; and No.318 National Highway is a vital route connecting Shanghai with Suzhou, Wuxi, Nanjing, Hangzhou and Ningbo. Changning is the "Western Gateway" for Shanghai's land transport links. The district provides more than 90 bus lines and is traversed by Metro Line 2 which links Zhongshan Park, People's Square, Lujiazui Financial and Trade Zone and Zhangjiang Hi-Tech Park; Metro Lines 3 and 4 run through the district and converge with Line 2 in Zhongshan Park; Inner Ring Elevated Road meets Yan'an Elevated Road inside the district, forming a stereo-traffic network which has become a crucial hub for human, material, information and cash flows.

The district is rich in tourist resources. Within it are 103 outstanding historical buildings (municipal level), former residences of historical figures and other traditional tourist attractions, as well as six exhibition halls for folk collections. Attractions include SOONG CHING-LING MAUSOLEUM, SHANGHAI ZOO, Zhongshan Park, Liu Haisu Art Museum, Shanghai History Museum, Shanghai Children's Museum and SASSOON'S VILLA. The district also has new scenic spots of the 1990s, such as Hongqiao Economic and 'Technological Development Zone, Gubei New Area, Shanghai Sculpture Space (built on the site of former factories), and Shanghai Fashion Hub. Social institutions in the district have been innovatively developed. Changning District People's Court took the lend in setting up China's first juvenile court, creating a precedent for China's juvenile justice system. The district also leads the way in formulating preferential policies for private science and technology enterprises, which has had an effect on the development of the entire city. Changning leads other Shanghai districts in terms of development of information resources and the application of information technology in government affairs, the economy and various social sectors, and it is carrying out a national pilot program in E-government.

2.3. Analysis of Changning District

2.3.1. Luxurious Apartment Buildings and Community for Overseas Residents

Before August 2001, overseas residents including those from Taiwan could only select apartments and houses for “outsiders” due to the policy. The areas for selection were very limited. After August 2001, the policy was revised and lots of luxurious buildings were constructed. The areas for selection for overseas residents expanded. Since 1995, Changning district featured mid-to-high ranking apartment buildings and houses with a stable increasing speed of 900,000 to one million square meters every year. Between 2000 and 2005, the newly constructed buildings were mostly along Changning road, Tianshan Road, the first and second zone of Gubei, and Hongqiao luxurious area.

2.3.2. Historical Garden Houses are Popular

Besides constructing new buildings, many overseas residents are also interested in old-style historical garden houses and new houses with great design.

There are many garden houses along Xinhua road, Yuyuan Road and Hongqiao Road, with a total area of 530,000 square meters, occupying 30% of all old garden houses in Shanghai. Moreover, Changning district also has the most newly designed garden houses. Among the 12 historical and cultural zones in central Shanghai, four are in Changning. And the convenient location, nice ecological environment, and rich cultural ambience all attracted many overseas residents to Changning. It is known to “live in Changning for health and peace.”

Changning is famed for containing lots of garden houses. Garden houses built before 1949, mostly along Yuyuan Road, Huashan Road, Fanyu Road, Jiangsu Road and Xinhua Road; occupy a total area of 464,000 square meters, 29% of all in the city. The garden houses are unique with distinct styles – Medieval style, British villa style, Spanish style, and American continental style. Some houses are decorated with traditional Chinese patterns and Western style frames, or vice-versa. The large groups of garden houses along Hongqiao Road, Huaiyin Road, and Hami Lu are mostly luxurious and equipped with dance halls, swimming pools and tennis courts. After 1949, seven houses including the Sassoon house (today's 2409, Hongqiao Road) were listed in the protection list by the municipal government. After the open-up policy, a group of luxurious residential buildings were built. By 1995, the number of newly founded garden houses and apartment buildings was counted as 523, among which 27 won design prizes approved by Shanghai Municipal Construction Commission and Municipal Science and Technology Commission. The luxurious residential buildings in Gubei, designed by famous French architects, occupy a total area of 66.30 square meters. The frames of the buildings are in the shape of arcs, and the windows are carefully decorated. The interior decorations are luxurious. [7]

2.3.3. Top Quality Commercial Buildings for Foreign Enterprises

In 2003, the preferential policies by China expired. Moreover, China had joined WTO for more than a year, so all-foreign enterprises in the development zone would enjoy the same policies as domestic companies. The development lost all advantages in terms of policies. Moreover, the surrounding areas' economic developed rapidly and became increasingly more competitive against the development zone. Changning district set up the developing strategy "develop Changning on the basis of Hongqiao to construct the Large Hongqiao Commercial and Trade Zone" to strengthen the development zone's functions, accumulate advantages, and expand opportunities. Total area of various functional buildings including commercial buildings, hotels, exhibiting facilities, malls and luxurious apartments reached 2.15 million square meters by June 2006, among which the area for commercial, office buildings and malls were 1.67 million square meters while luxurious apartment buildings 480,000 square meters. The core area, Hongqiao Development Zone of 0.65 square Kms, was already equipped with 1.34 million square meters of functional buildings including the International Trade Center and New Hongqiao Building, etc., among which 500,000 square meters were for commercial and office uses while 300,000 for exhibiting, 280,000 for hotels and 260,000 for residential. The central zone and extended zone contained 810,000 square meters of various economic buildings with 590,000 for commercial and office uses and 220,000 for residential.

Now, a total of 760,000 square meters of buildings are under construction, among

[7] "Journal of Changning District", Shanghai Academy of Social Science Publishing House, 1st edition, January 1999

which 530,000 for commercial, office and hotel uses while 230,000 for residential.

Many cross-nation group corporations and institutes gather in Hongqiao including GM, Ericsson, 3M, etc. A total of 3,500 enterprises are within 1.77 square Kms of the Hongqiao area, among which more than 1900 are foreign ones, 54% of total. The 0.65-square-km-core-area contains more than 2,000 companies (55% are foreign ones). The total number of companies in the central zone is about 1,500 (53% are foreign ones).

In 2005, the total tax revenue from the 1.77-square-km-range reached 1.5 billion Yuan with six buildings submitting more than 100 million Yuan of taxes, 67% of the whole Changning district.

There are 863 national science research projects in the area including High Functional ADSL Research Center, Shanghai Institute of Foreign Trade Gubei Campus, Changning Information Zone, Shanghai Fashion Zone, Shanghai University of Engineering Science and Technology Xiaxian Road Campus, and Shanghai Vocational Training Center, etc. The total number of information enterprises in Changning Information Zone was 233 by the end of this June, among which 90 were municipal approved software companies. There are 25 international and domestic industry associations, design institutes, talent training centers, animation production companies, and fashion enterprises in Shanghai Fashion Zone. Shanghai Institute of Foreign Trade has set up post-degree training center and WTO training center while is also preparing to build WTO Training Building. High Functional ADSL Research Center has succeeded in applying to 10,000 households in Gubei and is expanding to even more.[8]

Besides, the group of foreign related consumption venues likes Hongqiao Friendship Mall and restaurants of various national styles also motivated the sales of the luxurious apartment buildings along Xianxia, Tianshan and Xinjing Town. Many overseas residents chose to live in apartment buildings or houses along Hongqiao Road and some also stayed in Hongqiao development zone.

2.3.4. Excellent Information Service for Overseas Residents

While attracting overseas residents with excellent hardware, Changning district also improved software environment to attract newly arrived overseas personnel to Changning. Many people who moved out of the district also came back.

The foreign related project of Changning district was led by the Information Office of the State Council and Shanghai Municipal Foreign Propaganda Office. As the number of overseas residents increases, the propaganda and foreign services in Changning district are

[8] Source: Hongqiao Foreign Trade Center website(Placeholder1)(Digital Changning)

facing a new challenge – how to keep overseas residents on the basis of attracting them?

Considering overseas residents' information demands for public services and life styles, Changning district foreign propaganda office focused on the four categories – "Education and Medical", "Culture and Entertainment", "Urban Traffic", and "Dining and Shopping"

2.3.5. Zhongshan Park Community: Place to Live, Work

Figure 2-9: Map of Zhongshan Park Business Zone

The best answer to the harmonious development of both living environment and commercial environment lies in Zhongshan Park Community, a landmark of Changning District, where many foreign expats stay for its commercial areas near the working places and its good living conditions. Business booms in its vicinity on the basis of the "ecological effect" created by this natural oxygen bar of the park. Commercial buildings around the park have been largely developed with properly arranged commercial facilities of different scales and types such as Cloud Nine Shopping Mall, Paris Spring Zhongshan Park Shop and Rose Street. With electrical appliances malls like Best Buy, Suning, Yongle and Gome, a prosperous business area has been formed. The business area has met the living requirements of foreign expats in this community. Moreover, a large number of commercial office buildings facilitate the expats who are pursuing their career in Shanghai to freely chase their dreams here.

Figure 2-10: Some Examples of Zhongshan Green Areas

Changning District government believes that Zhongshan Park has enormous potential in eco-improvements, environment upgrading and business growth. A "plan in developing Zhongshan Park" emphasizing "ecological effect" has already been mapped out. One of its goals is to integrating the ecological effect of the park into the leisure requirements of the expats by optimizing commercial leisure facilities of the area. For instance, the upcoming transformation for protecting historic features of Yuyuan Road, Phase One, will be another highlight of regional business and leisure. However, there are some administrative office buildings, management buildings and school buildings around the park in contravention of the overall image of the area, to be included in the "development plan around the Zhongshan Park". For example, the shabby administrative office buildings obstructing the open space of the green park will be turned into the complementary business carrier to the existing one. The crunchy school precinct around the park finds it hard to meet the growing requirements for regular teaching and learning. Moreover, the western part of Changning District is encountered by the lack of the education resources. Therefore, the District will consider transforming the school buildings into creative industrial parks for the development of service and trade industry.

2.3.6. Life in the District

Overseas residents have formed a unique cultural phenomenon in Changning district, a special culture fused by features of various countries and Chinese elements.

2.3.6.1. Food

There are many Korean and Japanese restaurants along the Hongqiao Road, but overseas residents also love trying Chinese cuisine. The Sichuan style and Hunan style restaurants on Xianxia Road often have overseas customers. Each country's residents have very distinct eating customs. Many Indians residents in Hongqiao neighborhood still keep the habit to eat at home.

2.3.6.2. Living

Like we mentioned before, overseas residents in Changning live according to their nationalities, like Gubei is filled with Japanese and Korean residents, while Europeans gather in Chengjiaqiao neighborhood and Xinjing Town. Besides luxurious apartments, villas and old-styled houses, many residents also love the authentic Chinese living style. For example,

2.3.6.3. Transportation

A private car is the major transportation for many overseas residents in Changning district. And you can often see some young foreigners biking along historical streets like Yuyuan Road and Xinhua Road.

2.3.6.4. Shopping

Most foreigners shop at large shopping malls like Zongshan Park, Hongqiao Friendship Mall, and Bailian Xijiao Shopping Mall, but you can also find them in some small shops on Xianxia Road and Dingxi Road.

2.3.7. Current Status of Overseas Residents in Changning District

Currently, more than 30,000 overseas residents from 114 countries and regions live in Changning district. The survey of Changning district propaganda departments shows the following features of overseas residents in Changning

2.3.7.1. Increasing number and concentrated residence

More and more overseas residents register in Changning district every year. In 2000, the number of registration was 11,675 person times. It was 21,981 person times in 2001, 29,489 in 2002, 21,888 in 2003 (the number reduced relatively because of SARS). The number of registration in Changning has doubled comparing to three years ago. Overseas residents gather in two major areas -- Hongqiao neighborhood and Chengqiao neighborhood. Many also live in Jiangsu, Xinhua, Xianxia and Tianshan neighborhood. Due to the influences from Hongqiao Airport, Gubei New Community and the large groups of luxurious houses along Hongqiao Road, Shanghai's largest international luxurious residential areas have become the major residence for overseas residents in Changning district. Hence, overseas residents in Changning district are mainly in the west area while very few live in luxurious or old-style apartments in other areas.

2.3.7.2. Residents from Hong Kong, Taiwan and Macau

In 2003, overseas residents in Changning district belong to 114 nations and regions, among which the region with most overseas residents was Taiwan, followed by Japan, and America. Overseas residents from Asian countries and regions made up 65%. Residents from various countries and regions live together according to their nationalities and languages. Most residents from Taiwan, Japan and South Korea gather in Hongqiao neighborhood while Europeans and Americans are mainly in Chengqiao neighborhood. Such distribution of residence also results in disparity in the affiliate facilities around the neighborhood, especially in fields of entertainment and dinning. The Ronghua community has become a featured Japanese and Korean street.

2.3.7.3. Male-female distribution

Among all overseas residents, 2/3 are males and 1/3 are females and most are between 30 and 50 years old. And foreign males between 35 and 40 years old form the largest population group.

2.3.7.4. Families and Business

Most overseas residents in Shanghai are delegates of foreign investors or international companies.[9] Moreover, the data from Changning district administration of entry/exit reflects that about 40% of overseas residents live with their families in Shanghai. Among all overseas residents arriving in Shanghai, most are businessmen and especially managers assigned from their own countries, which is why it is mostly middle-aged males.

Moreover, the recent date shows that there are 750 Taiwanese, 139 Hong Kong, 14 Macau and 15 Chinese students with foreign nationalities in middle schools, primary schools and kindergartens in Changning district. The data shows 801 foreign students and 518 students of minorities. The numbers of Taiwanese and foreign students increased by 12% and 14% respectively comparing to the year of 2006.

[9] (Shanghai - Heaven for Foreign Employees, 2003)

2.4. Wusong River (Suzhou creek)

Figure 2-11: Suzhou Creek

As the most important tributary of Huangpu River, and an important inland waterway in Shanghai, Wusong River, originates from Guajingkou of Taihu Lake, and runs through the counties of Wujiang, Wuxian, Kunshan in Jiangsu Province, then crosses nine districts of Shanghai (Qingpu, Minhang, Jiading, Changning, Putuo, Zhabei, Jing'an, Huangpu, and Hongkou), and finally flows into Huangpu River at Waibaidu Bridge. With a total length of 125 kilometers, Wusong River runs 53.5 kilometers into Shanghai, including 16.7 kilometers from Beixinjing to Waibaidu Bridge in the old urban district. With a width of 40 to 80meters and a depth of 2 to 8meters, it has a navigation capability of 100 tons. After Shanghai was opened as a trading port in 1843, Wusong River was customarily called Suzhou Creek by westerners who noticed that the river led upstream to Suzhou. Since the 1980s, the name "Suzhou Creek" has been expanded to include the headwaters so Wusong River that stretches across Shanghai is also referred to as Suzhou Creek today.

As one of the three main channels to the sea in the lower reaches of Taihu Lake during ancient times, Wusong River was once the largest river on the southern bank of Changjiang River Estuary. Wusong River was discharged into the sea at QINGLONG TOWN via Hudu River. It is from this "Hu" that the abbreviation for Shanghai originated. However, in 1042 and 1048, a causeway and a long bridge in Wujiang County were constructed, which obstructed outflow from Taihu Lake. The lower reaches of Wusong River gradually became shallower, affecting shipping and drainage. Consequently, the ten-kilometer-wide estuarine section of Wusong River during the Tang Dynasty was shortened to 4.5 kilometers in the Song Dynasty, and to 2.5, 1.5 and as kilometers thereafter. River cutoff measures were taken on Baihe River in 1061. In the Mid-Southern Song Dynasty, Wusong River flowed into Changjiang River through Dacangpukou (later renamed as Wusongkou). In the early Yuan Dynasty, Wusong River became gradually shallower again because of tide-influenced shoal development in the lower reaches of the river. Later dredging work was undertaken repeatedly, but to little avail. In the first star of the reign of Emperor Yongle of the Ming Dynasty, after Fanjiabang Creek was excavated to link Wusong River with Huangpu River, the situation of "Huangpu controlling Wusong" emerged, making Wusong River a branch of Huangpu River. After this, the present river system came into being. In 1521, the 16th year of the reign of Emperor Zhengdeof the Ming Dynasty, a river section from Beixinjing to Caojiadu in the lower reaches of Wusong River was opened by Li Yunsi with farm laborers, which joined and widened Songjiabang Creek (the part of Suzhou Creek that stretches from Caojiadu to Waibaidu Bridge), In 1569, the third year of the reign of Emperor Longqing of the Ming Dynasty, Hai Rui dredged the old channel, which remained from the engineering works of Li Yunsi, and finally established the present shape of Suzhou Creek in the urban area.

As one of the mother rivers of Shanghai, Wusong River (Suzhou Creek) not only created ancient civilization, but also recorded the century of trauma and history that gave rise to the modern industry and commerce the area is now world-renown for. After Shanghai was opened as a trading port in 1843, westerners swarmed into Shanghai to control important places. The architecture built along Huangpu River were sites mostly for finance and trade, while parks, hotels (e.g. RICHARD'S HOTEL, Broadway Mansions), apartments, hospitals (e.g. Shanghai General Hospital), foreign diplomatic and consular organizations (e.g. American, British, Japanese, and Russian Consulates) and post offices (e.g. SHANGHAI POST OFFICE BUILDING) were built in the eastern part of Suzhou Creek. Chinese and foreigners both built quite a few bridges over the river, the most famous two bridges were Wills' Bridge (now Waibaidu Bridge) built by foreign businessmen in 1856, and Huitong Bridge (Hengfeng Road Bridge today) built by the Chinese in 1903. There were other bridges such as Zhapu Road Bridge, Sichuan Road Bridge, Jiangxi Road Bridge, Henan Road Bridge, Fujian Road Bridge, Zhejiang Road Bridge, and Xizang Road Bridge. In 1876, the earliest railway station in China was constructed on the northern end of Henan Road Bridge along Suzhou Creek, and SONGHU RAILWAY, China's first commercial railway, started to extend toward Wusong

After 1900, local capitalists deemed it important to revitalize domestic industry in order to retrieve economic advantage from the increasing economic infiltration of foreign capitalists in Shanghai. Therefore, the industry of Shanghai had a period of great development, resulting in the city's moving westward. Factories and warehouses for textile spinning, chemical engineering, and grain processing were built in succession along the west bank of Suzhou Creek, creating famous Huxi Industrial Zone, which corresponded with Yangshupu Industrial Zone on the west bank of the lower reaches of Huangpu River. The celebrated Shanghai Union Brewery and Foh Sing Flour Mill, two century-old Chinese enterprises, were established during this time. SHEN HSIN SPINNING AND WEAVING CO. was the largest textile mill in old China, and was located on Aomen Road on the south bank of Suzhou Creek. The famous Sihang Warehouse, owned by four private banks (i.e. Yien Yieh Commercial Bank Ltd., Kincheng Banking Corporation, Continental Bank, and China &South Sea Bank Limited), was located north of Xizang Road Bridge. Urban public service enterprises involving water, electricity, and coal were first to be built along Suzhou Creek. The earliest gas lamps and electric lights in Shanghai were seen in the area of confluence between Suzhou Creek and Huangpu River.

Initially, Suzhou Creek was so clear that fish and shrimp could be seen, and it was used as one of the earliest water sources to provide running water. The former Zhabei Waterworks was built in 1911, taking the source water from the section of Suzhou Creek around

Hengfeng Road Bridge. Running water processed from the river was eulogized by using a couplet: "Iron pipes go underground to the river, and running water arrives at households across streets and houses." In the 1920s to 19305, sediment deposition and deterioration of water quality prevented citizens from using the water. So Zhabei Waterworks was moved to the banks of Huangpu River, since 1949, its river way has been renovated many times Flood prevention walls on both banks have been heightened and ports have been constructed. Now factories stand in great numbers on its banks, and many wharfs can be seen. In the late 1980s, along Suzhou Creek there were more than 860 factories and 5,000 sailing vessels. There were 447 quay berths with a length of 16.8 kilometers, accounting for 16.8 percent of the total number of wharfs and 18.8 percent of the total length in inland rivers. In 1956, severe contamination was diffused into Beixinjing. Having been completely polluted in 1980, the river could no longer serve as a water source, becoming yet another notorious, black, smelly river.

Since 1988, SUJHOU CREEK COMPREHENSIVE REHABILITATION PROJECT was launched to improve the ecology of Suzhou Creek. Many measures have been implemented such as sewage interception, pipeline transportation, purification treatment, sediment dredging, dock wall building, removal of factories, dock clearing, construction of scenic routes on each bank along the river, and renovation of creeks in outskirts. Meanwhile, efforts have been taken to develop the creative industry along the bank where old factories once stood. In 1991, a tidal barrage for Wusong Road Sluice Bridge was built at the estuary of Suzhou Creek in order to prevent disasters causal by incoming tides. Today, fish and shrimp have begun to reappear in the river as the water quality has noticeably begun to improve. In 2008 the century-old Waibaidu Bridge, the most famous old bridge on Suzhou Creek, was completely renovated. In 2009, 17 bridges on Suzhou Creek were renovated as well. Meanwhile, many green spaces have been built, some key historical areas have been rejuvenated, and waterbuses have begun operation, affording tourists a firsthand look at both yesterday and today's Suzhou Creek.

2.4.1. Water environmental protection

After Shanghai was opened as a trading port, the size of the city expanded continuously with the rise of trade, finance and industries, and the city's population increased rapidly. Consequently, unprocessed industrial wastewater, sewage and consumer waste were discharged and dumped into rivers without any regulation. Inevitably, water quality in the rivers of urban areas declined. In the 1920s, Shanghai built three urban sewage treatment plants in the north district, cast district and west district with a daily processing capacity of around 35,500 cubic meters. In the late 1920s, Zhabei Waterworks, which was originally near Hengfeng Road Bridge and took in water from Suzhou Creek, was moved to Jungong Road because of polluted water in Suzhou Creek, and began to take in water from the cleaner HUANGPU RIVER. In the late 1930s, Shanghai's industries developed rapidly, and soon the city was home to over 5,000 enterprises and almost three million residents. Untreated industrial wastewater and sewage were discharged directly into Huangpu River and its tributaries, further polluting the water After the 1940s, fecal sewage, wastewater and factory waste were discharged into rivers and creeks, causing a stench at low tides.

In the 1950s and early 1960s, Shanghai Municipal People's Government built nine wastewater and sewage treatment plants, laid sewage pipes and filled in streams, and turned Zhaojiabang Creek into a boulevard. The Municipal Government also researched sewage and wastewater treatment, launched hydrographic surveys and water quality tests of Suzhou Creek, and organized buoy tests in Changjiang River. In 1963, Huangpu River developed a foul odor. In order to control and solve these pollution problems, government authorities enhanced the use and treatment of the "three wastes”. From 1960 to 1964, the city retrieved around 578,400 tons of acid, and in 1964, the city's 14 printing and dyeing mills recycled 600.000 tons of diluted lye, and retrieved noble metals (such as gold, silver) and heavy metals (such as copper, lead, zinc and nickel) from the electroplating and printing wastewater. During this period, the main technology for treating industrial wastewater was neutralization and precipitation. Some experts proposed a pollution treatment plan of scattered processing and discharge in concentration into Changjiang River. It was also suggested that the pollution in Suzhou Creek and Huangpu River could be alleviated by tides, and water pumped and channeled from Changjiang River. In the late 1960s and early 1970s, two sewage pipelines were constructed in the southern and western districts to discharge sewage into Changjiang River Estuary, part of which was used for agricultural irrigation, thus improving water quality in Suzhou Creek and Huangpu River to some extent.

In the 1970s, a series of local environmental protection regulations and government regulations were issued for pollution control. The prevention and treatment of industrial wastewater pollution was promoted by Shanghai Industrial Waste Water Discharge Standards (Draft) and People's Republic of China Environmental Protection Law (Draft).In the 1980s, Shanghai formulated and published Shanghai Regulations on Huangpu River Upstream Water Sources Protection and relevant details of implementation. During this period, enterprises increased wastewater treatment efforts following the principle of "he who pollutes treats it", and alternate technology for treatment developed rapidly. For instance, the chemical coagulation method, electrolysis, the ion exchange method, and the countercurrent rinse-evaporation method were adopted for the treatment of heavy metal wastewater, and the activated carbon adsorption method and the ozone oxidation method began to be used. Since 1986, Shanghai has taken the lead in the execution of total quantity control of water pollutant discharge in the upper reaches of Huangpu River and implemented the discharge permit system. Emissions trading was also tried in some enterprises.

Over the past 20 years, Shanghai has progressively perfected its sewage collection and processing system, and a number of projects and plants have been completed, including the first, second and third phases of the project for convergent sewage treatment; a great number of sewage collection pipelines; and Bailonggang Sewage Disposal Plant, Zhuyuan Sewage Treatment Plant and many other suburban and town sewage treatment plants. Efforts have focused on promoting regional pollution treatment systems, pollution treatment of key drinking water source reserves, the comprehensive treatment of Taihu Lake Basin water environment, countryside pollution treatment, and sewage collection within industrial areas. Draining of wastewater into pipelines is the main method employed, in combination with renovation of pollution treatment facilities and implementation of environmental monitoring and control levels. Full-scale pollution treatment was implemented in the central urban areas, for the main rivers in the suburbs and for the Project of Cleaning 10,000 Rivers, over 20billion Yuan was invested to complete SUZHOU CREEK COMPREHENSIVE REHABILITATION PROJECT, and treat 201 black and odorous rivers and channels in the central urban areas (226 kilometers in all). Over 90 percent of the rivers in the central urban areas were deodorized, and one third of the main rivers have reached scenic water standards. Over 20,000 rivers and streams (with a total length of 17,000 kilometers) in the towns and villages of the suburban areas were dredged or treated for the collection and disposal of sewage.

By the end of 2008, Shanghai had completed the construction of about 10,000 kilometers of sewage pipelines. There are a total of so urban and town sewage processing plants, with a processing capacity of 6.72 million cubic meters per day, and disposition rate of urban and town sewage has reached 75.5 percent. Shanghai is well on the way to ending the direct discharge of consumer sewage and industrial wastewater into rivers. In order to enhance the monitoring and control of the polluting sources, governmental agencies have implemented category management systems in the main polluting industrial enterprises and sewage processing plants and installed online monitoring and measuring facilities. In 2008 the attainment rate of the wastewater discharge by enterprises was above 93 percent on average.

2.4.2. Water transportation

Thanks to HUANGPU RIVER, Suzhou Creek, and Taihu Lake, water tourism, featuring cruising boats, Yachts and liners, has become an important part of city tourism in Shanghai. Tourists are highly recommended to take the Huangpu River cruising boats and enjoy the architectural spectacle of historic buildings on the west bank and the modern high-rises at Lujiazui on the east. There are 32 different cruising boats on Huangpu River, such as Pujiang Tour No.1, Oriental Pearl, Kaffir Lily, Princess Rose and Captain No.3.During Shanghai Tourism Festival, colorful boats cruise Huangpu River, attracting millions of local citizens and tourists. Currently, the Huangpu River tourism has expanded from unitary sightseeing to business meetings, friendly get-togethers, wedding ceremonies, feasts, and salons on chartered boats. Suzhou Creek, after comprehensive improvements, welcomes tourists both from China and abroad with its clear water and pleasant environment. Apart from sightseeing by boat, there is the City Dragon Boat Race during Dragon Boat Festival every year. Tourists can also ride in a boat and appreciate the ancient riverside towns of Southern China in Zhujiajiao in Qingpu, Fengjing in Jinshan, Qibao in Minhang, Luodian in Baoshan, or Cangqiao in Songjiang, which gives them a feeling of floating in a beautiful Chinese painting DIANSHAN LAKE is an ideal place for sailing, boardsailing, rowing and canoeing. Tourists enjoy a wide range of choices on the lake: they can go dragon boat racing, sailing, boardsailing, rowing, canoeing, water-skiing, etc.; they can also enjoy themselves at the lakeside resort. The man-made beaches such as Bihai Jinsha Beach (Blue Sea and Golden Beach) in Fengxian and Jinshan City Beach in Jinshan are ideal for a summer vacation. The newly developed cruise tours also attract great attention. In 2008, SHANGHAI PORT INTERNATIONAL CRUISE TERMINAL by Huangpu River took on a completely new appearance, attracting 150,000 visitors with over 60 luxury liners. Representative offices are set up in Shanghai to deal with international cruise lines like Carnival Corporation, Star Cruises and Royal Caribbean.

2.5. Site Analysis

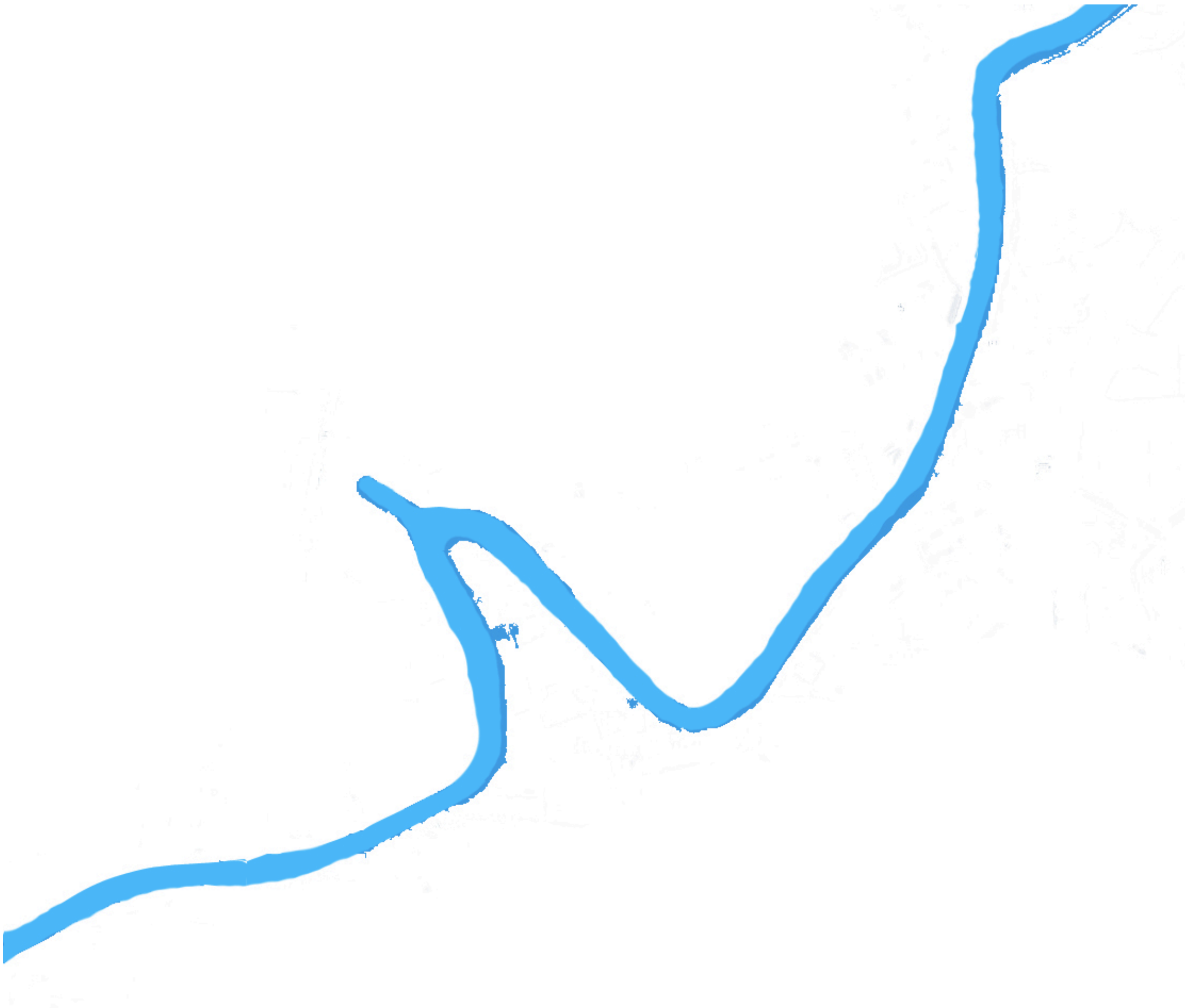


Figure 2-12: Suzhou Creek

The basis of the selection of the site is on Suzhou Creek. As the most important tributary of Huangpu River, and an important inland waterway in Shanghai, Wusong River (Suzhou Creek), originates from Guajingkou of Taihu Lake, and runs through the counties of Wujiang, Wuxian, Kunshan in Jiangsu Province, then crosses nine districts of Shanghai (Qingpu, Minhang, Jiading, Changning, Putuo, Zhabei, Jing'an, Huangpu, and Hongkou), and finally flows into Huangpu River at Waibaidu Bridge. With a total length of 125 kilometers, Wusong River runs 53.5 kilometers into Shanghai, including 16.7 kilometers from Beixinjing to Waibaidu Bridge in the old urban district. With a width of 40 to 80 meters and a depth of 2 to 8meters, it has a navigation capability of 100 tons.

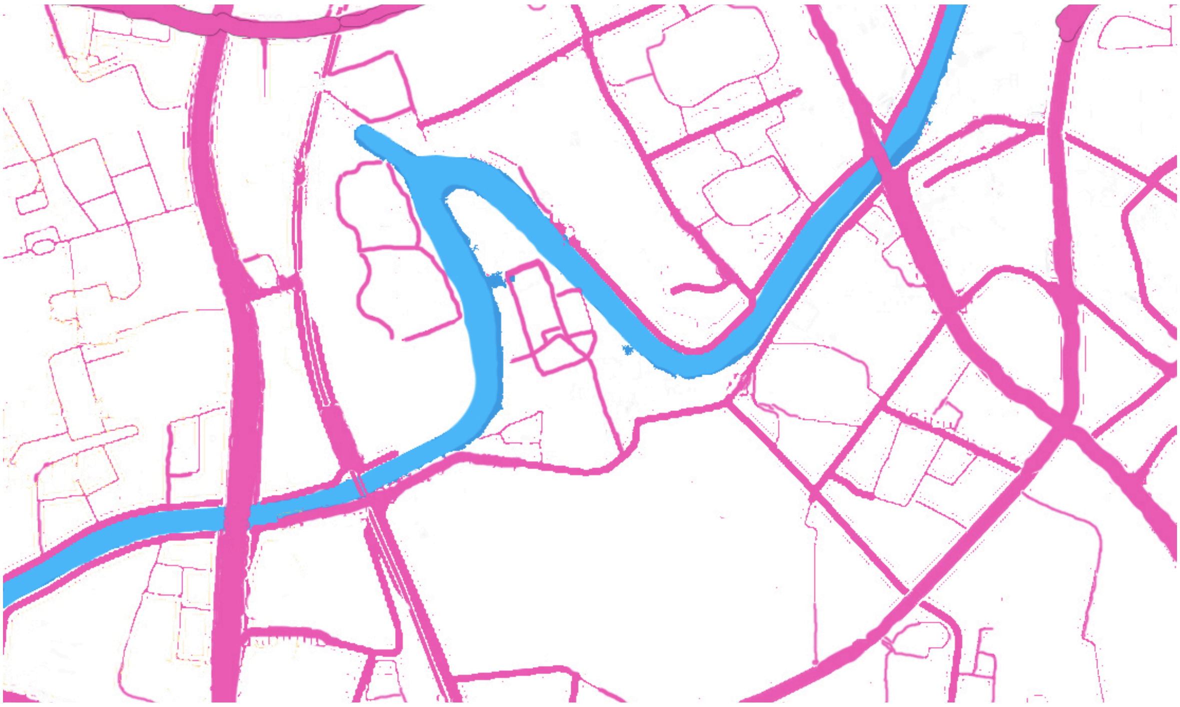


Figure 2-13: Streets

The area is a crowded area because by terms of the number of cars moving because of the existence of some important roads in the area and bridges over the Suzhou Creek.

Figure 2-14: Main Roads

Figure 2-15: Railway

The railway is one of the important features of the area beside the subway system.

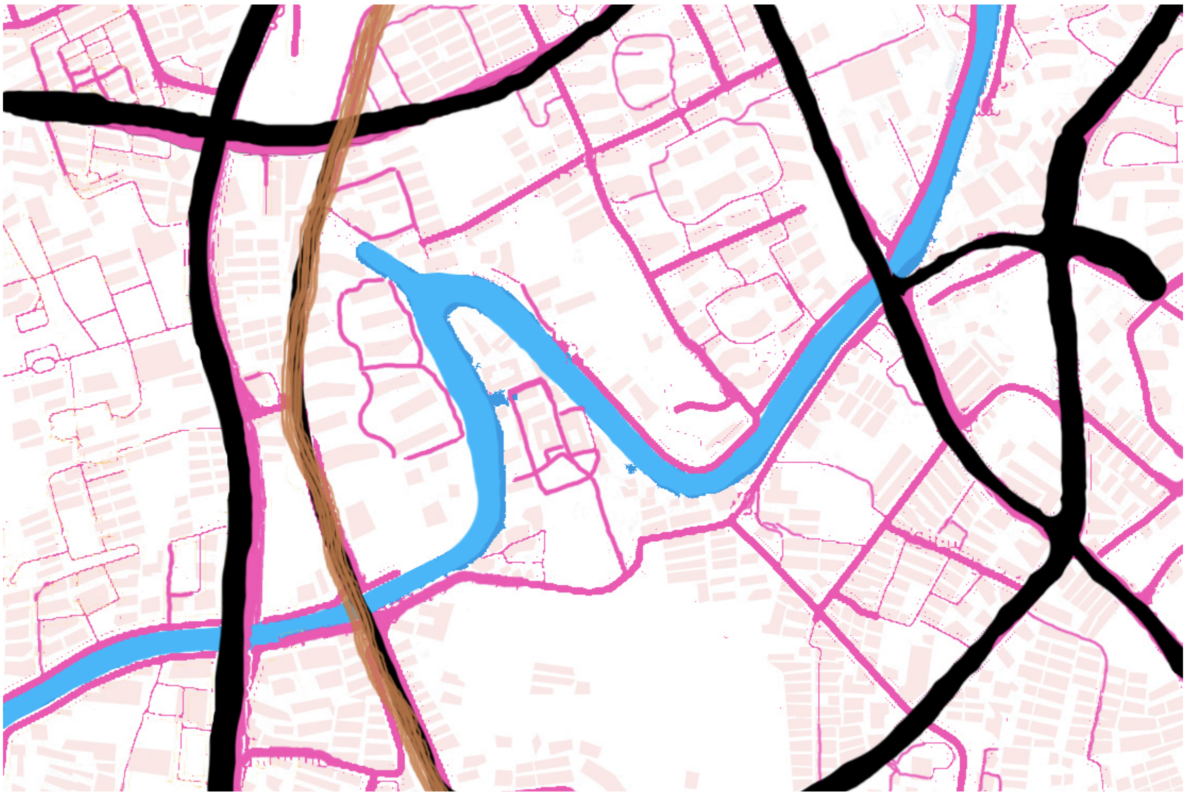


Figure 2-16: Buildings

The area above is occupied by lots of buildings mostly residential, mainly Medium-rise to high-rise depending on the zone and some offices because of the Economical Zone around the Zhongshan Park.

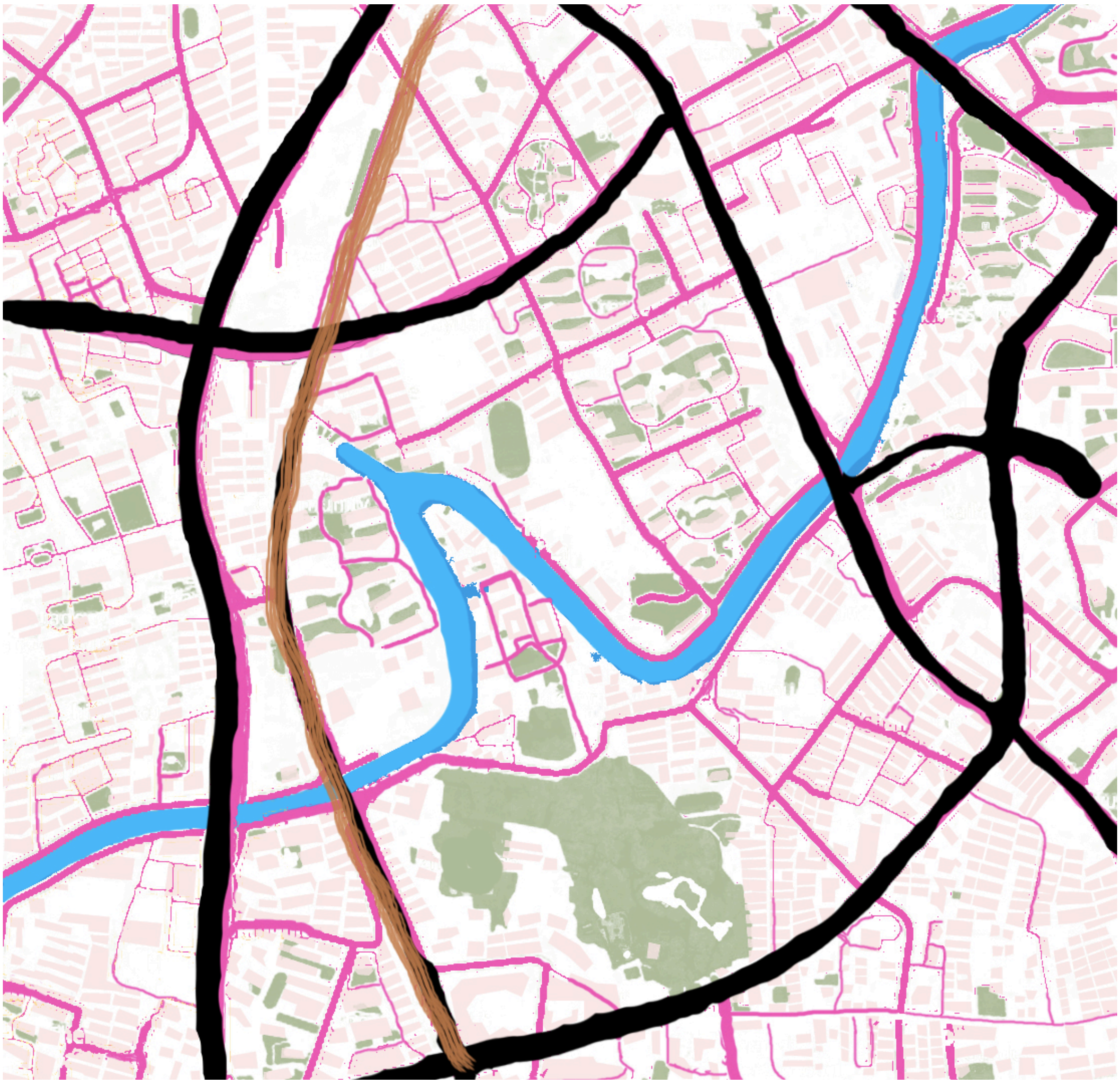


Figure 2-17: Green Areas

The Zhongshan Park is the main green area around our site. It is a large size botanic park with some cultural, historical features inside.

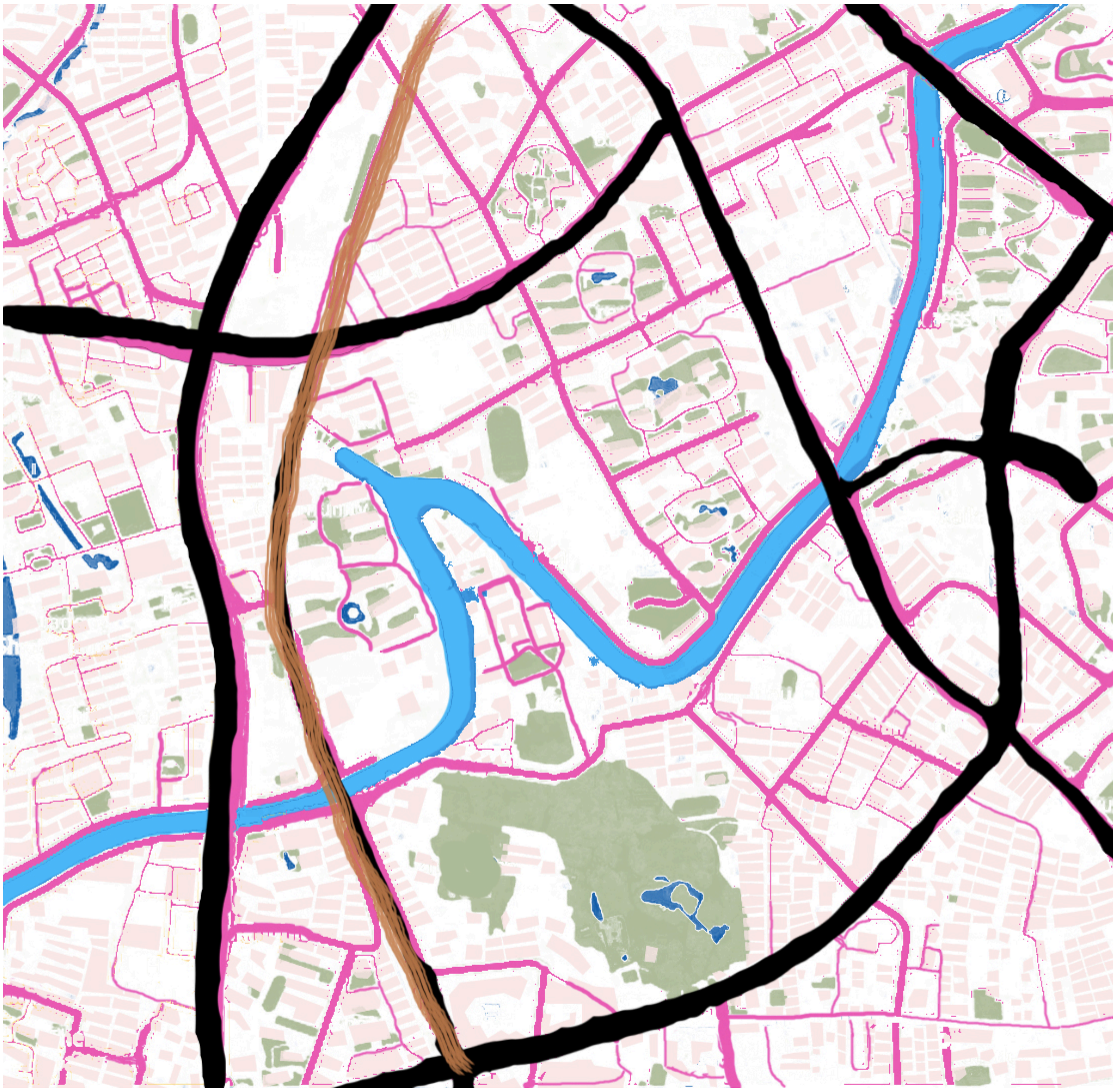


Figure 2-21: Water

The main resource of water in the site is the Suzhou creek, which plays a critical role in the area's environment. In addition to the river, there are also some ponds and pools inside the Zhongshan Park and the residences in the site nearby.

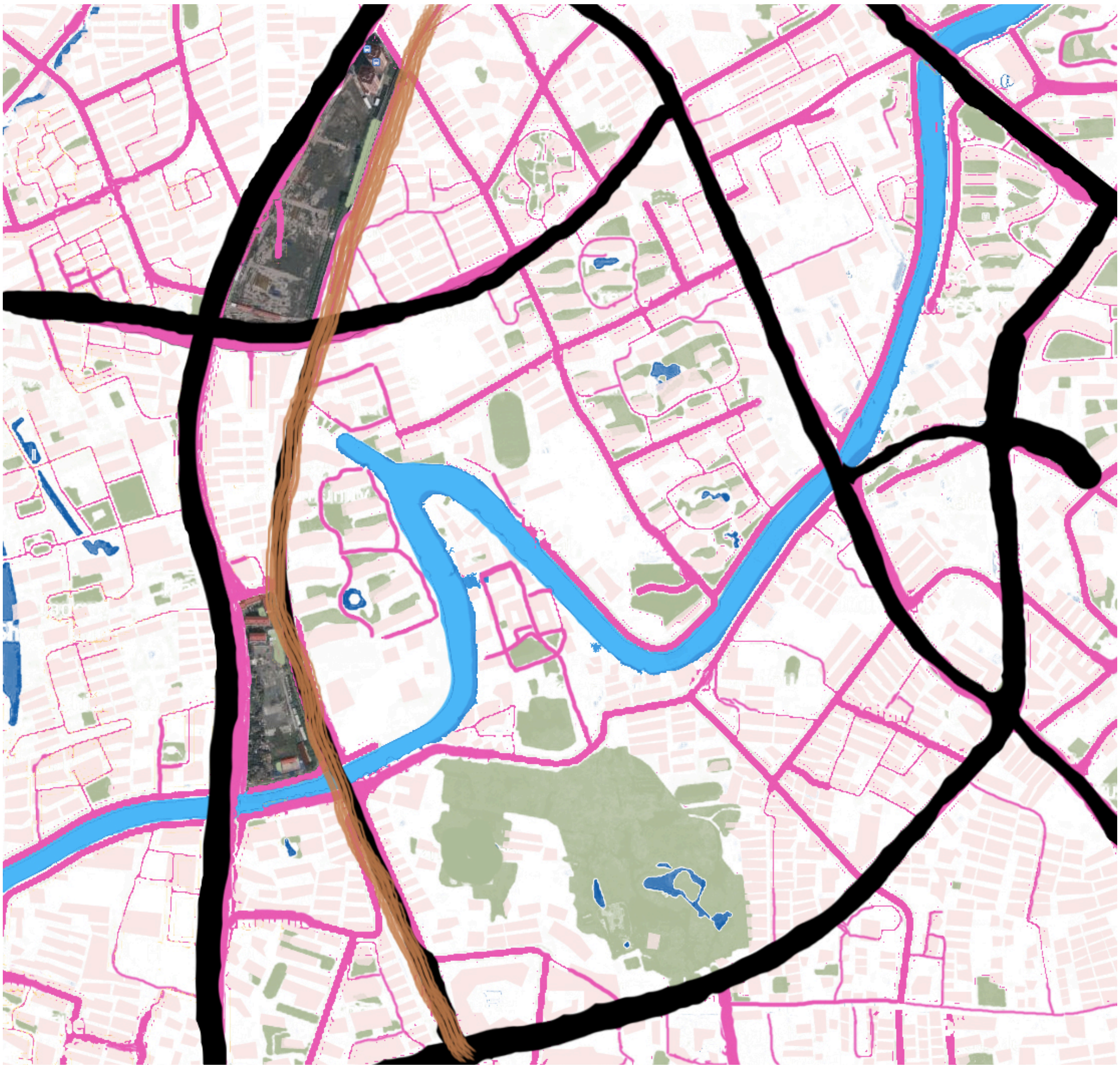


Figure 2-18: Undeveloped Areas

Undeveloped areas above are mainly the areas around the railway that they do have chaotic patterns for the few buildings inside, but they are likely to be developed in the near future.

Figure 2-19: Undeveloped Residential Areas

This area above is next to the railway, inside the undeveloped areas but with some residential buildings inside.

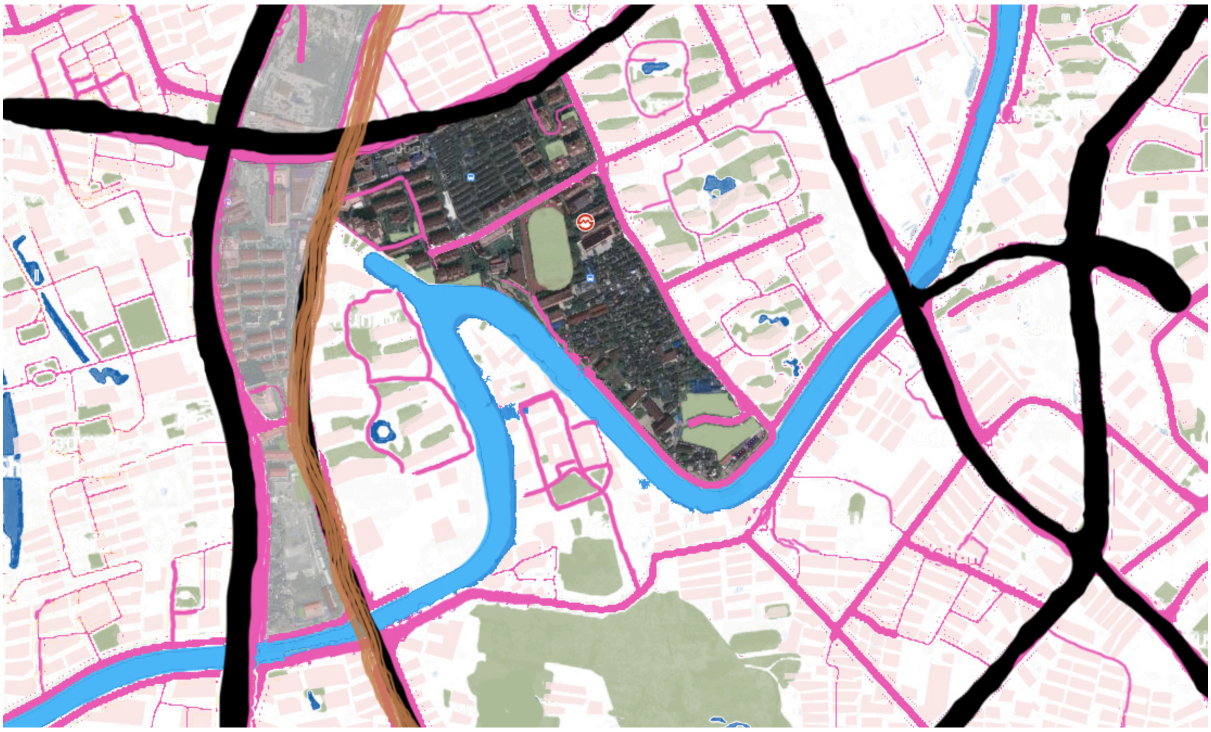


Figure 2-20: Dense Low-Rise Residential Areas

Low-rise buildings are inside the area above, mainly residential. The area above looks more historical with the old pattern of the city than the areas around.

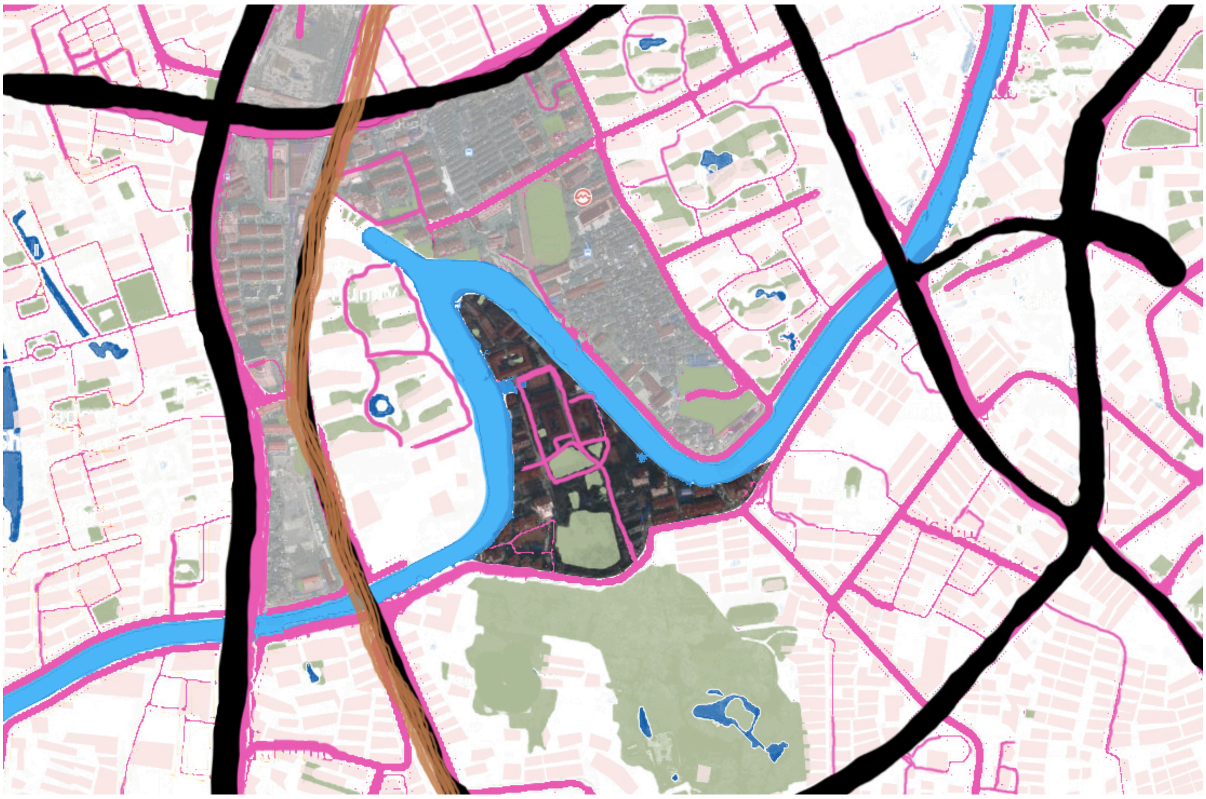


Figure 2-21: Chosen Site

Figure 2-22: Dense Medium-Rise Residential Areas

The zone above is mainly occupied with medium-rise residential buildings.

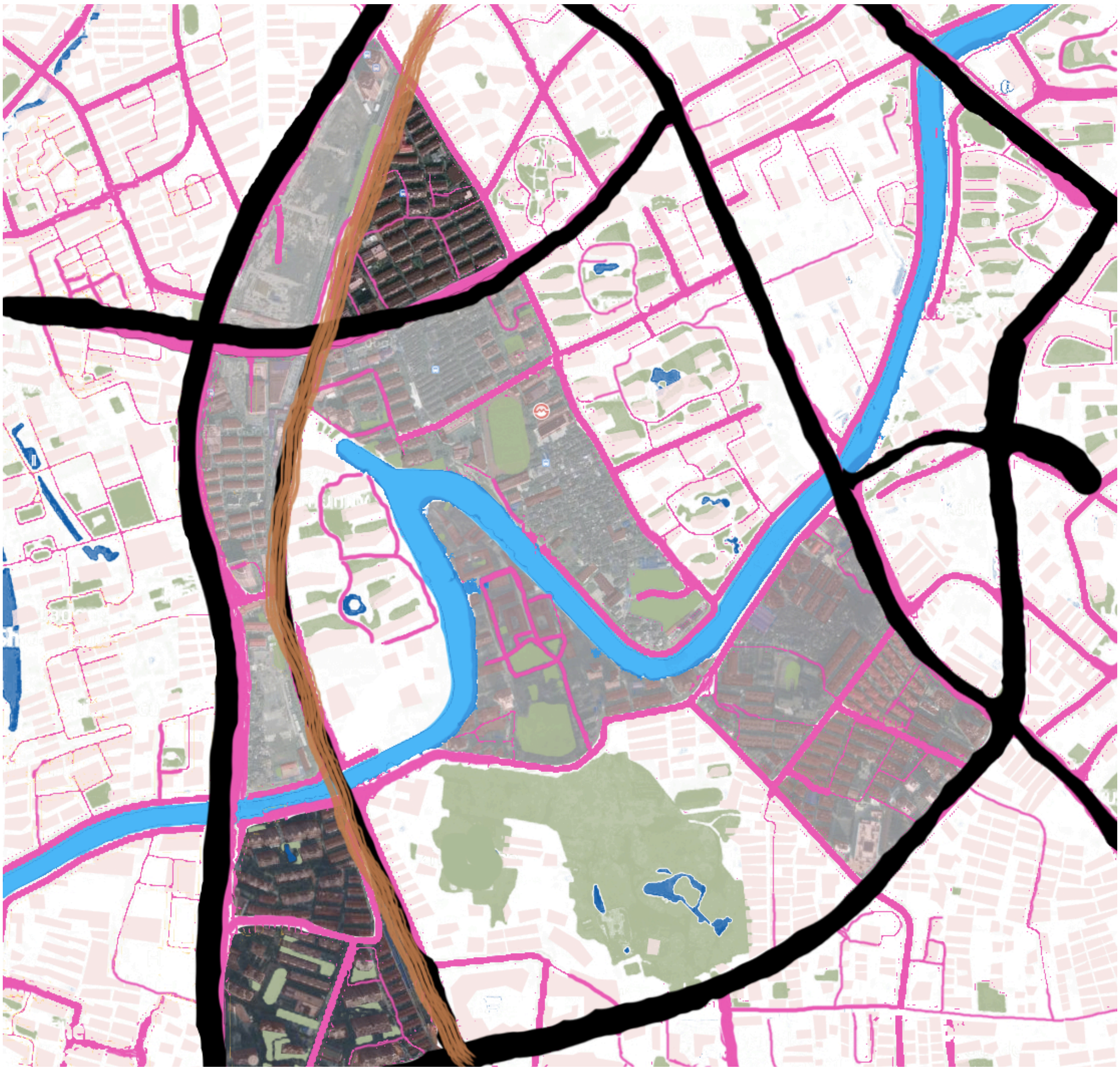


Figure 2-23: Dense Medium-High-Rise Buildings

The zone above is mainly occupied with medium-rise to high-rise residential buildings.

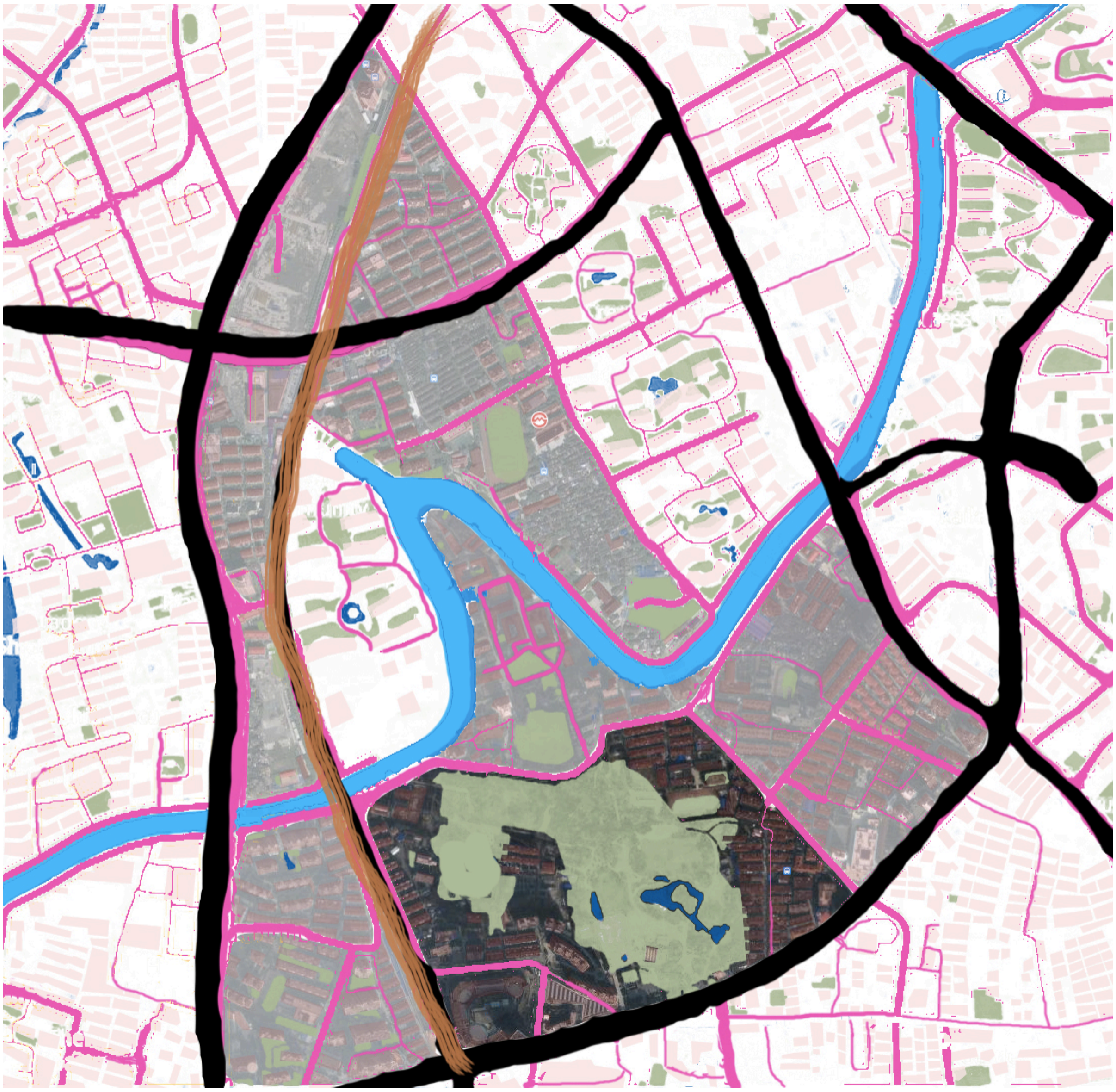


Figure 2-24: Zhongshan Park Business Zone

The largest zone around our site which is famous for the Zhongshan Park and the business areas around, including a big shopping mall called "Cloud Nine" and a very high hotel attached to it in the south west part and some businesses in the east part including shopping, hotel and business, also some residential high-rise buildings. The Subway is passing this area and the stop is also called the same as the park to show the importance of the park.

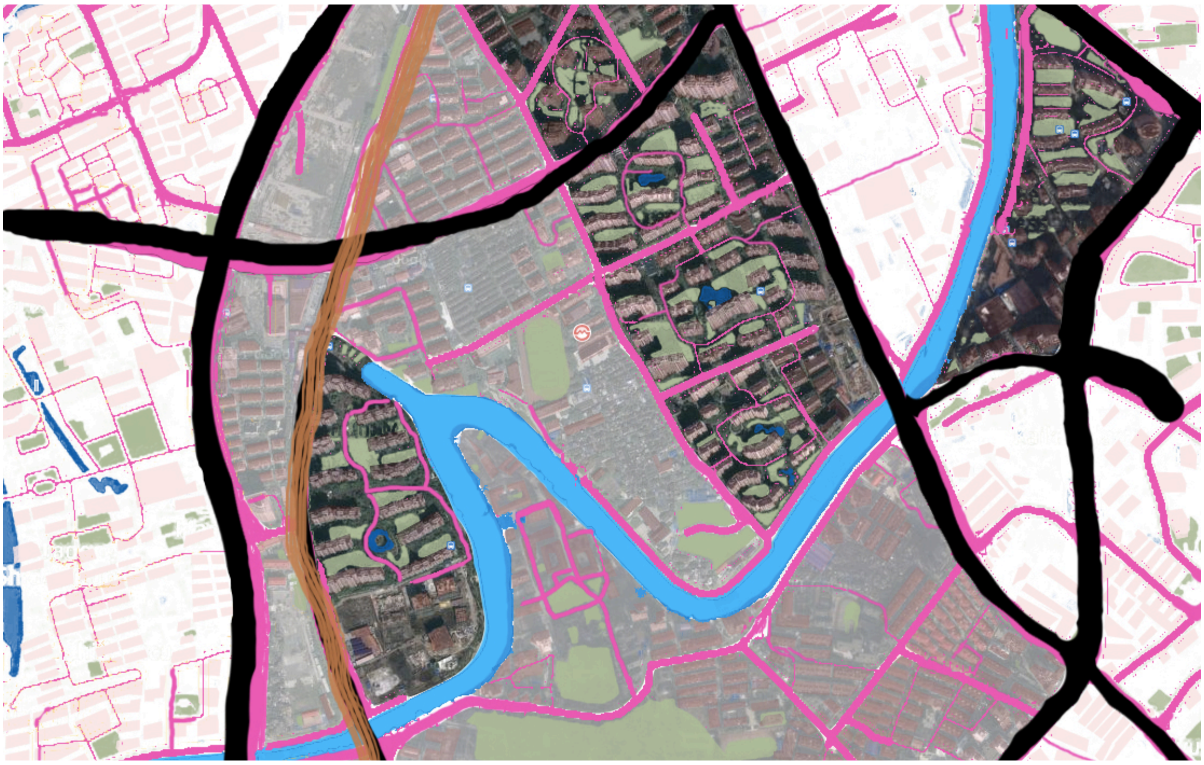


Figure 2-25: Dense High-Rise Residential Areas

The zone above is mainly occupied with high-rise residential buildings mainly following the same shape, size and orientation.

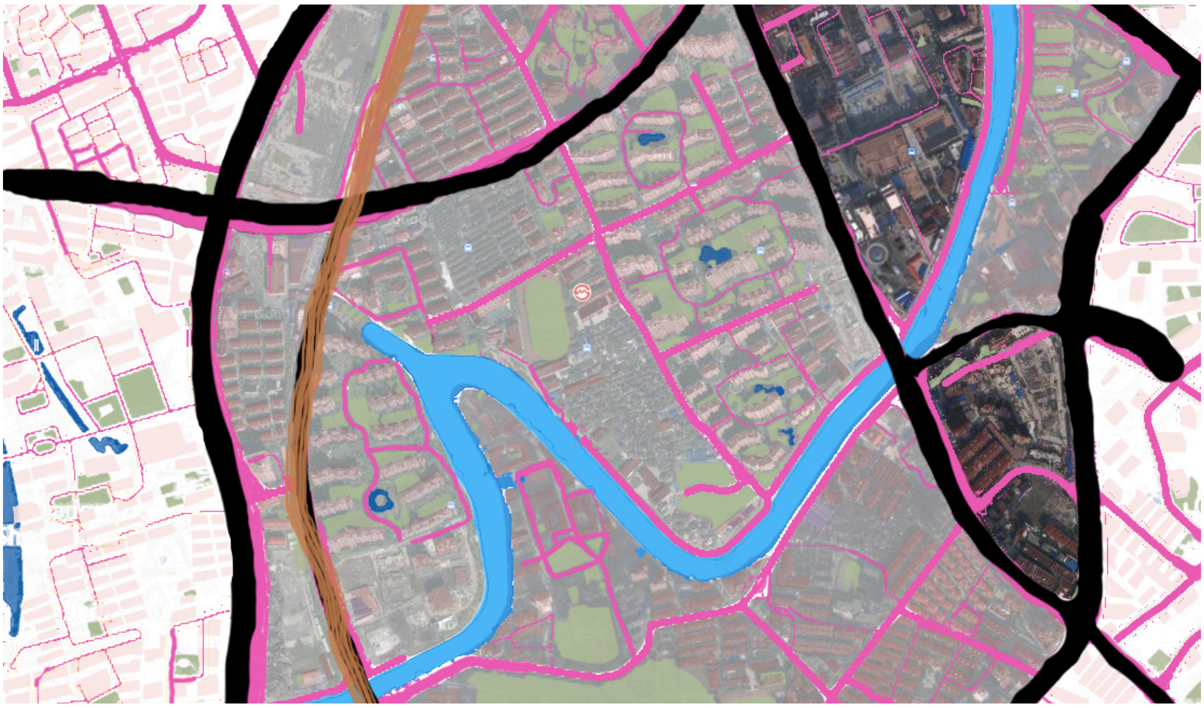


Figure 2-26: Mixed Use Area

The zone above is mainly occupied with mixed-use buildings including some old factories, small businesses and small houses.

