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Polo Regionale di Lecco

Expo'10 Green Tower Shanghai, China

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CHAPTER 1

URBAN DESIGN

1.1. Introduction

1.2 The general information of Shanghai

Shanghai is the most populous city in China and one of the most populous cities in the world. A global city, Shanghai exerts influence over global commerce, finance, culture, art, fashion, research and entertainment. The city is located at the middle portion of the Chinese coast, and sits at the mouth of the Yangtze.

Once a fishing and textiles town, Shanghai grew to importance in the 19th century due to its favourable port location and as one of the cities opened to foreign trade by the 1842 Treaty of Nanking. The city flourished as a centre of commerce between east and west, and became a multinational hub of finance and business by the 1930s. After 1990, the economic reforms introduced by Deng Xiaoping resulted in intense re-development and financing in Shanghai, and in 2005 Shanghai became the world's largest cargo port.

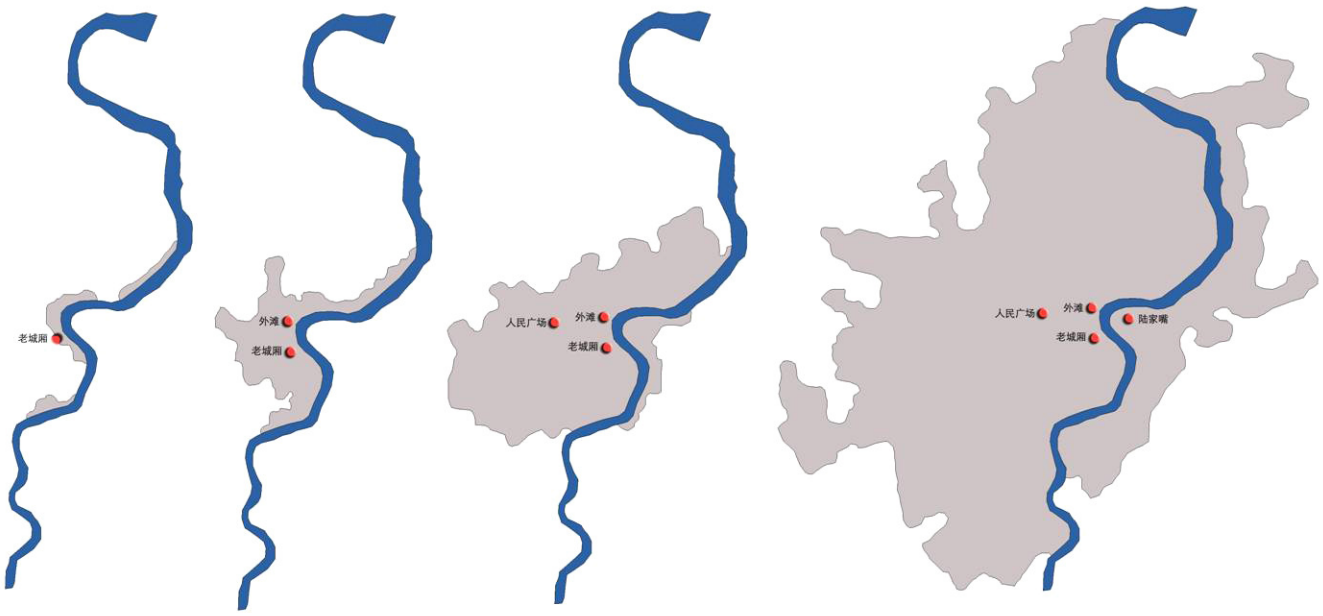
The city is a tourist destination renowned for its historical landmarks such as the Bund and City God Temple, and its modern and ever-expanding Pudong skyline including the Oriental Pearl Tower. Today, Shanghai is the largest centre of commerce and finance in mainland China, and has been described as the "showpiece" of the world's fastest-growing major economy.

Shanghai before 1840 Fishing village

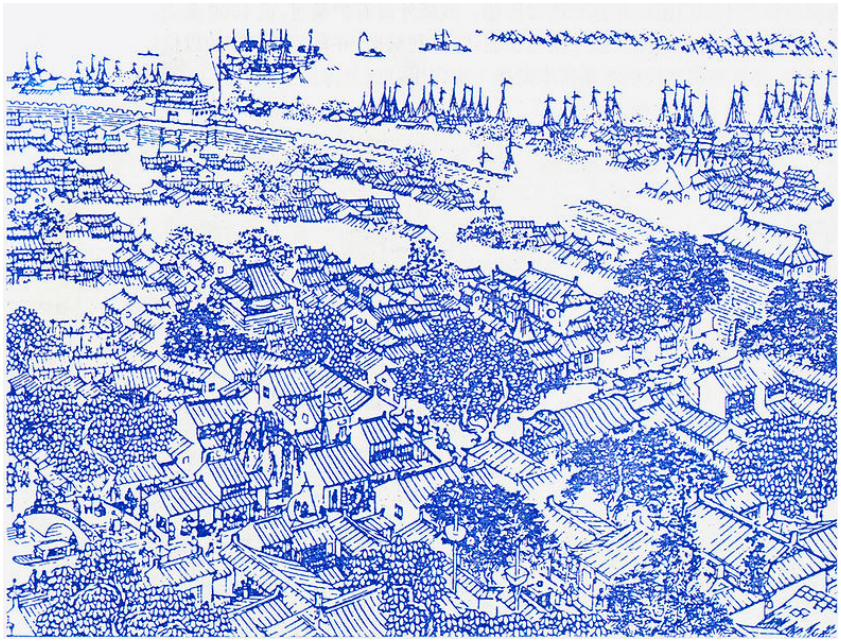
Shanghai (1842--1949)
Regional centre

Before the reform and open policy
(1949—1978) The status of Regional centre lost

After the reform and open policy (1978)
The reestablish of regional centre



1600S 1700S 1980S 1990S



The walled city of Shanghai during the Ming Dynasty.

A view of the Bund in 1928.

Nanjing Road in the 1930s.

Shanghai has seen massive development since the mid 1990's.

Shanghai in 2009.

Clockwise

From top: A view of the Pudong skyline, Yuyuan Garden, China Pavilion along with the Expo Axis,
Neon Sign at Nanjing Road,
and The Bund in Puxi

1.3. The general information of Shanghai Expo 2010

World Expositions are galleries of human inspirations and thoughts. Since 1851 when the Great Exhibition of Industries of All Nations was held in London, the World Expositions have attained increasing prominence as grand events for economic, scientific, technological and cultural exchanges, serving as an important platform for displaying historical experience, exchanging innovative ideas, demonstrating esprit de corps and looking to the future.

Chapter 1

With a long civilisation, China favours international exchange and loves world peace. China owes its successful bid for the World Exposition in 2010 to the international community's support for and confidence in its reform and opening-up. The Exposition will be the first registered World Exposition in a developing country, which gives expression to the expectations the world's people place on China's future development.

So what will Expo 2010 Shanghai China deliver to the world? There is no doubt the Chinese people will present to the world a successful, splendid and unforgettable exposition.

Expo 2010 Shanghai China will be a great event to explore the full potential of urban life in the 21st century and a significant period in urban evolution. Fifty-five percent of the world population is expected to live in cities by the year 2010. The prospect of future urban life, a subject of global interest, concerns all nations, developed or less developed, and their people. Being the first World Exposition on the theme of city, Exposition 2010 will attract governments and people from across the world, focusing on the theme "Better City, Better Life." For its 184 days, participants will display urban civilisation to the full extent, exchange their experiences of urban development, disseminate advanced notions on cities and explore new approaches to human habitat, lifestyle and working conditions in the new century. They will learn how to create an eco-friendly society and maintain the sustainable development of human beings.

Chapter 1

Expo 2010 Shanghai China will centre on innovation and interaction. Innovation is the soul, while cultural interaction is an important mission of the World Expositions. In the new era, Expo 2010 Shanghai China will contribute to human-centred development, scientific and technological innovation, cultural diversity and win-win cooperation for a better future, thus composing a melody with the key notes of highlighting innovation and interaction in the new century.

Expo 2010 Shanghai China will also be a grand international gathering. On the one hand, we shall endeavour to attract about 200 nations and international organisations to take part in the exhibition as well as 70 million visitors from home and abroad, ensuring the widest possible participation in the history of the World Expositions. On the other hand, we will put Expo 2010 Shanghai China in a global perspective and do our best to encourage the participation and gain the understanding and support of various countries and peoples, in order to turn Expo 2010 Shanghai China into a happy reunion of people from all over the world.

In addition, Expo 2010 Shanghai China will offer a wonderful opportunity for cross-culture dialogues. Before the conclusion of the Exposition, a "Shanghai Declaration" will be issued. This declaration, hopefully a milestone in the history of the World Expositions, will epitomise the insights to be offered by the participants and embody people's ideas for future cooperation and development and extensive common aspirations, thereby leaving a rich spiritual legacy of urban development to people throughout the world.

Chapter 1

The Chinese Government will go to great lengths to make Expo 2010 Shanghai China a special event that carries on traditions and opens a new vista into the future. Our motto is: "Keeping in mind the next 60 years' development while preparing for the six months' Exposition." We count on the continuing attention, support and participation of all the peace-loving countries.

Three types of pavilions to be grouped by the Continent each country belongs to or by their nature are available for official participants:

Type 1: refers to a pavilion designed and built by an official participant on the plot allocated by the Organizer, or Self-built Pavilion;

Type 2: refers to a stand-alone pavilion built by the Organizer and rented to an official participant, or Rented Pavilions;

Type 3: refers to the covered exhibition space in a joint pavilion constructed by the Organizer and allocated to developing countries free of charge, or Joint Pavilion.

Taking into account such factors as proper walking distance and perception of visitors, the master plan of Expo Shanghai puts forward a five-level structure of park, enclosed area, zones, groups and clusters.

Park: The Expo Site covers a total area of 5.28 sq km, including the enclosed area and outside areas of support facilities. The Expo Site spans both sides of the Huangpu River, with 3.93 sq km in Pudong and 1.35 sq km in Puxi.

Enclosed Area: Enclosed area measures 3.28 sq km (2.39 sq km in Pudong and 0.9 sq km in Puxi).

Zones: There are five functional zones marked A, B, C, D and E respectively, each with an average area of 60 hectares.

Groups: There are 12 pavilion groups, 8 of which in the Pudong Section and 4 in the Puxi Section, each with an average area of 10–15 hectares.

Clusters: There are 26 pavilion clusters, each covering 2–3 hectares. The average floor area of each pavilion cluster can accommodate 40–45 exhibition units with each exhibition unit covering a total floor area of 20,000–25,000 square meters. For the sake of convenience, each pavilion cluster will contain small canteens, shops, telecom, toilets, nursing services and other public facilities.

Foreign national pavilions, to be grouped by the continent they belong to, will include 3 types: Type 1, pavilions designed and built by official participants; Type 2, stand-alone pavilions built by the Organizer and rented to participants; Type 3, joint pavilions constructed by the Organizer and offered spaces to developing nations free of charge.

Zone A is located between the Expo Boulevard to the west and the Bailianjing rivulet to the east in the Pudong Section. Zone A will host China Pavilion and national pavilions for Asian countries except Southeast Asian ones.

Zone B covers an area between Zone A to the east and Lupu Bridge to the west, hosting national pavilions of Southeast Asian and Oceanian countries, Pavilions for International Organizations, Theme Pavilions, Expo Centre and Performance Centre.

Zone C is located in Houtan to the west of Lupu Bridge in the Pudong Section. It will host European, American and African national pavilion clusters. A large public amusement park of about 10 hectares will be built at the entrance.

Zone D is located to the west of the Expo Boulevard in the Puxi Section. The land is one of the original places of modern Chinese national industry and the site of the Jiangnan Shipyard. Some of the old industrial buildings will be kept and renovated into corporate pavilions. The docklands and slipway to the east of the corporate pavilions will be reserved and made into space for outdoor public exhibition and cultural exchange.

Zone E located to the east of the Expo Boulevard in the Puxi Section, will host stand-alone corporate pavilions, Urban Civilization Pavilion, Urban Exploration Pavilion and the Urban Best Practices Area.

Permanent Buildings:

China Pavilion

The China Pavilion is designed with the concept of "Oriental Crown". The traditional Chinese wooden structure architecture element -- Dougong brackets is introduced. The design concept, "the Oriental Crown, the Crest of Chinese, the Barn for the World and Wealthy People," reflects the deep accumulation of Chinese culture. The main colour of the China Pavilion is the traditional and sacred colour, "Gugong (Forbidden City) Red" which represents the taste and spirit of Chinese culture. The China Pavilion consists of the 47,000-square-meter Chinese national pavilion, 38,000–square-meter

Regional joint pavilion and 3,300-square-meter pavilion of Hong Kong, Macao and Taiwan.

China Pavilion

Theme Pavilions

The Theme Pavilions are located in Zone B of the enclosed area of the Expo Site and to the west of Expo Boulevard. The shape of the Theme Pavilions borrows from the "lane" and "dormer" of the old Shanghai, to form a two to three-dimensional spatial structure by means of "origami". The Theme Pavilions will be built into a "green, energy-saving, environment-friendly" building with an aboveground area of 80,000

square meters and underground of 40,000 square meters.

Expo Boulevard

The Expo Boulevard is located in the centre of the Pudong part of the Expo Site and is the largest stand-alone structure within the Expo

Site. The Expo Boulevard has two floors underground, one above the ground and one canopy. The Expo Boulevard is a semi-open structure and will serve as a large transportation and commercial centre with multiple purposes. The Expo Boulevard will act as the main axis for human traffic flow and sightseeing in the Expo Site during Expo Shanghai and will continue to be main axis of landscapes in the city after Expo Shanghai.

Expo Boulevard

World Expo Centre

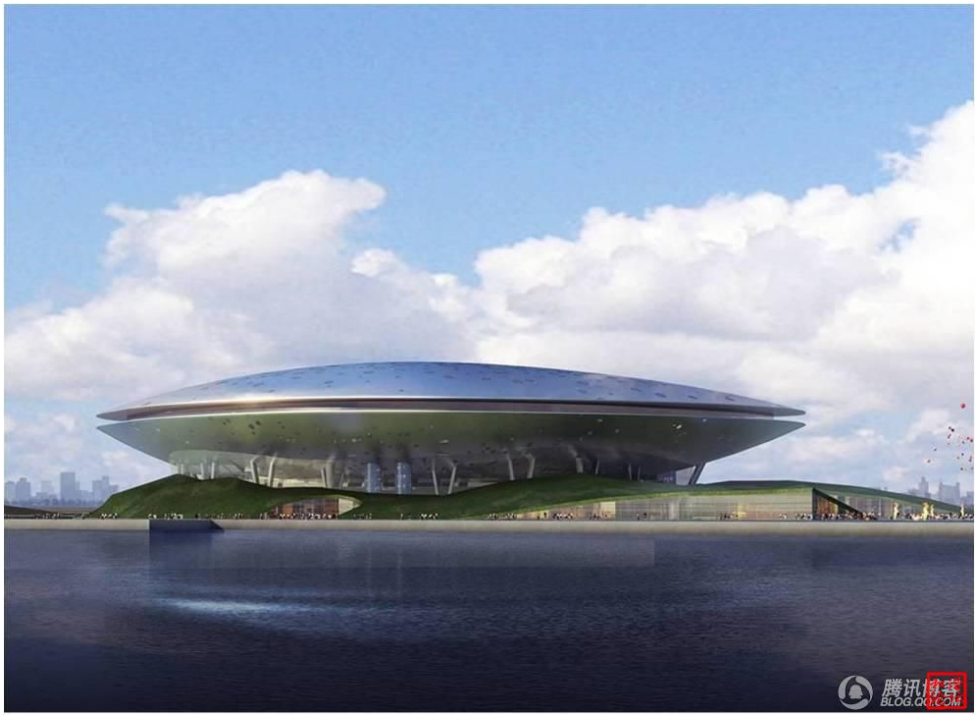
The Expo Centre is located at the water-front greenland in Zone B of the Expo Site. This building stretches 350 meters from the west to the east, and 140 meters from the north to the south, with a total floor area of 140,000 square meters. The Expo Centre will be completed and put into trial operation by the end of 2009. Being one of the major permanent buildings, the

Centre will serve as the centre for ceremonies and conferences, press conferences and various forums during Expo Shanghai.

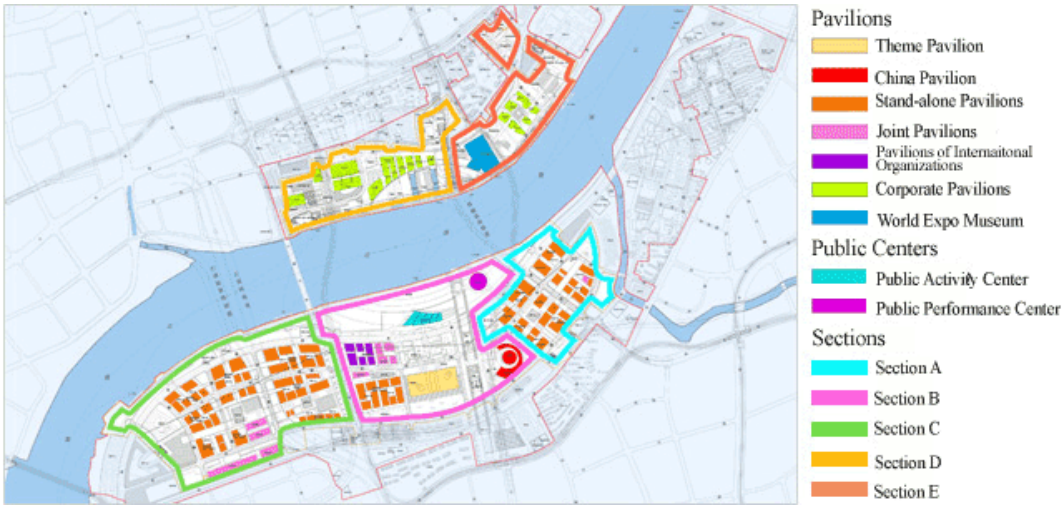
Expo Performance Centre.

Located in the north of the Pudong Section of the Expo Site and to the east of the Expo Boulevard, the Expo Performance Centre has a floor area of 126,000 square meters, of which 74,000 square meters is above ground and 52,000 square meters underground area. It will be completed and put into trial operation by the end of 2009.

The centre mainly consists of large central stage, large functional hall which can house 18,000 audiences and supporting facilities. The audience seats are convertible between 4,000 seats, 8,000 seats, 12000 seats and 18,000 seats based on requirements for performance and volume of audiences. The central stage is the first of its kind in China which can be adjusted to form different shapes within 360 degrees. Therefore, it can provide huge space for stage design, artistic innovation and imagination for various performances.



Expo Performance Centre




总平面图


上海世博会园区
A
B
C
D
E
FDB 福步
http://bbs.fobshanghai.com

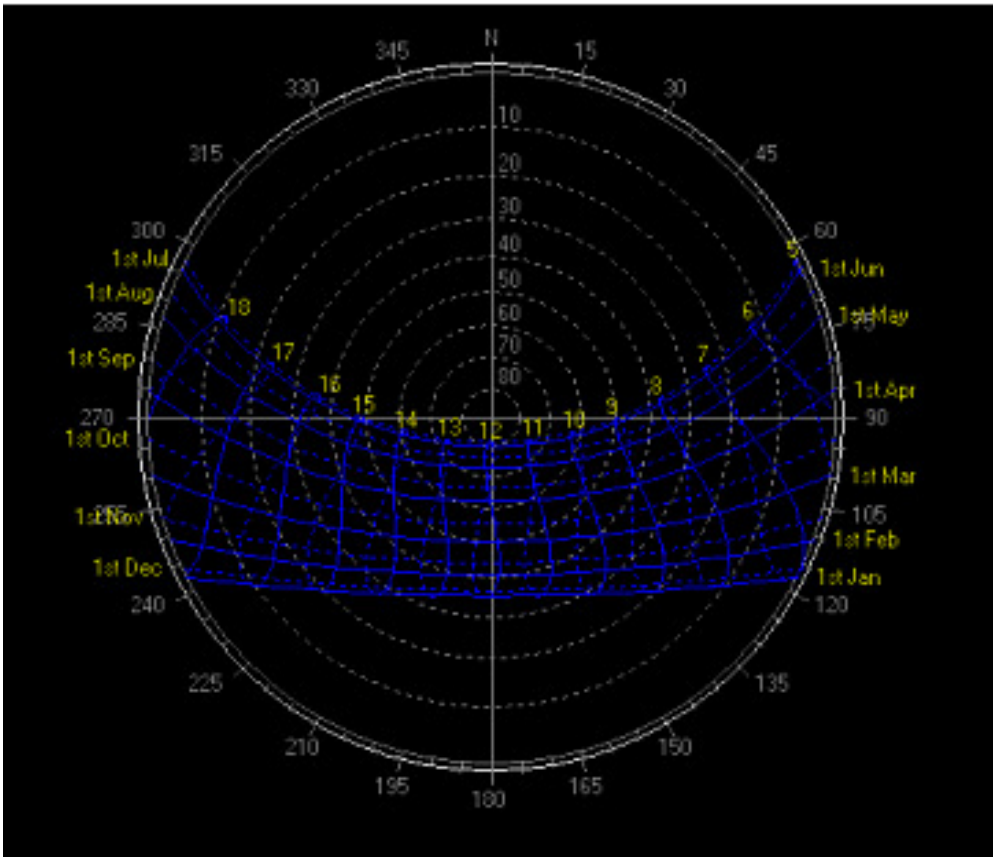
1.4 .Enviromental data

Factors such as wind, sun path were also cons idered for the design of the project.

Sun Path

The sun path was used in aiding as to where t o put the green areas. Most of the green buff er zones are located in areas where shading is needed the most.

Location: latitude 31.1N, 121.3E.



Standard climate data of Shanghai from year 1971-2000:

Month	Ave. Pressure [Pa]	Average temperature [°C]	Max temperature [°C]	Min temperature [°C]	Relative humidity [%]	Average wind speed [m/s]	Precipitation [mm]
1	102610	4.7	19.2	-5.5	75	3	75.3
2	102420	6	26.4	-4.5	72	3.1	43.7
3	102020	9.2	26.1	-7	78	3.3	117.6
4	101520	14.7	32.2	2.4	75	3.2	63.2
5	101090	20.3	34.9	9.4	74	3.3	85.2
6	100650	23.8	36.8	16	82	3.2	211.6
7	100490	28	37.7	20	80	3.2	141.8
8	100640	27.8	37.8	19.9	81	3.4	230.1
9	101230	24.4	36.7	13.9	77	3.3	76.1
10	101930	19.2	32.2	6.5	74	2.9	63.5
11	102330	13.5	26.5	-1.9	74	3	42.6
12	102650	7.8	20.3	-7.7	73	2.9	33.7
	Average	Average	Max of year	Min of year	Average	Average	Year total
Year	101630	16.6	37.8	-7.7	76	3.2	1184.4

The prevailing winds in summer is from south-east, while in winter is from northwest. It was u sed to locate the best area to harness the energy from windmills. It was also used to design
the massing of the site, for example which are a would be the best to have higher buildings and where to locate lower ones.

1.5 Principles of After-use

To Serve the Overall Urban Development Strategy

In light of the social and economic development strategy of Shanghai, and according to the current city functions and facilities, the Organizer will try to make the Exposition a complement to the shortfalls in urban functions during and after the great event and see to it that the after-use may fit into the overall development strategy of the city. It is important to take into full account all the tangible assets created by Expo 2010, such as the massive transport system, various architectures and facilities, as well as its intangible legacy to the whole society after the close of the Expo 2010.

To Be Consistent with the Expo Theme

The full elaboration of the theme of Expo 2010 "Better City, Better Life", will run through the Expo site planning process. The after-use study is based on the theme as the predominant philosophy. The impact of Expo 2010 will go beyond its 6 months' duration. The spirit inherent in the theme will be carried on in the next 60 years. The area will therefore project Shanghai's new image and become a landmark of the upgrading of city functions.

To Adapt to Geographical Position

The Expo site is located at the midpoint between the Pudong International Airport and the Hongqiao International Airport. It goes along the Huangpu River, between Nanpu Bridge in the north and Lupu Bridge in the south, with Xupu Bridge farther south and the Lujiazui Financial Zone in the northeast. It

is also backed up by such logistics centers as the Yangshan Deep Water Port and the Waigaoqiao Bonded Zone. All in all, it shows an obvious advantageous location in terms of transport, finance and logistics, which will render rationality and feasibility to its after-Expo development as an international trade zone. Comparable to the Lujiazui Financial Zone in all configurations, the Rear Bund Area is well positioned as International Trade Zone in Shanghai. An entirely new Trade Center will emerge on the Expo site when the after-use plan is carried out.

To Be Economically and Technically Feasible

According to an analysis of the land value of the Exposition site before, during and after the Exposition respectively, it is clear that initial investment in Expo 2010 will be substantially rewarded during and after the Exposition through reasonable management and operation. However, the post-Expo value will be the true legacy to the residents of Shanghai and the Chinese people as a whole. Herein lies the ultimate evaluation of Expo 2010. To make the Exposition a success, it is crucial that we should take full account of after-use while drawing up plans and implementing them at an early stage so that the value expected of the Exposition may be realized to its full extent both economically and technically.

To Be Flexible

In line with the principle of flexibility for after-use and keeping pace with the times, the Organizer will reserve sufficient space at the Exposition site for sustainable development to ensure close connection between the re-development of the site and the overall development of the city. This will

help maximize comprehensive benefits and leave enough time and space to after-use development.

To Achieve Cultural Continuity and Urban Renaissance

After Expo 2010, the Exposition site will constitute an important part of the city of Shanghai, presenting not only quality urban life of a metropolis, but also the features and spirit of the city's culture.

1. 5.1 New Buildings and Renovated Buildings

After Expo 2010, some buildings with distinctive features and large pavilion facilities will be preserved.

According to relevant regulations of the BIE and the tradition of World Expositions, all pavilions shall be temporary pavilions and the sites assigned to participants shall be returned to their original condition after the Exposition. The Organizer encourages the participating foreign countries to construct their own national pavilions in a manner that reflects the theme of the Exposition, their respective national cultural heritages, and the architectural styles of their cities. The Organizer, together with the participants concerned, may decide which pavilions can be preserved and to which location they may be re-assigned.

The pavilions to be preserved shall fit into the eco-environmental agenda of the 21st century, with special attention paid to nature, environment, health and energy efficiency. They shall reflect the contemporary desire for sustainable development with harmony between human beings and the nature, and

display the perfect combination of good design and natural ecology. The buildings shall also reflect the state of the art technologies in the use of new materials, new technologies and new structures. The building materials shall be environment-friendly materials easy for assembly and disassembly, so as to make future removal and reconstruction technologically and economically possible.

China Pavilion to be located in Zone A will be permanently preserved as a symbol of the cooperation of the Expo by China and BIE.

In Zone B, the theme pavilions will be temporary buildings, the Community Center will become a first-class large-scale conference center and the performance center will continue to be an important venue for cultural exchanges between countries.

The building cluster on the original site of Jiangnan Shipyard will be preserved selectively and in the light of the after-use plan, and turned into a Modern Industry Museum with the major function of large-scale industrial exhibition and cultural and art exchange.

The World Exposition Museum to be located in Zone E and its support facilities will be a legacy to Shanghai as a world-class culture and exhibition research center.

The Expo Village complex, based on the existing structures, with the full consideration of the after-use, is planned to be turned into a comprehensive urban community with an integration of all the functions of commerce, tourism and entertainment, where service apartment houses dominate with complete support facilities of service.

The planning of public support facilities of service will be made in very close connection with the planning of the after-use of the Expo Park, and those facilities will be an organic part of the Expo Park after the Expo duration through preservation, renovation and removal.

1.5.2.Protected and Preserved Buildings

Different ways of preservation will be taken, in the light of the current condition of the buildings within the park and the master plan of the Expo, and the preservation projects of the buildings concerned and value differences of the buildings themselves. The planning will divide the protected buildings and preserved buildings within the site boundary into three types: protected buildings, preserved heritage buildings and generally preserved buildings during the Expo.

a. Protected buildings

They are legally protected buildings as well as permanently preserved buildings, including cultural products protecting institutions and Shanghai Municipal Excellent Heritage Architectures. According to the *Cultural Products Protection Law of the People's Republic of China*, a total of seven places within the Expo Park have been placed on the second list of Shanghai municipal excellent heritage architectures.

b. Preserved heritage buildings

They are heritage buildings with distinctive features in terms of architectural style, architectural structure, architectural decoration and cultural legacy. They are also categorized as permanently preserved architectures.

c. Generally preserved buildings

They meet the requirements of the Expo space or support facilities of service during the Expo in terms of architectural structure and form. Whether they are to be torn down or be preserved after the Expo depends on the future requirements.

1.6 Preliminary Plan for Land Re-development

1.6.1Planning Structure

The re-development of the Expo area will be conducted in line with both the functions and the future development of this area. International cultural exchange is one of the city's important functions and a significant means to demonstrate the city spirit. However, the city lags far behind other international metropolitan cities in terms of cultural amenities, especially large complexes. As the number of foreign consulates-general and representative offices in Shanghai rises year by year and more domestic and overseas agencies converge in Shanghai, along with the accelerated development of the modern service industry, the shortfall of such facilities is even more apparent. As the policy for the downtown area is to increase public space and common green area, decrease FAR (floor area ratio) and total buildings, the demand for the first class office buildings will continue to grow and exceed supply. We will take advantage of the impact of the Exposition to re-develop the site with a view to meeting the demand for international cultural exchange facilities and business services. In this way, the Exposition site will be turned into a complex catering to international cultural exchanges,

international relations, business, and tourism with adequate residential quarters.

According to the theme "Better City, Better Life", a really vigorous and dynamic urban area will be built here that will fit into the current urban fabric and merge with the life in the surrounding area.

The re-developed area on the Expo site will extend along the city functional axis line, running northwards along South Xizang Road to the People's Square, the Administration Center and the downtown area, and be closely connected to the downtown area by the transport axis line of South Xizang Road and Metro Line 8.

The Expo Plaza and the axis line (the Expo Boulevard) will remain as a municipal public center for outdoor gatherings and cultural performances. The plaza cluster and the pedestrian sightseeing route, in somewhat diminished size, will selectively emerge as a space system for local public activities with all the dining and entertainment facilities intact. The performance center and cultural squares will become a stage for urban activities in this region where cultural feats may be always presented.

1.6.2 Functional Layout

(1) The Exposition site will be used mainly for international trade with supplementary functions of conference and exhibition, cultural exchange, tourism, leisure and business.

(2) The permanent facilities will concentrate in the enclosed area between Lupu Bridge and the Expo axis line. Those in

the Pudong Section will be preserved for a future Exhibition and Conference Center, and those in the Puxi Section for a Cultural Exchange Center.

(3) There are three major areas for re-development after Expo 2010: the first is located to the west of Lupu Bridge reserved for urban development, the second is located between the Bailianjing rivulet and the Expo axis line for urban commercial and residential development, and the third is located to the east of the Expo axis line in the Puxi Section for development of residential quarters.

1.7 After-use of the New Infrastructure Facilities

The new infrastructure facilities will remain after Expo 2010 and form a framework to support Shanghai's efforts to set up four centers, namely, economic, financial, commercial and shipping centers; and to meet the demand of 20 million residents for urban infrastructure facilities and public utilities.

1.7.1 Urban Open Green Area

a. The riverside green land to remain as the Expo Park

The Riverside Green Land will be preserved as a large open space for public activities in Shanghai after Expo 2010.

b. Two waterfront green belts to be kept

The two waterfront green belts will be kept and constitute part of the open space on both sides of the Huangpu River.

c. The green wedges leading to the waterfront to be partially preserved

The green wedges will also be partially kept and, with the land re-development, strengthen the connection between the waterfront areas and the water. They will bring the city closer to nature, thereby increasing the value of the waterfront land.

1.7.2 Support Service Facilities

a. International trade zone

The future International Trade center will serve functions of business, conference, exhibition and other events and ensure the normal and efficient operation of the whole area.

b. Local commercial network

In order to ensure quality life for the residents in this area after Expo 2010, the local commercial network will be completed and further improved. The construction of the commercial network will keep up with the pace of residential building construction and be rationally distributed.

1.8. SWOT ANALYSIS:

Strengths:

- Good views of the waterfront
- Proximity to metro lines, ferry boat and tunnel are available
- Full of culture atmosphere due to the presence of China Pavilion and Culture centre.
- Presence of water features within the site
- Good location ,close to the axis of the Expo
- Relatively flat land
- Flat land

- Only China pavilion and Culture Centre are preserved, other pavilions are totally dismantled, giving enough space and freedom.

Weaknesses:

- Traffic congestion,
- High density of People
- Lacking of pedestrian street.
- It is difficult for people to go there by walking
- Green space is limited
- The function of this area is limited and can't satisfy the people who are living there

Opportunities:

Relatively flat land

Future of Dongtan City

Create a new residential area close to a major city in China (Shanghai)

Water channels can create a new mode of transp ortation within the site

Threats:

- The new develop may lead to the loss of memory of the expo
- The investment
- The culture identity may get lost due to the develop of new centre.