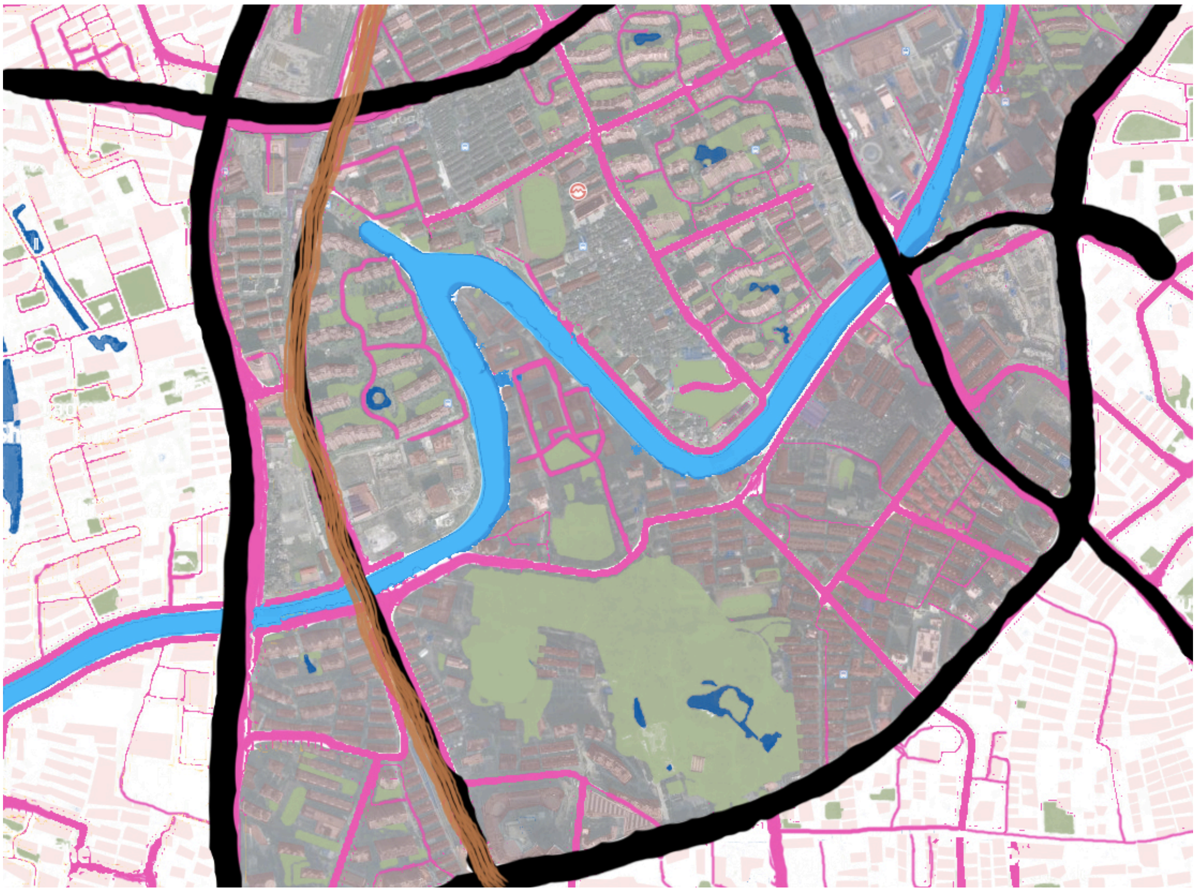


Figure 2-27: Whole Area Map

Figure 2-28: Nolli Map of the Site

2.5.1. SWOT Analysis

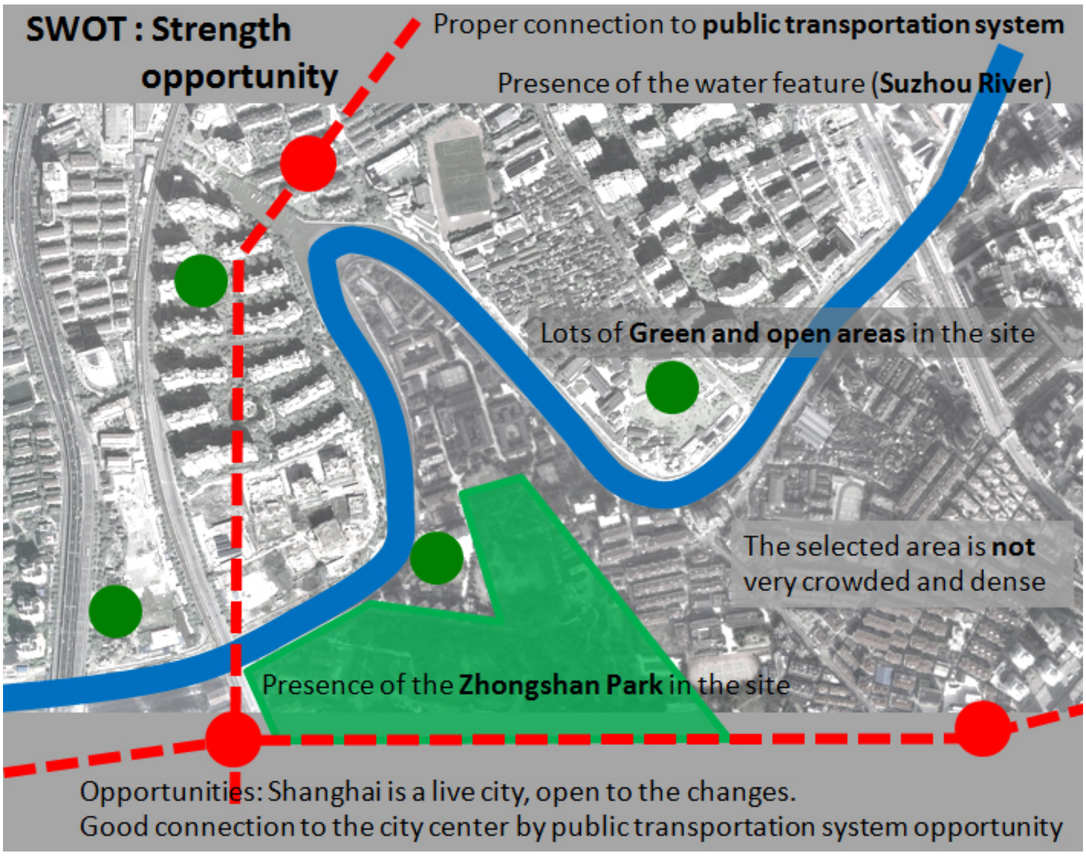


Figure 2-29: SWOT Analysis, Strength and Opportunity

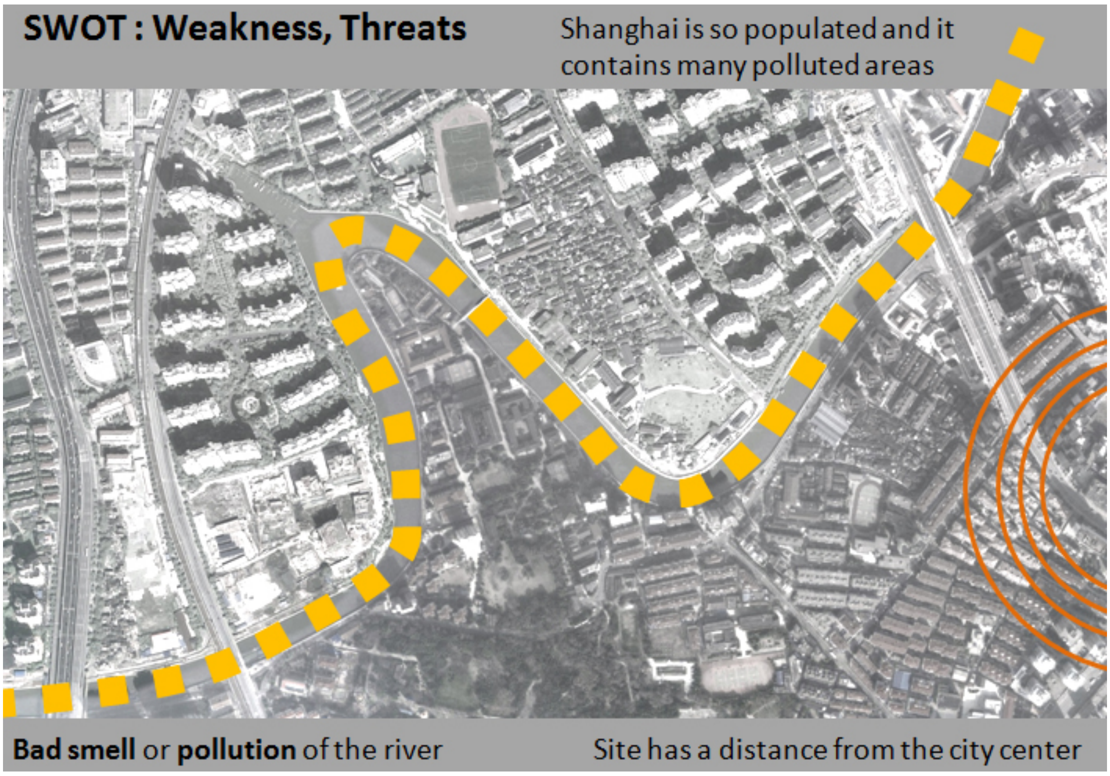


Figure 2-30: SWOT Analysis, Weakness and Threat

2.5.2. Urban Design

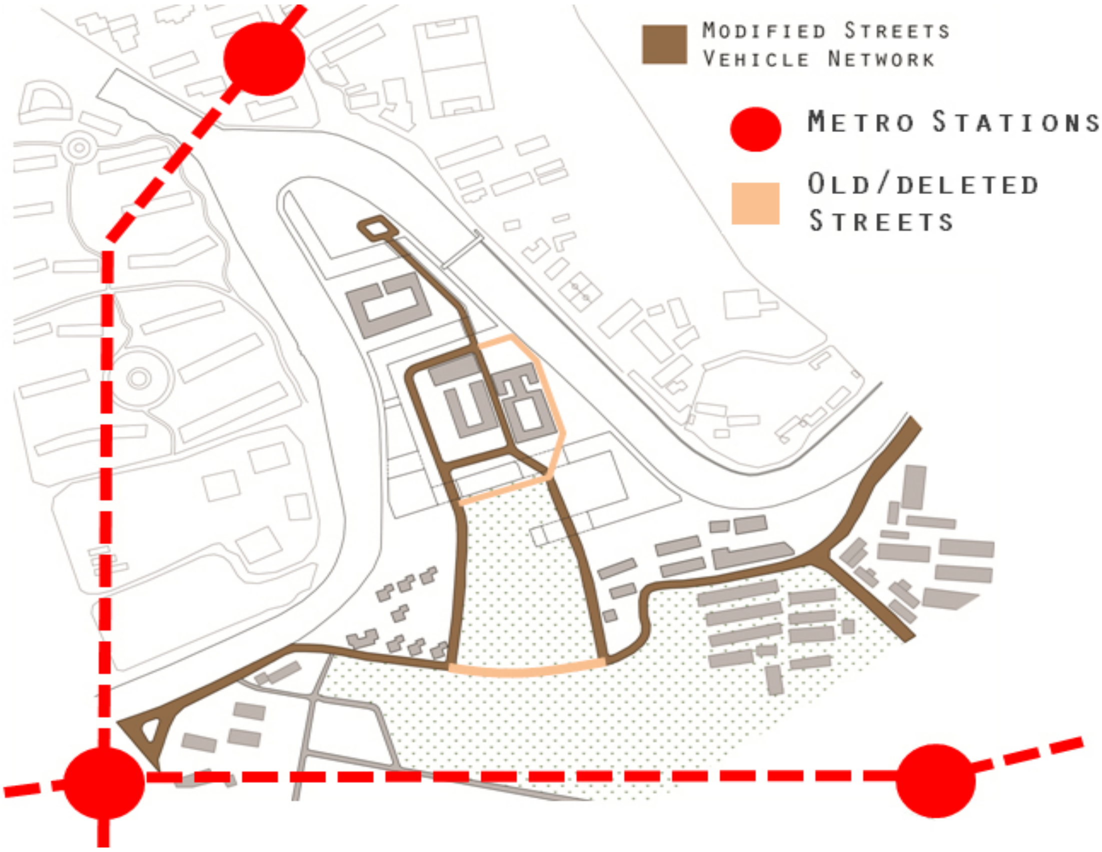


Figure 2-31: Urban Design, Modified Vehicle Network

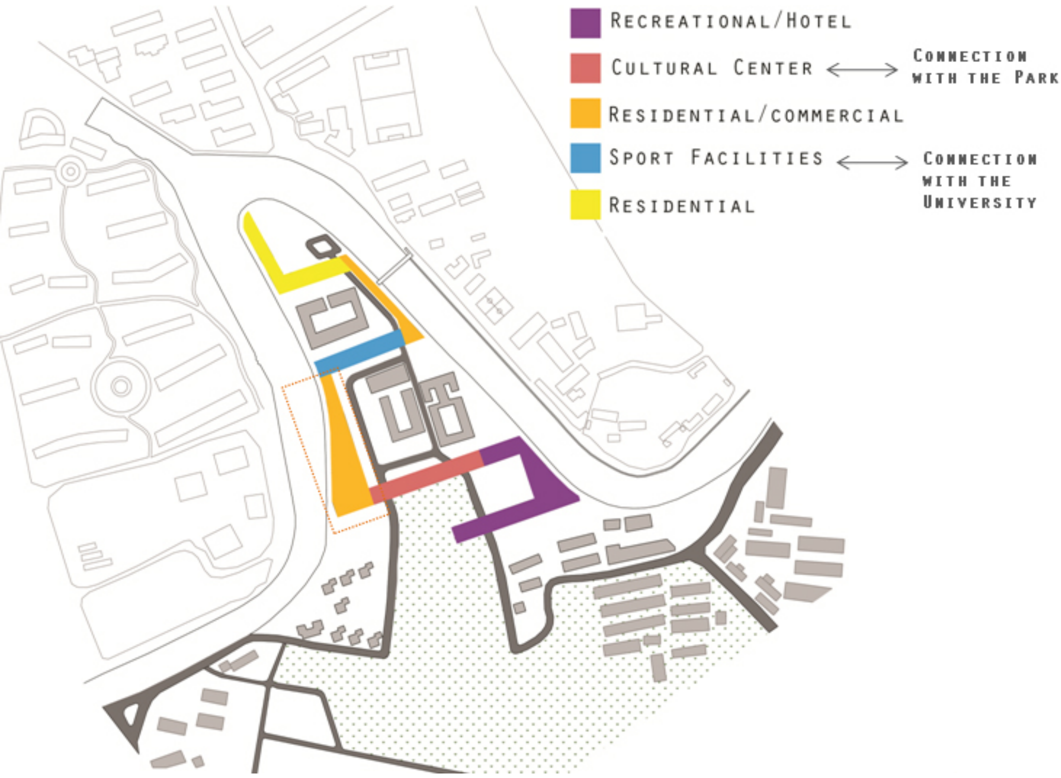


Figure 2-32: Proposed Functions in the Site

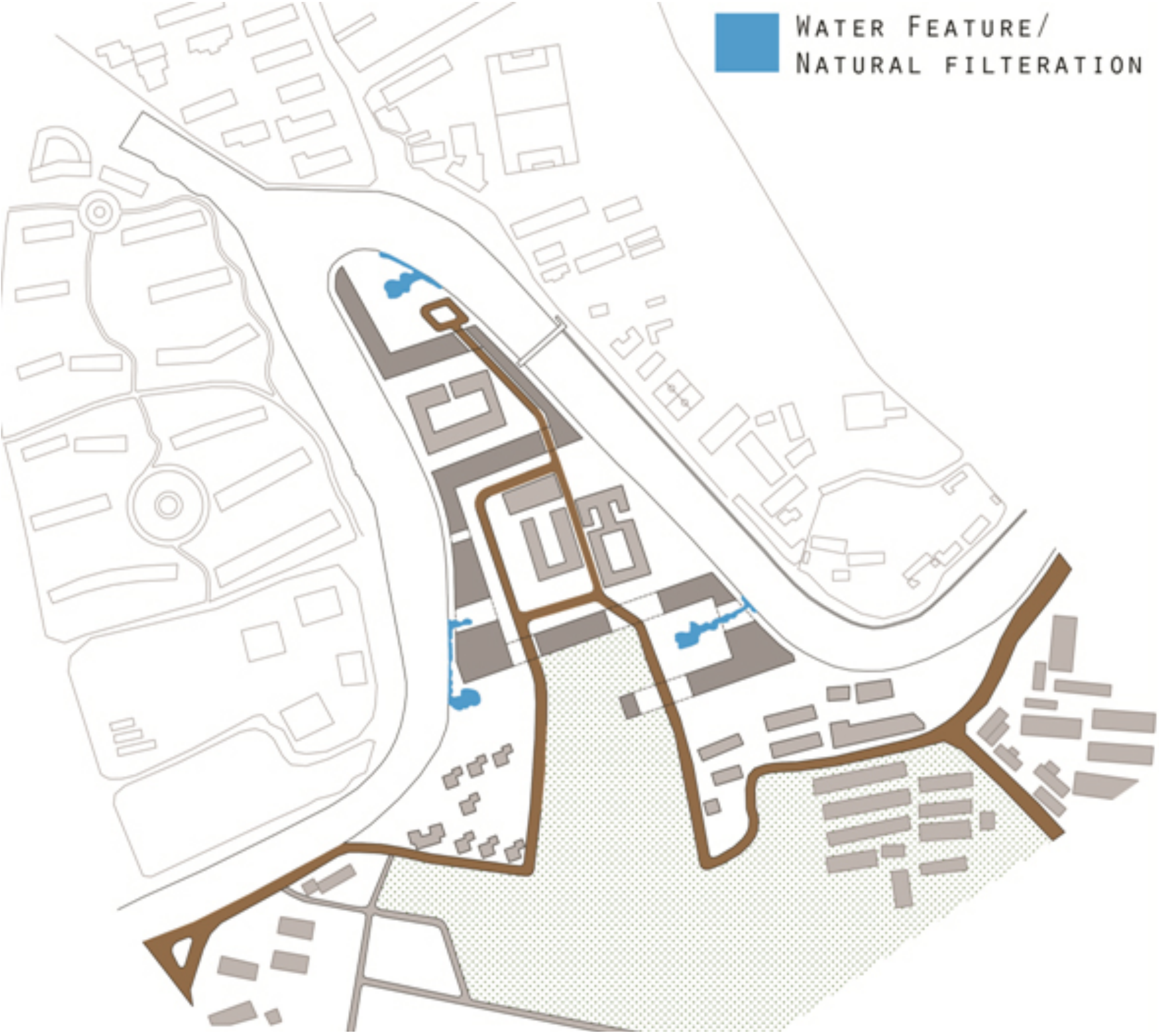


Figure 2-33: Proposed Water Features

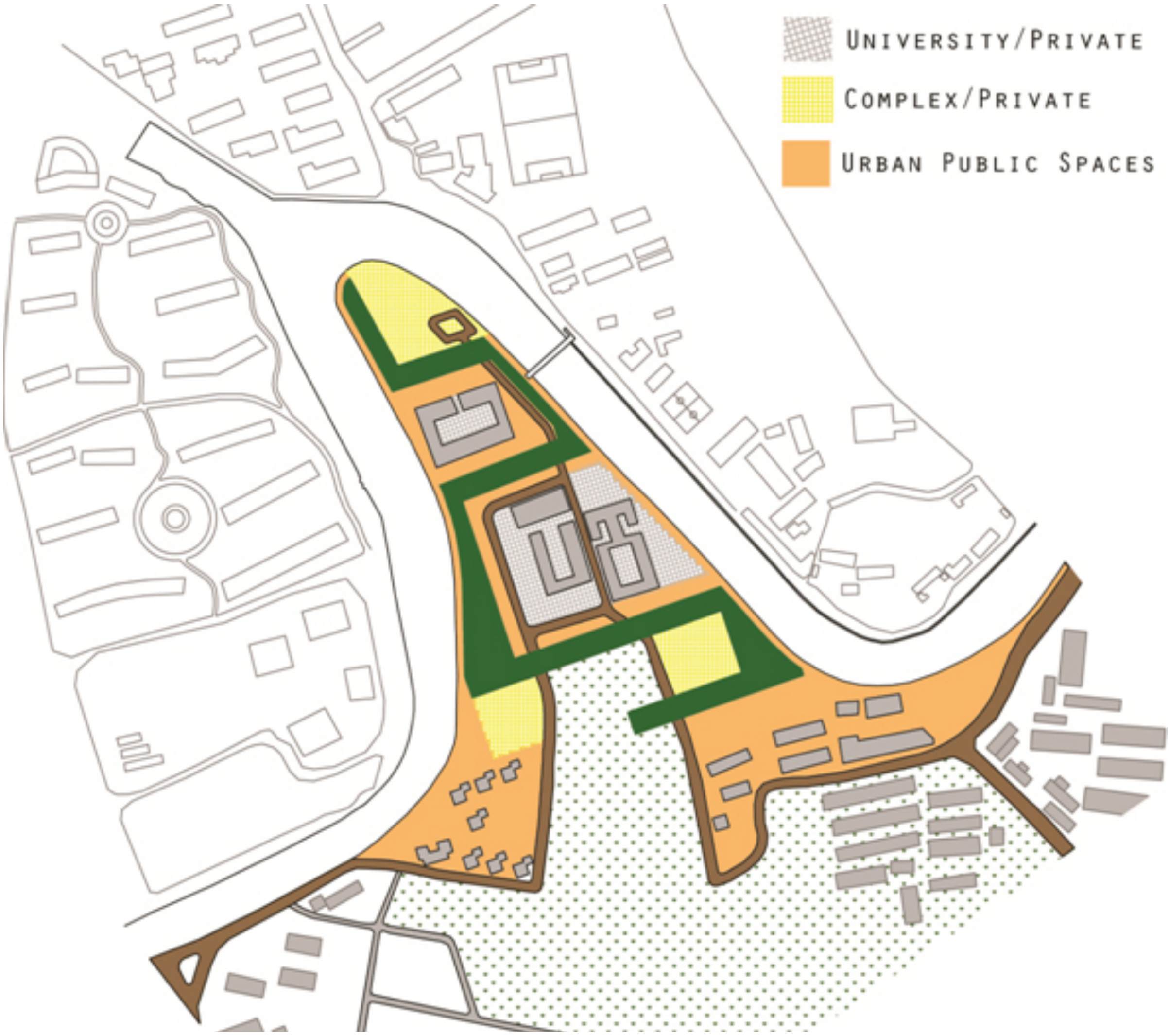


Figure 2-34: Private and Public Areas

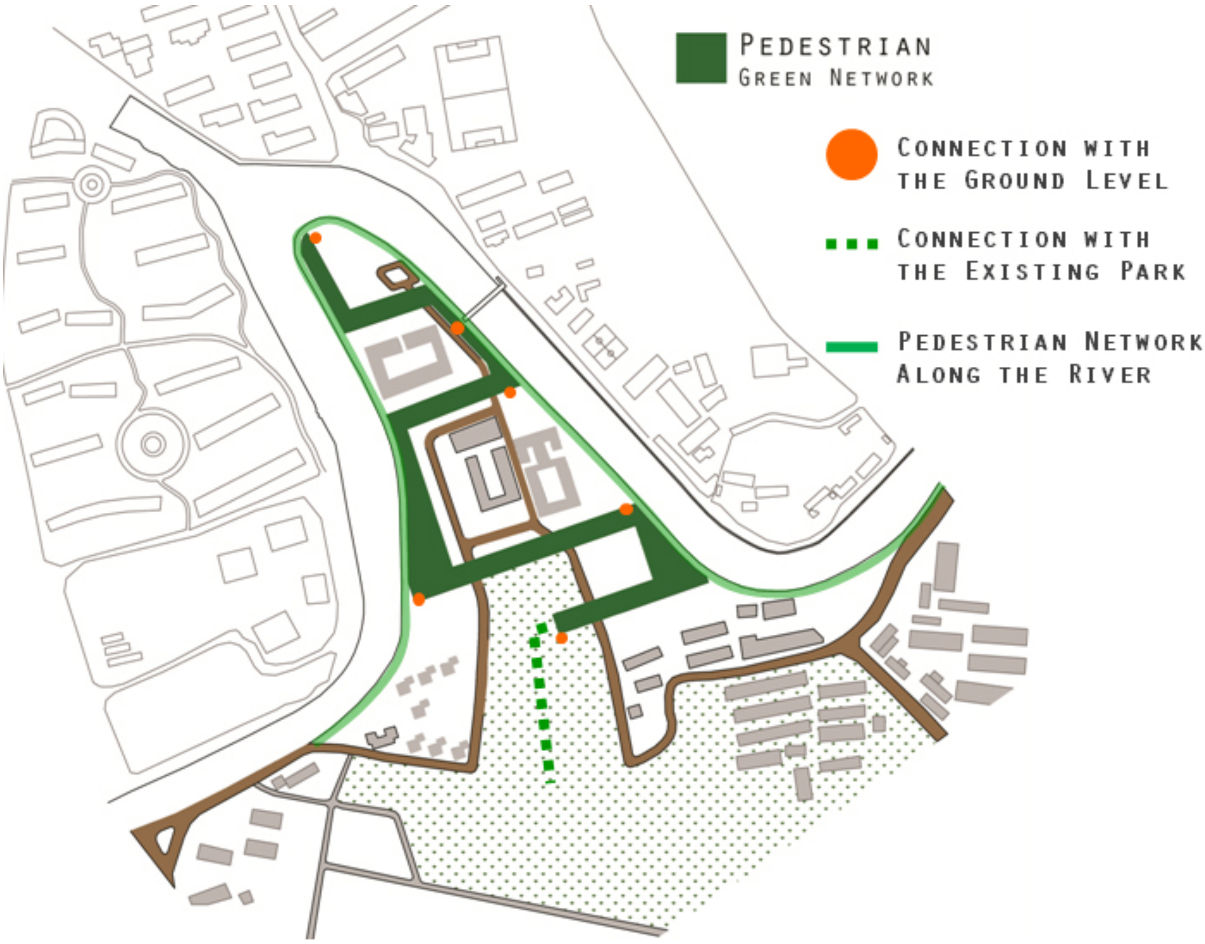


Figure 2-35: Connections

2.6. Case Studies

2.6.1. Leamouth Peninsula

Because of the unique shape of the land, in many similar case studies the main concept was taken from the shape of the site. The project has an interesting dynamic design. Also, there is a good combination of the built areas and open areas in the site, providing good connection to the city, and changing the area in order not to be isolated.

Figure 2-36: Leamouth Peninsula Study Case

Figure 2-37: Leamouth Peninsula Study Case

2.6.2. Malacca Malaysia

Studying several final theses in "Malacca Malaysia" because of the similarities between that site and ours, we classified different approaches to the project including:

- The weather, climate and sustainability as the main concepts reaching to the best orientation and volume of the buildings
- Taking the concept from the traditional buildings
- Bringing the natural water feature inside the site
- Paying attention to connections and separation of Built areas and open spaces

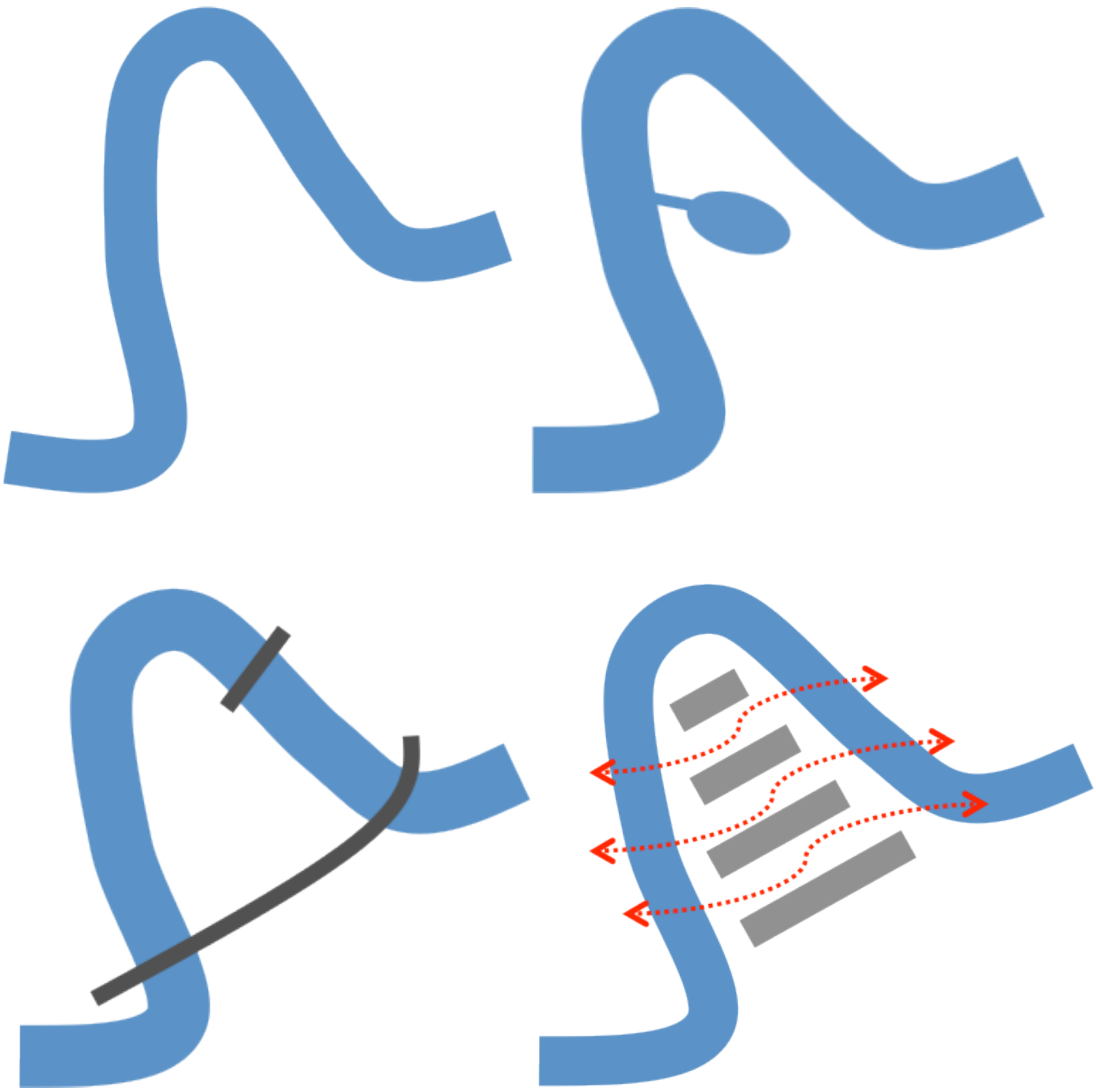


Figure 2-38: Different Case Studies' Concepts


Concept

3. Concept

3.1. Approach to the options for the concept

Figure 3-1: Keywords to the Concept

According to the requirements of the project we came with several ideas:

- Flexible built modular elements along the river, keeping the existing buildings and attaining the opportunity to build the prototype anywhere along the river.
- To build over the river, not to touch the existing buildings along the river.
- To clean and bring the water inside our peninsula.
- Following the shape of the river for the new buildings.

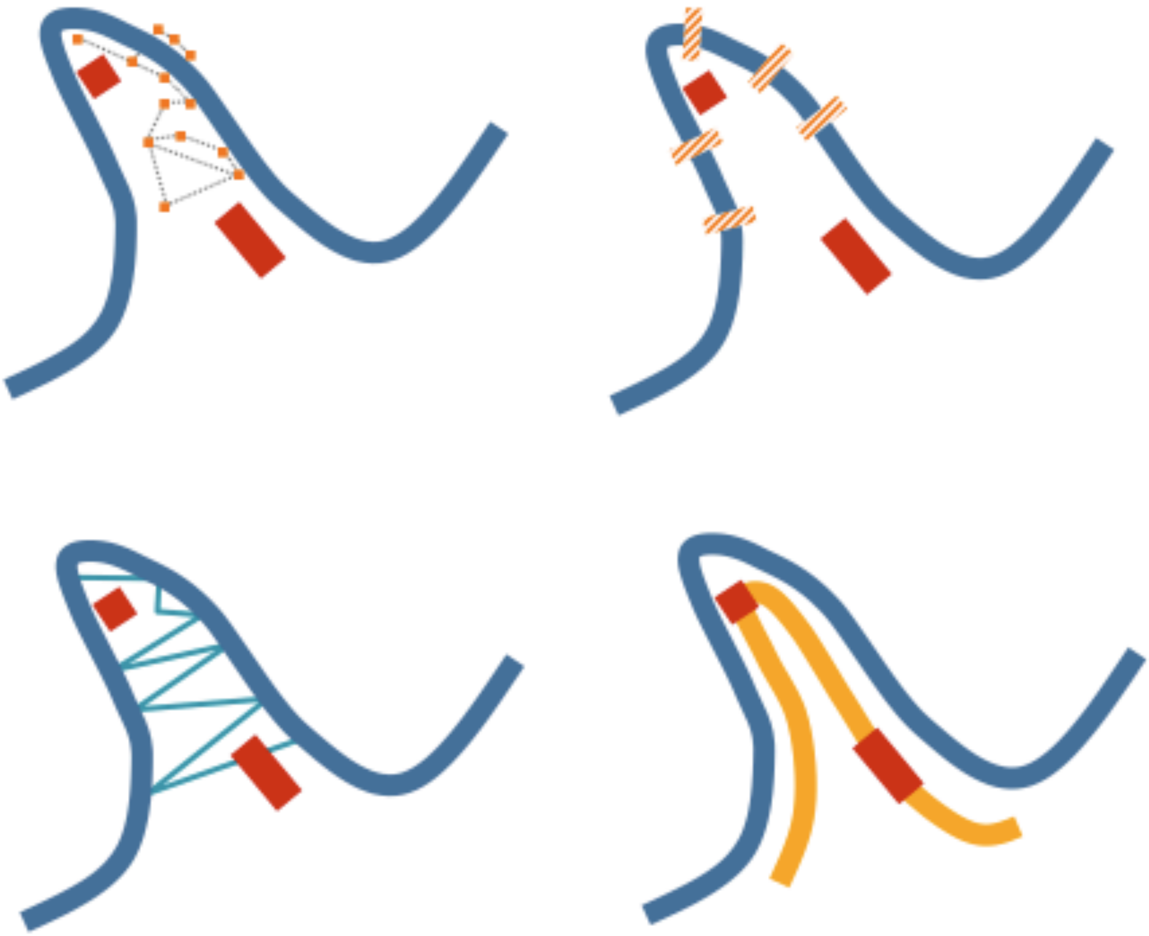


Figure 3-2: First Approach to the Concept

3.2. Main Concept

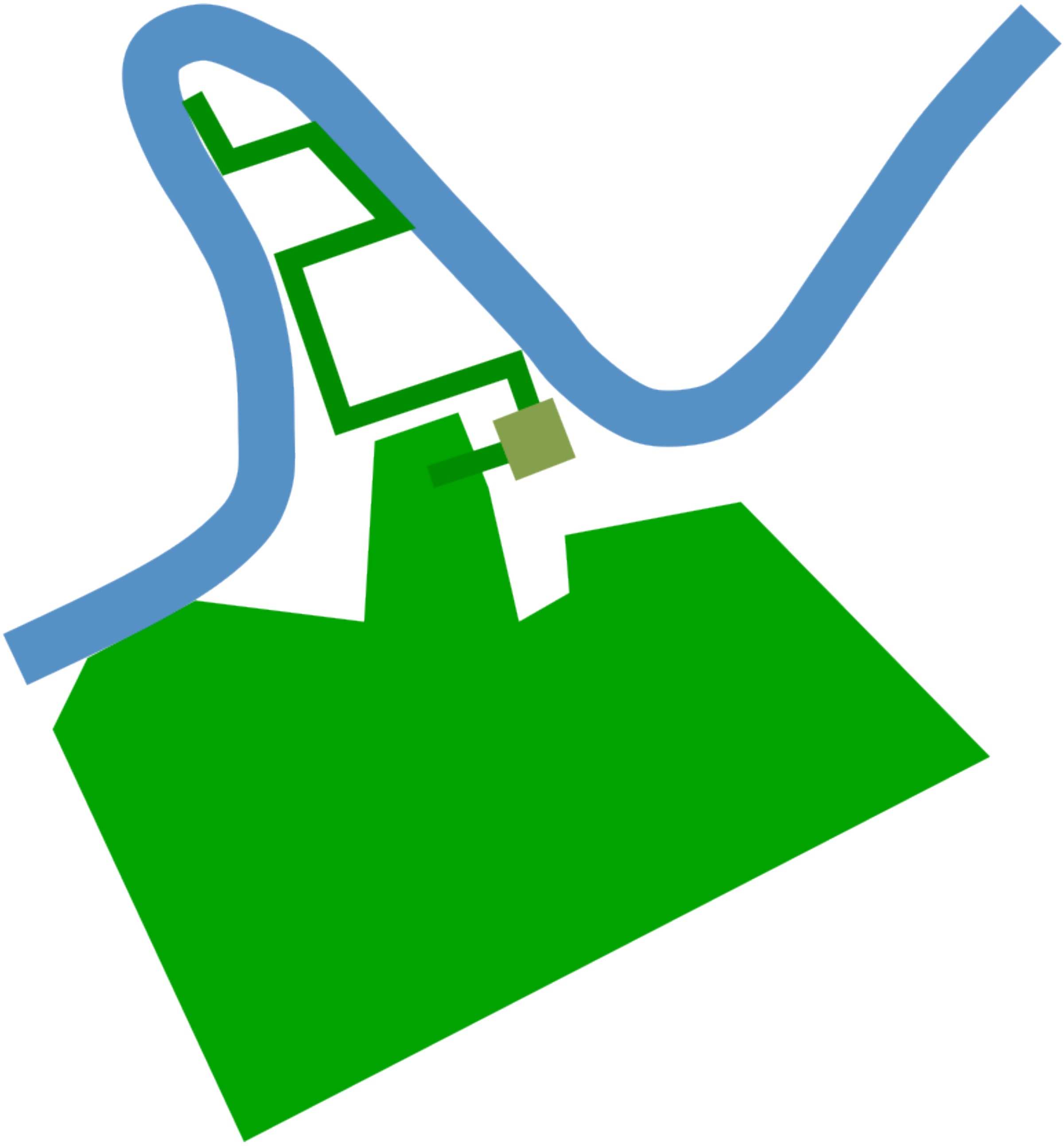


Figure 3-3: Concept

After choosing the location of our site within shanghai borders along Suzhou River, outside dense city center of Shanghai (having in mind that Shanghai is a mono-center city which tends to become a poly-center one), we came up with a flexible, technologic idea, which leads us to Re-think not only about our site but also Shanghai.

In this idea we do not traditionally divide the site to built and non-built areas, but we see it containing different layers of functions which are deeply connected vertically and horizontally.

Filtering water Layer, Vehicle circulation Layer and Green pedestrian zone which all pass through the built commercial, residential buildings, while keeping the historical and important buildings of the site and going around them. At the same time, creating a new generation of Green space in a bigger scale than ordinary single green roofs, giving the opportunity

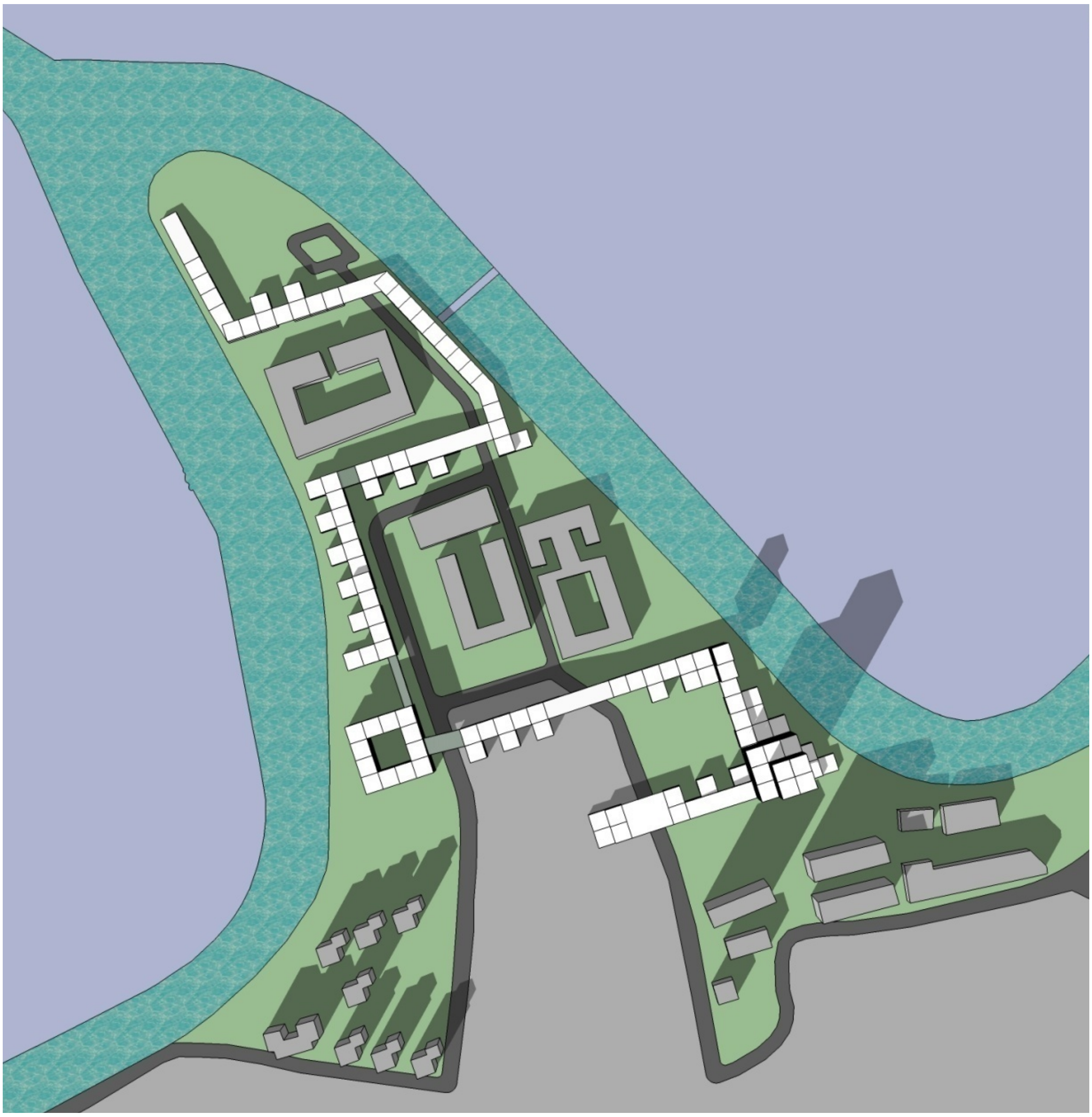


Figure 3-4: Concept

3.3. Analyzing the Concept

3.3.1. 3D City

In common city-planning strategies, a city is divided into built spaces and open areas (including: roads, pedestrian pathways and green areas). Therefore, when a city planner wants to develop a part of a city, he should decide about the function, quality and proportions of the built spaces and the open areas.

On the contrary, in latter strategies with more complex city planning concepts, buildings, green areas, roads and pedestrian pathways cross each other and make a more linked urban space. Consequently, the planners and designers face fewer limitations for any further developments.

Our selected site is surrounded by Suzhou Creek and from the south direction it is confined to an existing park, therefore, it can be considered as a peninsula. There are some important educational buildings to keep in the site and also some existing roads. For further development of the site, we re-arranged the vehicle road to gain better circulation within the site.

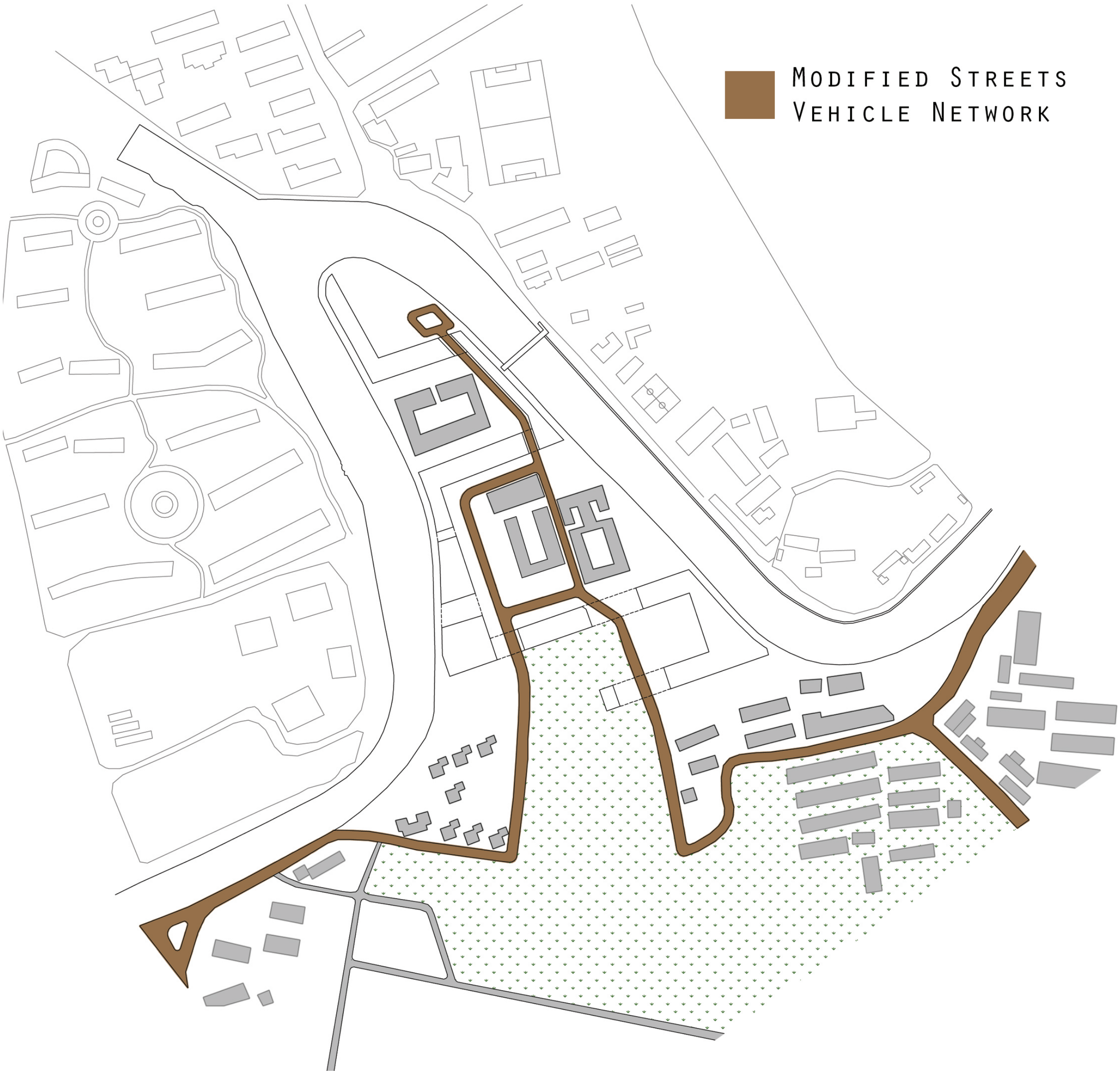


Figure 3-5: Modified Streets

In order to fulfill the requirements of the competition to "*design a visionary proposal for a sustainable architectural intervention*" while occupying 150,000 square meters of land containing residential, office, and commercial functions, we decided to have a range of multifunctional building complexes with a new urban pattern mainly following the nature around the site with the goal of expanding and connecting the green areas. The arrangement of the buildings is in a way to follow the borders of the creek while passing over the existing roads. Whenever the building is facing to the creek the view is more private especially in those areas with residential function, considering that Chinese people care about privacy in their houses, while it is more public when facing streets.

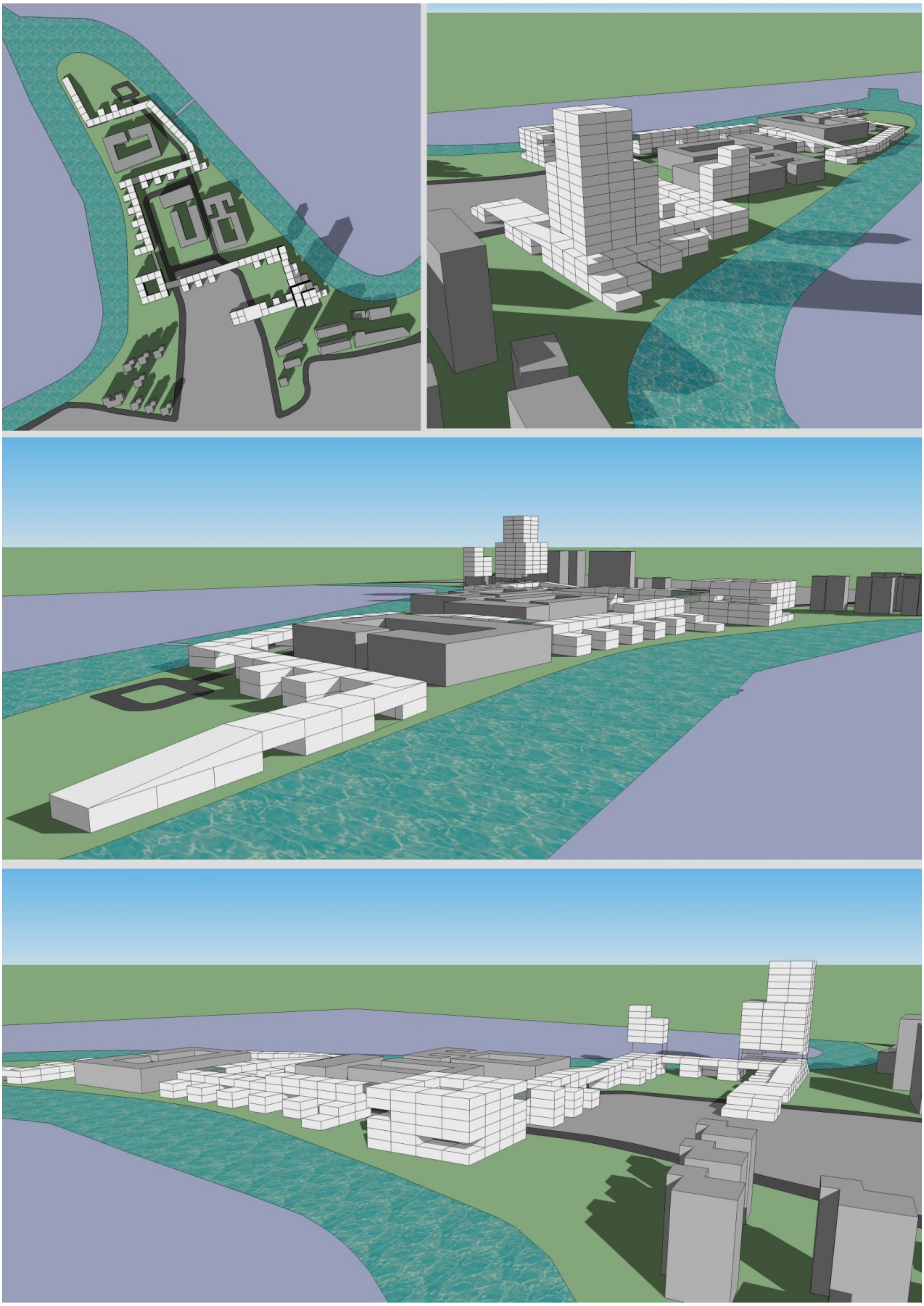


Figure 3-6: Primary Renders

3.3.2. Green Pathways: Energy, Landscape and Connection

In accordance with the requirements of the competition to maximize the Green areas in the site within our design, considering the existence of a park in the south of our selected site, we created a Green pedestrian pathway at the roof of the buildings to connect the surrounding nature to the existing park. As a result, we also reach the separation of the pedestrian pathway from the vehicle road which is a safe and lovable for the users.

Having in mind that in most projects with separated pedestrian pathways in the upper levels the final result is not desirable for the users as they prefer to choose the most convenient way to pass from one point to another. Consequently the only-pedestrian pathways become abandoned and empty of people. Therefore, we mixed the functions at the roof level to make people who are already using the upper levels use this opportunity as an alternative one. It is true that people on the ground would chose the river side pathway and people who are already in the upper levels of the buildings especially the roof will chose the designed green pathway.

Moreover, using this concept we create an extra function to the roofs of the buildings to promote the green areas within the site in addition to providing sustainability solutions using the "Green roof concept". Therefore, our green pleasant pathway functions as a thermal insulation for the roof.

Connecting the buildings with this green roof that sometimes passes through tall buildings of the site makes a homogenous building complex in accordance with the whole environment. There are vertical connections to the Green pathway for the public, separated from the private circulations.

3.3.3. Water Treatment

One of our concentrations in the project is water treatment. Shanghai had serious problems in the past 30 years about water pollution mainly in the creek because of the industries and factories along the creek also the transportation using the creek. At that time people were suffering from the smell as well as the disturbing view of a polluted river.

They started to find a solution to stop this problem, after some legislation, short-term and long-term plans they slowed down the water pollution. They cleaned the water in a way that they held rowing competition in the creek.

Now the water is clean, but it is obvious that if the treatment process stops or mismanaged, it is going to be polluted again. We thought about the possibility of water treatment in our area in the easiest, most applicable way, and we understood for water treatment we need many tools and it costs a lot but we can use the traditional ways for water treatment to enhance the quality of water in the area as an urban feature which gives the project an aesthetic view.

The use of biological filters like Reed Bed filters is one of the traditional ways of water treatments many years ago, nowadays by having some changes in the design of the filters is applicable to be used in areas when it is necessary to have clean water not in a way to be drinkable but in a way to be clean and odorless which can give a good feeling to the people passing by.

The Common Reed (Phragmites Australis) has the ability to transfer oxygen from its leaves, down through its stem, porous speta and rhizomes, and out via its root system into the rhizosphere (root system.) As a result of this action, a very high population of microorganisms occurs in the rhizosphere, with zones of aerobic, anoxic, and anaerobic conditions. Therefore with the wastewater moving very slowly and carefully through the mass of Reed roots, this liquid can be successfully treated, in a manner somewhat similar to conventional biological filter bed systems of sewage treatment. Earlier Reed Bed Sewage Treatment systems used the horizontal flow type of reed bed, where the liquid flows horizontally through the bed. However it is essential that any form of treatment of sewage should have the capability to not only treat the sewage effectively, but also that its maturation time should be kept to a minimum. To achieve this, the reed plants are partially pre-grown, and also with the development of a vertical reed bed system, this maturity of the total system can be more readily achieved. Reed Bed Sewage Treatment Systems can be used to treat a variety of pollution loadings, but great care must always be exercised in their design and implementation.

In our project we are planning to make some ponds in some special places in order to move water inside our site so that people can enjoy the view and also by putting some reeds inside those ponds we can support our idea of cleaning water in the simplest way.

3.3.3.1. Case Study:

There is a case study of using Reeds for water treatment in a project, which is somehow similar to our project. The project is called Flussbad, Berlin; they decided to make the longest swimming pool by cleaning water in a long hand in a part of a river. They are proposing the use of reed bed for water treatment. By use of this material they can clean the water in a way that is even good for swimming.

Figure 3-7: Water Treatment in the Case Study, ***Flussbad, Berlin***

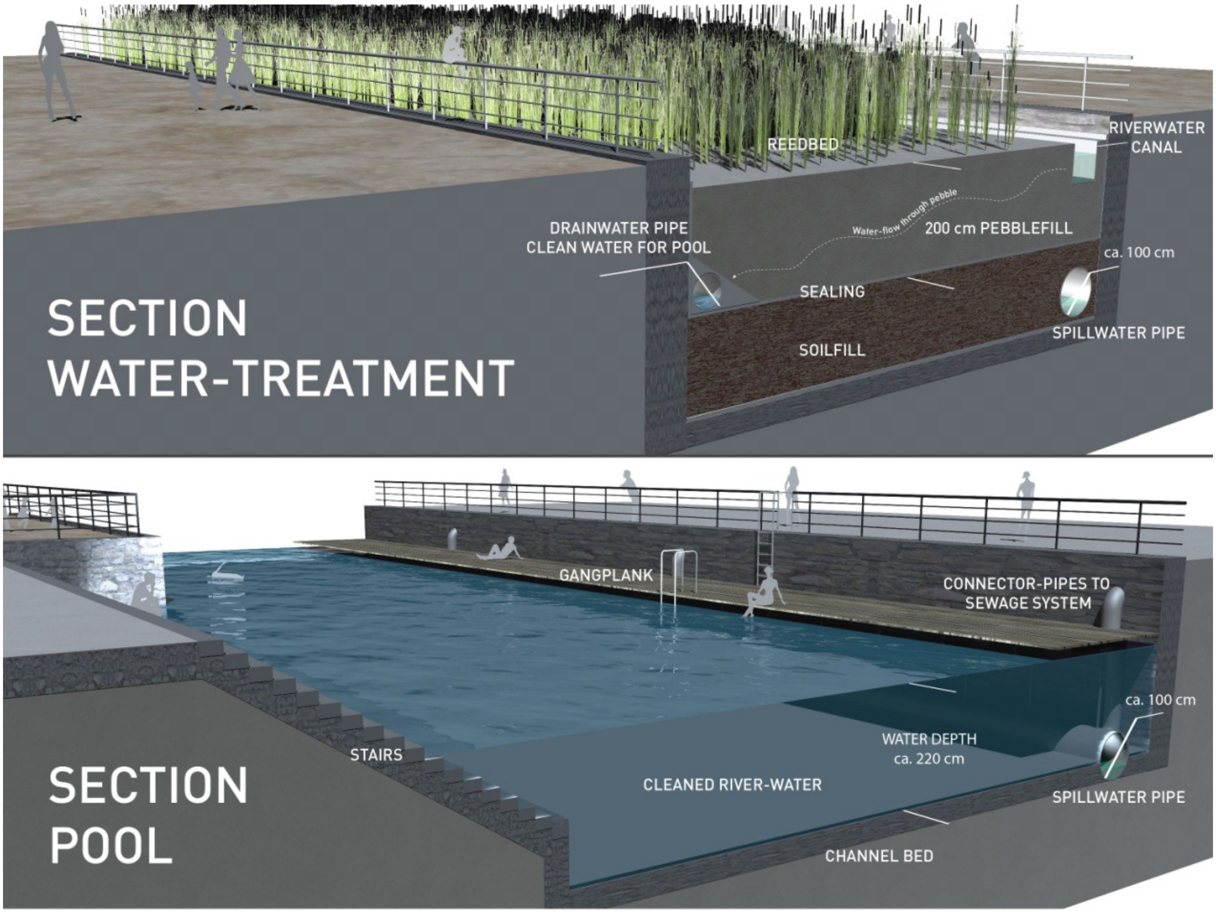


Figure 3-8: Water Treatment in the Case Study, ***Flussbad, Berlin***

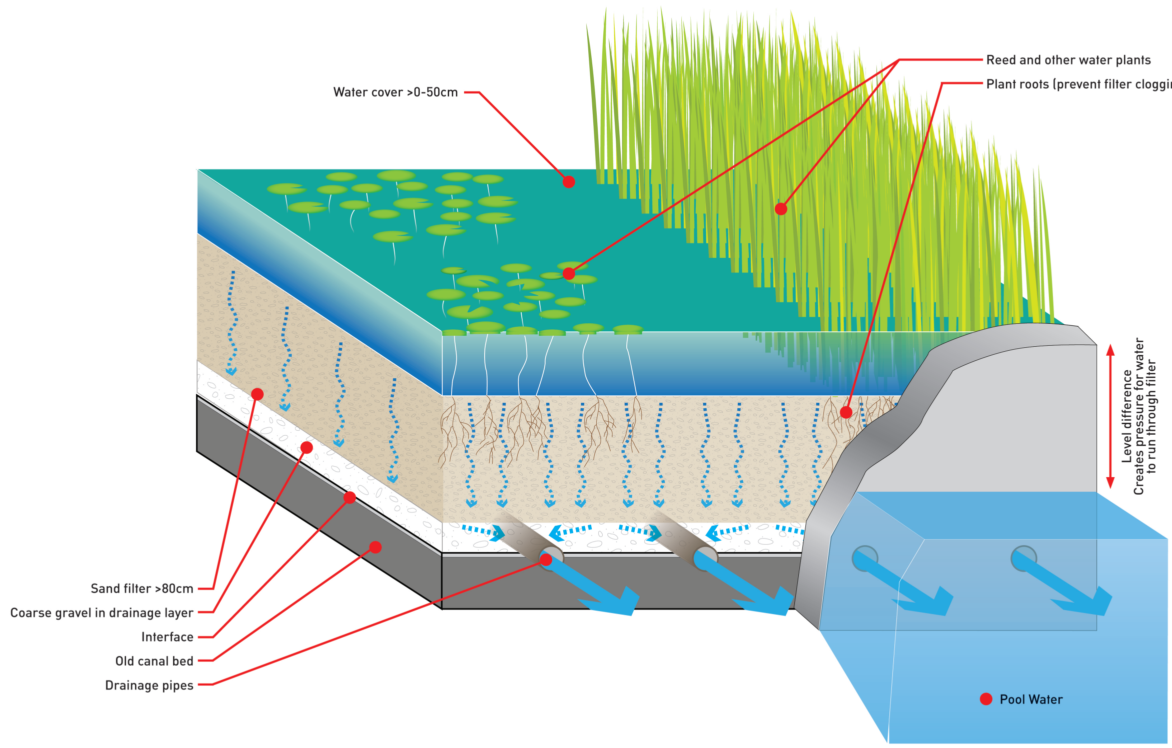


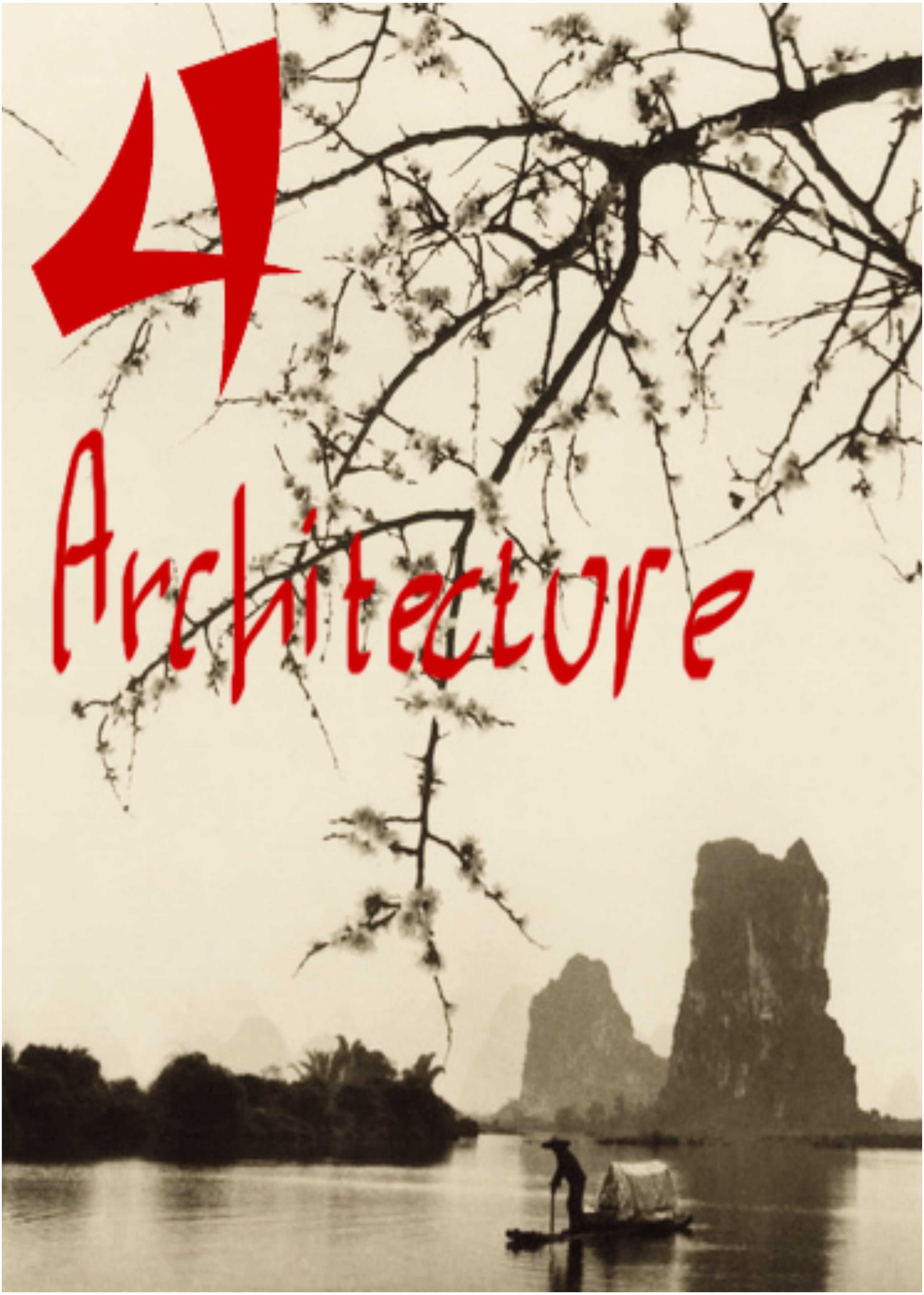
Fig.2 **FUNCTIONAL DIAGRAM OF FILTER BASIN**

Figure 3-9: Proposed Water Treatment System

3.4. Master plan

Figure 3-10: Master Plan, Voids and Buildings

Figure 3-11: Green Pedestrian Pathway


4
Architecture

4. Architecture

4.1. Different types of Residential Buildings in Shanghai10

4.1.1. New apartment mansion

They are everywhere in the city with a wider range of prices for different qualities, e.g. to rent a new well decorated apartment with two bedrooms, two living rooms, a kitchen and two bathrooms in Jing'an may cost you 6,000 yuan (US$750) to 8,000 yuan a month. But the rent price for a set of similar apartment in Xingzhuang or other suburb areas may cost 3,000 yuan or 4,000 yuan a month.

Figure 4-1: New Apartment Mansion

[10] (Us Department of Energy)(Natural Scenery: Suzhou Creek)

4.1.2. Old apartment

Most of the old apartments are built before 1949. Designed by western architects, they are differed from local stone gatehouses and traditional Chinese houses, but have a closer relationship and strain with their foreign peers in Europe and America. They were well equipped with all modern facilities of the time. However, they now become historic architectures with a charming flavor of old times.

Figure 4-2: Old Apartment

Similar as the old villas, some well-furnished old apartments are pricy. The purchasing price for each square meter will be no less than US$2,500. If you rent a two-bedroom suite in Xuhui along Huaihai Road, it will cost you at least US$1,000 a month. But when you wake up at morning, you can go downstairs and have your brunch at a café at the street corner or go directly to your office with a walk distance, you may find it is worthy.

4.1.3. Old garden villa

Most villas in downtown areas are built before 1949, with nice appearances outside, facilities in them may be old, but still a lot of them are renovated with modern facilities by their owners for rent or sell.

The prices for sale are very high; some may even more than US$1 or 2 million. That's the reason why most of the expatriates choose to rent. The price for renting an old villa in the area will cost you from 10,000 yuan (US$1,250) to 100,000 yuan a month, which depends on the area and facilities.

Figure 4-3: Old Garden Villa

If their owners protected them well, inside the old villa, you may see polished brown floorboard and well-decorated fireplace, even the chimneys and pipes are also working. Some may be equipped with old furniture, which may arouse people's memories to earlier times of last century.

With a small garden in the front or at the behind, you may enjoy tea in a sunshine afternoon or hold parties at weekend.

4.1.4. Townhouse

Old ones are concentrated in downtown areas. Some are changed beyond recognition, however still a lot of them are well protected by their owners. Some old house agencies will provide you the rent or even purchase services.

New ones are mainly built in suburbs, such as Guibei and Jinqiao, with fresh air and green sceneries around, which is suitable to those people who wish to live a quiet and peaceful life.

Figure 4-4: Townhouse

4.1.5. Independent lane house

They are hidden inside in downtown areas and separated from each other by lanes and high walls. With a small yard in the front and a door backside, it will provide you a large space as well as a well-protected private life. The prices for rent or sale are less expensive than old villa, but they are still high.

Figure 4-5: Independent Lane House

4.1.6. Duplex house

Without a private owned fence around garden, they are lying in some residential areas in suburbs. Living in them, people may have more privacy then those live in townhouses. Most of the trees and green spaces around are for public use, so, you may share and enjoy the happy outdoor life with your neighbors in sunny afternoons or weekends.

Figure 4-6: Duplex House

4.1.7. Service apartment

Run by several large hotel groups, service apartments are good choices for expatriates who plan to stay here for a short period of time, say several months. Well furnished, 24-hours butler service, which makes life easier and treats you like a king of the city. Most of the service apartments are concentrated in downtown and expatriate communities.

Figure 4-7: Service Apartment

4.1.8. Privatized public apartment

Most of them have a similar appearance as their Russian or East European peers and were built after 1949. They can be found everywhere in the city, however rents differ from each other, depending on their locations. In downtown, such as Xuhui and Jing'an, a set with one bedroom, one small bathroom, a kitchen as well as a small living room may cost a rent of 2,000 yuan a month, while in suburbs the same housing type only worth 1,000 yuan a month or less.

Figure 4-8: Privatized Public Apartment

4.2. Modern housing case studies in Shanghai

Figure 4-9: Modern Housing

Location: Hangzhou, Zhejiang Province

Status: Won competition, Completed 2011

Client: Zhejiang Kulun Company

Program: High Quality Housing, 130.000 m^2 above ground and 60.000 m^2 under ground. Within the narrow confines of Chinese speculative housing, this project seeks to create a project, which is culturally relevant, socially and environmentally sustainable, cost effective and beautiful. The unique invention on the project is the creation of a courtyard around the base of each tower. This counters the alienation issues of universal space created by the client's mandatory lifting of each tower from the ground.

Figure 4-10: Modern Housing

Location: Qingpu District, Shanghai

Status: Completed June 2007

Client: Jindi, Gemdale

Program: 2ha housing; 13No 11 story towers; 42No 6 story buildings; 20,000 m^2 retail. This concept provides variety and randomness within a regular arrangement of small street blocks. Each block consists of two buildings facing one another forming a shared garden. As the project proceeds new building designs can be added to create diversity and to fit the rapidly evolving lifestyles of the Shanghai population.

Figure 4-11: Modern Housing

Figure 4-12: Modern Housing

Location: Wuxi, Jiangsu Province, China.

Status: Completed 2007.

Client: Fudi Development.

Program100 apartment buildings on 35ha site, divided in 13 blocks of different identity and density.

4.3. Urban Design Strategies:[11]

This design brings diversity and openness to this typically enormous Chinese housing development. Approximately 11,000 residents will live in over 100 apartment buildings on the 35ha site. The program also includes a range of mixed use and commercial buildings. The project is organized into thirteen city blocks that are linked by a network of parkland. This parkland unites the site, connects it with the surrounding city and provides a place for residents to recreate and establish informal communities. Each of the 13 blocks has a different identity and density. Eleven blocks are housing communities. One block is a mixed-use district in and around an existing village. Another block is a single-occupant-home-office (SOHO) development situated above supermarket, services and retail. A string of small commercial programs connects the larger ones and creates a commercial network across the site. Originally the 13 blocks were independent gated communities and the parkland was open to the city. For the developer the small size of the communities was too radical a departure from the Chinese typology. To maintain a public character, especially in the sharing of resources, the size of the gated communities needed to go to the other extreme; the site has now only two gated communities, each so large that they are essentially public. The project is situated in a new satellite town of Wuxi. The urban design framework of the town indicates that this project's site is intended to be the district's commercial center. In a typically pragmatic and fluid approach to town planning the government allowed the developer to radically change the functional zoning of the site. The immediate context was likewise in planning flux as we designed this project. The neighboring sites are now set to become shopping centers, placing our planned commercial blocks in flux.

Following the urban design concept the housing design develops 13 blocks in different scale and character. Each block has a similar mix of apartment types making each stage and each site suitable for an economic and social mix of people. An emphasis has been placed on providing residents with a place where informal community structures can readily emerge, an idea rarely taken into account on the majority of housing developments.

[11] (Housing Guide)

Figure 4-13: Chinese Housing Development in Urban Scale (Housing Guide)

4.4. Suzhou Creek[12]

Figure 4-14: Suzhou Creek

Suzhou Creek is an area often left unexplored by tourists and expats in Shanghai. One of the principal outlets of Lake Tai, Suzhou Creek has a length of 125 km, of which 54km are within the administrative region of Shanghai and 24 km within the city's highly urbanized parts. The river flows into the Huangpu River at the northern end of the Bund in Huangpu District.

Writer-director Lou Ye's second film, Suzhou River takes as its background the chaotically built-up riverside architecture of factory buildings and abandoned warehouses along the Suzhou River, rather than the glitzy new face of Shanghai. Since this film, the Suzhou Creek has been endowed with a melancholy character.

4.4.1. Strategic Importance

Suzhou Creek has played an important role for being the demarcation line between political spheres of influences throughout Shanghai's history. After the Treaty of Nanjing forced China to open up in 1842 and Shanghai became an international trade port, the river

[12] (Knapp, 2005)

formed the boundary between the British concession (Southern bank) and the American settlement (Northern bank) until both concessions were merged into the International Settlement in 1863. When the Japanese invaded Shanghai in 1937, the river formed the boundary between the International Settlement (South) and the Japanese concession.

Figure 4-15: The Old Suzhou Greek as a Hustling Trade Port

4.4.2. Redevelopment and Future

Since 1992, the Shanghai Municipal Government has been pursuing a redevelopment of the area. In 1998, authorities launched the Suzhou Creek Rehabilitation Project, a 12-year-program to improve the water quality, mitigate flood impact, introduce wastewater and water resource management and push for urban revitalization and a higher living standard in the desolated areas along Suzhou River. In the meantime, Suzhou River is considered clean enough to host annual rowing competitions.

Originally, most old factories and warehouses along Suzhou River were set be demolished in favour of the construction of modern high-rise buildings in Shanghai's fast-developing city centre, aiming at a social and economic regeneration of the Suzhou River area. However, following initiatives of artists in the late 1990s the riverside has been designated as a protected heritage zone and many warehouses have been conserved, now providing quarters for Shanghai's flourishing art scene. In 2002, new plans for the redevelopment of the riverfront of Suzhou Creek were approved.

These plans, based upon proposals by three international firms, call for the construction of entertainment facilities and 1 square kilometer of parks along the downtown section of Suzhou Creek between Zhongshan Park and its confluence with Huangpu River, aiming to raise the commercial attractiveness of this central part of the river. New structures include shops, bars and a total of 95 greenbelts at the banks of the river, which are supposed to be planted by 2010, the time the Suzhou Creek Rehabilitation Project is completed. While some areas already leased to investors will have to be reclaimed and old residential and industrial facilities are supposed to be replaced, authorities assert that the protection of historical buildings, especially warehouses, will be respected.

4.4.2.1. Bridges

Suzhou Creek is crossed by a number of distinctive bridges, often European in style, the most famous one being Waibaidu Bridge (Garden Bridge) right at its confluence with Huangpu River.

Facilitating north-south traffic in the ever-growing metropolis, a number of new bridges are currently being constructed. Gubei Road Bridge, to be opened in late 2006, will be the longest bridge over the waterway. By 2007, there will be thirty bridges spanning Suzhou Creek.

Figure 4-16: Waibaidu Bridge Over the Suzhou Creek

Figure 4-17: Shanghai General Post Office Along the Suzhou Creek

4.4.2.2. Places along the river

Due to its location in the former International Settlement, a number of landmarks from that period can be found along or close to Suzhou Creek. Following the river westward from its confluence, important or famous places include:

- Huangpu Park and the northern end of the Bund
- Astor House
- Consulate-General of Russia
- Shanghai Mansions (previously Broadway Mansions)
- People's Hospital No. 1
- Shanghai General Post Office
- Suzhou Creek Art District
- Sihang Warehouse

4.5. Vernacular Architecture: Inner Courtyard[13]

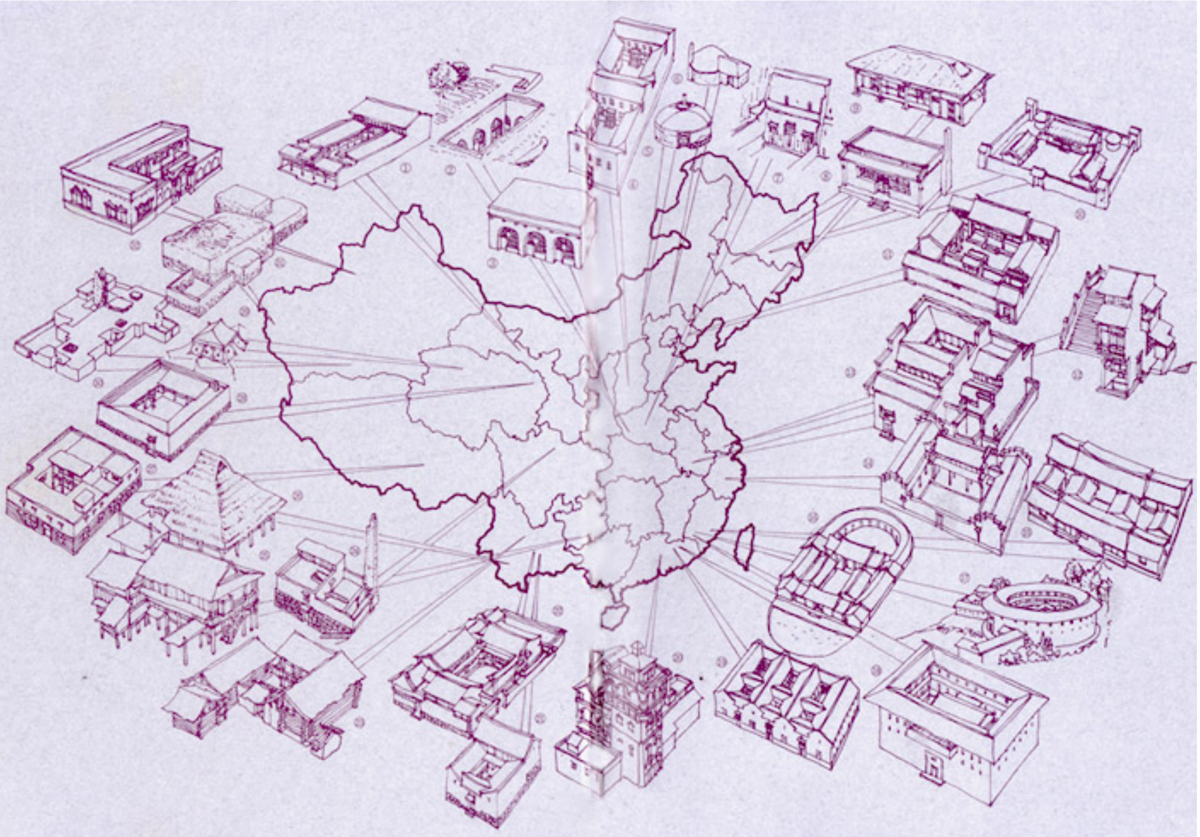


Figure 4-18: Chinese Vernacular Housing Architecture

The vernacular architecture of China is characterized by a striking consonance among built forms. Although significant geographical variations reflect the country's rich ethnic diversity, many, if not most, traditional Chinese houses, royal palaces, town dwellings and farm- houses alike, share a number of architectural, spatial and cultural elements. These include, for example:

- The use of modular units (jian)
- The complementary creation of closed and open spaces (courtyards)
- The ritual importance of the location and orientation of buildings
- These elements are not just geographically widespread but deeply rooted in history and relate closely to Chinese notions of 'family' and 'home'.
- Therefore, through design process of the residential complex we also took into account these three main elements of Shanghai traditional housing.

[13] (Suzhou Creek)(Knapp, 2005)

Figure 4-19: Samples of Shanghai Vernacular Architecture

4.6. Water in Vernacular Architecture

As mentioned in the Introduction chapter, importance and presence of water in Chinese vernacular architecture is not deniable. Water represents lightness and communication and carries the food of life.

Figure 4-20: Water and Buildings

In Chinese Garden, softness of water contrasts with the solidity of the rock. The main buildings are placed beside the pond, and pavilions surround the lake and are located over the water to view them.

Figure 4-21: Chinese Garden

4.7. Water in Modern Architecture: Case Study

The Water House by Li Xiaodong Atelier, Lijiang, Yunnan Province, China

The Water House is a family home in Lijiang, an ancient trading settlement whose old town is famous for its historic network of waterways and bridges. The site lies at the foot of Yulong Mountain, its peaks forming a dramatic backdrop to Li's architecture. The house synthesizes traditional forms and techniques to make a contemporary building that resonates with place and history.

Figure 4-22: Modern Chinese Architecture

Conceived as an interlocking series of contemplative, inward-looking courtyards, the house is separated from the outside world by gently defensive elements such as low stonewalls and shallow pools. Yet it is also has openness and permeability, conceived as a place to contemplate the grandeur of its surroundings.

Figure 4-23: Modern Chinese Architecture

The architectural language is refreshingly modest and unassuming. The cluster of simple timber and glass pavilions with tile-clad pitched roofs evokes traditional forms but is still evidently of its time. Lightweight, slatted walls delicately veil the light, and bamboo plants form a luxuriant green heart in the building's central courtyard. The cooling, calming presence of water threads through the house and low eaves frame and enclose indoor/outdoor spaces.

Figure 4-24: Modern Chinese Architecture

Local laborers executed much of the construction. Li regards local involvement as essential to his projects, affirming a spirit of engagement with the region. The jury admired both his thoughtful approach and its highly poetic outcome.

4.8. Design Process

After choosing the concept, the design strategy starts with keeping the important buildings on the site as they are before, like the university, then we provide the proper distance from the these old important building and then we start our design. In this stage after selecting a proper module to repeat in the site we decide the functions of the building considering the existing elements inside the site.

To choose the dimensions for the buildings we started to build a physical model with some movable cubes to understand the height and the combinations, then by changing the cubes we got to the final decision about the height of the buildings in different parts, voids, connections, starting point, the slope of the roof and the focal point of the design. Orientation of the blocks and the buildings, as well as choosing the open spaces inside the site are decided after analyzing and changing the physical model in a way to provide public functions on the roof keeping the inner courtyard private, and having around 100 m2 of residential areas.

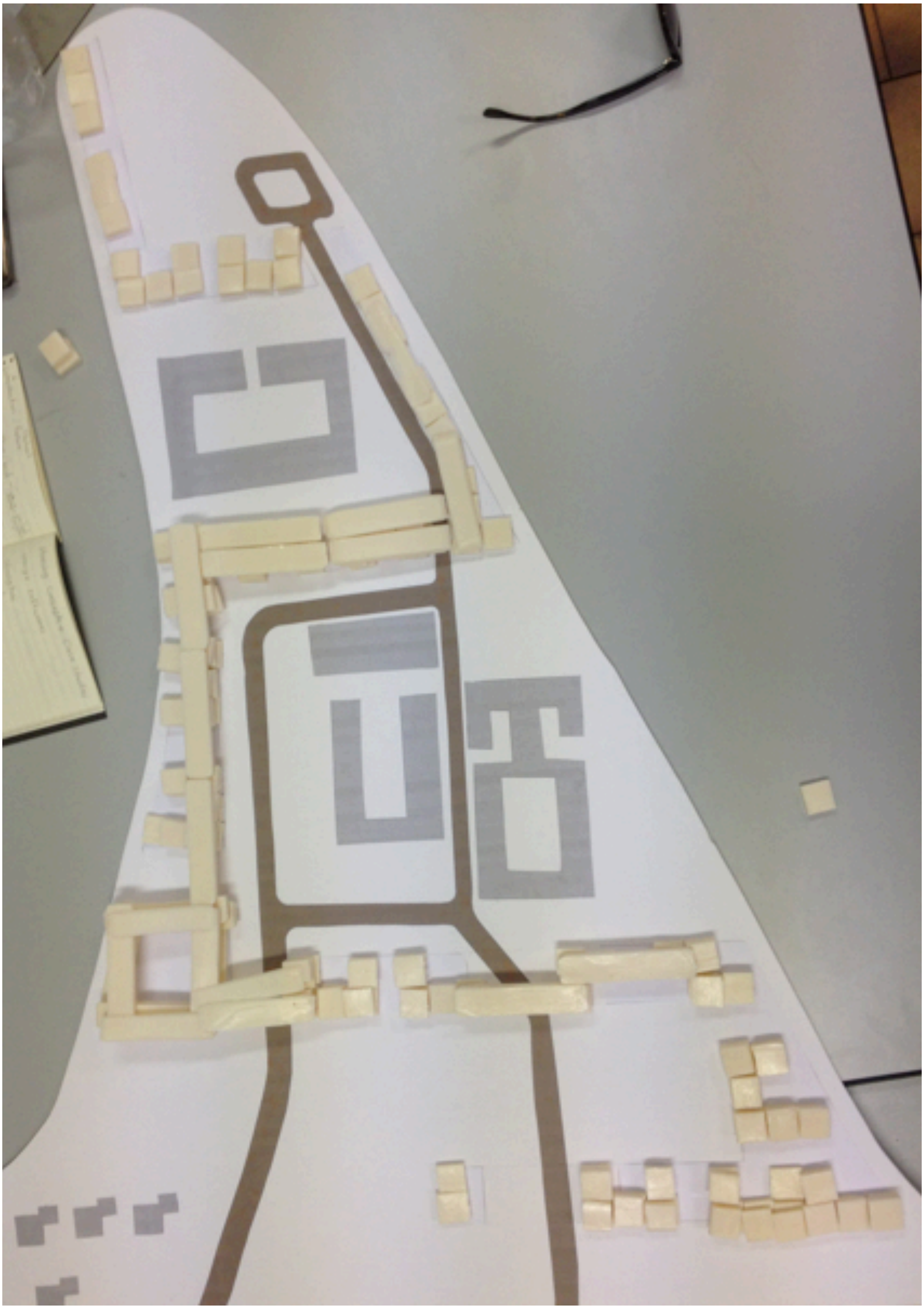


Figure 4-25: Physical Model

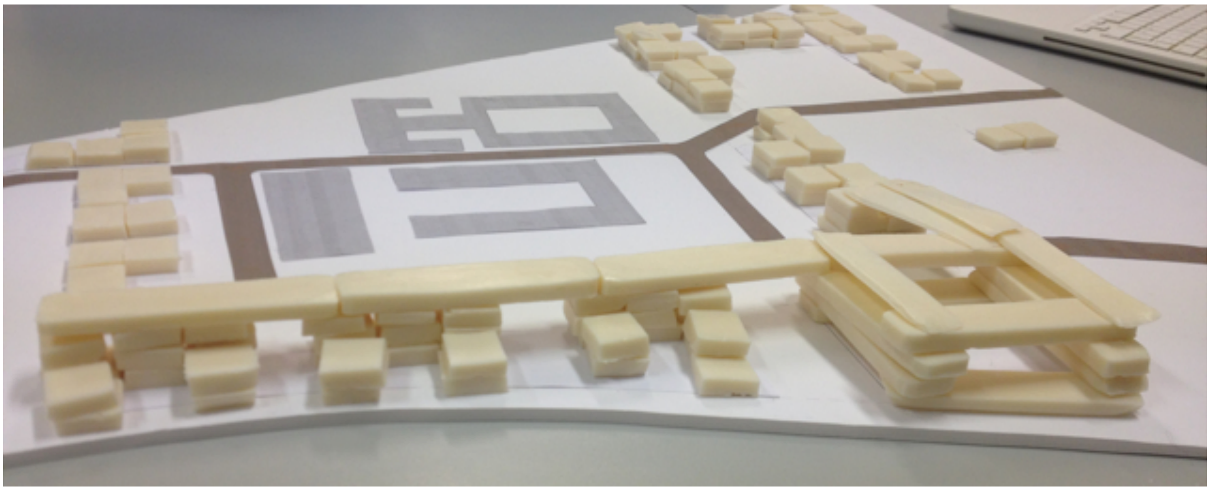


Figure 4-26: Physical Model

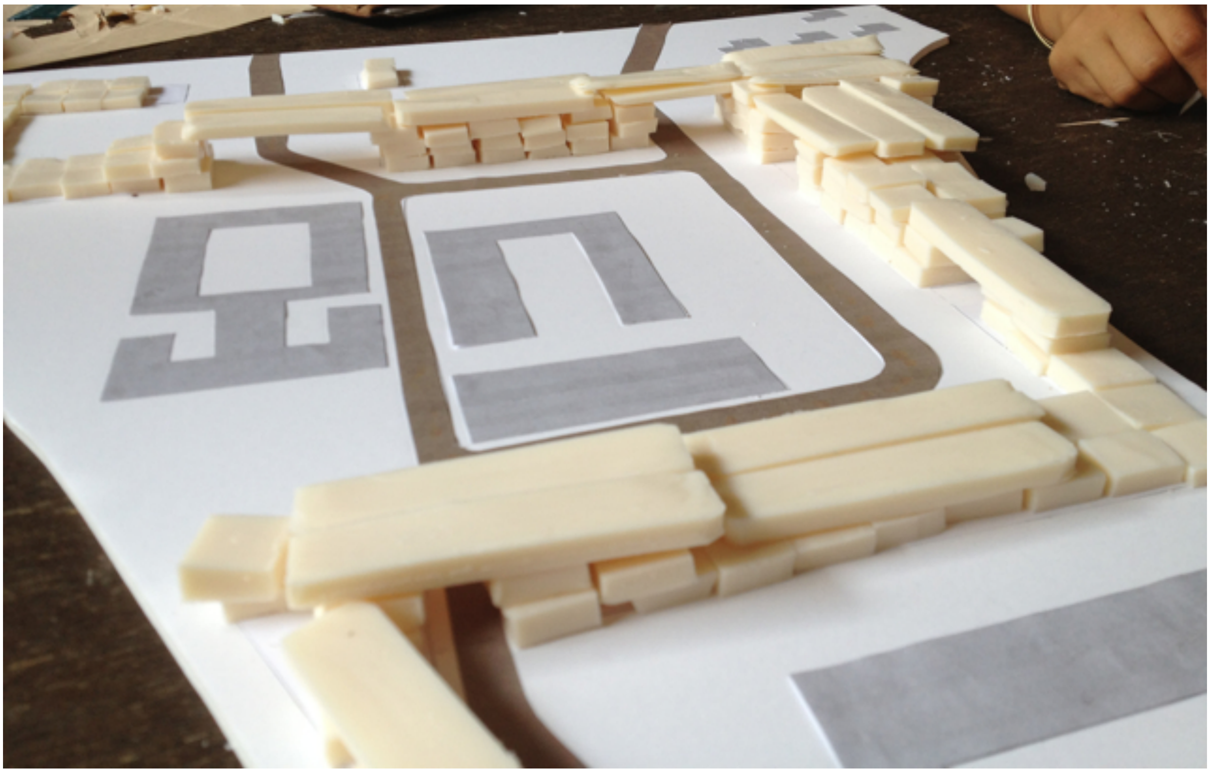


Figure 4-27: Physical Model

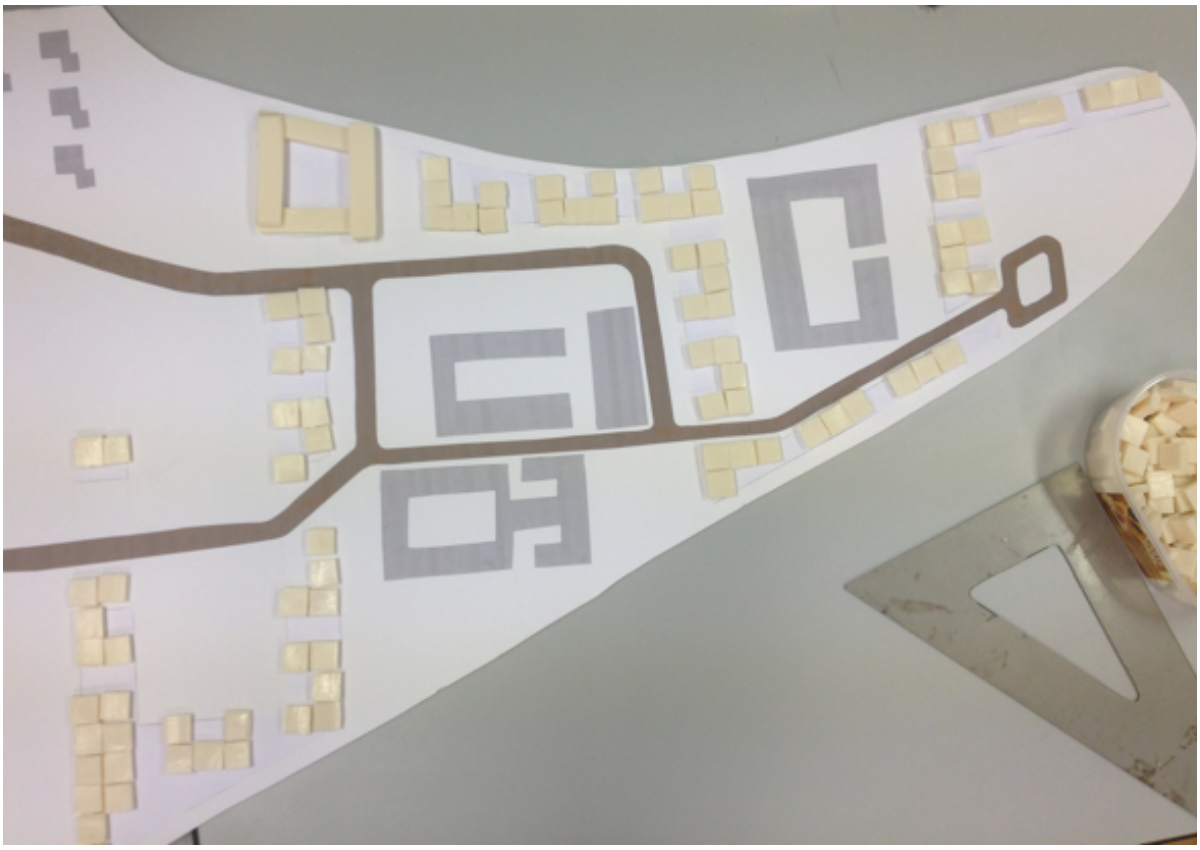


Figure 4-28: Physical Model

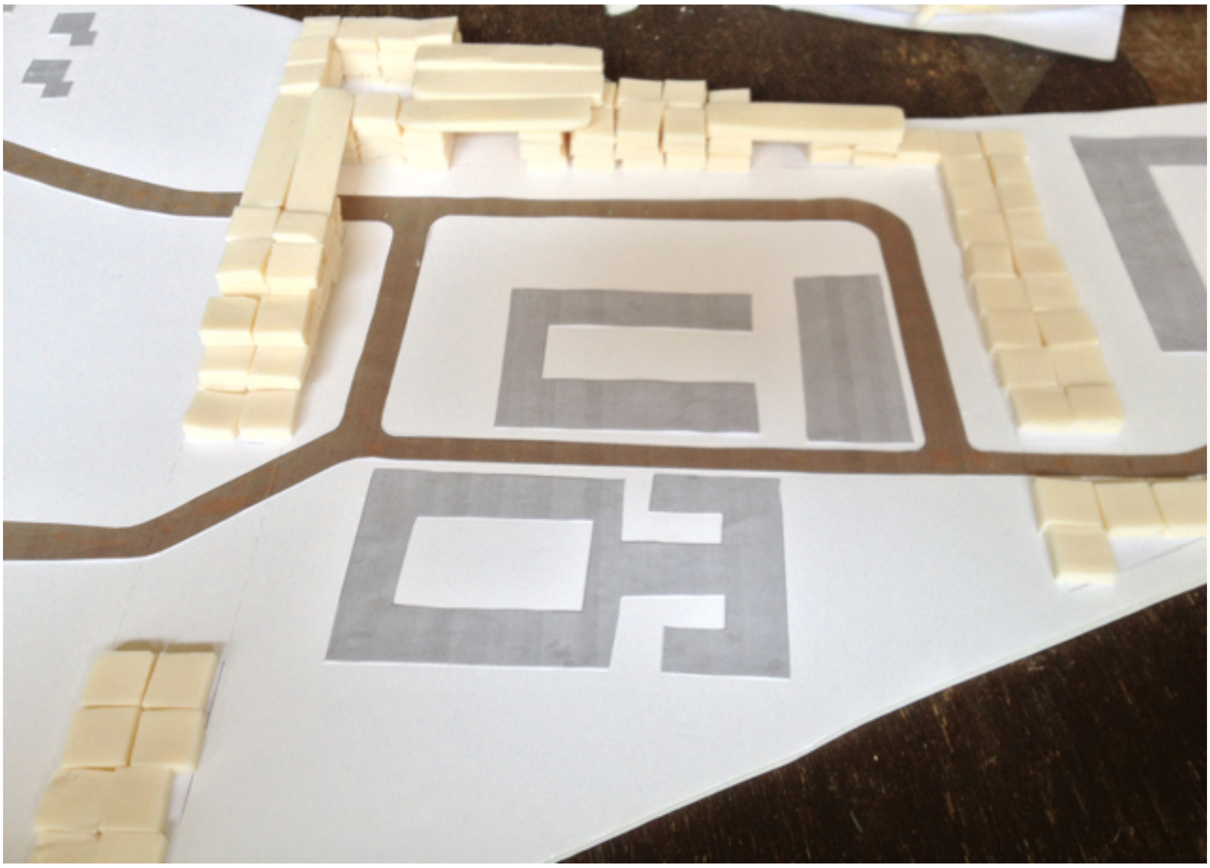


Figure 4-29: Physical Model

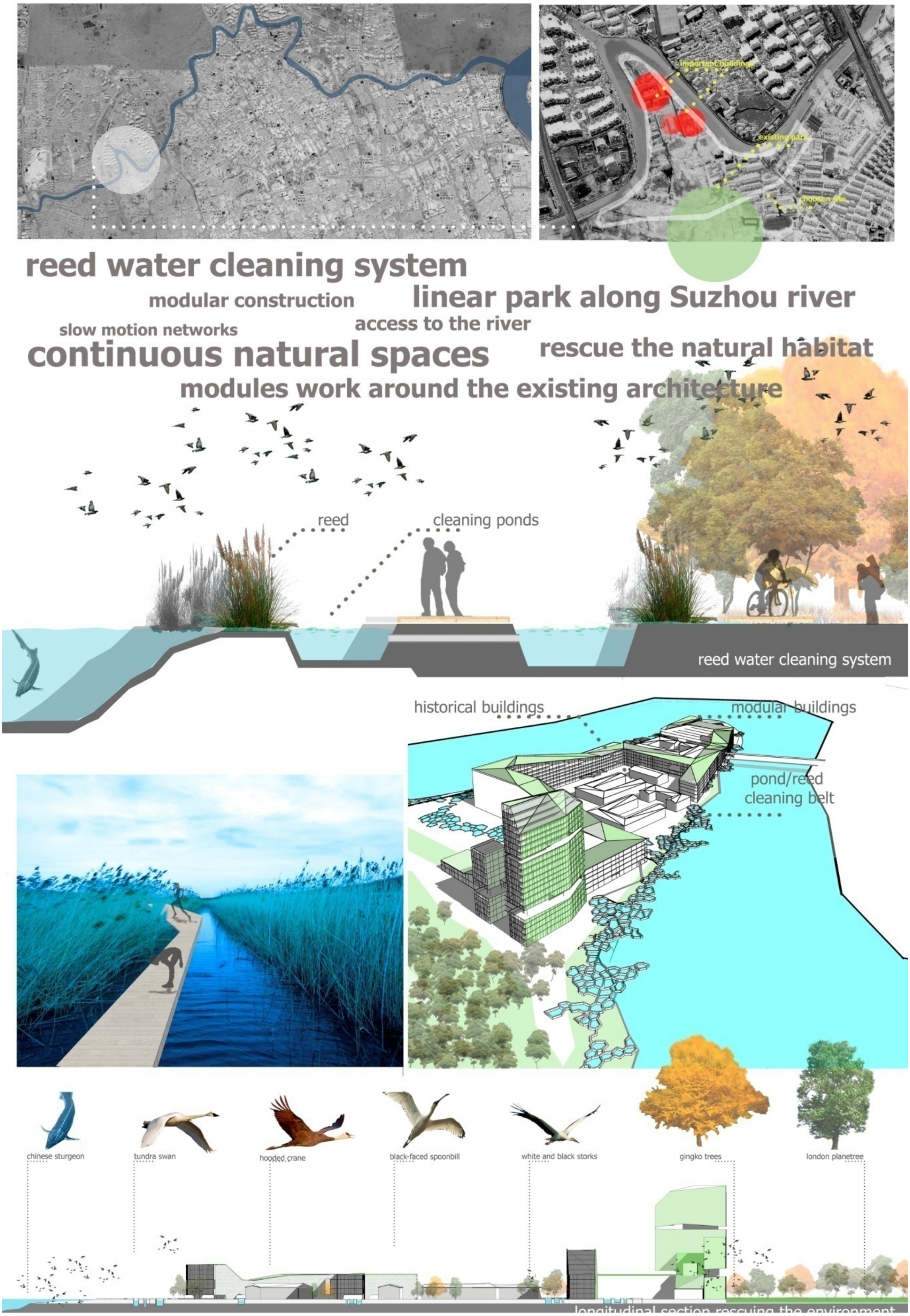


Figure 4-30: Conceptual Design of the Project

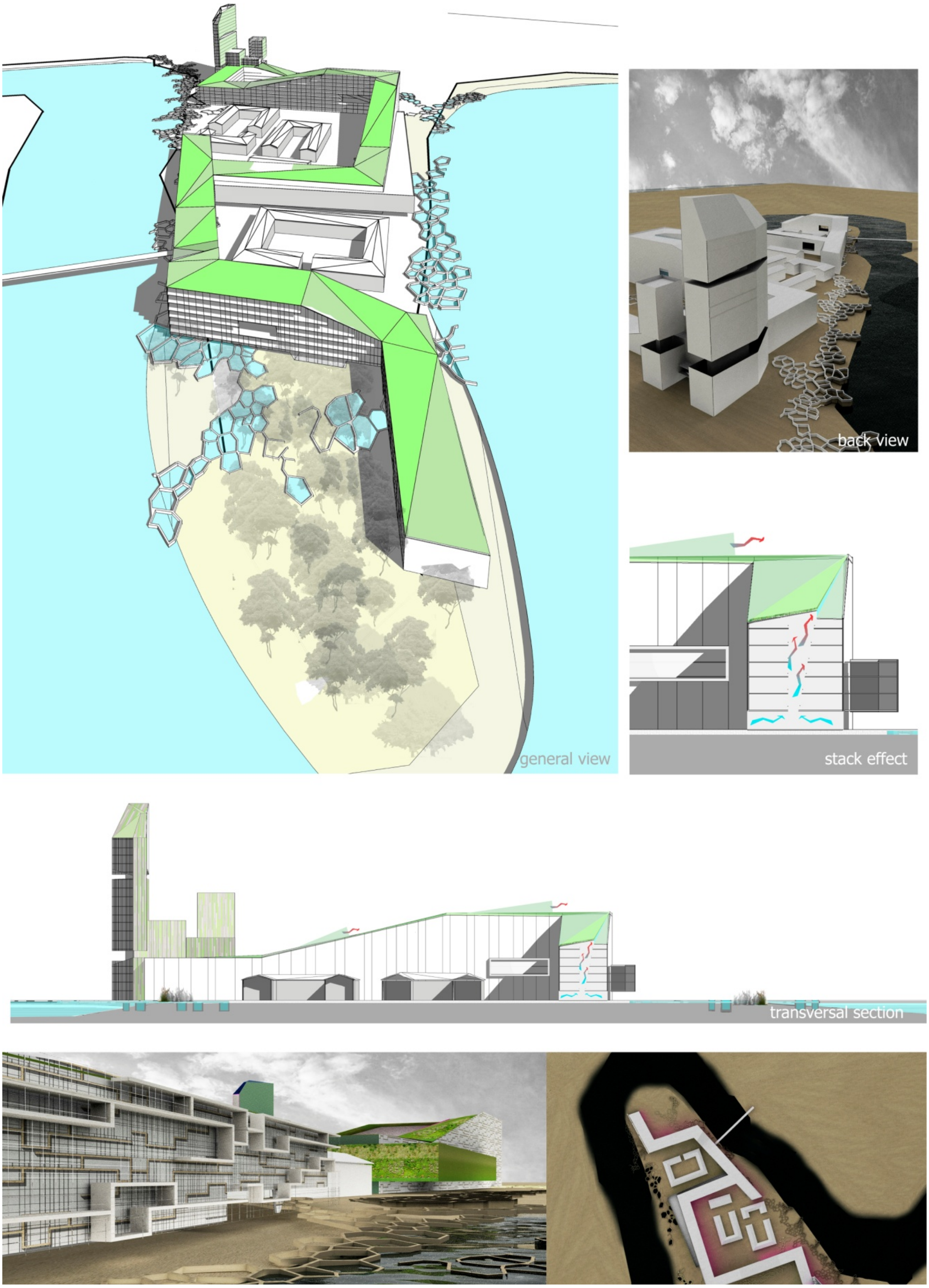


Figure 4-31: Conceptual Design of the Project

4.9. Material

4.9.1. Terracotta Facade

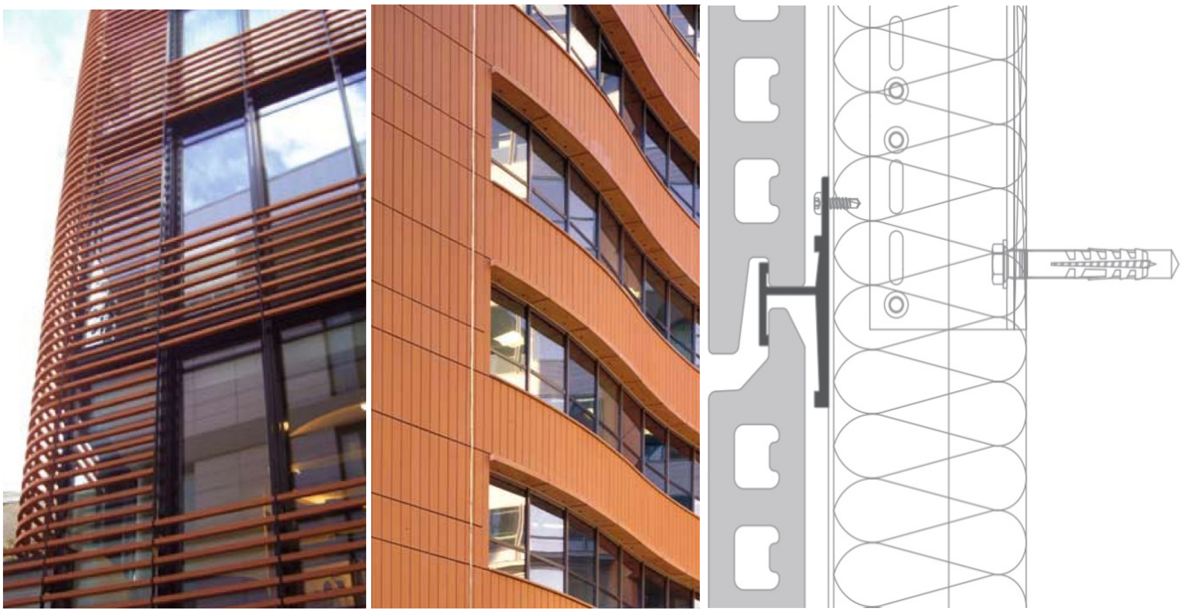


Figure 4-32: Terracotta Façade Installation

Terracotta is a clay-based unglazed or glazed ceramic, where the fired body is porous. Its uses include vessels, water and waste water pipes, bricks, and surface embellishment in building construction.

Considering the visual characteristics of the surrounding buildings, using terracotta for the façade of the building creates pleasant harmony with the brick material of the existing buildings in the site.

Moreover, modern use of Terracotta for the ventilated and heat-insulated facade is an ideal choice for external walls while dividing the physical and technical building functions and allocating them to the different layers of the wall design, results in the following benefits:

- Much lower heat loss and Reliable heat protection in summer
- Effective weather protection and specific wicking of moisture
- Simple planning and assembly
- Resistant to all kinds of aggressive environmental influences
- Long life span and high cost-effectiveness
- High architectural design quality which is in a good harmony with Brick facades of the surrounding existing buildings


Technology

5. Technological Analysis

5.1. Energy in Shanghai[14]

Shanghai residential energy consumption is growing quickly with the increase of Chinese living standards. Household electricity consumption was around 1618kWh/year/household in 2000 and raised to 2480 kWh/year/household in 2004

5.1.1. Energy consumption and GHG emissions

The energy supply mix of the city is also composed of coal, but in a much lower proportion than the national level. Oil represents an important part of the mix, increasing over the years in order to equal the percentage of coal as supply primary energy. This is linked with Shanghai's rapid rise in vehicle ownership. Natural Gas contribution is minor but increasing, as well as electricity coming from other sources, reflecting the increase of cleaner sources.

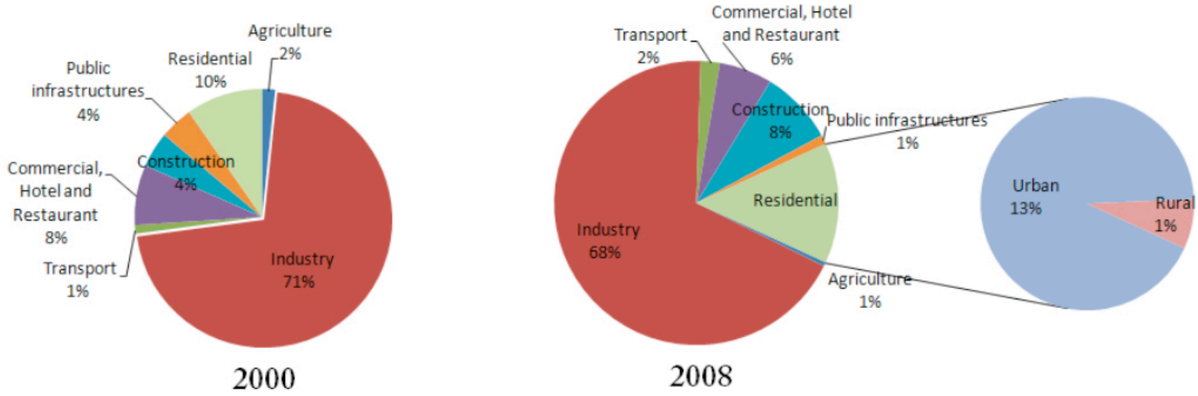


Figure 5-1: Shanghai Electricity Consumption by Sector Evolution[15]

5.1.2. Main Actions

The main energy actions are mainly on buildings, industries, transportation and renewable energies.

5.1.2.1. On Buildings

Shanghai Municipality committed in 2007 (in The Implementation Plan for Energy Conservation and Emission Reduction in Shanghai, 2007) to implement the standard that newly erected buildings shall follow a binding energy-saving 50 percent standard and would like to soon extend it to a 65 percent standard. Reaching the standard should be the

[14] (China Energy Yearbook, 2008)
[15] (China Energy Yearbook, 2008)

precondition for getting a construction permit. With these measures, Shanghai expects to reach its building energy saving goal of 15 percent. Shanghai would also like to transform all public and government buildings into energy-saving buildings to give a good example to the construction industry. However, a study by the Chinese Ministry of Construction has shown that only 53 percent of the newly Chinese constructed buildings meet the net standards of energy efficiency. Although respecting energy-saving standards would only increase building costs by 5-10 percent, many real estate developers are unwilling to bear the cost, favoring short-term profit over long-term considerations.

5.1.2.2. On renewable energies

The Shanghai Green Electricity Scheme offers electricity consumers in Shanghai the opportunity to “green” their electricity consumption by buying some amount of green electricity for which a premium needs to be paid. To improve the energy efficiency in Shanghai, the Shanghai government not only adopted macro-control policies to address energy issues but also promote energy conservation idea from public awareness. The Shanghai experience shows that it is important to keep the local residence aware of the problem of energy conservation and environment pressures. Shanghai Municipality would like to reach a wind power installed capacity of 200-300 MW in 2010. Space is limited in the Shanghai municipality and only allows three wind parks (Fengxian, Nanhui and Chongming) to produce a total of 24.4 MW. Nevertheless, offshore wind farms bear a higher potential for Shanghai: 100 MW of offshore wind capacity are planned by 2009/2010 in Donghai. For solar energy, the target of Shanghai Municipality is to reach a production of 10 MW until 2010. Shanghai’s power companies are also now financing nuclear power plant projects in nearby provinces. One illustration in the Qinshan nuclear power plant in Zhejiang province, which disposes of two 650 MW reactors and is planning two more 700 MW reactors.

5.1.3. General considerations: China, an energy consuming development

All over the country, economic growth and increase of consumption linked with urbanization generate acute challenges in terms of energy supply. Power generation illustrates well the trend: China has about 1,000 GW of installed power today and some 100 GW additionally installed every year. The country energy mix is clearly linked with its national natural resource: namely coal. Studies give primary energy mix and electricity mix with still 80% of electricity produced by coal fired thermal plants and nearly 66% of its total primary energy. Shanghai is interested in importing more hydropower – which is considered as a renewable and clean energy – to reduce its controversial high share of coal-generated power (Wehrle, 2008).

The region of Shanghai was composed of around 5 million natural gas consumers at the beginning of 2007. China's domestic natural gas production does not suffice to cover the demand on the Chinese market. Hence, China is now investing in building capacities to import Liquefied Natural Gas (LNG). The power generation in 2007 was of 74 billion kWh and the power consumption of 107 billion kWh. Overall energy consumption was of 98 million tons of coal equivalent in 2008 (3.5 % of China Energy Consumption).

Shanghai is located in the "Hot Summer and Cold Winter". It is worth noting that, south of the Yangtze River, buildings do not integrate heating systems. The peak time for electricity consumption comes in summer with the massive usage of individual Air-Conditioner. Generalization of air conditioner uses represents a growing burden on power supply in summer with peak loads getting more and more difficult to manage. It represented about 400MW on summer days in 1990 and was higher than 1200 MW in 20025. Shanghai still faced shortages in 2009 during peak loads.

Regarding these peak loads, Chinese cities generally use gas-fired power plants for peak- load regulation since the start-up of gas turbine is much faster than coal-fired power plants and more flexible in terms of operation (but more expensive). Huaneng Power group installed in Shanghai the first unit gas-fired power plant for peak hour grid regulation in 2006. It operates only in summer, when the demand is the highest. Shanghai also buys electricity at higher prices coming from the neighboring provinces

5.1.4. Residential

Shanghai residential energy consumption is growing quickly with the increase of Chinese living standards. Electricity now dominates households' energy consumption.

Household electricity consumption was around 1618kWh/year/household in 2000 and raised to 2480 kWh/year/household in 2004, in which air-conditioning is around 776 kWh, or 31% of total consumption. This figure includes the space heating; Shanghai does not have district-heating system like northern Chinese cities, people use individual reversed air-conditioning device for space heating in winter.

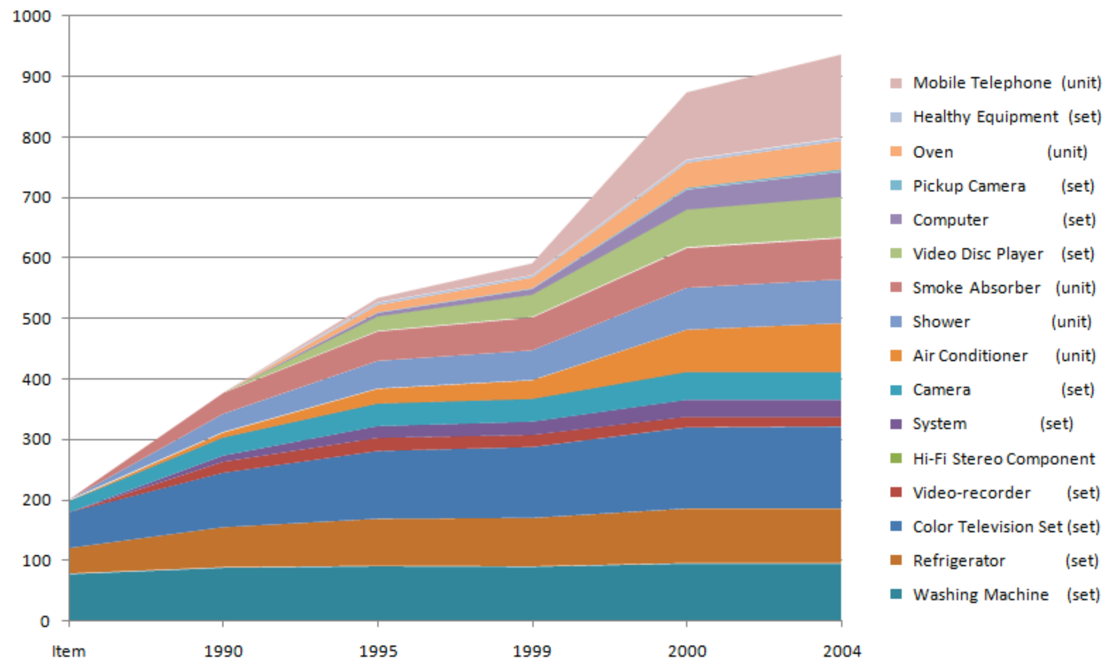


Figure 5-2: Trend of Electric Devices for 100 Chinese Households[16]

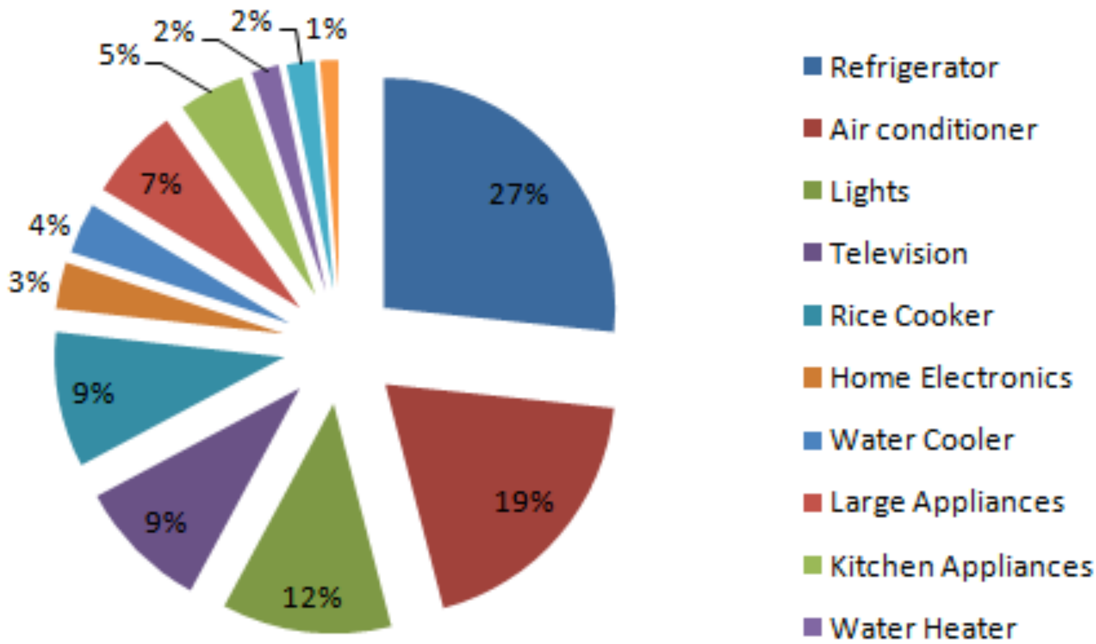


Figure 5-3: Composition of Shanghai Household Electricity Consumption in 2000

[16] (China, 2006)

The increase of living standards also impacts the per capita floor area jumping from 22 sqm in 2002 to 30sqm today and expected to reach 42sqm in 2030. However, energy price in China remains very low (due to heavy subvention from the State) with electricity being sold to end user at 0.5 RMB/kWh nowadays. Energy consumption is globally higher in summer while the consumption of energy during swing seasons evolves differently according to the building type.

5.1.5. Policies

The Renewable Energy Law entered into effect in January 2006. The law stipulates the connection of renewable energy sources to the grid and the integration of renewable energy in public buildings. According to the Renewable Energy Law, the MOHURD (Ministry of Housing and Urban Development) is obliged to develop technical standards for renewable energy technology such as solar water heaters and heat pumps. Also in the 11th five-year period, the Work Plan for Energy Conservation and Pollutant Discharge reduction was launched, detailing the measures and actions to be undertaken nationwide. It aimed at cutting energy consumption per unit of gross domestic product by 20% over the course of the 11th five-year plan, as well as cutting the discharge of major pollutants by 10%.

The 12th five-year plan (2011-2015), just signed in April 2010, fixed an objective of 45% reduction GHG emissions per GDP unit by 2020 compared to 2005 levels. Pilot low carbon cities projects are set up all over the country.

5.1.6. Plans and Objectives

Shanghai strategies to reduce its energy challenges are divided in different categories:

- Develop renewable Energies
- Increase gas supply
- Improve energy efficiency, especially for industries, transport, construction, new energies
- Shanghai needs to reduce the proportion of coal in its energy structure as this primary energy source carbon emission factor is the highest.

5.1.7. Sectoral Policies

5.1.7.1. Buildings

Shanghai Municipality committed in 2007 (in The Implementation Plan for Energy Conservation and Emission Reduction in Shanghai, 2007) to implement the standard that newly erected buildings shall follow a binding energy-saving 50 percent standard and would like to soon extend it to a 65 percent standard. Reaching the standard should be the precondition for getting a construction permit. With these measures, Shanghai expects to reach its building energy saving goal of 15 percent. Shanghai would also like to transform all public and government buildings into energy-saving buildings to give a good example to the construction industry. However, a study by the Chinese Ministry of Construction has shown that only 53 percent of the newly Chinese constructed buildings meet the set standards of energy efficiency. Although respecting energy-saving standards would only increase building costs by 5-10 percent, many real estate developers are unwilling to bear the costs, favoring short-term profits over long-term considerations.

Shanghai Energy-efficient Building Design Standards, adaptation of the national standard of the same name, encourage contractors to use energy-efficient materials and adopt energy- saving technologies for heating, cooling, ventilating, and lighting public buildings. In the respects of building energy conservation, eco-building is strongly promoted.

A 71-story tower in Shanghai is expected to become end 2010 the world's most energy-efficient tower on the road to its "zero" energy footprint goal. It is expected to consume 58% less energy than a tower following current energy codes, thanks to use of wind energy, internally ventilated double wall facade to limit heat absorption and act as insulation, radiant panels, light responsive automatic blinds and Photovoltaic (PV) panels. Shanghai ecology demonstration office building is also a good candidate to show the example: it is the winner of the 'Green Innovation Design Award' and the 'Top 10 Best Construction Achievement Award'. It uses 75 per cent less energy than comparable buildings. Twenty per cent of the total construction energy will be sourced from renewable energy.

5.1.7.2. Renewable Energies

The Shanghai Green Electricity Scheme offers electricity consumers in Shanghai the opportunity to "green" their electricity consumption by buying some amount of green electricity for which a premium needs to be paid. To improve the energy efficiency in Shanghai, the Shanghai government not only adopted macro-control policies to address energy issues but also promote energy conservation idea from public awareness. The Shanghai experience shows that it is important to keep the local residence aware of the problem of energy conservation and environment pressures. The public awareness makes it possible to meet the energy and environment challenge through the joint effort of the whole society.

- Wind power
- Nuclear power

According to The Eleventh Five-Year Plan of Shanghai Municipality for Energy Sources Development, however, the renewable energies consumption in Shanghai is expected to reach only 0.5% of projected total energy consumption, far lower than the target as set in Renewable Energy Development Plan. Therefore, there is huge potential for the development of renewable energy in Shanghai (UNEP-Tongji).

5.2. Climate Analysis[17]

Using the weather data for Shanghai[18] as the input of the software, Climate Consultant, we can analyze the climatic conditions in Shanghai.

The weather data is from:

Location: Shanghai/Hongqiao, CHN

Latitude/Longitude: 31.17* North, 121.43* East, Time Zone from Greenwich 8

Data Source: SWERA 583620 WMO Station Number, Elevation 7m

This weather data station is chosen among the few stations in Shanghai because it is closer to the latitude and the longitude of our site among all the others available.

WEATHER DATA SUMMARY

LOCATION: SHANGHAI/HONGQIAO, –, CHN
Latitude/Longitude: 31.17° North, 121.43° East, Time Zone from Greenwich 8
Data Source: SWERA 583620 WMO Station Number, Elevation 7 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	246	322	362	422	450	390	475	461	363	361	285	273	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	170	152	153	191	199	141	229	262	184	250	211	247	Wh/sq.m
Diffuse Radiation (Avg Hourly)	161	231	258	277	293	278	292	263	238	205	171	153	Wh/sq.m
Global Horiz Radiation (Max Hourly)	609	727	873	968	984	985	954	959	852	808	686	576	Wh/sq.m
Direct Normal Radiation (Max Hourly)	697	639	695	768	785	699	771	779	722	816	814	764	Wh/sq.m
Diffuse Radiation (Max Hourly)	409	481	520	626	633	654	672	577	589	472	375	324	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2263	2989	3645	4752	5130	4870	5420	5213	3918	3468	2685	2289	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	1551	1400	1528	2140	2278	1796	2617	3015	2047	2483	2018	2075	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1493	2165	2624	3149	3380	3489	3379	3007	2578	1998	1635	1317	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	26874	35271	39904	46729	50149	43917	53778	51975	40592	39802	31163	29604	lux
Direct Normal Illumination (Avg Hourly)	16286	14953	15130	18205	18570	12487	19618	22866	16100	23494	19898	23356	lux
Dry Bulb Temperature (Avg Monthly)	4	6	8	14	20	23	27	27	22	18	12	6	degrees C
Dew Point Temperature (Avg Monthly)	0	1	2	9	15	19	23	23	19	13	9	1	degrees C
Relative Humidity (Avg Monthly)	74	74	70	75	77	83	80	77	81	75	81	74	percent
Wind Direction (Monthly Mode)	290	320	90	90	140	110	140	140	90	20	320	290	degrees
Wind Speed (Avg Monthly)	3	2	2	3	3	3	2	2	2	2	3	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	9	8	8	9	14	18	22	23	22	20	16	12	degrees C

Figure 5-4: Weather Data Analysis from Climate Consultant Software

[17] All the data and graphics in this chapter is the output of the software, Climate Consultant 5.4

[18] (Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone, 2010) (Us Department of Energy)

COMFORT MODEL	LOCATION:	SHANGHAI/HONGQIAO, -, CHN
	Latitude/Longitude:	31.17° North, 121.43° East, **Time Zone from Greenwich** 8
	Data Source:	SWERA 583620 WMO Station Number, **Elevation** 7 m

COMFORT MODELS:

Human Thermal comfort can be defined primarily by dry bulb temperature and humidity, although different sources have slightly different definitions. Select the model you wish to use:

◉ California Energy Code Comfort Model, 2008 (DEFAULT)

For the purpose of sizing the heating and cooling system the indoor Dry Bulb temperature should be 70°F (21.1°C) to 75°F (23.9°C). The maximum humidity is set at 80% with a lower Dew Point of 27°F (-2.8°C) (which all can be changed on the Criteria screen). This is the default comfort temperature definition used in Climate Consultant.

○ ASHRAE Handbook of Fundamentals Comfort Model, 2005

For people dressed in normal winter clothes, Effective Temperatures of 68°F (20°C) to 74°F (23.3°C) (measured at 50% relative humidity), which means the temperatures decrease slightly as humidity rises. The upper humidity limit is 64°F (17.8°C) Wet Bulb and a lower Dew Point of 36F (2.2°C). If people are dressed in light weight summer clothes then this comfort zone shifts 5°F (2.8°C) warmer.

○ ASHRAE Standard 55-2004 using PMV (Predicted Mean Vote) Model

Thermal comfort is based on dry bulb temperature, clothing level (clo), metabolic activity (met), air velocity, humidity, and mean radiant temperature. Indoors it is assumed that mean radiant temperature is close to dry bulb temperature. The zone in which most people are comfortable is calculated using the PMV model. In residential settings people adapt clothing to match the season and feel comfortable in higher air velocities and so have wider comfort range than in buildings with centralized HVAC systems.

○ Adaptive Comfort Model in ASHRAE Standard 55-2004

In naturally ventilated spaces where occupants can open and close windows, their thermal response will depend in part on the outdoor climate, and may have a wider comfort range than in buildings with centralized HVAC systems. This model assumes occupants adapt their clothing to thermal conditions, and are sedentary (1.0 to 1.3 met). There must be no mechanical Cooling System, but this method does not apply if a Mechanical Heating System is in operation.

Figure 5-5: Used Standard in Climate Consultant Software

For the model we are using, California Energy Code Comfort Model, 2008, because it is newer than the other models in the software, and also it is closer to the data we are using for other analysis.

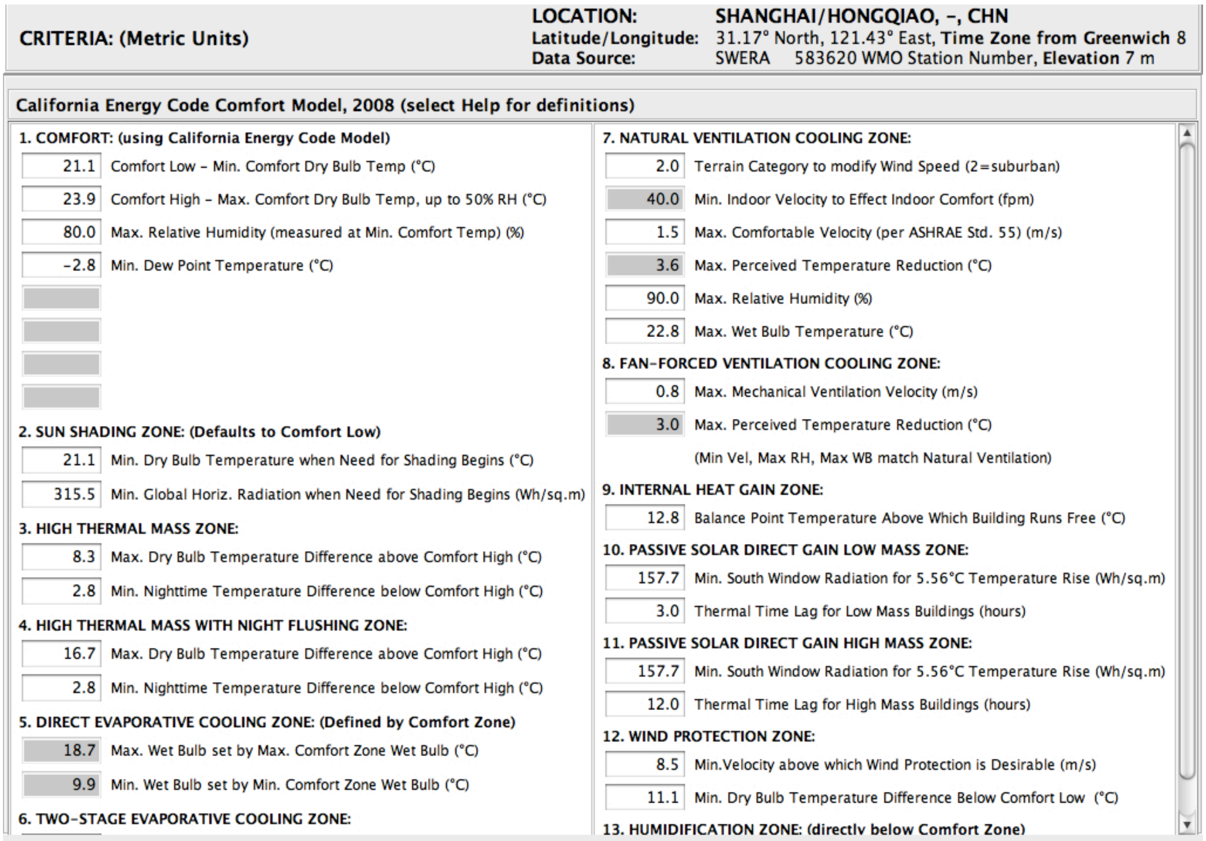


Figure 5-6: Weather Data Values from Climate Consultant Software

In this model, the indoor conditions are 50% relative humidity and 23.9°C for the maximum comfort dry-bulb temperature in this relative humidity. The outdoor conditions are 80% maximum relative humidity and -2.8°C for the minimum dew point temperature.

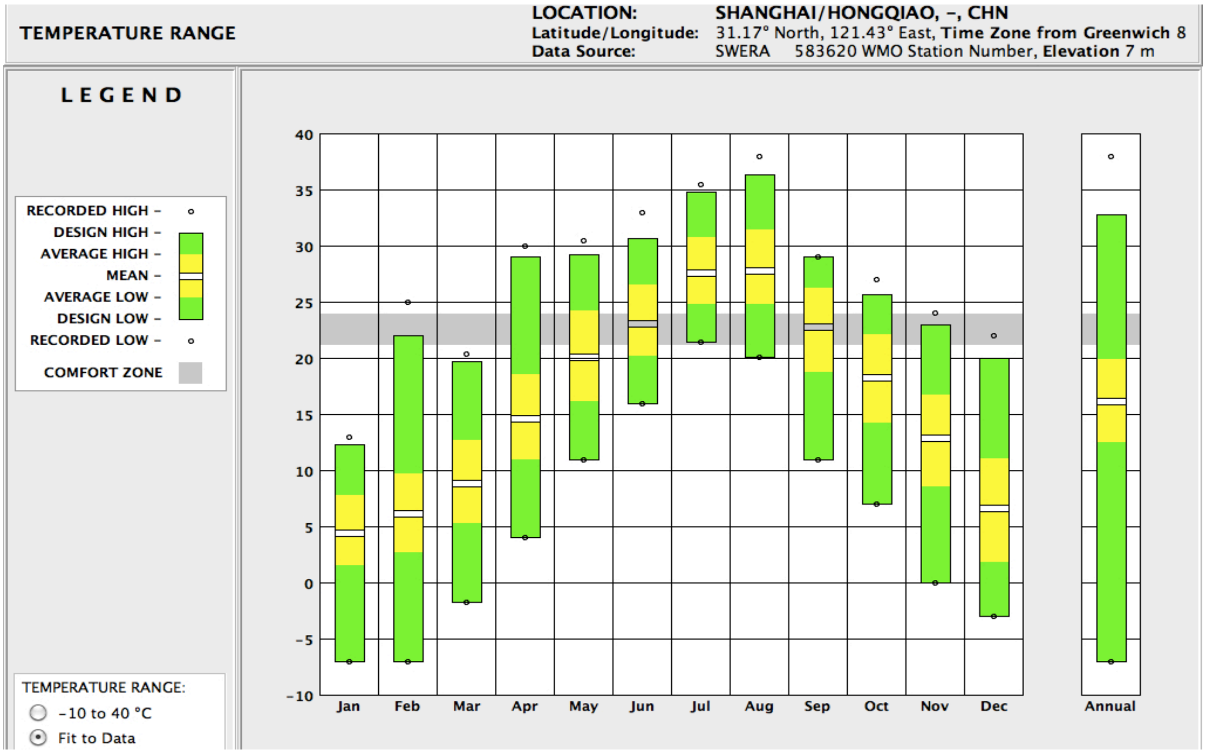


Figure 5-7: Temperature Range Diagram

As we see from the chart, temperature range is mostly below the comfort range but still the annual average is not so low and is about 16°C.

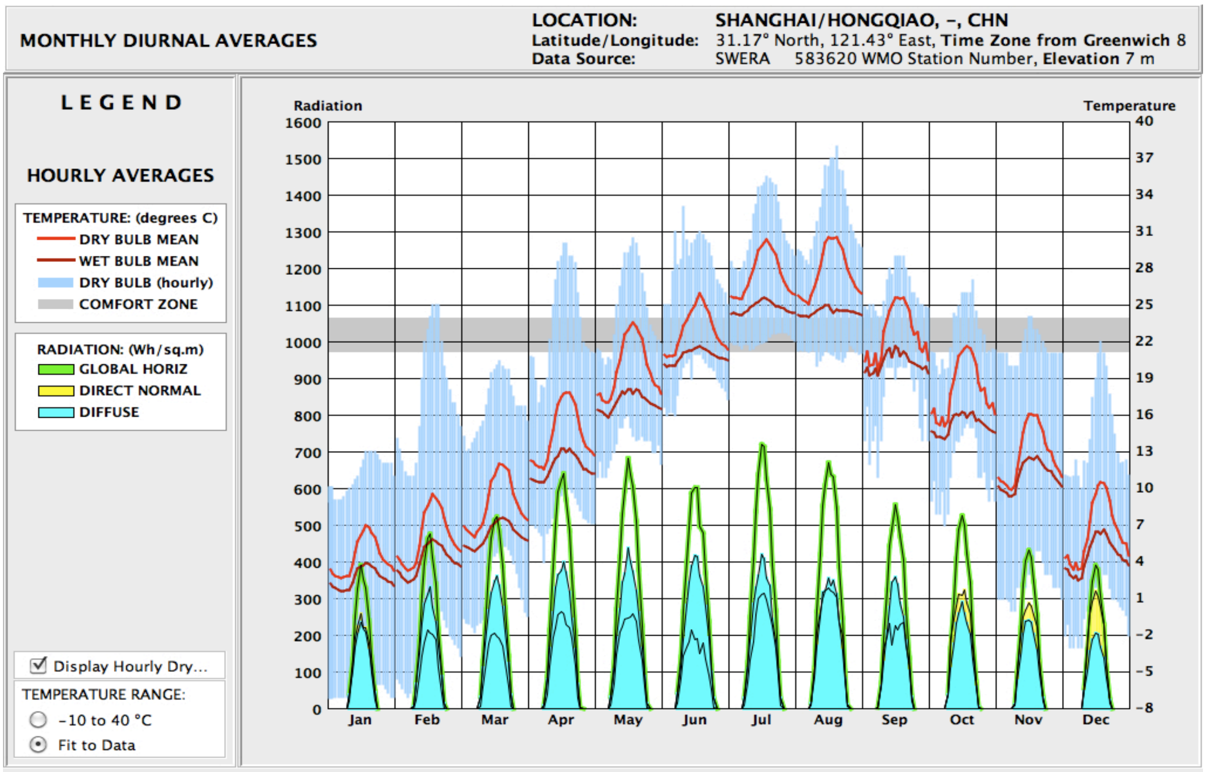


Figure 5-8: Monthly Diurnal Averages

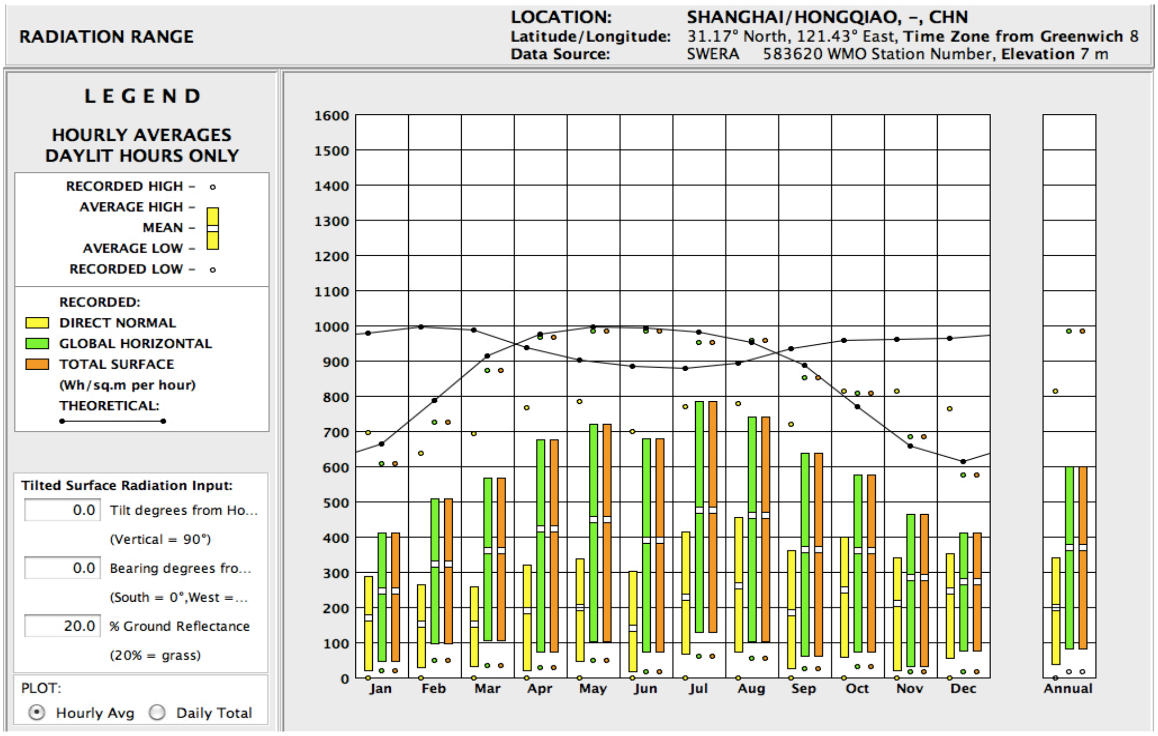


Figure 5-9: Radiation Range, Hourly Average

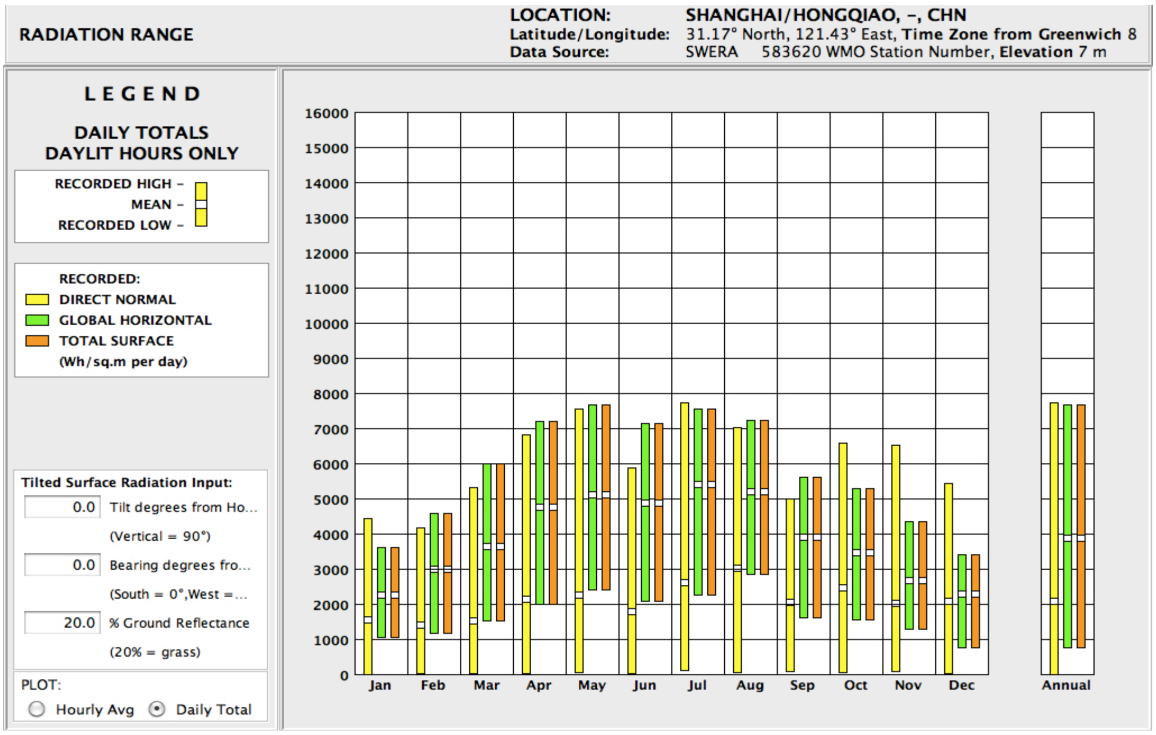


Figure 5-10: Radiation Range, Daily Average

Annual average of direct normal radiation is almost 200 Wh/sqm per hour and almost 2000 Wh/sqm per day. Annual average of global horizontal radiation is almost 380 Wh/sqm per hour and almost 3900 Wh/sqm per day. Annual average of total surface radiation is almost the same as the annual average of global horizontal radiation.