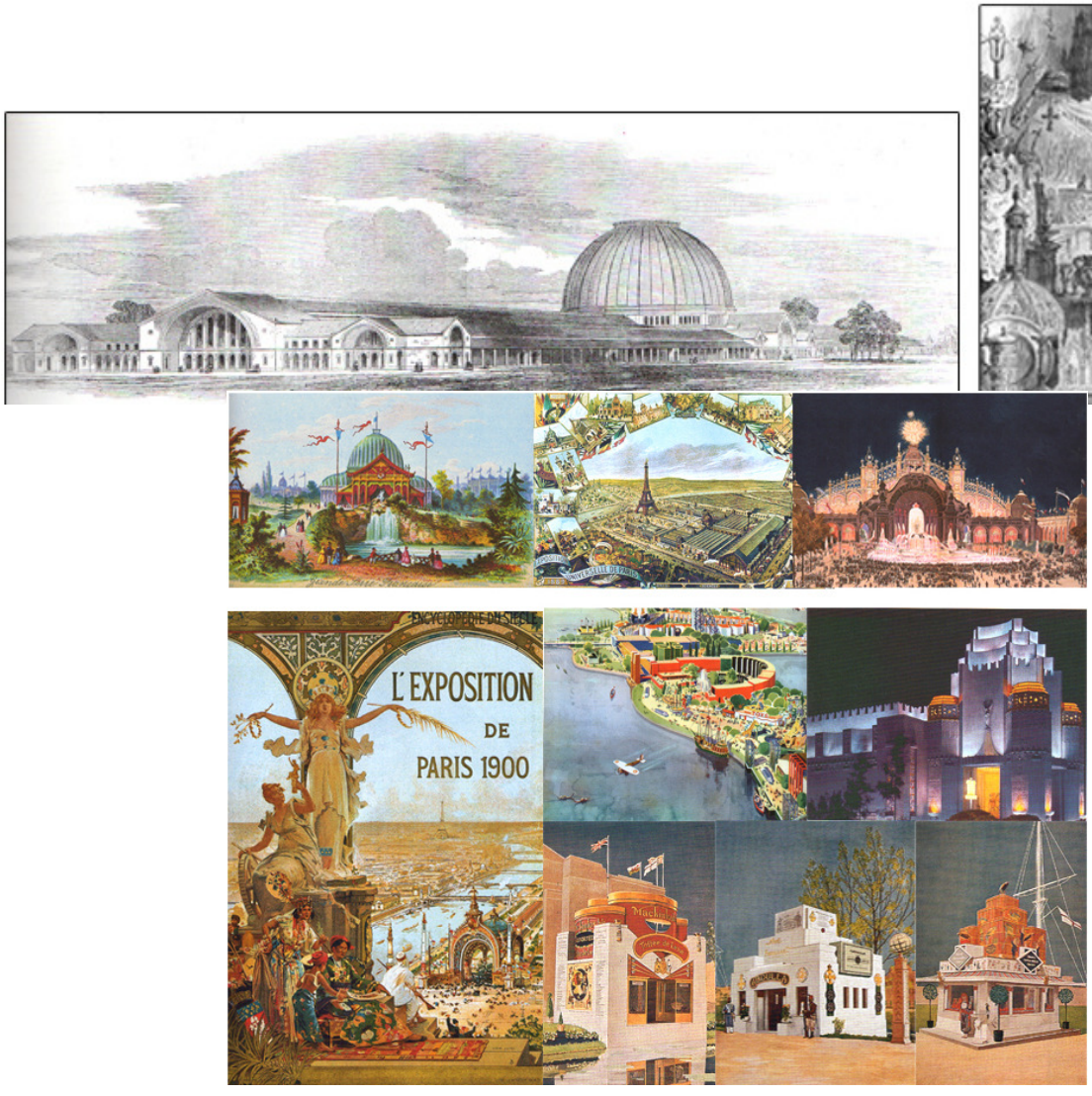
The concept, is that we must both grasp the functions of natural laws and adjust the processes in the changes of nature; that we must acknowledge the objectivity of natural changes and their laws, on the one hand, and affirm the initiative of the subject, on the other.

1.9. Previous Expo studies

1.9.1.Without any After-use plan

In1851,The Great Exhibition of the Works of Industry of All Nations

In 1867,the Paris Expo.



1.9.2. **With some After-use plan**

Year	Place	The main strategies of After-use	The influence to the develop of city
1873	Vienna	The main site is royal hunting ground, after-use to be corn exchange	Foundation of the city structure develop
1876	Philadelphia	Art Pavilion was preserved for good, now is a entertainment centre.	Little influence
1879-80	Sydney	Main pavilion becomes a museum, the site changed to be a royal garden.	
1883	AMSTERDAM	Voor Volks vlijt is preserved for good. the rest building are sold	
1885	Antwerp	No reference found	No reference found
1889	Paris	Symbolic building ——the Eiffel Tower	Laid foundation of the city structure, symbol of Paris
		Galerie des Machines was dismantled	
1893	Chicago	Palace of Fine Arts is the only building preserved. the site becomes a park. Massive construction of Metros.	Important public and museum areas.
1900	Paris	the first metro line in Paris. First Electric Train station Gare D'Orsey, Named after Tsar, the Pont Alexandre III, Permanent pavilion Grand Palais andPetit Palais。	Infrastructures greatly improved
1904	St. Louis	Half of the site turned out to be forest park, only Gass Gillbert is	Fundamental development

		preserved till now. The other half of the site turned out to be city hall, bank, hospital ,mass media centre ,churches. In 1904,summer Olympic game was held at the same place.	of the city
1929	Barcelona	The same site of 1992 summer Olympic game	
1933	CHICAGO	After the expo, three buildings were preserved administration building, Jehon ,etc. but all were demolished after	
1937	Paris	Centralized in Champ de Mars and Trocadero	The infrastructure of city was getting rich
1939-40	New York	The site used to be Garbage Dump, afterwards was changed to be green space and Flushing Meadow-Corona	Very important public space for city

Conclusion

The contribution to the development of city was objective to the planner as almost no after use exits.

The influence on the infrastructure of the city is dramatic ,making the way for the further development

The stimulation to economic is that :the acceleration develop of urban infrastructure, as it is shown by the completion of canal of Rhine in 1973 and the metro in Paris in 1900.the other aspect is the status of the city around the world in rising ,like Barcelona ,after successfully holding the expo, it turned out to be a tourist destination.

1.9.3 With detailed After-use plan

1958	Brussels	Most of building were dismantled ,five out of two hundred was remained. some of the building was rebuild。The only real pavilion is Atomium，every year 300000 people visit this place	The site is still the expo plaza, after years of years of adding new facilities, now it is a commercialized ,cultural and entertainment centre
1962	Seattle	The suburbs of Seattle was used as the site for the expo ，many building are kept permanently，grand theatre becomes a public and multi-functional complex。Alweg Monorail，and lots of building were remained ，including American pavilion which is Pacific Science now 。other facilities are public space ,theatre ,plaza.	Seattle becomes the regional centre of west-north America, bidding big event every year.
1967	Montreal	The roads ,museums and metros are remained.	After bidding the expo in island ,the territory of the space is enlarged, afterwards it turned out to be a world-class park, also the facilities for F1 is well developed ,making Montreal international ever since.
1968	San Antonio	Large number of historical buildings remained. part of site becomes hemispheric park, with historical building scattered around.	

1970	Osaka	Theme pavilions remained, it becomes public plaza.	In 2002, 2 million people visited Japanese garden ,culture and nature garden, national museum. elevated single-track trolley bus is well integrated with the city ,make the city a gigantic city park.
1974	Spokane	Three building permanently remained：America pavilion；Washington stage pavilion was renovated to be a conference centre and threat；Spokane pavilion was changed to be the home of carrousel。300 benches in the park was returned to the twenty cities in north-east coast ，one commemorative plaque was said used in the Expo 1974 。	The social condition of water frond area was getting better, the site is still an important part of the city.
1998	Lisbon	Most of buildings remained.90% of the building were kept. The new building took the place of the specialized old ones.	The road net is getting better. The plan in energy use and environment protection is effective. The place is now a multi-functional area, still attracting 1.2 million people every year.
1992	Seville	Two theme pavilion remained。2/3 of the west part turned out to be garden and high-rising apartment，east part was used as Molson Indy racing。The long term contribution of this expo：Scientific world education centre 、high-speed railway，Canada pavilion and nation plaza。	North of high-tech zoon is university campus、south part is administration 、the west is leisure area。400 thousand out 600 thousand squares are still being used.

		。	The construction of new railway facilitated the city's transportation network；The three new roads turned out be the main loop of the city ； The area of the island of Cartuja is enlarged—The canal around the city and new bridges making the city more dynamic
2000	Hanover	Using the existing facilities ， 2/3 of the all the pavilion are the properties of Deutsche Messe AG ,still being used after the expo；1/3 is used as expo park。EXPO square is preserved as city space，the ambient land was about to be sold before the expo，except the expo threat and church，all the others are well kept.。	The goal of the Expo Site is the giant complex, including education ,research, and enterprises.
2008	Zaragoza	The theme park is as public activities area. the site is used as culture and scientific zoon	The environment and transportation was getting improved .After the new landscape of the city ,dynamic activities are still welcomed

Conclusion

The post-expo design should be well considered, as it is still beneficial to the furtherer development of the city. 。

Not only the development of new area (the development of Cartuja),but also it can

make up what the city is still lacking of(Seville expo).Or it is a promotion to city 'certain function (Exhibition in Hannover)

The further develop ,always, is not that successful as people expected.

1.9.4 Whole area was demolished.

In2005,aichi hold the expo ,the theme of which is "the nature's wisdom". Therefore, before the start this exposal master plan was published, demolishing all the all, trying to make the area what it used to be. Also, it is the need of sustainability.

◆ "Complete recover "is impossible and ideal

◆ waste of investment and labor force .

◆The loss of the memories of Expo.

1.9.4. Case study of Osaka Expo 1970

City	EXPO Site to the city centre	AREA	Number of People	After-use
Osaka 1970	15KM	3.30km2	64.2million	Theme park
Shanghai 2008	5.3 KM	3.28km2	70.00million (estimated)	

Osaka Expo is not only one of the most successful expos in Asian, but also in the world 。Also ,the Japan was holding the Expo, the economy was booming, just like what is now in Shanghai.

1.9.5 Case study of Osaka Expo

Before the expo: Osaka was greatly destroyed during the second world war. One third of the city was nothing but ashes. The amount of population declined from 3.25 million to 1.1 million, only one third of that before war. The total mount of traffic road is

69.1 kilometers,475 trams and 70 buses in all. The metro was only between Umeda to Tennoji ,which was 8. 8 kilometers。The port was far from the city centre, making the transportation convenient ;At the same time,

Osaka was greatly influenced by the west-north prevailing wind, some people even suggested to abundant this port.

Tower of the Sun, Expo '70 in Suita, Osaka, Japan.

Osaka Expo'70 Kodak & Ricoh Pavilion

After the expo：the metro line got extended, making it the main way to the site of expo 。The Umeda area ,in front of national railway line. a Central Artery was built crossing shipyard zoon，sennitimae-sen line was established as well. The transportation was dramatically improved 。In terms of metro，soon after the second world war ,it was 8.8 kilometers ,in 1945 turned out to be 11.9 kilometers, the year on which Osaka was appointed to hold the expo ,the total length is 31.9 kilometers. In the aspect of highway, before the year of 1965,only 2.3 kilometers ,at the year of 1969,the total length was turned out to be 42.3 kilometers. What was more, the Osaka international airport was built.

Site in 1971

Site in 1995

Income: during the expo,64.22 million people visited expo, more than half of the total number of the national population. At least 3.3 trillion JPY was created, account more than 5% gross national product. According to the statistics ,during the expo, the investment nearby the site of expo is 0.35 trillion JPY, the total amount of consumption is 0.33 trillion. The consumption related to expo is 0.7 trillion. The number of people using the Tokaido Shinkansen was increased by 43%, the occupancy rate of hotels in the jinmin area is increased by 58%,the year of 1970 the occupancy rate was nearly 98%.During the expo ,the tax income was two hundred billion JPY, and the national railway income is exceeding 4.5 billion

What we can learn from this expo

Develop public facilities before expo：the main way Osaka successfully hold the expo was using the investment from government to develop the public facilities in the city ,especially the infrastructure development ,making a good foundation the future develop of Osaka.

After use：the essential reason of this successful expo is that Japanese carefully plan the after use long before the start of expo. Taking the opportunity of Osaka, the city was given a completely new identity in a larger scale ,that is the leading city in Kansai area and international transportation node.

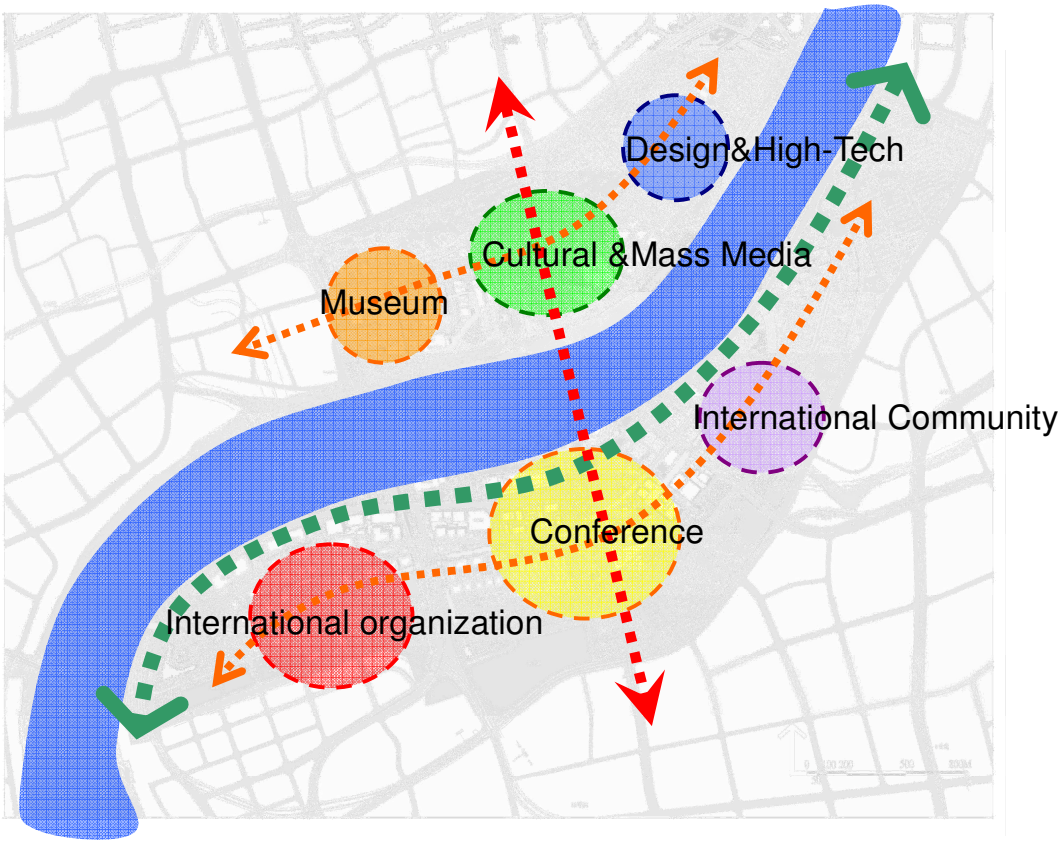
After ten years of development of expo , one of City Ring in the world was formed ,kaisai economic belts .Now, Osaka is the centre of commerce ,finance, information , Center for the allocation of resources , Marketing Center and Global Service Center ,only second to Tokyo ,making optimum distribution of resources and Industrial system renovation.

1.10.Design goal

Function: Exhibition centre ,culture and media centre, international organization centre , Creativity and New Business centre
Space: open space integrated with tourism ,leisure, business, entertainment, culture .
Transportation: traffic hub integrated with Metro, Magnetically Levitated Train ,water-bus, bus,
Industrial: a service centre focused in exhibition, conference, creativity and new business, culture and media, e-business ,tourism

1.10.1 Space organization——The strategy for the south and the north

The north bund—Cultural &Mass Media, Museum, Design & High-Tech. City Park
Heritage from jiangnan boatyard ,according to the plan ,also supported by the high tech from UBPA ,the northern bund will be a culture , media centre Creativity and New Business centre. The unique space characteristics ,cultural atmosphere ,high-tech will contribute a lot to it. Also it is well demonstrated the past and the future. Jiangnan Park will provide large green space for Shanghai.
The south bund——International organization, Conference centre, International Community, city park. Exhibition ,conference, international organization centre, city park give us the space for the post-expo development, especially for the big exhibition centre.
The previous large amount of foreign pavilions will be dismantled ,thus giving space for the international organization. The expo-village will be transformed to living space of staff who are working for the international organization.



The explanation of this organization:
Shanghai is regional centre in China, equipped with Financial central, Corporation Headquarters , maritime centre .Also during the development ,Shanghai is facing many difficulties, like From 2003,the foreign investment in manufacturing industry in Suzhou is more than Shanghai, From 2006,the growth of GDP is slower than the national averaged, Recently years ,the service industry is in the trend of declining. The government advocates to transform the 'made 'industry to 'design' industry. According to the brief, the Expo should take this opportunity. In UPBA, which is area where green building and high-tech are displayed ,after the expo, it will be transformed to Design &High-Tech

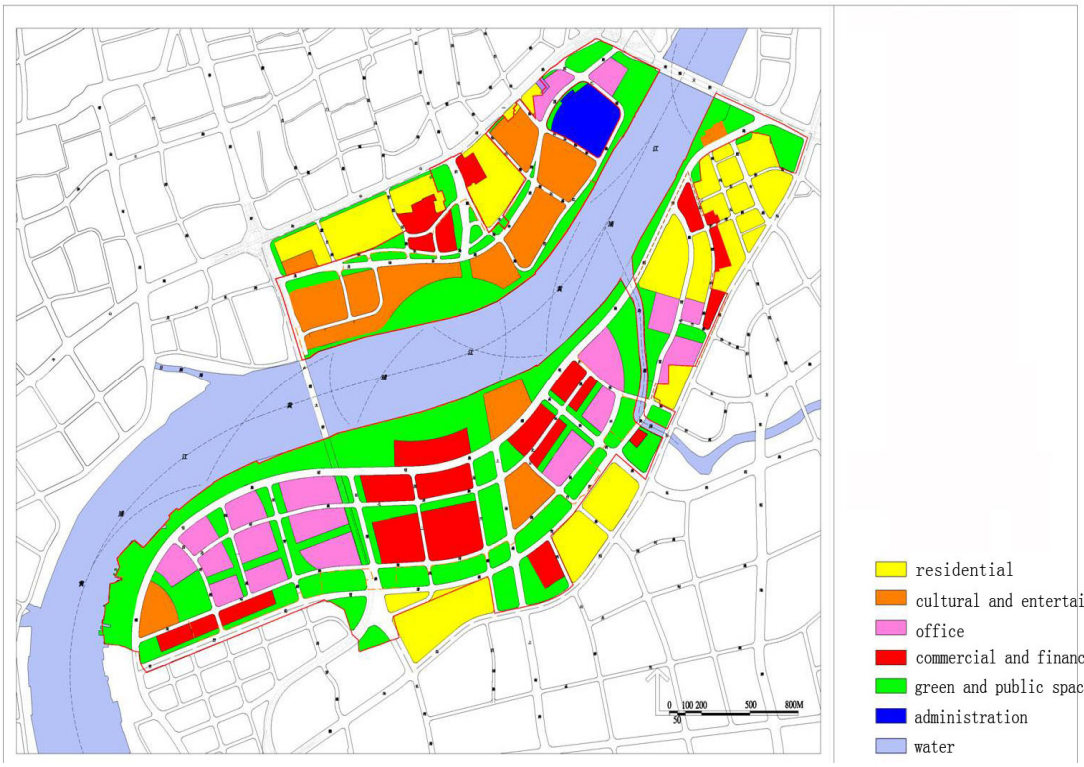
area, taking advantage of the advanced technology accumulated during the Expo. The same reason ,the area where are the multi-national pavilions ,will be

transformed to international organization and international community ,which is badly needed in Shanghai, judging the identify and position of Shanghai in the world.

1.10.2.Concept Plan

we started our concept urban plan with a much bigger area than the planning one, in order to organize a feasible transportation system, residence expansion and green connection. As shown in this plan, the main axis is defined by the river,. On
the north, it is mainly for cultural and entertainment ,.on the south, it is mainly for offices and commercials. We arranged the residential at the lateral part of the each side. Also the height of the building is generally increasing from the river to land, which makes also everyone can enjoy the scenery of the whole site.

Concept plan



Land Use Plan Description:

The site, as are clearly divided, has the followi ng sections: residential, commercial, mix use commercial/residential, educational, transpor t , green area.

Site design has been done, respecting the exi sting water bodies or channels that exist prior to the development of the project. These wat er channels, while some see as a hindrance is used as a form of transport, also a way to ad d a sense of place to the area. It also to allow to connect the place to other existing devel opments in the area, as all of them would hav e the same water features.
Commercial: The commercial area, which

may consist of small independent shops, offices, gym a shopping mall etc is scattered all over the site. The proximity to the residential area will offer a positive impact for the residents to not use their cars to go to such places. There is also some commercial area that is designed, for the betterment of the community by integrating the community aspect into the design of the space. A big portion of the commercial area is also in the border of the site to be able to assist the proje ct, as well as the existing developments aroun d the site.

Mix□Use Commercial/Residential

These areas are dedicated for office space, Small
independent shops, residential apartment spaces that may be used by people who do not necessarily want their own house. These a reas are designed to be able to help the com munity have more diversity, as well as to allow residents to take up office space in the devel opment as well. The area might be able to he lp the areas around the site for residents
to take up office space in the project area, s o as not to create a ghetto style housing development.

Educational

The educational area consists of a kindergart en for the children of the community to go to, and also a public library for the residents to b e able to have a public space to read books, as well as to socialize with other residents of t he project site, and people from other areas as well.

Residential

Mainly it is the skyscrapers as the price of land

in Shanghai is so high. But people still can benefit a lot from it ,they can use the facilities around and cultural things ,to socialize with people who are living there as well.

Transport

The transport hubs are designed in areas, where it would be optimal for residents or visitors of the site to park their cars into so people would not bring their cars into the site. Bicycle parking is also available in the transport hub to push the use of bicycles into the site.

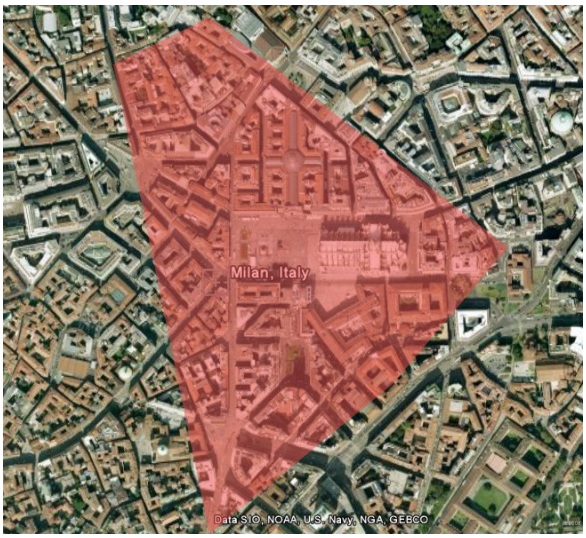
Green

Green areas most especially public parks and vegetation are designed to help to cool the site, as well as to create public areas for exercising and socializing. Some of the green areas are designed in such a way that it will foster socializing, and to create more areas for relaxation and breathing as well.

1.10.3 Site Comparison

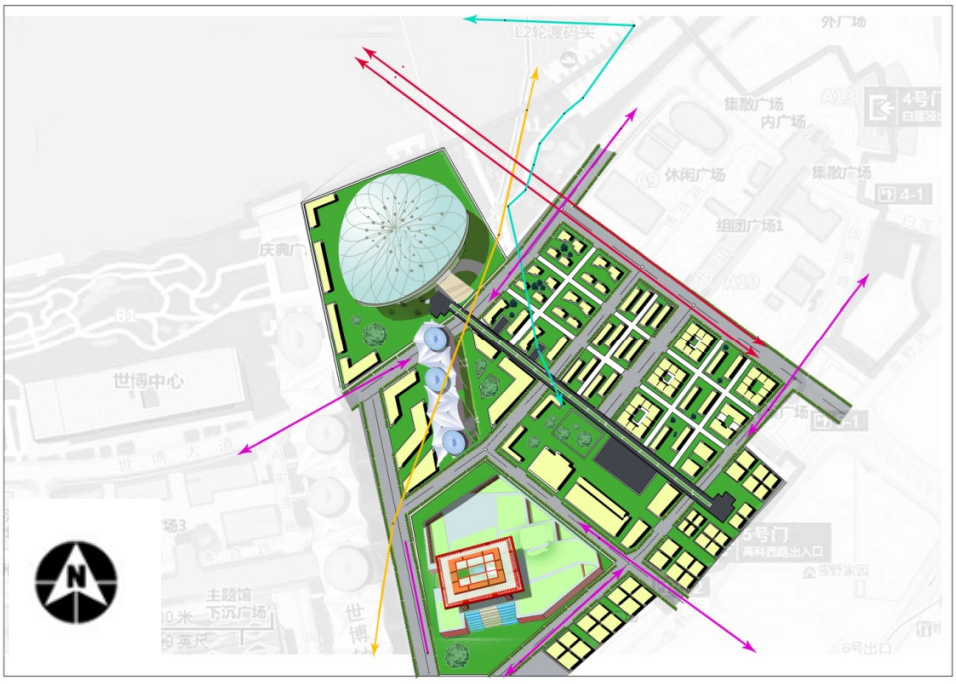
We choose one area for our master plan. First of all, we will have the comparison of the site. The area is 32.232hecter.

Comparison Between Lecco, Milano and our site.



1.10.3 Transportation

As we kept the original arrangement of the space, also the china pavilion and performance centre should be kept, we decided to fully use the whole existing transportation system. People can come to this place easily by using metro. At the same time, if you hope to enjoy the view, the ferry boat is also provided. There also exists a tunnel ,providing the most convenient way for people who are working and living here. We considered that as it is in the city centre, the traffic light should be placed properly ,otherwise traffic congestion will be created ,which is already a big problem in Shanghai. We kept the main green boulevard, trying to take advantage of the free space ,as the space in Shanghai is so expensive. The performance centre and China pavilion will be connected directly using this green

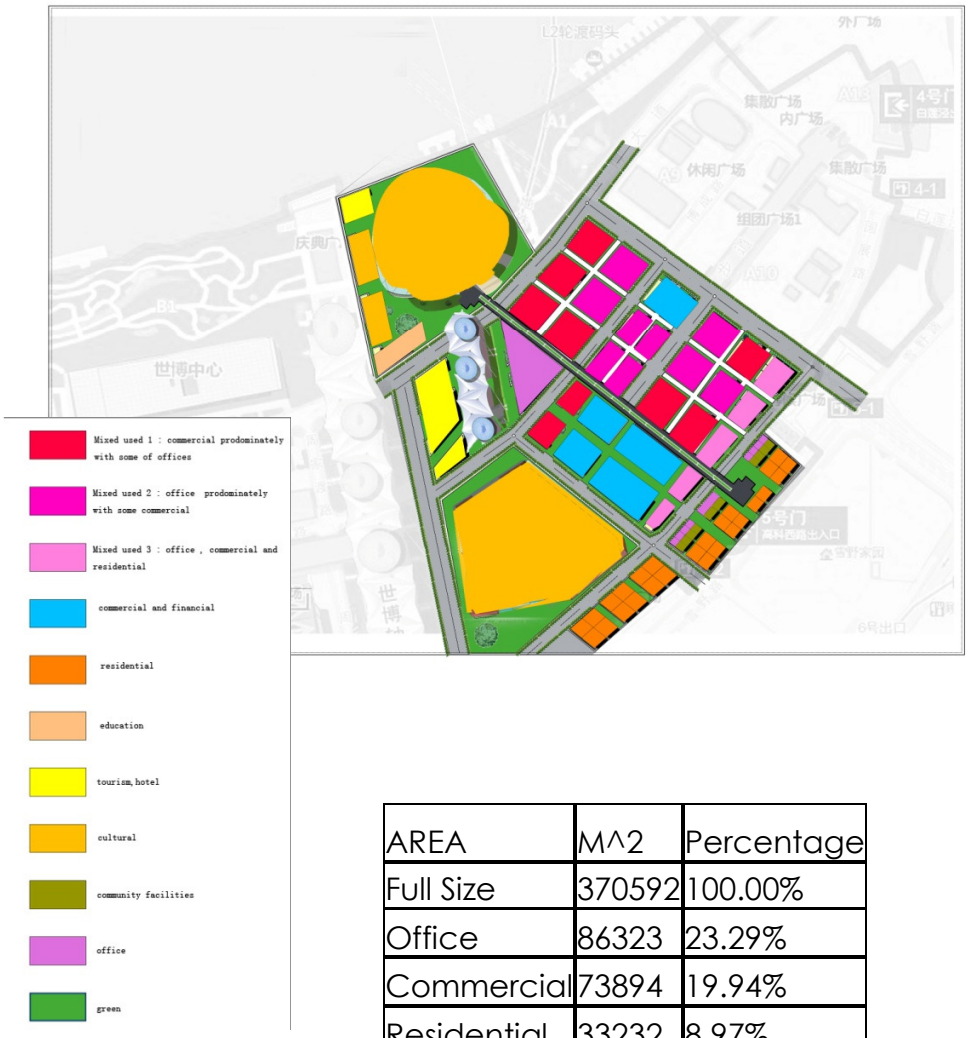


chapter, we use the different of the building to make everything enjoy the all view of this area. The residential area will be more condensed, in order to solve the problem of living in China.

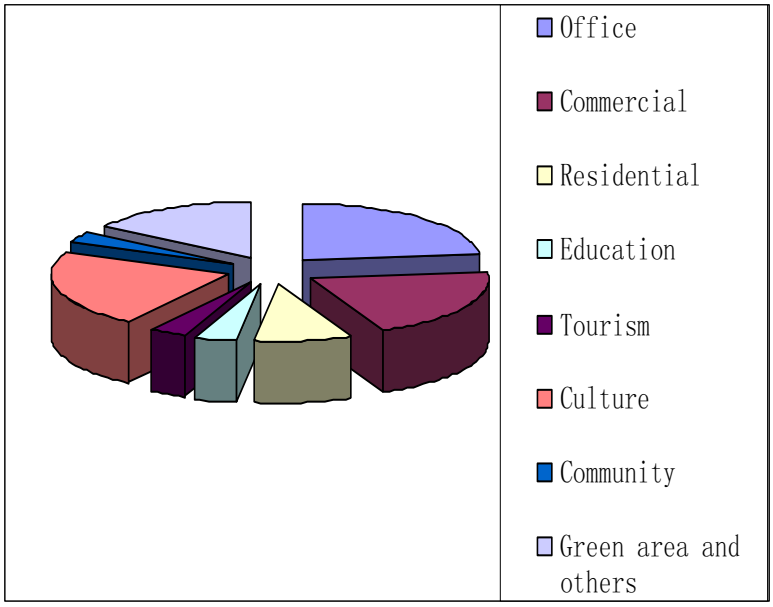
1.10.5 levels of this area

1.10.6 Detailed land use

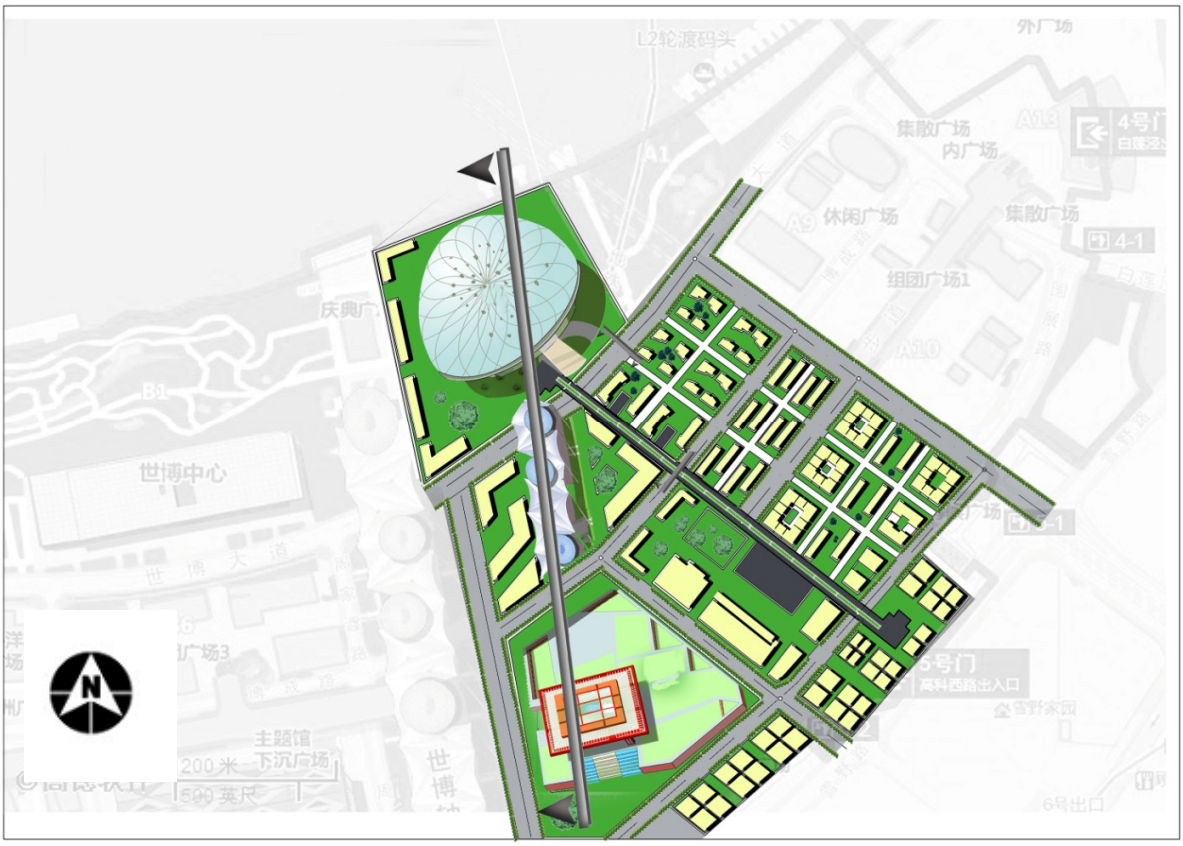
We gave the detailed use of this area, which is commercial and residential dominated. We have a rich environment of culture ,therefore, educational activities are also considered. We also give people the opportunity to the green area ,as living in the 'concrete forest' is not so comfortable sometimes. The mixed use is our main philosophy, we have three kinds of mixed. The function of mixed use building is also a popular concept in the world.