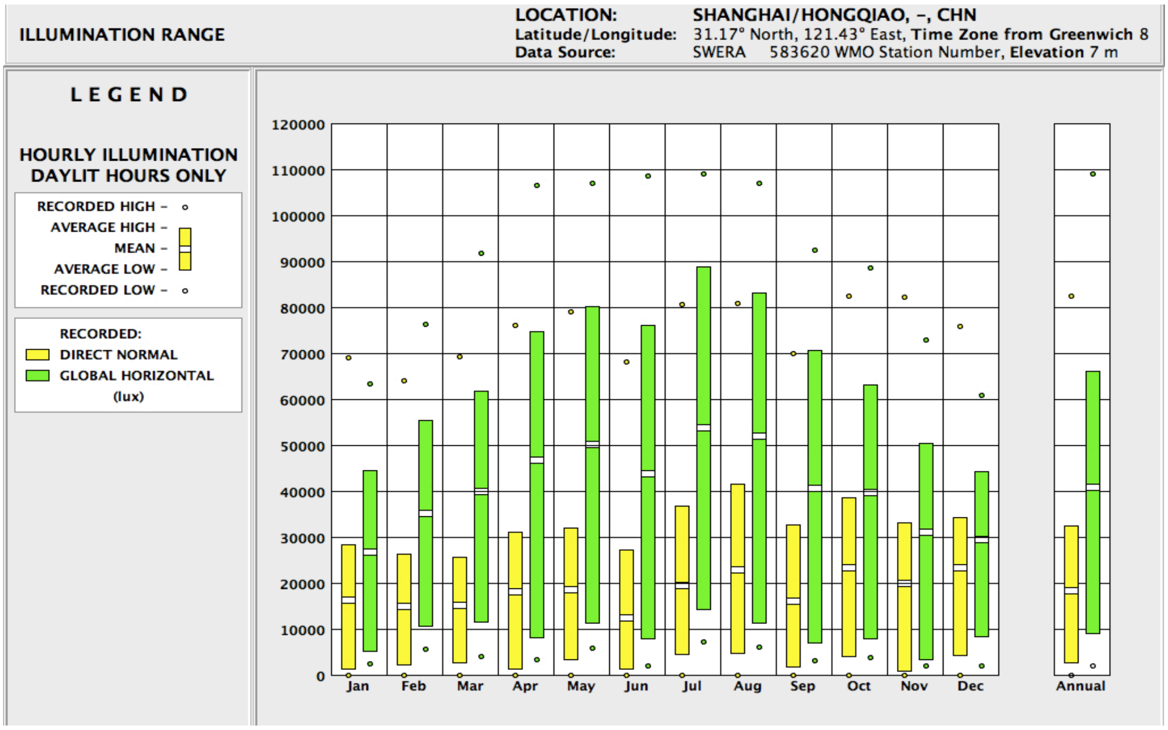


Figure 5-11: Illumination Range

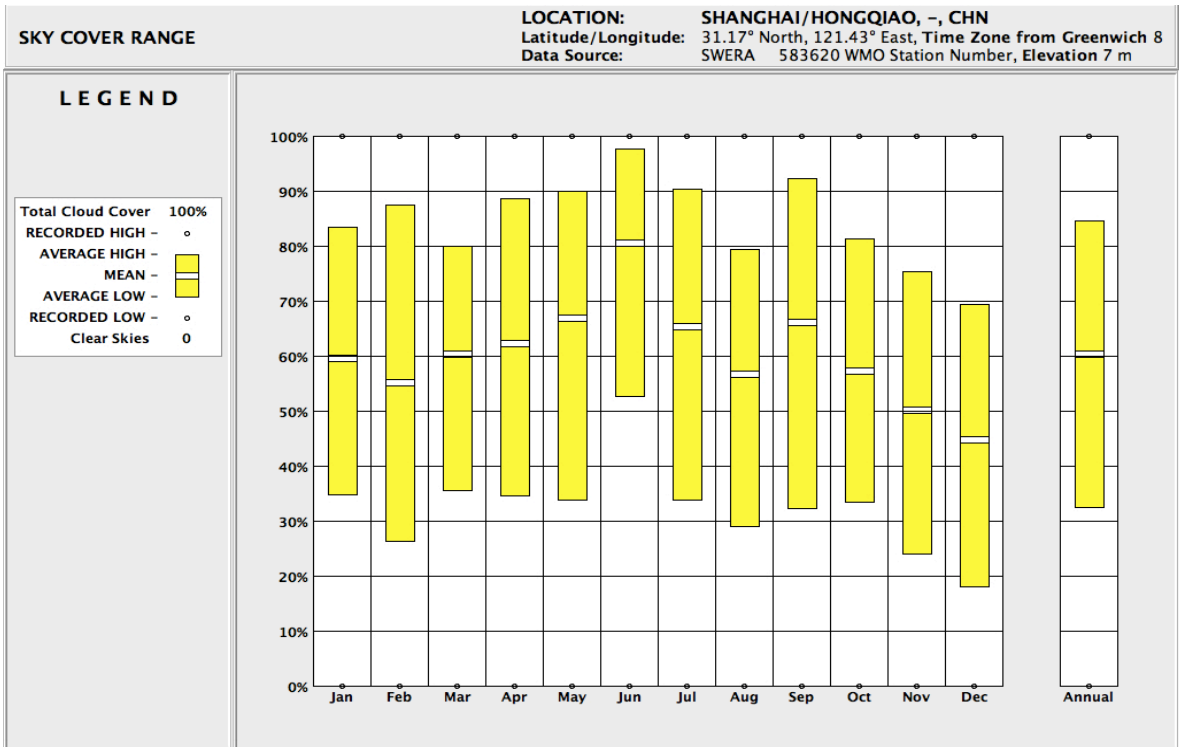


Figure 5-12: Sky Cover Range

From the chart we understand that averagely most of the year the sky is more than half covered and the annual average of sky cover is almost 60%, which is high and sometimes not economical to use solar collectors except in cases of having a very good orientation.

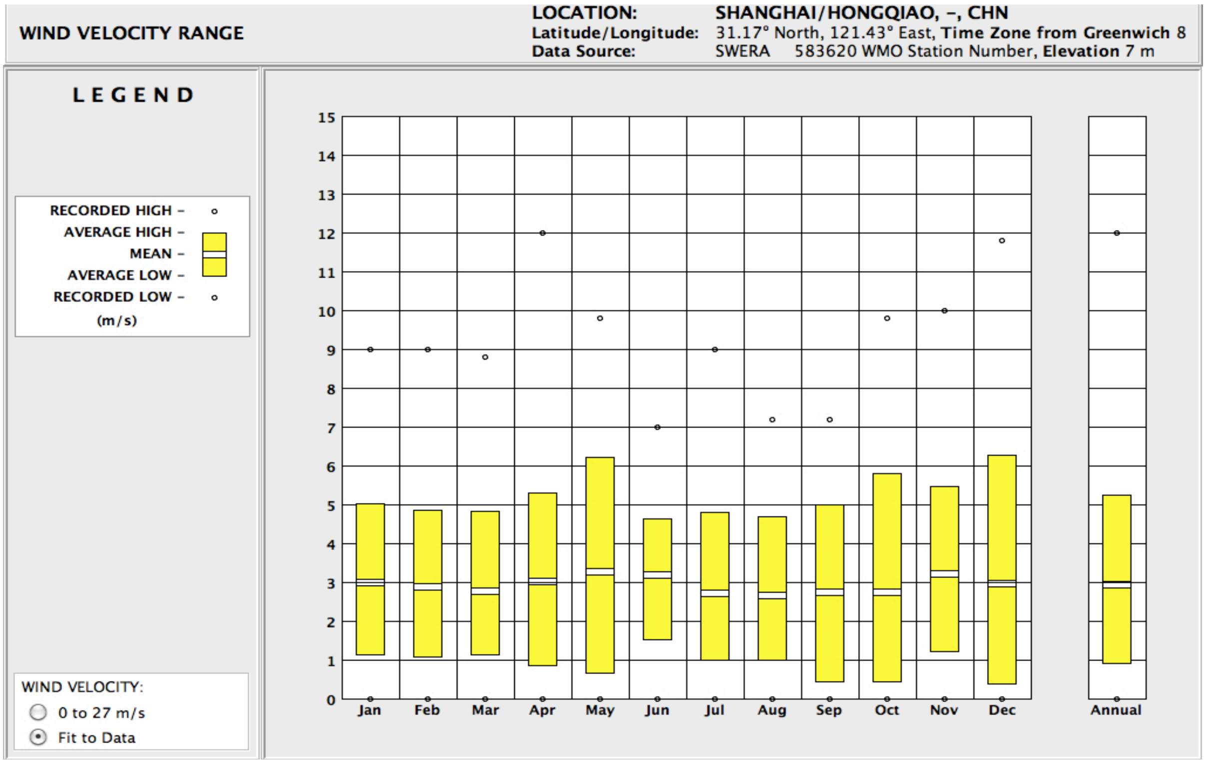


Figure 5-13: Wind Velocity Range

Annual average wind velocity is about 3 m/s, which is low for us to think about wind energy.

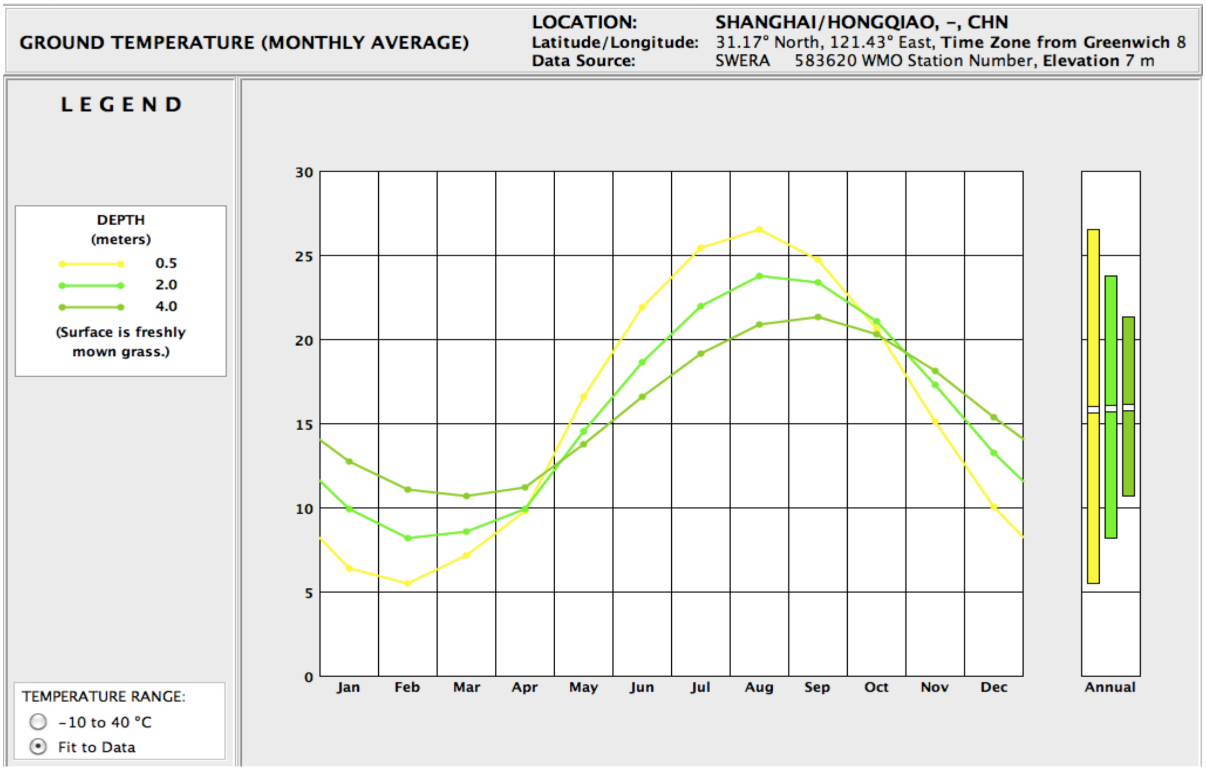


Figure 5-14: Ground Temperature, Monthly Average

Ground temperature range value is very useful for us to see if it is feasible to use heat pumps to generate energy from geothermal energy. We see the annual range and the average of the ground temperature in depth of 0.5m are 6-27 and 16, for the depth of 2.0m these values are 8-24 and 16, and for the depth of 4.0m they are 11-22 and again 16. These ranges and averages are enough to show it is practical to use geothermal energy.

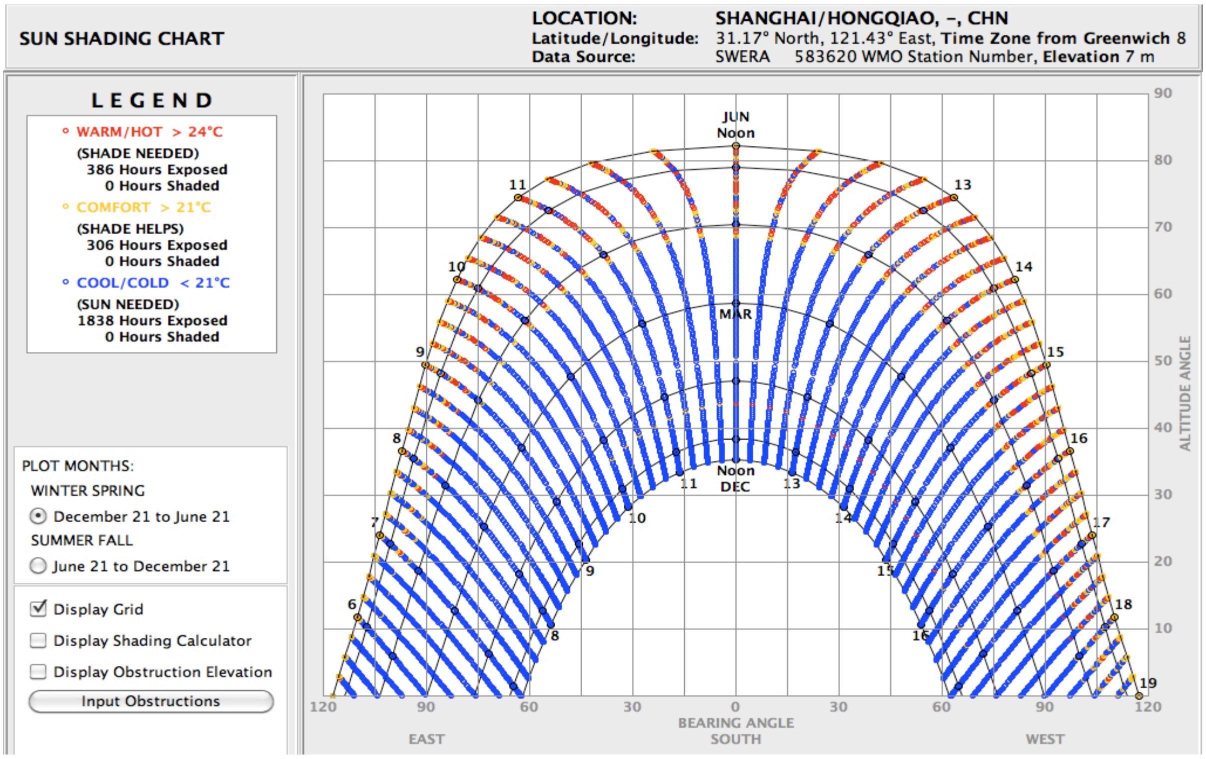


Figure 5-15: Sun Shading Chart, Dec to Jun

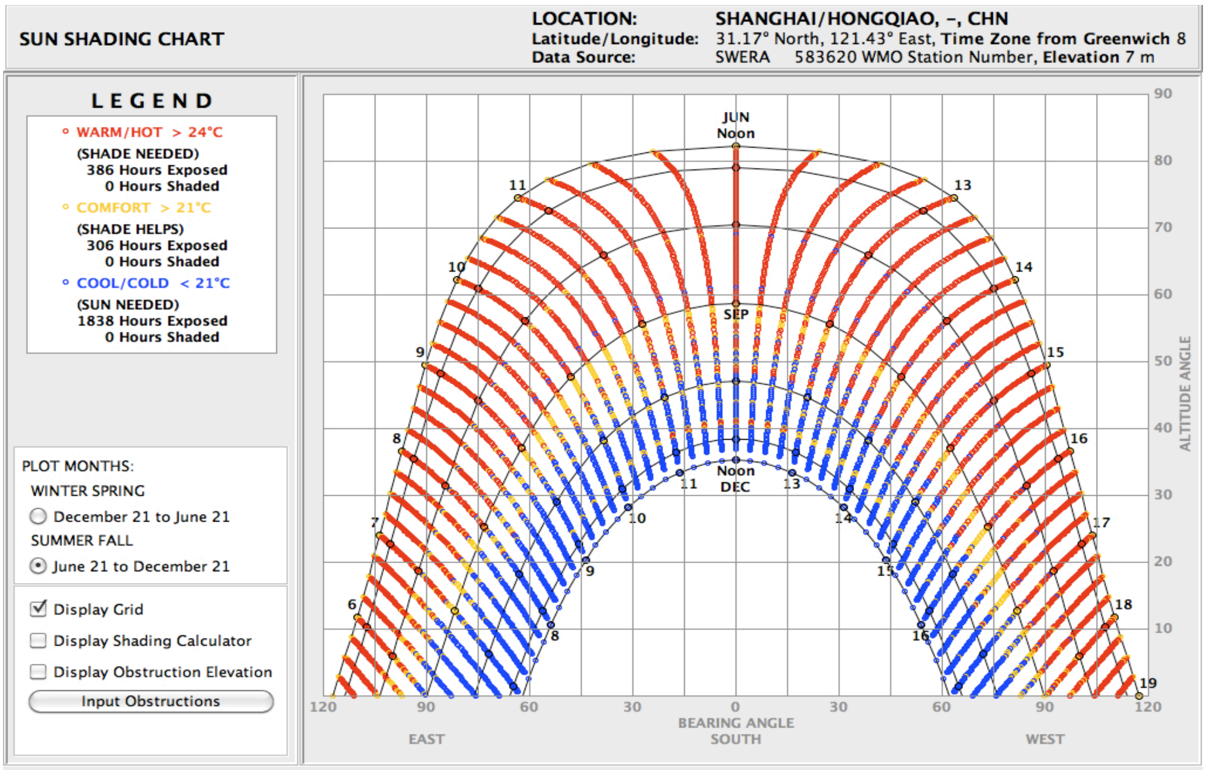


Figure 5-16: Sun Shading Chart, Jun to Dec

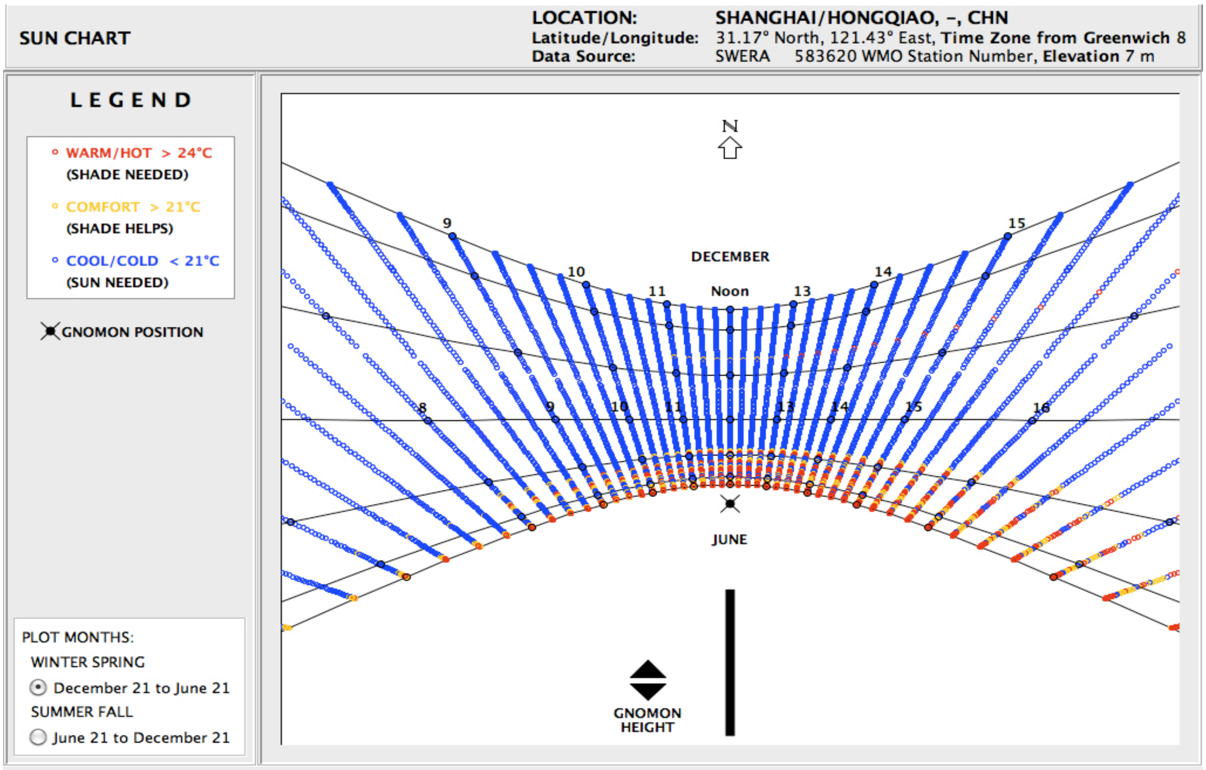


Figure 5-17: Sun Chart, Dec to Jun

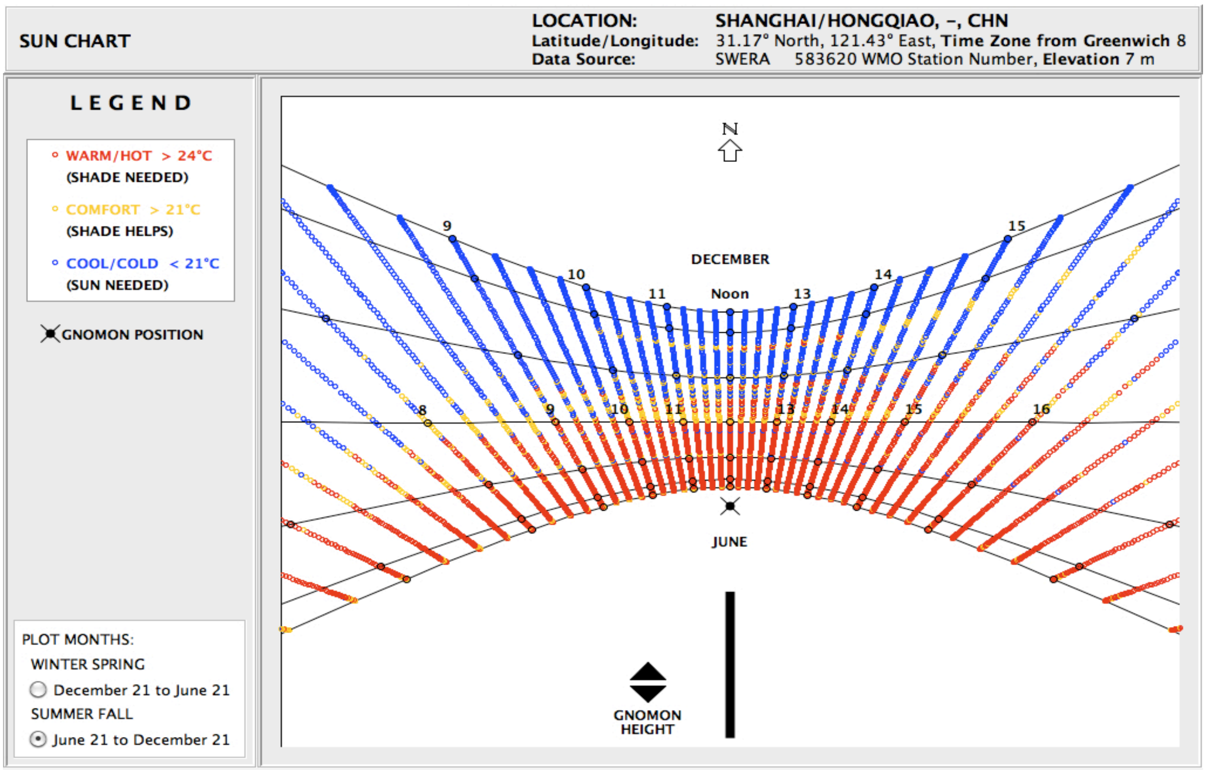


Figure 5-18: Sun Chart, Jun to Dec

From the sun charts and sun shading charts we understand that in the warm months mainly summer shading is needed and in the winter time it is not a problem not to have shading systems and even sometimes there is a need to have sun for lighting and thermal reasons, therefore we should have some kinds of shading systems which can work during summer in the needed hours and we can change the direction in a way to get more sun during the other hours of the year.

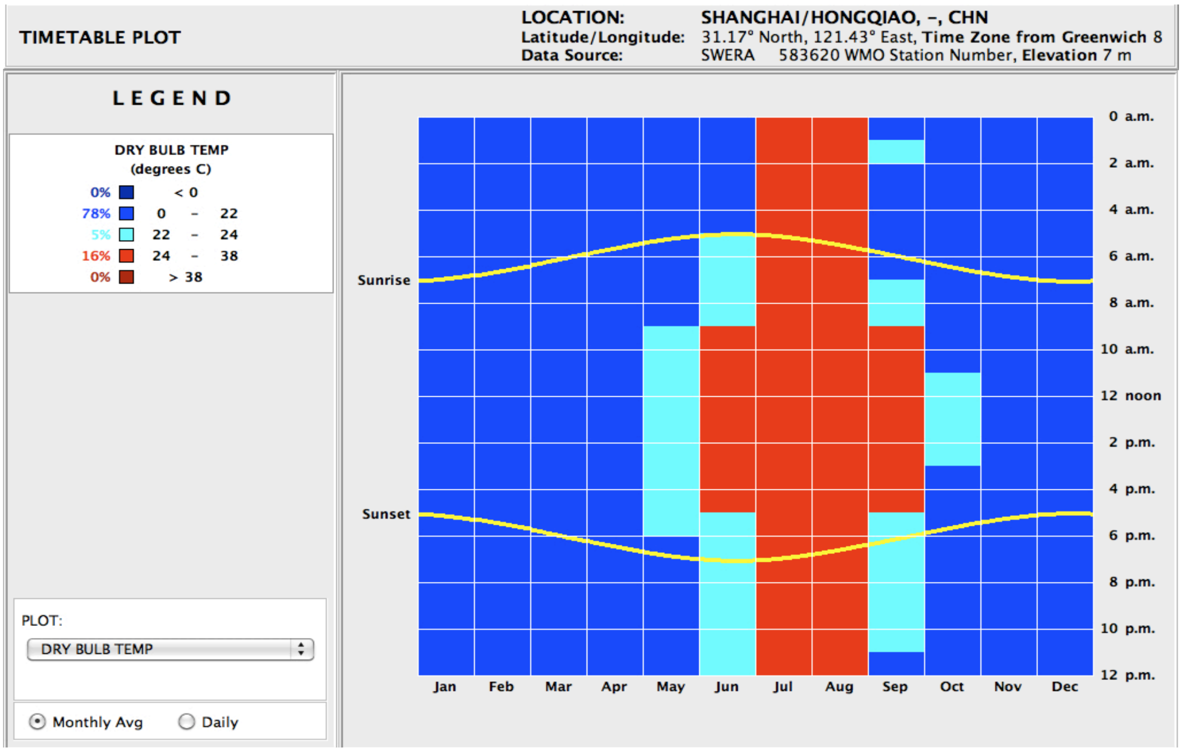


Figure 5-19: Dry Bulb Temperature, Monthly

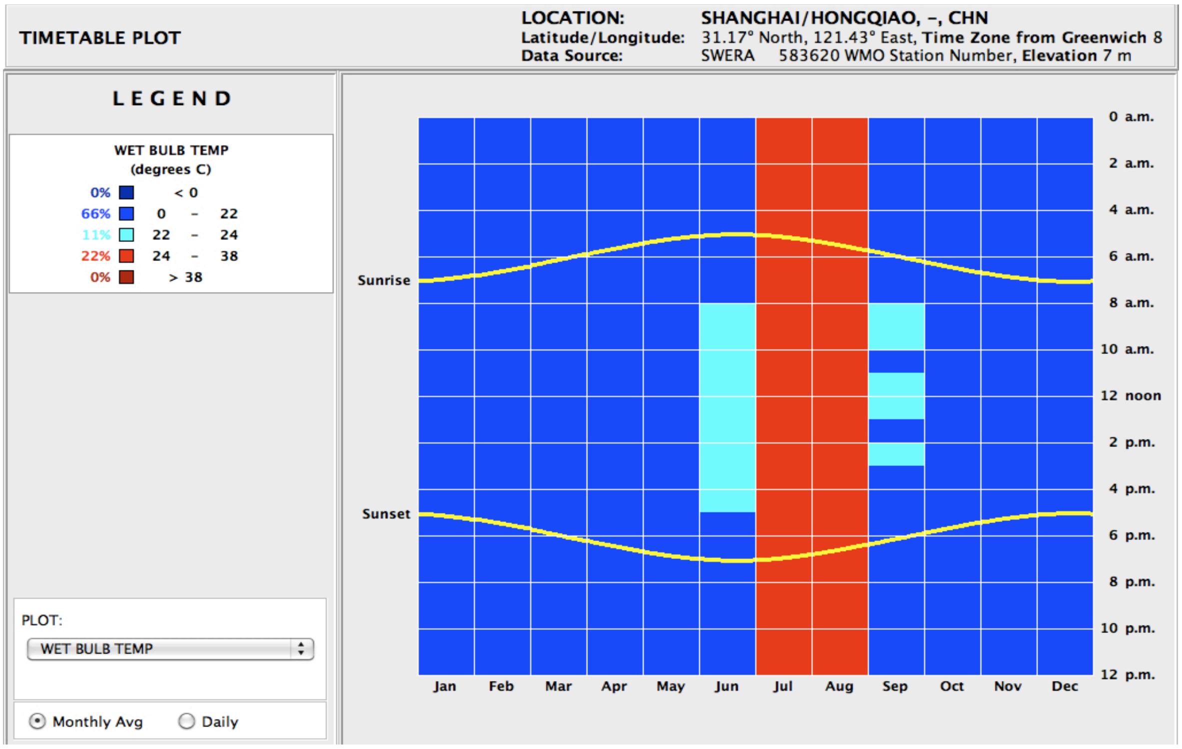


Figure 5-20: Wet Bulb Temperature, Monthly

From the plots, we can get that the dry-bulb temperature range in 78% of the time is from 0 to 22 which is below the comfort range, 5% of the time it is in the comfort range which is between 22 and 24 and only 16% of the time it is between 24 and 38 which is more than the comfort range.

These percentages are almost the same for the wet-bulb temperature as well, which are 66% below the comfort range 11% in the comfort range and 22% more than the comfort range.

July and August are the two major months with the high dry-bulb and wet-bulb temperature, June and September are the two main months with both temperature in the comfort range, and the other months of the year have mainly the temperature less than the comfort range.

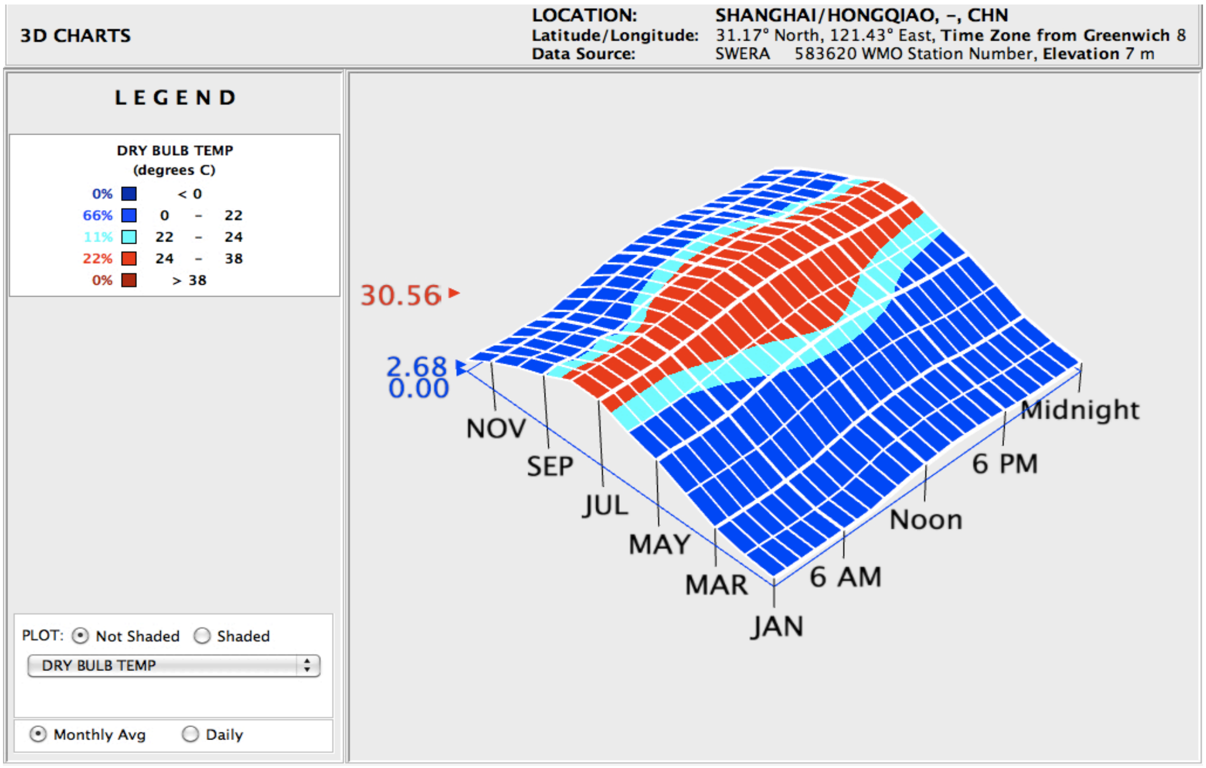


Figure 5-21: Dry Bulb Temperature, 3D Diagram

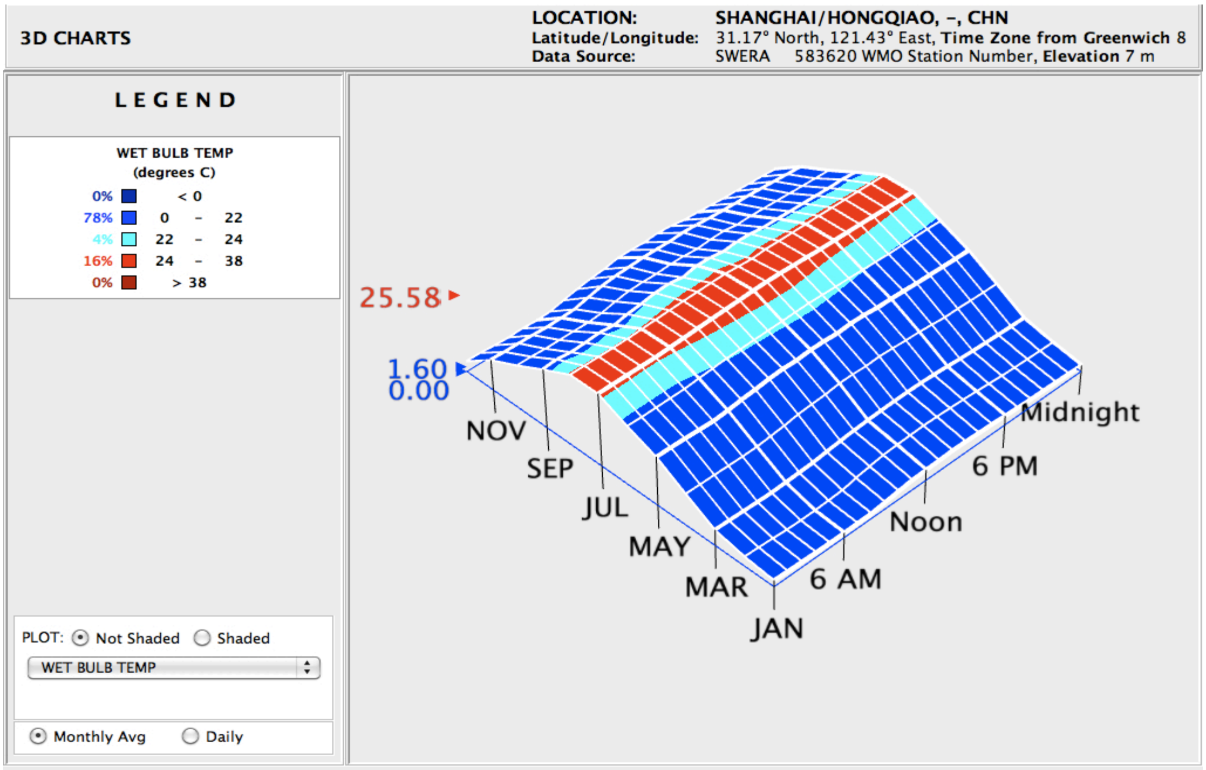


Figure 5-22: Wet Bulb Temperature, 3D Diagram

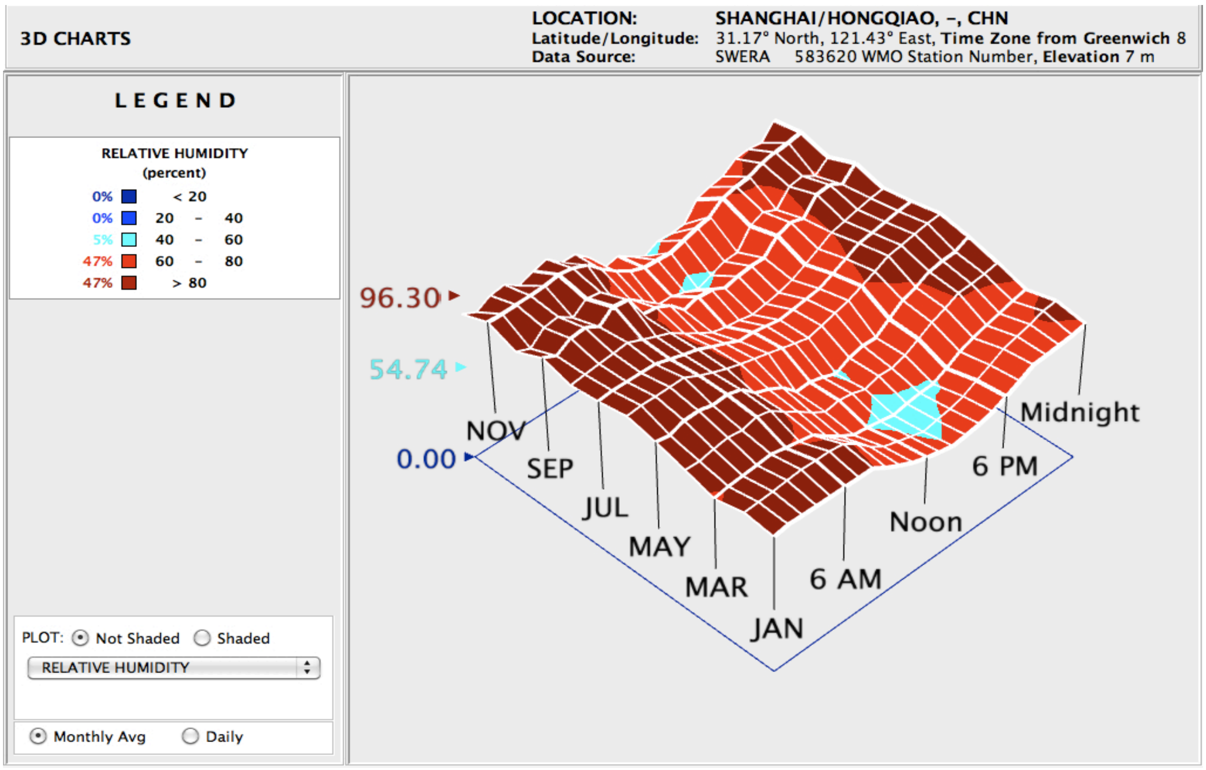


Figure 5-23: Relative Humidity, 3D Diagram

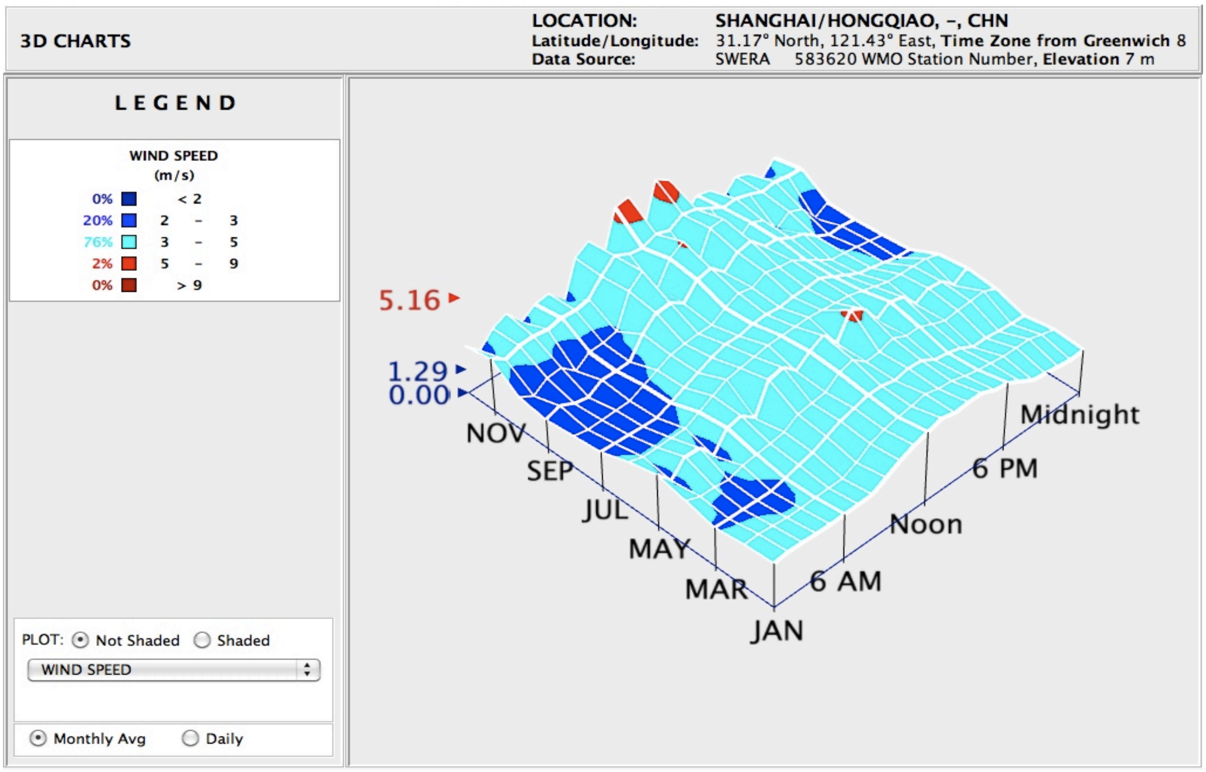


Figure 5-24: Wind Speed, 3D Diagram

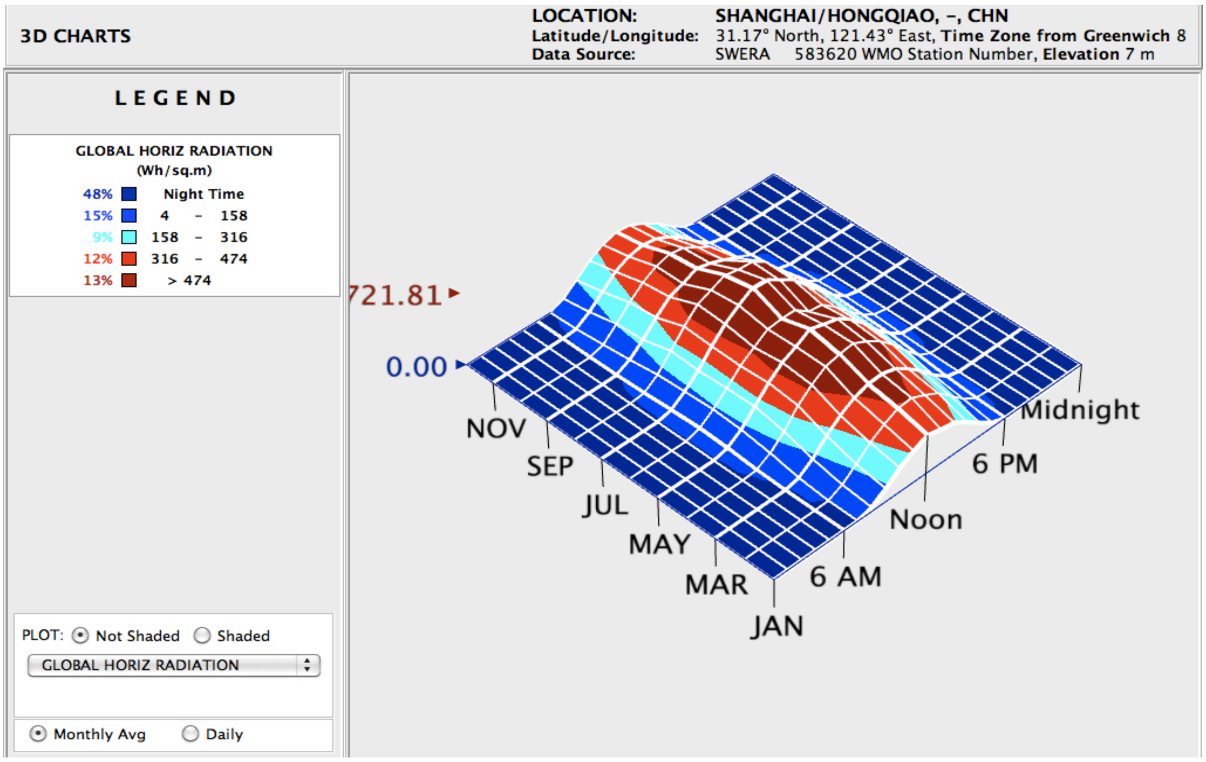


Figure 5-25: Global Horizontal Radiation, 3D Diagram

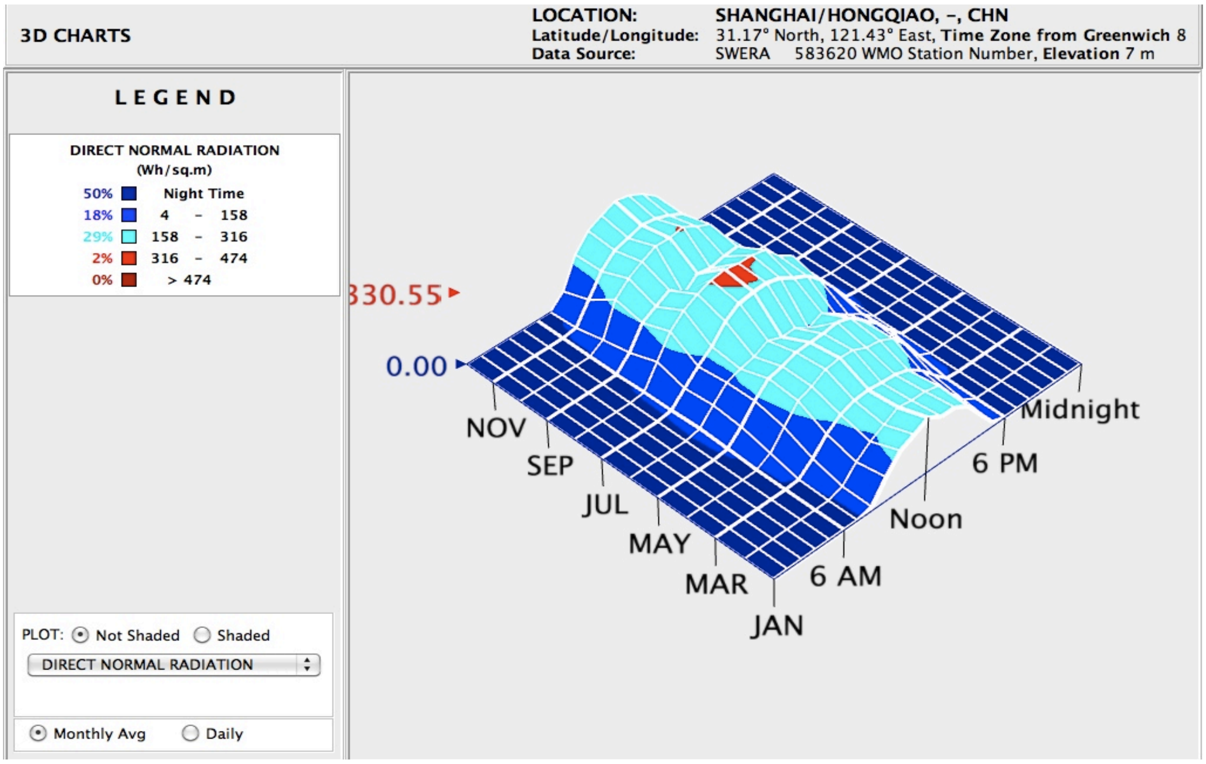


Figure 5-26: Direct Normal Radiation, 3D Diagram

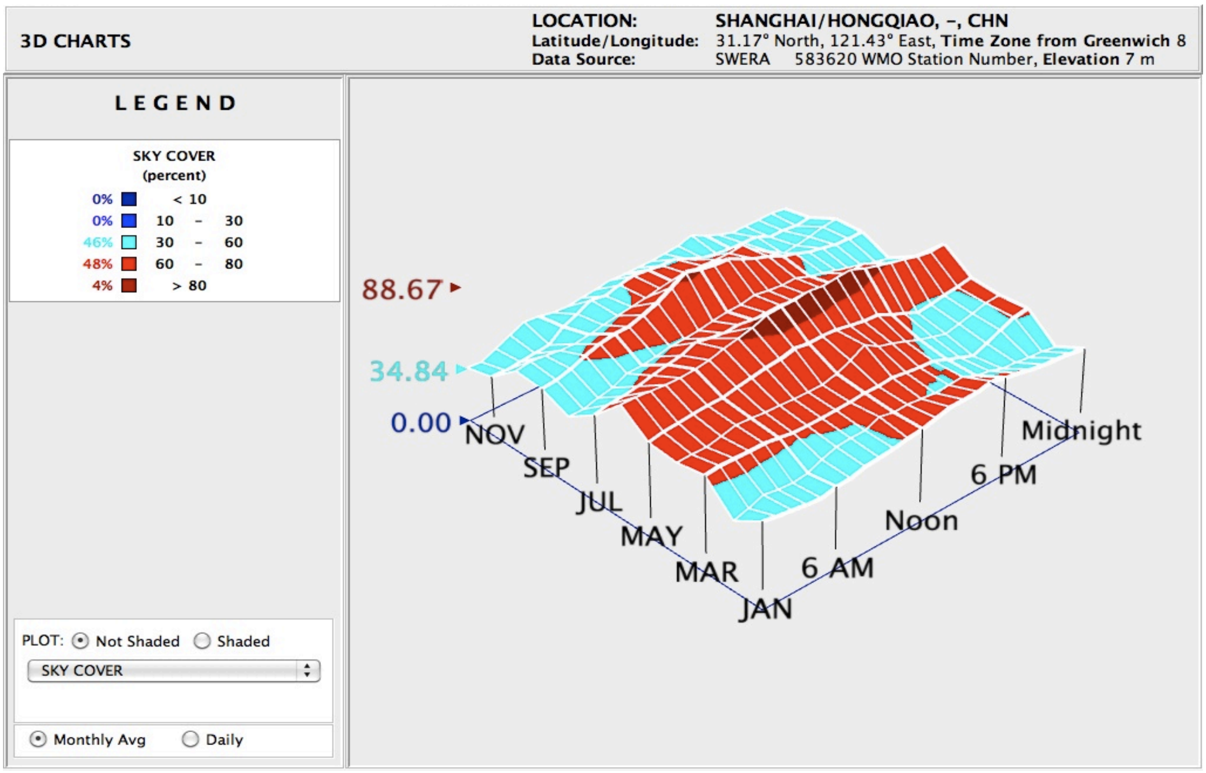


Figure 5-27: Sky Cover, 3D Diagram

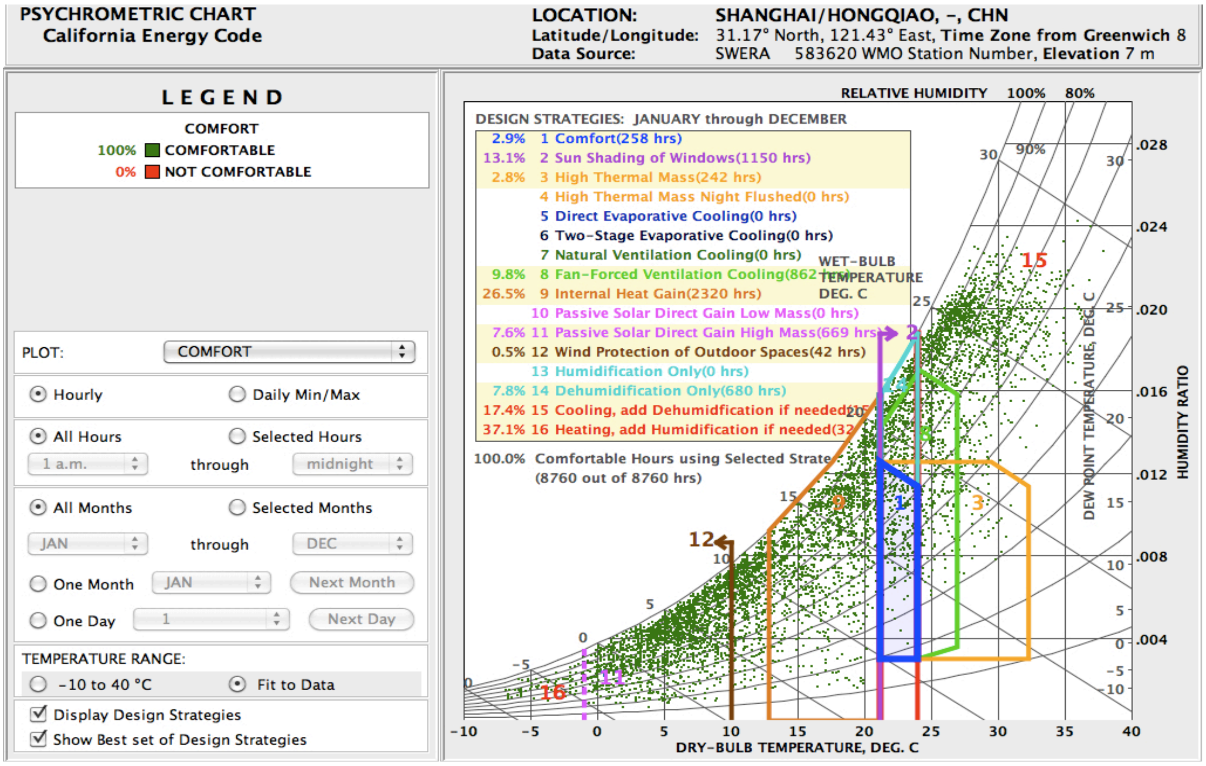


Figure 5-28: Psychrometric Chart

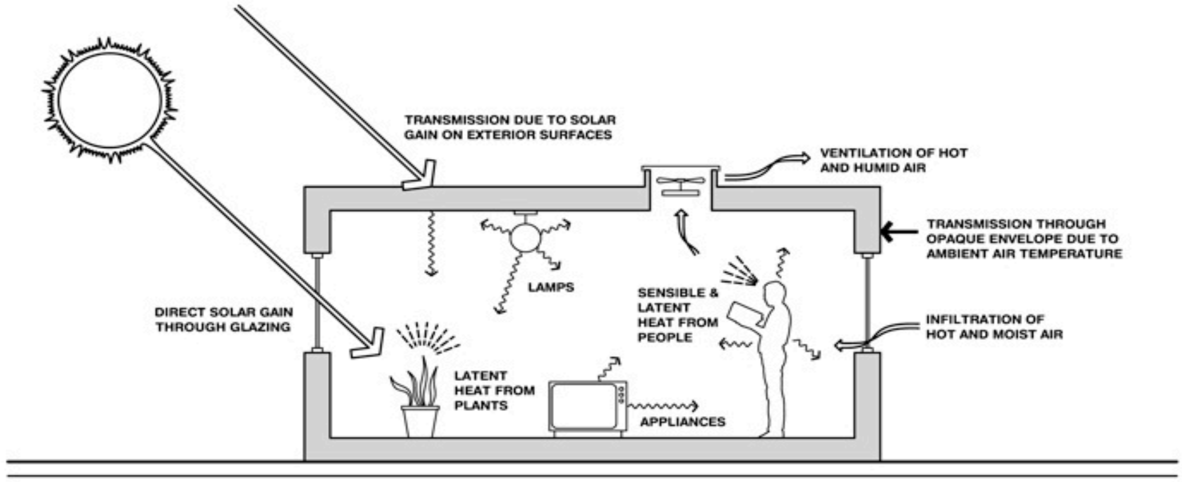
DESIGN GUIDELINES (for the Full Year)
User Modified Criteria
User Modified Design Strategies

LOCATION: SHANGHAI/HONGQIAO, -, CHN
Latitude/Longitude: 31.17° North, 121.43° East, **Time Zone from Greenwich** 8
Data Source: SWERA 583620 WMO Station Number, **Elevation** 7 m

Assuming only the Design Strategies that were selected on the Psychrometric Chart, 100.0% of the hours will be Comfortable.
This list of Design guidelines applies specifically to this particular climate, starting with the most important first.
Click on a Guideline to see a sketch of how this Design Guideline shapes building design. (See Help for more details.)

11	Heat gain from equipment, lights, and occupants will greatly reduce heating needs so keep home tight, well insulated (use ventilation in summer).
18	Keep the building small (right-sized) because excessive floor area wastes heating and cooling energy.
3	Lower the indoor comfort temperature at night to reduce heating energy consumption (lower thermostat heating setback) (see comfort low criteria).
10	Glazing should minimize conductive loss and gain (minimize U-factor) because undesired radiation gain or loss has less impact in this climate.
37	Window overhangs (designed for this latitude) or operable sunshades (extend in summer, retract in winter) can reduce or eliminate air conditioning.
42	On hot days ceiling fans or indoor air motion can make it seem cooler by at least 5 degrees F (2.8C) thus less air conditioning is needed.
4	Extra insulation (super insulation) might prove cost effective, and will increase occupant comfort by keeping indoor temperatures more uniform.
15	High Efficiency furnace (at least Energy Star) should prove cost effective.
14	Locate garages or storage areas on the side of the building facing the coldest wind to help insulate.
8	Sunny wind-protected outdoor spaces can extend living areas in cool weather.
16	Trees (neither conifer nor deciduous) should not be planted in front of passive solar windows, but rather beyond 45 degrees from each corner.
59	In this climate air conditioning will always be required, but can be greatly reduced if building design minimizes overheating.
35	Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes.
26	A radiant barrier (shiny foil) will help reduce radiated heat gain through the roof in hot climates.
38	Raising the indoor comfort temperature limit will reduce air conditioning energy consumption (raise thermostat cooling setpoint) (see Criteria).
1	Tiles or slate (even on low mass wood floors) or a stone-faced fireplace can help store winter daytime solar gain and summer nighttime 'coolth'.
63	Traditional homes in cold overcast climates used low mass tightly sealed, well insulated construction to provide rapid heat buildup in morning.
5	Carefully seal building to minimize infiltration and eliminate drafts, especially in windy sites (house wrap, weather stripping, tight windows) .
31	Organize floorplan so winter sun penetrates into daytime use spaces with specific functions that coincide with solar orientation.
40	High mass interior surfaces like stone, brick, tile, or slate, feel naturally cool on hot days and can reduce day-to-night temperature swings.

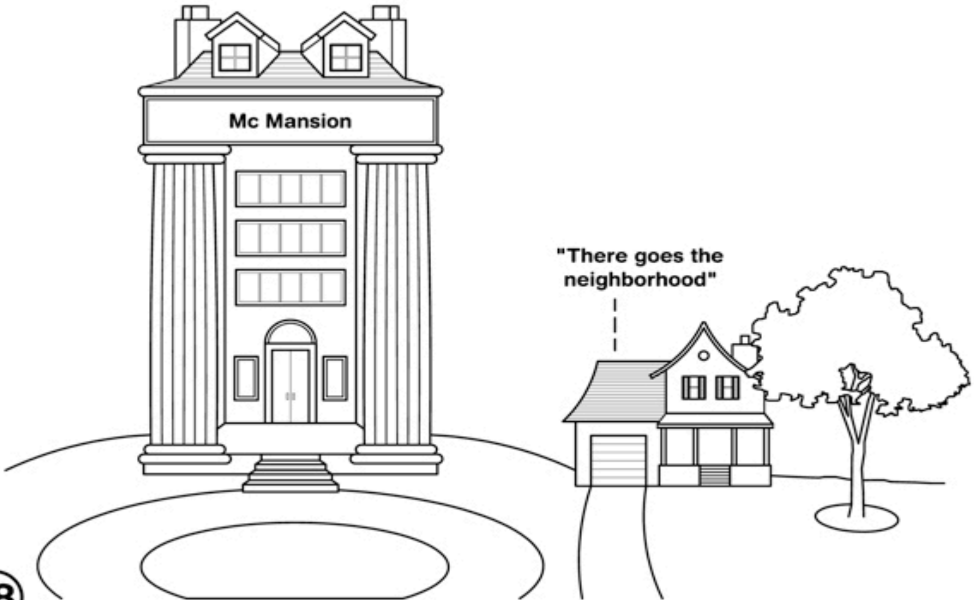
Figure 5-29: Design Guidelines



(11)

Heat gain from equipment, lights, and occupants will greatly reduce heating needs so keep home tight, well insulated (use ventilation in summer).

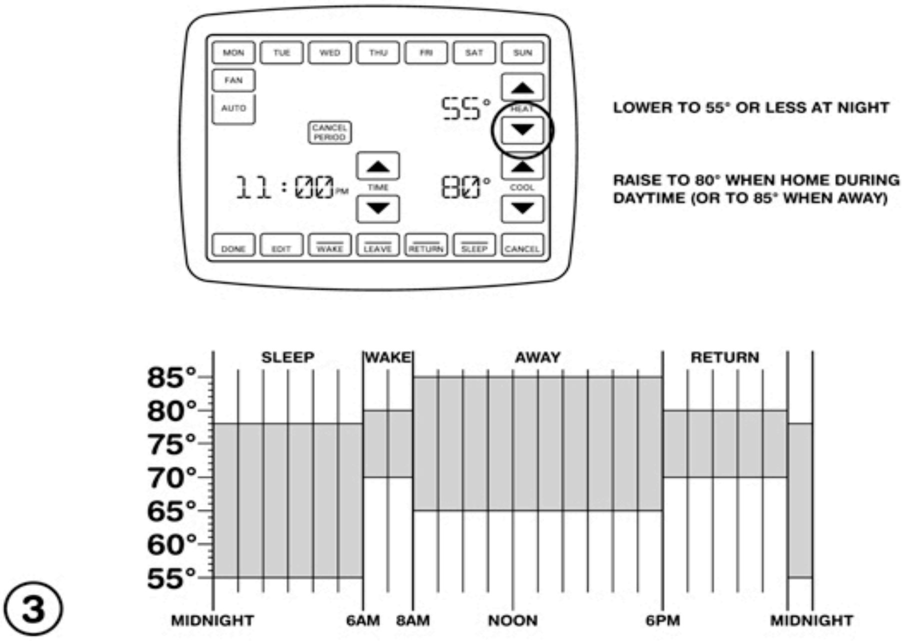
Figure 5-30: Design Guidelines



(18)

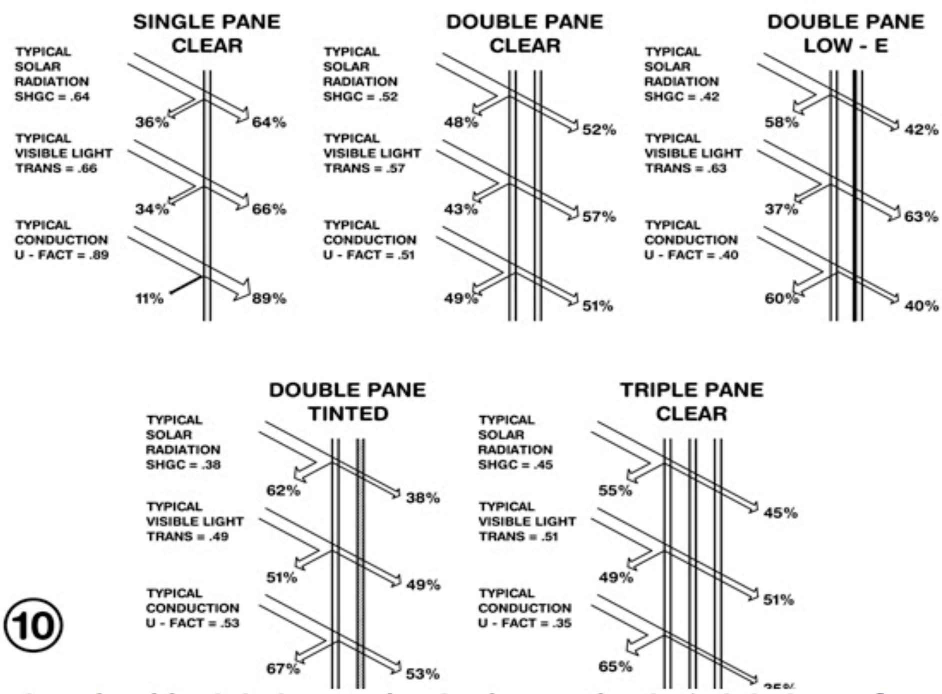
Keep the building small (right-sized) because excessive floor area wastes heating and cooling energy.

Figure 5-31: Design Guidelines



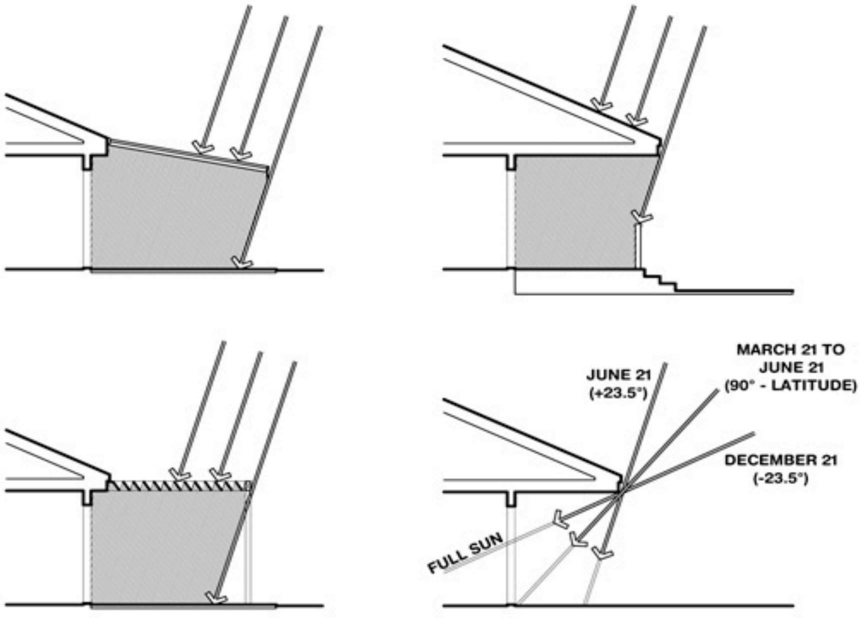
Lower the indoor comfort temperature at night to reduce heating energy consumption (lower thermostat heating setback) (see comfort low criteria).

Figure 5-32: Design Guidelines



Glazing should minimize conductive loss and gain (minimize U-factor) because undesired radiation gain or loss has less impact in this climate.

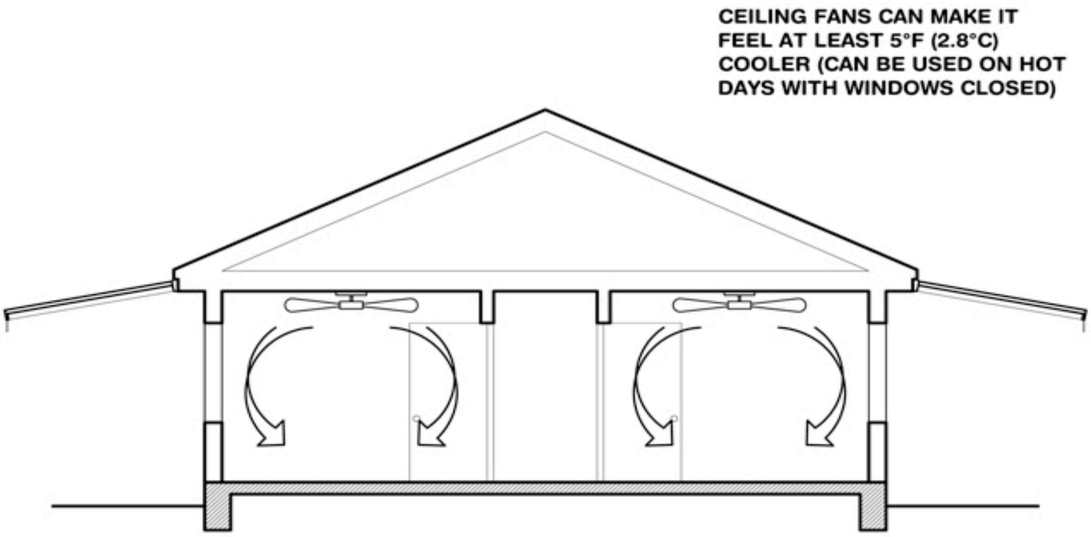
Figure 5-33: Design Guidelines



37

Window overhangs (designed for this latitude) or operable sunshades (extend in summer, retract in winter) can reduce or eliminate air conditioning.

Figure 5-34: Design Guidelines



42

On hot days ceiling fans or indoor air motion can make it seem cooler by at least 5 degrees F (2.8C) thus less air conditioning is needed.

Figure 5-35: Design Guidelines

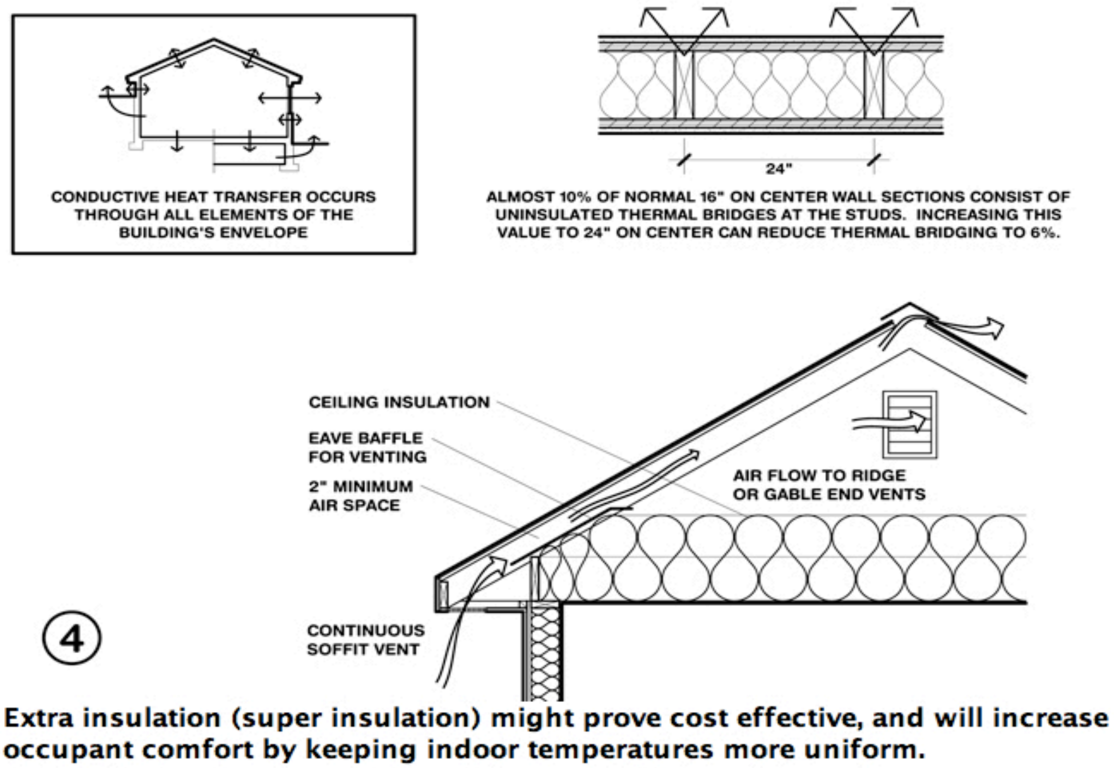


Figure 5-36: Design Guidelines

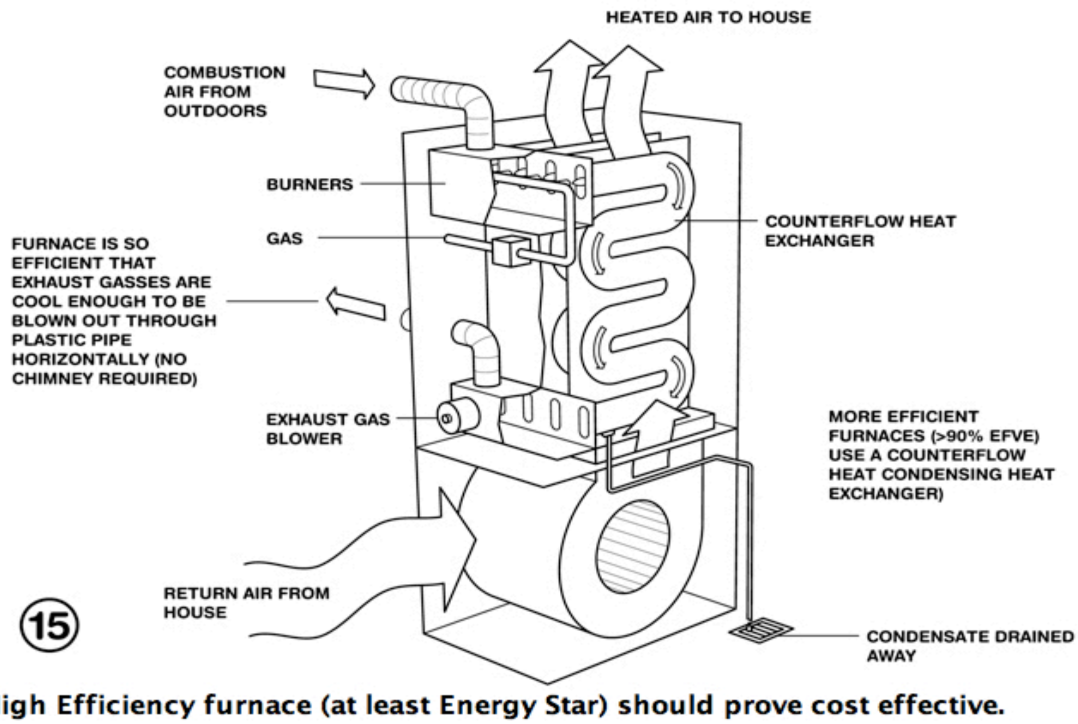
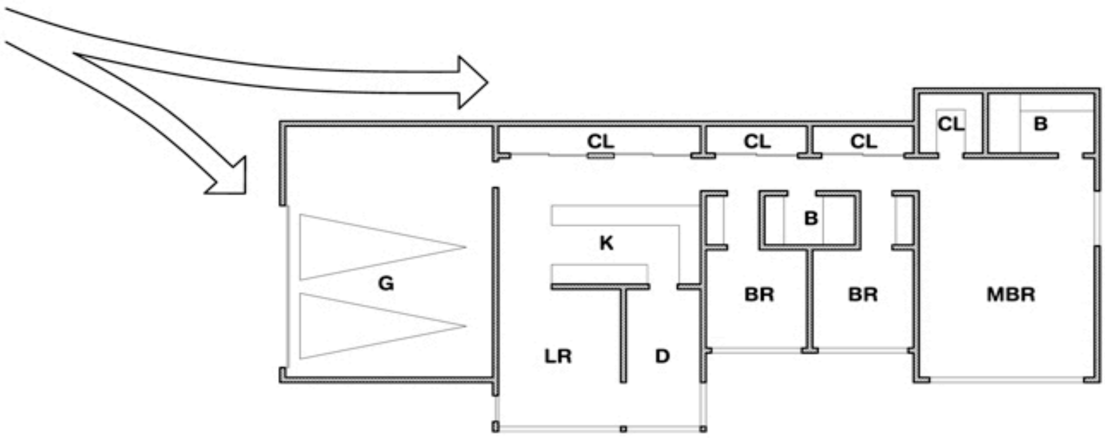


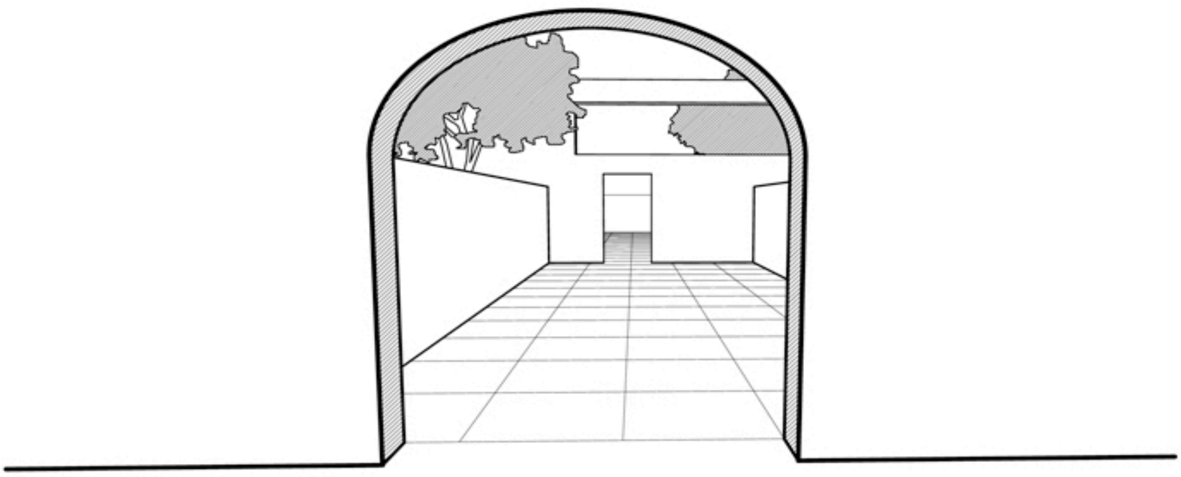
Figure 5-37: Design Guidelines



⑭

Locate garages or storage areas on the side of the building facing the coldest wind to help insulate.

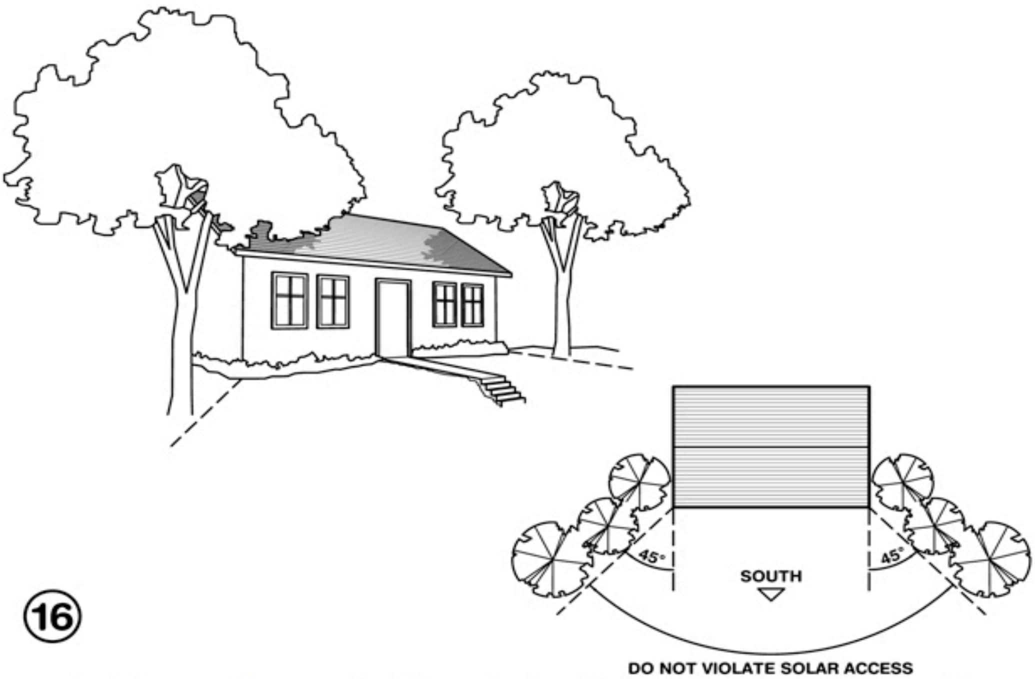
Figure 5-38: Design Guidelines



⑧

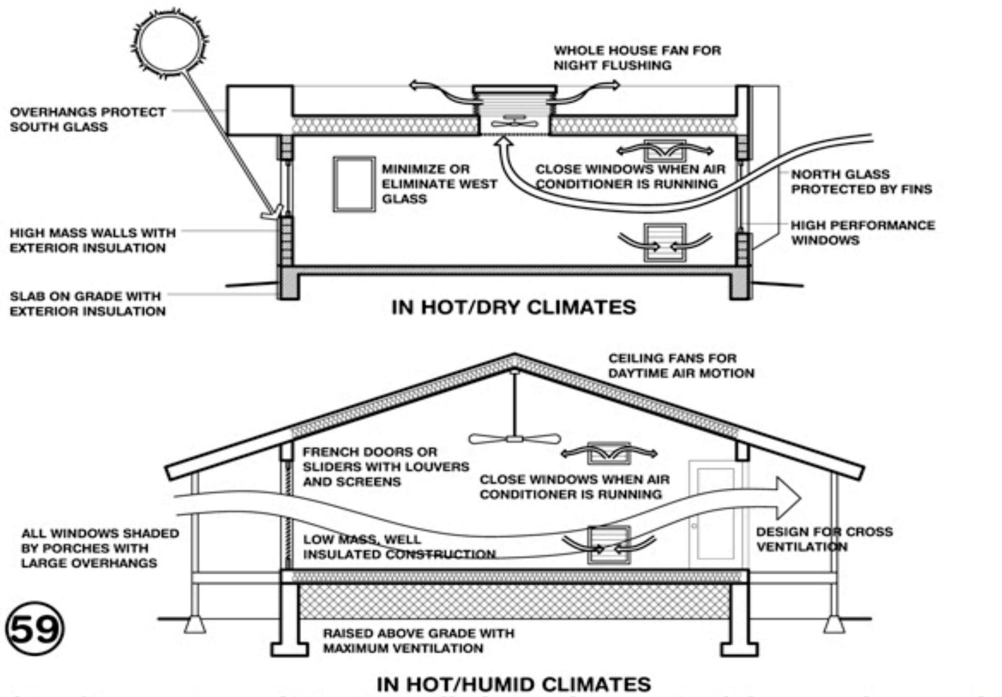
Sunny wind-protected outdoor spaces can extend living areas in cool weather.

Figure 5-39: Design Guidelines



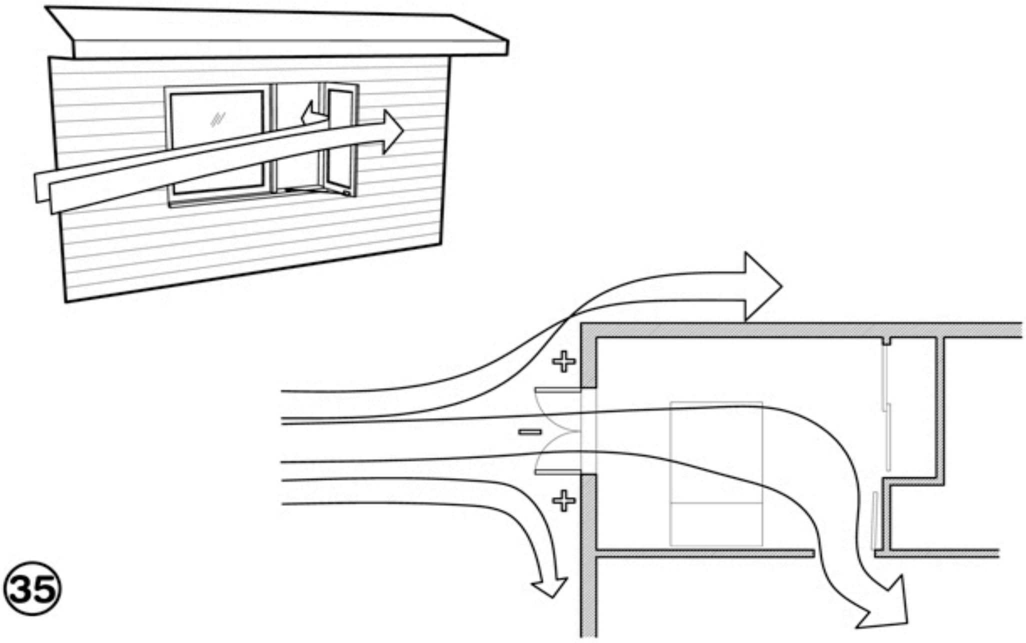
Trees (neither conifer nor deciduous) should not be planted in front of passive solar windows, but rather beyond 45 degrees from each corner.

Figure 5-40: Design Guidelines



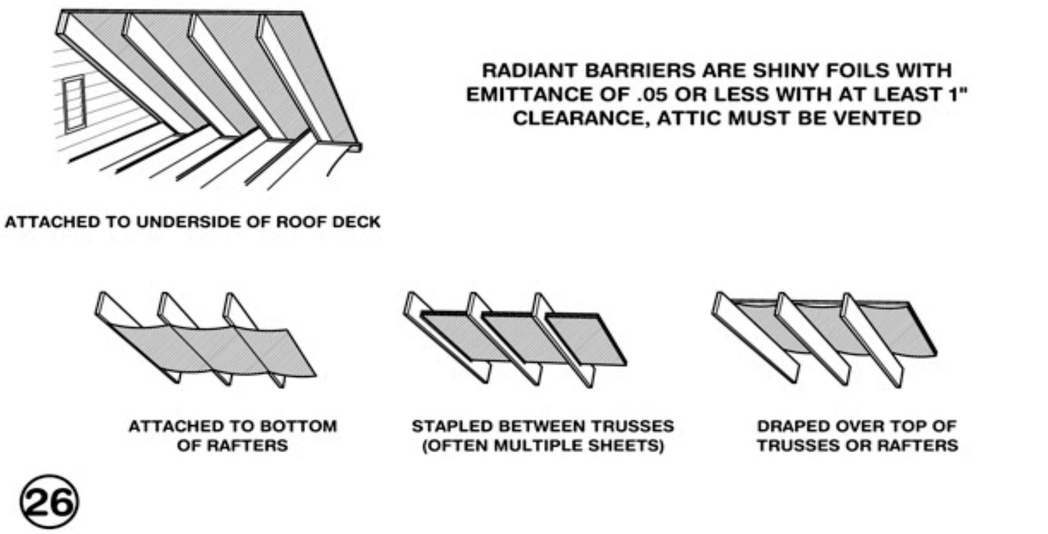
In this climate air conditioning will always be required, but can be greatly reduced if building design minimizes overheating.

Figure 5-41: Design Guidelines



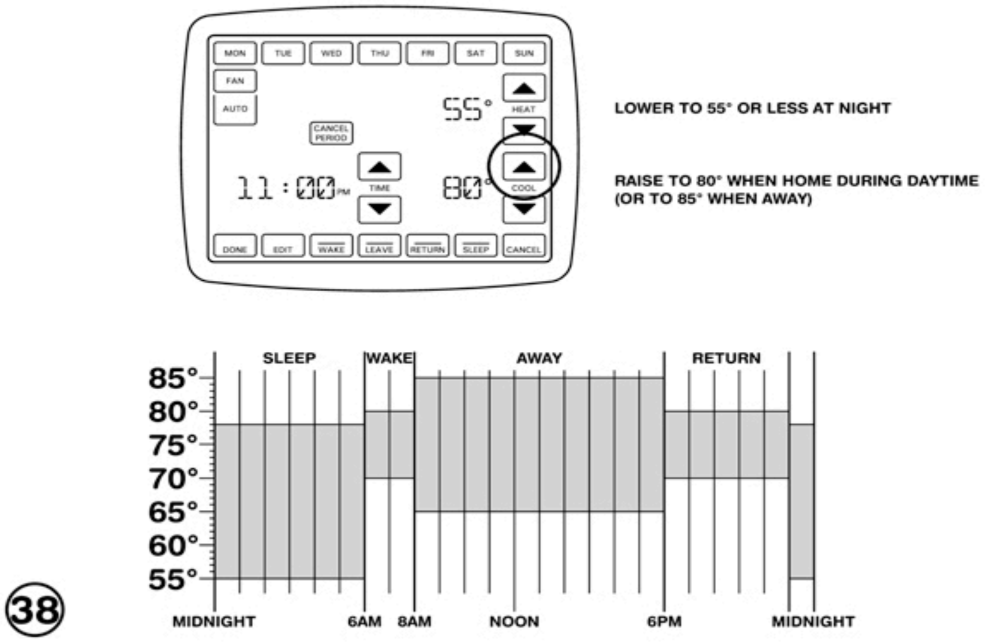
Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes.

Figure 5-42: Design Guidelines



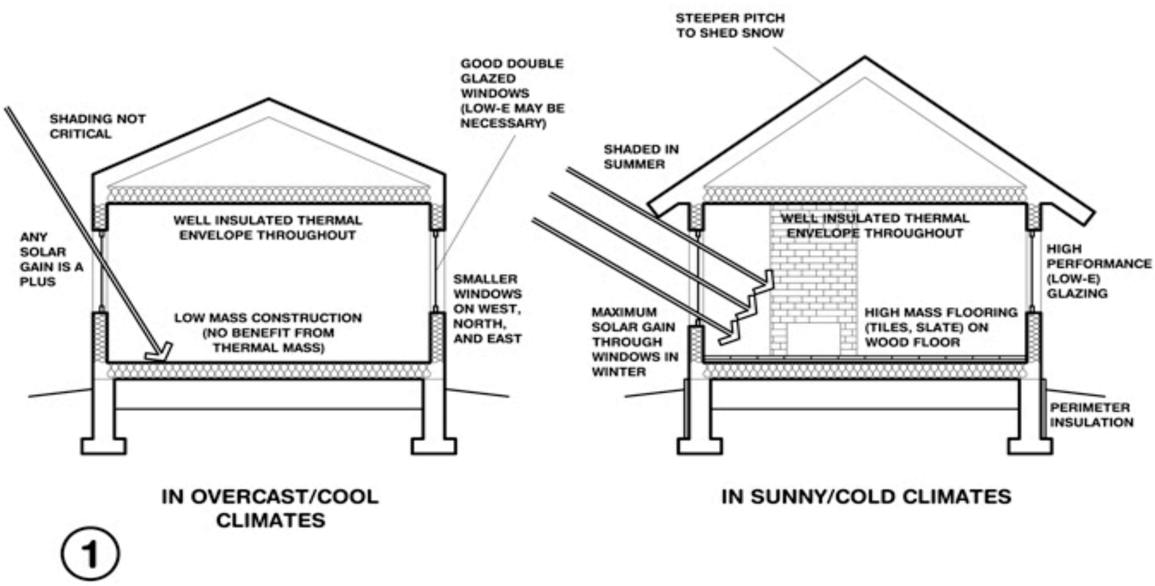
A radiant barrier (shiny foil) will help reduce radiated heat gain through the roof in hot climates.

Figure 5-43: Design Guidelines



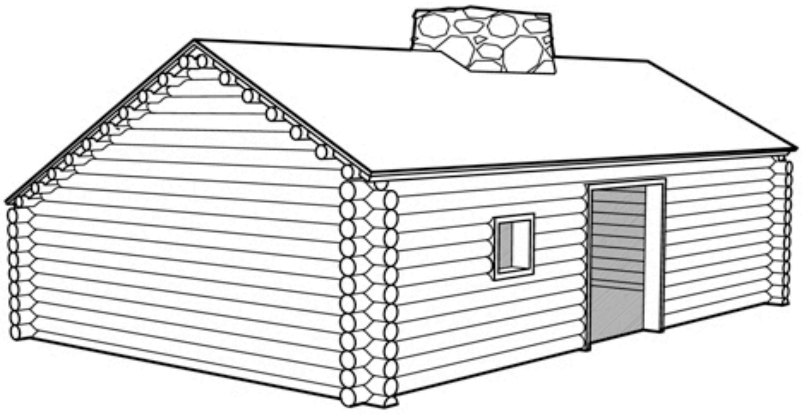
Raising the indoor comfort temperature limit will reduce air conditioning energy consumption (raise thermostat cooling setpoint) (see Criteria).

Figure 5-44: Design Guidelines



Tiles or slate (even on low mass wood floors) or a stone-faced fireplace can help store winter daytime solar gain and summer nighttime 'coolth'.

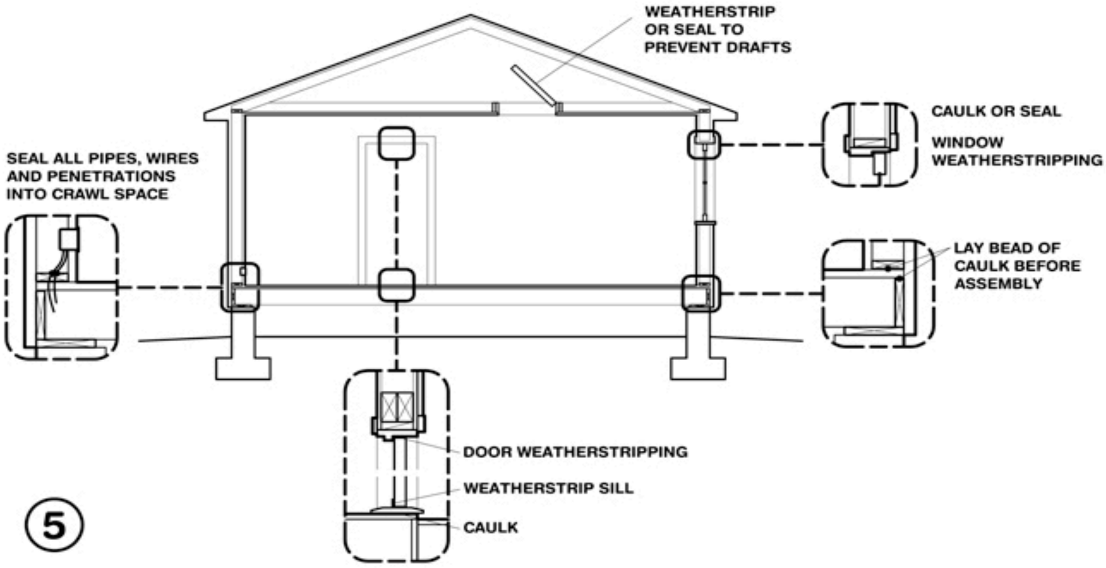
Figure 5-45: Design Guidelines



63

Traditional homes in cold overcast climates used low mass tightly sealed, well insulated construction to provide rapid heat buildup in morning.

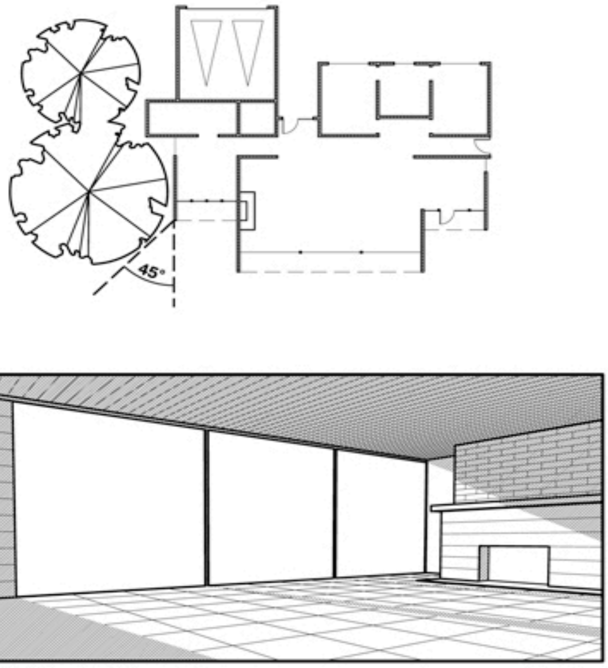
Figure 5-46: Design Guidelines



5

Carefully seal building to minimize infiltration and eliminate drafts, especially in windy sites (house wrap, weather stripping, tight windows) .

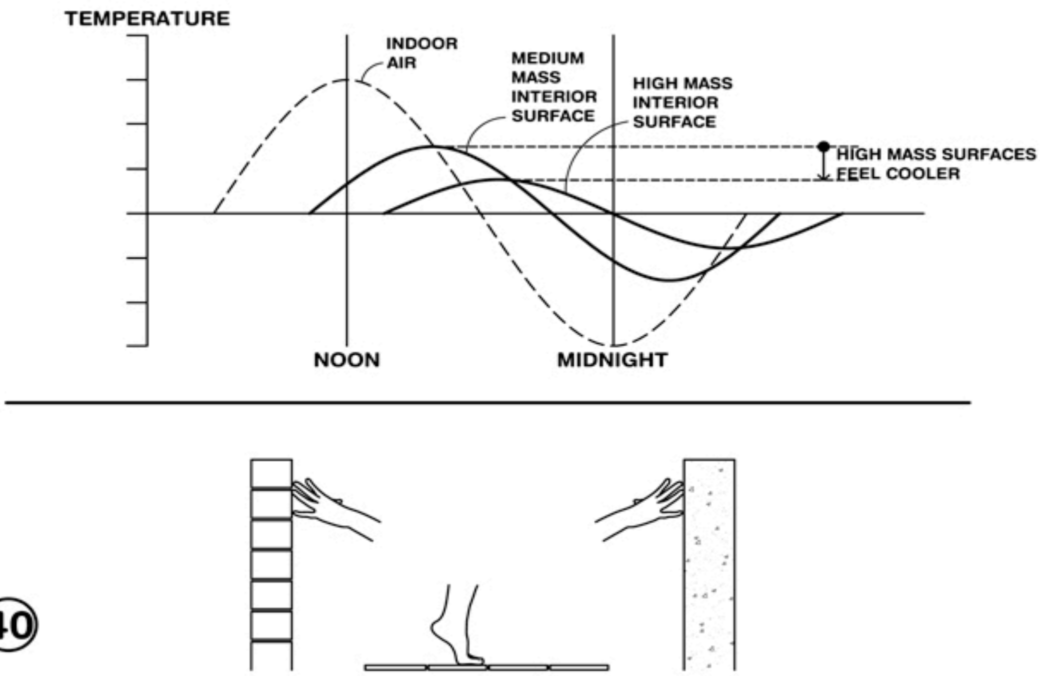
Figure 5-47: Design Guidelines



31

Organize floorplan so winter sun penetrates into daytime use spaces with specific functions that coincide with solar orientation.

Figure 5-48: Design Guidelines



40

High mass interior surfaces like stone, brick, tile, or slate, feel naturally cool on hot days and can reduce day-to-night temperature swings.

Figure 5-49: Design Guidelines

5.3. Calculating HDD and CDD:

5.3.1. Heating/Cooling Set Point

According to a study, a typical residential building model is simulated in "Design Builder" with settings following the average value from measurements and surveys. According to this model, the average set points for heating and cooling in the real situation are 12 °C and 29 °C. The real average indoor operative temperatures in heating and cooling periods are 15 °C and 30 °C respectively. They are 3 °C~4 °C different from the ideal indoor temperatures. The indoor thermal conditions both in heating and cooling periods are unsatisfied, since it is cooler in winter and warmer in summer. This study also shows that, in Shanghai, the indoor thermal condition in winter is much worse than in summer. Improvement of the building thermal performance in winter is an emergency.

For this project, since there isn't enough data about specifically Shanghai's Heating and Cooling set points we use the book "Design standard for energy efficiency of residential buildings in hot summer and cold winter zone", according to which, the set points for heating and cooling are suggested to be 18 ◦C and 26 ◦C respectively. These set points are in ideal environment.[19]

The geographical coordinates of the site are 31°23' north and 121°41′ east. For calculating the degree-days we use the website of degree-days [20]and the closest station to our site, which is, ZSSS: Shanghai / Hongqiao, CN (121.34E, 31.20N), and for the suggested heating and cooling set points we get the results below.

Later with the help of ECOTECT we can have precise values for the HDD and CDD.

[19] (Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone, 2010)
[20] (ASHRAE Transactions 2002, Honolulu, 2002)(Degreedays Website)

5.3.2. HDD: Heating degree days

Heating degree-days are a measure of how much (in degrees), and for how long (in days), the outside air temperature was below a certain level. They are commonly used in calculations relating to the energy consumption required to heat buildings.

Table 3: HDD, Heating Degree Days

Description:	Celsius-based heating degree days for a base temperature of 18.0C
Source:	www.degreedays.net (using temperature data from www.wunderground.com)
Accuracy:	No problems detected
Station:	Shanghai / Hongqiao, CN (121.34E,31.20N)
Station ID:	ZSSS

Month starting	HDD
10/1/11	18
11/1/11	72
12/1/11	356
1/1/12	411
2/1/12	390
3/1/12	258
4/1/12	53
5/1/12	5
6/1/12	0
7/1/12	0
8/1/12	0
9/1/12	1

The sum of the values for HDD during all the months of the year gives us the total HDD of the year which is 1564 in this case.

5.3.3. CDD: Cooling degree days

Table 4: CDD, Cooling Degree Days

Description:	Celsius-based cooling degree days for a base temperature of 26.0C
Source:	www.degreedays.net (using temperature data from www.wunderground.com)
Accuracy:	No problems detected
Station:	Shanghai / Hongqiao, CN (121.34E,31.20N)
Station ID:	ZSSS

Month starting	CDD
10/1/11	0
11/1/11	0
12/1/11	0
1/1/12	0
2/1/12	0
3/1/12	0
4/1/12	0
5/1/12	10
6/1/12	25
7/1/12	130
8/1/12	104
9/1/12	13

Cooling degree-days are a measure of how much (in degrees), and for how long (in days), the outside air temperature was above a certain level. They are commonly used in calculations relating to the energy consumption required to cool buildings.

5.4. Solar radiation

5.4.1. Overview of the current situation

Using one of the few articles[21] about solar radiation in Shanghai, we can debate on how economical it is to use solar panels in Shanghai.

These values help us to know whether it is economical and practical to use solar panels in our area or not, then we can analyze precisely with ECOTECT to know the exact values.

			Degree Days and Degree Hours				Temperatures				Average Daily Solar Radiation	
Location	Lat (N)	Lon (E)	HDD 18°C	CDD 18°C	CDD 26°C	CDH 26°C	Max. (°C)	Avg. Daily Max (°C)	Avg. Daily Min. (°C)	Min. (°C)	Total Horiz. (W/m²)	Direct Normal (W/m²)
Beijing	39.9	116.3	2684	874	72	3633	39.3	32.1	-8.4	-12.8	3996	4134
Changchun	43.9	125.2	4820	375	0	520	30.8	26.6	-21.5	-25.4	3564	3583
Changsha	28.2	112.9	1556	1352	280	7340	39.2	34.2	0.3	-2.2	2752	1534
Chengdu	30.7	104.0	1426	887	31	2055	33.2	28.3	3.1	-1.3	2422	1094
Chongqing	28.2	112.9	1068	1388	251	6830	38.4	33.1	4.0	2.5	2045	652
Fuzhou	26.1	119.3	800	1605	319	6692	38.8	32.7	5.1	2.4	3011	1607
Guangzhou	23.1	113.3	389	2074	365	8639	35.9	32.4	7.1	4.8	2936	1395
Guiyang	26.6	106.7	1536	735	3	817	31.3	27.3	1.0	-1.7	2615	1195
Hangzhou	30.2	120.2	1649	1235	208	5430	36.9	32.0	-1.3	-3.6	3046	1847
Harbin	45.8	126.8	5360	318	0	351	30.3	25.8	-24.8	-32.4	3459	3551
Hefei	31.9	117.2	1863	973	113	3388	36.4	32.0	-2.9	-5.3	3080	2007
Hohhot	40.8	111.7	4301	300	0	782	33.8	26.3	-19.2	-23.1	4332	4638
Ji'nan	36.7	117.0	2279	1197	155	5334	37.4	32.4	-6.8	-9.5	3844	3375
Kunming	25.0	102.7	1255	340	0	31	29.9	23.0	-9.6	-35.3	3995	3154
Lanzhou	36.1	103.9	3170	367	0	1195	35.4	26.3	-15.0	-18.3	3746	3052
Nanchang	28.6	115.9	1470	1413	264	6566	37.5	33.0	-1.9	-3.6	2938	1550
Nanjing	32.0	118.8	1994	1123	178	4933	36.6	32.5	-1.9	-5.7	3202	2193
Nanning	22.8	108.4	431	2088	405	9252	38.1	31.8	8.2	4.5	2822	1260
Shanghai	31.2	121.4	1707	1075	165	4303	37.3	32.8	-0.4	-3.5	3051	1903
Shenyang	41.8	123.4	3955	584	15	1491	32.3	28.4	-17.2	-22.2	3650	3500
Urumqi	43.8	87.6	4442	467	12	1634	36.3	32.8	-21.6	-24.6	3760	3593
Wuhan	30.6	114.1	1694	1249	221	5833	37.3	32.8	-0.6	-2.9	3005	1732
Xi'an	34.3	108.9	2336	839	82	3529	38.1	30.3	-5.4	-9.6	3294	2336
Xining	36.6	101.8	3984	39	0	84	30.0	21.1	-12.2	-19.2	4061	3785
Yining	44.0	81.3	3671	462	6	2174	36.7	28.0	-16.6	-24.3	3764	3766
Yinchuan	38.5	106.2	3639	416	2	1131	33.4	27.0	-14.9	-19.9	4169	4057
Yichun	47.7	128.9	6145	208	0	576	31.6	24.9	-27.5	-36.0	3330	3413
Zhengzhou	34.7	113.7	2262	1016	106	4467	37.6	30.4	-5.8	-10.8	3711	3114

Table 5: Variations of annual average daily totals of solar radiation

[21] (Geothermal Energy) (ASHRAE Transactions 2002, Honolulu, 2002)

5.5. Geothermal Energy[22]

Geothermal energy is the heat from the Earth. It's clean and sustainable. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.

Almost everywhere, the shallow ground or upper 10 feet of the Earth's surface maintains a nearly constant temperature between 50° and 60°F (10° and 16°C). Geothermal heat pumps can tap into this resource to heat and cool buildings. A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchanger, a system of pipes buried in the shallow ground near the building. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.

Geothermal heat pumps (GHPs), sometimes referred to as Geo Exchange, earth-coupled, ground-source, or water-source heat pumps, have been in use since the late 1940s. They use the constant temperature of the earth as the exchange medium instead of the outside air temperature. This allows the system to reach fairly high efficiencies (300% to 600%) on the coldest winter nights, compared to 175% to 250% for air-source heat pumps on cool days.

Although many parts of the country experience seasonal temperature extremes, from scorching heat in the summer to sub-zero cold in the winter, a few feet below the earth's surface the ground remains at a relatively constant temperature. Depending on latitude, ground temperatures range from 45°F (7°C) to 75°F (21°C). Like a cave, this ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. The GHP takes advantage of this by exchanging heat with the earth through a ground heat exchanger.

As with any heat pump, geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water. Some models of geothermal systems are available with two-speed compressors and variable fans for more comfort and energy savings. Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

[22] (Geothermal Energy)

A dual-source heat pump combines an air-source heat pump with a geothermal heat pump. These appliances combine the best of both systems. Dual-source heat pumps have higher efficiency ratings than air-source units, but are not as efficient as geothermal units. The main advantage of dual-source systems is that they cost much less to install than a single geothermal unit, and work almost as well.

Even though the installation price of a geothermal system can be several times that of an air-source system of the same heating and cooling capacity, the additional costs are returned to you in energy savings in 5 to 10 years. System life is estimated at 25 years for the inside components and 50+ years for the ground loop.

5.5.1. Types of Geothermal Heat Pump Systems[23]

There are four basic types of ground loop systems. Three of these, horizontal, vertical, and pond/lake, are closed-loop systems. The fourth type of system is the open-loop option. Which one of these is best depends on the climate, soil conditions, available land, and local installation costs at the site. All of these approaches can be used for residential and commercial building applications.

5.5.1.1. Closed-Loop Systems

Most closed-loop geothermal heat pumps circulate an antifreeze solution through a closed loop, usually made of plastic tubing that is buried in the ground or submerged in water. A heat exchanger transfers heat between the refrigerant in the heat pump and the antifreeze solution in the closed loop. The loop can be in a horizontal, vertical, or pond/lake configuration.

One variant of this approach, called direct exchange, does not use a heat exchanger and instead pumps the refrigerant through copper tubing that is buried in the ground in a horizontal or vertical configuration. Direct exchange systems require a larger compressor and work best in moist soils (sometimes requiring additional irrigation to keep the soil moist), but you should avoid installing in soils corrosive to the copper tubing. Because these systems circulate refrigerant through the ground, local environmental regulations may prohibit their use in some locations.

[23] (Geothermal Heat Pumps)

5.5.1.2. Horizontal

This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench.

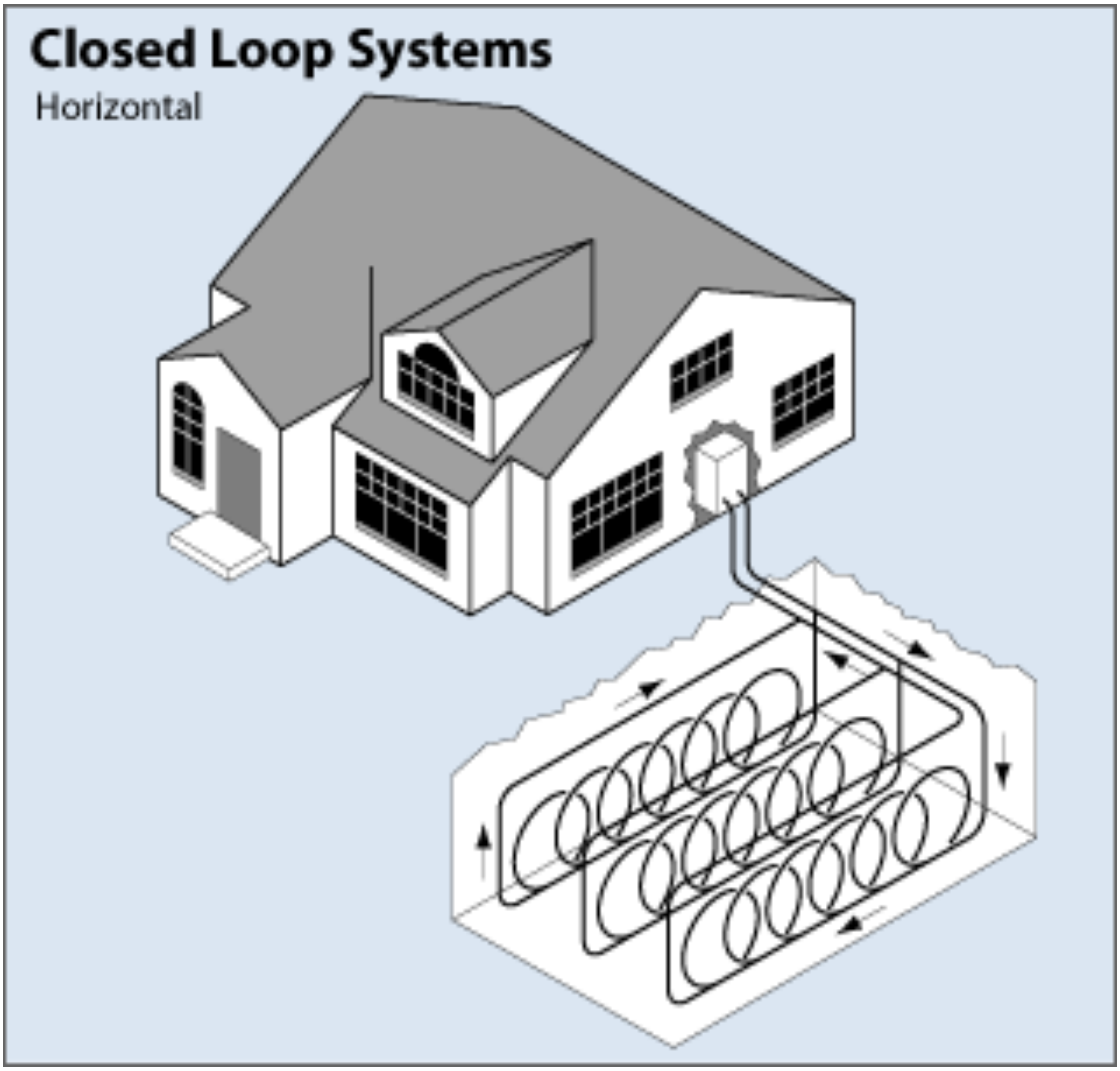


Figure 5-50: Closed Loop Horizontal Heat Pump System

5.5.1.3. Vertical

Large commercial buildings and schools often use vertical systems because the land area required for horizontal loops would be prohibitive. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to existing landscaping. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100 to 400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe (i.e., manifold), placed in trenches, and connected to the heat pump in the building.

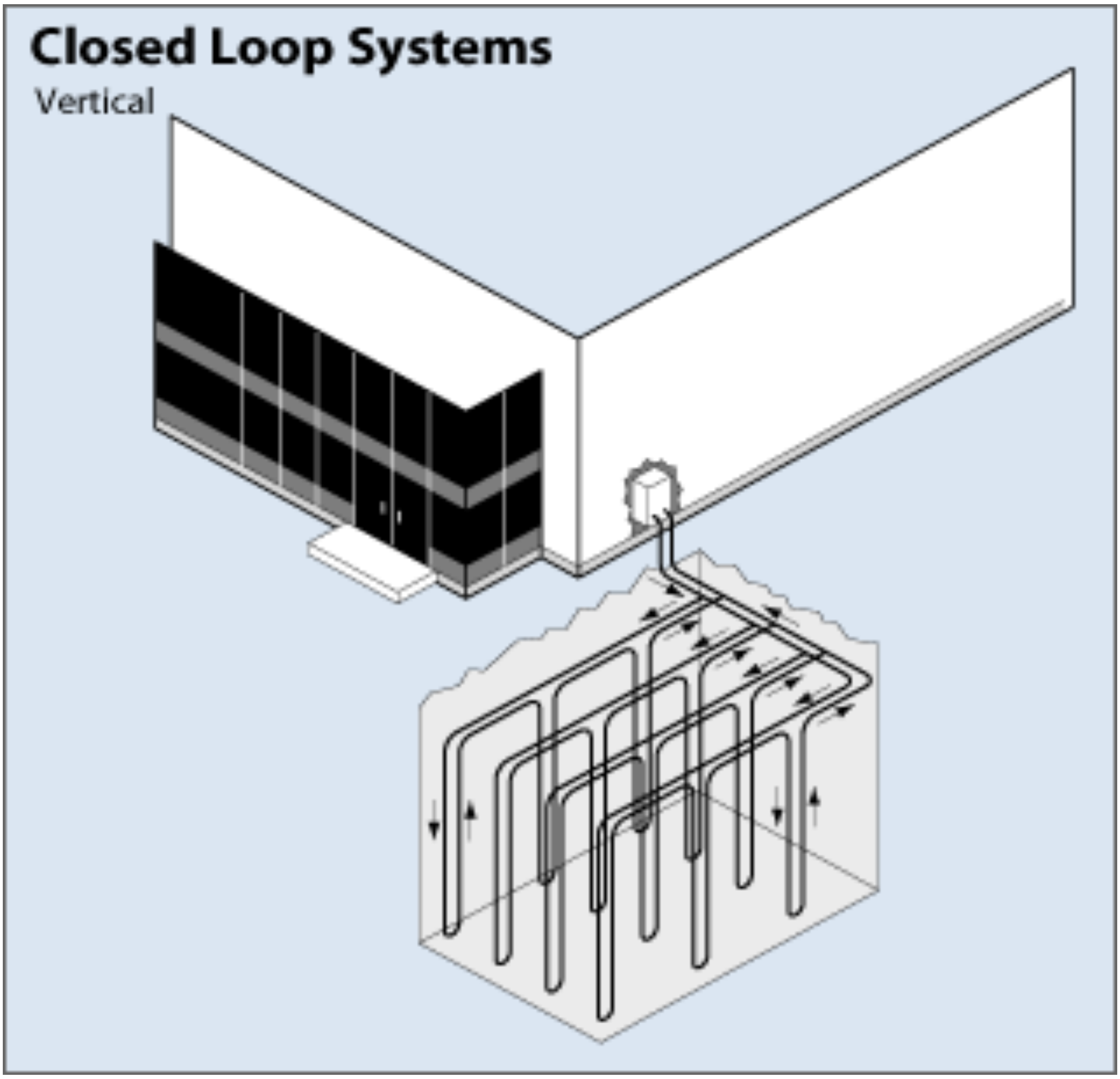


Figure 5-51: Closed Loop Vertical Heat Pump System

5.5.1.4. Pond/Lake

If the site has an adequate water body, this may be the lowest cost option. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria.

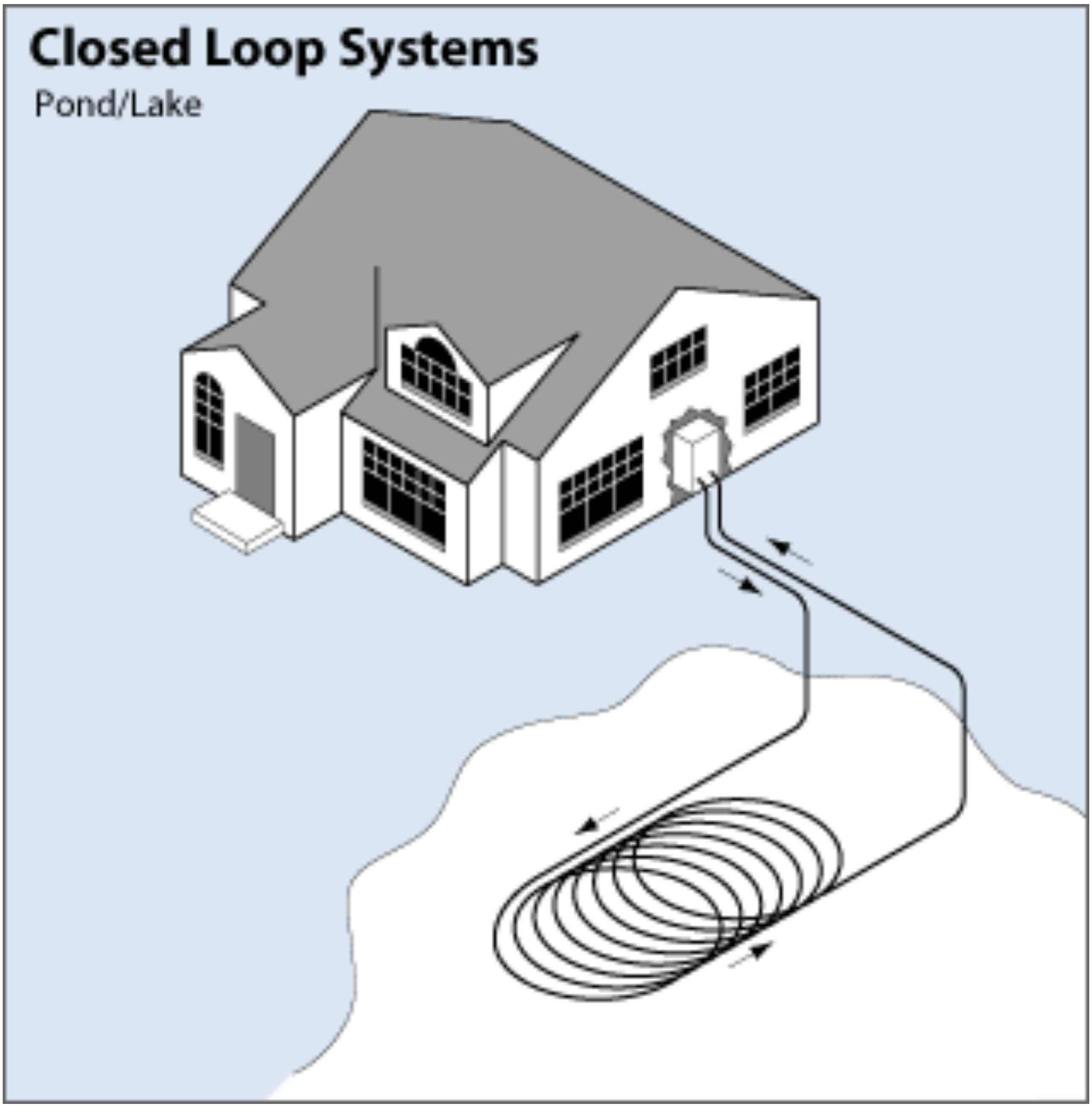


Figure 5-52: Closed Loop Pond/Lake Heat Pump System

5.5.1.5. Open-Loop System

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.

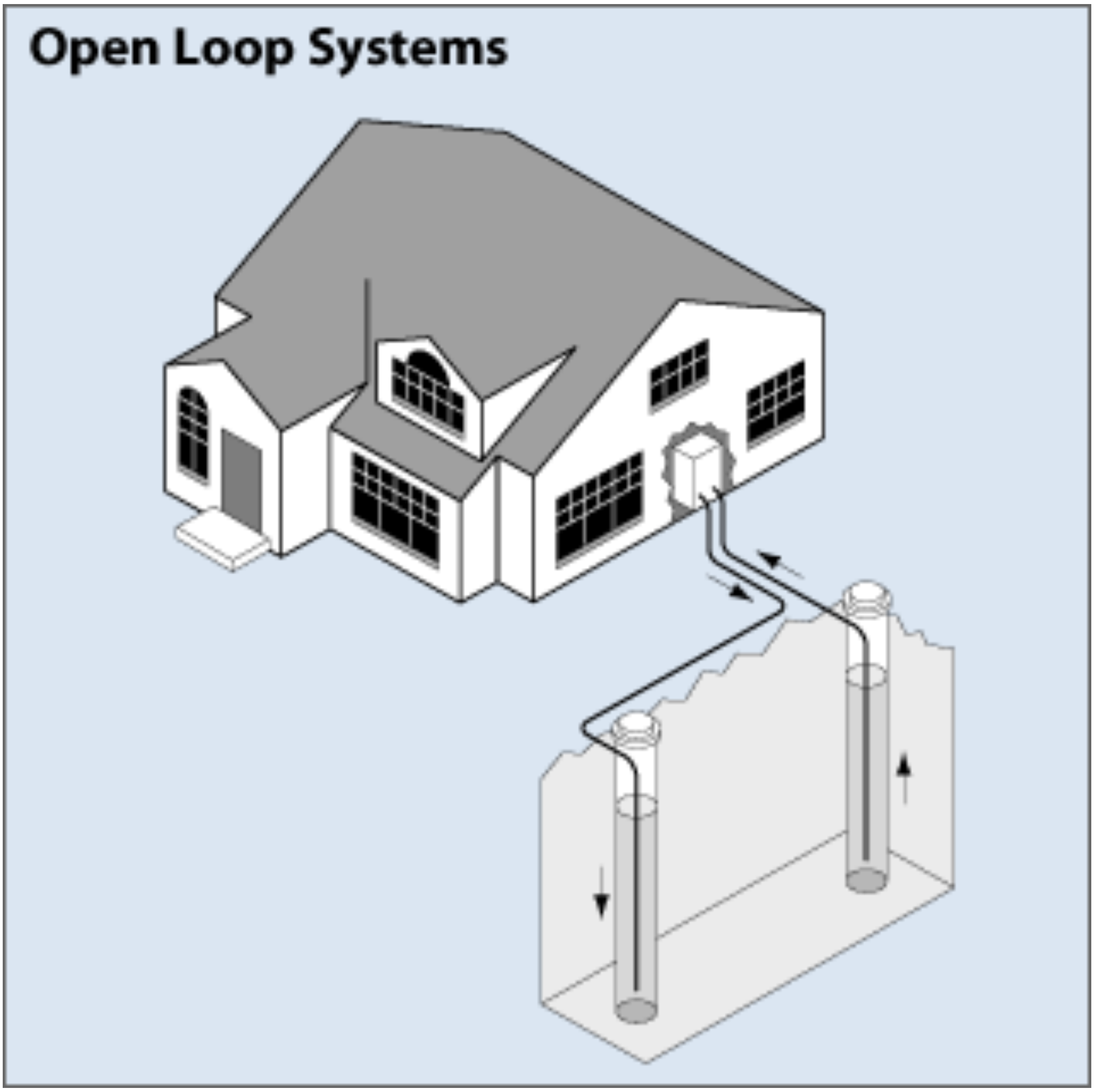


Figure 5-53: Open Loop Heat Pump System

5.5.1.6. Hybrid Systems

Hybrid systems using several different geothermal resources, or a combination of a geothermal resource with outdoor air (i.e., a cooling tower), are another technology option. Hybrid approaches are particularly effective where cooling needs are significantly larger than heating needs. Where local geology permits, the "standing column well" is another option. In this variation of an open-loop system, one or more deep vertical wells are drilled. Water is drawn from the bottom of a standing column and returned to the top. During periods of peak heating and cooling, the system can bleed a portion of the return water rather than reinjecting it all, causing water inflow to the column from the surrounding aquifer. The bleed cycle cools the column during heat rejection, heats it during heat extraction, and reduces the required bore depth.

5.5.1.7. Selecting the System

For our design, the system to use the geothermal energy depends on the location of the building in our site, In the buildings next to the Creek, we can use the water-related systems like pond/lake systems, but in other places where the building is not next to the water, we can use Closed-Loop systems mainly vertical because we do not have enough space to use the horizontal system.

5.6. Climatic Considerations for the Design Solutions[24]

5.6.1. Region with cold winters and hot-humid summers

Regions with cold winter and hot-humid summers are found mainly in the eastern parts of continents between the latitudes of approximately 30 and 45* N.

The combination of warm temperature and high humidity in the summer calls for ample natural ventilation as the major strategy for minimizing thermal stress in countries which cannot afford mass use of air conditioning. (or it is not economical) The fact that the summer is also the rainy season presents more design difficulties. Natural ventilation through open windows should be provided while rain penetration into the building is prevented. The need to provide ample natural ventilation in summer calls for specific urban and building-design guidelines.

In evaluating the relative importance of the summer and winter conditions, and the "turning" of the design more to one of the seasons, the following factors should be considered:

- Personal protection from cold (e.g. by heavier clothing during waking hours and heavier blankets at night) is more readily attainable than personal protection from excessive heat stress.
- Heating can be provided by simple and relatively inexpensive devices, while air conditioning is more expensive.
- Prevention of wind penetration into a building in winter can be accomplished by simple design solution (appropriate windows and exterior doors), even in windy areas.
- Effective cross-ventilation can be provided only if the wind speed around the building has some minimum values and if air can flow freely through the building from inlet to outlet openings.
- Modern insulating materials can greatly reduce heating energy consumption even in cold regions. Materials with heat-retention properties are less effective in modifying the indoor temperature when comfort in summer is considered.

Therefore, the summer comfort issues may have higher priority from the urban design aspect, except in regions where the winter is much more severe than the summer.

[24] (Givoni, 1998)

5.6.2. Priority of hot-humid summer conditions

The main design objectives in hot-humid regions can be summarized as below:

- Minimizing solar heating of the building
- Maximizing the rate of cooling in the evening
- Providing effective natural ventilation, even during rain
- Preventing rain penetration, even during rainstorms
- Preventing entry of insects while the windows are open for ventilation
- Providing spaces for semi outdoor activities as integral part of the "living space"

The main building design details which affect the attainment of these objectives are:

- Building layout
- Orientation of the main rooms and the openings
- Size and details of windows and doors
- Organization and subdivision of the indoor space
- Shading of openings and walls
- Provision of verandas and balconies
- Roof type and details
- Thermal and structural properties of walls and roof
- Site landscaping

5.7. Analysis of the Wall and Floor types

The U-values for the solutions are designed for the walls, floors, and ceiling which are between indoor and outdoor spaces to maintain a low value below 0.20 $W/m^2.K$. Design and analysis of the walls are available in A3 pages in the second book.

5.8. ECOTECT

5.8.1. Ecotect Modeling and Renders

In this part of our design we have three U-Shaped modules, which are almost the same in size, function, and shape. We are going to focus on the module in the middle for Ecotect analysis.

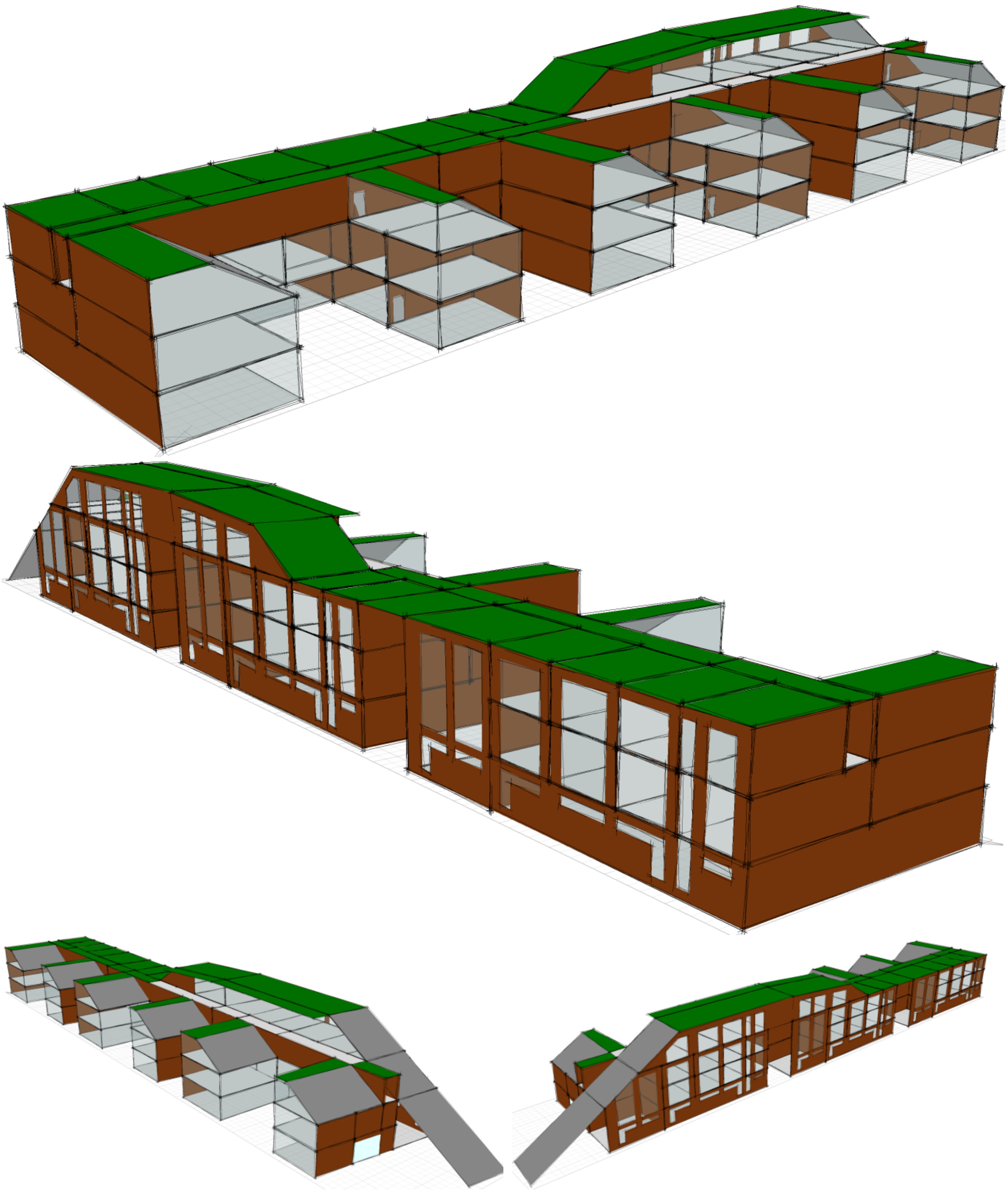
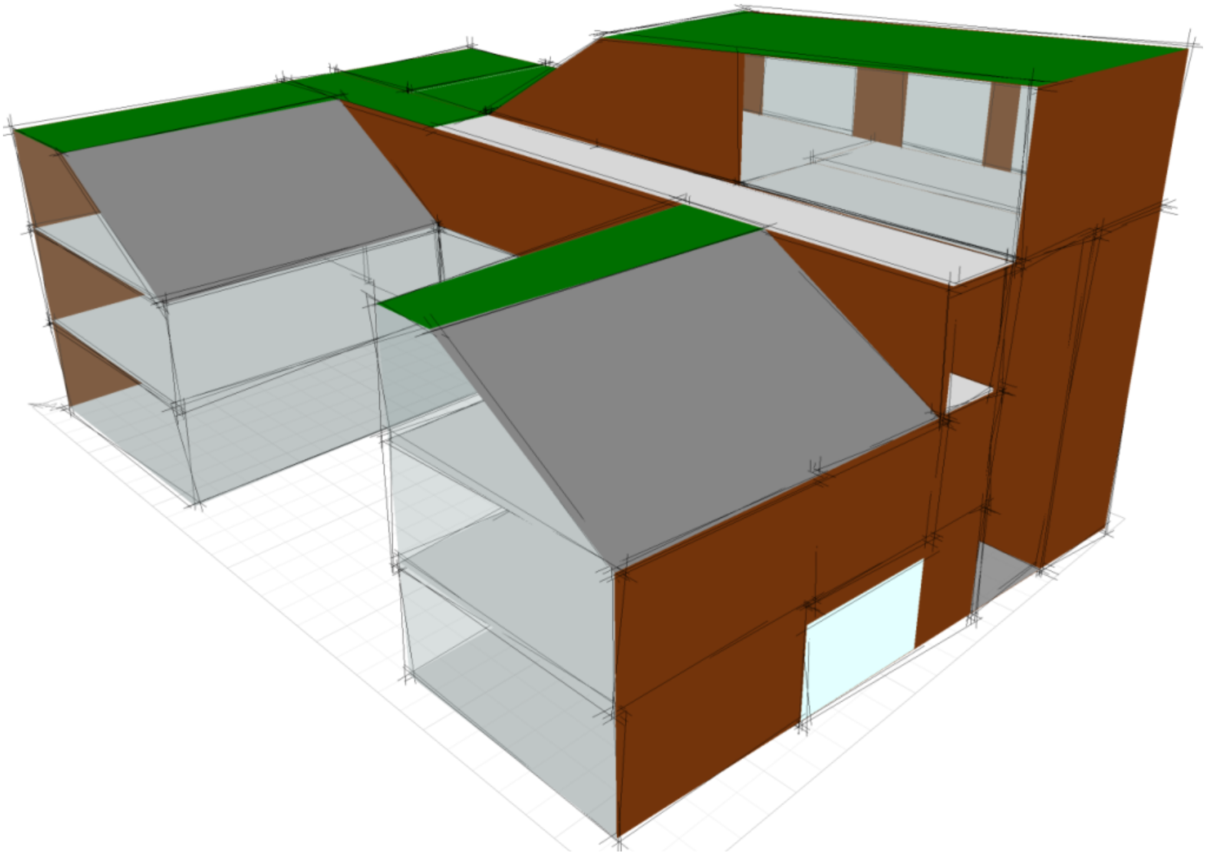


Figure 5-54: Ecotect Renders of Three Modules Together

A U-Shaped block in the middle is modeled in Ecotect in a way to act as close as possible to the real piece of the whole three-module block. Because of that, some parts are closed, also some parts are acting as non-thermal zones.



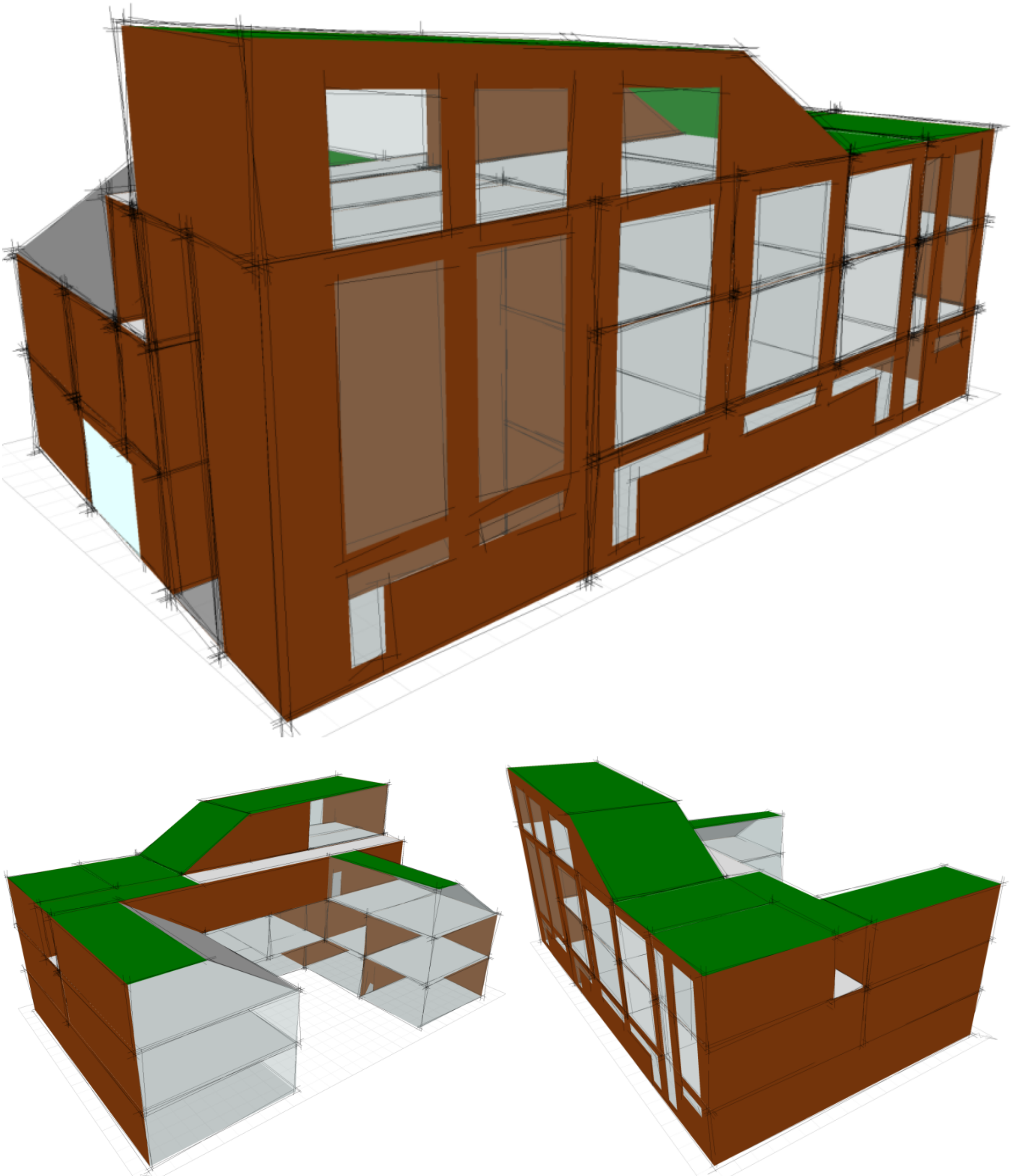


Figure 5-55: Ecotect Renders of a U-Shaped Module

According to the geographical coordination of the site, here the annual sun path and also daily sun path are drawn.