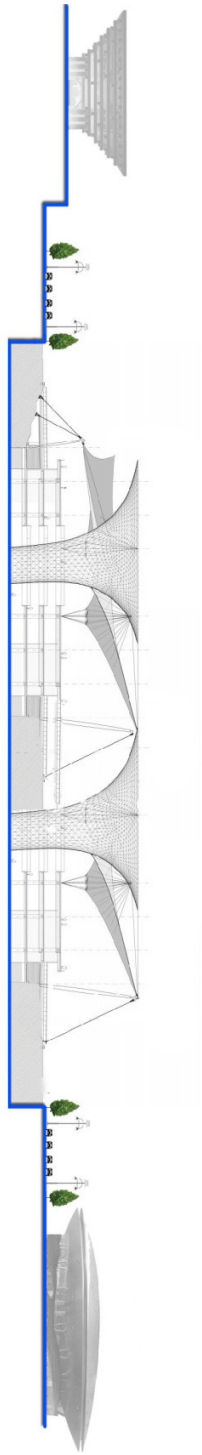
AREA	M^2	Percentage
Full Size	370592	100.00%
Office	86323	23.29%
Commercial	73894	19.94%
Residential	33232	8.97%
Education	14592	3.94%
Tourism	12127	3.27%
Culture	82342	22.22%
Community	10342	2.79%
Green area and others	57740	15.58%



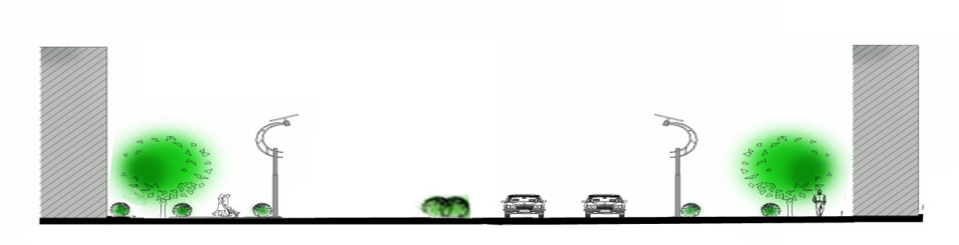
1.10.7 Master Plan and Section


L2轮渡码头
外广场
集散广场
内广场
4号门
休闲广场
集散广场
4-1
组团广场1
庆典广
B1
世博中心
世博大道
广场3
主题馆
下沉广场
200米
500英尺
5号门
高科西路出入口
6号出口

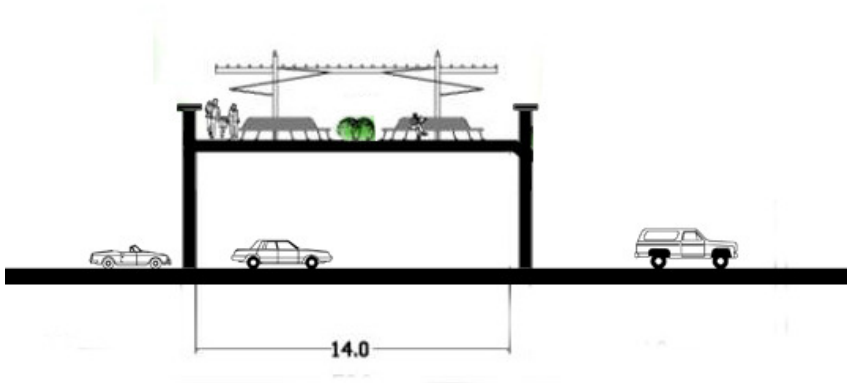
Section A-A



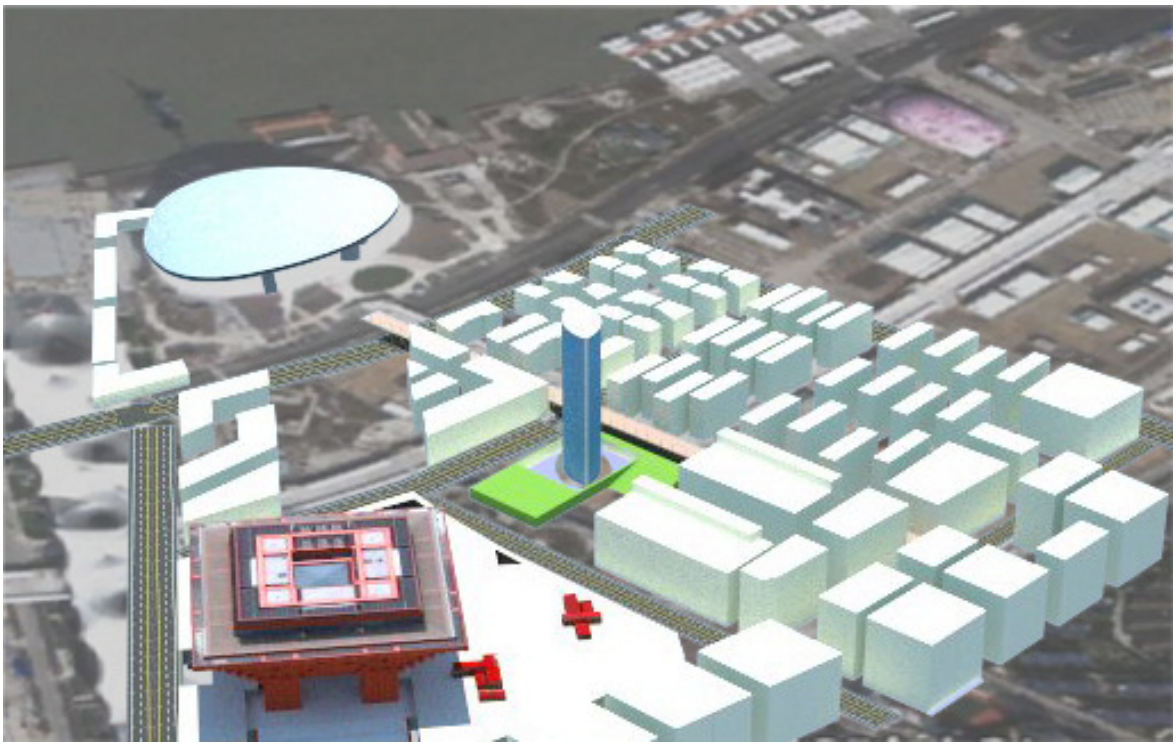
Section B-B



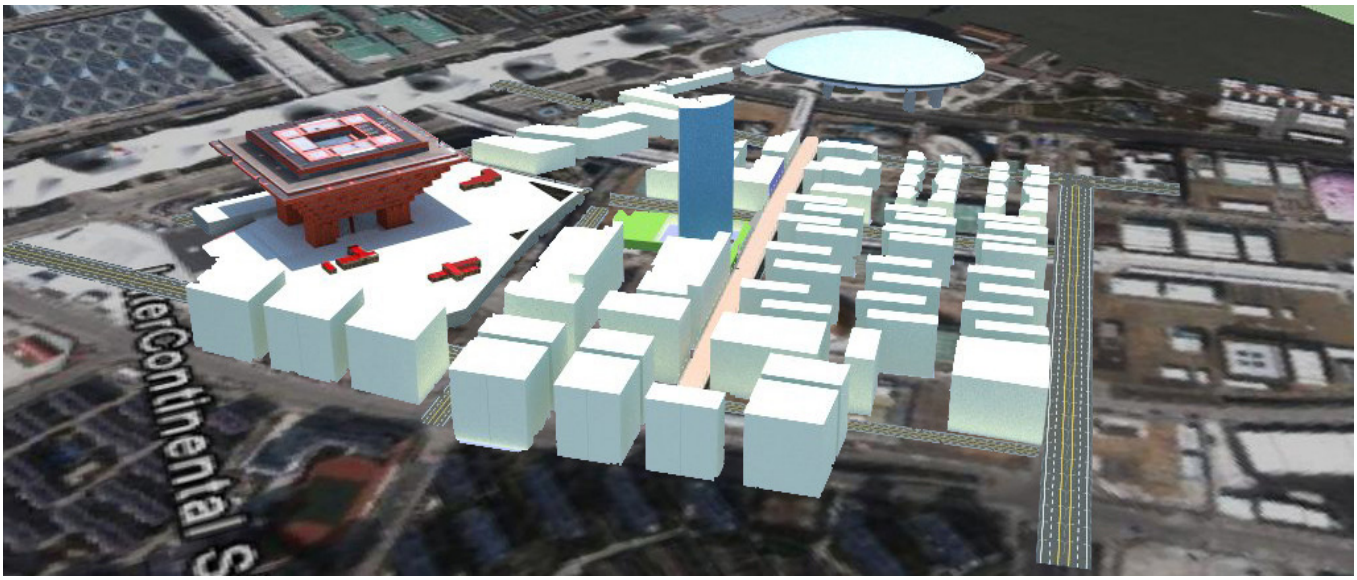
Section C-C

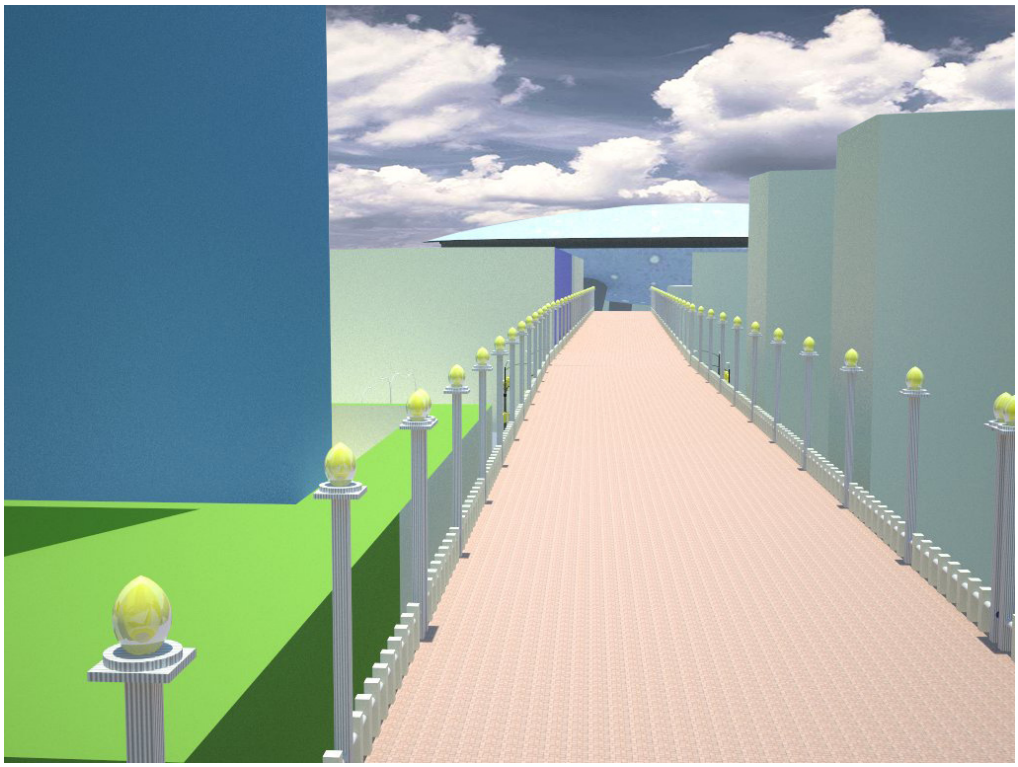


1.10.8 .Prospective of the area.

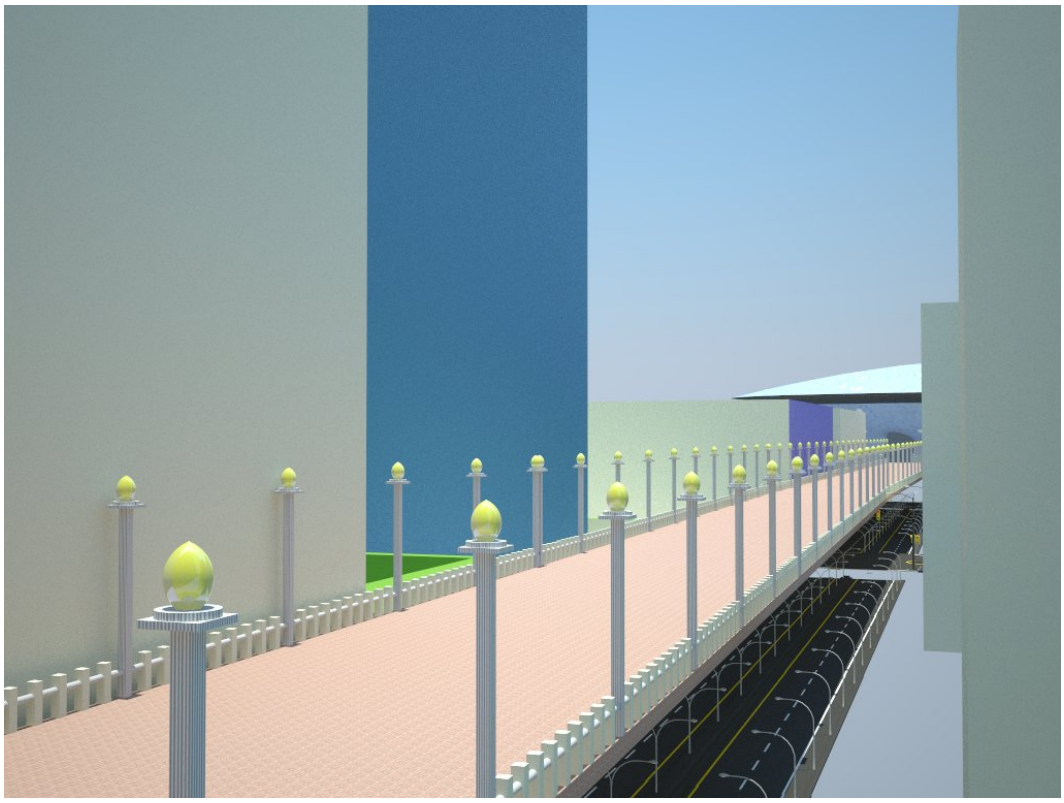


Thethree main elements, the expo performance centre ,China pavilion , and the tower, forming an triangle. Also,the tower ,which is highest point in this area, will give people the possibility to look around at the top floor, enjoying the splendid view.

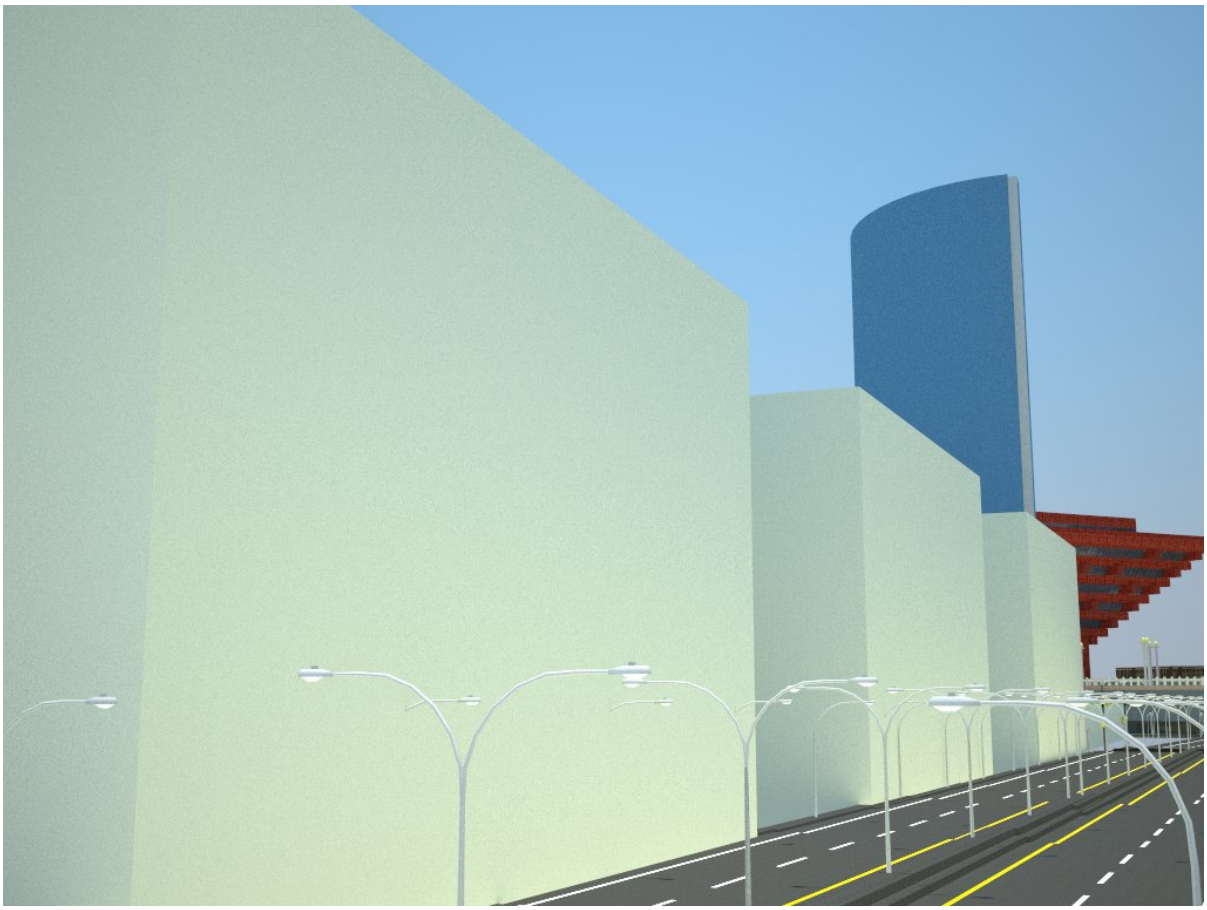




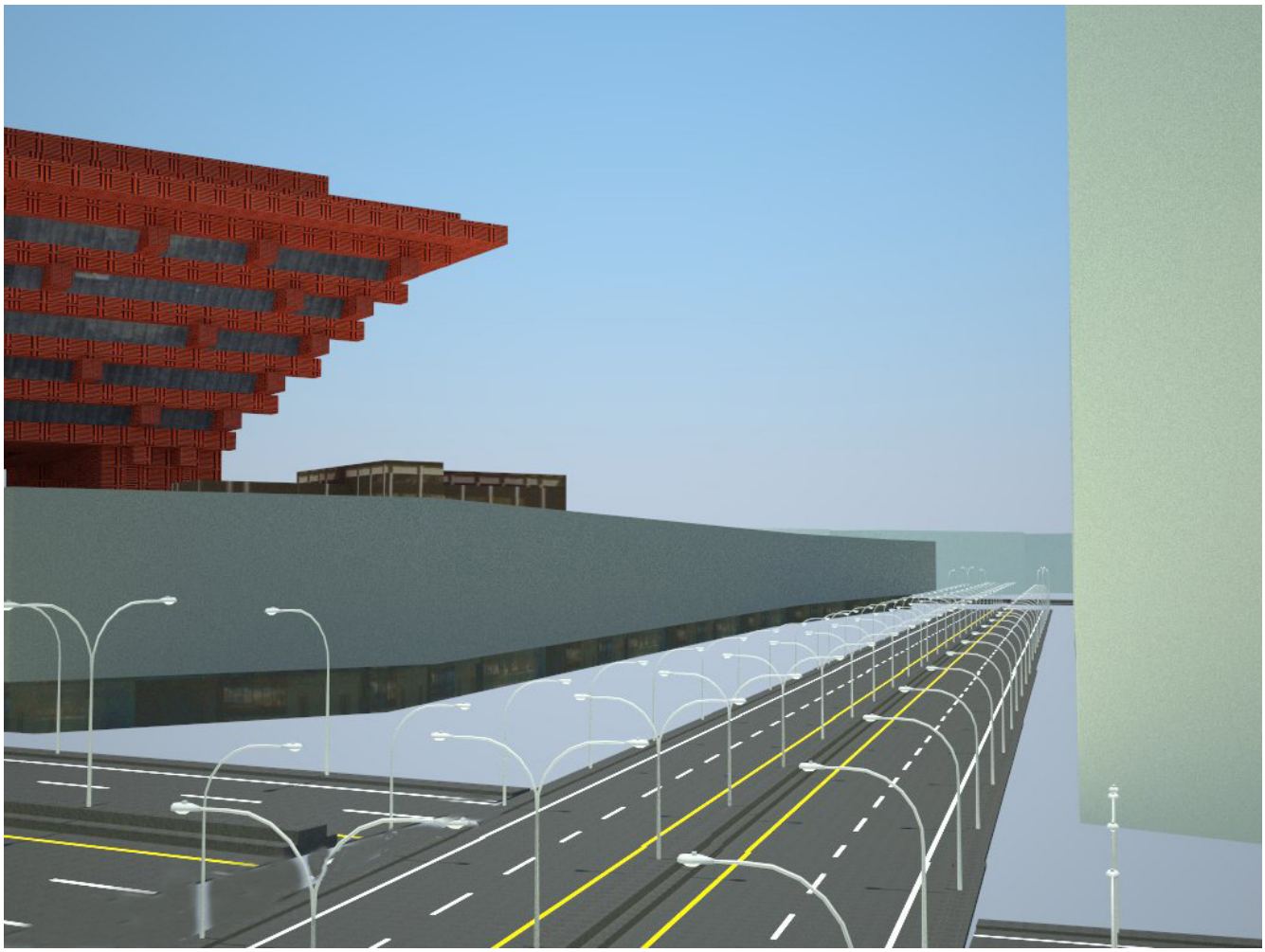
The bridge connecting the Performance center and the residential area, giving the direct link.



Under the bridge, it is allowed to pass the car. This design will mitigate the traffic congestion in this area.

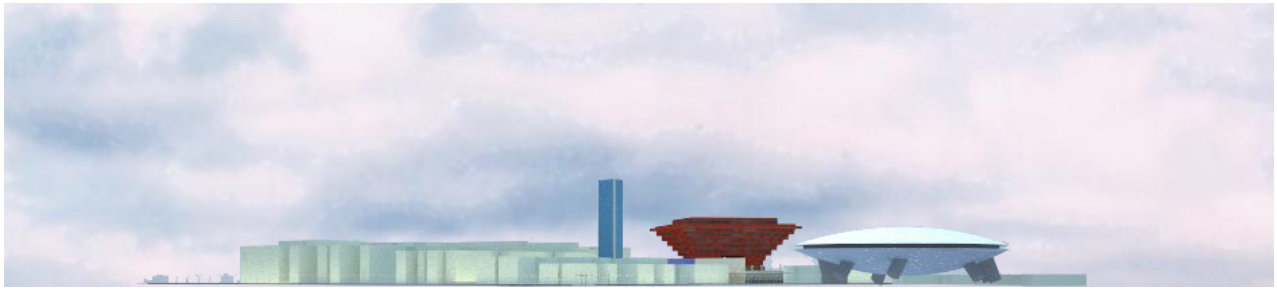


The relationship between the China pavilion and the tower.

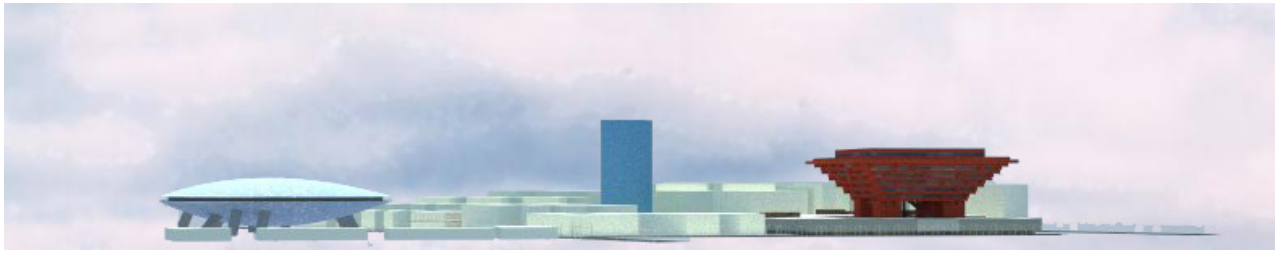


Anyway, China pavilion is still a landmark in this area.

East Elevation



West Elevation



North Elevation

South Elevation

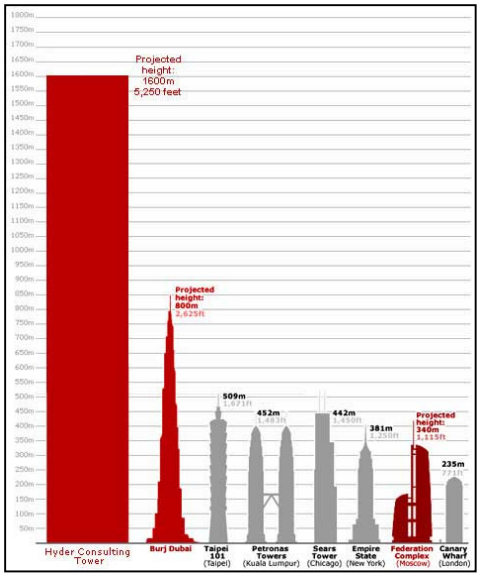
CHAPTER 2

ARCHITECTURAL DESIGN

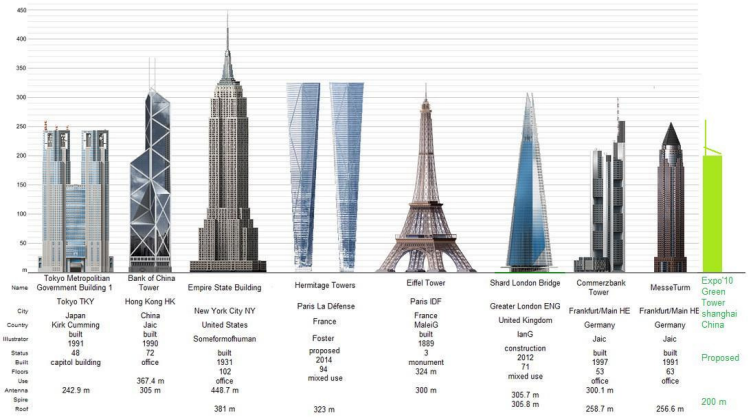
2.1. Introduction

Since the beginning of the last century there seems to have been a nearly inseparable correlation between economic growth rates and the heights of the towers. When the economy grows, so do the high rises. The first high-rise buildings were erected circa 1870-80 in the contribution of New York and Chicago in the United States. They arose in urban areas where increased land prices and great population densities created a demand for buildings that rose vertically rather than spread horizontally, thus occupying less precious land area. High-rise buildings were made practicable by the use of concrete and steel structural frames and glass exterior sheathing. By the mid-20th century, such buildings had become a standard feature of the architectural landscape in most countries in the world.

By the beginning of 20th century, boom in the economy and on the stock market resulted in a competition for building height, for which there seemed to be no limit.



The world high-rise race



Comparison of Expo'10 with world famous high-rises

The proposed 1.6 Km high rise in The Kingdom of Sudi Arabia.

Recently, the highest skyscraper of the world is built in Dubai with the height of 800 meter.

In china, cities are growing upwards since the 1980s. the economic reforms introduced by Deng Xiaoping led to the establishment of Special Economic Zones which permit capitalist investment in specified areas. Through these experimental zones, China, its communist system notwithstanding, is opening up to the world economy, giving its stagnating economy a powerful boost.

Shanghai is the is the center of economic activity in china. In the last 19th century, during the colonial era, the colonial powers forced Shanghai to open its economy to foreign trade. The growth of trade and industry made Shanghai the fifth largest city in the world by 1911. When red army entered the city after the Second World War, all companies there were taken over by the state and economic ties to the outside world were served. It was only with the economic reforms of the 1980s and gradual introduction of market forces that Shanghai again became an attractive investment location for foreign corporations.

2.2. Design Concept

2.2.1. The shanghai

Centrally located on the Chinese coastline, the city of shanghai used to be the "gateway to the world" at the Yangtze delta. Shanghai is now continuing where it left off. Of all Chinese cities,

People's Square

it has the most considerable potential for establishing links with the world economy. In 1990, the Special Economic Zone of shanghai Pudong was created on a hitherto undeveloped site. Shanghai's old city districts are also undergoing a phase of total reconstruction. Shanghai is the largest city in China with a history of more than 700 years and more than 20 million people. Shanghai was once the financial center in China. Since the reforms that began in the 1990s, great changes have taken place in the city. The municipal government is working towards building Shanghai into a modern metropolis and into a world economic, financial, trading and shipping center by 2020.

Shanghai night

Shanghai is a metropolis with diversity and unique charm that you can hardly find in other cities, therefore, it's always a hot destination for most tourists.

Shanghai is such a strange city that whoever you are and wherever you are from, you will be attracted at your first sight of it. If you come from a small village or town, Shanghai means quite a lot to you. Getting lost among high buildings and heavy traffic, you may want to leave your hometown ever since. If you come from cities like Beijing, Guangzhou, Hongkong and Taipei, you could taste the special landscape of Shanghai style. Perhaps you decide to settle down in Shanghai thence. If you are from abroad, you will realize the real aspect of the biggest city in China. Shanghai is not only a

metropolis similar to the international style of New York, but also an elegance of the Orient.

High-rises row limelight on both sides of the Huangpu River. Standing out among the skyscraper in Ljiazui, the Oriental Pearal Tower and Jinmao Tower lordly look down on all the living things in the blaze of the sun. Besides, huge vessels of full loads are seen sail in the billows, which add a characteristic touch of the city.

Pudong, Shanghai

2.2.2. High-rises in shanghai

Between 1992 and the end of 1997, 2437 high-rises were built in shanghai alone, of which 966 rise to a height of over 20 floors. According to observers, it seems as, a new skyscraper is completed every day.

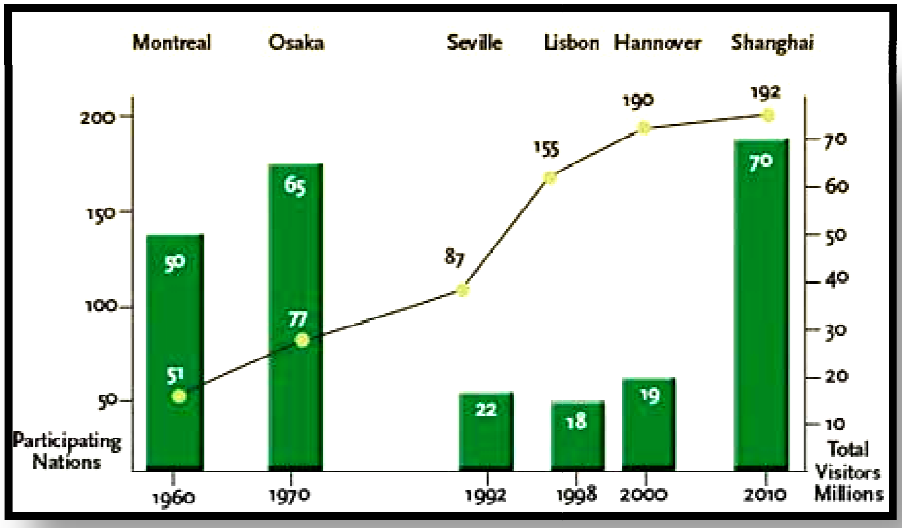
Pudong, Shanghai, 1998

Pudong, Shanghai, 2008

2.2.3. The Twist of shanghai

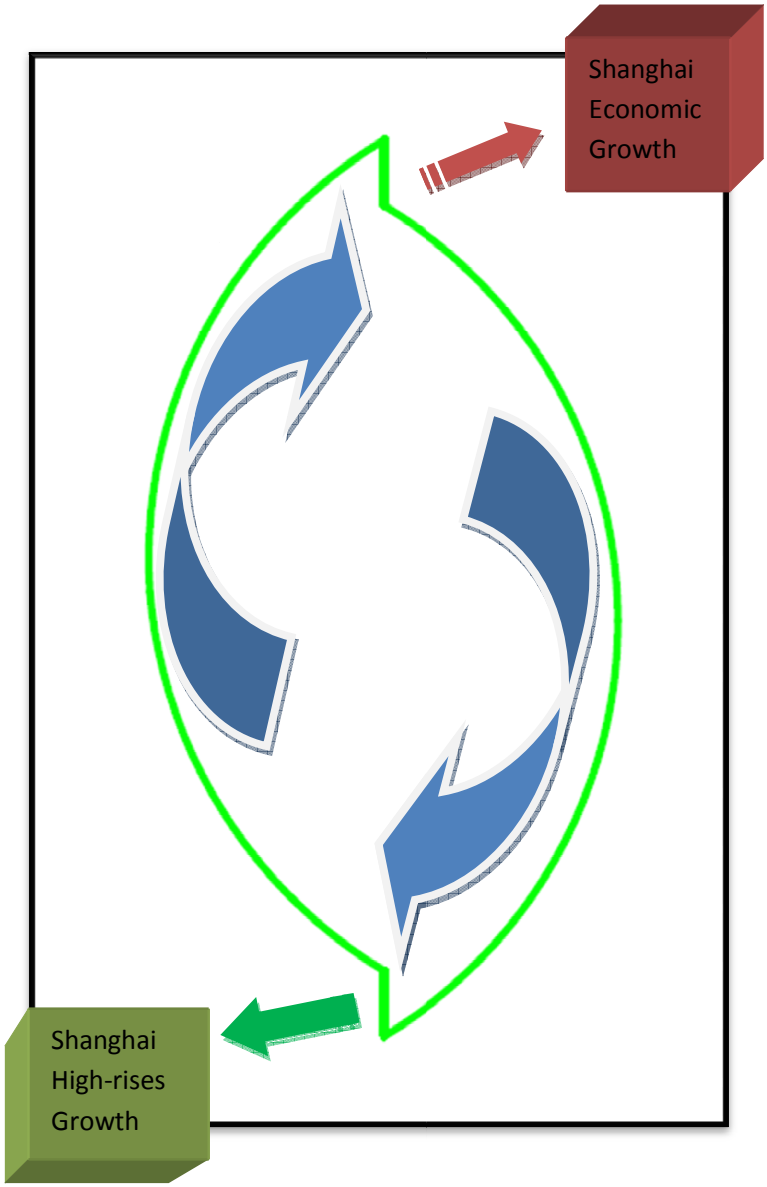
Within ten years Shanghai developed so rapidly in both economy and high-rises, can be said the twist of shanghai. Refer to the figures place above.

The Expo'10 green tower is being proposed at the site of shanghai expo 2010, which is going on. If we make a comparison of this Shanghai Expo'10 with some world expos specially with most attended one of Osaka Expo'70, we can justify the twist of shanghai.



2.2.4. The shape

With this concept of Shanghai twist of economy, development and record breaking attendance of Expo'10, we select a twisting shape of the proposed Expo'10 green tower in Shanghai, which will be a presentation of Shanghai rapid growth.

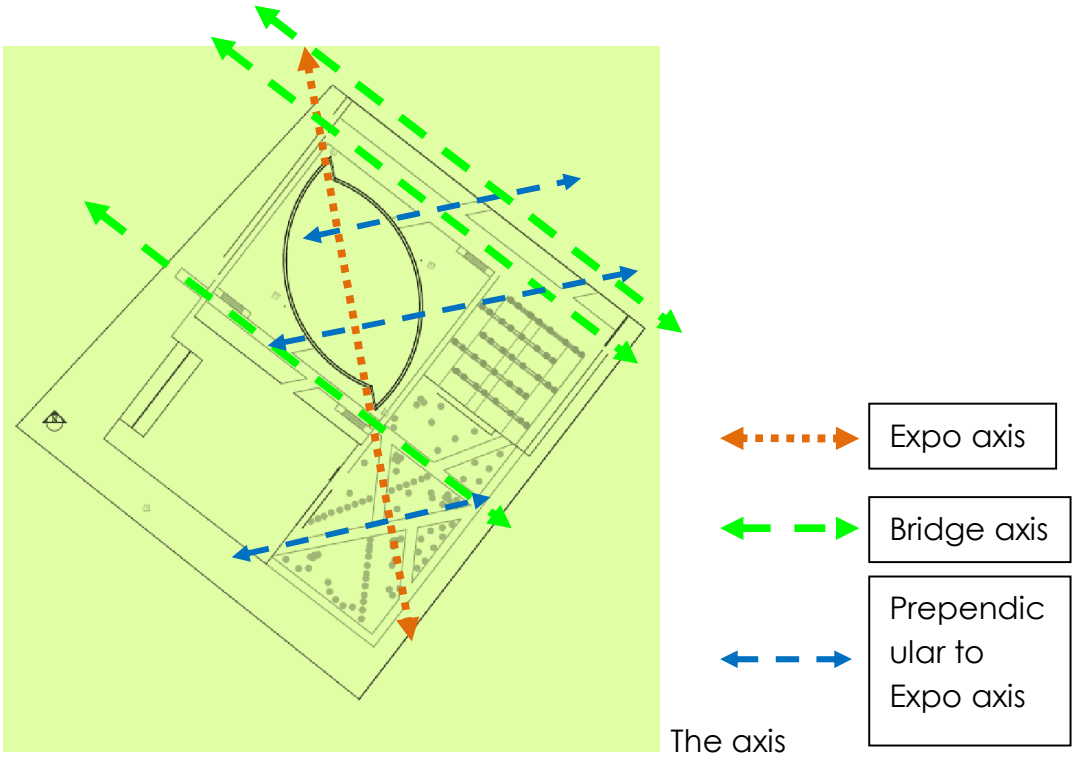


2.2.5. The Axis

The orientation of the Expo'10 green tower, Shanghai is parallel to the axis of expo, which is connecting the china Pavilion and china performing art center, and will be kept after the

expo event. This orientation will give the opportunity to the users to have look on these two main element of the site equally.

1. Pavilions of the Americas
2. Pavilions of African joint
3. Pavilions of the Europe
4. Pavilions of Southeast Asia Oceania
5. Theme Pavilions
6. Pavilions of international organizations
7. Dining and entertainment district
8. Event Hall
9. Expo Center
10. China's pavilion
11. Performing Arts Center
12. Pavilions of Asian countries
13. Expo Village
14. Enterprise pavilion

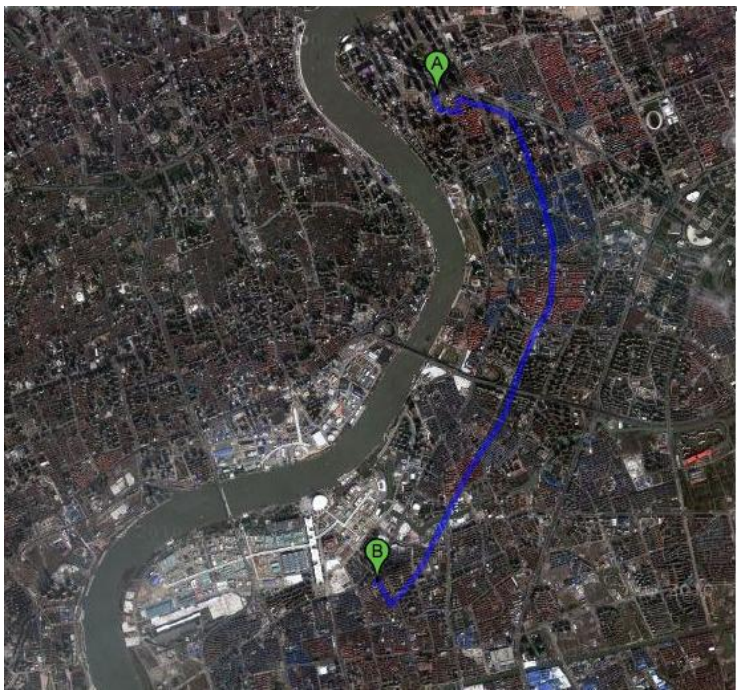


The axis

2.2.6. The shanghai skyline

The shanghai skyline is approaching the approximately five hundred meters above ground level and increasing on daily basis. The Expo'10 green tower is in the neighborhoods of the Pudong area, which is relatively not high, so Expo'10 green tower will make a visual connection with Pudong high-rises and Expo'10 site.

The Pudong high-rises



"A" The Pudong Economic Area "B" The Expo'10 site

The Expo'10 green tower in the background of Pudong high-rises.

With this background tower makes a smooth visual curvature from the Oriental Pearl TV Tower to the financial tower.

2.2.7. High-rise, a need

The high-rises arose in urban areas where increased land prices and great population densities created a demand for buildings that rose vertically rather than spread horizontally, thus occupying less precious land area.

The shanghai density

The Expo'10 green tower is providing the needs of the dense area by accommodating shops, offices, and houses keeping in view the Shanghai future population and economical development.

2.3. Architectural Ideology

Influenced heavily from the urban tissue and the surroundings, we achieve, in a sense, harmony of the new building with the existing conditions. The newly designed volume that is focal on the tower reflects the urban conditions without contradiction between the old and the new.
According to this philosophy, Expo'10 square has mainly urban grids along the river, but we focus only on the two main grids which have created our building form. Therefore, we tried to combine these two grids, one the Expo axis grid and the other pedestrian bridge grid and from these two grids the outline of the continuity of the building is achieved. The orientation of the tower is in such a way that the tower longer side is parallel to the Expo axis and approximately along the north, which is giving the opportunity to the tower users to enjoy the view of china

pavilion , china performing art center and surrounding city on east side of the tower and on the backside of the tower pudong high-rises and west shanghai city.

2.4. The Objective

The main objective of our tower is to be the focal point of Expo'10 Square. To serve as a central place for business, shopping, residences and facilities of significance for the people of Shanghai.

- A meeting place that is open for innovation and change, providing its users opportunities to meet and socialize, stimulate interest and curiosity in the Expo history of shanghai.
- A new heart of the community, able to attract people to gather on it, able to vibrate the whole neighborhood round the clock.

2.5. The Planning

2.5.1. Accessibility

The tower should be easily accessible to all. Along with the ease of understanding the functioning of services, for identifying pathways, entrances, exits, internal distribution and various parts of complex.
Special care in design for people with disability.

2.5.2. Articulation

- Adequate correspondence between spaces and functions that should, if necessary, they can use for different ways and times.

- An architectural space must be "centered about" allowing a vision and use a variety of spaces and differential interiors. To serve the purpose a four storey high internal lobby is provided at lower ground level.

2.5.3. Visibility

- Easily recognizable in the urban context, as the only high-rise in the expo'10 site. Easily identifiable individual shares and their paths internal and external connections.
- The ability to strike and remain in the memory and becoming urban icon in the collective.

2.5.4. Wellness

- A high-rise must be comfortable in the sense broadest of terms, it must be a place where you go for pleasant experience. This means that we need to ensure adequate requirements, comfort, heat-humidity levels, sound and visual equilibrium, in the end ergonomic and psychological comfort.

- Although wellness should be the main criteria, the balance between comfort and energy efficiency is necessary.
- Special attention should be taken to achieve comfort and health in Building. The interactive nature of the relationship between buildings and their occupants is complex therefore must be studied as a whole unit.

2.5.5. Sustainability

- Strive to use materials with low environmental impact, and easy to maintain, that are most durable, and are proven reliable.
- The project should seek to use the thermal inertia of mass in the building while still adopting systems mixed-air water for the heating and cooling.
- It should also give priority natural lighting and ventilation.
- Sustainability is not just about being green its also about a better, healthier, more rewarding and more efficient built environment for the people living and working there.
- Incorporate Smart growth principles in the project development process.
- Strive for good environmental quality of the interiors, which will have a direct impact on individual well-being.

2.5.6. Multiplicity

- Place excellence in multiculturalism, multimedia and congregation of people, able to welcome and meet the needs of the whole community.
- Be able to better accommodate the different functions and accommodate different audiences.

2.6. The usage

The Expo'10 green tower in located in the zone where the area is distributed in commercial activities, financial activities and residences, providing the reason to accommodate

hereunder mentioned functions in the tower building.

1. Shops
2. Offices
3. Residences
4. Entertainment
5. Parking

To analyze these function in towers few high-rises are studied by famous architect.

2.7. Analysis and study

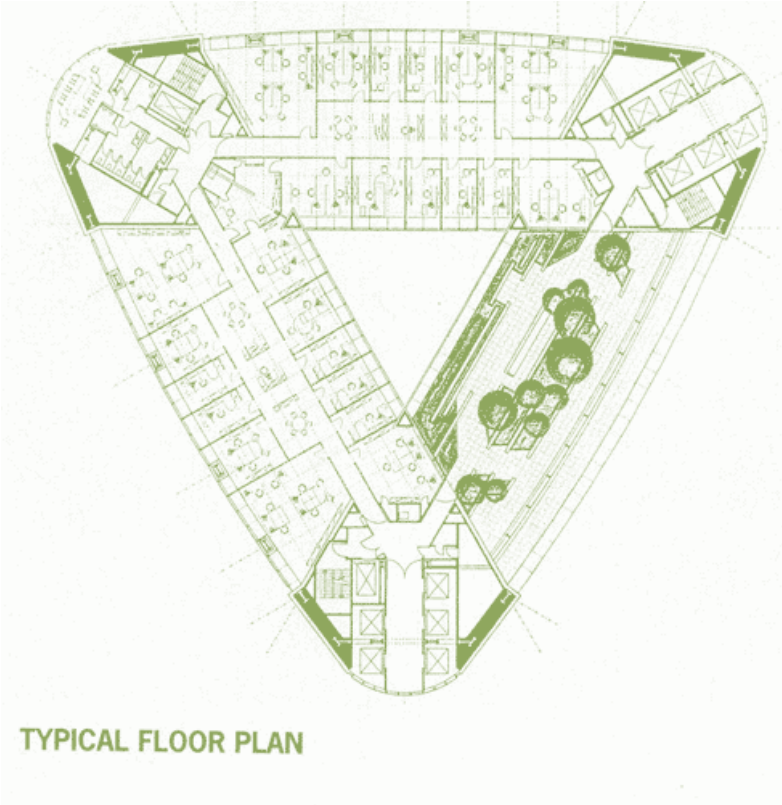
2.7.1. Offices Tower Study

○ **The commerzbank, Frankfort am Main By Foster and Parteners, 1997.**

The tower is designed for office use by Foster and Partner, London in a way that the energy consumption could be minimize. The initiative were taken by providing the hanging gardens at different levels of the tower. The natural ventilation with the use of double skin façade cut off the energy utilization. The German rules of 6 meter depth for working from the window also reducing the lighting energy consumption.

The commerzbank, Frankfort am Main, By Foster and Parteners, 1997.

The cubical type offices are designed on both



TYPICAL FLOOR PLAN

sides to have the natural light in side and central space is given to the common facilities.
The mobility services are provided at the corner of the tower in plan.

- **122 Leadenhall Street, London**

By Rpgers Partnership.

The entrance lobby is dedicated to nature for its rewards of ventilation. The view of this lobby create a significant broadness in vision when you are at ground level or at the fifth floor.
The vertical transportation is kept at the back of the tower as its become thin toward back when goes high.

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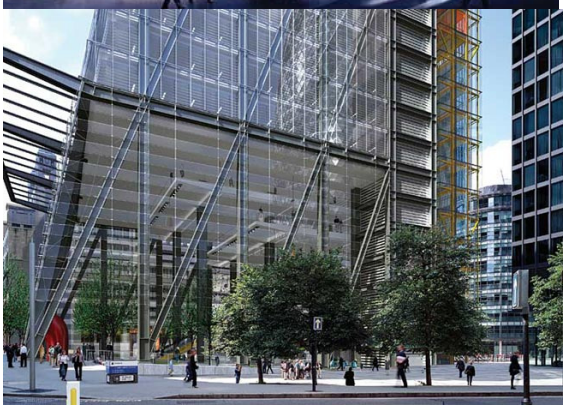

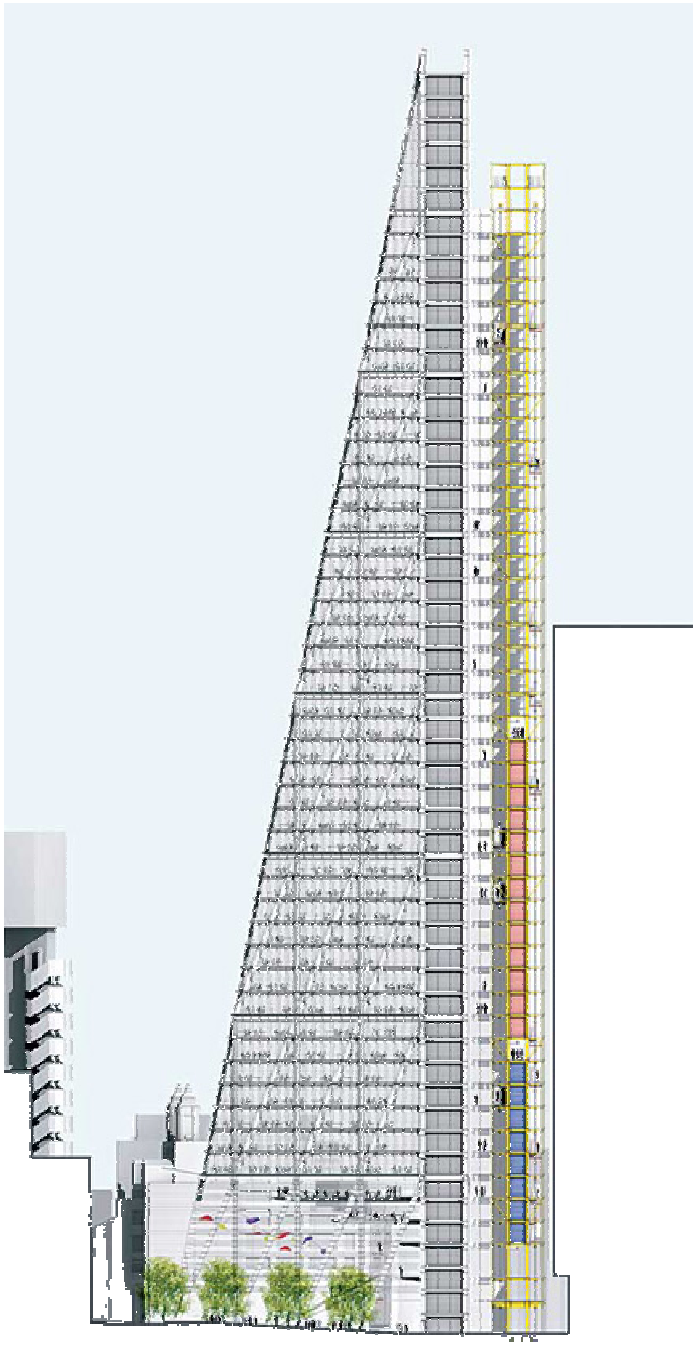

The entrance lobby is making a visual connection between inside and outside of the tower.

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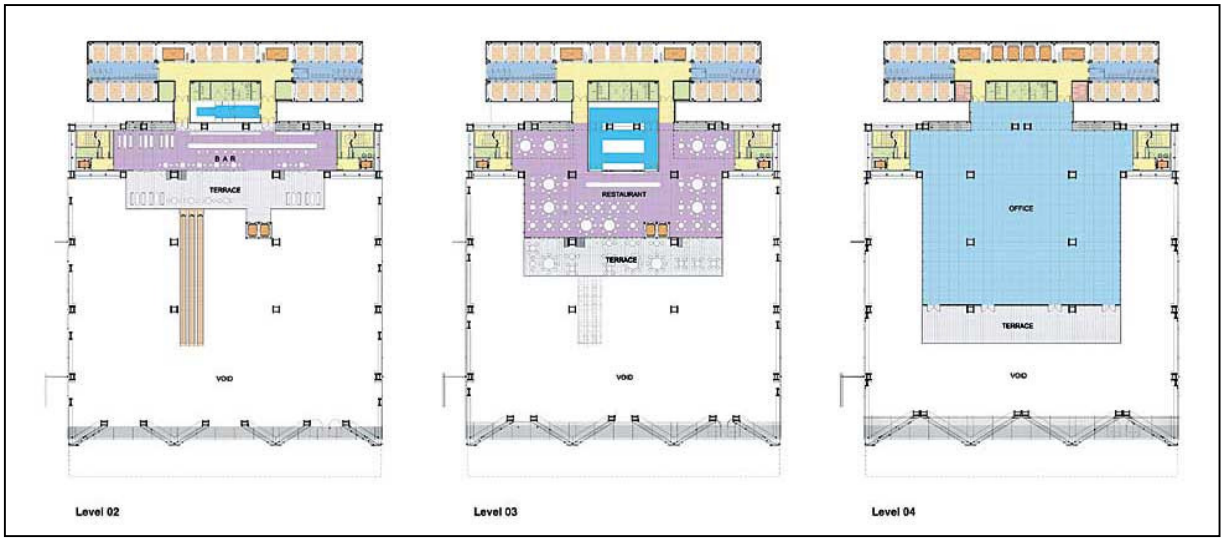
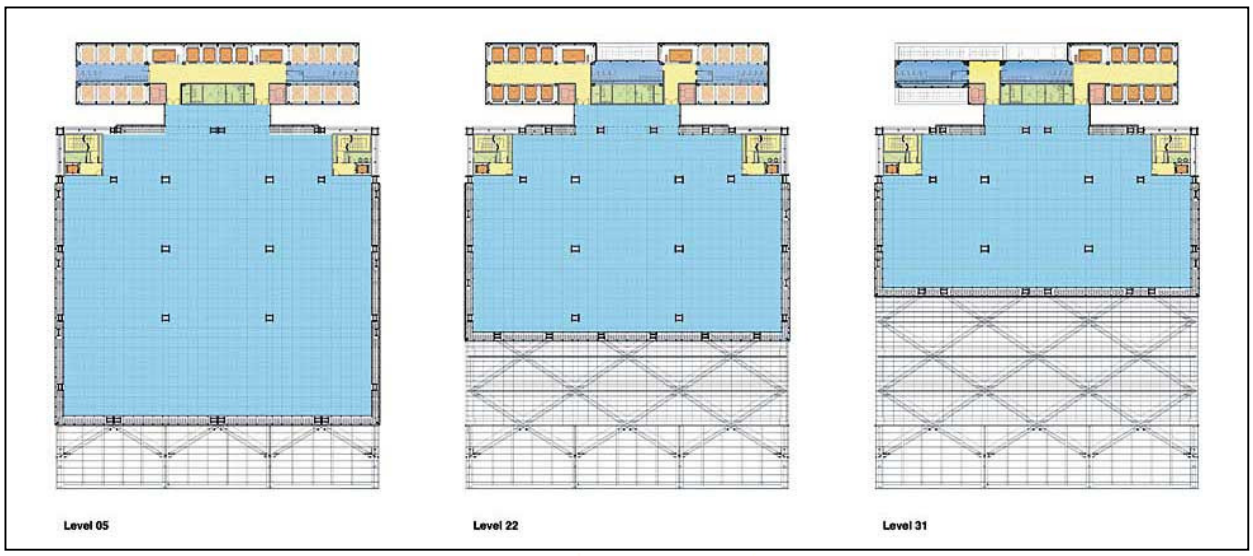
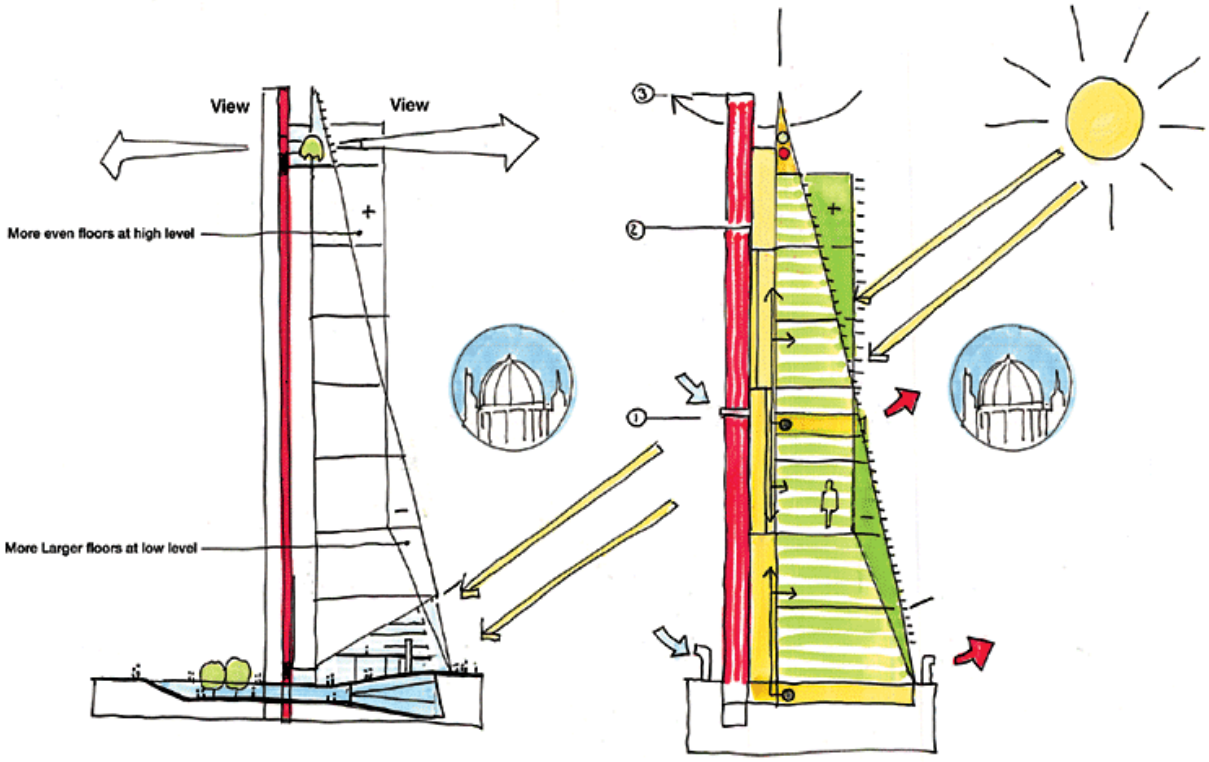
Ground Level
Mezzanine Level
Level 01


BAR
TERRACE
VOID
Level 02
RESTAURANT
TERRACE
VOID
Level 03
OFFICE
TERRACE
VOID
Level 04





The design philosophy.

2.7.2. Offices Tower Analysis

2.7.2.1. Area efficiency

The most important demand placed on the architect is the design of the floor plans. The decisive question is; how much area is lost through access, internal circulation, washrooms and offices area that are difficult to utilize.

The standard differences in the market can be as high as 30 percent. The comparability of objects is ensured through occupancy planning. A typical functional workstation consists of

- Table
- Room to move
- Filing cabinet

With reach of the employee, at times an additional

- Small meeting area

The common facilities
- Meeting room
- Library
- Lounge
- Tear or café area
- Toilets

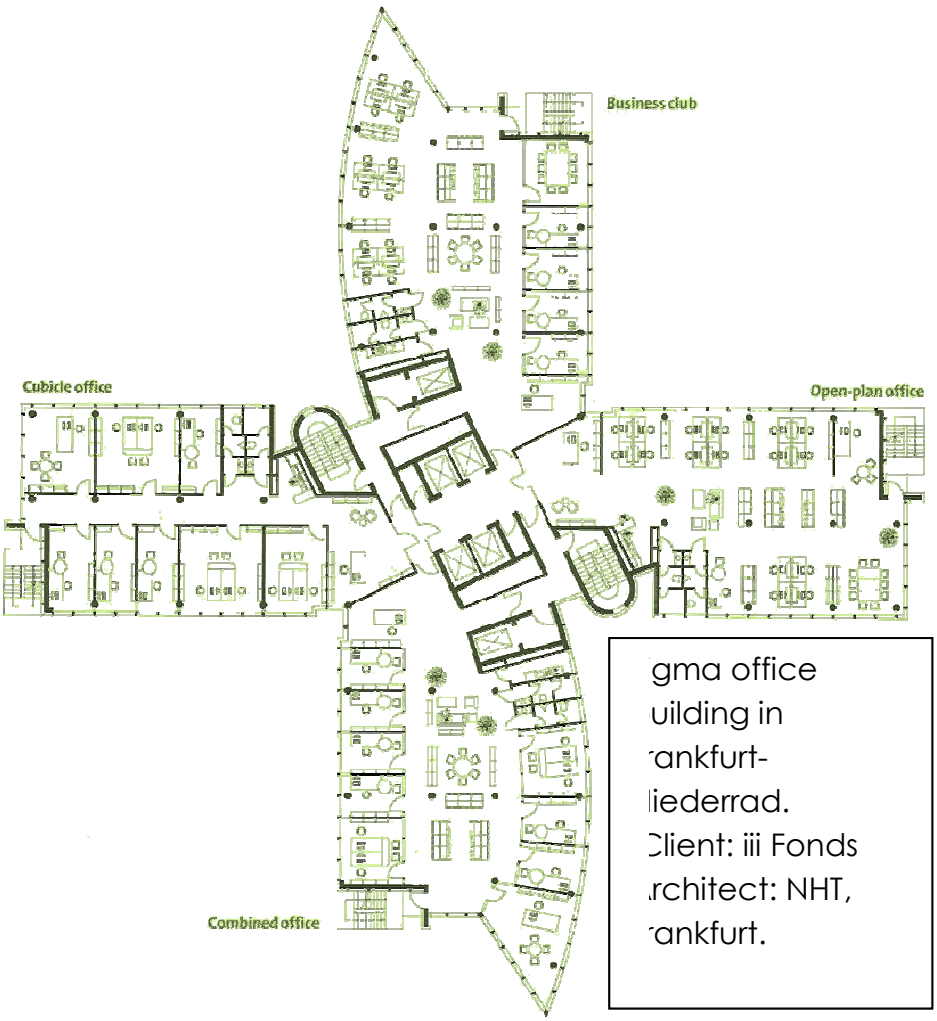
2.7.2.2. The Flexibility

Many office towers are planned and authorized for only one office concept. Yet the organizational requirements fluctuate for many companies. The potential for savings in space

consumption is especially high in the choice of use strategy, depending on the company requirements. Office concept such as

1. Group office
2. Modular office
3. Combination office
4. Business club

Should all be considered in planning.



gma office
uilding in
ankfurt-
iederrad.
Client: iii Fonds
rchitect: NHT,
ankfurt.

Thanks to the flexible floor plan, the building can be completed to accommodate all standard office concepts.

2.7.2.3. The use strategy

Work and business processes, points of contact and synergy potential must be exploited to the fullest; relocation offers a rare opportunity to do so. *Retrospective analysis of past experience is often insufficient as a basis for supplying answer for the future.*

Careful planning can make it possible to promote employee concentration and communication and simultaneously to reduce vacant spaces. Up to 30 percent of space can easily be saved by giving the right use strategy. if

1. Desk sharing
2. Alternating workstation
3. Teamwork
4. Tele-working

Are considered in the company, can increase the functional space.

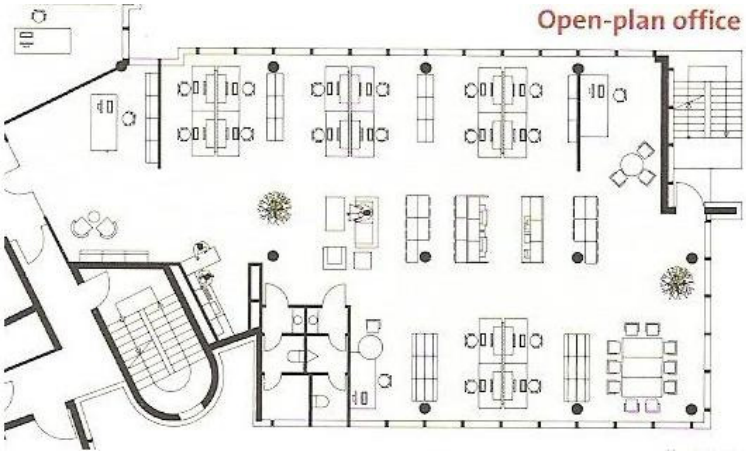
Combination offices are a good basis for the requirements tomorrow.

2.7.3. Office Type, Organization and building grid

In times when only modular offices or open plan were known, there were two fundamentally different grid typology:

Description	Dimension
Two rows of modular offices with central corridor and a standard clear building depth	12 m
The façade grid	1.2 – 1.8 m
The room width for double	3.6 m
The table depth roughly	80 cm
Open plan offices on a single floor level	Variaty of structural and façade grids

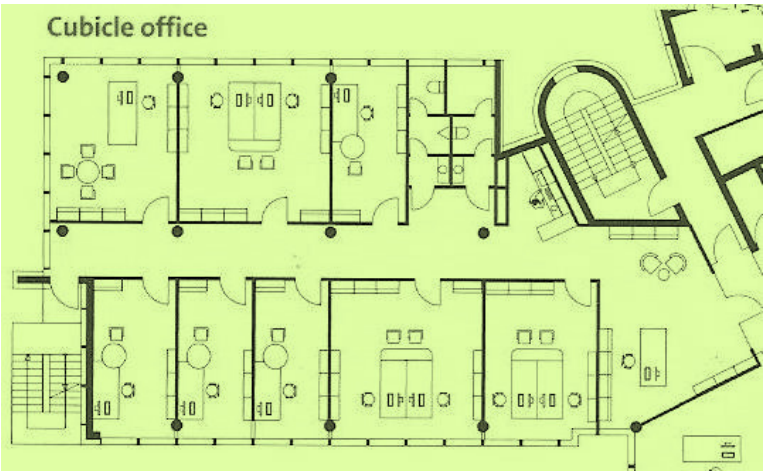
2.7.3.1. Group or Open offices



The layout is done without internal partition walls between the workstations, usually 3 to 5 employee are grouped in one place with combine cabinets and moving spaces.

2.7.3.2. The Modular offices

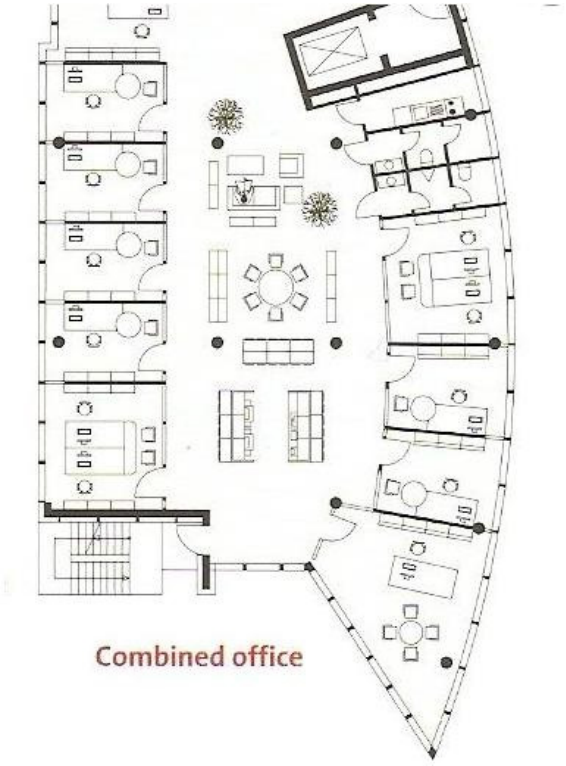
The standard layout is to arrange single and double rooms along the façade. Double rooms are often used to accommodate three employee.



Description	Dimension
Modular office clear depth per workstation	2.2 m
Modular office clear depth for double room	4.4 – 5.5 m
The façade grid	1.5 m
Central corridor	2 m

2.7.3.3. The combination office

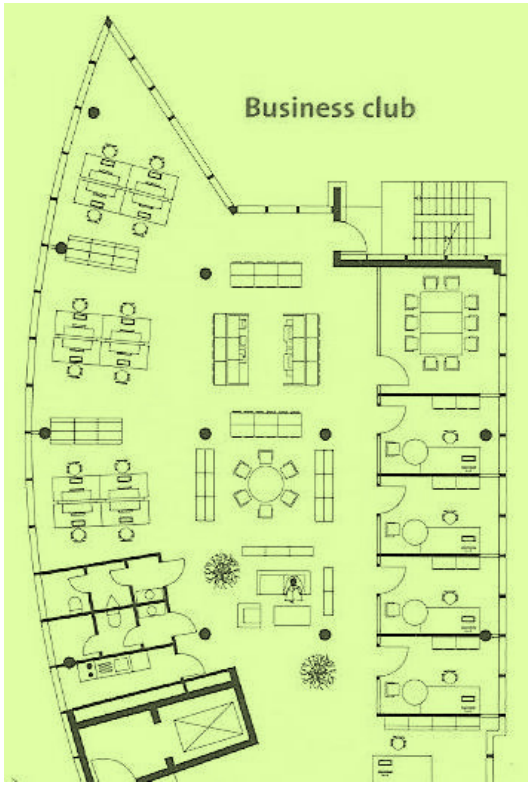
The combination offices consists of 20 to 25 single rooms grouped around a common central zone.