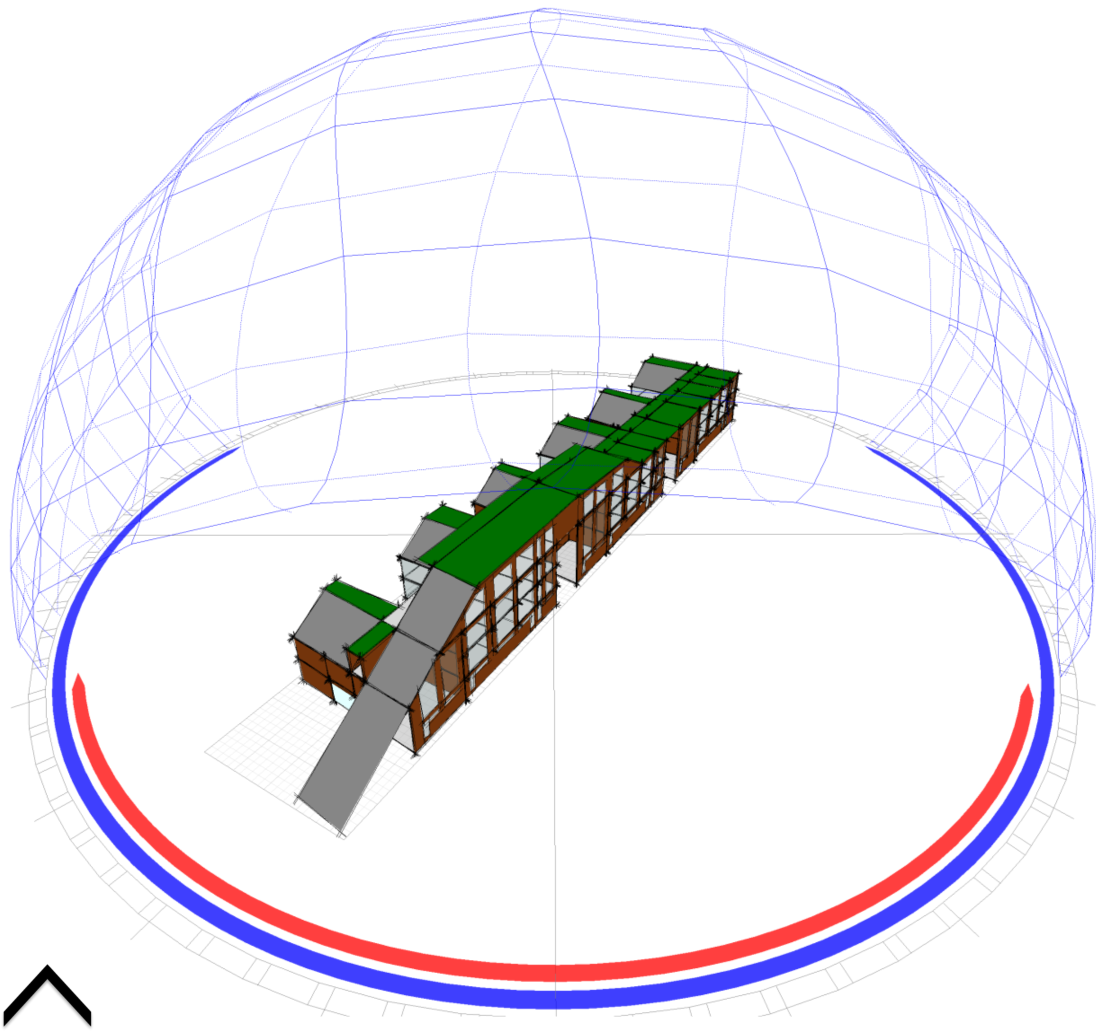


Figure 5-56: Annual Sun Path

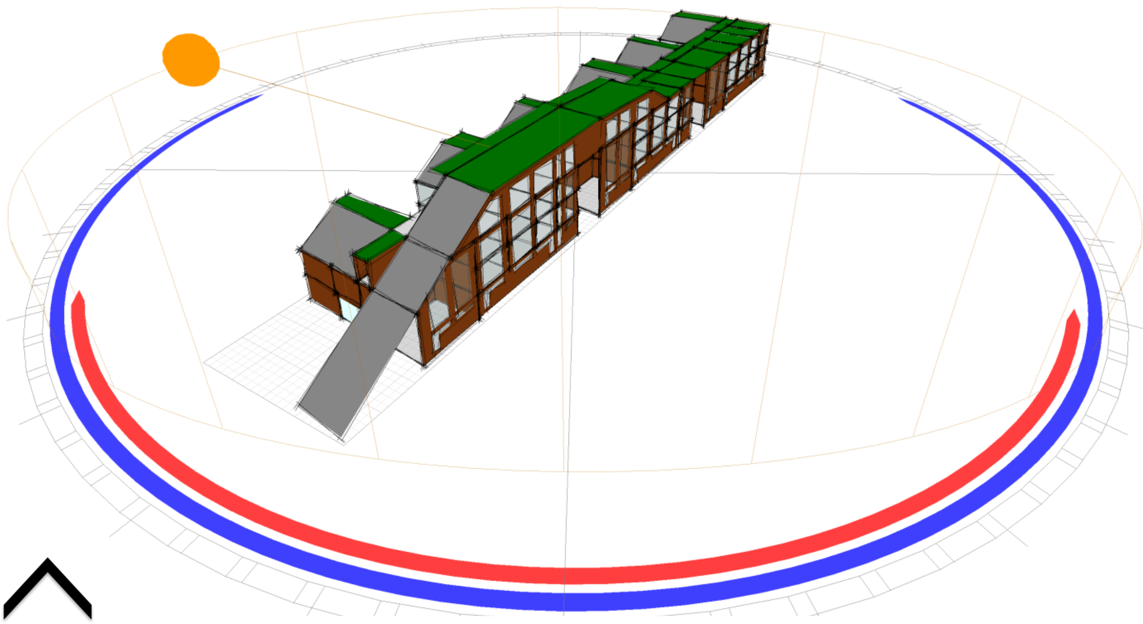


Figure 5-57: Daily Sun Path

According to the both daily and annual sun path the accumulative shape of the shadow during the year and the shadow range are drawn from 8:00 to 18:00.

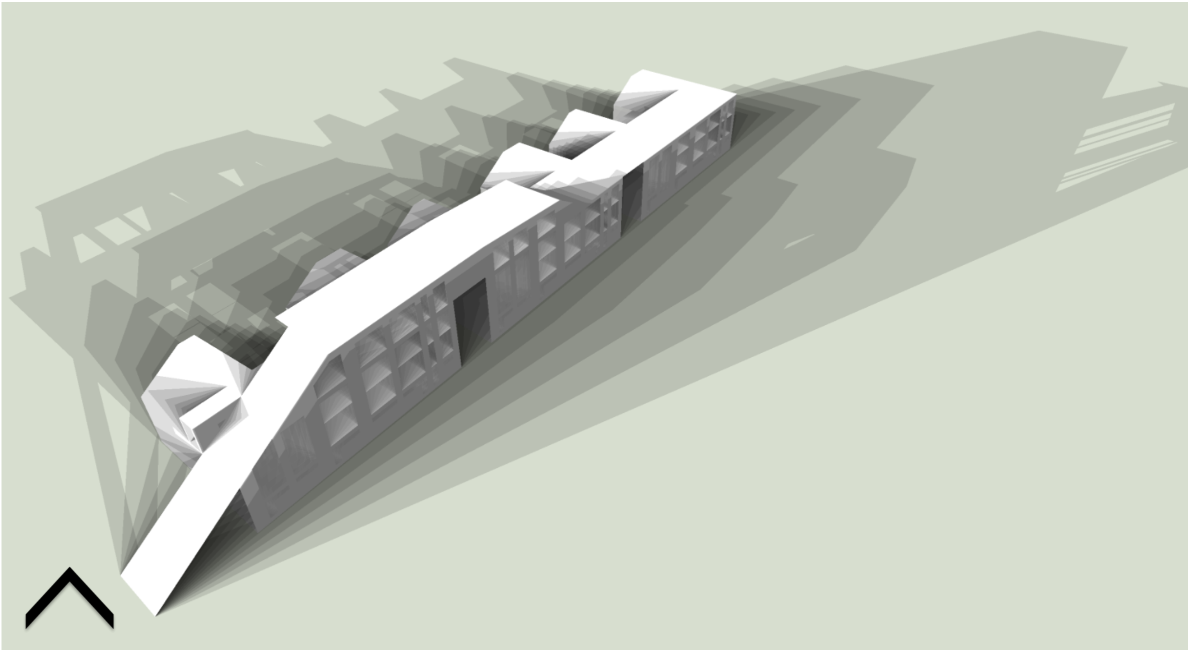


Figure 5-58: Total Shadows

5.8.2. Daylight Factor Analysis

The Building Research Establishment (BRE) Split-Flux method is a widely recognized and very useful technique for calculating daylight factors. This method is based on the assumption that, ignoring direct sunlight, there are three separate components of the natural light that reaches any point inside a building:

- Sky Component (SC) - Directly from the sky, through an opening such as a window.
- Externally Reflected Component (ERC) - Reflected off the ground, trees or other buildings.
- Internally Reflected Component (IRC) - The inter-reflection of 1 and 2 off surfaces within the room.

Separate consideration of these three components is justified by the fact that each is affected by different elements within the design. The daylight factor is thus given as a percentage and is simply the sum of each of these three components.

DF = SC + ERC + IRC

5.8.2.1. Overall Analysis

Since we have glass façade in Eastern facade there will be more light and the value of the daylight factor will increase in these zones.

Almost everywhere close to the glass façade the value of the daylight factor is strangely high and when we get a few meters far from it, the values become reasonable but still high, which means we need to consider a shading system for the glass façade. Instead of normal shading systems we designed some kind of louvers to cover some parts of the glass façade with the width of 4 cm and the distance of 4 cm from each other. This solution helps the building to have less amount of light inside especially in the zones next to the glass façade.

In the analysis, we consider the whole area as the analysis grid and since we have glass façade in some parts the value of the daylight factor close to the façade is very high which is reasonable.

5.8.2.2. Lobby

Since the function of this area is lobby, the blue zone of daylight factor and also the purple one which are less than 10% and less than 20%, are acceptable for our design according to the concept. To decrease the red parts in the diagram where we have the values around 30 to 40 % for the daylight factor, we are following the solution which is being explained in the overall analysis, and it is using louvers for the glass facades. Without considering the very close areas to the facades, whether the glass façade or the other side which has large windows, the average value of the daylight factor would be less than 10% that is very rational for the lobby.

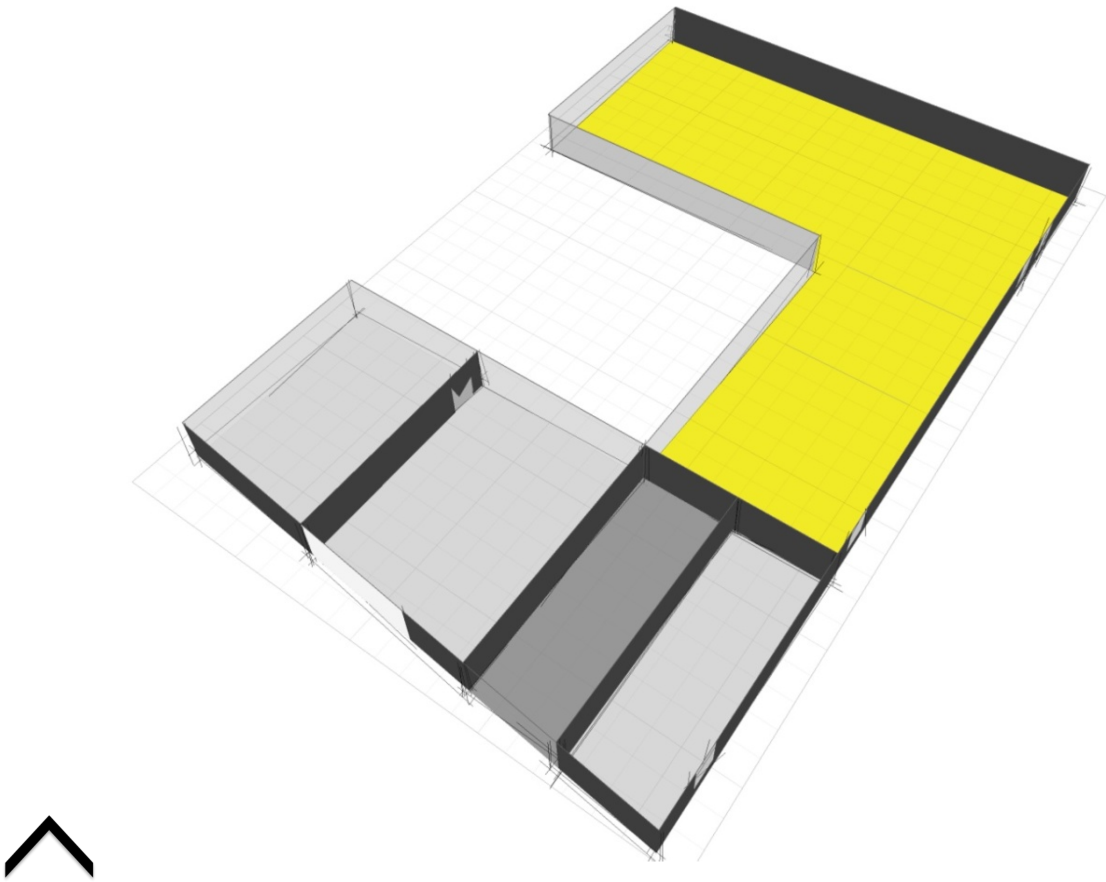


Figure 5-59: Lobby Area

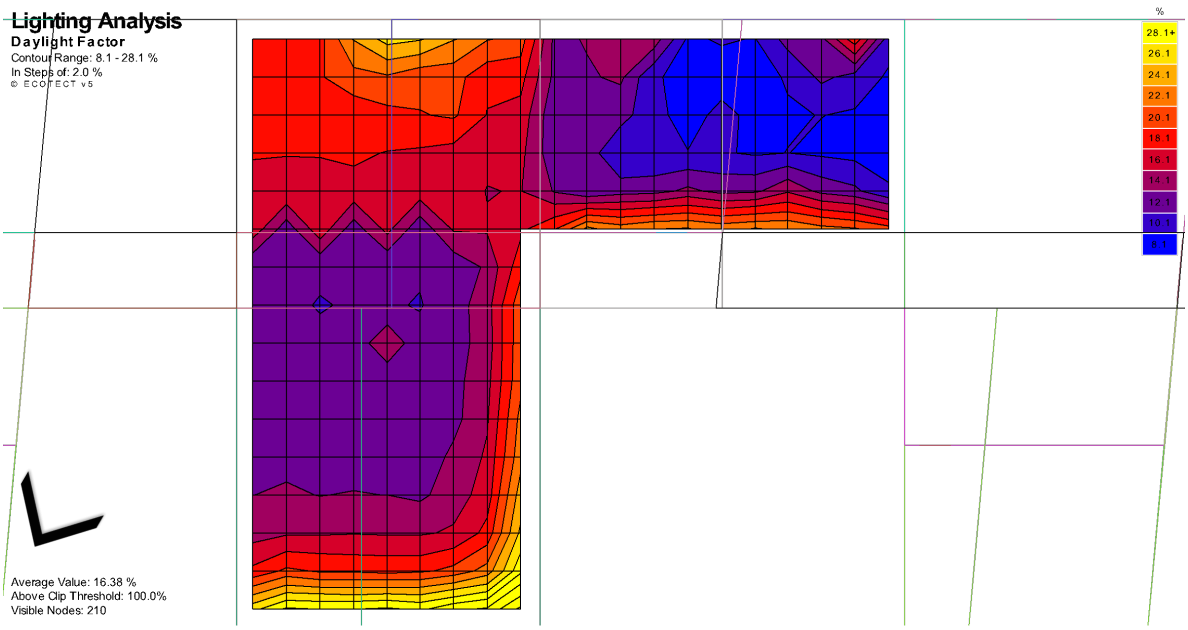


Figure 5-60: Daylight Analysis for the Lobby Area

5.8.2.3. Apartments in different floors

In the analysis the average value for the daylight factor is around 25-35 % with a maximum of almost 40-60% next to the glass façade and a minimum of around 10-20% in the other side, depending on the floor in which the apartment is located and the northern or the southern side of the U-Shaped module.

Again following the concept of having large glass facades, to get a lot of light and also have a great view toward the creek and then covering some areas of the façade by louvers to control the entering light we can have a lower value of daylight factor for all these apartments. After all these louvers we will decrease the value of the daylight factor to less than half which is almost acceptable, because in the Ecotect model for simplifying the model we assigned one zone to each apartment without considering the walls and partitions, but in reality we have rooms in the apartments with walls that stops the light in some cases therefore the value of the daylight factor will be rational if in this model they are around 10-15 %.

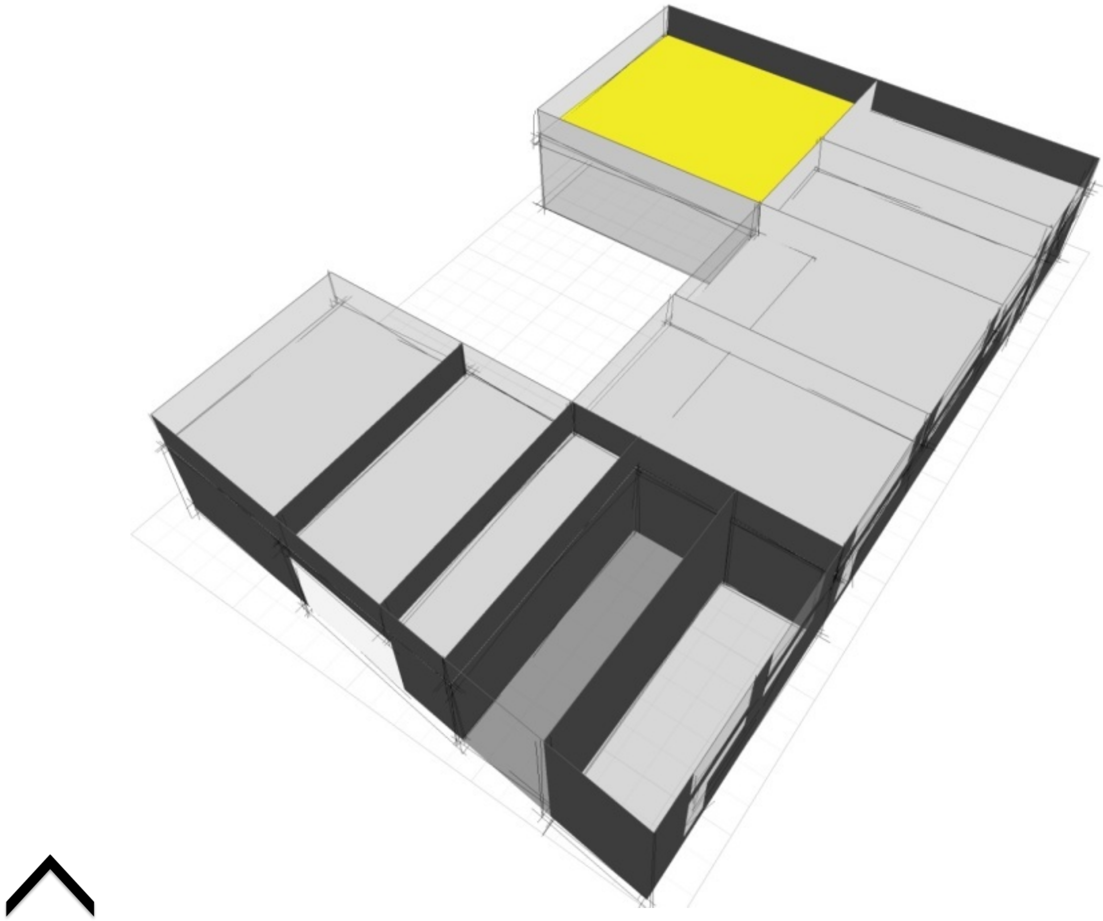


Figure 5-61: Apartment with Glass Facade Area, First Floor

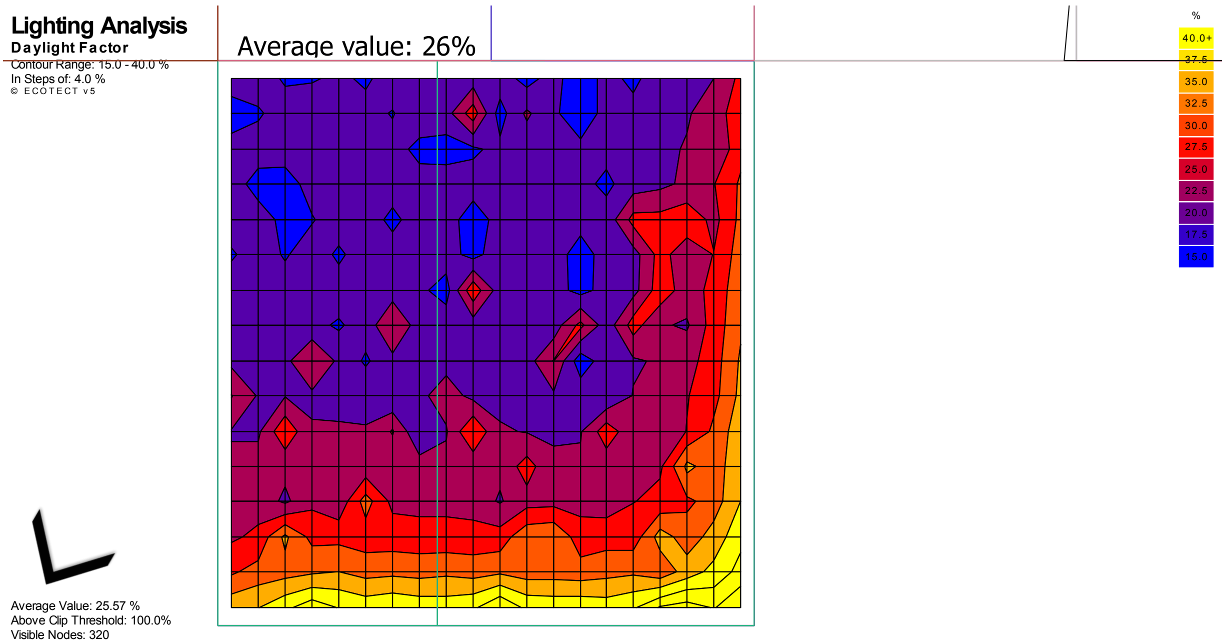


Figure 5-62: Daylight Analysis for Apartment with Glass Facade Area, First Floor

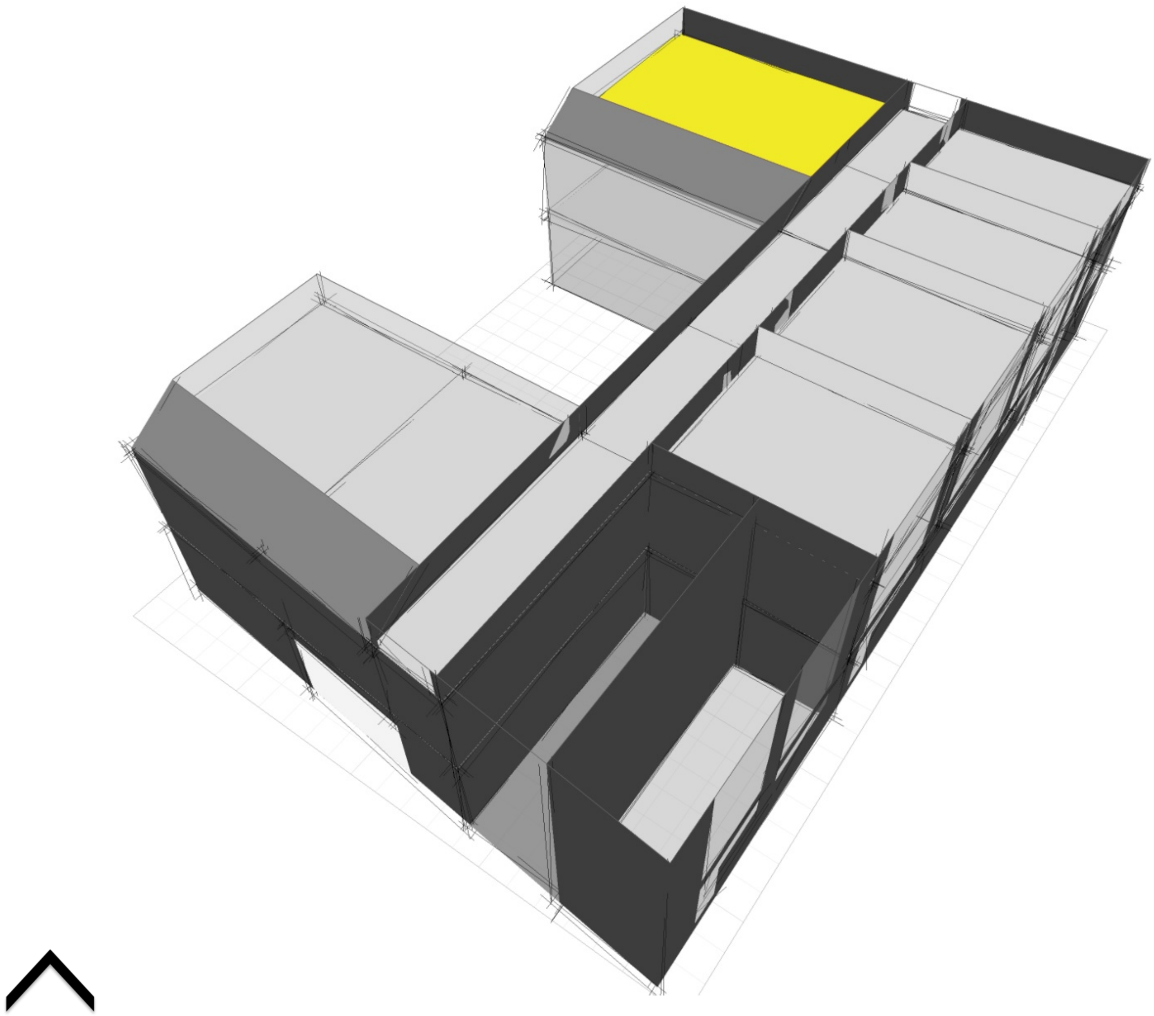


Figure 5-63: Apartment with Glass Facade Area, Second Floor

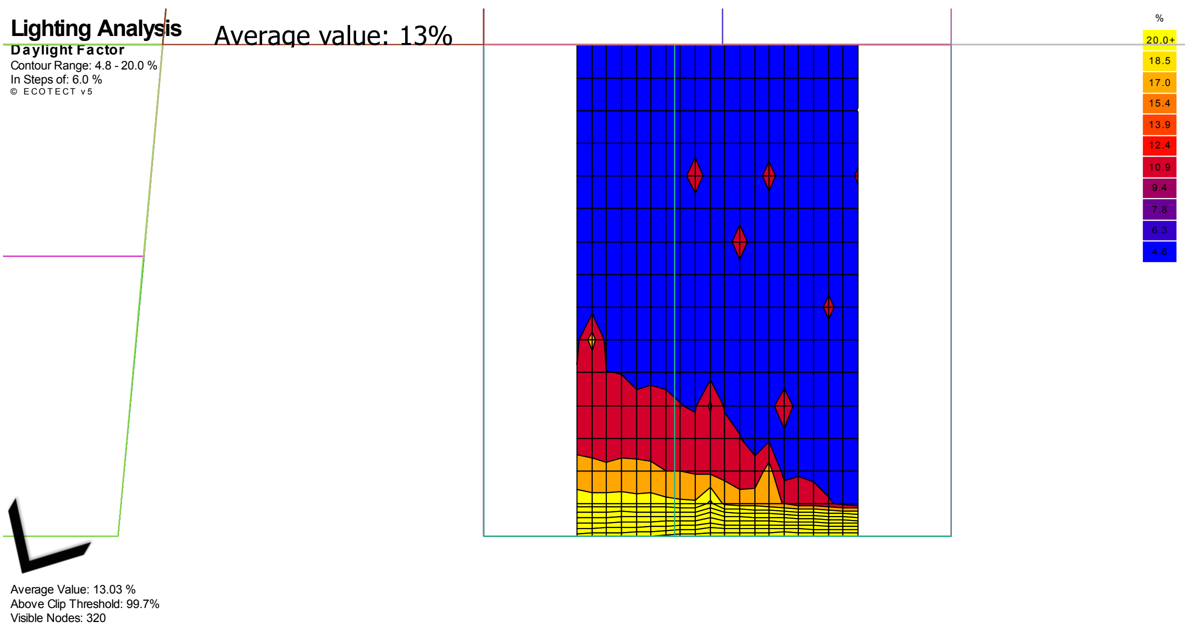


Figure 5-64: Daylight Analysis for Apartment with Glass Facade Area, Second Floor

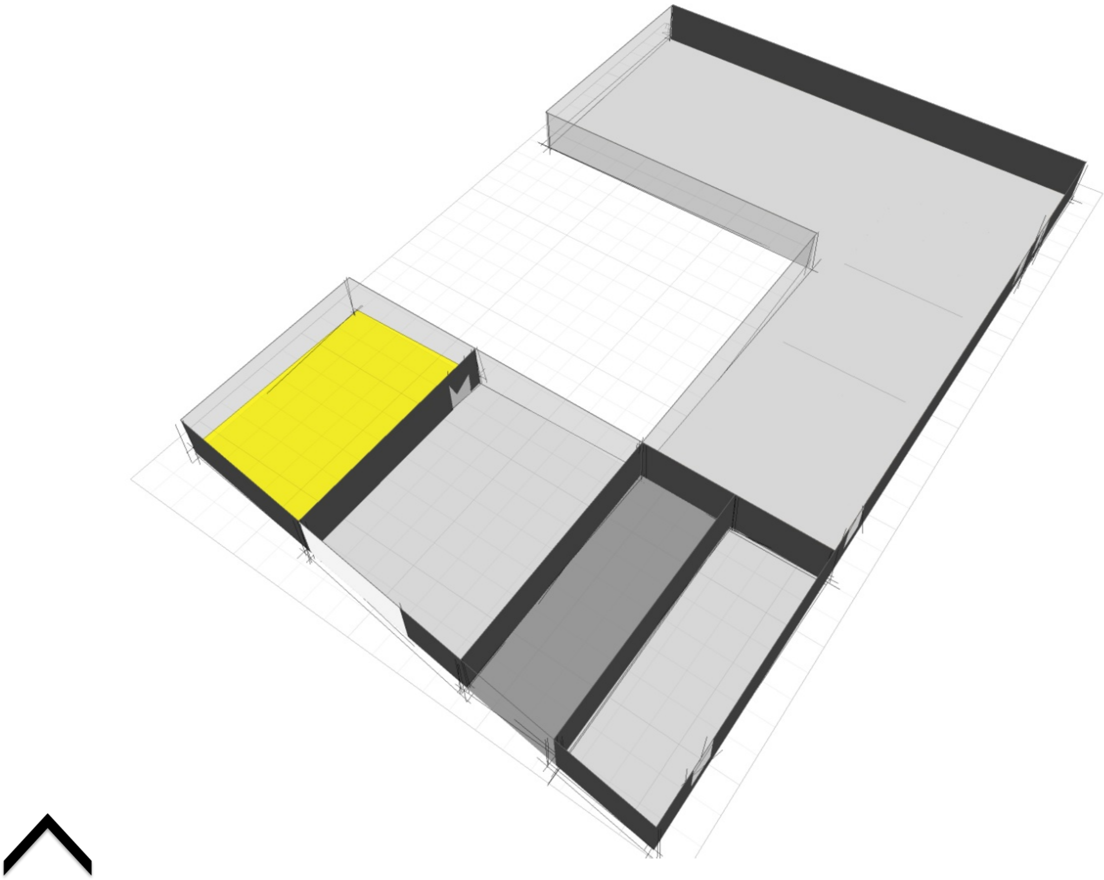


Figure 5-65: Apartment with Glass Facade Area, First Floor

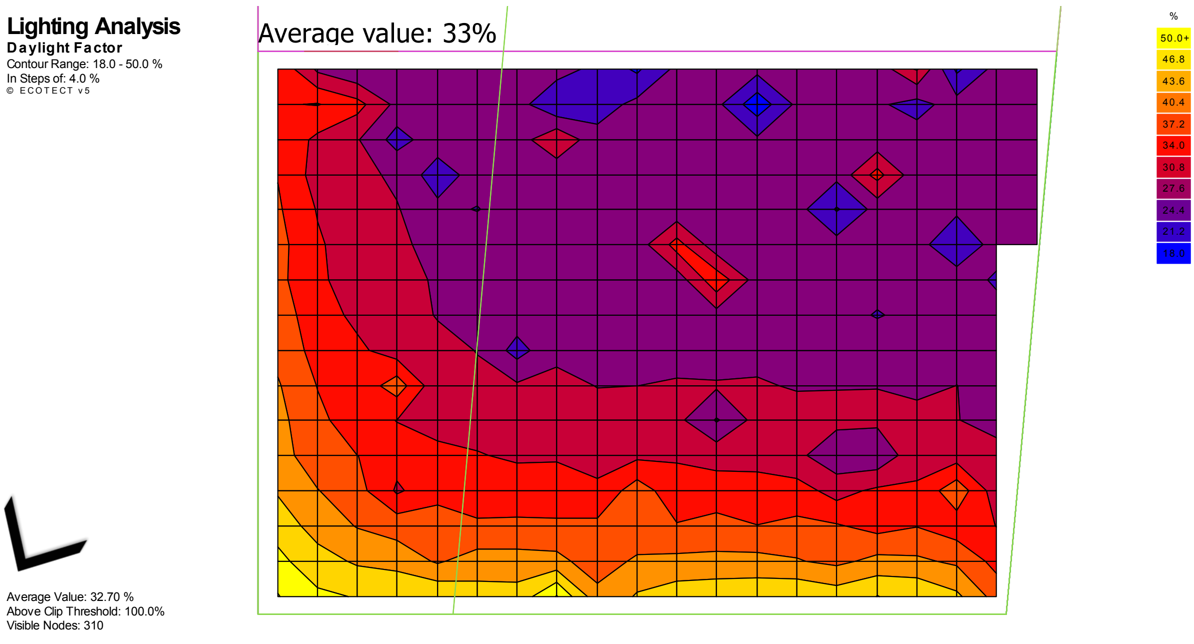


Figure 5-66: Daylight Analysis for Apartment with Glass Facade Area, First Floor

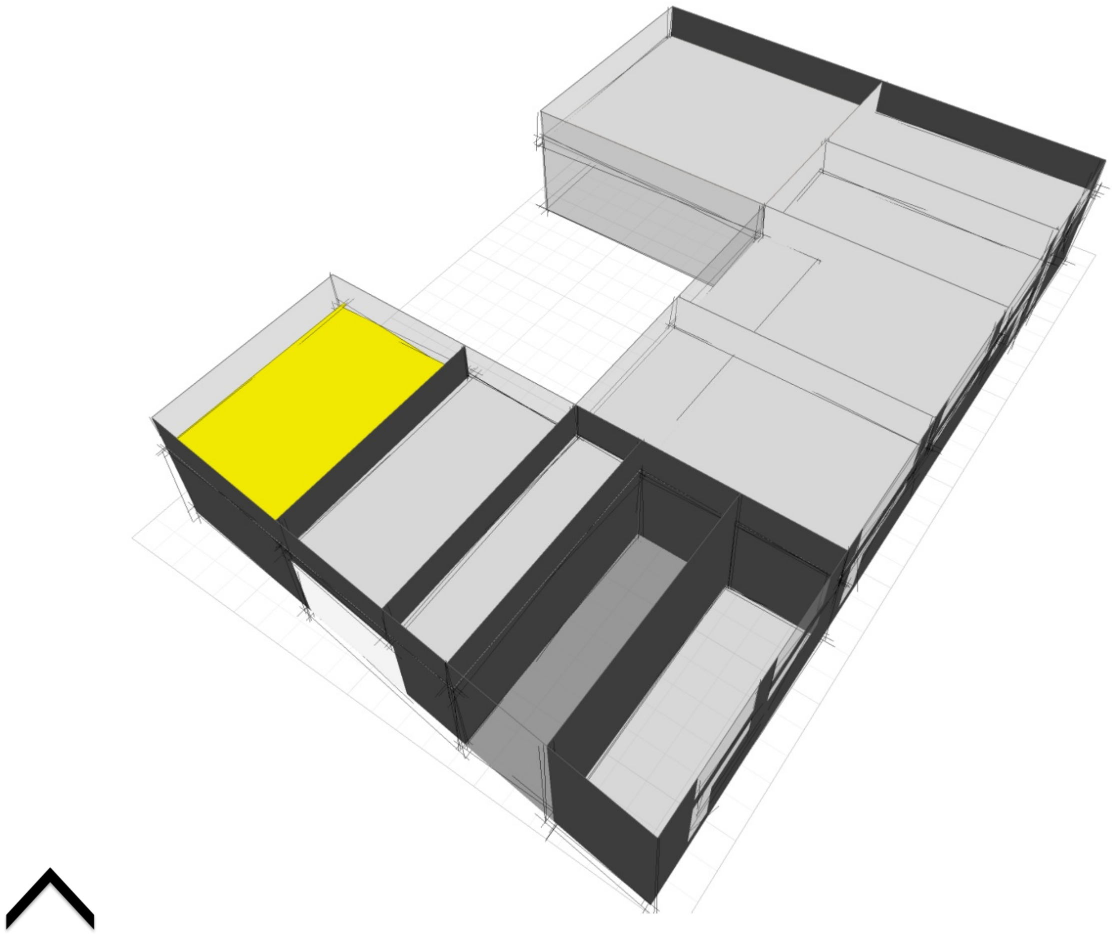


Figure 5-67: Apartment with Glass Facade Area, Second Floor

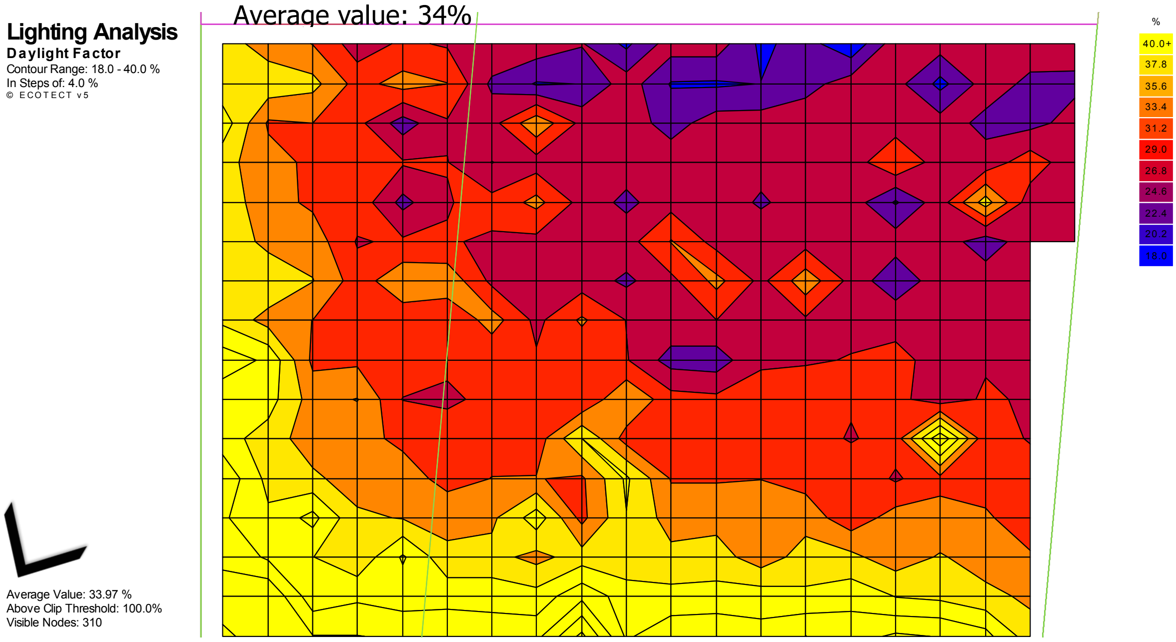


Figure 5-68: Daylight Analysis for Apartment with Glass Facade Area, Second Floor

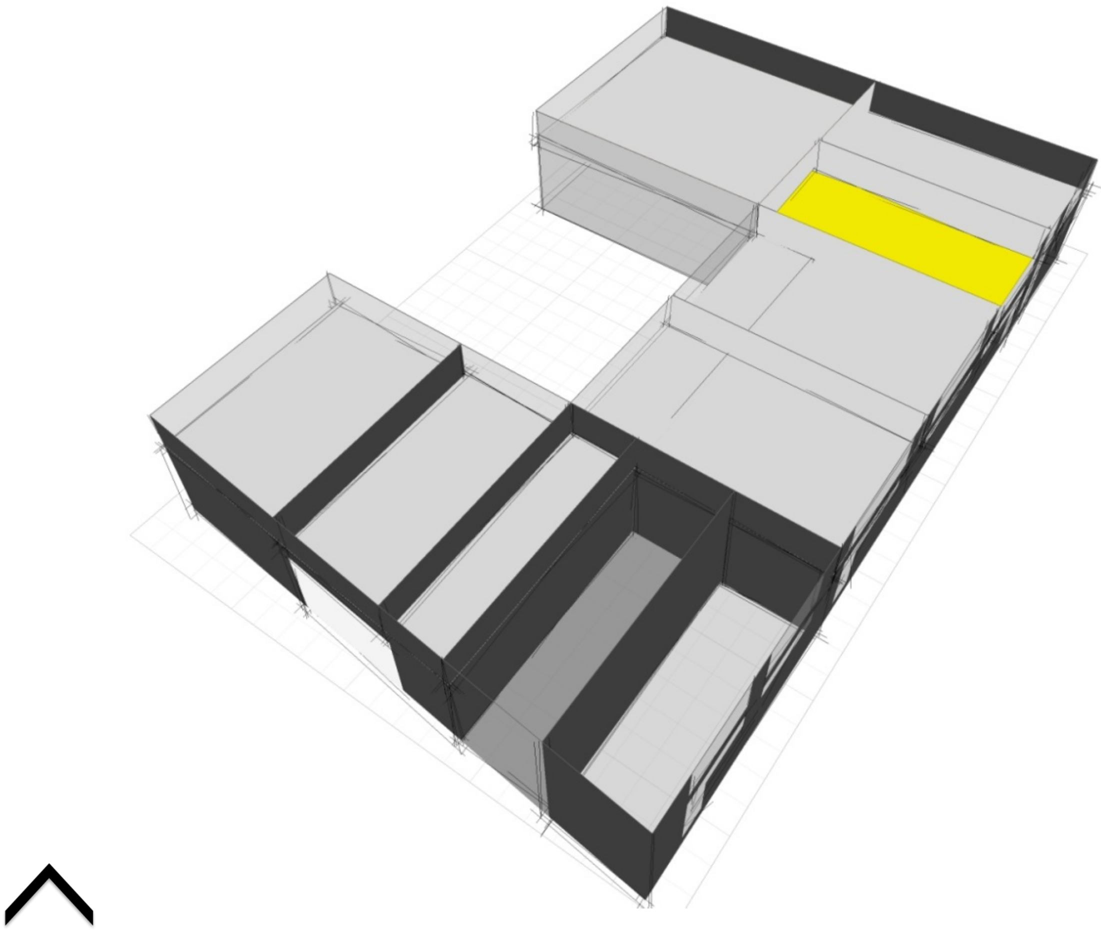


Figure 5-69: Normal Apartment Area, Second Floor

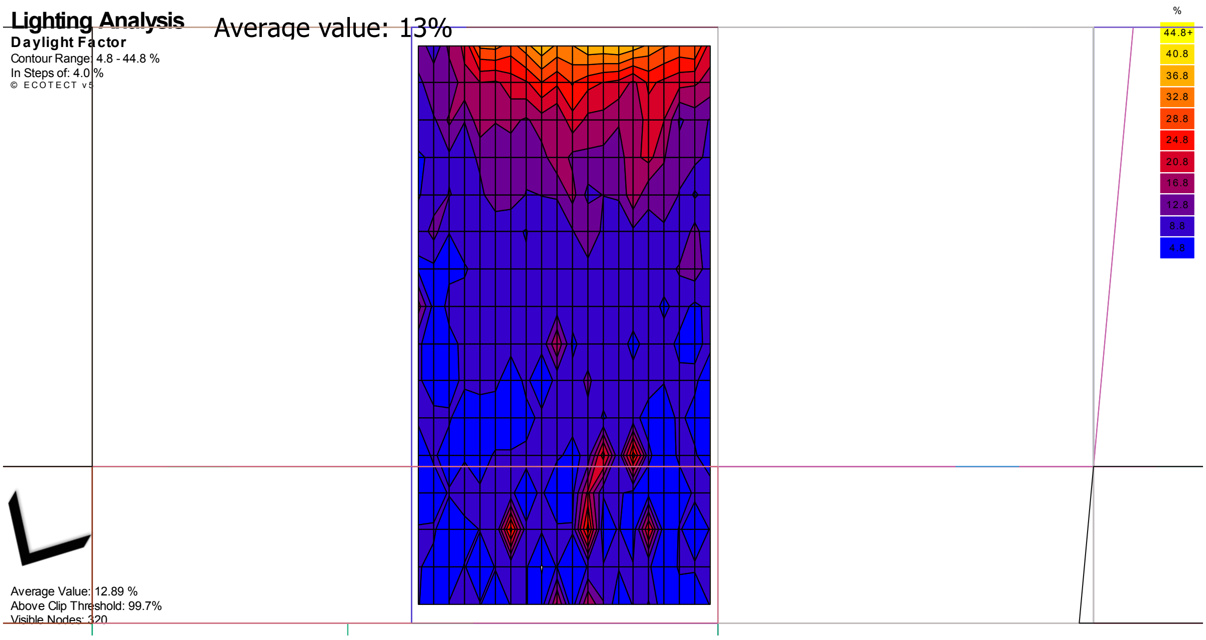


Figure 5-70: Daylight Analysis for the Normal Apartment area, Second Floor

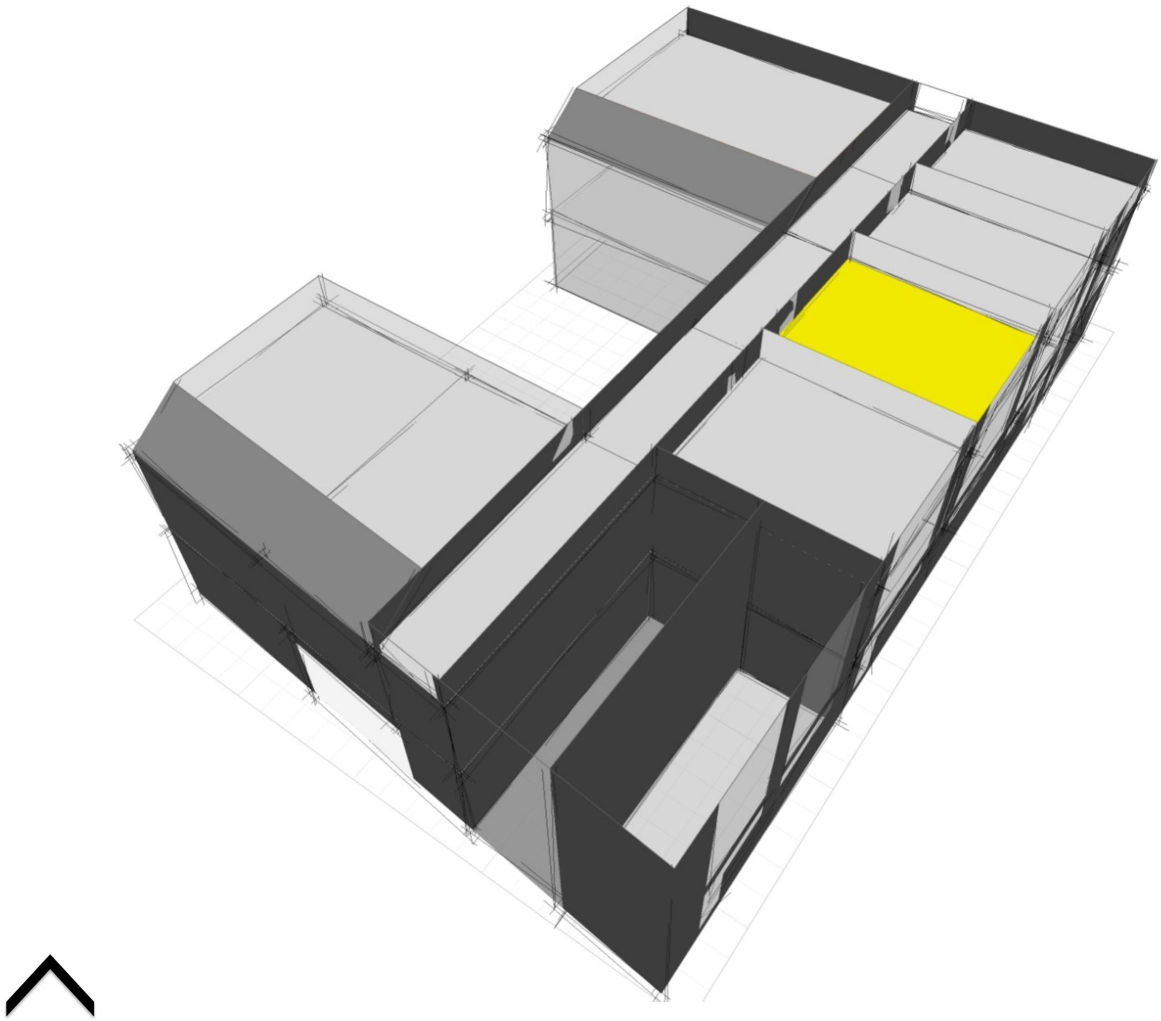


Figure 5-71: Normal Apartment Area, Third Floor

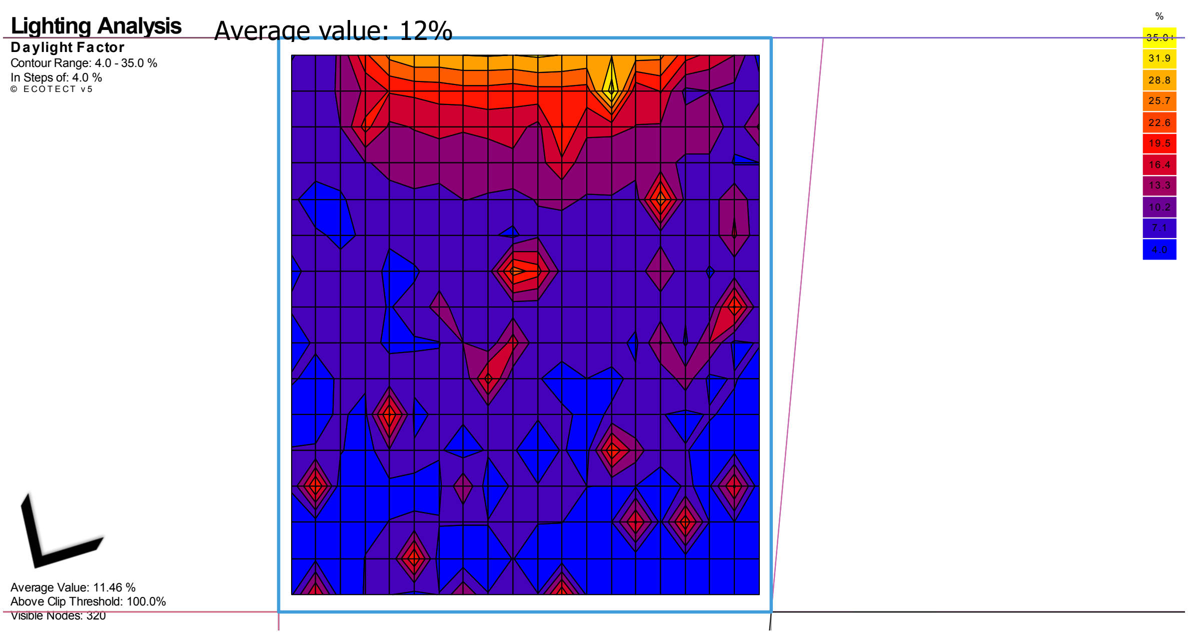


Figure 5-72: Daylight Analysis for the Normal Apartment area, Third Floor

5.8.2.4. Gym

Gym area is almost completely covered in glass in the northwestern side and large windows in the opposite side. Because of the function of the gym, it needs to get a large amount of light, and also to lead the view of the people there to the view toward the creek we need to provide glass façade. The average daylight factor value is 25% which is 10-20% in the middle of the gym, the only problem is again like everywhere in our design close the facades, which comes with the solution of having louvers in the glass façade and horizontal shading systems on the opposite side.

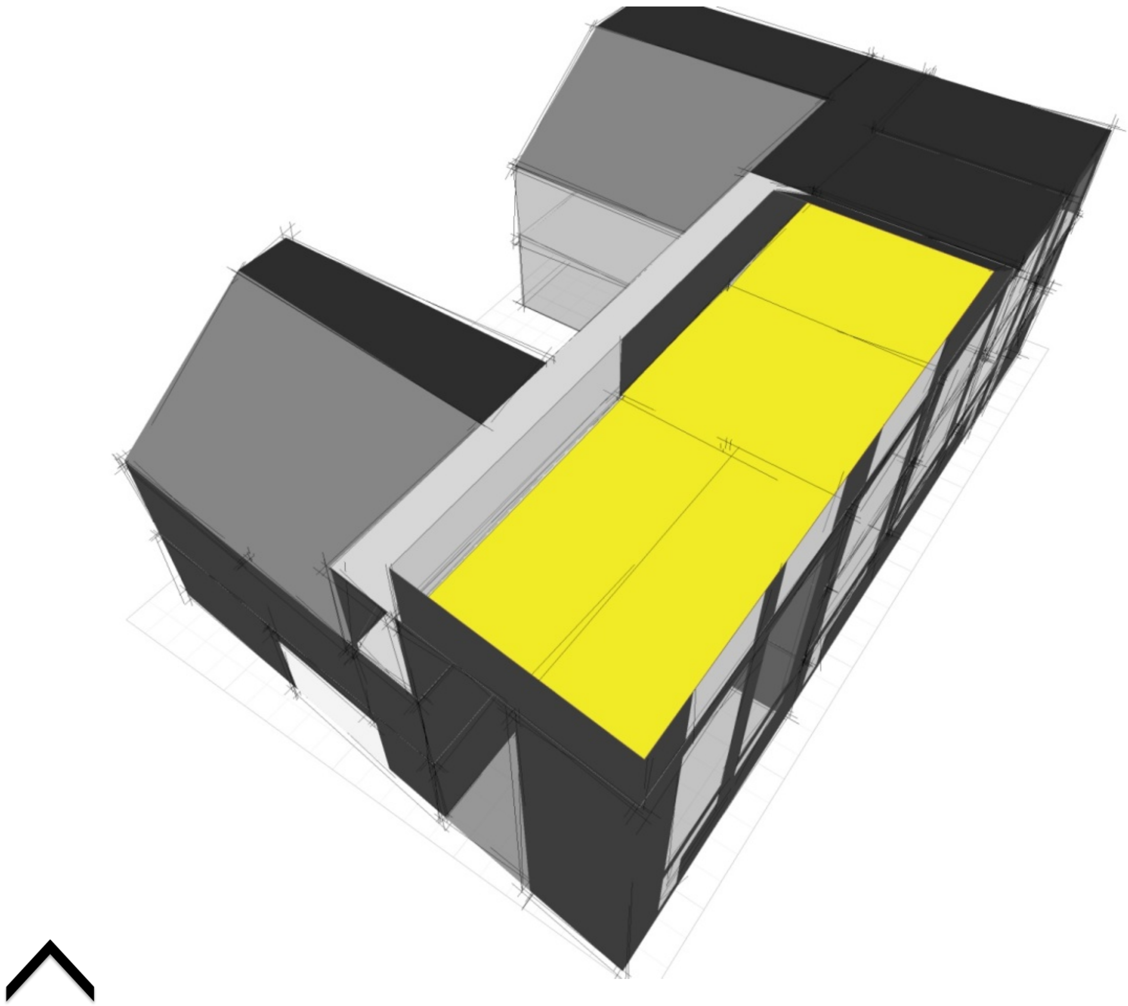


Figure 5-73: Gym Area

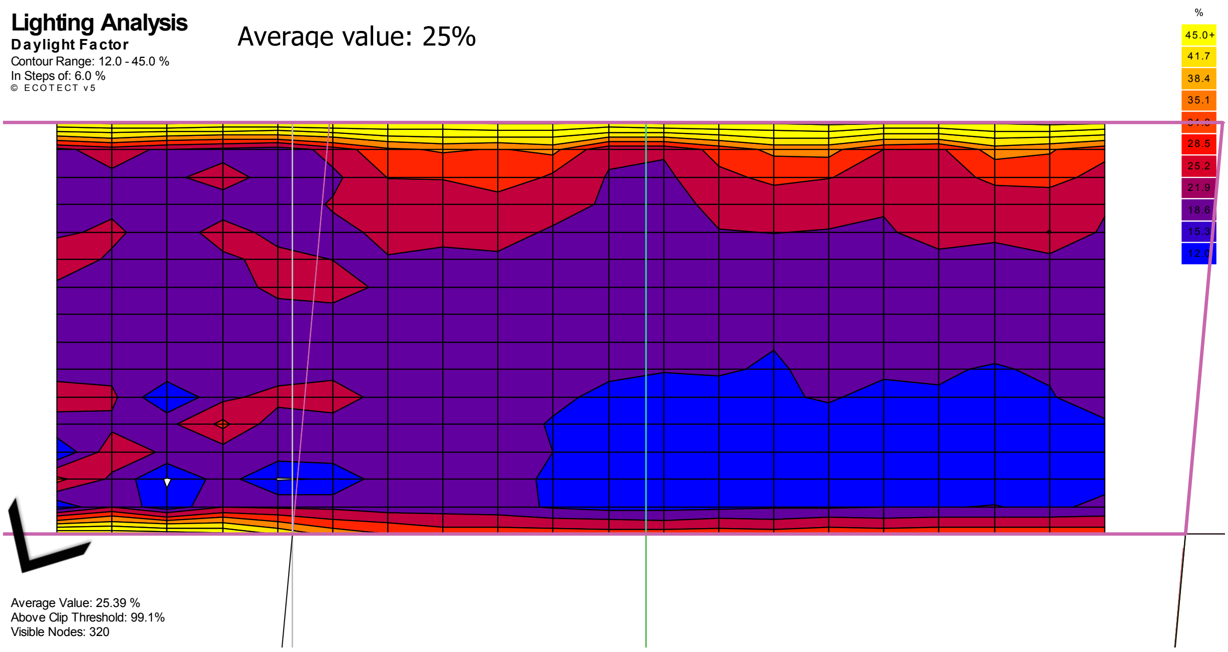


Figure 5-74: Daylight Analysis for the Gym

5.8.3. Solar Exposure Analysis: incident Solar Radiation

Incident solar radiation, also termed insolation, refers to the wide spectrum radiant energy from the Sun, which strikes an object or surface. This includes both a direct component from the Sun itself (sunshine) and a diffuse component from the visible sky (skylight).

In our design in all the modules we have two tilted surfaces which function as solar panels. The angle of the slope is 31.2 degrees which is the same as the latitude of our site therefore it can get the most of the radiation from the sun. Here we compare the other surfaces around the tilted surface to compare the amount of the radiation to see how better is the surface to be the solar collectors than the rest.

5.8.3.1. Overall analysis:

The value of the Total Annual Incident Solar Radiation for the northern solar panel is 1335351Wh/m2 and for the southern one is 1301980 Wh/m2 and the highest amount happens in summer and spring.

The same analysis for the vertical and horizontal surfaces to put the solar panels over them gives us the values of 525410 Wh/m2 and 1402494 Wh/m2. According to these values, also by comparing the shading surfaces which is always zero percent for the horizontal surface but 15-25% for the tilted one, we can understand the optimized type of the solar panel is the tilted one with the precise angle which we are using now but without any shaded surface if possible that is not happening according to the design concept and architecture of the design but it was tried to decrease the shaded surface as much as possible for the solar panels.

Considering the area of the solar panels, we can get to an approximation of 192 MWh per year for the Total Annual Incident Solar Radiation in each U-shaped block with the same coordination and size. And according to the capacity of the panels with the efficiency of 12%, which is most probable among the different solar panel types, we can produce about 23 MWh electricity.

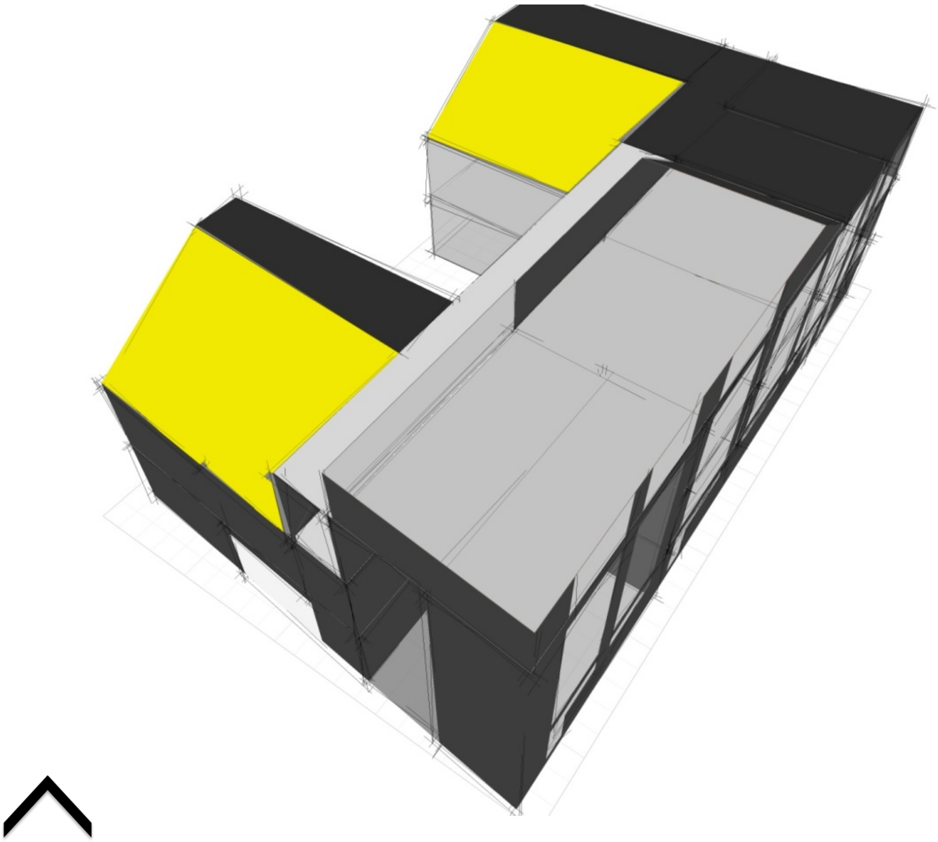


Figure 5-75: The Places of Solar Panels in a U-shaped Module

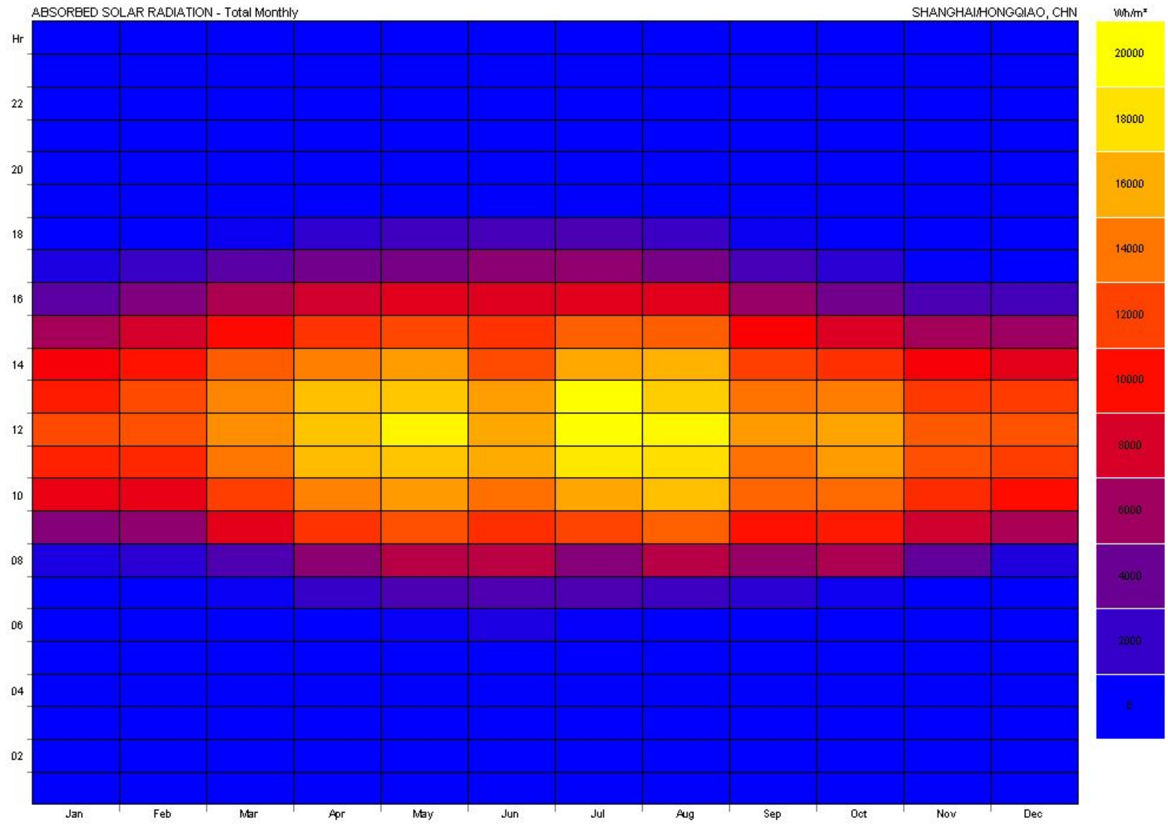


Figure 5-76: Absorbed Solar Radiation for a Solar Panel, Total Monthly

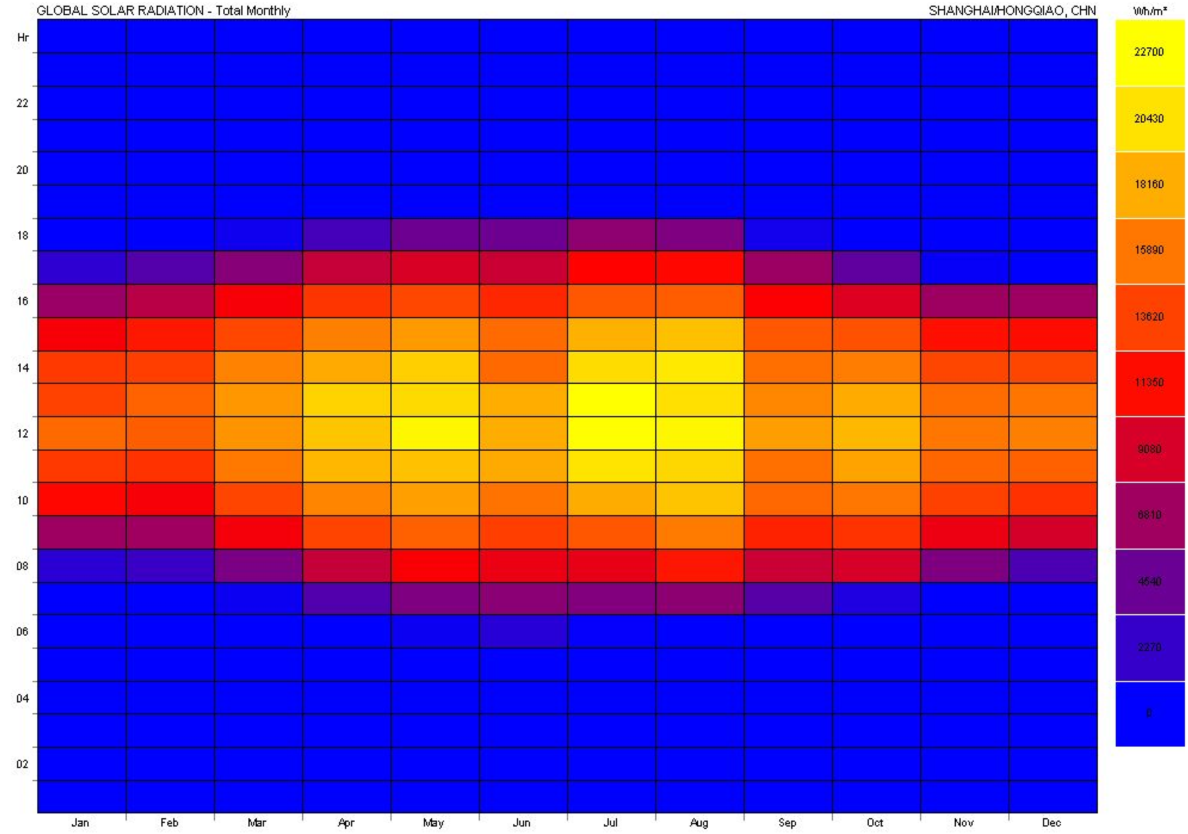


Figure 5-77: Global Solar Radiation for a Solar Panel, Total Monthly

Figure 5-78: Percentage of Unobstructed Sky for a Solar Panel, Total Monthly

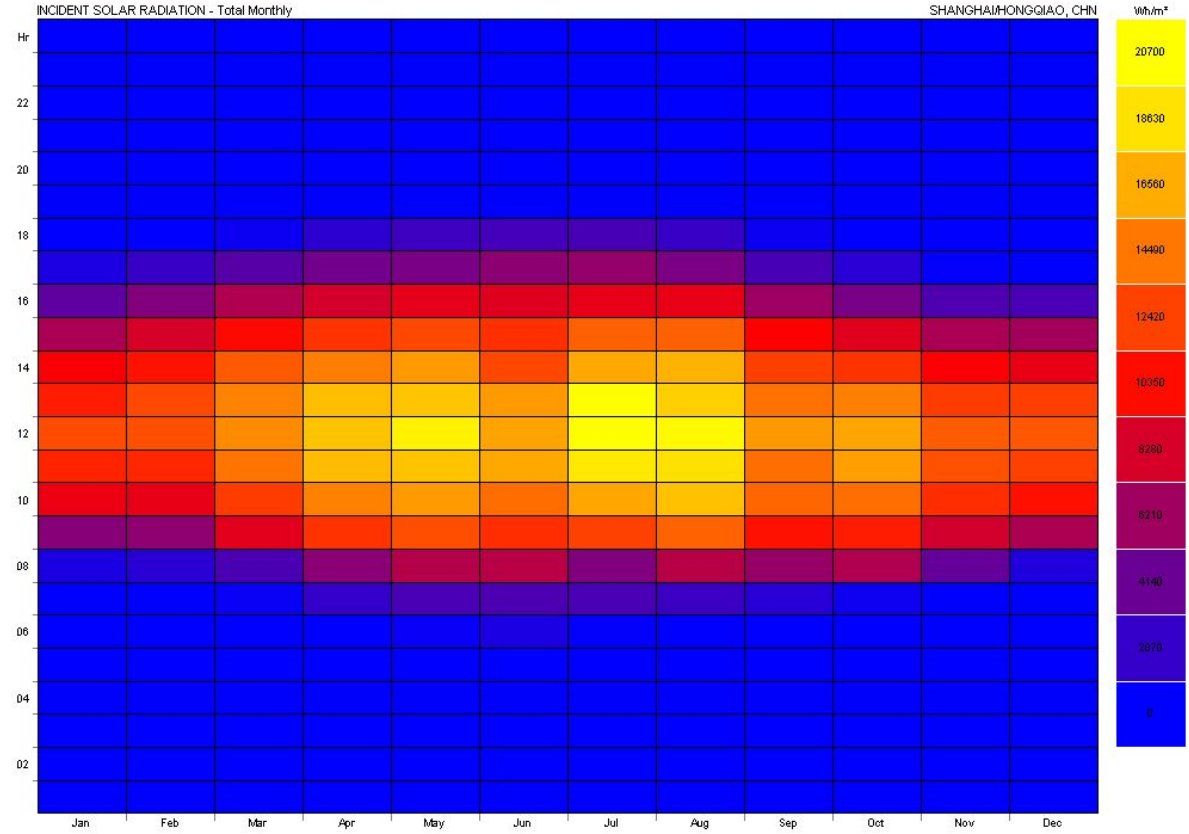


Figure 5-79: Incident Solar Radiation, Total Monthly

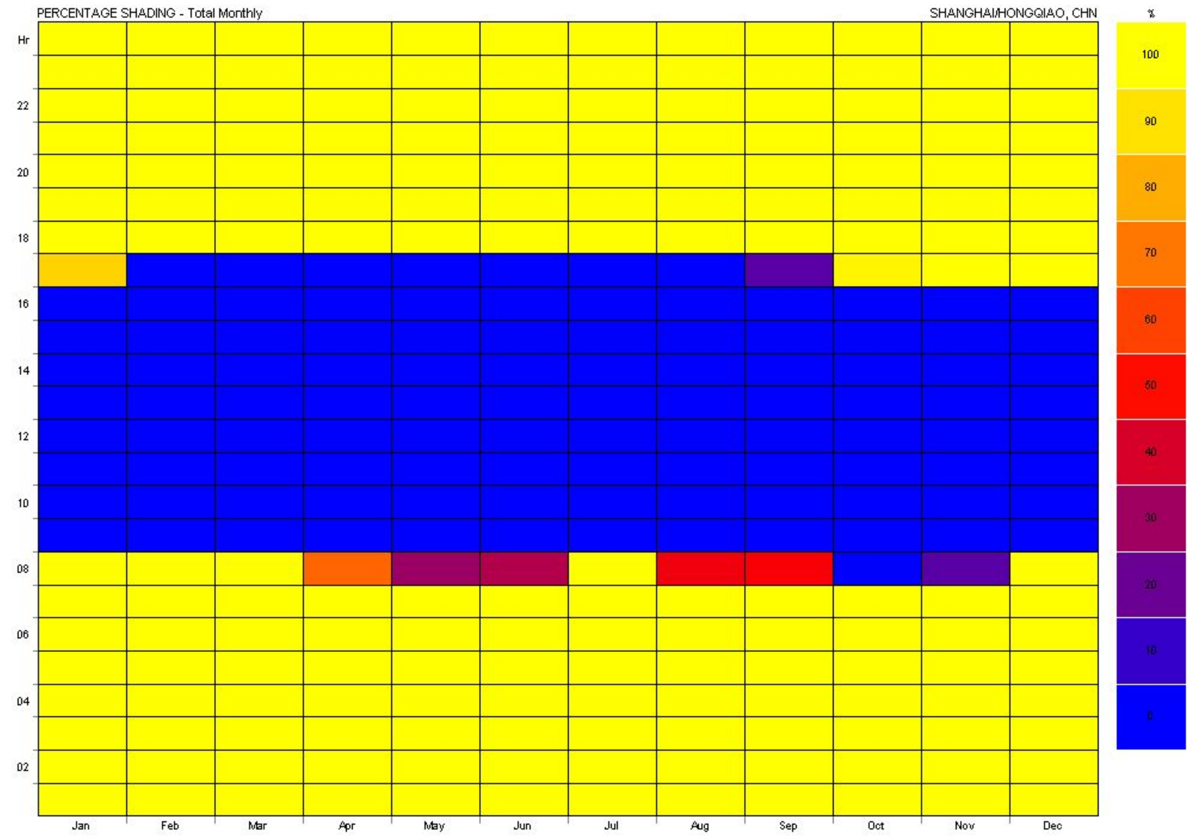


Figure 5-80: Shaded Percentage for a Solar Panel, Total Monthly

Table 6: Total Monthly Solar Exposure for the Northern Solar Panel in the Module

TOTAL MONTHLY SOLAR EXPOSURE									
SHANGHAI/HONGQIAO, CHN									
Object: 96 (72.661 m2) (Azi: 121.20 °, Alt: 58.65 °)									
	AVAIL.	AVG	REFLECT	INCIDENT		ABSORBED		TRANSMITTED	
MONTH	Wh/m2	SHADE	Wh/m2	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh
Jan	98292	17%	0	74757	5431912	71680	5208358	0	0
Feb	100665	10%	0	80386	5840918	77887	5659396	0	0
Mar	124467	16%	0	100900	7331549	98097	7127852	0	0
Apr	159866	22%	0	128419	9331054	124466	9043892	0	0
May	177195	21%	0	140005	10172961	135593	9852386	0	0
Jun	157828	26%	0	125735	9136065	122551	8904710	0	0
Jul	183447	26%	0	144112	10471372	139306	10122130	0	0
Aug	182126	21%	0	140078	10178261	134742	9790518	0	0
Sep	138612	18%	0	108279	7867706	104518	7594428	0	0
Oct	136908	13%	0	105732	7682600	100933	7333924	0	0
Nov	108330	3%	0	82066	5963012	78250	5685780	0	0
Dec	99613	11%	0	71512	5196140	67794	4925982	0	0
TOTALS	1667349		0	1301980	94603560	1255818	91249360	0	0