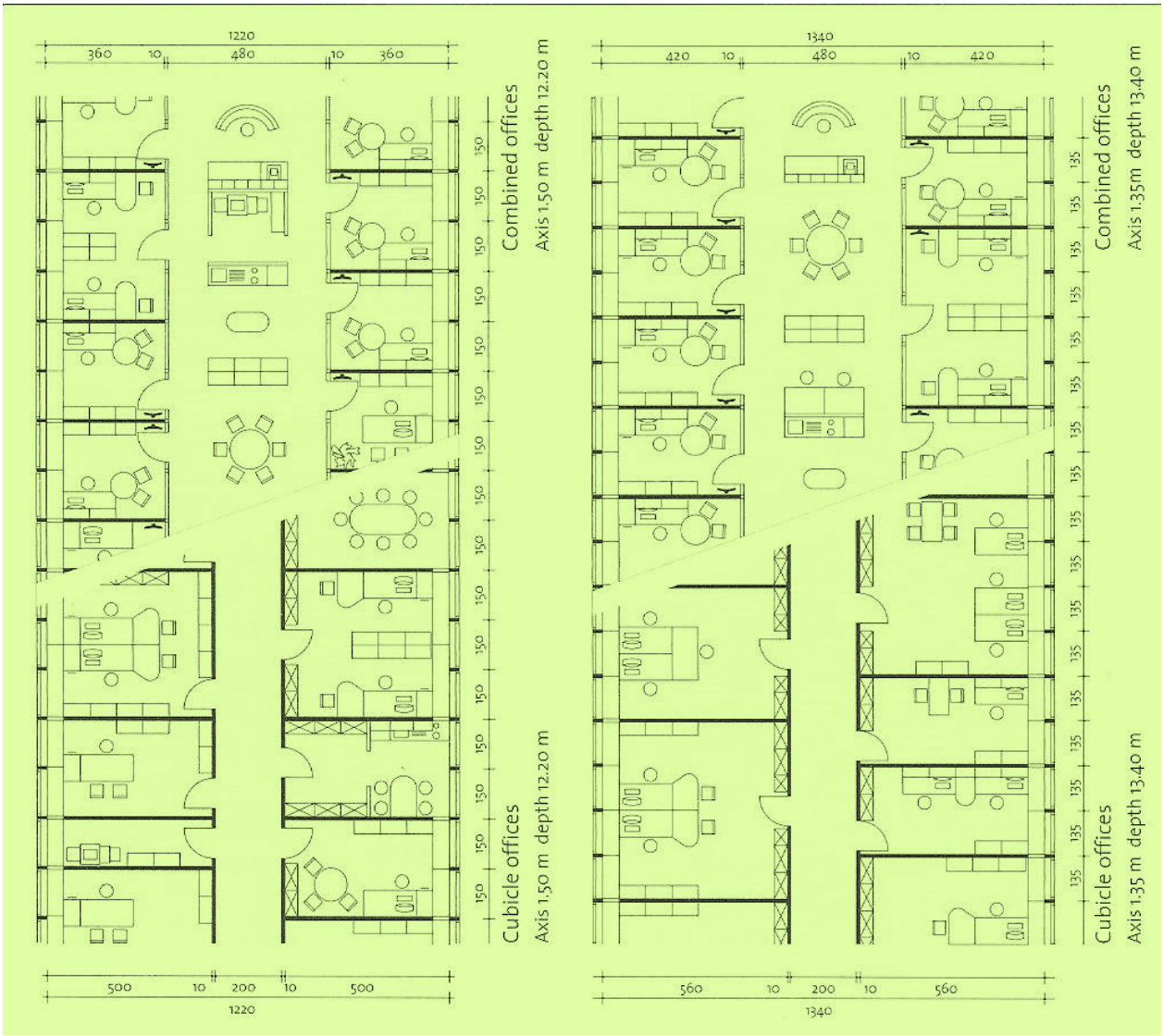
Description	Dimension
The depth of combination offices	4 m
The façade grid	1.25 m
The room width for double	3.6 m
The table depth roughly	80 cm
The area	10 sqm

2.7.3.4. Business club

The floor area is designed in such a way that cubical offices are arranged along one façade and open offices are kept on the second façade with central common facilities.



2.7.4. A comparison of combined versus modular offices



2.7.5.A comprehensive Example

Floor plan
Detail of one of the six arms of the main administrative building of the dvg in Hanover. Each department has been assigned one of these units. The service functions (lockers, espresso bars, conference and project rooms as well as the secretary's office) are permanently available to the staff at the business center. The workplaces are not personalized, but arranged in accordance with the type of work performed: the staff can choose between open workplaces, working while standing, closed single rooms, group workplaces or the lounge, depending on the day's requirements.

2.8. Offices types in Expo'10 Green Tower

Three level management is organized in three floors,

- First level management with cubical offices and some open offices
- Second level management with cubical, double and some open offices
- Third level management with open all open offices

The common facilities of meeting, printer, lounge, toilets, and tea or café are kept same at all levels.

2.9. Comparison of spaces: Expo'10 Green Tower

2.9.1. The Modular offices

Description	Standard	Expo'10 GT
Modular office clear depth per workstation	2.2 m	3.8 – 4.7 m
Modular office clear depth for double room	4.4 – 5.5 m	4.8 – 5 m
The façade grid	1.5 m	1.5 m
Central corridor	2 m	2 m

2.9.2. The combination office

Description	Standard	Expo'10 GT
The depth of combination offices	4 m	3.8 – 4.7 m
The façade grid	1.25 m	1.5 m
The room width for double	3.6 m	3 m
The table depth roughly	80 cm	80 cm
The area	10 sqm	14 sqm

2.10. Area distribution of Expo'10 Green Tower

Description	Dimension
Tower gross area	1605 sq m
Core area (lifts, staires, services)	213.5 sq m
Corridores	194 sq m
Emergency	66 sq m
Total services	473 sqm
Services percentage (Standard 30 %)	29.5 %

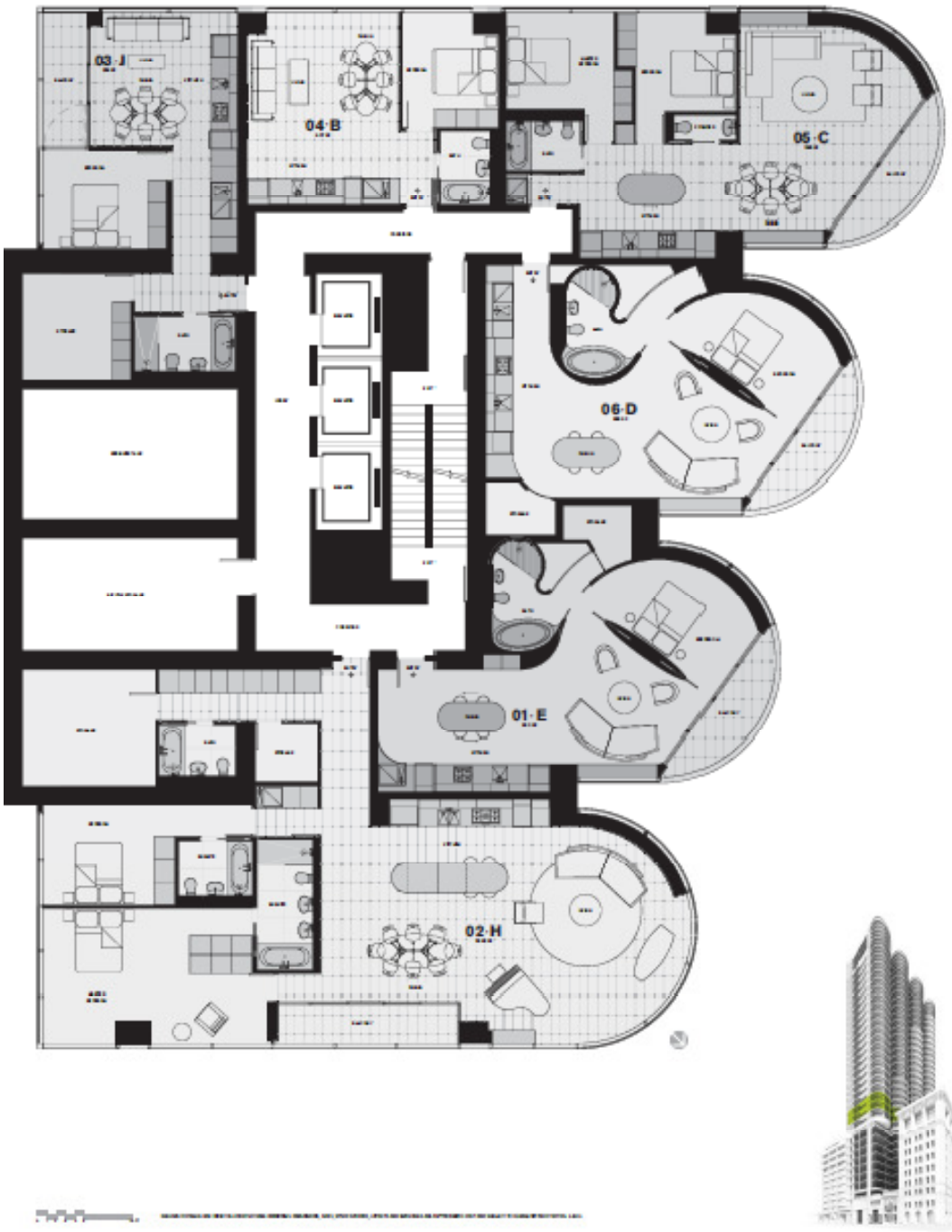
2.11. Analysis and study of Residences

2.11.1. Residential Tower Study

Jameson House, Vancouver, Canada
By;
Foster & Partners

The residential towers designed by Foster and partner give a significant information regarding the space distribution for different dwellings in a single floor. The main emphases is given to the living area and bed rooms in terms of outside view. The living area given more space rather than bed rooms, as most of the time is being spend in this area.

LEVELS 15–16



2.11.2. The Area requirement for bed rooms.

Description	Standard
Bed room couple	12 sq m
Bed room single	9 sq m
Bed room twins	14 sq m
Kitchen	6 – 10 sq m
Baths	3 - 5 sq m

2.11.3. The types of houses in Expo'10 Green Tower

1. A type
2. A' type
3. B type
4. C type

Description	Master bed room	Bed room	Attach bath to bed M. B	Common bath
A type	1	1	1	1
A' type (less living area)	1	1	1	1
B type	1	0	0	1
C type (less living area)	1	0	0	1

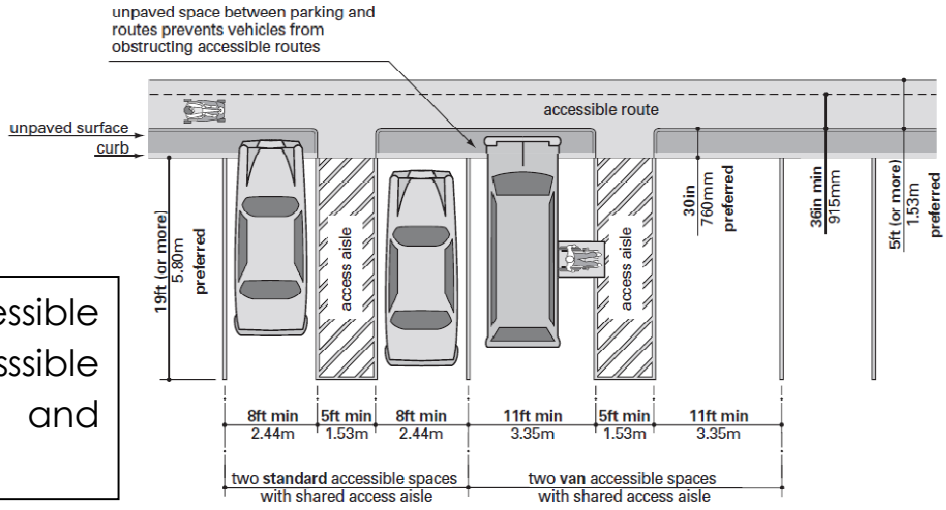
2.11.4. Number of house per floor in Expo'10 Green Tower

Description	No.	Total
A type	2	54
A' type	2	54
B type	4	108
C type	2	54
Total houses		270

2.12. The parking

The parking is provided in the 2 basements to accommodate 284 numbers of cares.

One basement parking will be utilized by offices and one basement parking for the residences.



Standard accessible and van accesssible parking spaces and aisales

Description	Standard	Expo'10 GT
Car parking	2.5x5-6 m	2.5x5-6 m
Drive way width	6 m	6 m
Ramp slope	10-15 %	14 %

2.13. The emergency exits

The emergency exits are provided according to the standard of REI.

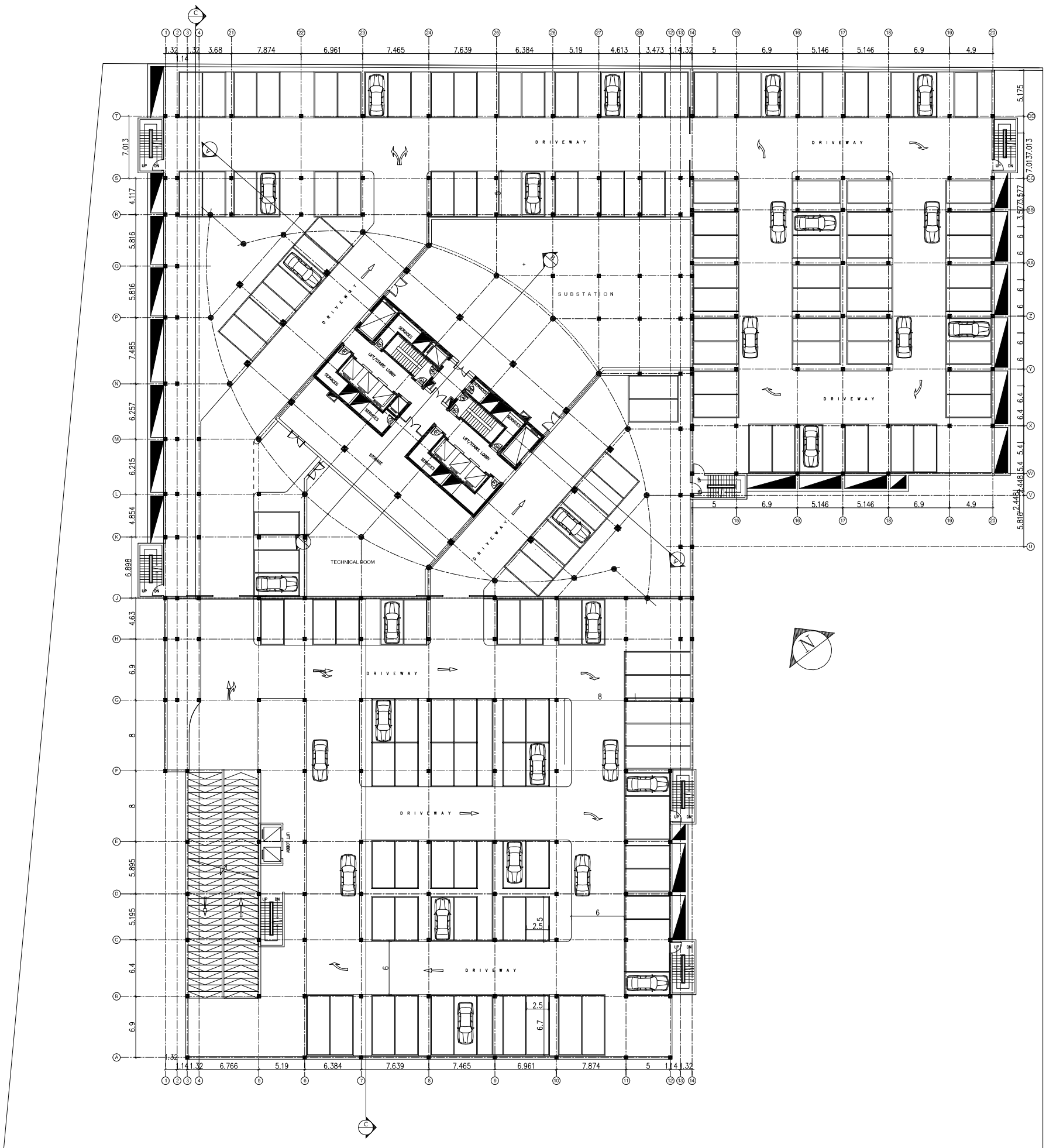
2.13.1. In the basements

In the basements emergency exits are provided at the distance of 40 meters max. and divided in to three zones, in case if fire broken in one zone it should not spread to the other areas.

2.13.2. For the tower

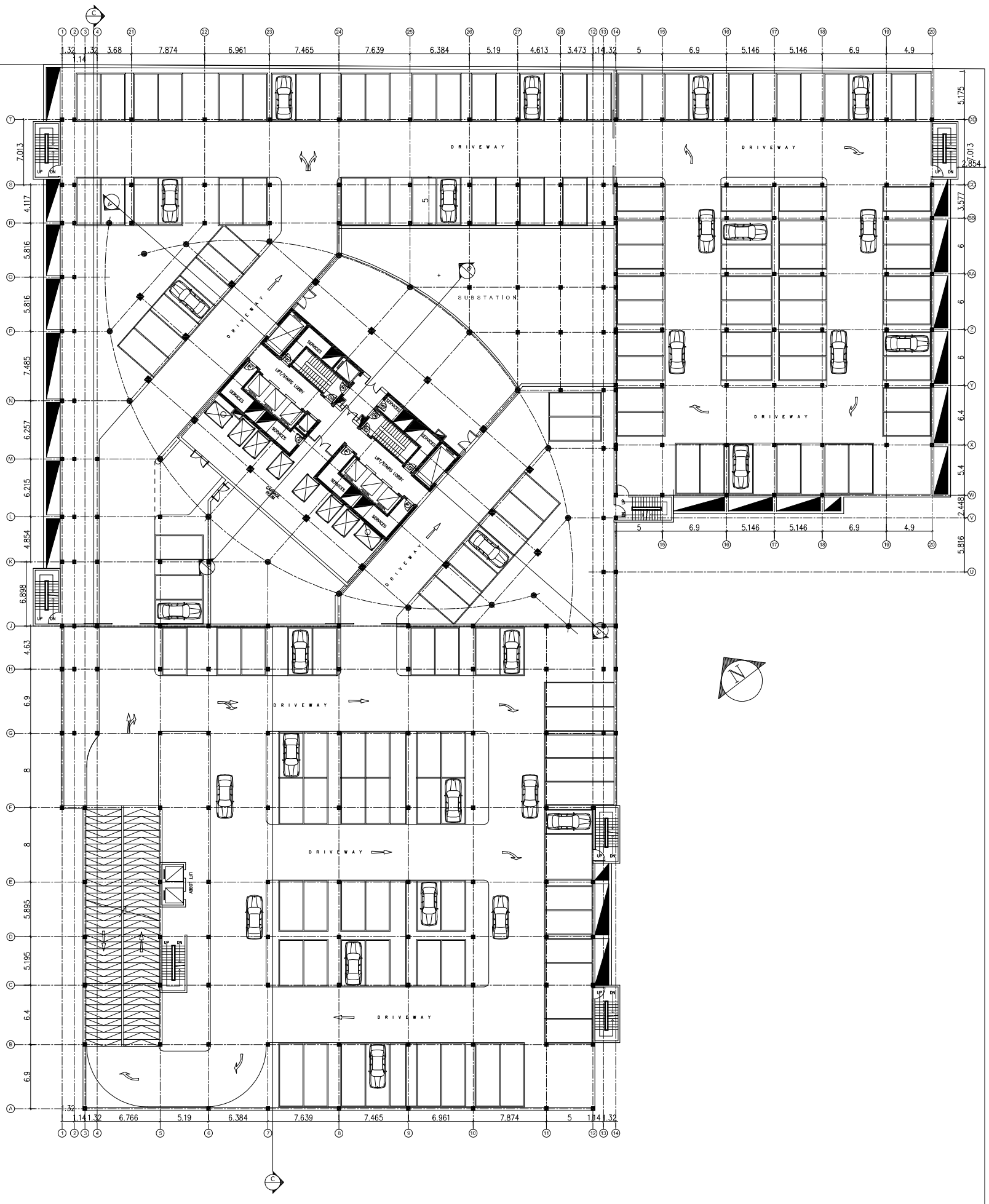
The four number of emergency exit staircases and one lift are provided at the max distance of 25 meters with smoke/fire free chamber.

EXPO'10 GREEN TOWER SHANGHAI.



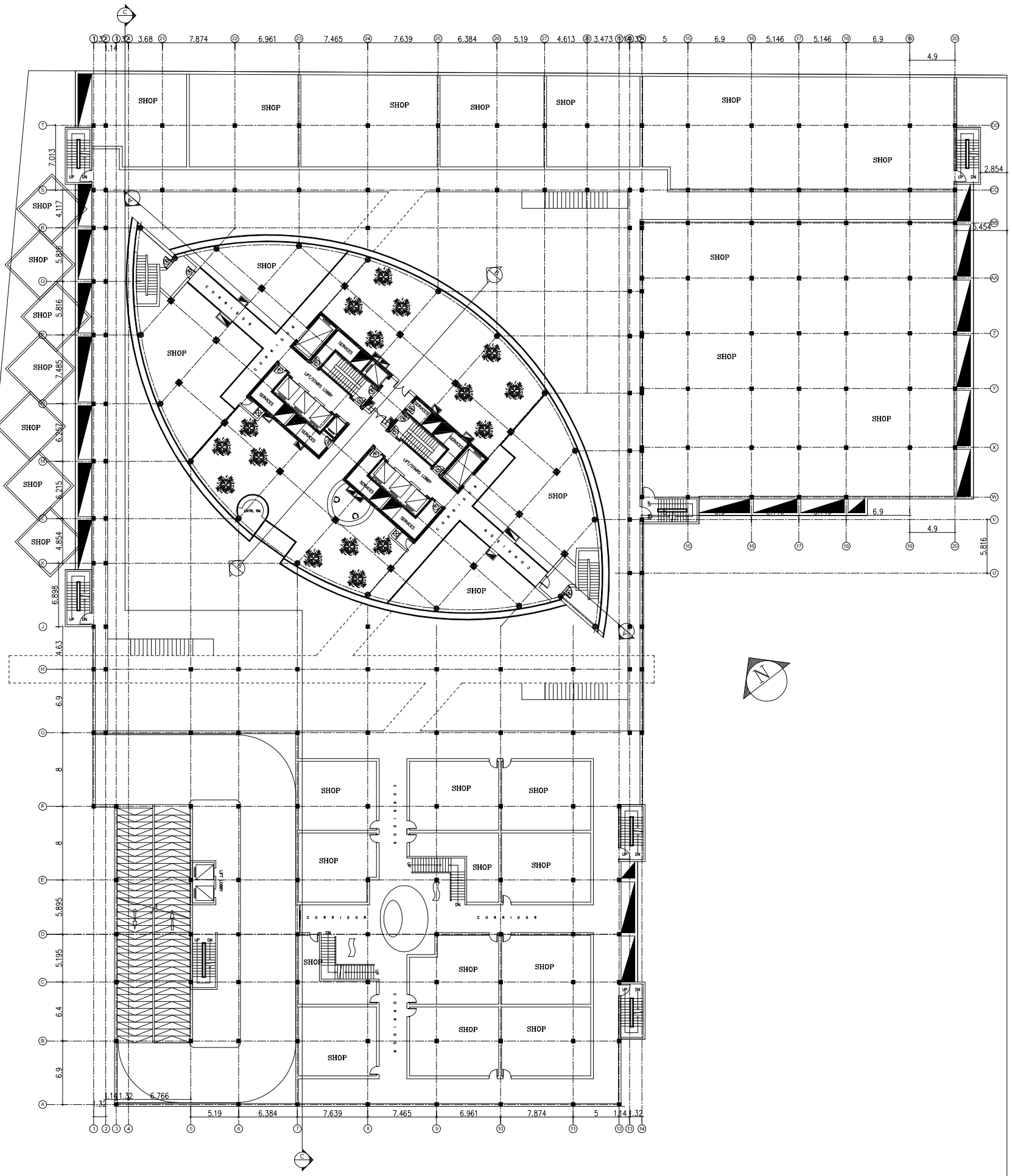
Basement 2

EXPO'10 GREEN TOWER SHANGHAI.



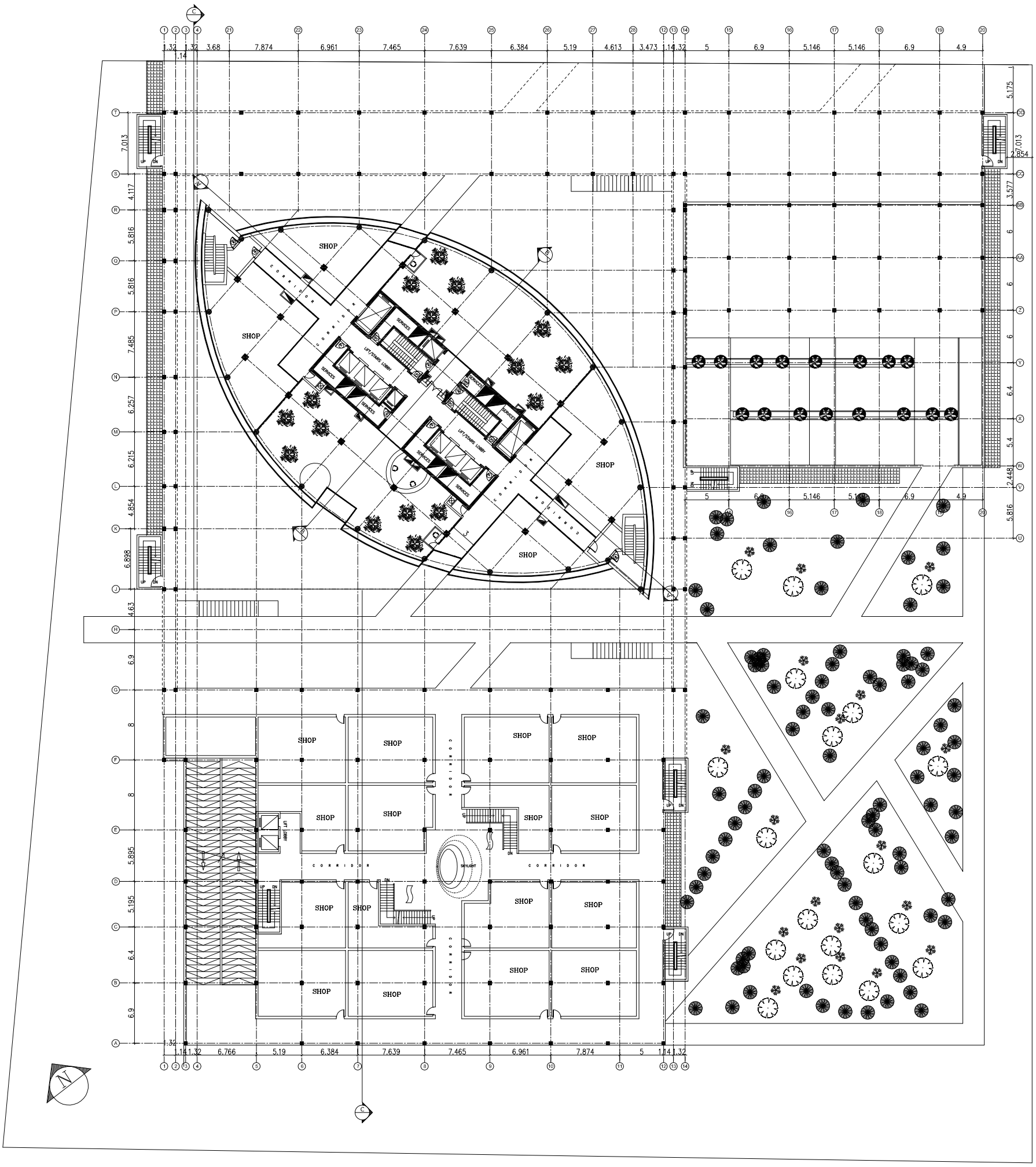
Basement 1

EXPO'10 GREEN TOWER SHANGHAI.



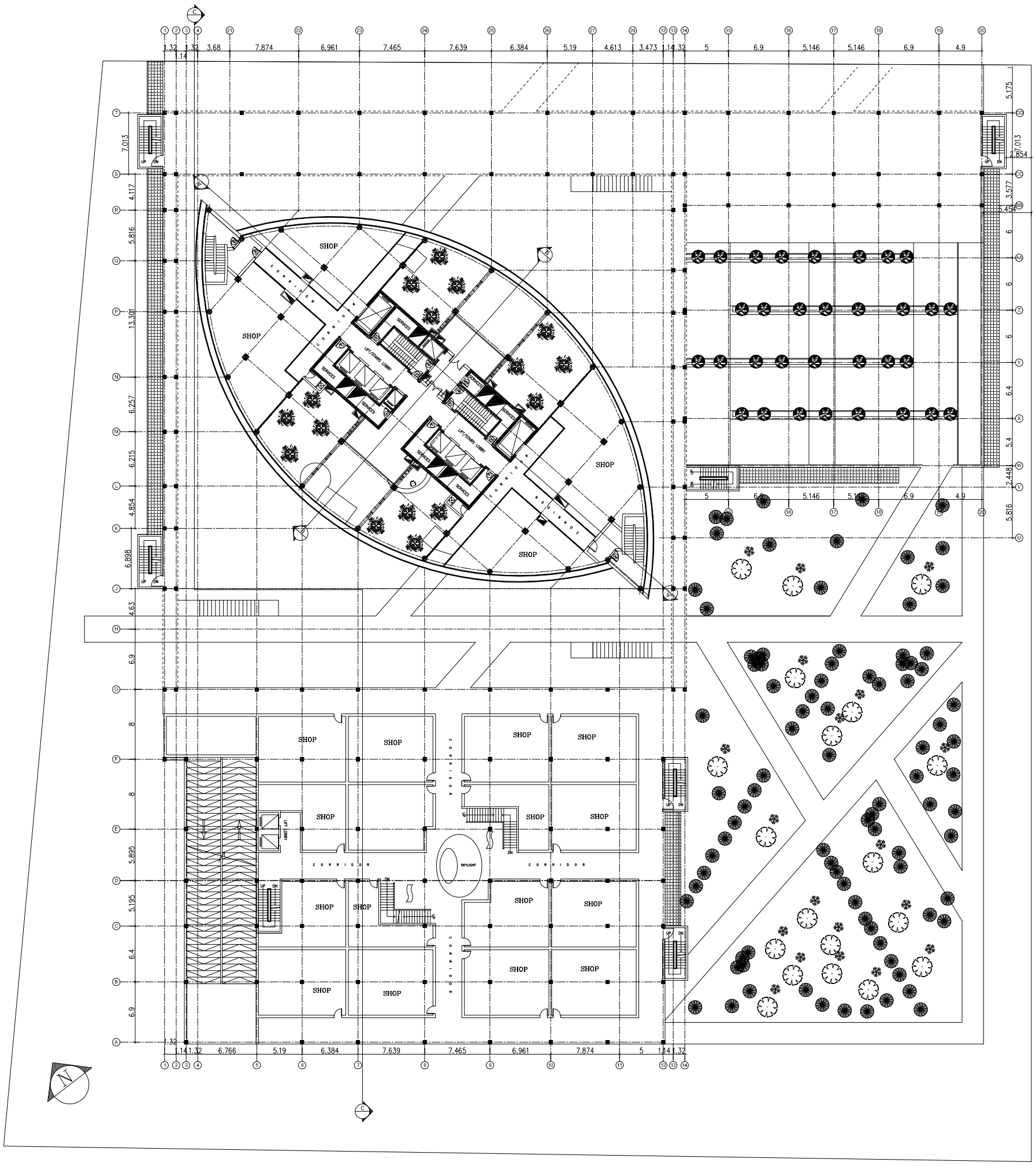
Lower Ground

EXPO'10 GREEN TOWER SHANGHAI.



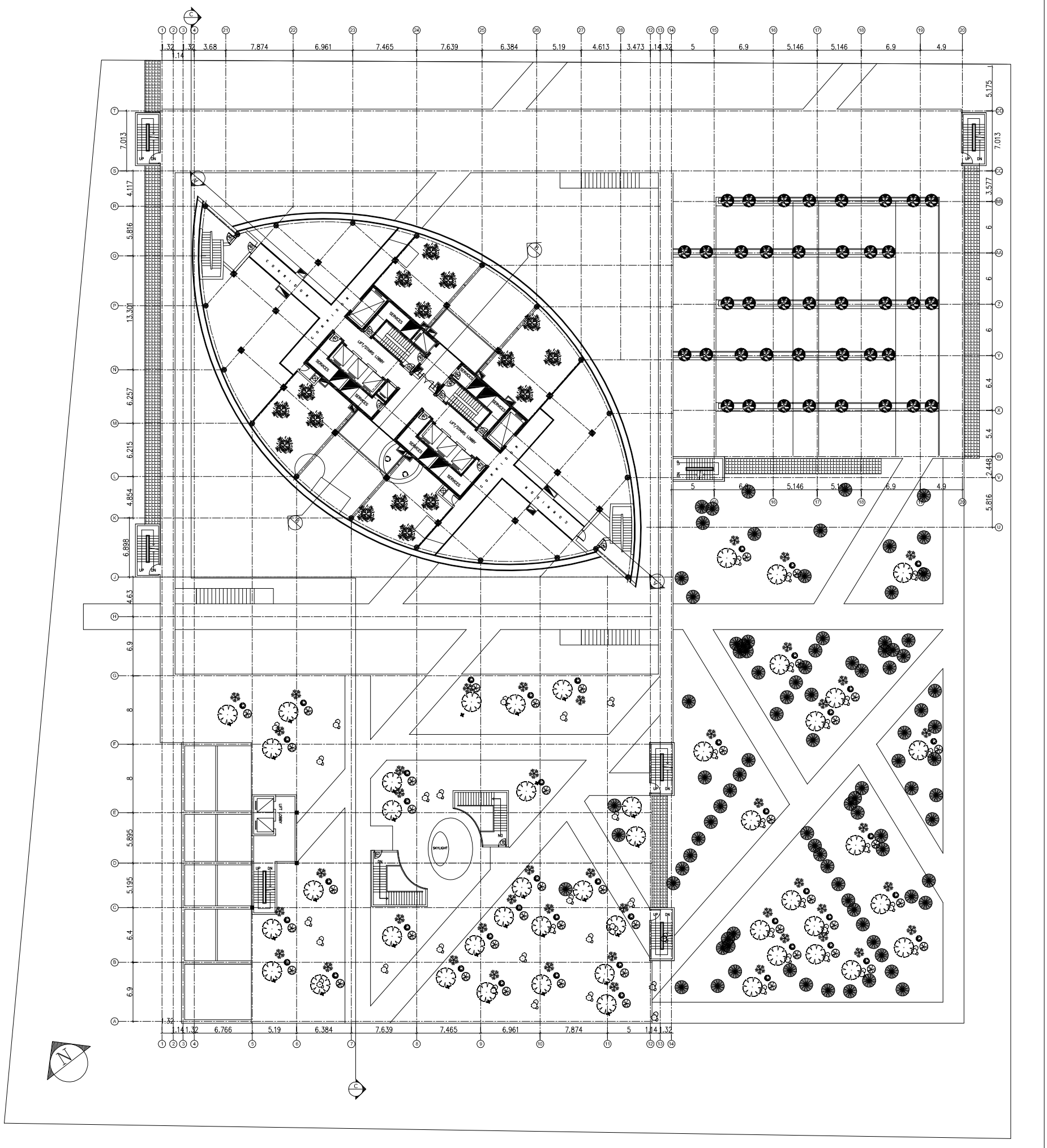
Ground

EXPO'10 GREEN TOWER SHANGHAI.



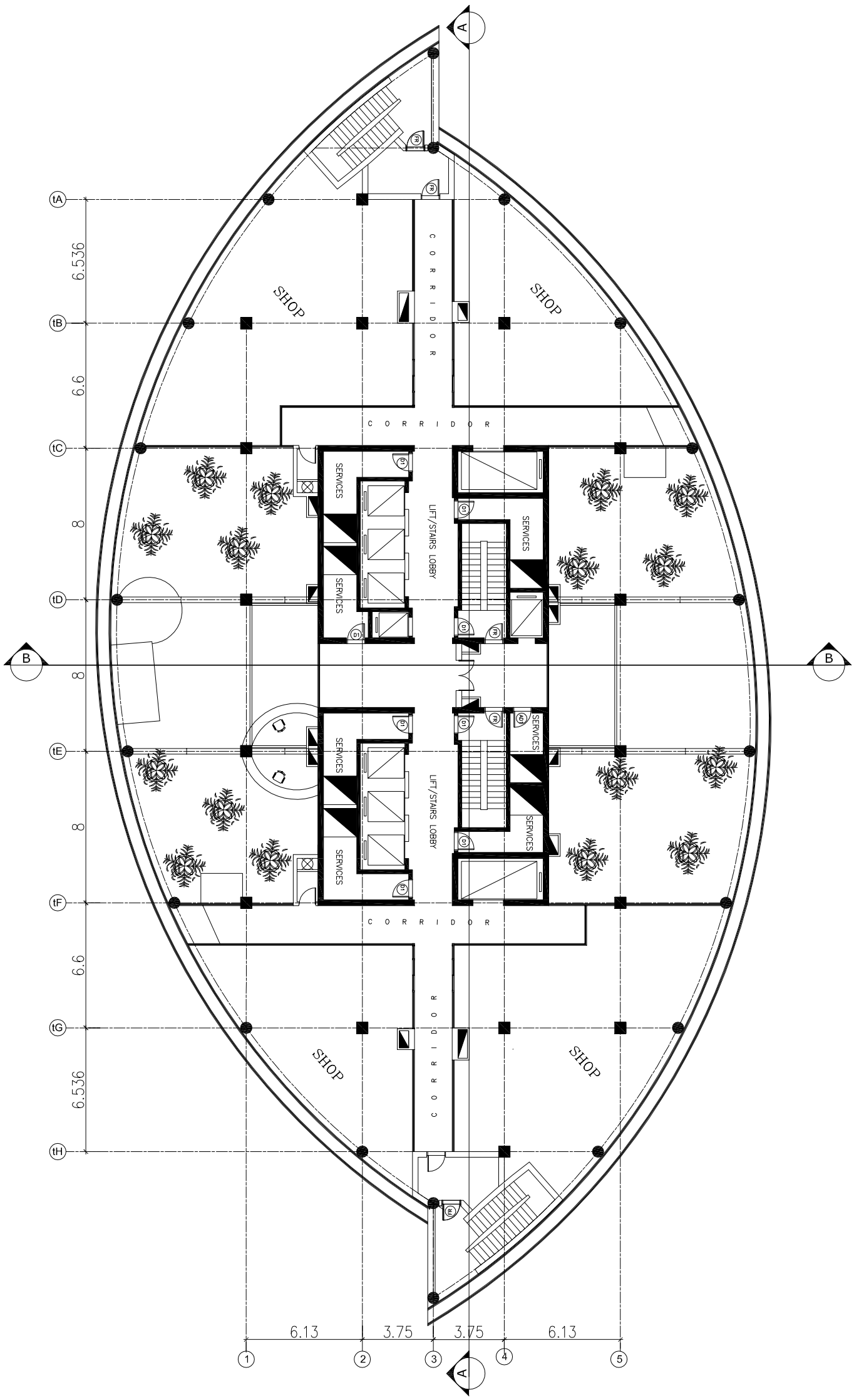
FIRST FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



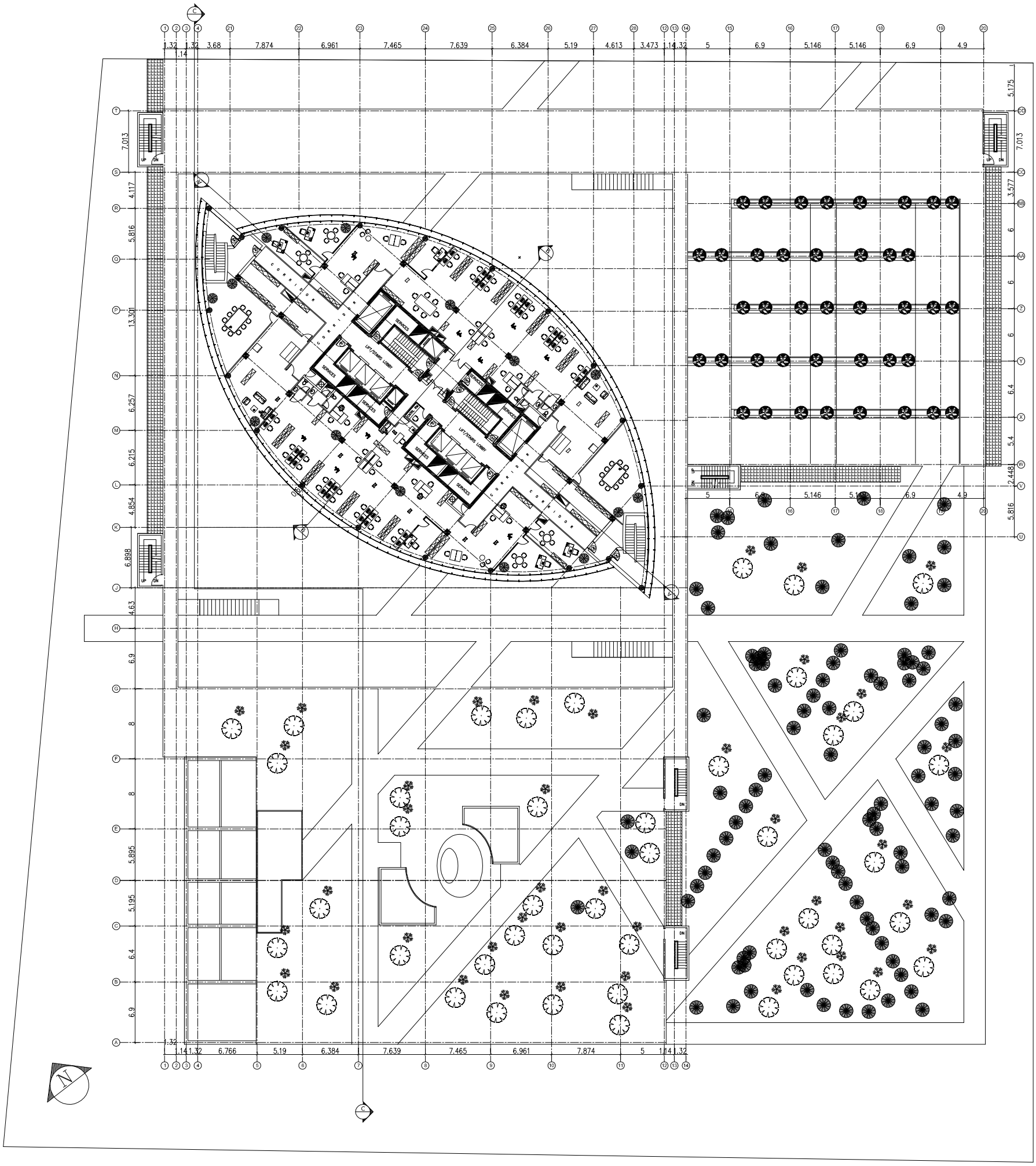
SECOND FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



SECOND FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



TYPICAL OFFICE 3,6,9,12,15,18,21 FLOOR

POLITECNICO DI MILANO

ARCHITECTURAL DESIGN

PLAN

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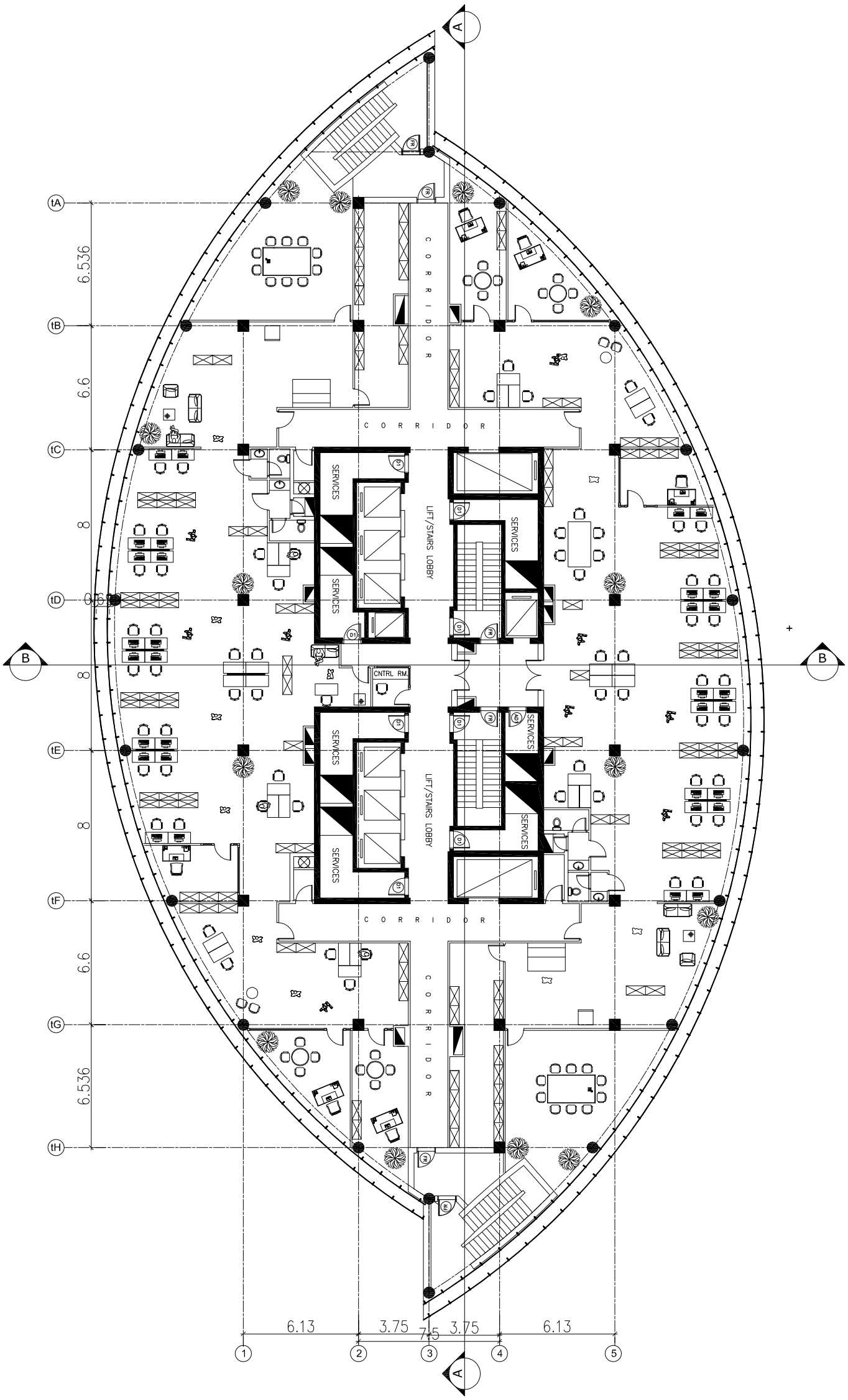
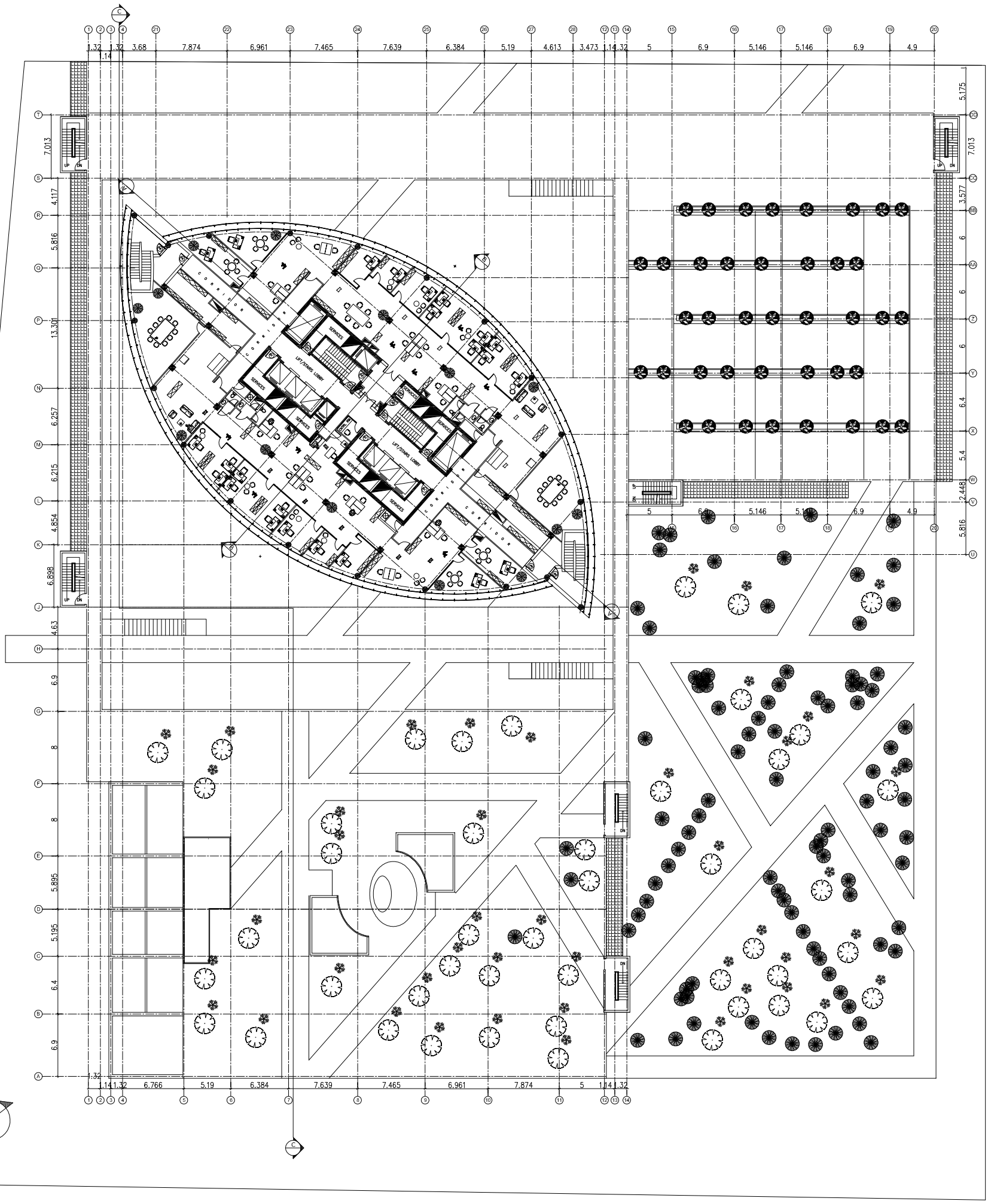
EXPO'10 GREEN TOWER SHANGHAI.



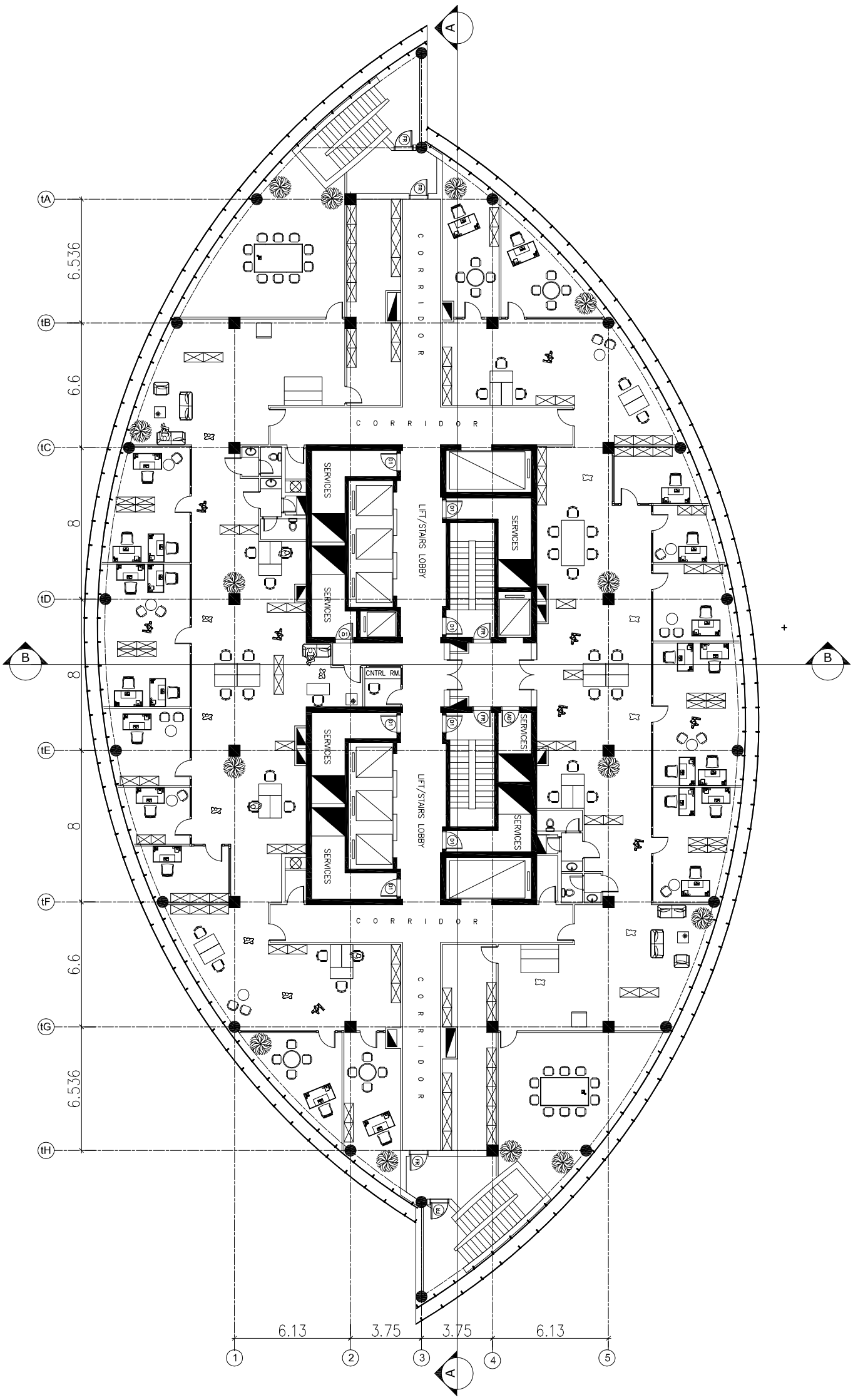
TYPICAL OFFICE 3,6,9,12,15,18,21 FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



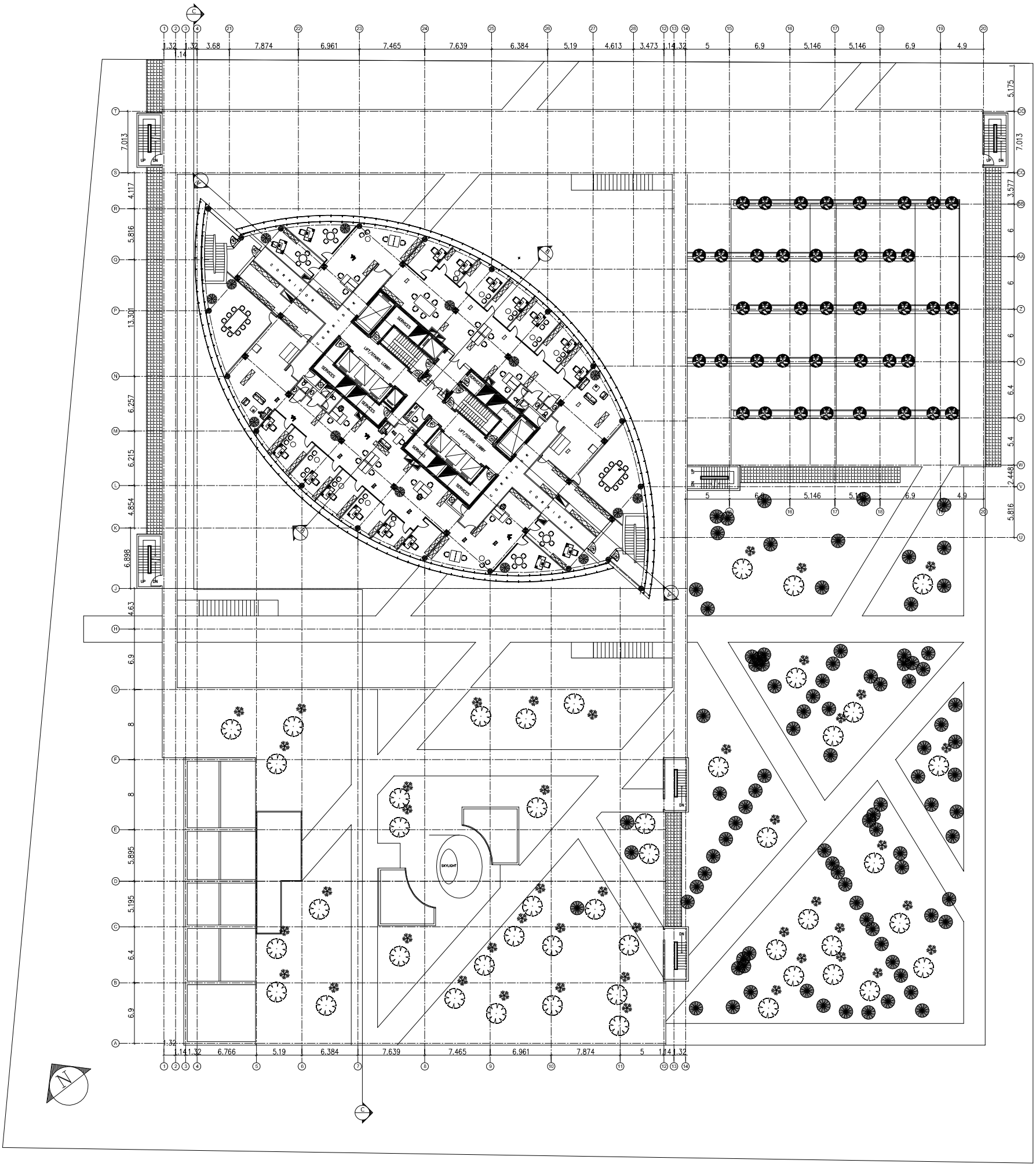
TYPICAL OFFICE 4,7,10,13,16,19,22 FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



TYPICAL OFFICE 4,7,10,13,16,19,22 FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



TYPICAL OFFICE 5,8,11,14,17,20,23 FLOOR

POLITECNICO DI MILANO

ARCHITECTURAL DESIGN

PLAN

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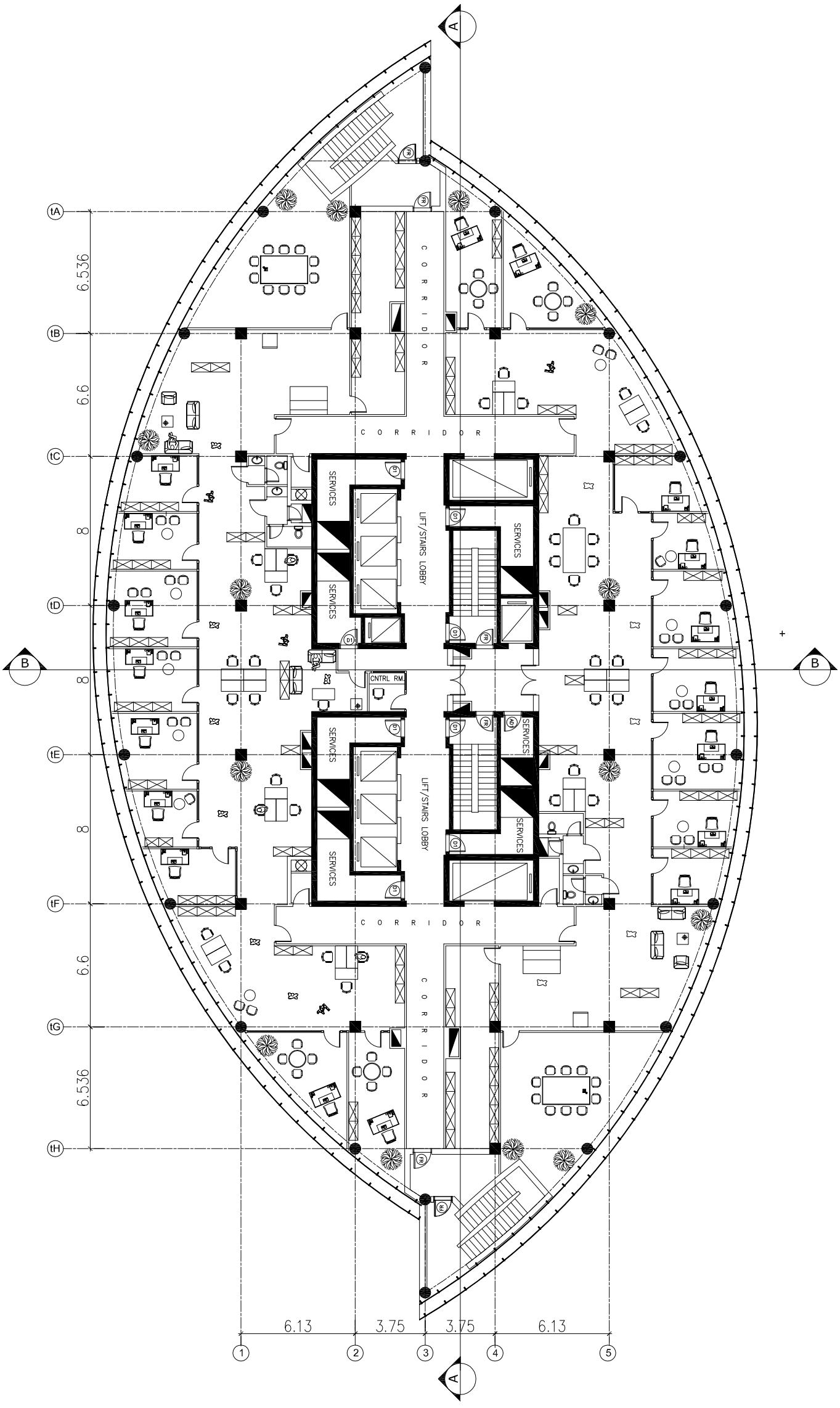
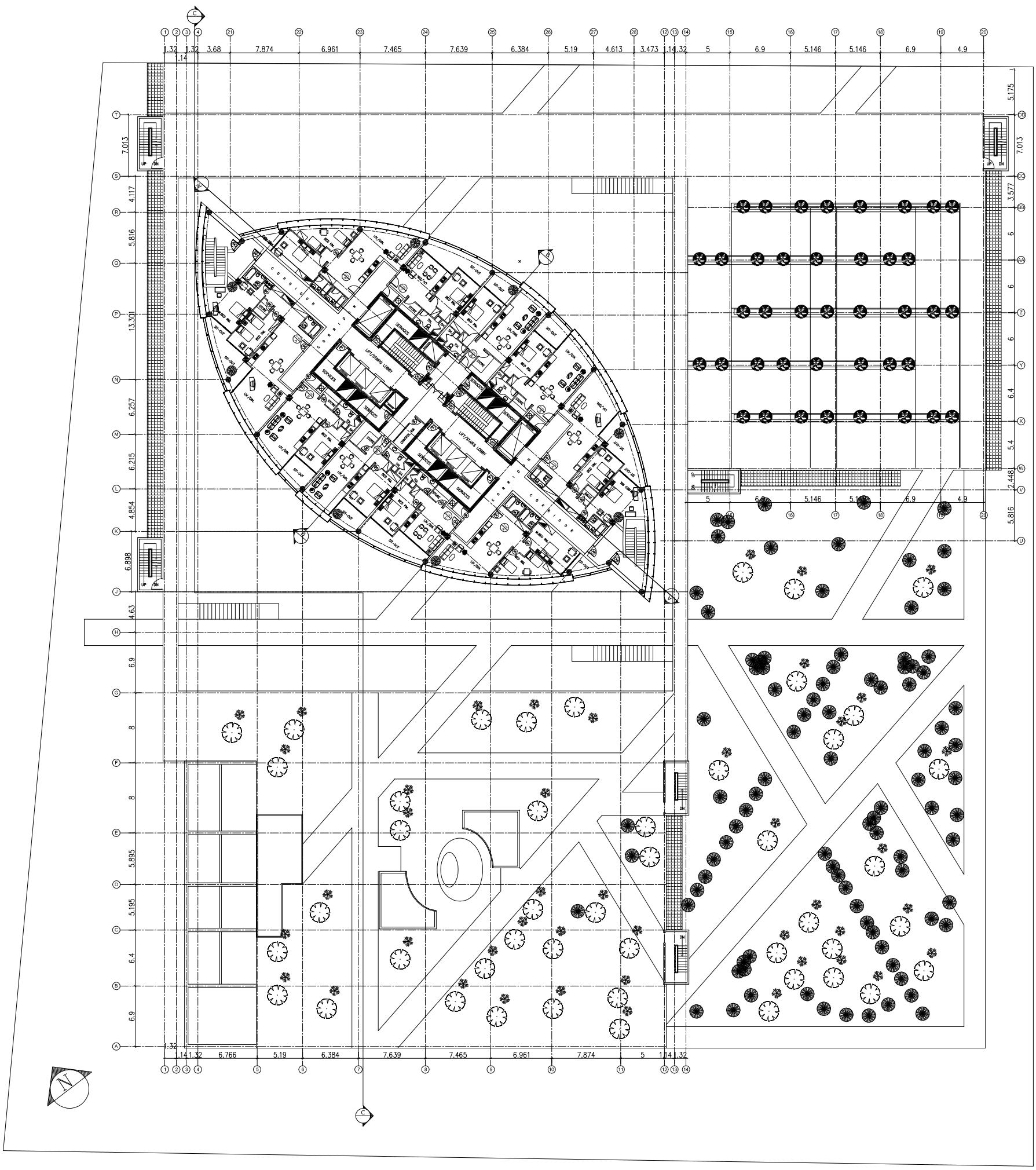
EXPO'10 GREEN TOWER SHANGHAI.



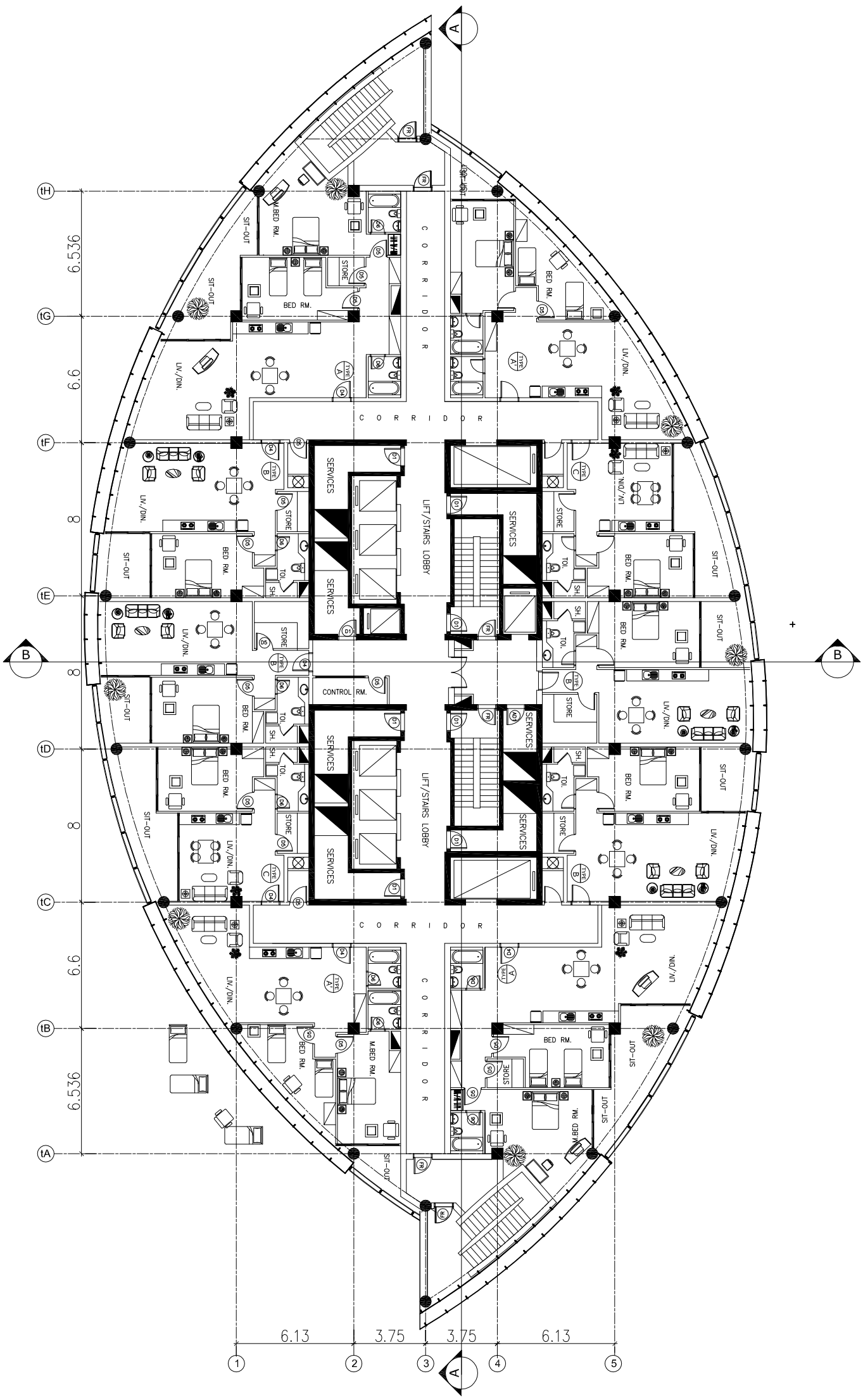
TYPICAL OFFICE 5,8,11,14,17,20,23 FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



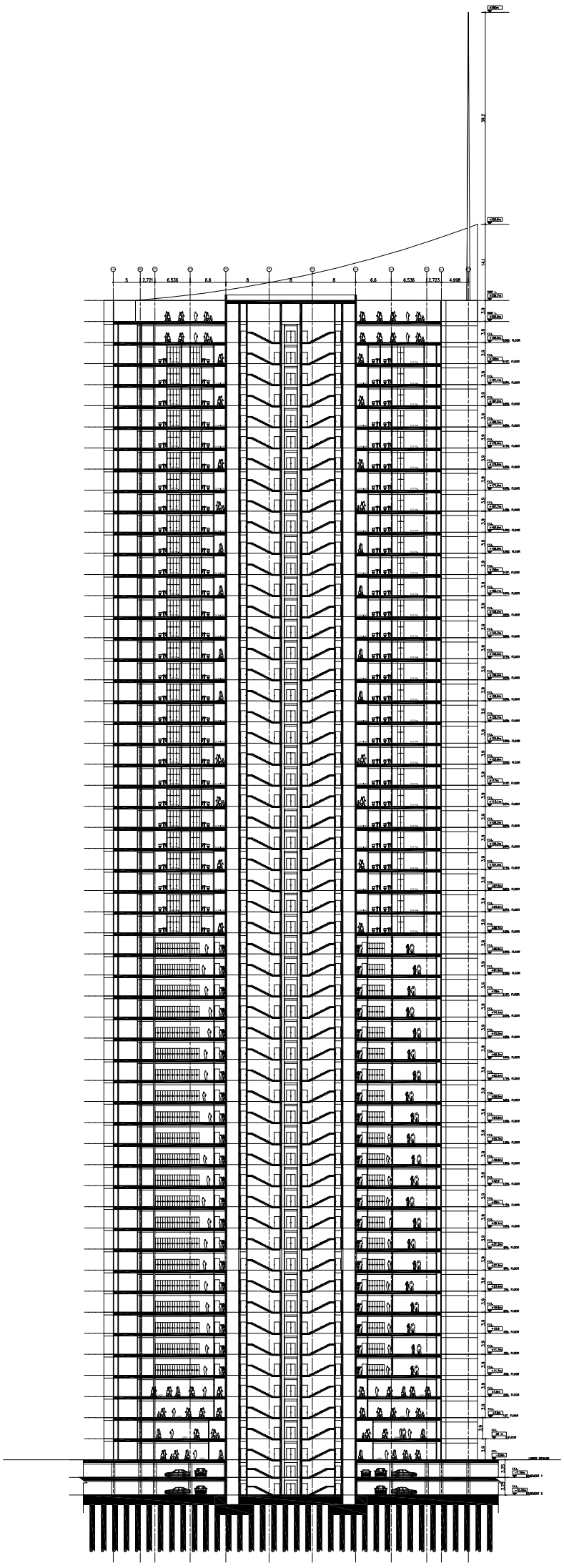
TYPICAL RESIDENTIAL 23-51 FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



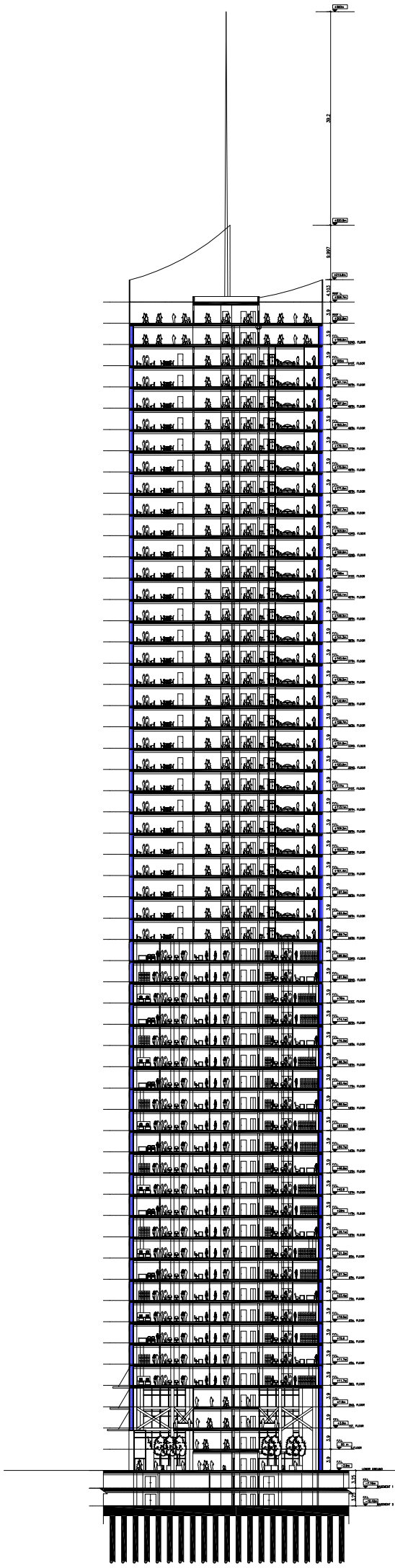
TYPICAL RESIDENTIAL 23-51 FLOOR

EXPO'10 GREEN TOWER SHANGHAI.