Table 7: Total Monthly Solar Exposure for the Southern Solar Panel in the Module

TOTAL MONTHLY SOLAR EXPOSURE									
SHANGHAI/HONGQIAO, CHN									
Object: 97 (72.741 m2) (Azi: 126.34 °, Alt: 58.55 °)									
	AVAIL.	AVG	REFLECT	INCIDENT		ABSORBED		TRANSMITTED	
MONTH	Wh/m2	SHADE	Wh/m2	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh
Jan	98292	0%	0	76671	5577132	73535	5349024	0	0
Feb	100665	0%	0	82040	5967692	79477	5781215	0	0
Mar	124467	4%	0	103367	7519004	100429	7305265	0	0
Apr	159866	8%	0	131298	9550739	127142	9248416	0	0
May	177195	11%	0	143294	10423305	138571	10079746	0	0
Jun	157828	15%	0	128642	9357556	125194	9106752	0	0
Jul	183447	9%	0	148335	10790001	143173	10414551	0	0
Aug	182126	8%	0	144622	10519894	138854	10100341	0	0
Sep	138612	5%	0	111073	8079534	107114	7791530	0	0
Oct	136908	6%	0	107786	7840458	102920	7486476	0	0
Nov	108330	1%	0	83866	6100508	80030	5821470	0	0
Dec	99613	0%	0	74357	5408788	70512	5129124	0	0
TOTALS	1667349		0	1335351	97134600	1286950	93613904	0	0

5.8.4. Thermal Analysis of U-shaped module

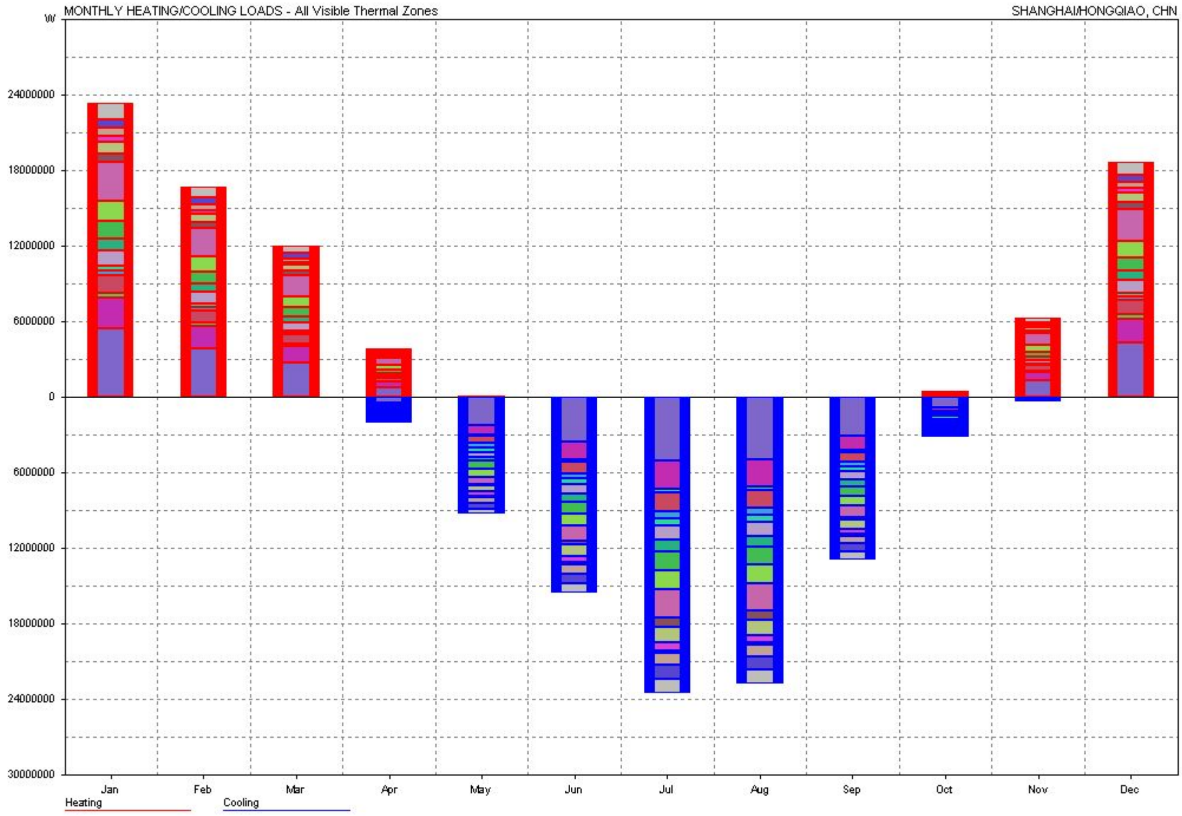


Figure 5-81: Monthly Heating and Cooling Loads

Table 8: Monthly Heating and Cooling Loads

Comfort: Adaptive - Free Running (± 1.75)			
Max Heating: 84223 W at 01:00 on 31st January			
Max Cooling: 92764 W at 12:00 on 14th July			
	HEATING	COOLING	TOTAL
MONTH	(Wh)	(Wh)	(Wh)
Jan	23271692	0	23271692
Feb	16690971	7589	16698560
Mar	12013582	14798	12028380
Apr	3816135	2038071	5854206
May	115140	9229116	9344256
Jun	0	15563179	15563179
Jul	0	23498258	23498258
Aug	0	22730414	22730414
Sep	1645	12935475	12937120
Oct	475394	3214722	3690116
Nov	6261162	346085	6607248
Dec	18618378	7259	18625636
TOTAL	81264104	89584960	170849056
PER M²	35451	39081	74533
Floor Area:	2292.265 m2		

Total annual heating loads for this U-Shaped module is around 81 MWh almost the same as the total annual cooling loads there which is around 90 MWh. It shows the HVAC system should work properly in both Heating and cooling with the highest efficiency. A part of the total annual heating and cooling load which is around 171 MWh can be produced by the solar panels that we are using in the design which produce about 21 MWh per year.

The total load of the building during the year is 74.533 KWh/m2. We can say the building is in the A3 level of energy according to BER energy rating. If we check the apartments inside, according to the location of the apartments, the levels of energy are different in different apartment in the range of A3 to B3.

Table 9: Energy Production and Consumption Comparison

MONTH	Total Monthly Heating and Cooling Loads	Total Monthly Energy Produced by Solar Panels
Jan	23,27	1,32
Feb	16,70	1,42
Mar	12,03	1,78
Apr	5,85	2,27
May	9,34	2,47
Jun	15,56	2,22
Jul	23,50	2,55
Aug	22,73	2,48
Sep	12,93	1,91
Oct	3,69	1,86
Nov	6,61	1,45
Dec	18,62	1,27

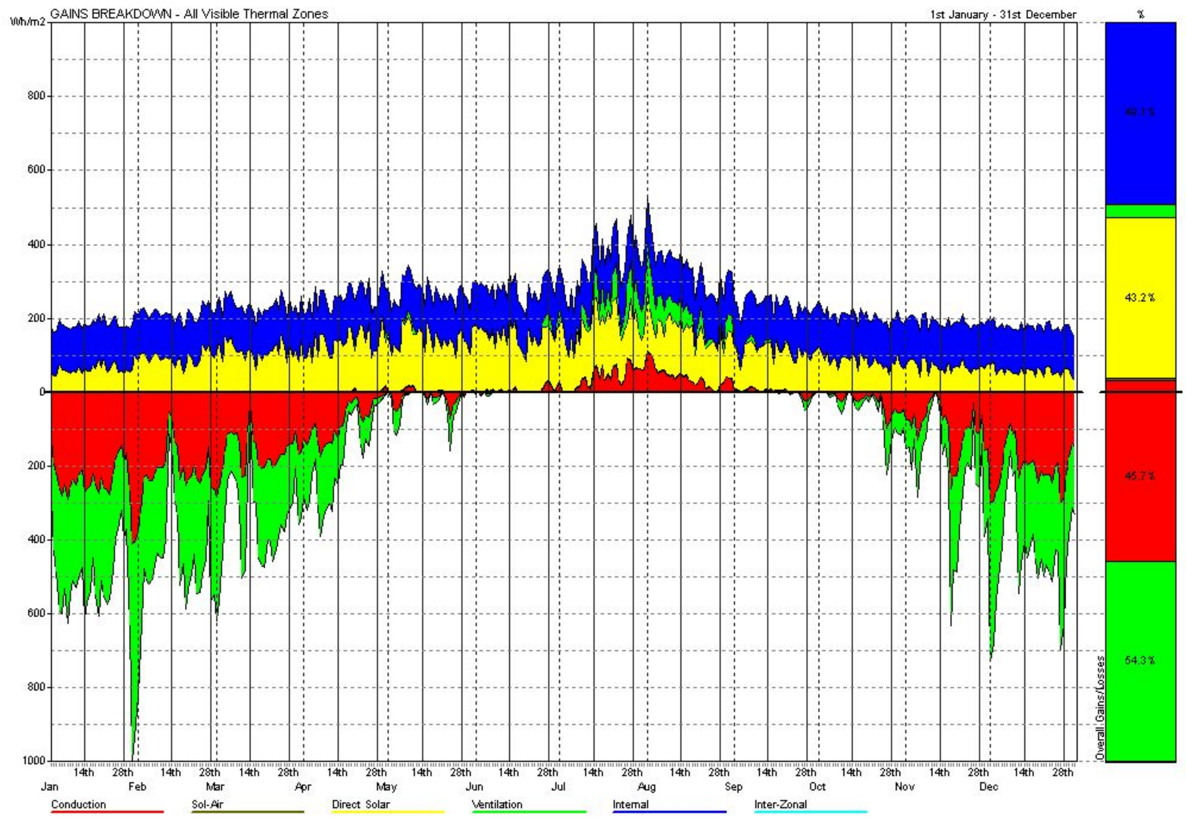


Figure 5-82: Gain Breakdown

Table 10: Gain Breakdown

GAINS BREAKDOWN - All Visible Thermal Zones		
FROM: 1st January to 31st December		
CATEGORY	LOSSES	GAINS
FABRIC	45.7%	3.1%
SOL-AIR	0.0%	0.9%
SOLAR	0.0%	43.2%
VENTILATION	54.3%	3.8%
INTERNAL	0.0%	49.1%
INTER-ZONAL	0.0%	0.0%

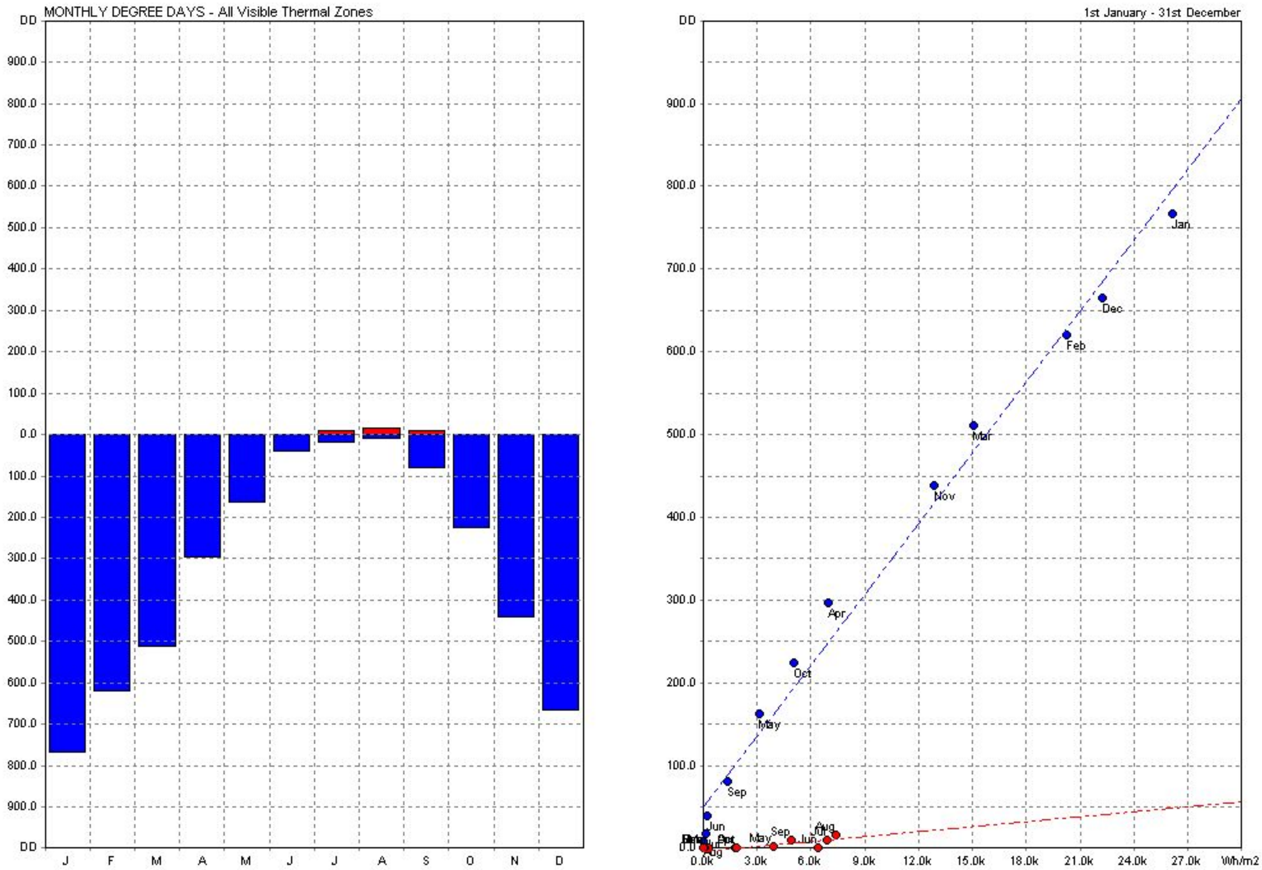


Figure 5-83: Monthly Degree Days

Table 11: Monthly Degree Days

MONTHLY DEGREE DAYS - All Visible Thermal Zones				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	421.7	0.0	10917	105
Feb	336.3	0.0	7854	717
Mar	286.4	0.0	5642	1729
Apr	132.8	1.8	1920	4400
May	22.7	3.6	118	7587
Jun	1.0	7.5	0	8335
Jul	0.0	66.8	0	10847
Aug	0.0	69.5	0	10449
Sep	4.4	5.1	18	6967
Oct	39.7	0.0	425	5297
Nov	164.5	0.0	3094	2418
Dec	356.4	0.0	8744	449

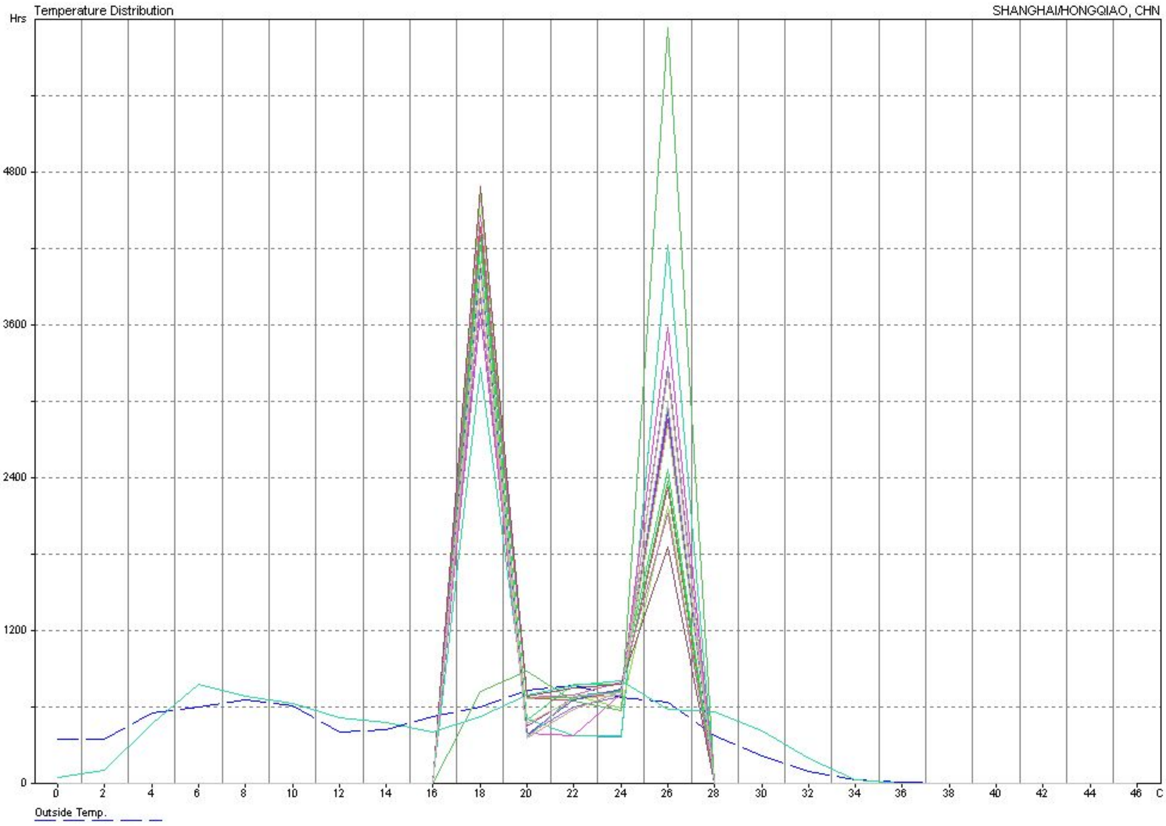


Figure 5-84: Temperature Distribution

5.9. HVAC System

5.9.1. Introduction

Uncontrolled moisture can reduce the quality of indoor air, make occupants uncomfortable, and damage a building's structure and furnishings. One form of moisture is water vapor entrained in the air.

Before the widespread use of air conditioning, humid weather meant high moisture levels indoors; indoor relative humidity remained acceptable, however, because the dry-bulb temperature indoors also increased. During warm weather, interior surfaces were only slightly cooler than the ambient temperature, so indoor condensation seldom occurred. The presence of any microbial growth primarily resulted from water leaks or spills, or from condensation on poorly insulated walls during cold weather.

Until 1970, designers typically chose constant-volume reheat or dual-duct systems to provide mechanical ventilation and air conditioning in commercial and institutional buildings. Both types of systems effectively (albeit coincidentally) controlled indoor humidity while regulating dry-bulb temperature. As the 1970s drew to a close, heightened concern about the availability and cost of energy prompted designers to choose system designs that neither used "wasteful" reheat energy nor mixed hot and cold air streams.

Although many of today's HVAC systems adequately control the indoor dry-bulb temperature, the lack of reheat or mixing allows humidity in the space to "float." High humidity levels can develop, especially during part-load operation. When coupled with the cold indoor surfaces that result from mechanical cooling, high humidity may lead to unwanted condensation on building surfaces.

5.9.2. Sources and Effects of Indoor Moisture

Moisture can enter a building as a liquid or a vapor via several paths: Liquid sources include ground-water seepage, leaks in the building envelope, spills, condensation on cold surfaces, and wet-cleaning processes (such as carpet shampooing). Water vapor develops inside the building or it can enter the building from outdoors. Indoor sources include respiration from people, evaporation from open water surfaces (such as pools, fountains, and aquariums), combustion, cooking, and evaporation from wet cleaning.

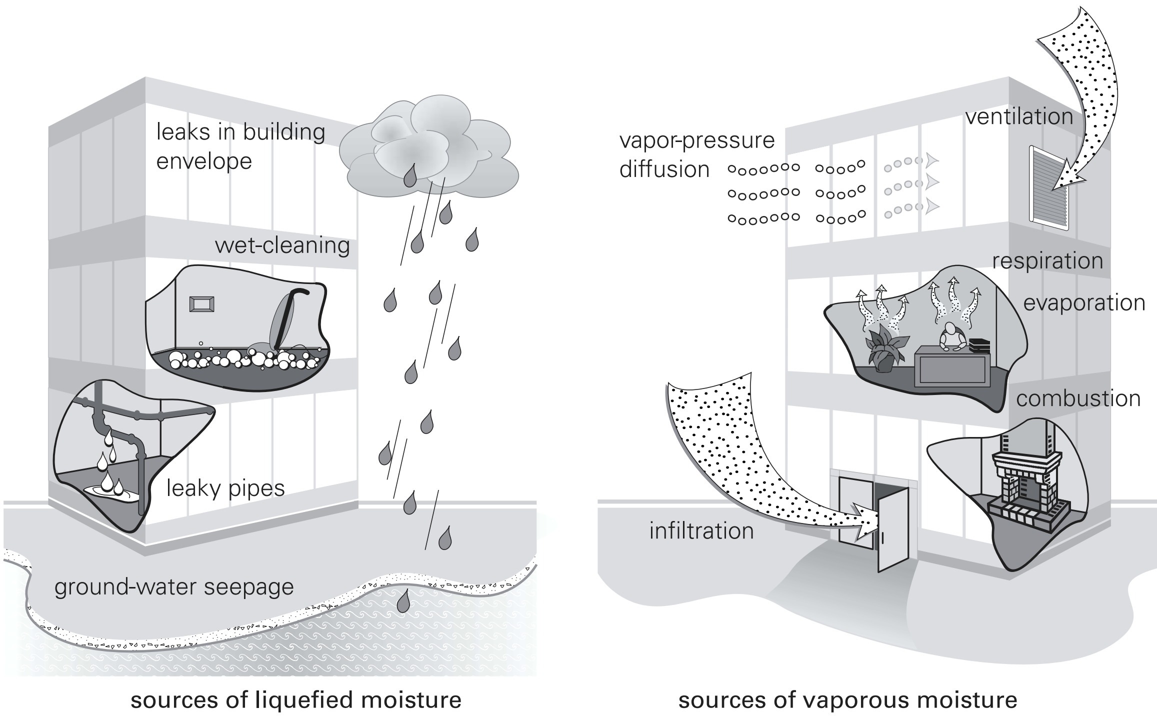


Figure 5-85: Sources of moisture in buildings

5.9.3. Indoor Air Quality

Scientists agree that excess water or “dampness” can contribute significantly to mold growth inside buildings. Minimizing sources of moisture is the best way to help minimize microbial growth.

ANSI/ASHRAE Standard 62–2001, Ventilation for Acceptable Indoor Air Quality, addresses the link between indoor moisture and microbial growth in this recommendation: Relative humidity in habitable spaces preferably should be maintained between 30 percent and 60 percent to minimize the growth of allergenic and pathogenic organisms.

5.9.4. Occupant Comfort and Productivity

In addition to curbing microbial growth, limiting indoor humidity to an acceptable level helps assure consistent thermal comfort within occupied spaces, which:

- Reduces occupant complaints
- Improves worker productivity
- Increases rental potential and market value

ANSI/ASHRAE Standard 55–1992, Thermal Environmental Conditions for Human Occupancy, specifies thermal environmental conditions that are acceptable to 80 percent or more of the occupants within a space.

Defined by Standard 55 represents a range of environmental conditions based on dry-bulb temperature, humidity, thermal radiation, and air movement. Depending on the utility of the space, maintaining the relative humidity between 30 percent and 60 percent keeps most occupants comfortable.

5.9.5. Types of Dehumidification

Maintaining the indoor humidity within the desired range requires a means of either locally removing moisture from the air that is already in the space, or replacing that moisture-laden air with drier air that was dehumidified elsewhere.

5.9.6. Processes for Dehumidification

An air-conditioning system typically uses one of two processes to dehumidify the supply air that ultimately reaches the space: condensation on a cold coil or adsorption via a desiccant.

5.9.7. Condensation on a Cold Coil

Water vapor condenses on a surface if the temperature of the surface is colder than the dew point of the moist air in contact with it. Controlled condensation dehumidifies an air stream by directing it across the cold surfaces of a finned- tube coil. Circulating either chilled water or evaporating refrigerant through the coil makes the coil surfaces cold enough to induce condensation. As warm, moist air passes through the coil, water vapor condenses on the cold surfaces; the condensate (liquid water) then drains down the coil fins and collects in the drain pan, where it is piped from the air handler. The air leaves the coil cooler and drier.

5.9.8. Adsorption Using a Desiccant

Desiccants used for commercial dehumidification are selected for their ability to collect large quantities of water vapor. The porous surface of the desiccant attracts and retains water molecules from the passing air stream. This dehumidification process is described as adsorption because the collected moisture does not chemically or physically alter the desiccant.

Vapor pressure at the desiccant surface is directly proportional to the surface temperature of the desiccant and the amount of moisture adsorbed there. When the desiccant is cool and dry, its surface vapor pressure is low; when the desiccant is warm and moist, its surface vapor pressure is high. Water vapor migrates from areas of high vapor pressure to areas of low vapor pressure. Consequently, a desiccant with a low surface vapor pressure will adsorb water molecules from the surrounding air, while a desiccant with a high surface vapor pressure will reject water molecules to the surrounding air.

5.9.9. Hybrid Solar Air Conditioning[25]

Hybrid Solar Air Conditioning, also known as Solar Assisted Air Conditioning, is a revolutionary system that uses the power of solar energy to assist a high efficiency compressor to reduce energy use dramatically. Like a traditional central air conditioning system, there is a compressor and an air handler, but added is a solar thermal collector mounted on the roof.

The Hybrid Solar Air Conditioning system takes a high efficiency 16 SEER compressor adapted to circulate refrigerant to the solar collector. The solar collector, made of evacuated glass tubes, superheats the refrigerant, making the job of the compressor easier, and thereby reducing energy use.

A conventional air conditioning system uses the compressor (powered by electricity) to pressurize and heat the refrigerant gas up to about 170 degrees. It then travels into the outside condensing coils where it changes from a gas into a saturated gas (partial liquid). Typically this occurs in the final third of the condensing coil. From there the saturated gas passes through an expansion device that allows the refrigerant to become a gas again. Once this happens it can absorb heat from the air passing through the inside coil of the air conditioner. From there the refrigerant goes back to the compressor where it starts the whole cycle again.

A hybrid solar air conditioning system uses the same basic equipment as a conventional system with a specialized solar collector that is placed between the compressor and the condensing coils. The primary task of the compressor is to pressurize and heat the refrigerant. The hotter it gets the better. A hybrid solar air conditioning system uses a highly efficient vacuum tube collector filled with an organic liquid product. The collector heats the organic substance to over 350 degrees using the FREE power of the sun to superheat the refrigerant above what the compressor would be able to heat it with electricity. The resulting efficiency derived from the solar collector allows for the refrigerant to work more efficiently with no additional moving parts or motors. This increases the ability of the gas to change back into a liquid much more quickly and dramatically reduces the energy requirement of the compressor. The gas now condenses back into saturated gas in the first third of the condensing coil not the final third. Therefore by the time the refrigerant reaches the expansion device in the inside coil, it is already almost a liquid. This allows the

[25] (Fafco Solar Energy)

near liquid refrigerant to be more efficient at absorbing heat, making it 5-6 degrees cooler in the inside coil, delivering colder, drier air to the building.

5.9.10. How is humidity controlled with an AC system?26

Humidity is becoming more of a concern to building operators and owners. High indoor humidity leads to mold and mildew growth inside the building. There are several methods of controlling indoor humidity. The simplest (and most expensive) method is to connect a humidistat to an electric heater. When the humidity inside the building rises above the humidistat set point, the heater is turned on. The additional heat causes the air conditioning system to run longer and remove more moisture.

A more efficient method of controlling humidity is to use the waste heat from the refrigeration cycle itself. Instead of rejecting the waste heat outdoors, the heat is directed inside when humidity control is required. One form of heat reclaim is called hot-gas reheat or "refrigerant desuperheating" where refrigerant is passed through a heat exchanger located downstream of the cooling coil. The hot high-pressure vapor leaving the compressor passes through this heat exchanger prior to entering the condenser coil. This in turn heats the indoor air and again causes the AC system to run longer to meet the thermostat set point. Although more energy is used, this is much more efficient than turning on an electric heater. Another form of heat reclaim is called sub-cool reheat. This strategy takes the warm liquid refrigerant from the condenser and passes it through a heat exchanger located downstream of the cooling coil. Less heat is available using this method because the majority of the heat has already been rejected at the condenser. Since more energy is used to pump liquid (as opposed to a gas) through the heat exchanger it would appear that this method is less efficient than the hot-gas method, however, the liquid in the heat exchanger is sub-cooled in the cold supply air stream, which increases the capacity of the air conditioner. Since more capacity is available, the AC units are able to meet the thermostat more quickly.

Heat pipe heat exchangers or run-around coils perform a similar function when humidity control is required. Two heat exchangers are placed in the air stream, one upstream of the cooling coil and the other downstream of the cooling coil. These heat exchangers are connected together with piping. A heat transfer fluid, whether water or refrigerant, is either pumped or gravity fed from one heat exchanger to the other. The heat exchanger downstream of the cooling coil (re-heat coil) cools the liquid medium inside the heat exchanger and heats the air passing over the heat exchanger. The cold liquid inside the

---

[26] (HVAC Systems)

heat exchanger is moved to the heat exchanger upstream of the cooling coil (pre-cool coil) where it pre-cools the air passing over the heat exchanger and warms the liquid passing through the heat exchanger. The effect of a heat pipe or run-around coil is to reduce the sensible heat capacity of the AC system. The latent capacity of the AC system increases if direct-expansion equipment is used or remains relatively constant if chilled water equipment is used. Since the sensible capacity of the AC system has been reduced, the system must run longer to meet the thermostat set point thereby removing more moisture.

5.10. Solar Energy Solutions

5.10.1. Solar Lights[27]

Tubular Skylights are energy efficient high performance lighting systems. They are cylindrical in shape and are designed to light rooms up with natural sunlight. A small clear collector dome on the roof allows sunlight to enter into a highly reflective "light pipe" that extends from the roof level to the ceiling level. The light pipe is coated with a silver finish mirror quality that allows the full spectrum of sunlight to be channeled. It disperses evenly into a room through the means of a diffuser located in the ceiling. Tubular Skylights are designed not to compromise roof integrity. The unit minimizes the size of roof penetrations, and is weather-tight, eliminating the chance of leaks.

5.10.2. Solar Electric (Photovoltaic) Systems[28]

Benefits of the Solar Photovoltaic Systems, we are using in the project

- Reduce you electric bill.
- Help the country become less dependent on fossil fuels.
- Know that you are reducing your carbon footprint.
- Sell excess energy back to the utility company.
- Take advantage of tax benefits and rebates.
- Hedge against future energy price increases.

[27] (Fafco Solar Energy)
[28] (Fafco Solar Energy)


Structure
水墨與都
Ink Painting

6. Structure

6.1. General description

We are going to use concrete for the structure in order to have better performance in the quake and also to make the complicated shapes of the roof. Our structure will be fixed-frame concrete structure. The software that we are using for the design of the structure is ETABS, which is one of the best in designing normal concrete buildings.

Design process starts with modeling the whole structure with all the elements including the columns with the first try approximation for the size and the reinforcements to be checked and the beams with the first try size without the reinforcements to be designed in the software. The loads should be assigned and the load cases and the combinations we are using in the design are according to ACI standard and also UBC97 in almost all the design except in some part that we are stricter, for example in the mass source we consider also live load. After the analysis of the structure according to the standards, by try and error we assign all the columns and we chose the dimension of the beams and from the design we get area for the reinforcements. Then we need to choose the type of the reinforcements, the size, and also we need to check the distance between them to be sure that we are still in the standard range mentioned in the standard. After designing by a few number repetitions of try and error we should check the displacement and the drift of the different levels and point to be reasonable. To show this process we show the process of design for one of the beams and one of the columns.

6.2. Modeling Process in ETABS

6.2.1. Structural Material

The concrete we are using has these material properties in Kgf-m:

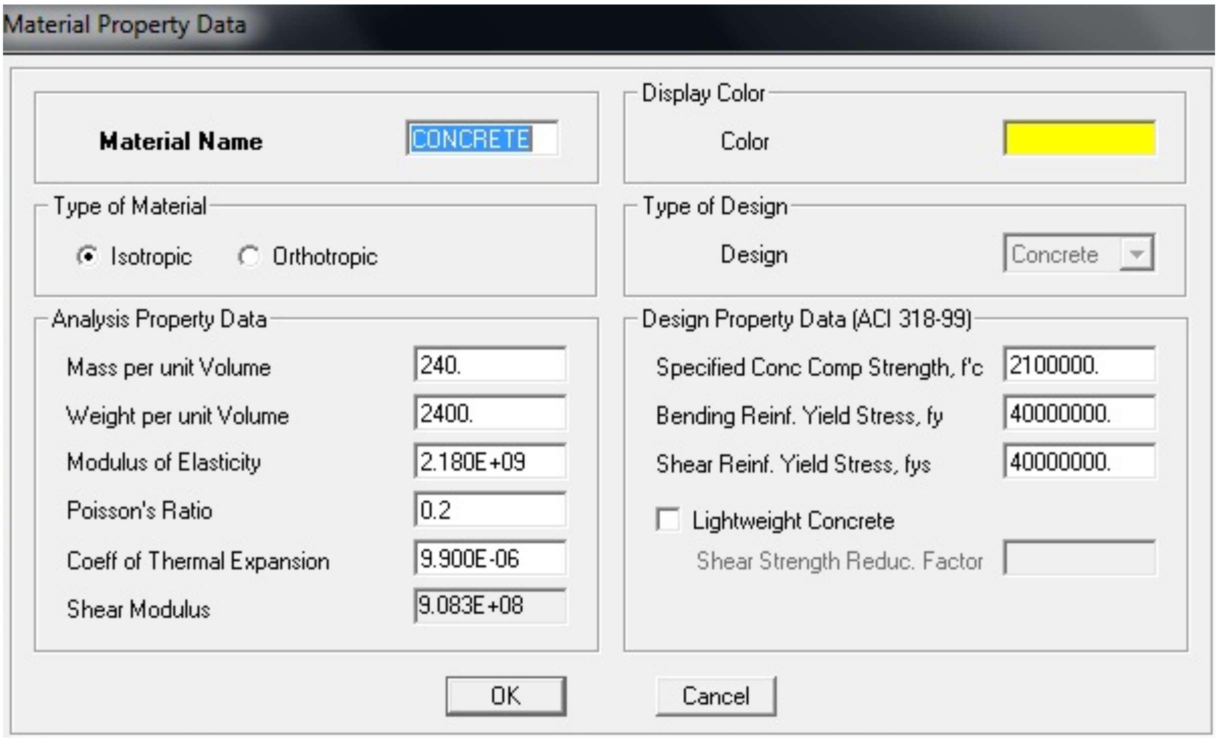


Figure 6-1: Material Properties

6.2.2. Load cases and the mass source

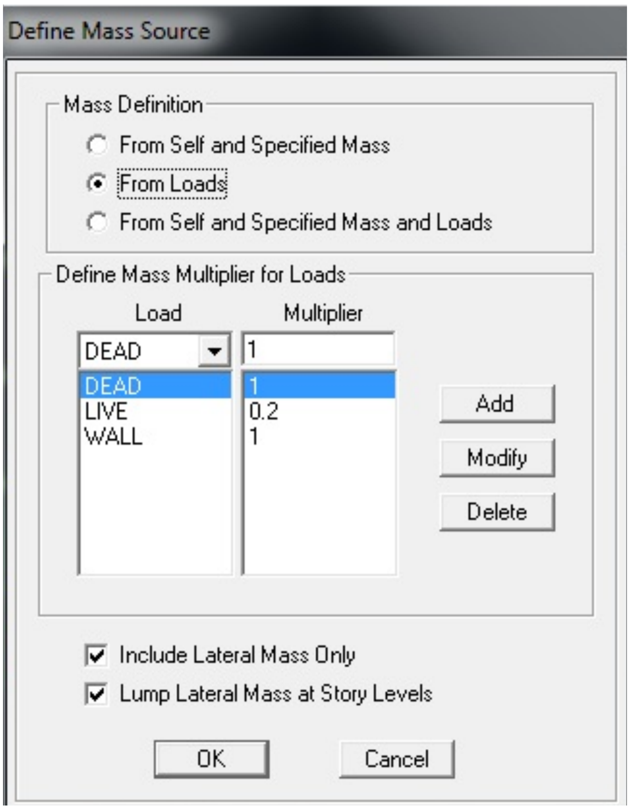


Figure 6-2: Mass Source

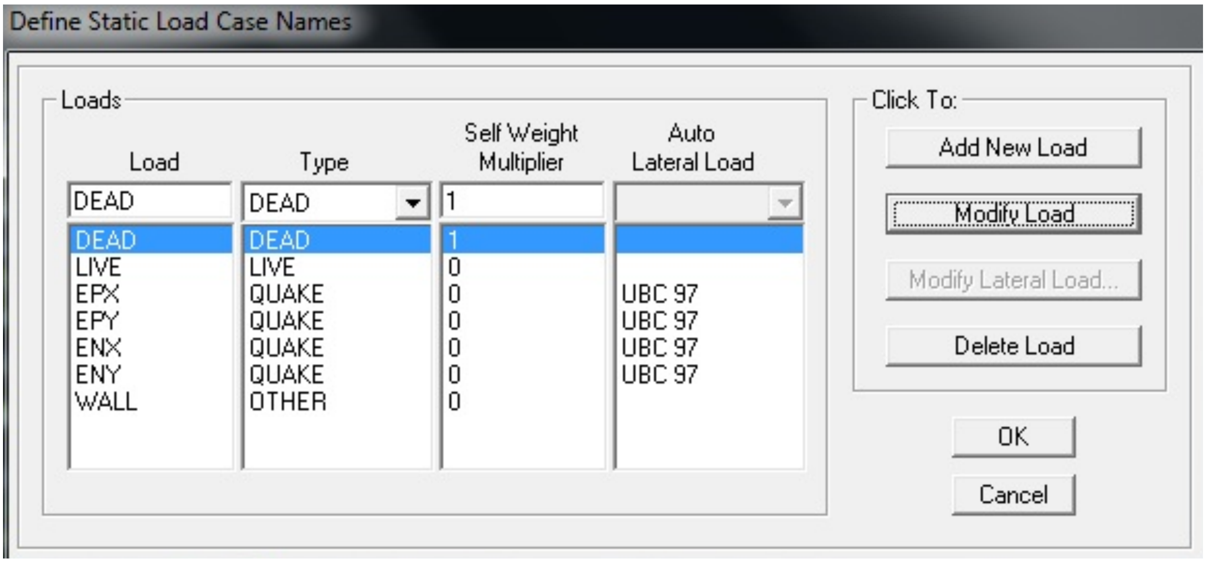


Figure 6-3: Static Load Cases

6.2.3. ETABS Structural Renders

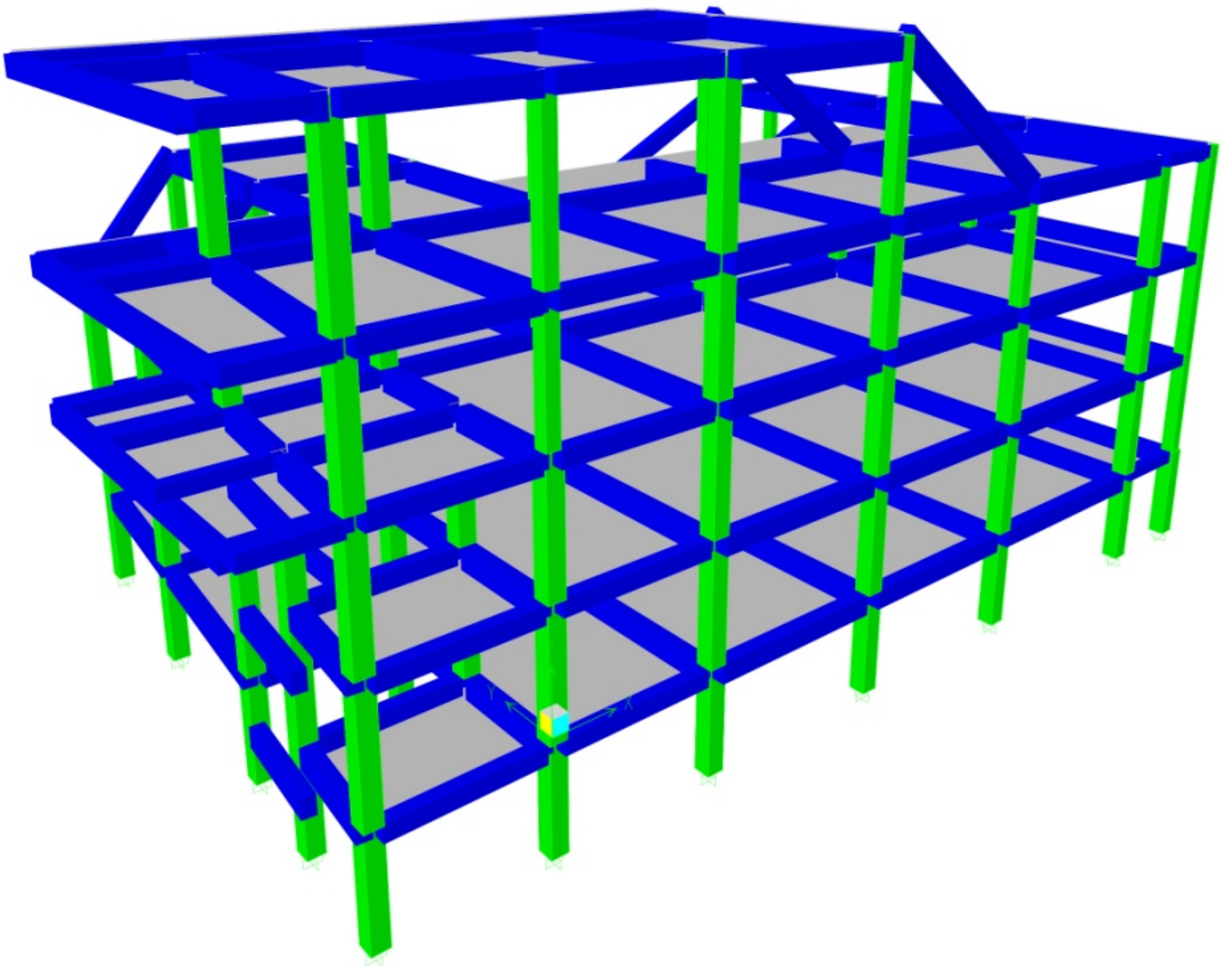


Figure 6-4: Structural Render from ETABS

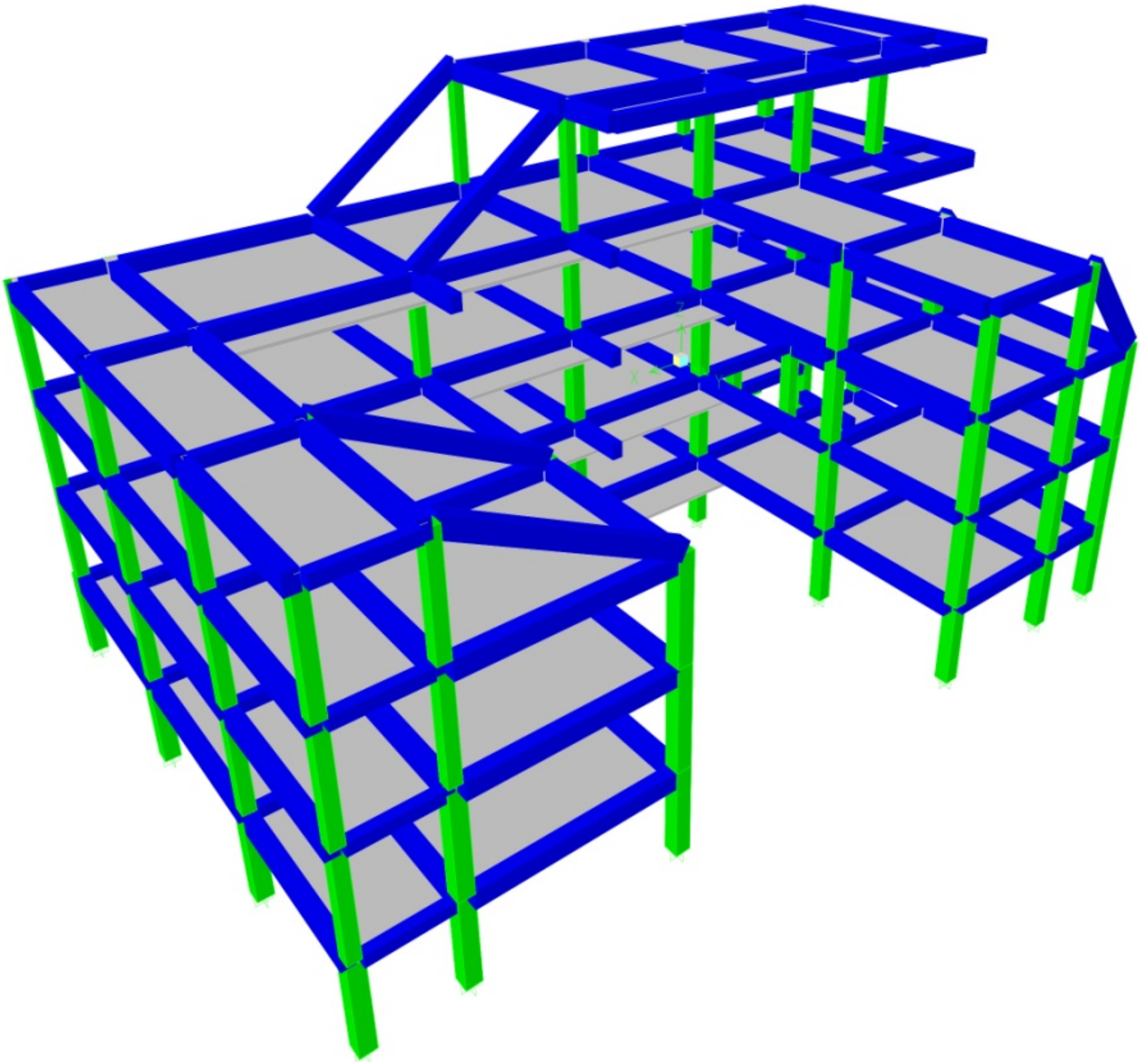


Figure 6-5: Structural Render from ETABS

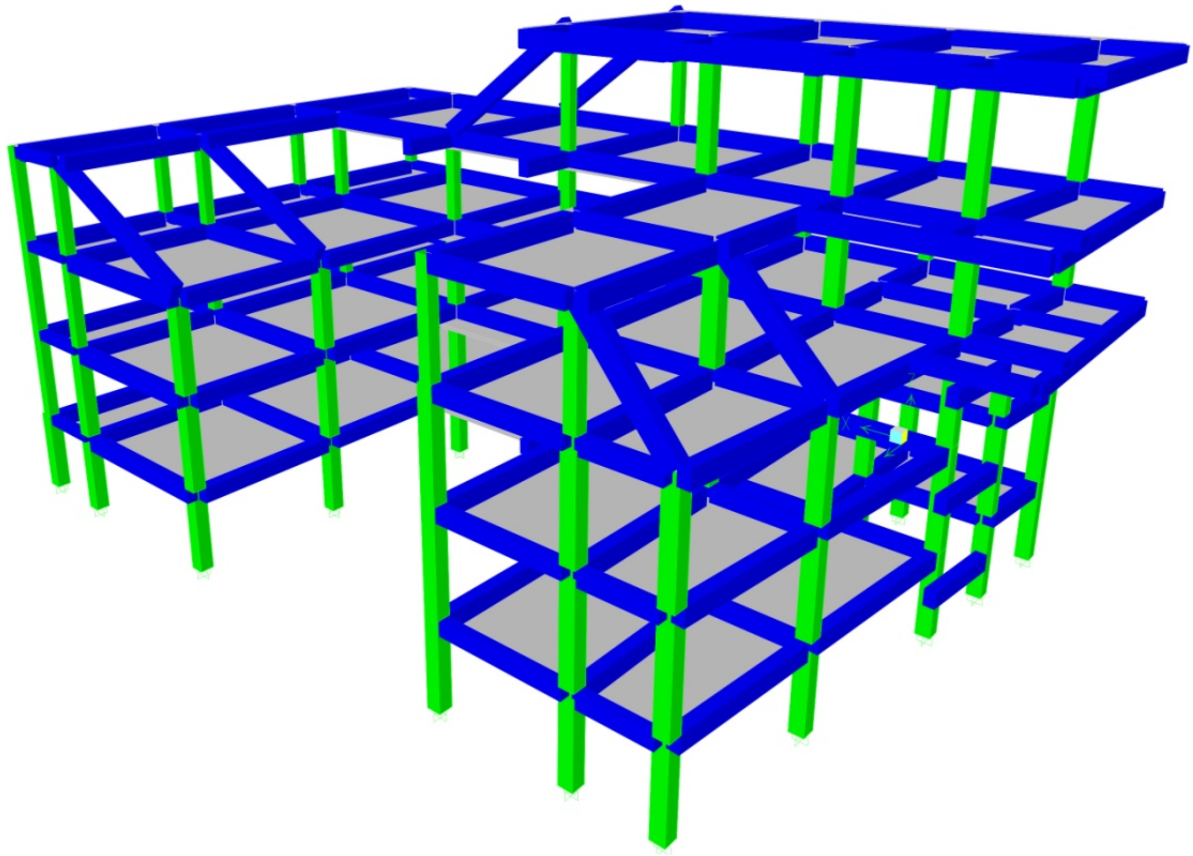


Figure 6-6: Structural Render from ETABS

6.2.4. Loading

The loads that we assigned on the structural elements are coming from the design of the walls and the floors before.

Table 12: Structural Loads

Weight	Kg/m2
External wall type 1	70
External wall type 2	90
Internal wall type 3	50
Internal wall type 4	90
Internal wall type 5	70
Internal wall type 6	50
Floor type 1	320
Floor type 2	270
Floor type 3	260
Floor type 4	210
Floor type 5	380
Floor type 6	230

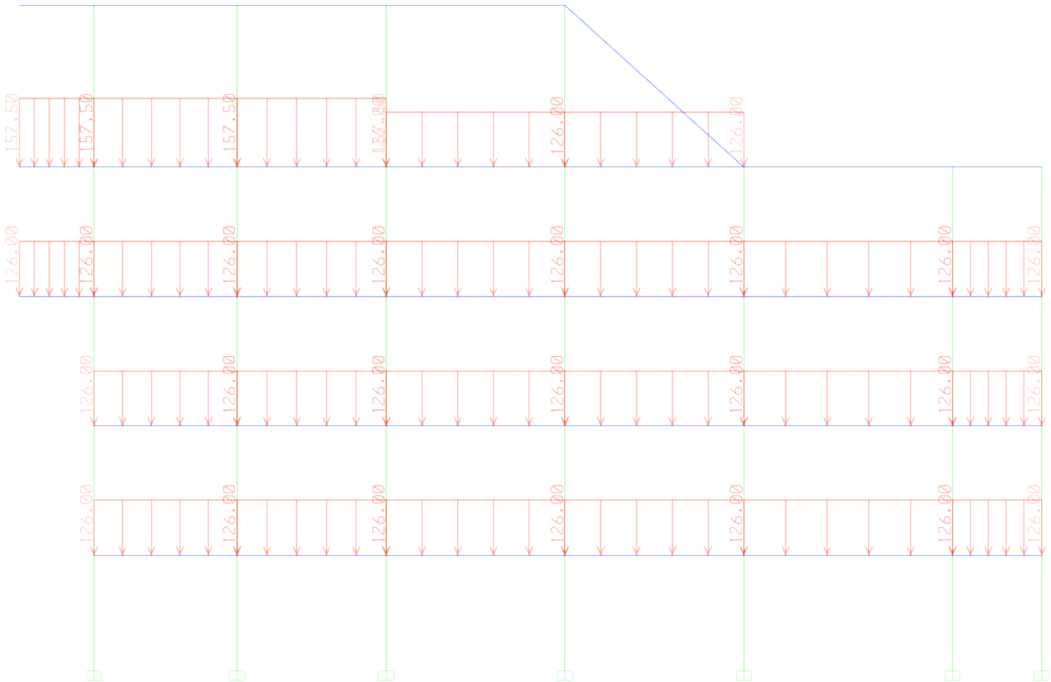


Figure 6-7: Wall Load

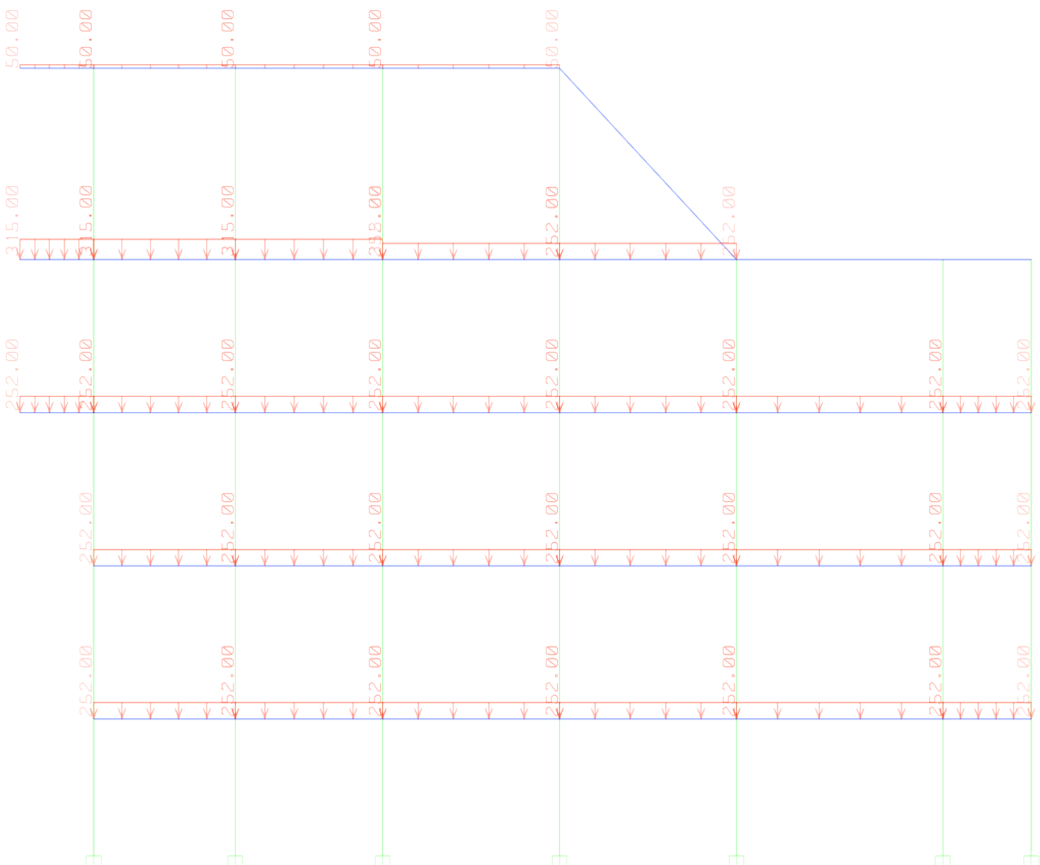


Figure 6-8: Dead Load

6.3. Structural Analysis

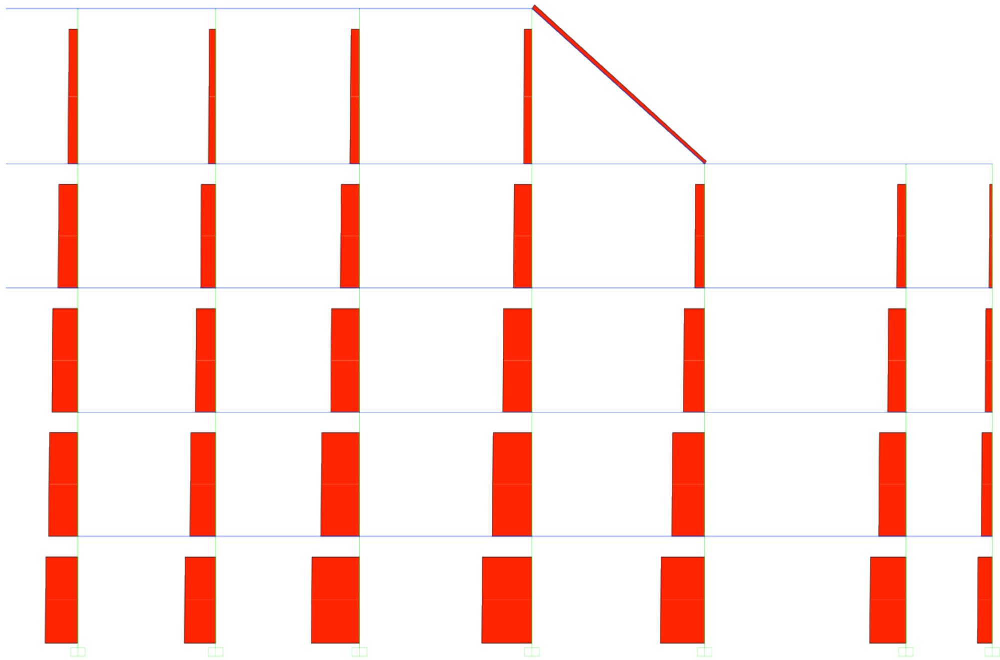


Figure 6-9: Axial Forces Diagram of the Frame Under Dead Load

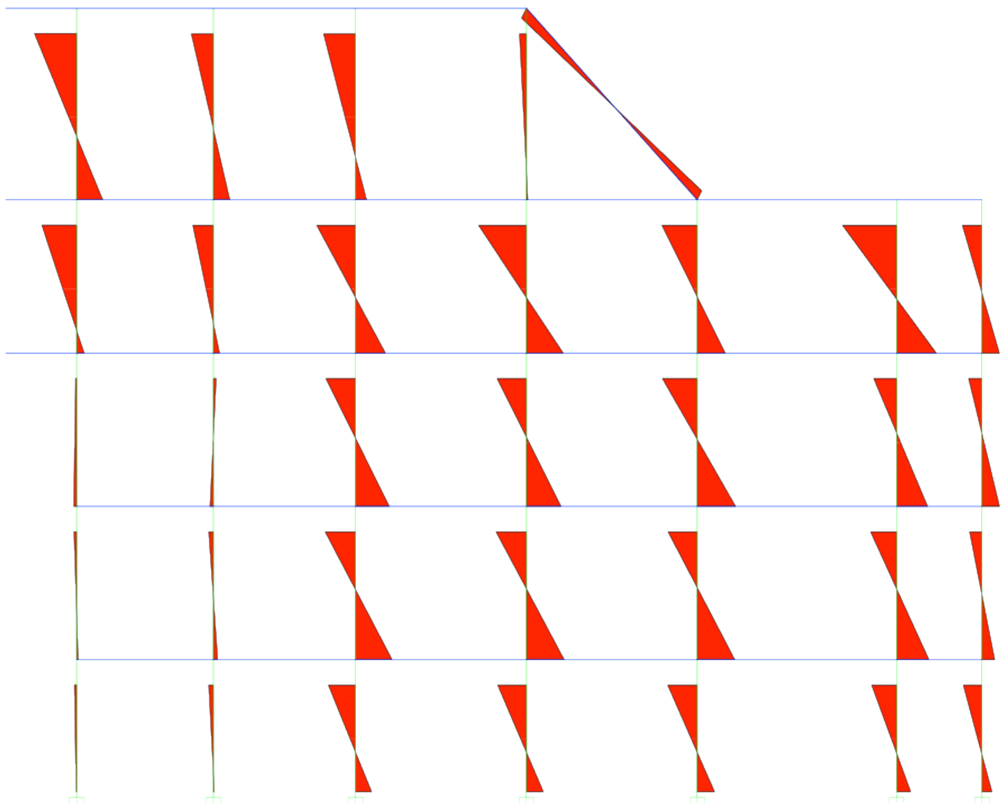


Figure 6-10: Moments Around Axis 2-2 Diagram of the Frame Under Dead Load

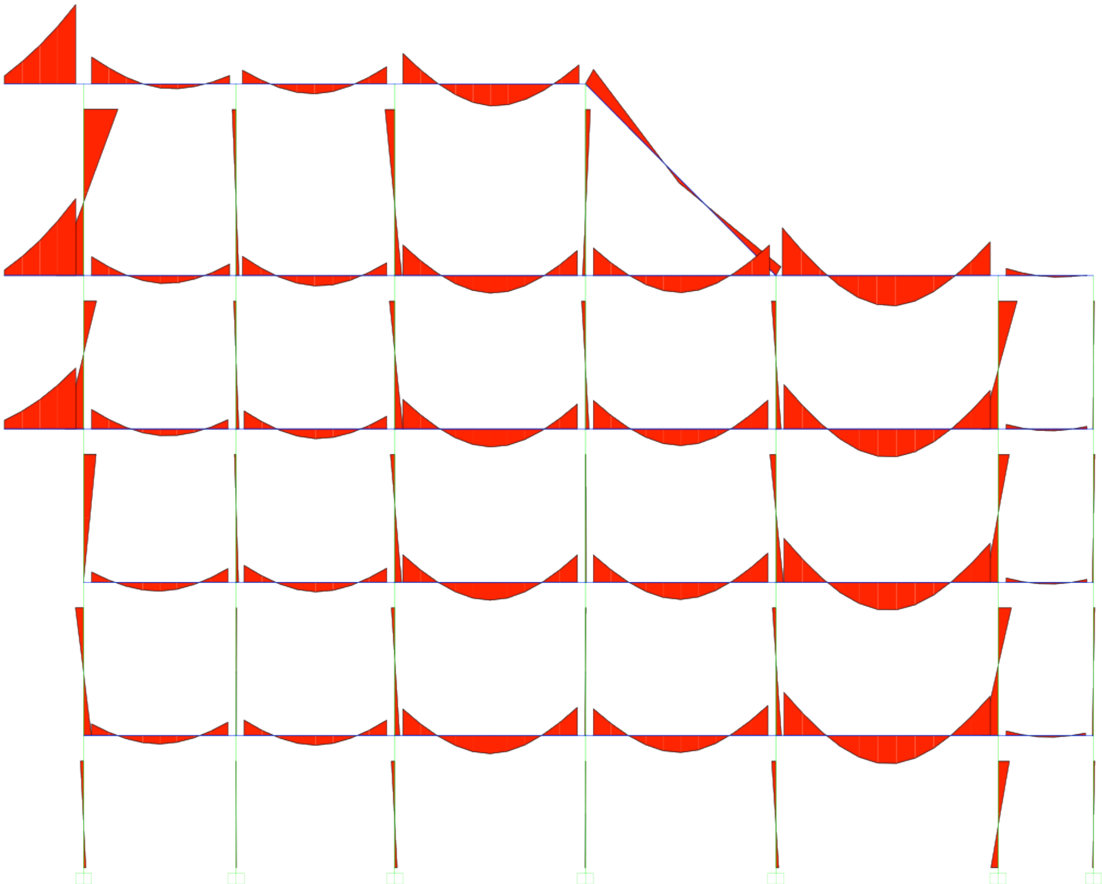


Figure 6-11: Moments Around Axis 3-3 Diagram of the Frame Under Dead Load

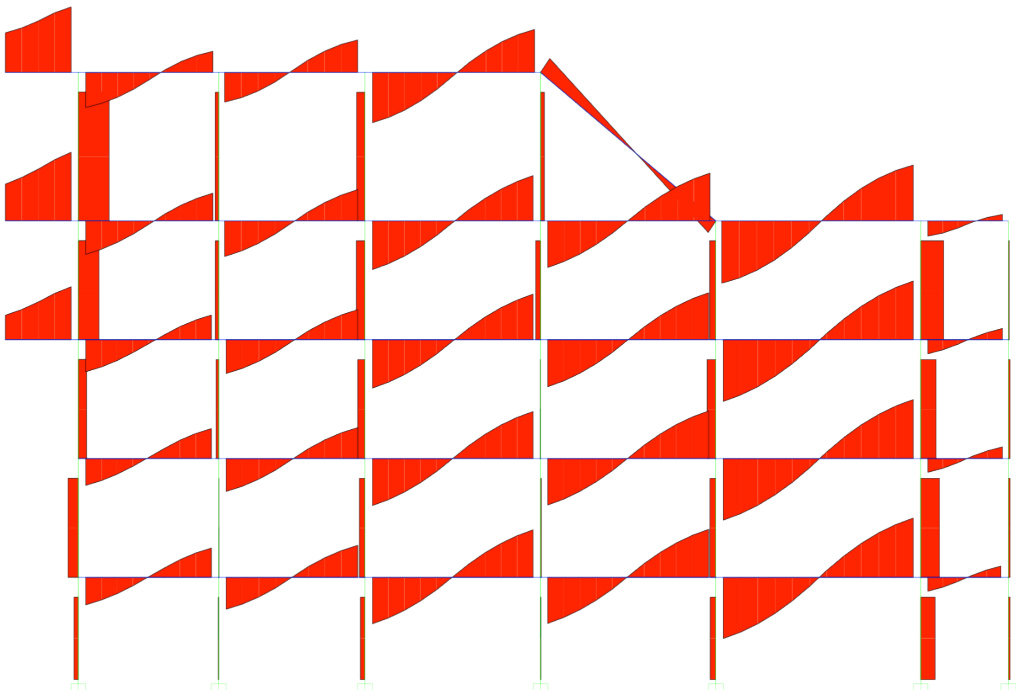


Figure 6-12: Shear Forces Around Axis 2-2 Diagram of the Frame Under Dead Load

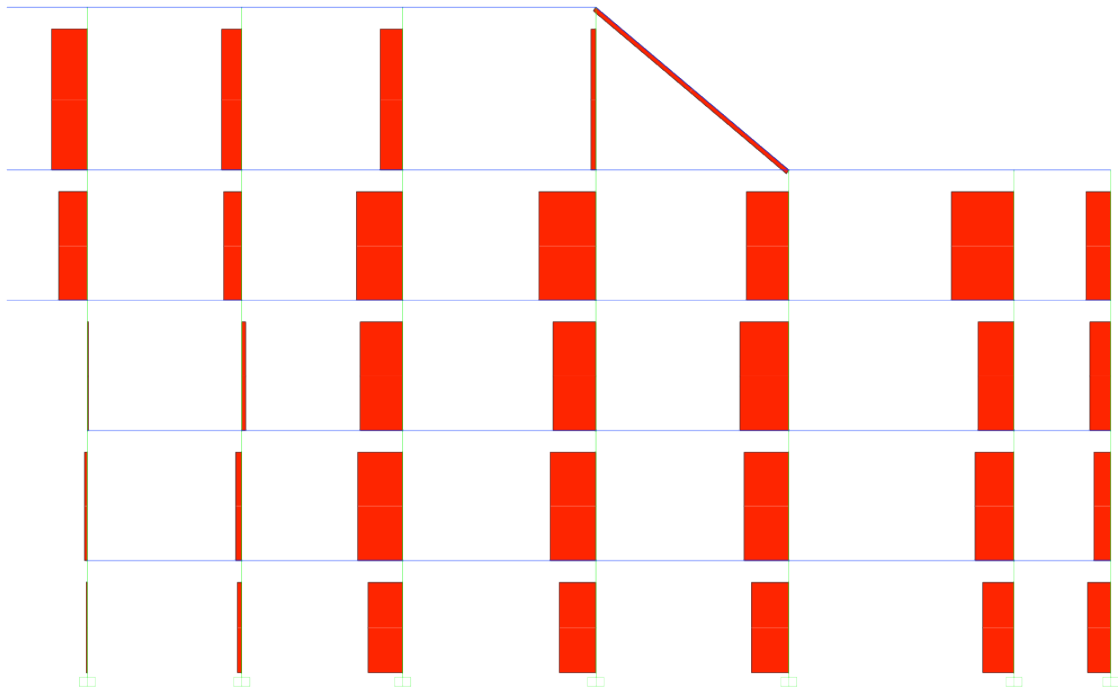


Figure 6-13: Shear Forces Around Axis 3-3 Diagram of the Frame Under Dead Load

Checking the values for the bending moments and the shears of the specific beam in STORY4 after the structural analysis of ETABS. In this kind of analysis the software gives us the maximum values among all the Load combination and it designs the element in order to tolerate the maximum force and moment of any kind among the standard load combinations.

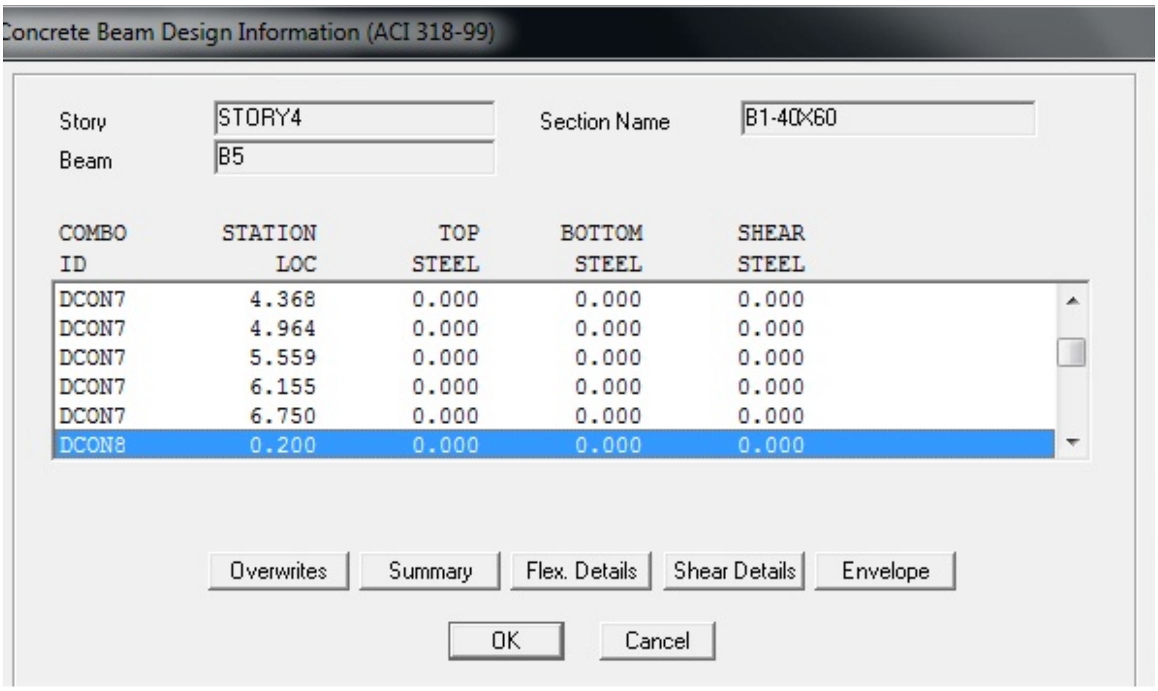


Figure 6-14: Concrete Beam Design Information

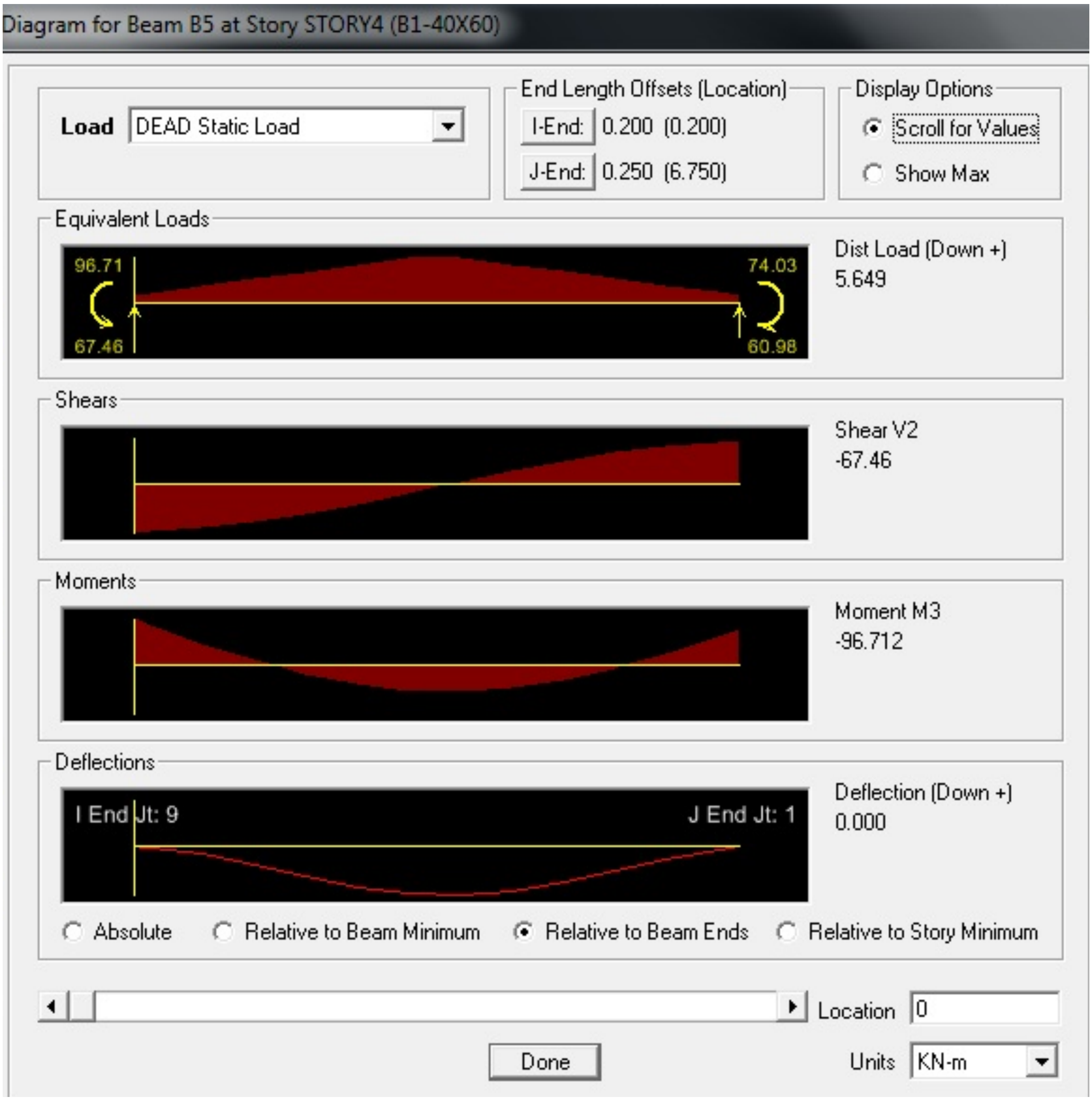


Figure 6-15: Diagrams for a Beam

6.4. Summary of a beam Design

```
Level       : STORY4         L=7.000
Element     : B5             D=0.600          B=0.400          bf=0.400
Section ID  : B1-40X60       ds=0.000         dct=0.050        dcb=0.050
Combo ID    : DCON8          E=21378497.44    fc=20593.965     Lt.Wt. Fac.=1.000
Station Loc : 0.200          fy=392266.008    fys=392266.008

Phi(Bending):  0.900
Phi(Shear):    0.850
Phi(Torsion):  0.850


Design Moments, M3
                        Positive    Negative      Special     Special
                          Moment      Moment     +Moment     -Moment
                          50.185    -150.555      50.185    -150.555

Flexural Reinforcement for Moment, M3
                        Required     +Moment     -Moment     Minimum
                           Rebar       Rebar       Rebar       Rebar
   Top    (+2 Axis)    8.087E-04       0.000   8.087E-04   7.734E-04
   Bottom (-2 Axis)    3.493E-04   2.620E-04       0.000   3.493E-04

Shear Reinforcement for Shear, V2
              Rebar        Shear       Shear       Shear       Shear
               Av/s           Vu     phi*Vc      phi*Vs          Vp
              0.000        0.000       0.000       0.000       0.000

Reinforcement for Torsion, T
              Rebar        Rebar     Torsion    Critical        Area   Perimeter
               At/s           Al          Tu     Phi*Tcr          Ao          Ph
          1.895E-04    8.410E-04      17.083       9.224       0.135       1.644
```

ETABS v9.6.0 - File:Structure (6) - KN-m Units

Figure 6-16: Summary of a Beam Design

6.5. Summary of a Column Design

```
ACI 318-99 COLUMN SECTION DESIGN  Type: Sway Intermediate  Units: KN-m  (Summary)

Level        : STORY4               L=3.600
Element      : C3                   B=0.500          D=0.500          dc=0.050
Section ID   : C1-50                E=21378497.44    fc=20593.965     Lt.Wt. Fac.=1.000
Combo ID     : DCON6                fy=392266.008    fys=392266.008
Station Loc  : 3.000                RLLF=0.971

Phi(Compression-Spiral): 0.750
Phi(Compression-Tied):   0.700
Phi(Tension):            0.900
Phi(Bending):            0.900
Phi(Shear/Torsion):      0.850


AXIAL FORCE & BIAXIAL MOMENT CHECK FOR PU, M2, M3
            Capacity       Design       Design       Design      Minimum      Minimum
               Ratio           Pu           M2           M3           M2           M3
               0.646      239.903      196.988      -73.705        7.255        7.255

AXIAL FORCE & BIAXIAL MOMENT FACTORS
                                Cm     Delta_ns      Delta_s            K            L
                            Factor       Factor       Factor       Factor       Length
   Major Bending(M3)         0.400        1.000        1.000        1.000        3.000
   Minor Bending(M2)         0.400        1.000        1.000        1.000        3.000

SHEAR DESIGN FOR V2,V3
                             Rebar        Shear        Shear        Shear        Shear
                              Av/s           Vu      phi*Vc       phi*Vs           Vp
   Major Shear(V2)           0.000       70.399      155.286        0.000      106.308
   Minor Shear(V3)       4.394E-04      134.874      154.162       65.931      134.874

JOINT SHEAR DESIGN
                       Joint Shear        Shear        Shear        Shear        Joint
                             Ratio        VuTop        VuTot       phi*Vc         Area
   Major Shear(V2)           0.410        0.000      394.406  1489362.826        0.250
   Minor Shear(V3)           0.489        0.000      470.097  1489362.826        0.250

(6/5) BEAM/COLUMN CAPACITY RATIOS
                             Major        Minor
                             Ratio        Ratio
                               N/A          N/A


Notes:
   N/A: Not Applicable
   N/C: Not Calculated
   N/N: Not Needed
```

.TABS v9.6.0 - File:Structure (6) - KN-m Units

Figure 6-17: Summary of a Column Design

According to the structural analysis the value written over and under the beams show the required area of longitudinal reinforcements in pressure and tension. Choosing three stations for every beam, we have the required amount of reinforcement on both side and in the middle. Then according to the area of different bars we should choose which dimension and how many of them we need to use to satisfy the requirements.

We are using 20mm diameter bars for the longitudinal reinforcements and 10mm diameter for the shear.

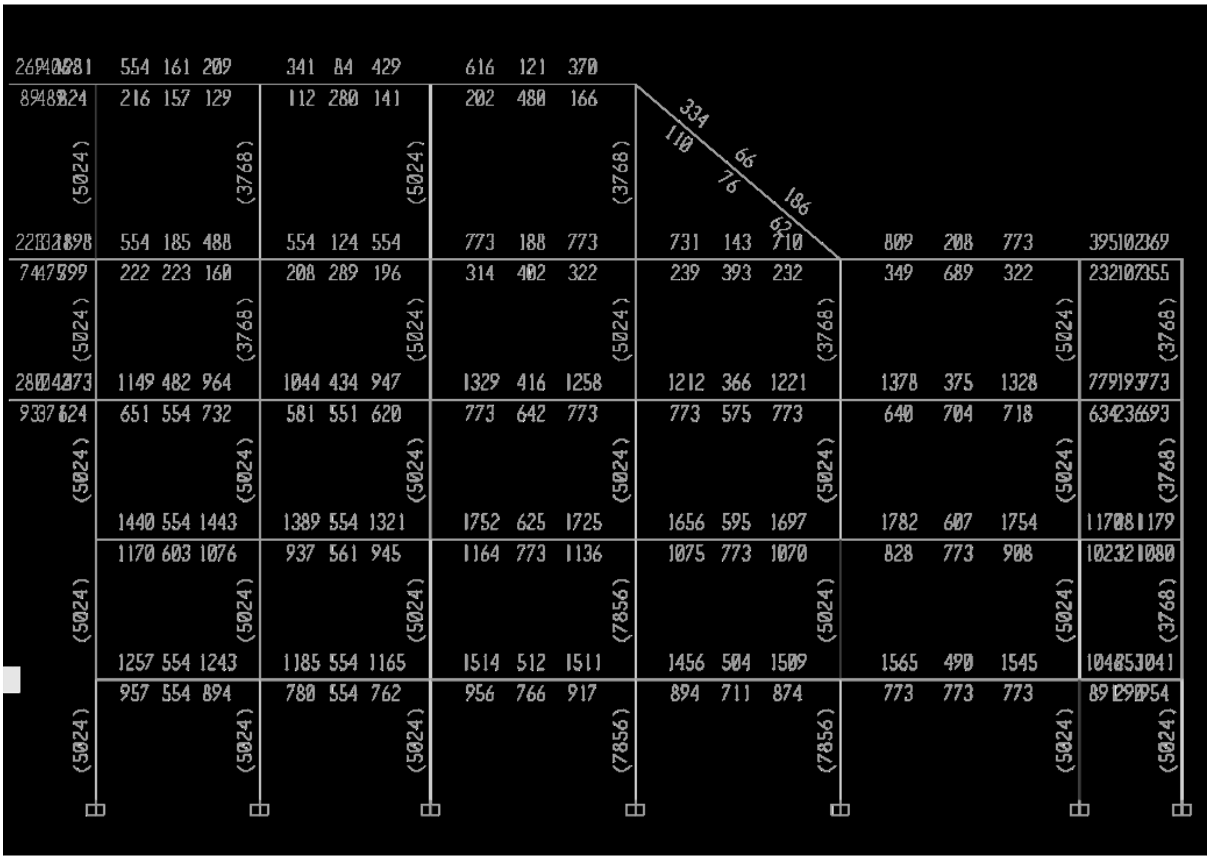


Figure 6-18: Longitudinal Reinforcement , KN.mm

6.6. Deformation under static dead load

It is rational to have deformations in the middle of the slab and also in the middle of the beams but it is not so much except the cantilever parts which are around 2 or 3 cm in the maximum points under the static dead load, since it happens in only some corners it can be acceptable.

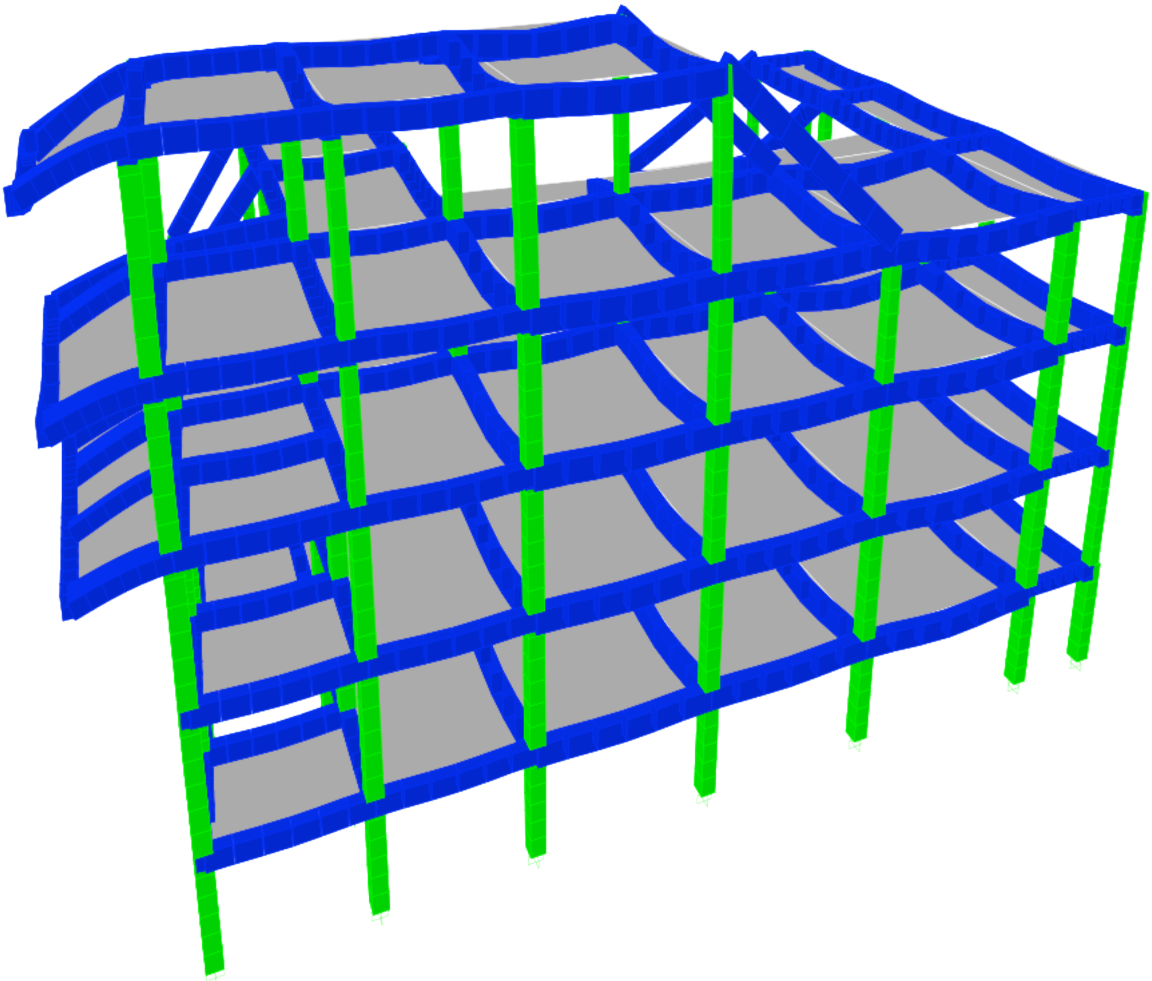


Figure 6-19: Deformation Under Static Dead Load

6.7. Checking the drift

Maximum drift of the floor is 6mm happening in the story2, which is less than 0.04*height, which is the standard maximum, and for our design is almost 10 mm.

The structural plans and sections of the elements are as below.

6.8. Types of Beams and Columns

Three stations are chosen in the software for the design of the beams. Here, using that information we designed to sides of the beam the same for all except the cantilever parts and in the middle using the required reinforcement value we designed the reinforcements again but in a way to have a good connection in the whole beam.

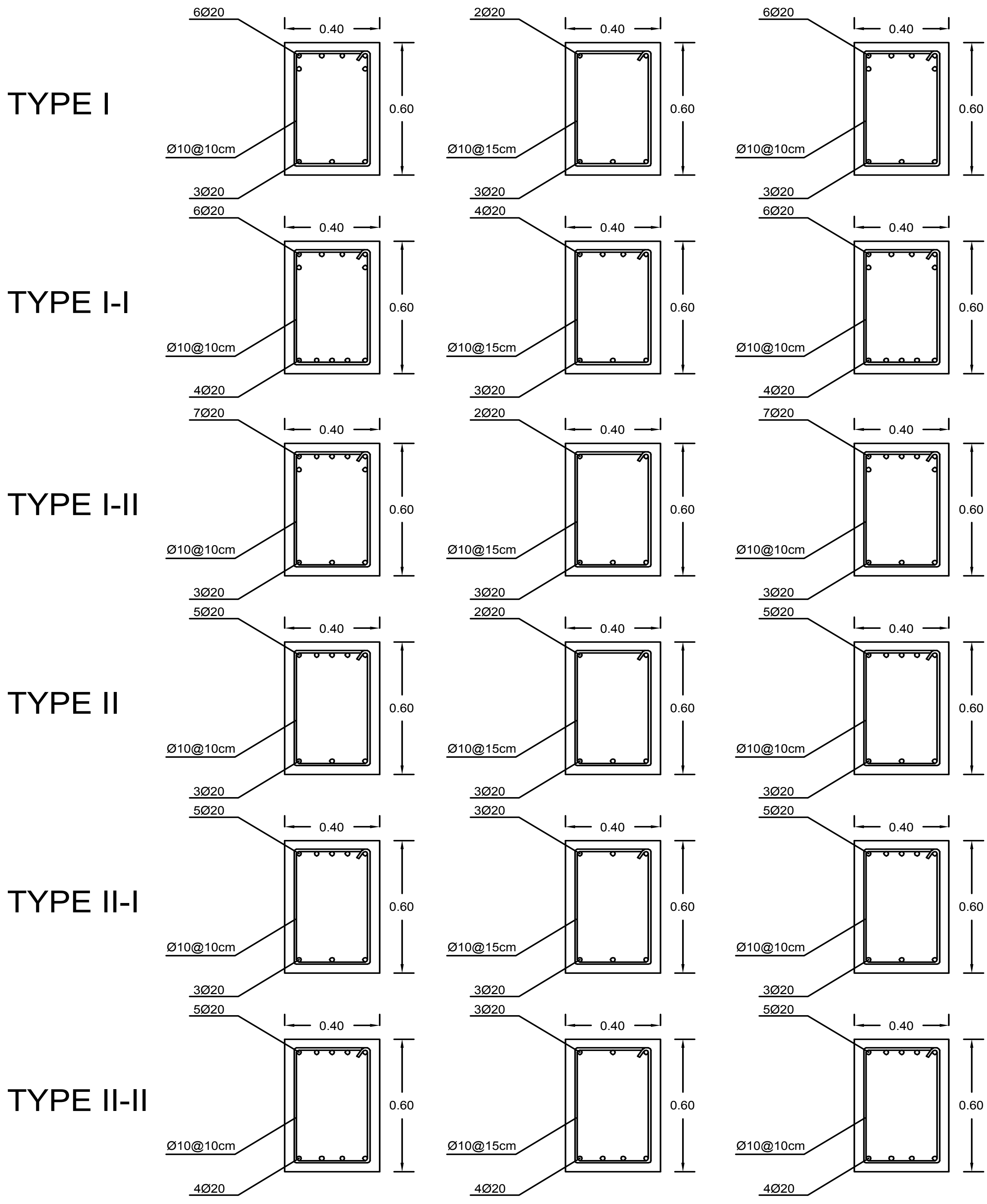


Figure 6-20: Beam Types

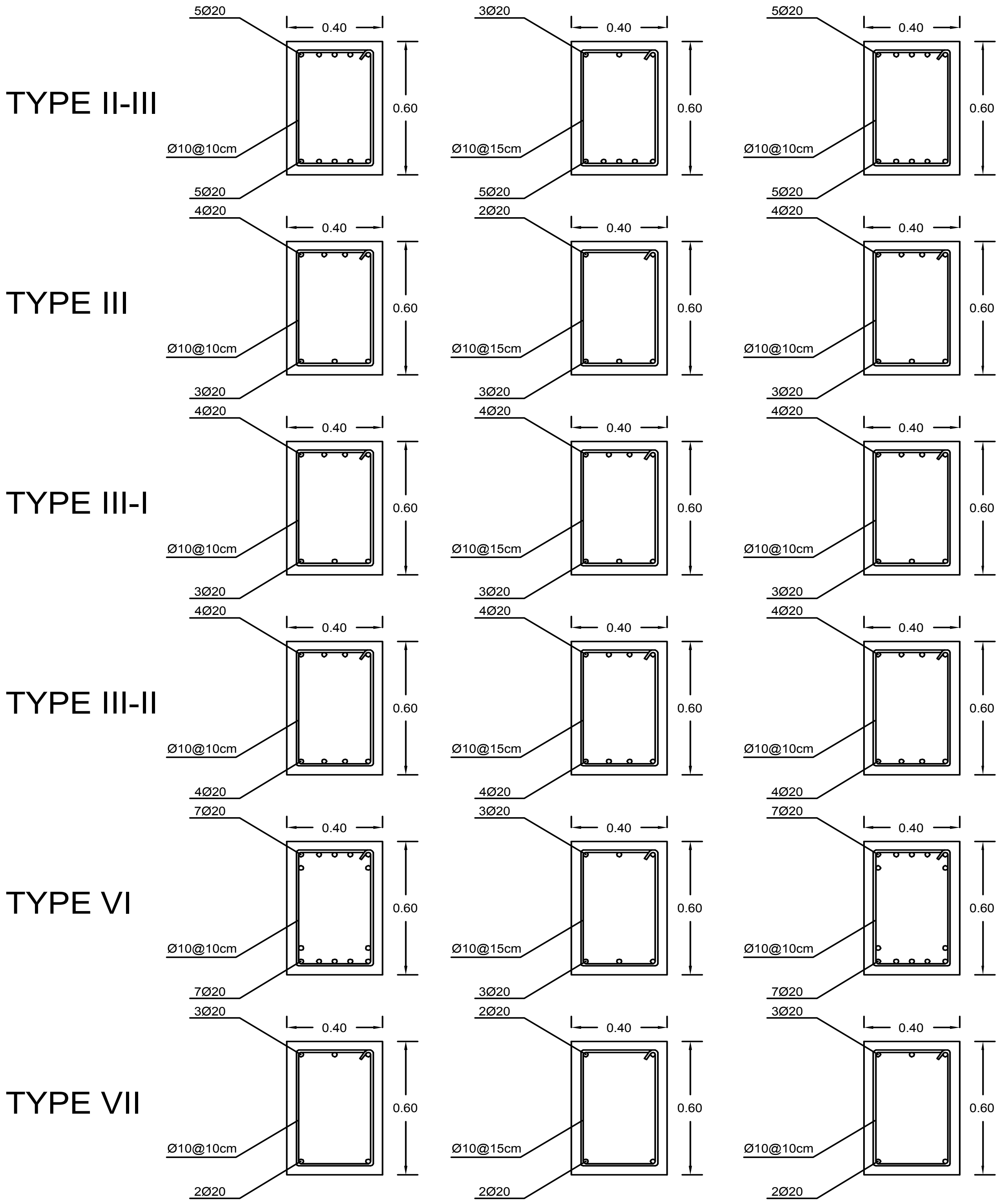


Figure 6-21: Beam Types

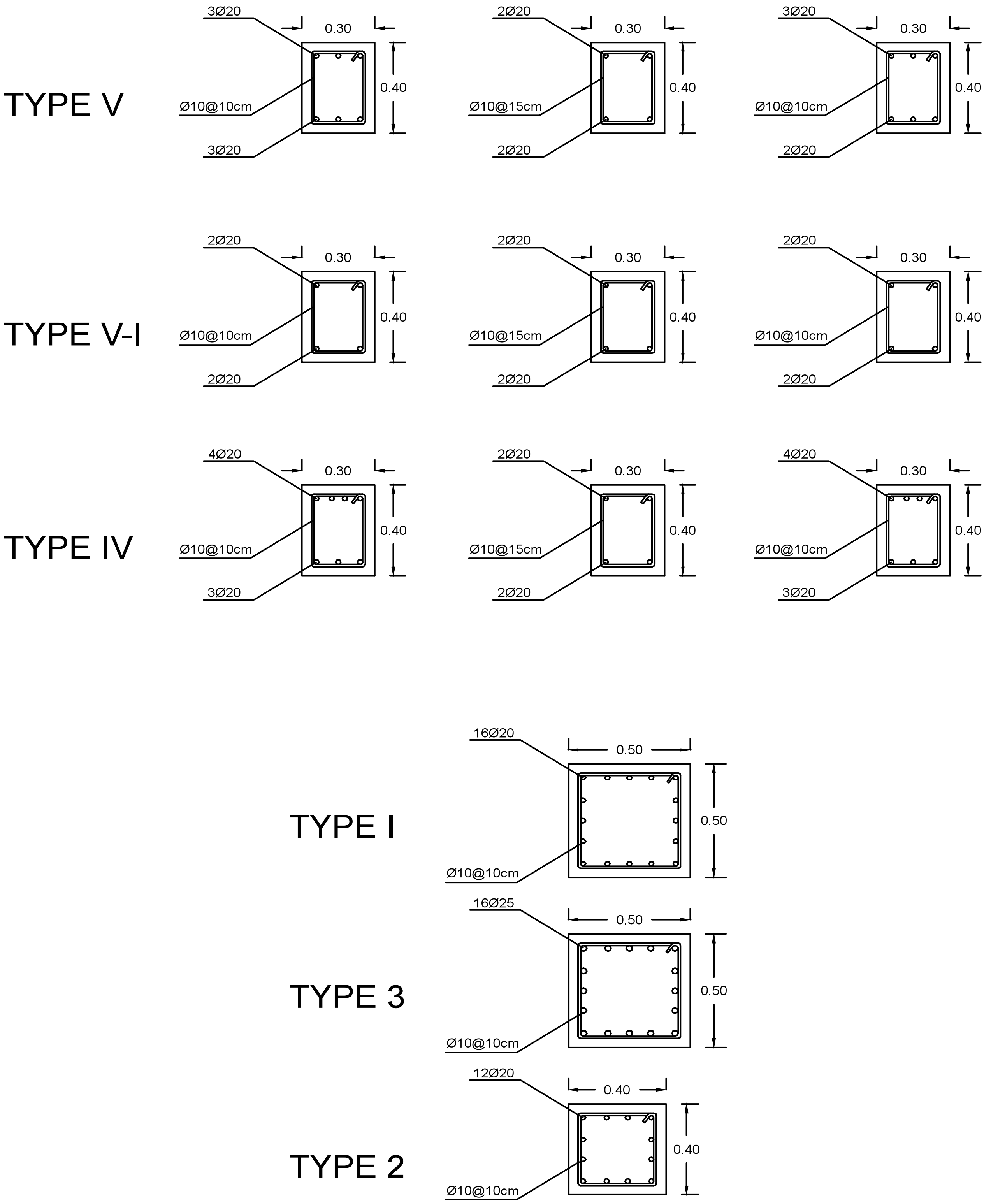


Figure 6-22: Beam and Column Types

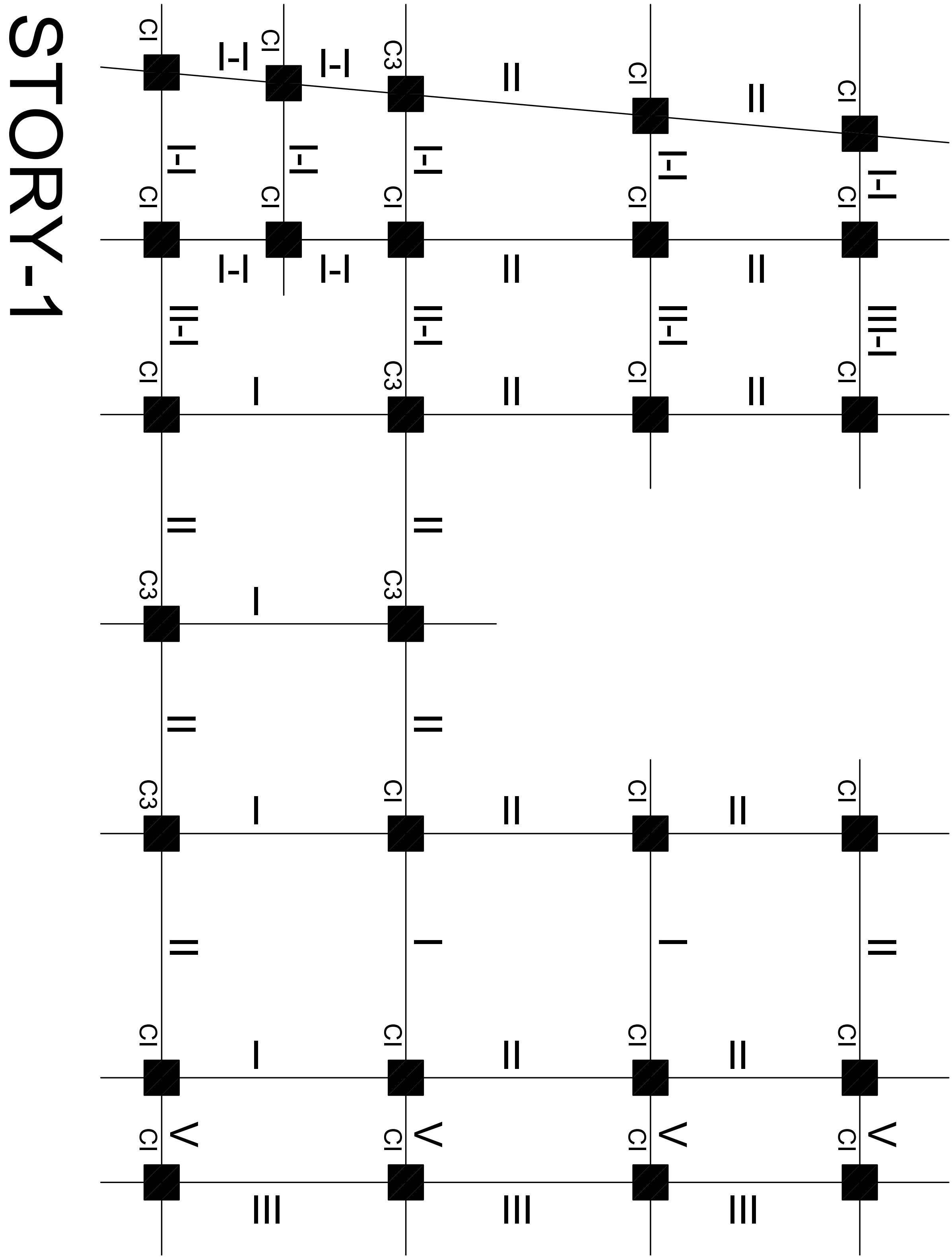


Figure 6-23: Structural Plan, Story1

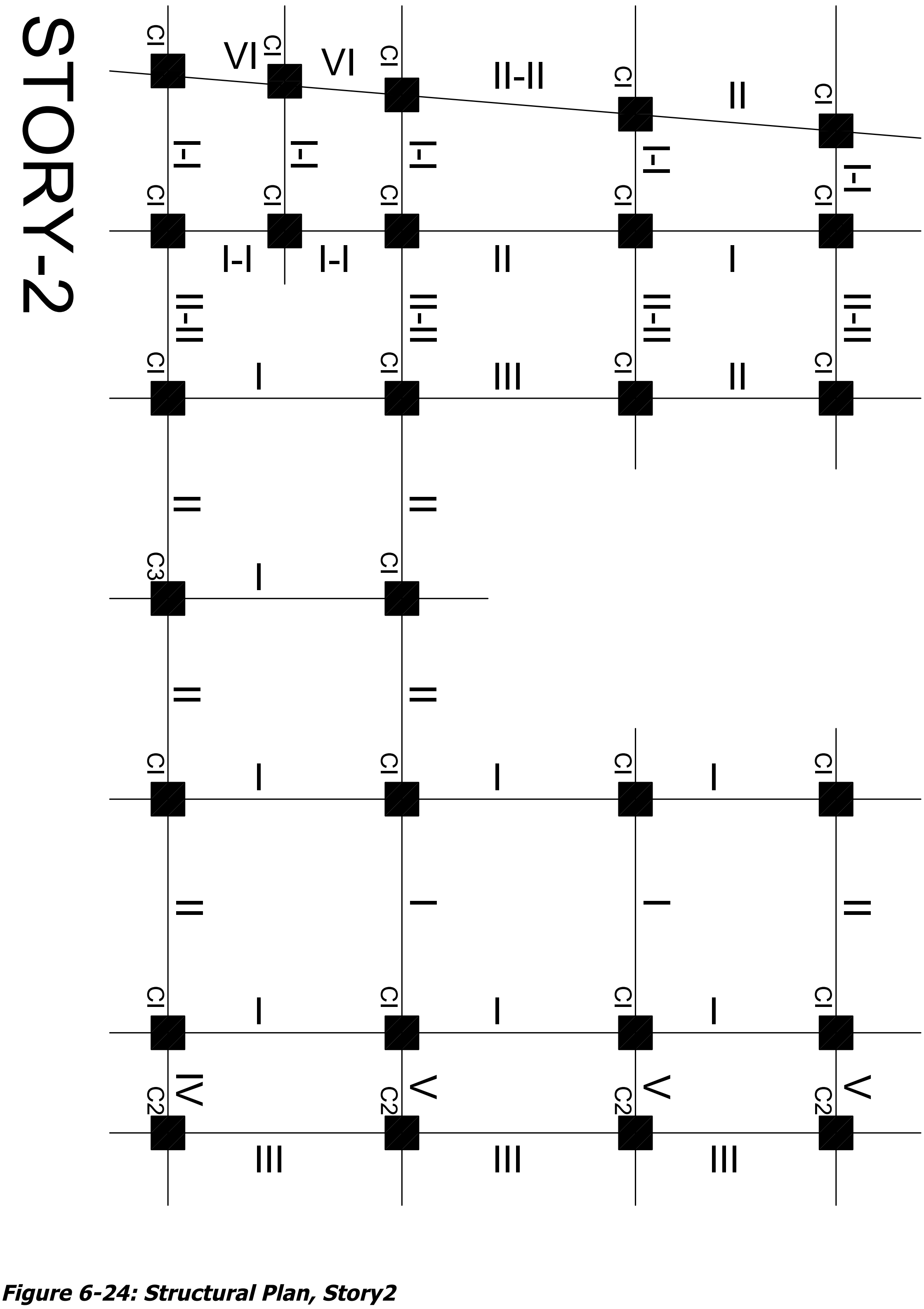


Figure 6-24: Structural Plan, Story2

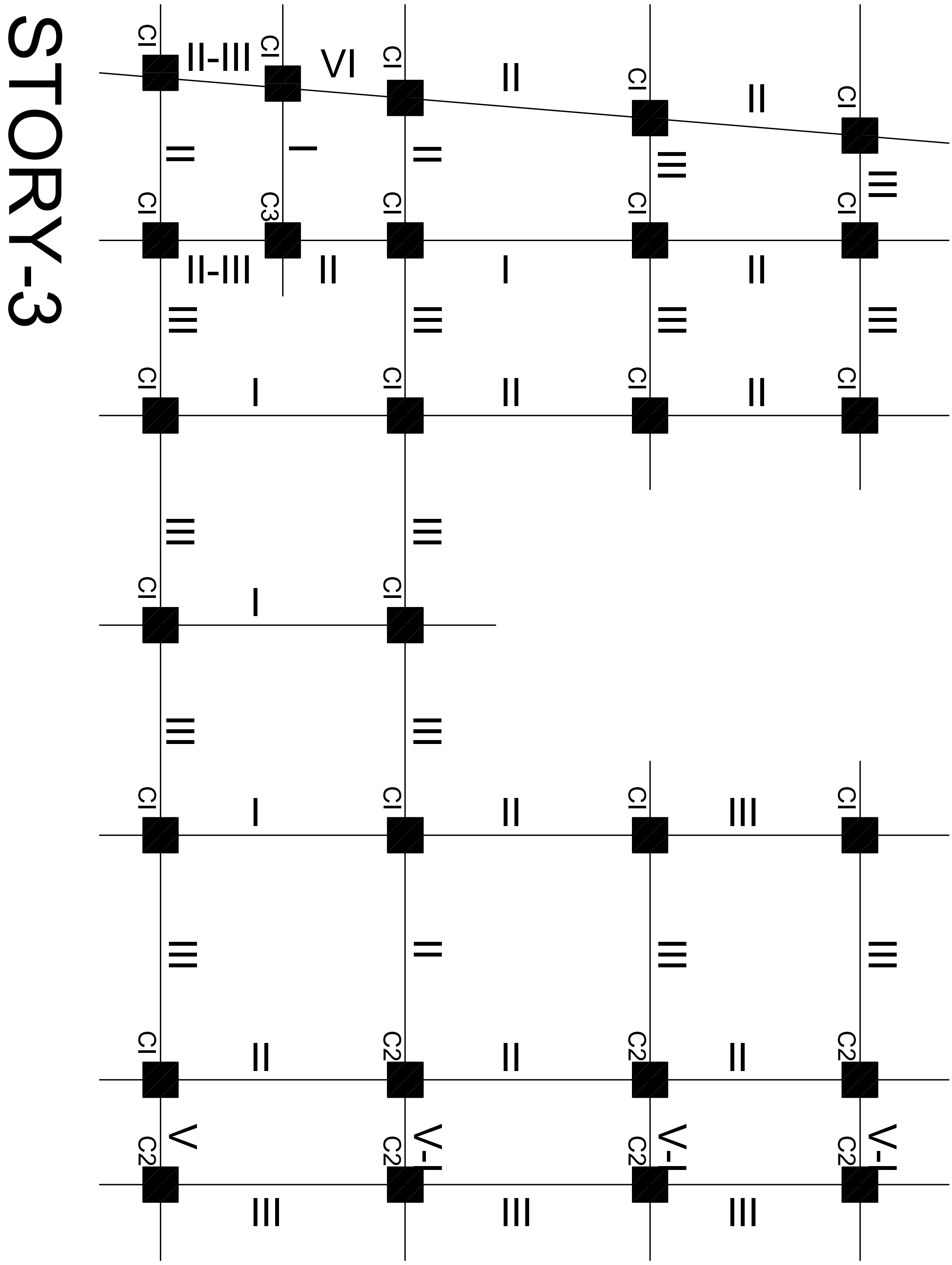


Figure 6-25: Structural Plan, Story3

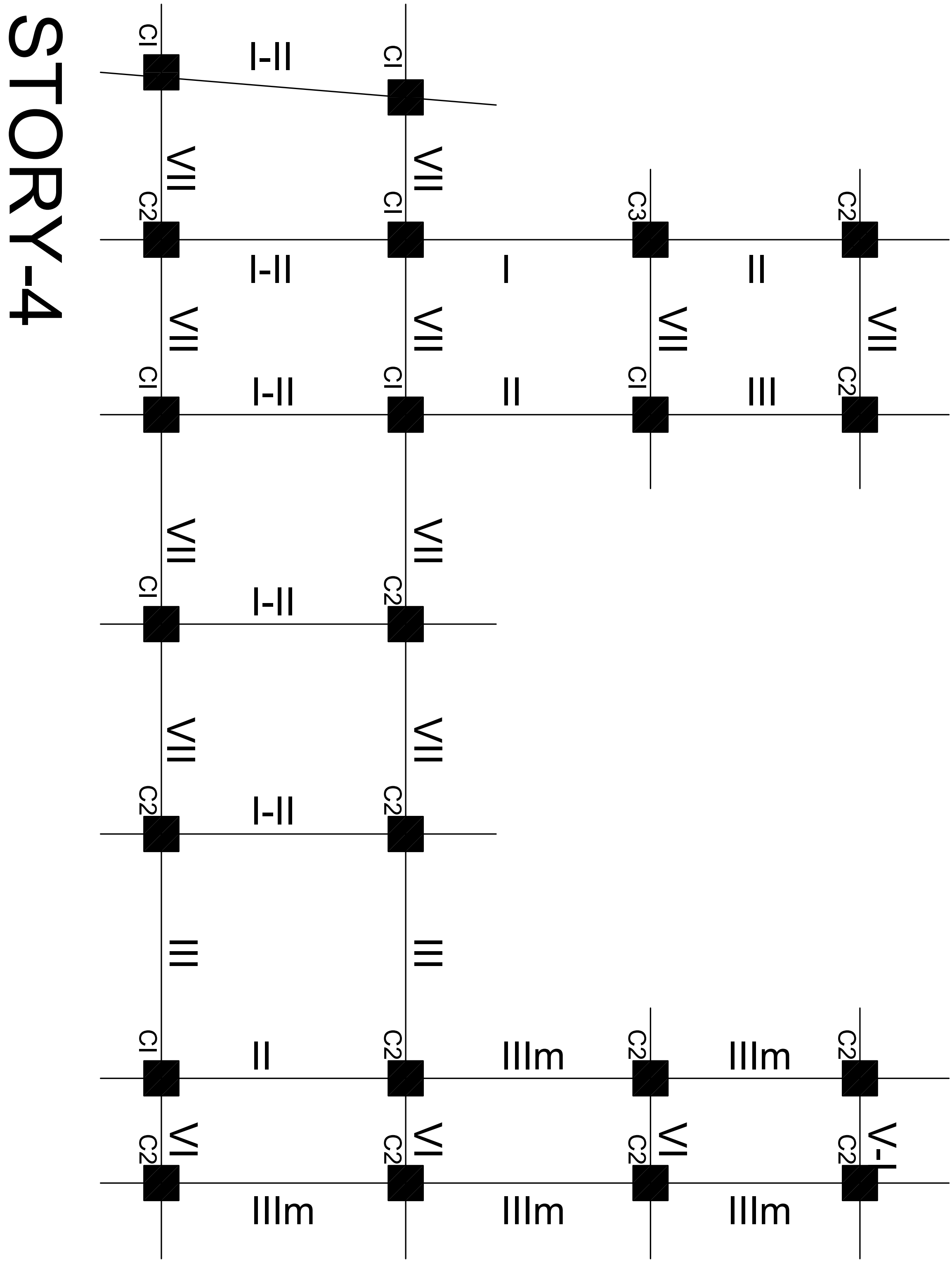
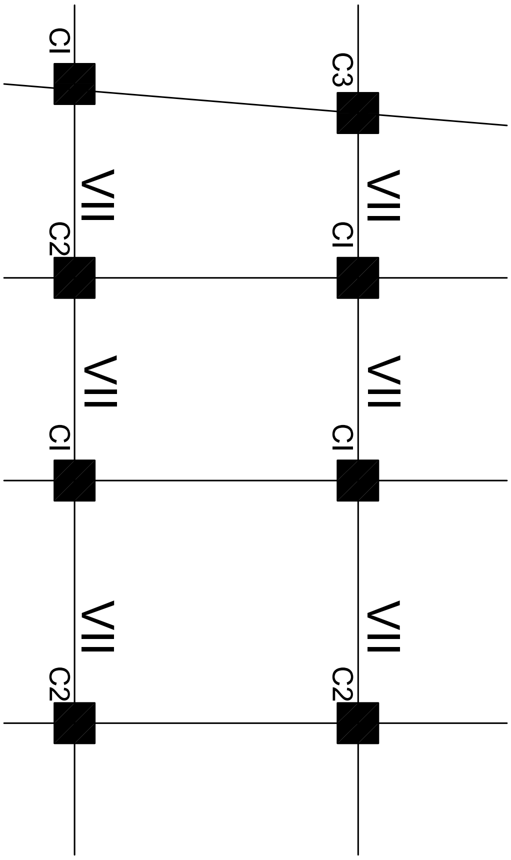


Figure 6-26: Structural Plan, Story 4

STORY-5



7. Index and Tables

7.1. Bibliography

- (n.d.). Retrieved from Governmental Webpage of Shanghai: http://www.shanghai.gov.cn
- *10+ competition*. (n.d.). (10Design Company) Retrieved from http://www.10design.com
- ASHRAE Transactions 2002, Honolulu. (2002).
- Brinkhoff, H. (n.d.). *The Principal Agglomerations of the World.* Retrieved from http://www.citypopulation.de
- *China Energy Yearbook.* (2008).
- China, S. Y. (2006).
- *Degreedays Website*. (n.d.). Retrieved from http://www.degreedays.net
- *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone.* (2010).
- *Digital Changning*. (n.d.). Retrieved from Hongqiao Foreign Trade Center: http://www.changning.net
- *Fafco Solar Energy*. (n.d.). Retrieved from http://www.fafcosolar.com
- *Geothermal Energy*. (n.d.). Retrieved from Renewable Energy World: http://www.renewableenergyworld.com
- *Geothermal Heat Pumps*. (n.d.). Retrieved from http://www.energy.gov
- Givoni, B. (1998). *Climate COnsiderations in Buildings and Urban Design.* USA: VAN NOSTRAND REINHOLD.
- Going Abroad and Getting Hired. (2003). *Shanghai - Heaven for Foreign Employees , 11th*, p. 18.
- *Hongqiao Foreign Trade Center*. (n.d.). Retrieved from Digital Changning: http://www.changning.net
- *Housing Guide*. (n.d.). Retrieved from Shanghai Daily: http://www.live.shanghaidaily.com
- How Big Can Cities Get? (2006, June 17). *New Scientist Magazine* , 41.
- *HVAC Systems*. (n.d.). Retrieved from Florida Solar Energy Center: http://www.fsec.ucf.edu
- Journal of Changning District. (1999). *Journal of Changning District , 1*.
- Knapp, R. G.-Y. (2005). House, Home, Family: Living and Being Chinese. *University*

of Hawaii Press .

- Maps, G. (n.d.). Retrieved from http://maps.google.com
- *Natural Scenery: Suzhou Creek*. (n.d.). Retrieved from Cultural China: http://www.cultural-china.com
- Shanghai - Heaven for Foreign Employees. (2003). *Going Abroad and Getting Hired* (11), p. 18.
- *Us Department of Energy*. (n.d.). Retrieved from http://www.eere.energy.gov
- Zheng, H. (2010). *The Encyclopedia of Shanghai.* Retrieved October 15, 2012, from China Shanghai: http://www.shanghai.gov.cn

7.2. List of Figures

FIGURE 1-1: SHANGHAI IN THE MAP OF CHINA ____ 10
FIGURE 1-2: MAPS OF SHANGHAI CITY CENTER ____ 11
FIGURE 1-3: MAP OF SUBURBS ____ 12
FIGURE 1-4: CHINA ELEVATION MAP ____ 13
FIGURE 1-5: PUDONG LOCATION WITHIN SHANGHAI ____ 20
FIGURE 1-6: SHANGHAI PUDONG DISTRICT TAKEN IN SEPTEMBER 1989 ____ 20
FIGURE 1-7: SHANGHAI PUDONG DISTRICT TAKEN IN SEPTEMBER 2006 ____ 21
FIGURE 1-8: FAST GROWING SHANGHAI FROM 1990 TO 2010 ____ 22
FIGURE 1-9: PUDONG SKYLIGHT AT NIGHT ____ 22
FIGURE 1-10: SHANGHAI EXPO AREA BEFORE THE CONSTRUCTION ____ 24
FIGURE 1-11: SHANGHAI EXPO MASTER PLAN ____ 25
FIGURE 1-12: POLISH PAVILION IN SHANGHAI EXPO 2010 ____ 25
FIGURE 1-13: COMPARISON AMONG THREE OTHER CITIES IN TERMS OF POPULATION DISTRIBUTION SHOWS THAT SHANGHAI IS A MONO-CENTER CITY GROWING TO BE A POLY-CENTER CITY. ____ 26
FIGURE 1-14: MAP OF SHANGHAI ____ 27
FIGURE 1-15: AIR POLLUTION IN SHANGHAI ____ 29
FIGURE 1-16: SHANGHAI CITY GROWTH ____ 30
FIGURE 1-17: SHANGHAI CITY GROWTH ____ 31
FIGURE 1-18: SUBWAY MAP OF SHANGHAI IN THE CITY SCALE ____ 32
FIGURE 1-19: SUBWAY MAP OF SHANGHAI ____ 33
FIGURE 1-20: OLD MAP OF SHANGHAI ____ 34
FIGURE 1-21: COMPETITION INTRODUCTION POSTER ____ 35
FIGURE 1-22: COMPETITION INTRODUCTION POSTER ____ 36
FIGURE 1-23: COMPETITION 1ST PRIZE WINNER'S POSTER ____ 37
FIGURE 1-24: COMPETITION 1ST PRIZE WINNER'S POSTER ____ 38
FIGURE 1-25: COMPETITION 1ST PRIZE WINNER'S POSTER ____ 38
FIGURE 1-26: COMPETITION 2ND PRIZE WINNER'S POSTER ____ 40
FIGURE 1-27: COMPETITION 2ND PRIZE WINNER'S POSTER ____ 41
FIGURE 1-28: COMPETITION 2ND PRIZE WINNER'S POSTER ____ 42
FIGURE 1-29: COMPETITION 2ND PRIZE WINNER'S POSTER ____ 43
FIGURE 1-30: COMPETITION 3RD PRIZE WINNER'S POSTER ____ 45
FIGURE 1-31: COMPETITION 3RD PRIZE WINNER'S POSTER ____ 46
FIGURE 1-32: COMPETITION 3RD PRIZE WINNER'S POSTER ____ 46
FIGURE 1-33: COMPETITION 3RD PRIZE WINNER'S POSTER ____ 47
FIGURE 1-34: COMPETITION 3RD PRIZE WINNER'S POSTER ____ 47
FIGURE 2-1: MAP OF SHANGHAI ____ 49
FIGURE 2-2: SELECTED SITE ____ 50
FIGURE 2-3: MAP OF SHANGHAI ____ 50
FIGURE 2-4: SELECTED AREA ____ 51
FIGURE 2-5: : PHYSICAL MODEL OF THE SITE FROM SHANGHAI URBAN PLANNING EXHIBITION CENTER ____ 51
FIGURE 2-6: MAP OF CHANGNING DISTRICT ____ 52
FIGURE 2-7: SOME HOTELS IN CHANGNING DISTRICT ____ 54
FIGURE 2-8: EDUCATIONAL-CULTURAL EXAMPLES IN CHANGNING DISTRICT ____ 55
FIGURE 2-9: MAP OF ZHONGSHAN PARK BUSINESS ZONE ____ 59
FIGURE 2-10: SOME EXAMPLES OF ZHONGSHAN GREEN AREAS ____ 60
FIGURE 2-11: SUZHOU CREEK ____ 64
FIGURE 2-12: SUZHOU CREEK ____ 71
FIGURE 2-13: STREETS ____ 72
FIGURE 2-14: MAIN ROADS ____ 72
FIGURE 2-15: RAILWAY ____ 73
FIGURE 2-16: BUILDINGS ____ 73
FIGURE 2-17: GREEN AREAS ____ 74
FIGURE 2-18: UNDEVELOPED AREAS ____ 76

FIGURE 2-19: UNDEVELOPED RESIDENTIAL AREAS 77
FIGURE 2-20: DENSE LOW-RISE RESIDENTIAL AREAS 77
FIGURE 2-21: CHOSEN SITE 78
FIGURE 2-22: DENSE MEDIUM-RISE RESIDENTIAL AREAS 78
FIGURE 2-23: DENSE MEDIUM-HIGH-RISE BUILDINGS 79
FIGURE 2-24: ZHONGSHAN PARK BUSINESS ZONE 80
FIGURE 2-25: DENSE HIGH-RISE RESIDENTIAL AREAS 81
FIGURE 2-26: MIXED USE AREA 81
FIGURE 2-27: WHOLE AREA MAP 82
FIGURE 2-28: NOLLI MAP OF THE SITE 82
FIGURE 2-29: SWOT ANALYSIS, STRENGTH AND OPPORTUNITY 83
FIGURE 2-30: SWOT ANALYSIS, WEAKNESS AND THREAT 83
FIGURE 2-31: URBAN DESIGN, MODIFIED VEHICLE NETWORK 84
FIGURE 2-32: PROPOSED FUNCTIONS IN THE SITE 84
FIGURE 2-33: PROPOSED WATER FEATURES 85
FIGURE 2-34: PRIVATE AND PUBLIC AREAS 86
FIGURE 2-35: CONNECTIONS 87
FIGURE 2-36: LEAMOUTH PENINSULA STUDY CASE 88
FIGURE 2-37: LEAMOUTH PENINSULA STUDY CASE 88
FIGURE 2-38: DIFFERENT CASE STUDIES' CONCEPTS 89
FIGURE 3-1: KEYWORDS TO THE CONCEPT 91
FIGURE 3-2: FIRST APPROACH TO THE CONCEPT 92
FIGURE 3-3: CONCEPT 93
FIGURE 3-4: CONCEPT 94
FIGURE 3-5: MODIFIED STREETS 96
FIGURE 3-6: PRIMARY RENDERS 97
FIGURE 3-7: WATER TREATMENT IN THE CASE STUDY, FLUSSBAD, BERLIN 100
FIGURE 3-8: WATER TREATMENT IN THE CASE STUDY, FLUSSBAD, BERLIN 100
FIGURE 3-9: PROPOSED WATER TREATMENT SYSTEM 101
FIGURE 3-10: MASTER PLAN, VOIDS AND BUILDINGS 102
FIGURE 3-11: GREEN PEDESTRIAN PATHWAY 103
FIGURE 4-1: NEW APARTMENT MANSION 105
FIGURE 4-2: OLD APARTMENT 106
FIGURE 4-3: OLD GARDEN VILLA 107
FIGURE 4-4: TOWNHOUSE 108
FIGURE 4-5: INDEPENDENT LANE HOUSE 109
FIGURE 4-6: DUPLEX HOUSE 109
FIGURE 4-7: SERVICE APARTMENT 110
FIGURE 4-8: PRIVATIZED PUBLIC APARTMENT 110
FIGURE 4-9: MODERN HOUSING 111
FIGURE 4-10: MODERN HOUSING 112
FIGURE 4-11: MODERN HOUSING 113
FIGURE 4-12: MODERN HOUSING 114
FIGURE 4-13: CHINESE HOUSING DEVELOPMENT IN URBAN SCALE (HOUSING GUIDE) 116
FIGURE 4-14: SUZHOU CREEK 117
FIGURE 4-15: THE OLD SUZHOU GREEK AS A HUSTLING TRADE PORT 118
FIGURE 4-16: WAIBAIDU BRIDGE OVER THE SUZHOU CREEK 119
FIGURE 4-17: SHANGHAI GENERAL POST OFFICE ALONG THE SUZHOU CREEK 120
FIGURE 4-18: CHINESE VERNACULAR HOUSING ARCHITECTURE 121
FIGURE 4-19: SAMPLES OF SHANGHAI VERNACULAR ARCHITECTURE 122
FIGURE 4-20: WATER AND BUILDINGS 122
FIGURE 4-21: CHINESE GARDEN 123
FIGURE 4-22: MODERN CHINESE ARCHITECTURE 124
FIGURE 4-23: MODERN CHINESE ARCHITECTURE 125
FIGURE 4-24: MODERN CHINESE ARCHITECTURE 125
FIGURE 4-25: PHYSICAL MODEL 127
FIGURE 4-26: PHYSICAL MODEL 128

FIGURE 4-27: PHYSICAL MODEL 128
FIGURE 4-28: PHYSICAL MODEL 129
FIGURE 4-29: PHYSICAL MODEL 129
FIGURE 4-30: CONCEPTUAL DESIGN OF THE PROJECT 130
FIGURE 4-31: CONCEPTUAL DESIGN OF THE PROJECT 131
FIGURE 4-32: TERRACOTTA FAÇADE INSTALLATION 132
FIGURE 5-1: SHANGHAI ELECTRICITY CONSUMPTION BY SECTOR EVOLUTION 134
FIGURE 5-2: TREND OF ELECTRIC DEVICES FOR 100 CHINESE HOUSEHOLDS 137
FIGURE 5-3: COMPOSITION OF SHANGHAI HOUSEHOLD ELECTRICITY CONSUMPTION IN 2000 137
FIGURE 5-4: WEATHER DATA ANALYSIS FROM CLIMATE CONSULTANT SOFTWARE 141
FIGURE 5-5: USED STANDARD IN CLIMATE CONSULTANT SOFTWARE 142
FIGURE 5-6: WEATHER DATA VALUES FROM CLIMATE CONSULTANT SOFTWARE 143
FIGURE 5-7: TEMPERATURE RANGE DIAGRAM 144
FIGURE 5-8: MONTHLY DIURNAL AVERAGES 144
FIGURE 5-9: RADIATION RANGE, HOURLY AVERAGE 145
FIGURE 5-10: RADIATION RANGE, DAILY AVERAGE 145
FIGURE 5-11: ILLUMINATION RANGE 146
FIGURE 5-12: SKY COVER RANGE 146
FIGURE 5-13: WIND VELOCITY RANGE 147
FIGURE 5-14: GROUND TEMPERATURE, MONTHLY AVERAGE 147
FIGURE 5-15: SUN SHADING CHART, DEC TO JUN 148
FIGURE 5-16: SUN SHADING CHART, JUN TO DEC 148
FIGURE 5-17: SUN CHART, DEC TO JUN 149
FIGURE 5-18: SUN CHART, JUN TO DEC 149
FIGURE 5-19: DRY BULB TEMPERATURE, MONTHLY 150
FIGURE 5-20: WET BULB TEMPERATURE, MONTHLY 150
FIGURE 5-21: DRY BULB TEMPERATURE, 3D DIAGRAM 151
FIGURE 5-22: WET BULB TEMPERATURE, 3D DIAGRAM 152
FIGURE 5-23: RELATIVE HUMIDITY, 3D DIAGRAM 152
FIGURE 5-24: WIND SPEED, 3D DIAGRAM 153
FIGURE 5-25: GLOBAL HORIZONTAL RADIATION, 3D DIAGRAM 153
FIGURE 5-26: DIRECT NORMAL RADIATION, 3D DIAGRAM 154
FIGURE 5-27: SKY COVER, 3D DIAGRAM 154
FIGURE 5-28: PSYCHROMETRIC CHART 155
FIGURE 5-29: DESIGN GUIDELINES 155
FIGURE 5-30: DESIGN GUIDELINES 156
FIGURE 5-31: DESIGN GUIDELINES 156
FIGURE 5-32: DESIGN GUIDELINES 157
FIGURE 5-33: DESIGN GUIDELINES 157
FIGURE 5-34: DESIGN GUIDELINES 158
FIGURE 5-35: DESIGN GUIDELINES 158
FIGURE 5-36: DESIGN GUIDELINES 159
FIGURE 5-37: DESIGN GUIDELINES 159
FIGURE 5-38: DESIGN GUIDELINES 160
FIGURE 5-39: DESIGN GUIDELINES 160
FIGURE 5-40: DESIGN GUIDELINES 161
FIGURE 5-41: DESIGN GUIDELINES 161
FIGURE 5-42: DESIGN GUIDELINES 162
FIGURE 5-43: DESIGN GUIDELINES 162
FIGURE 5-44: DESIGN GUIDELINES 163
FIGURE 5-45: DESIGN GUIDELINES 163
FIGURE 5-46: DESIGN GUIDELINES 164
FIGURE 5-47: DESIGN GUIDELINES 164
FIGURE 5-48: DESIGN GUIDELINES 165
FIGURE 5-49: DESIGN GUIDELINES 165
FIGURE 5-50: CLOSED LOOP HORIZONTAL HEAT PUMP SYSTEM 172
FIGURE 5-51: CLOSED LOOP VERTICAL HEAT PUMP SYSTEM 173

FIGURE 5-52: CLOSED LOOP POND/LAKE HEAT PUMP SYSTEM 174
FIGURE 5-53: OPEN LOOP HEAT PUMP SYSTEM 175
FIGURE 5-54: ECOTECT RENDERS OF THREE MODULES TOGETHER 179
FIGURE 5-55: ECOTECT RENDERS OF A U-SHAPED MODULE 181
FIGURE 5-56: ANNUAL SUN PATH 182
FIGURE 5-57: DAILY SUN PATH 182
FIGURE 5-58: TOTAL SHADOWS 183
FIGURE 5-59: LOBBY AREA 185
FIGURE 5-60: DAYLIGHT ANALYSIS FOR THE LOBBY AREA 185
FIGURE 5-61: APARTMENT WITH GLASS FACADE AREA, FIRST FLOOR 187
FIGURE 5-62: DAYLIGHT ANALYSIS FOR APARTMENT WITH GLASS FACADE AREA, FIRST FLOOR 187
FIGURE 5-63: APARTMENT WITH GLASS FACADE AREA, SECOND FLOOR 188
FIGURE 5-64: DAYLIGHT ANALYSIS FOR APARTMENT WITH GLASS FACADE AREA, SECOND FLOOR 188
FIGURE 5-65: APARTMENT WITH GLASS FACADE AREA, FIRST FLOOR 189
FIGURE 5-66: DAYLIGHT ANALYSIS FOR APARTMENT WITH GLASS FACADE AREA, FIRST FLOOR 189
FIGURE 5-67: APARTMENT WITH GLASS FACADE AREA, SECOND FLOOR 190
FIGURE 5-68: DAYLIGHT ANALYSIS FOR APARTMENT WITH GLASS FACADE AREA, SECOND FLOOR 190
FIGURE 5-69: NORMAL APARTMENT AREA, SECOND FLOOR 191
FIGURE 5-70: DAYLIGHT ANALYSIS FOR THE NORMAL APARTMENT AREA, SECOND FLOOR 191
FIGURE 5-71: NORMAL APARTMENT AREA, THIRD FLOOR 192
FIGURE 5-72: DAYLIGHT ANALYSIS FOR THE NORMAL APARTMENT AREA, THIRD FLOOR 192
FIGURE 5-73: GYM AREA 194
FIGURE 5-74: DAYLIGHT ANALYSIS FOR THE GYM 194
FIGURE 5-75: THE PLACES OF SOLAR PANELS IN A U-SHAPED MODULE 196
FIGURE 5-76: ABSORBED SOLAR RADIATION FOR A SOLAR PANEL, TOTAL MONTHLY 196
FIGURE 5-77: GLOBAL SOLAR RADIATION FOR A SOLAR PANEL, TOTAL MONTHLY 197
FIGURE 5-78: PERCENTAGE OF UNOBSTRUCTED SKY FOR A SOLAR PANEL, TOTAL MONTHLY 197
FIGURE 5-79: INCIDENT SOLAR RADIATION, TOTAL MONTHLY 198
FIGURE 5-80: SHADED PERCENTAGE FOR A SOLAR PANEL, TOTAL MONTHLY 198
FIGURE 5-81: MONTHLY HEATING AND COOLING LOADS 200
FIGURE 5-82: GAIN BREAKDOWN 202
FIGURE 5-83: MONTHLY DEGREE DAYS 203
FIGURE 5-84: TEMPERATURE DISTRIBUTION 204
FIGURE 5-85: SOURCES OF MOISTURE IN BUILDINGS 206
FIGURE 6-1: MATERIAL PROPERTIES 213
FIGURE 6-2: MASS SOURCE 214
FIGURE 6-3: STATIC LOAD CASES 214
FIGURE 6-4: STRUCTURAL RENDER FROM ETABS 215
FIGURE 6-5: STRUCTURAL RENDER FROM ETABS 216
FIGURE 6-6: STRUCTURAL RENDER FROM ETABS 217
FIGURE 6-7: WALL LOAD 218
FIGURE 6-8: DEAD LOAD 218
FIGURE 6-9: AXIAL FORCES DIAGRAM OF THE FRAME UNDER DEAD LOAD 219
FIGURE 6-10: MOMENTS AROUND AXIS 2-2 DIAGRAM OF THE FRAME UNDER DEAD LOAD 219
FIGURE 6-11: MOMENTS AROUND AXIS 3-3 DIAGRAM OF THE FRAME UNDER DEAD LOAD 220
FIGURE 6-12: SHEAR FORCES AROUND AXIS 2-2 DIAGRAM OF THE FRAME UNDER DEAD LOAD 220
FIGURE 6-13: SHEAR FORCES AROUND AXIS 3-3 DIAGRAM OF THE FRAME UNDER DEAD LOAD 221
FIGURE 6-14: CONCRETE BEAM DESIGN INFORMATION 221
FIGURE 6-15: DIAGRAMS FOR A BEAM 222
FIGURE 6-16: SUMMARY OF A BEAM DESIGN 223
FIGURE 6-17: SUMMARY OF A COLUMN DESIGN 224
FIGURE 6-18: LONGITUDINAL REINFORCEMENT , KN.MM 225
FIGURE 6-19: DEFORMATION UNDER STATIC DEAD LOAD 226
FIGURE 6-20: BEAM TYPES 228
FIGURE 6-21: BEAM TYPES 229
FIGURE 6-22: BEAM AND COLUMN TYPES 230
FIGURE 6-23: STRUCTURAL PLAN, STORY1 231

FIGURE 6-24: STRUCTURAL PLAN, STORY2 ____ 232
FIGURE 6-25: STRUCTURAL PLAN, STORY3 ____ 233
FIGURE 6-26: STRUCTURAL PLAN, STORY 4 ____ 234

7.3. List of Tables

TABLE 1: POPULATION AND POPULATION DENSITY (YEAR-END OF 2008) 27
TABLE 2: ALL AGGLOMERATIONS OF THE WORLD WITH A POPULATION OF 1 MILLION INHABITANTS OR MORE AT THE REFERENCE DATE 2012-10-01 28
TABLE 3: HDD, HEATING DEGREE DAYS 167
TABLE 4: CDD, COOLING DEGREE DAYS 168
TABLE 5: VARIATIONS OF ANNUAL AVERAGE DAILY TOTALS OF SOLAR RADIATION 169
TABLE 6: TOTAL MONTHLY SOLAR EXPOSURE FOR THE NORTHERN SOLAR PANEL IN THE MODULE 199
TABLE 7: TOTAL MONTHLY SOLAR EXPOSURE FOR THE SOUTHERN SOLAR PANEL IN THE MODULE 199
TABLE 8: MONTHLY HEATING AND COOLING LOADS 200
TABLE 9: ENERGY PRODUCTION AND CONSUMPTION COMPARISON 201
TABLE 10: GAIN BREAKDOWN 202
TABLE 11: MONTHLY DEGREE DAYS 203
TABLE 12: STRUCTURAL LOADS 217

Thanks to
Prof. Gabriele Masera
Prof. Massimo Tadi
Prof. Danilo Palazzo
Prof. Matteo Colombo
Michele Sauchelli
Carlo Galimberti

Special thanks to our families, classmates, and friends
Misagh Ketabdari
Roozbeh Hasanzadeh Nafari
Yu Jianghao

Thanks to
Nicolas Jaar
Shlohmo
Boiler Room
Ebrahim Hamedi
Dr. Annabella Burdi
Dr. Asghar Masoudi

Thanks to
Politecnico di Milano
Autodesk
Adobe
Dropbox
Youtube
Spotify
Soundcloud
Wikipedia
Facebook
Gmail