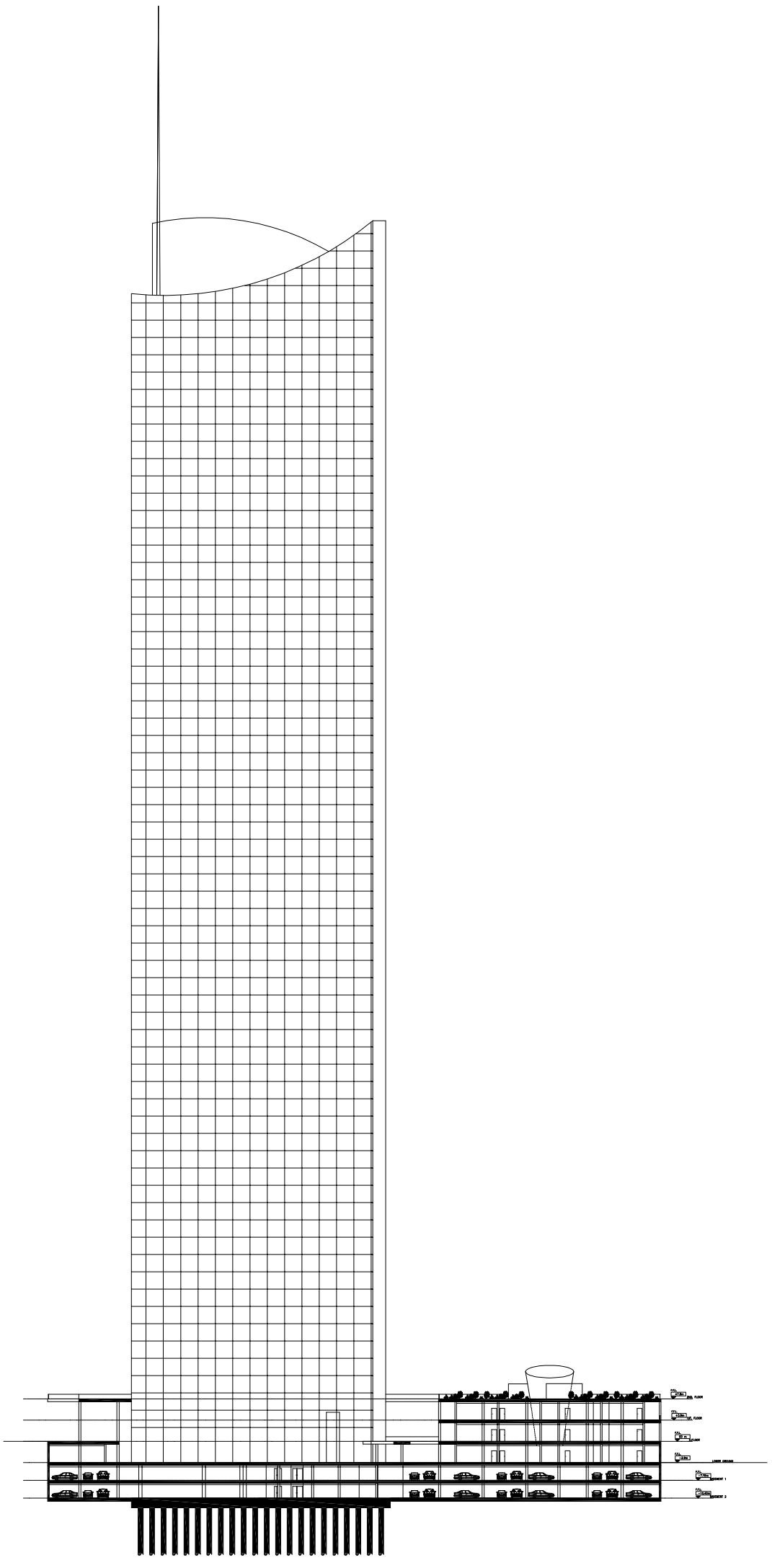
SECTION AA

EXPO'10 GREEN TOWER SHANGHAI.



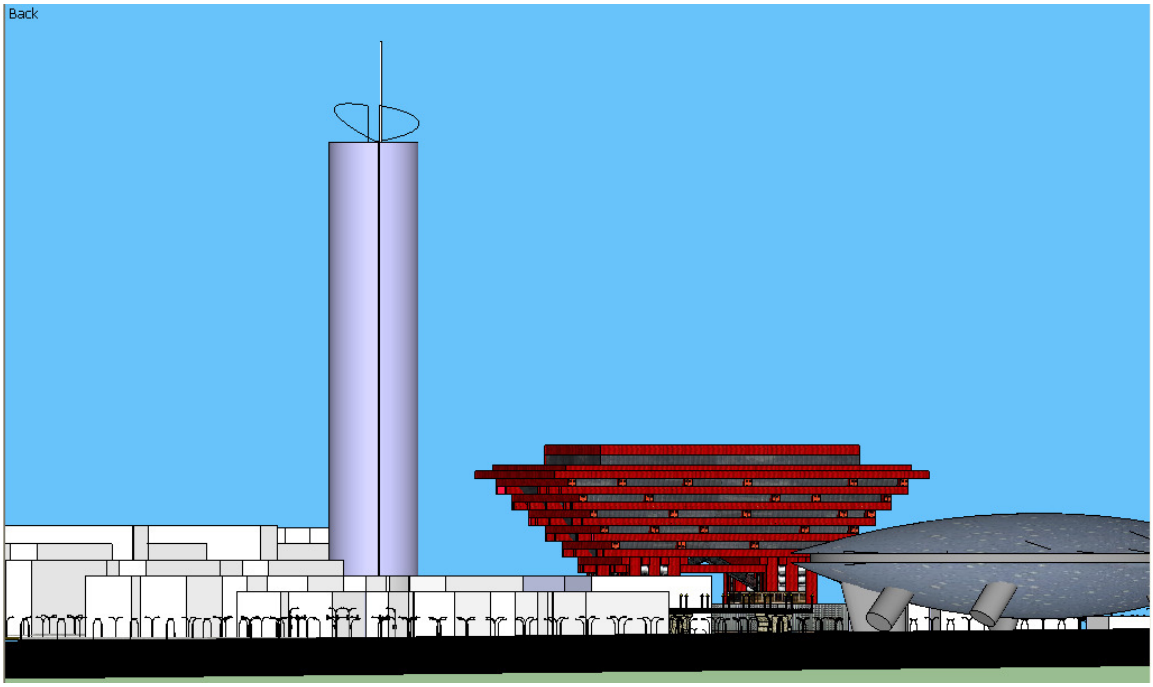
SECTION BB

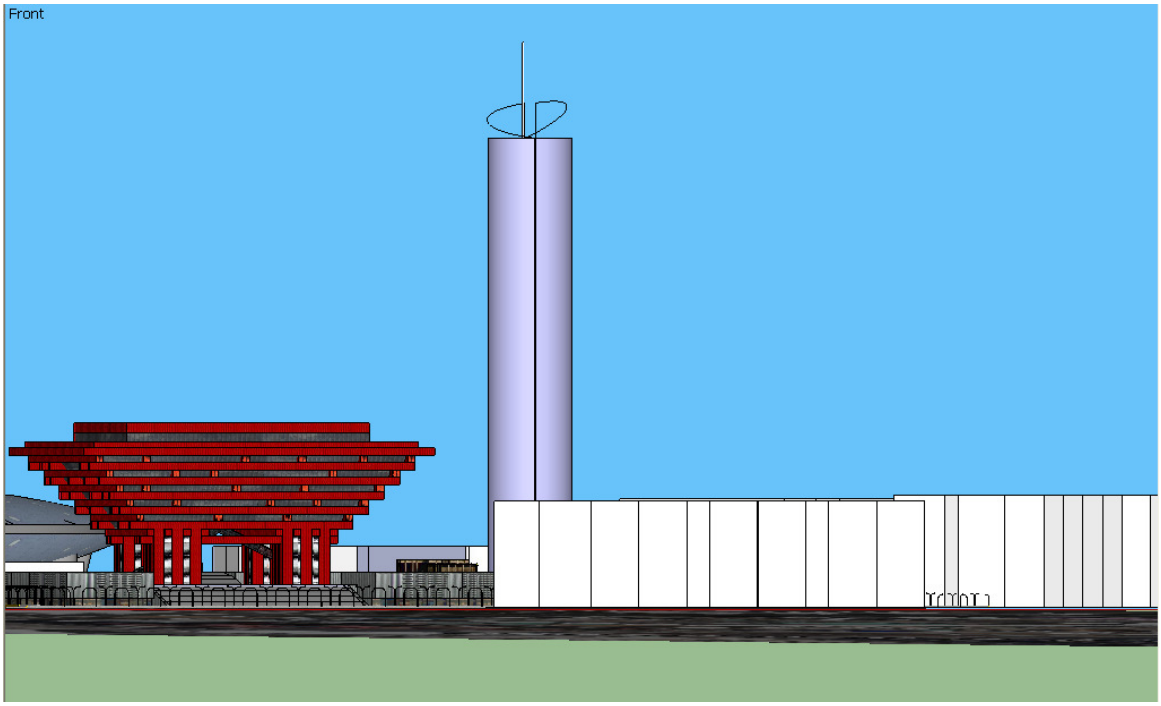
EXPO'10 GREEN TOWER SHANGHAI.



SECTION CC

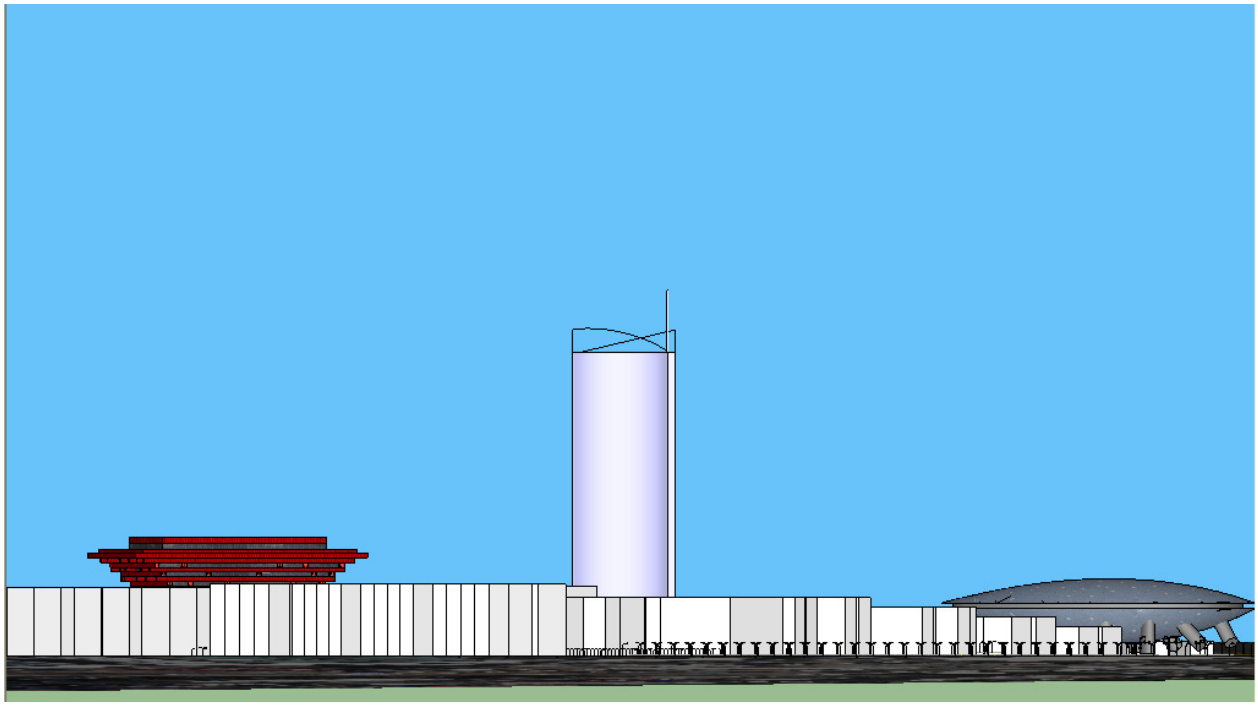
NORTH ELEVATION

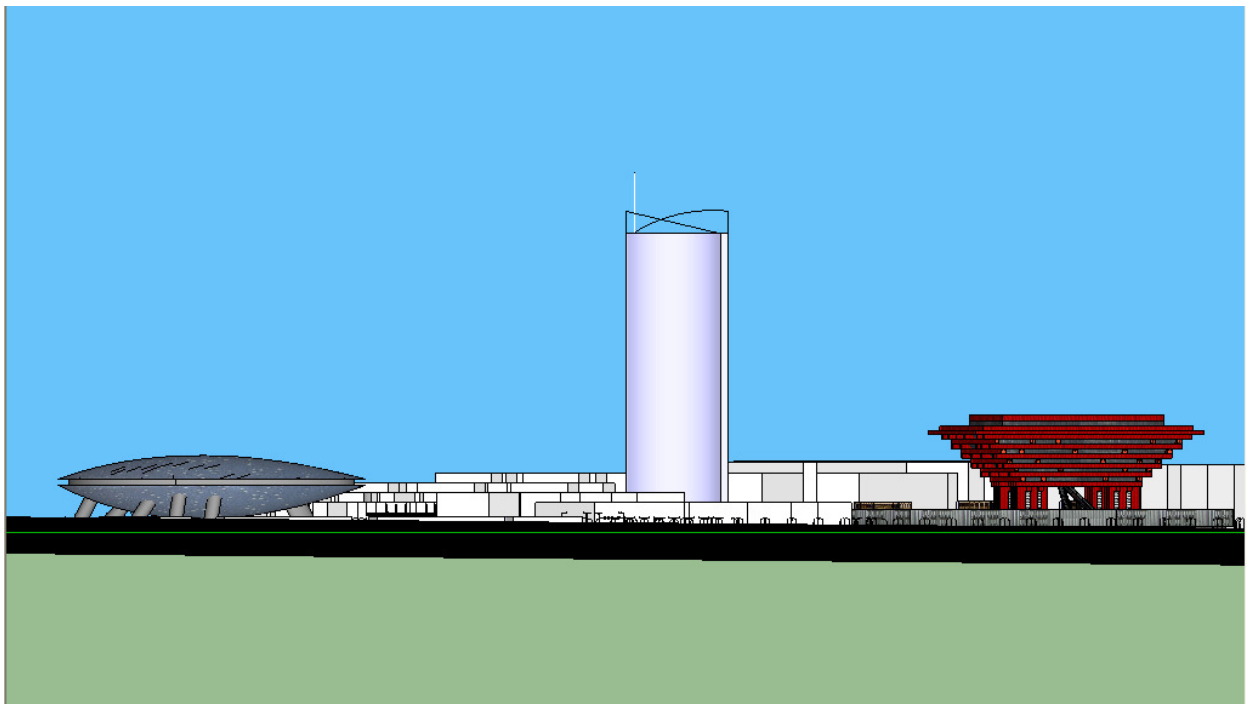




SOUTH ELEVATION

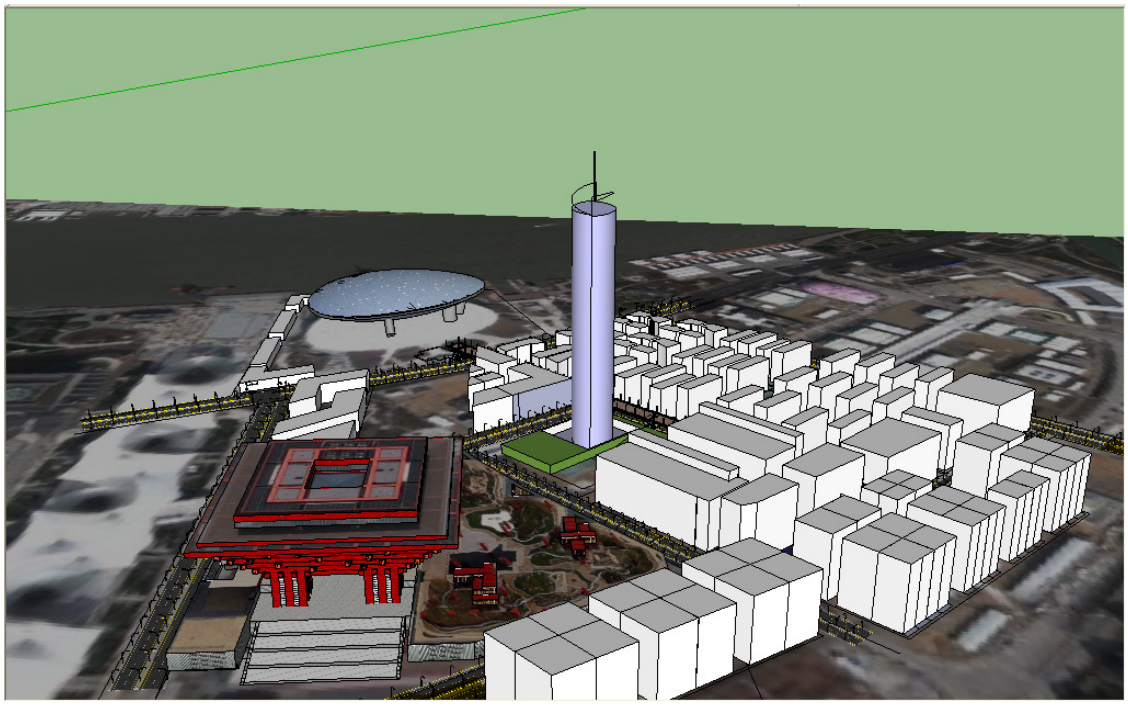
EAST ELEVATION

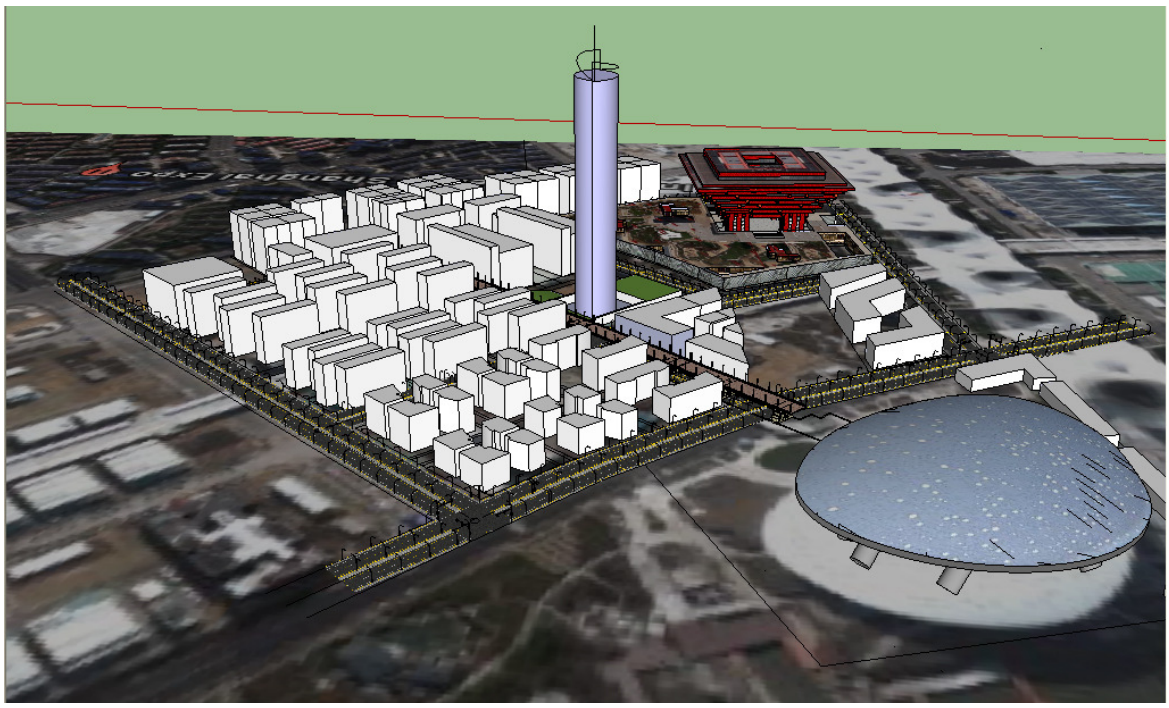


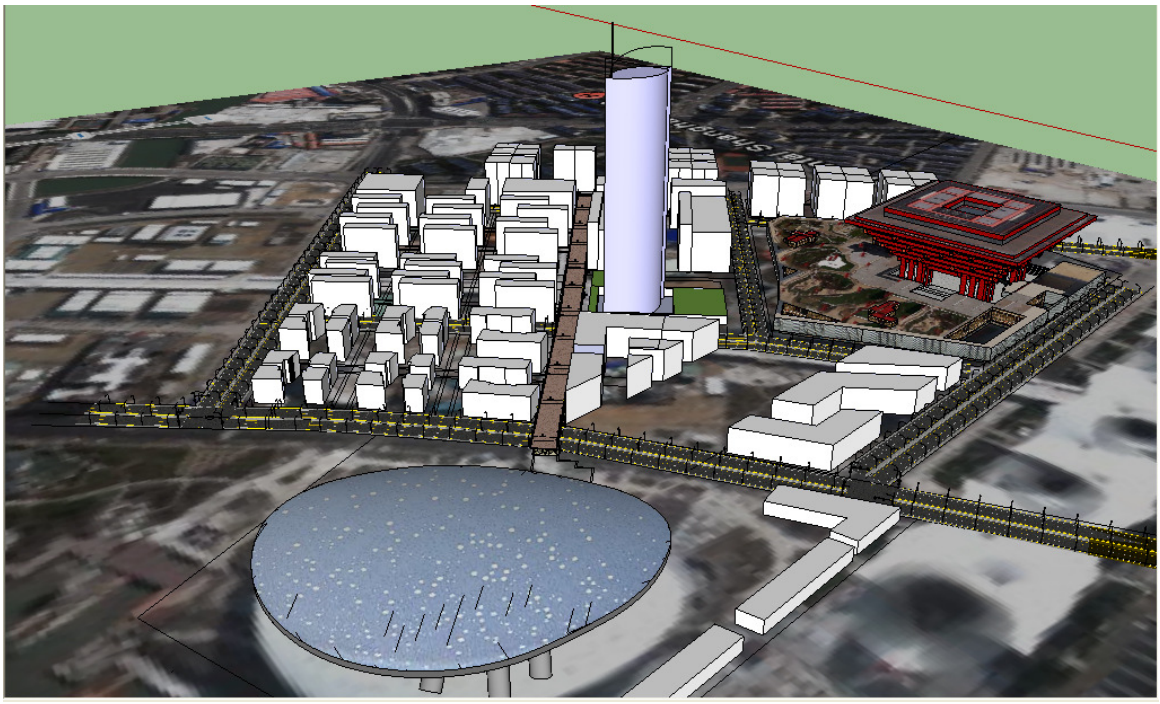


WEST ELEVATION

PROSPECTIVES







CHAPTER 3.

STRUCTURAL DESIGN

3.1. Introduction

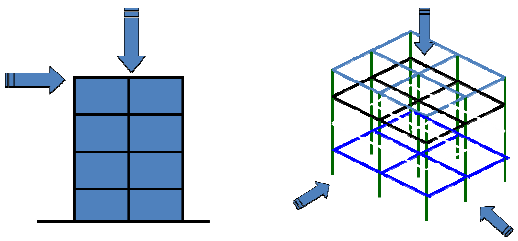
The Expo'10 Green Tower is 57 storey high-building in the area of Expo 2010, Shanghai, China.

3.2. The structure

The structure for a building must ensure that it is able to stand up safely, able to function without excessive deflections or movements which may cause fatigue of structural elements, cracking or failure of fixtures, fittings or partitions, or discomfort for occupants. It must account for movements and forces due to temperature, creep, cracking and imposed loads.

3.3. The Frame

Coplanar system of beam (or slab) and column elements dominated by flexural deformation.



There are 2 different options to design structure of the project, which are reinforced concrete frame structure and Steel frame structure.

3.3.1. Reinforced Concrete frame Structure

Reinforced concrete structure is the most prolific and versatile structural material in use today. It is composed of two distinct materials. Both concrete and reinforcement, each of which can be varied in quality, disposition and quantity to fulfill almost any requirement.

Advantage:

a) Economical

b) Popular, materials are available

c) Manpower is available

d) Easy for maintenance work

e) High ability of fire resistance

Disadvantage:

a) Construction process takes a long time

b) Heavy structure, it's dangerous if there is earthquake

3.3.2. Steel frame Structure:

Steel structure is the technology which is developed rapidly. Especially be used in the high rise buildings in big city like in Beijing orShanghai, if the earthquake and fire risks are dealt well.

Advantage:

a) Construction process is quick
b) Recyclable material

c) Light structure, it has good behavior in case earthquake happen if joints are designed with full attention.

d) Satisfy the architectural beauty and high technique demand

Disadvantage:

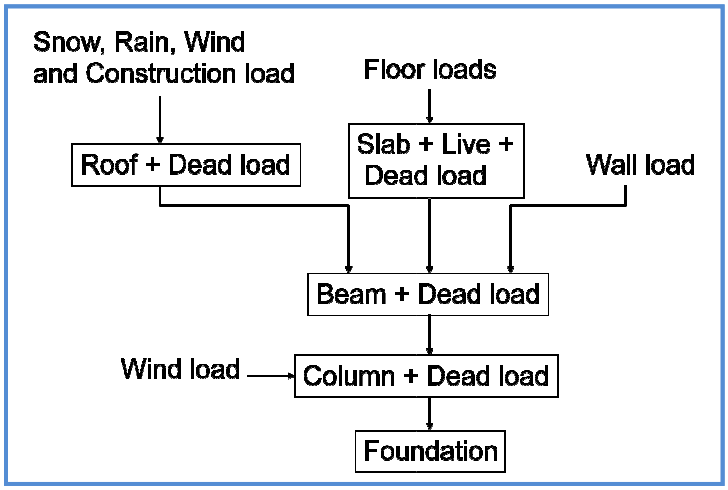
a) High cost

b) Difficult for maintenance

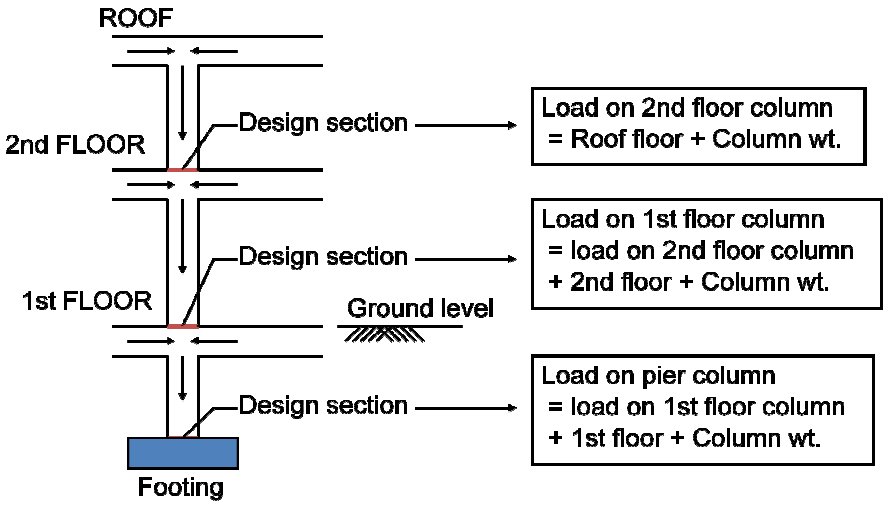
c) Bad behavior with fire

Based on our design concept, we choose concrete structure for our building.

3.4. Load Transfer in Structure



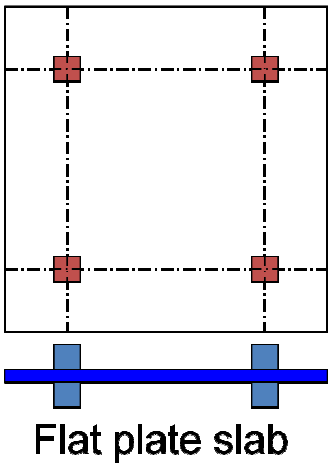
3.5. Load summation on columns

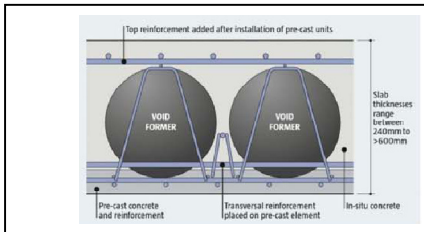


3.6. The Slab

The slab is the horizontal element of the structure which takes the loads from inhabitants and its self weight and transfer to the beams or columns.

3.6.1. Types of slabs

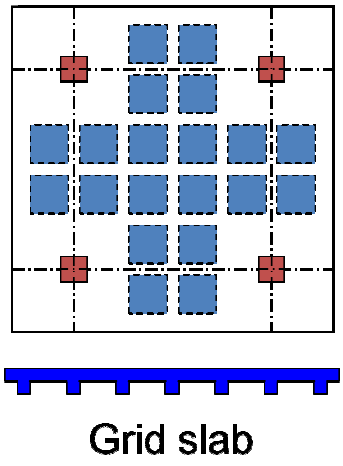


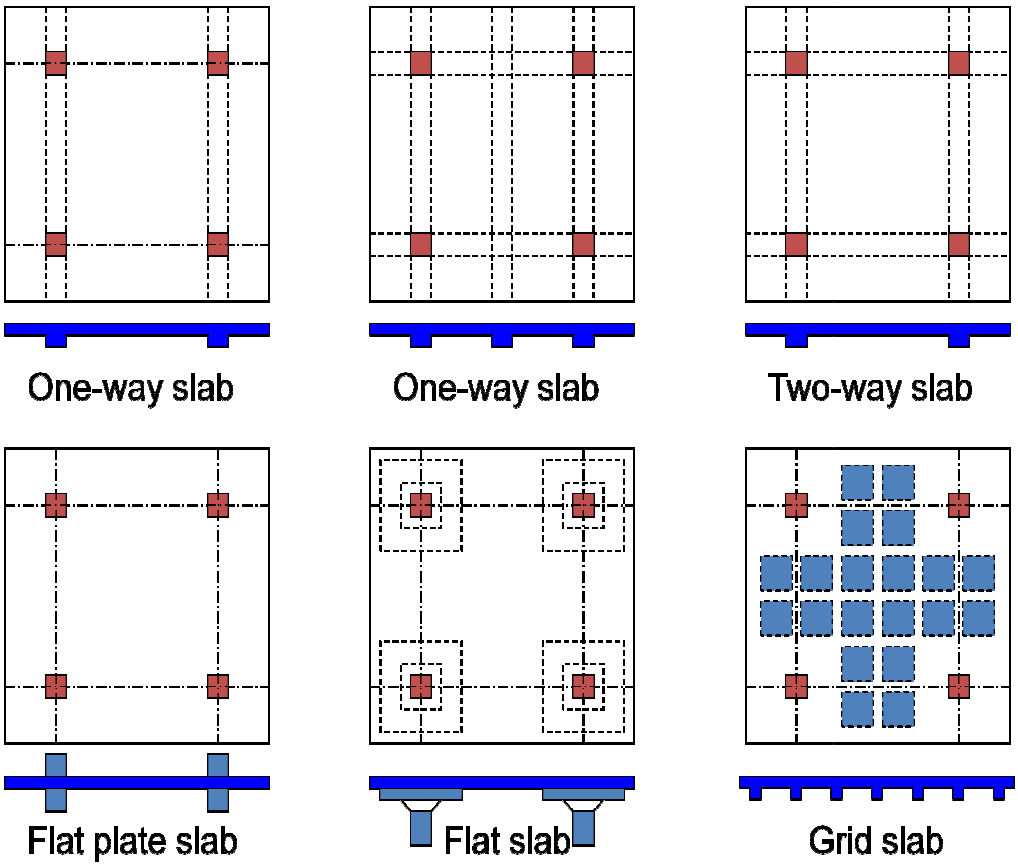


With spherical voids

Biaxial hollow flat plate/

Grid slab



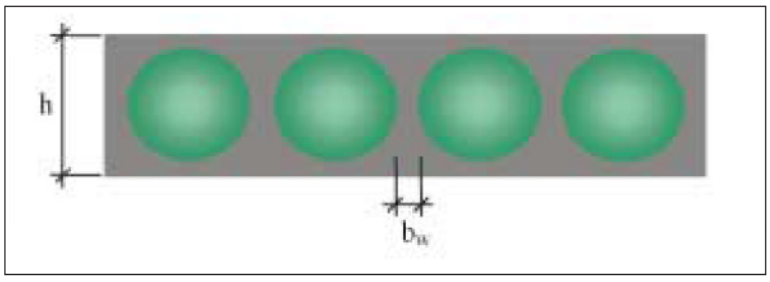


3.6.2. Biaxial hollow flat plate slab

The combination of grid slab and flat plate slab. The main advantage of biaxial hollow slabs compared with solid slabs (or hollow slabs spanned in one direction) is the significant saving in dead weight. At the same time, they offer very high load carrying capacity and flexibility. In contrast to conventional hollow slabs with load transfer in only one direction, in biaxial hollow slabs load transfer is possible in any direction.

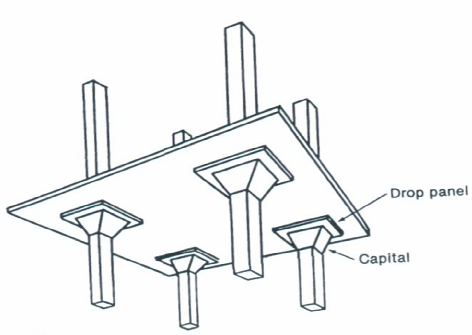
3.6.2.1. Principle of Biaxial hollow flat plate slab

This results in significant benefits in terms of choice and configuration of load-bearing structural elements. Slab systems of this type enable more slender supporting structures and larger spans. The design principle of these slabs is based on industrially produced spherical hollow bodies made from plastic that are combined to form reinforcement cage modules. These reinforcement cage modules are placed on the lower, load bearing re-bars, either in pre-casting works or on site (pure in-situ concrete solution). The upper load-bearing re-bars are then placed on top of the ready-made reinforcement cage modules. The hollow body saves material where it is not required for structural reasons.

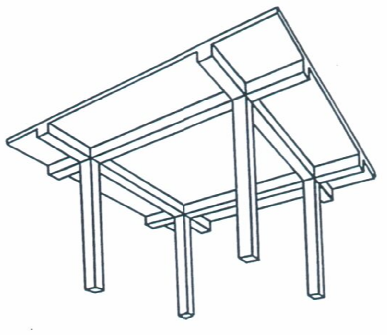


3.6.2.2. A modular concept

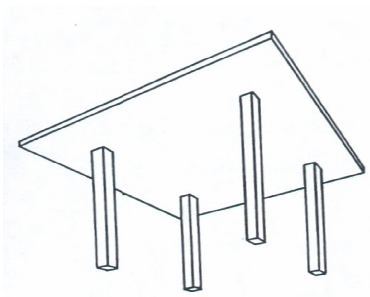
Modular unite is available as cage module and is suitable for insitu applications as well as for delivery to precast production facilities. It can be used with other building techniques such as post tensioning and composite structures.



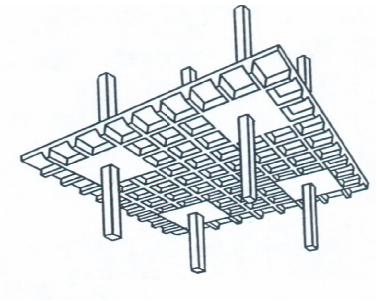
Flat slab



Two-way slab with beams



Flat Plate



Waffle slab

slab with conventional

3.6.3. Advantages and disadvantages of slabs

3.6.3.1. Flat Plate suitable span 6 to 7.5 m

Advantages

a) Low cost formwork
b) Exposed flat ceilings
c) Fast construction process

Disadvantages

a) Low shear capacity
b) Low Stiffness (notable deflection)

3.6.3.2. Flat Slab suitable span 6 m to 9 m

Advantages

a) Low cost formwork
b) Exposed flat ceilings
c) Fast construction process

Disadvantages

a) Need more formwork for capital and panels

3.6.3.3. Waffle Slab suitable span 9 m to 14.5 m

Advantages

a) Carries heavy loads
b) Attractive exposed ceilings

Disadvantages

a) Formwork with panels is expensive

3.6.3.4. Biaxial hollow slab 6 m to 18 m

Advantages

Light – flat – biaxial

- Up to 30% lighter slabs
- Reduced deflection
- Slim columns
- Reduced foundation loads
- Biaxial load bearing

Span

- Up to 18m span
- No beams
- Up to 40% less columns

Open plan

- Spacious area
- Open plan flexibility
- Better user acceptance
- Eased change of use, horizontal and vertical
- Column supported flat slab

Earthquake resistance

- Weight reduction
- Limited damage risk

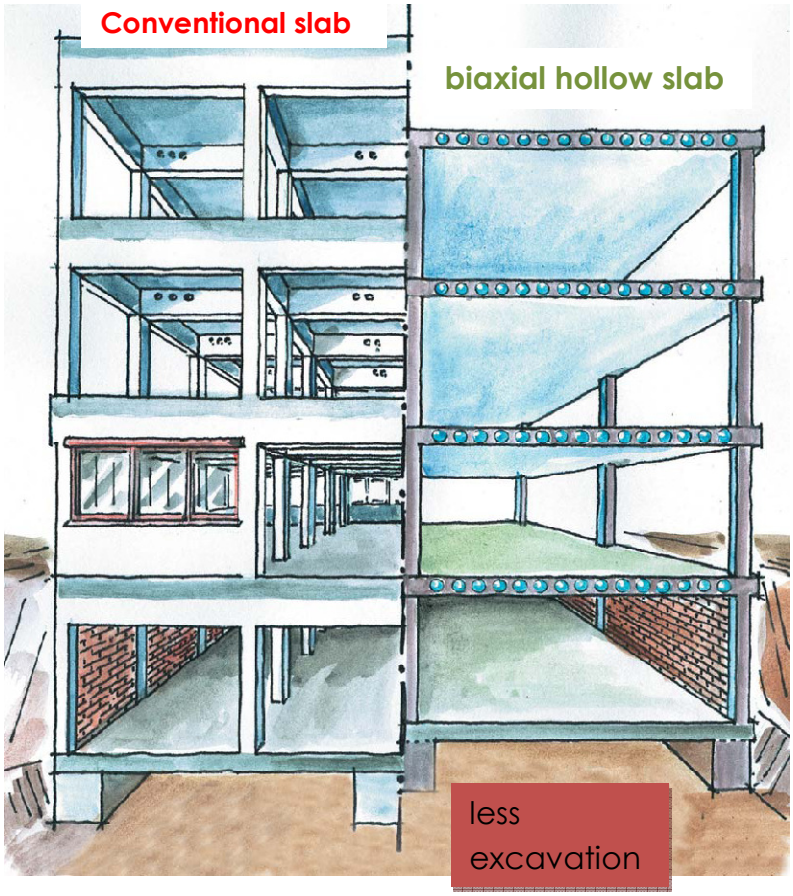
Resource effectiveness

- Concrete reduction
- Reduction of building

Elements

- Reduction of reinforcement
- Reduction of CO2 emissions
- Optimized construction time
- Sustainability

A comparison of biaxial hollow flat plate slab with conventional slabs

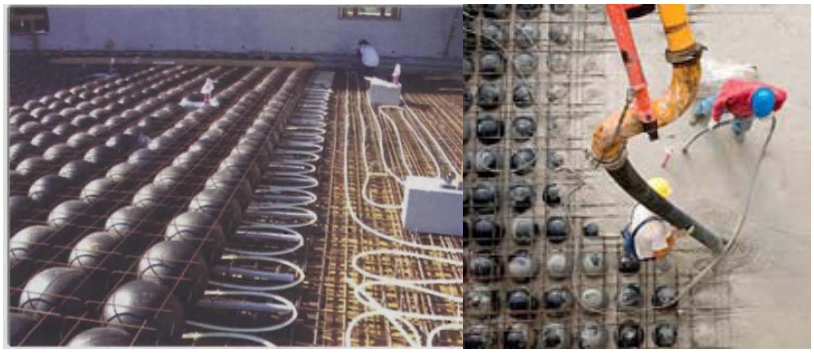


Ref.

www.cobiax.com

cobiax

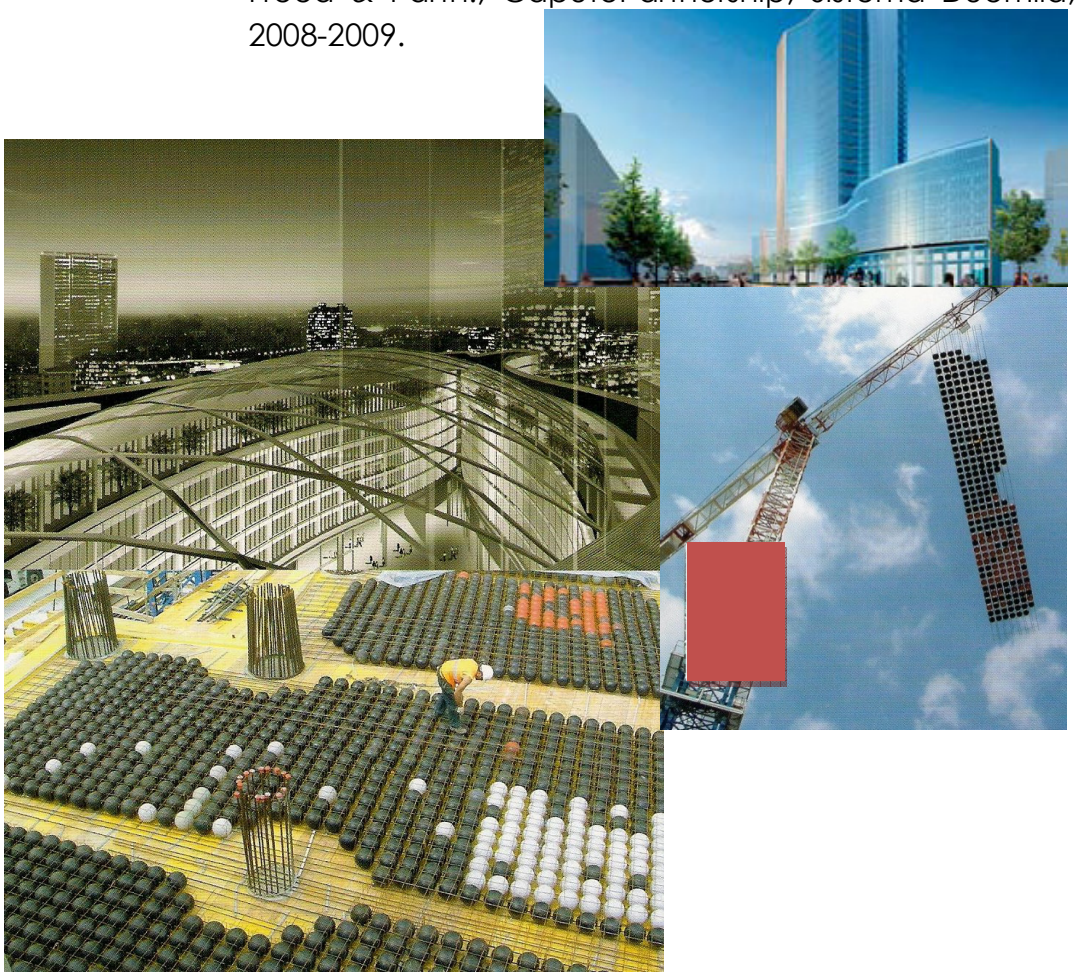
cobiax-flat slabs



The construction process of biaxial hollow slab

An Example

"Altra Sede" Offices, Milano, Italy Architects: Pei Cobb Freed & Partn., CaputoPartnership, Sistema Duemila, 2008-2009.



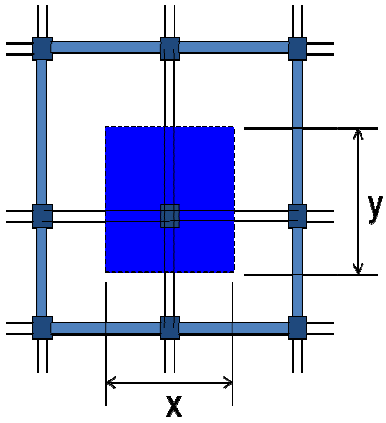
3.6.4. The slab for Expo'10 green tower

After analyzing different types of slabs, The slab selected for Expo'10 green tower Is biaxial hollow flat plate slab. It allows longer spans, fare ceiling surface and less weight, which make it economical as well.

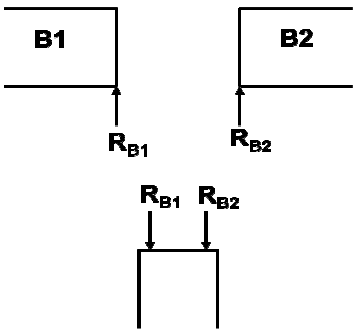
3.7. The column

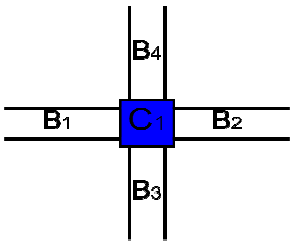
Column takes load from beams and slabs, it can be calculated by the following two method.

1. Tributary area method
   Half distance to adjacent columns
   - Load on the column = Area x floor load
   - Floor load = DL + LL
   - DL = slab and floor finishes self weight.



2. Beams reaction method





3.8. The Foundation

Foundation is a structural member used to support columns and walls and to transmit and distribute their loads to the soil in such a way that the load bearing capacity of the soil is not exceeded, excessive settlement, differential settlement, or rotation are prevented and adequate safety against overturning or sliding is maintained.

3.8.1. Types of foundations

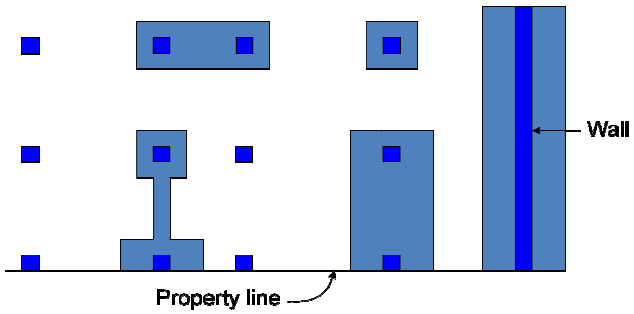
There are two major categories of foundations,

1. Shallow foundation
2. Deep foundations

3.8.1.1. Shallow foundation

Shallow foundations are those founded near to the finished ground surface; generally where the founding depth is less than the width of the footing and less than 3m. Shallow foundations (sometimes called 'spread footings') include pads ('isolated footings'), strip footings and rafts. Shallows foundations are used when surface soils are sufficiently strong and stiff to support the imposed loads; they are generally unsuitable in weak or highly compressible soils.

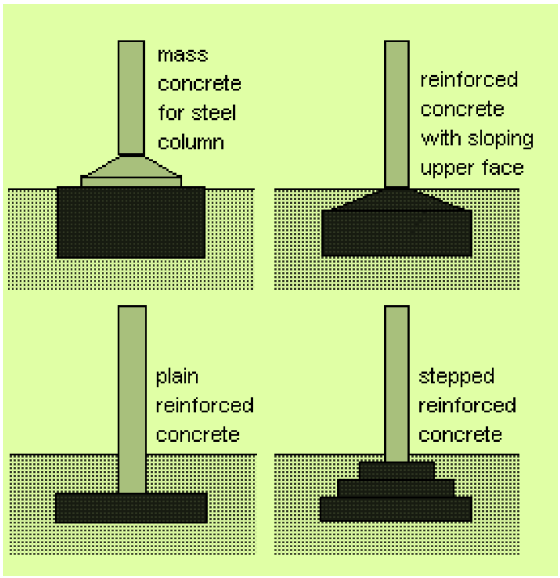
Shallow foundation is including three types:



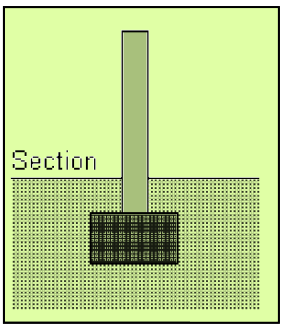
Pad foundation:

Pad foundations are used to support an individual point load such as that due to a structural column. They may be circular, square or rectangular. They usually consist of a block or slab of uniform thickness, but they may be stepped or hunched if they are required to spread the load from a heavy column. Pad

foundations are usually shallow, but deep pad foundations can also be used.



Pad foundation



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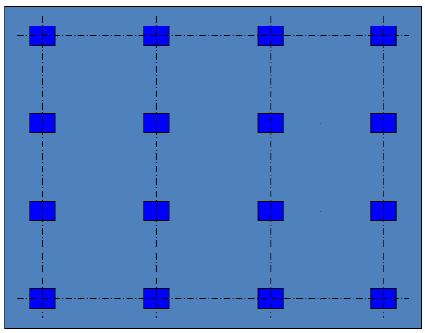
Strip foundation:

Strip foundations are used to support a line of loads, either due to a load-bearing wall, or if a line of columns need supporting where column positions are so close that individual pad foundations would be inappropriate.



Raft foundation

Raft foundations are used to spread the load from a structure over a large area, normally the entire area of the structure. They are used when column loads or other structural loads are close together and individual pad foundations would interact.

A raft foundation normally consists of a concrete slab which extends over the entire loaded area. It may be stiffened by ribs or beams incorporated into the foundation.

Raft foundations have the advantage of reducing differential settlements as the concrete slab resists differential movements between loading positions. They are often needed on soft or loose soils with low bearing capacity as they can spread the loads over a quite a larger area.

3.8.1.2. Deep foundations

Deep foundations are those found too deeply below the finished ground surface for their base bearing capacity to be affected by surface Conditions. Their depth is usually more than 3 m below ground. They include piles, piers and caissons or compensated foundations using deep basements and also deep pad or strip foundations. Deep foundations can be used to transfer the loading to deeper, more competent Strata if unsuitable soils are present near the surface.

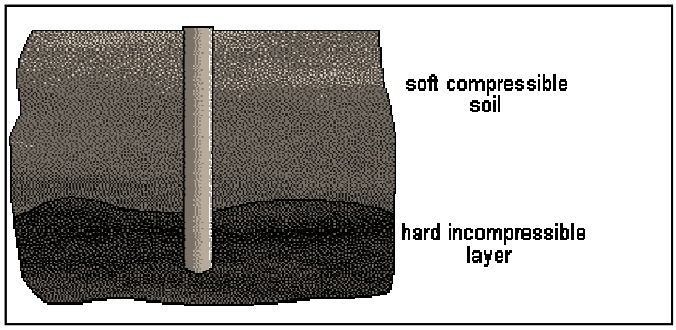
The main type of deep foundation is piles. Piles are often used because adequate bearing

capacity cannot be found at shallow enough depths to support the structural loads. It is

important to understand that piles get support from both end bearing and skin friction. The proportion of carrying capacity generated by either end bearing or skin friction depends on the soil conditions. Piles can be used to support various different types of structural loads.
There are two main type of piles.

End bearing piles

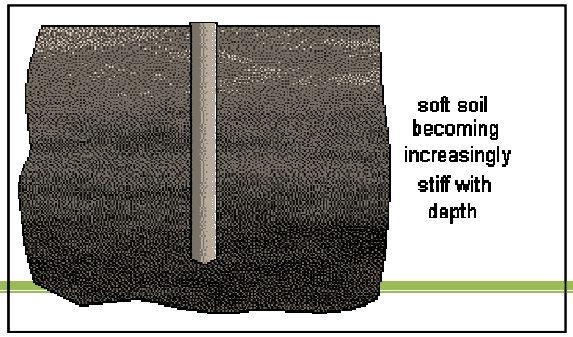
End bearing piles are those which terminate in hard, relatively impenetrable material such as rock or very dense sand and gravel. They derive most of their carrying capacity from the resistance of the stratum at the toe of the pile.



iles

Friction piles

Friction piles obtain a greater part of their carrying capacity by skin friction or adhesion, This tends to occur when piles do not reach an impenetrable stratum but are driven for some distance into a penetrable soil. Their carrying capacity is derived partly from end bearing and partly from skin friction between the embedded surface of the soil and the surrounding soil.



Friction piles

3.8.2. The foundation for Expo'10 green tower

The foundation for Expo'10 Green Tower consists of piles foundation as the soil condition of 392.7 udong, Shanghai area is ash soil. The heavy loads of the 57 storey tower and with the consideration of wind and average earthquake province of the site, justify piles foundation .

3.9. Design theories

3.9.1. The Limit State Design

Limit state design (LSD) refers to a design method used in structural engineering. The method is in fact a modernization and rationalization of engineering knowledge which was well established prior to the adoption of LSD. Beyond the concept of a limit state, LSD simply entails the application of statistics to determine the level of safety required by or during the design process.

Limit state design requires the structure to satisfy two principal criteria:
the ultimate limit state (ULS) and the serviceability limit state (SLS). A limit state is a set of performance criteria (e.g. vibration levels, deflection, strength, stability, buckling, twisting, collapse) that must be met when the structure is subject to loads. Any design process involves a number of assumptions. The loads to which a structure will be subjected must be estimated, sizes of members to check must be chosen and design criteria must be selected. All engineering

design criteria have a common goal: that of ensuring a safe and functional structure.

To satisfy the ultimate limit state, the structure must not collapse when subjected to the peak design load for which it was designed. A structure is deemed to satisfy the ultimate limit state criteria if all factored bending, shear and tensile or compressive stresses are below the factored resistance calculated for the section under consideration. Whereas Magnification

Factor is used for the loads, and Reduction Factor for the resistance of members.

To satisfy the serviceability limit state criteria, a structure must remain functional for its intended use subjected to routine loading, and as such the structure must not cause occupant discomfort under routine conditions. A structure is deemed to satisfy the serviceability limit state when the constituent elements do not deflect by more than certain limits laid down in the building codes, the floors fall within predetermined vibration criteria, in addition to other possible requirements as required by the applicable building code. Examples of further serviceability limit requirements may include crack widths in concrete, which typically must be kept below specified dimensions. A structure where the serviceability requirements are not met, e.g. the beams deflect by more than the SLS limit, will not necessarily fail structurally. The purpose of SLS requirements is to ensure that people in the structure are not unnerved by large deflections of the floor, vibration caused

by walking, sickened by excessive swaying of the building during high winds, or by a bridge swaying from side to side and to keep beam

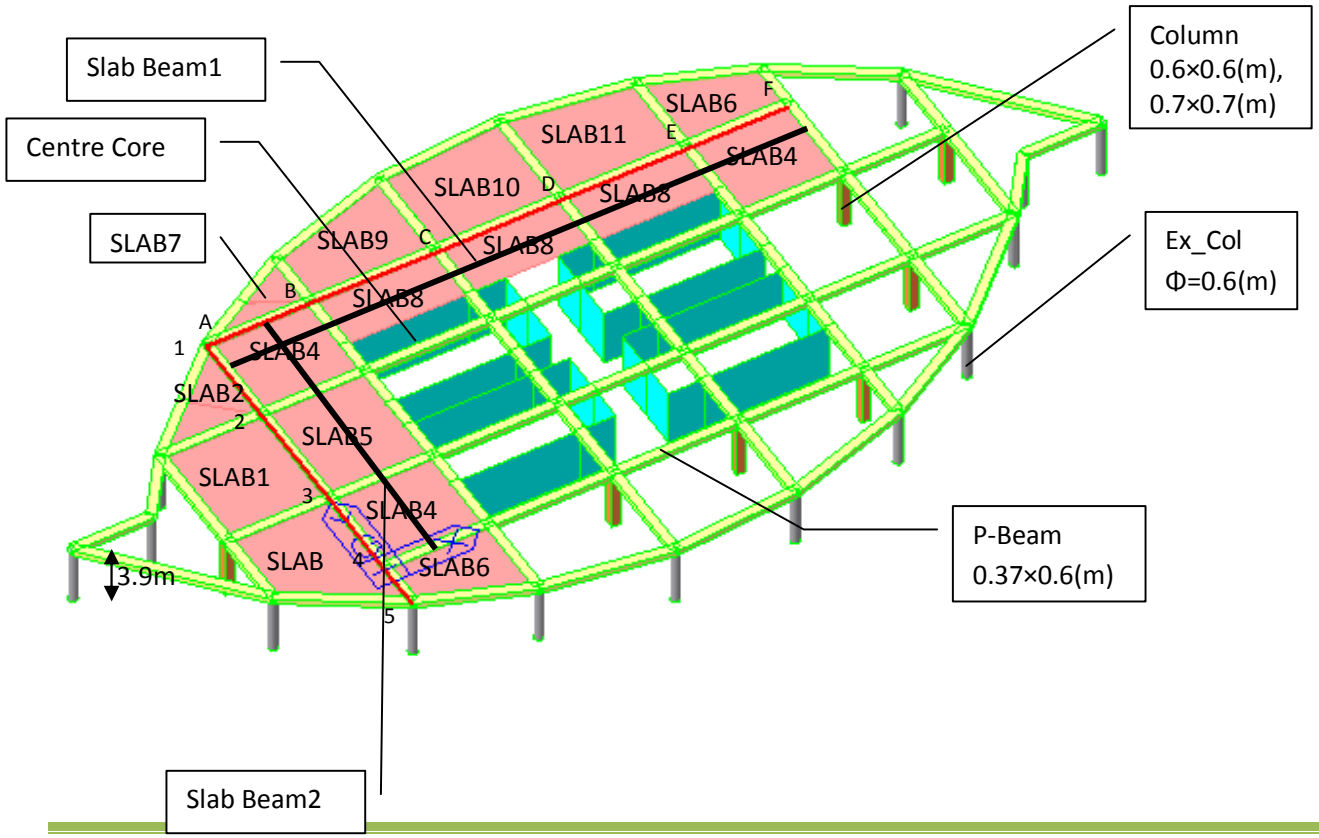
deflections low enough to ensure that brittle finishes on the ceiling above do not crack, affecting the appearance and longevity of the structure. Many of these limits depend on the finish materials (sheetrock, acoustical tile) selected by the architect, as such, the limits in the building codes on deflections are generally descriptive and leave the choice to the engineer of record.

DESIGN CALCULATIONS.

1. Structural Arrangement
Planar View of ordinary floor

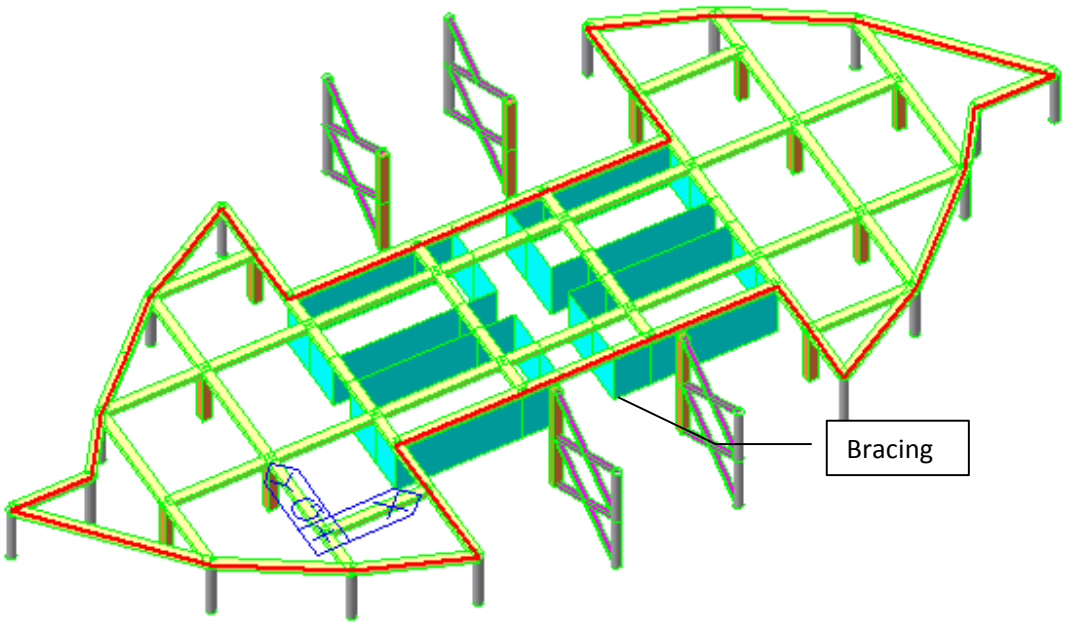
- Two way slab and primary beam in X&Y direction.
- 11 types of slab are considered.
- storey height 3.25m for -3F and -2F, 3.9m for storeys above.
- Two kinds of columns—external one (circular section),internal one (rectangular section)

- **Frames in our consideration 1~5; A~F, indicated by red line.**



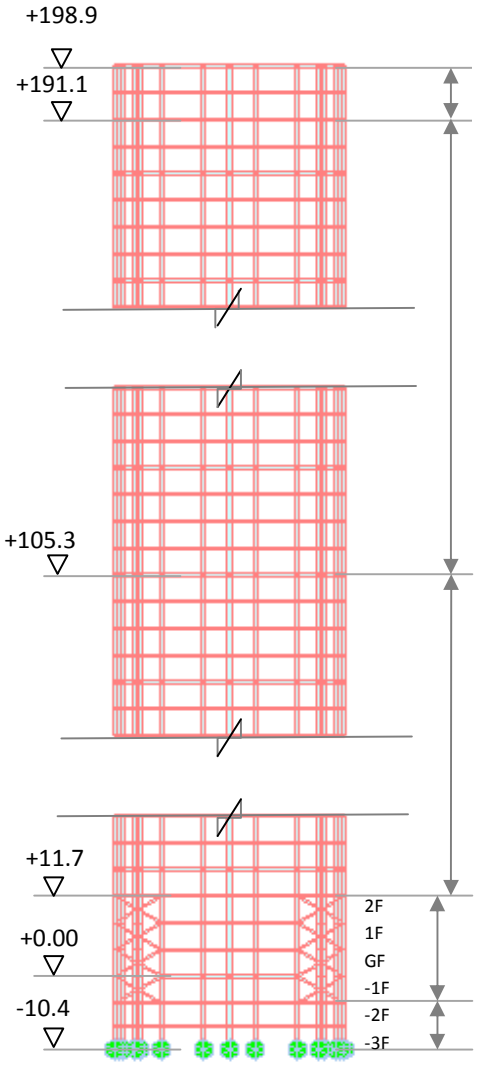
Planar View of floors: -1F~2F

-Boundary line of slab is highlighted by red colour
-Void in the middle part, symmetrically, columns applying bracing



Elevation View of the Building

57-storey building, for each storey, according to its design functional purpose, has different value of live load. The roof floor should consider smaller live load while take into account also the snow load.



ROOF
Visitor area

28 storeys
RESIDENTIAL

21 storeys
OFFICE

4 Storeys with hollow and bracing

-3F&-2F, Garage 3.25m Height

Unit (kN/m^2)

Type	Cate.	g_k	q_k	s
Roof	H	Self-w	0.4	1.28
Top2	C1	Self-w	2.5	-
Resi	A	Self-w	2.0	-
Office	B	Self-w	2.5	-
Public	C3	Self-w	3.0	-
Garage	F	Self-w	2.5	-

Load Cases

According to EN1991-1-1 [6.3], determine the characteristic values of imposed loads. Principle "(1)P" indicates that areas in residential, social commercial and administration buildings shall be divided into categories according to their specific uses shown in Table 6.1 in EN1991, in this case:

Category	Location	Specific Use	Description
A	27F~48F	Areas for domestic and residential activities	Rooms in residential buildings and houses; bedrooms and wards in hospitals; Bedrooms in hotels and hostels kitchens and toilets
B	3F~26F	Office Areas	
C	-1F~2F & top 2 storeys	Areas where people may congregate	C1: Restaurants C3: Access Areas in public and administration buildings, hotels…

To be conservative, we don't put a reduction coefficient on the load values. According to Table 6.2 [Imposed loads on floors, balconies and stairs in buildings] in EN1991-1:

- For Category A.
  Floors $q_k = 1.5 \text{to} 2.0\ \text{kN/m}^2$, it's recommended to take 2.0 here as is on the safe side.
- For Category B.
  $q_k = 2.0 \text{to} 3.0\ \text{kN/m}^2$, take average value as $2.5\ \text{kN/m}^2$
- For Category C.
  -C1(Restaurant) $q_k = 2.0 \text{to} 3.0\ \text{kN/m}^2$,take average value as $2.5\ \text{kN/m}^2$
  -C3 (Access Areas) $q_k = 3.0 \text{to} 5.0\ \text{kN/m}^2$, take lower value as $3.0\ \text{kN/m}^2$

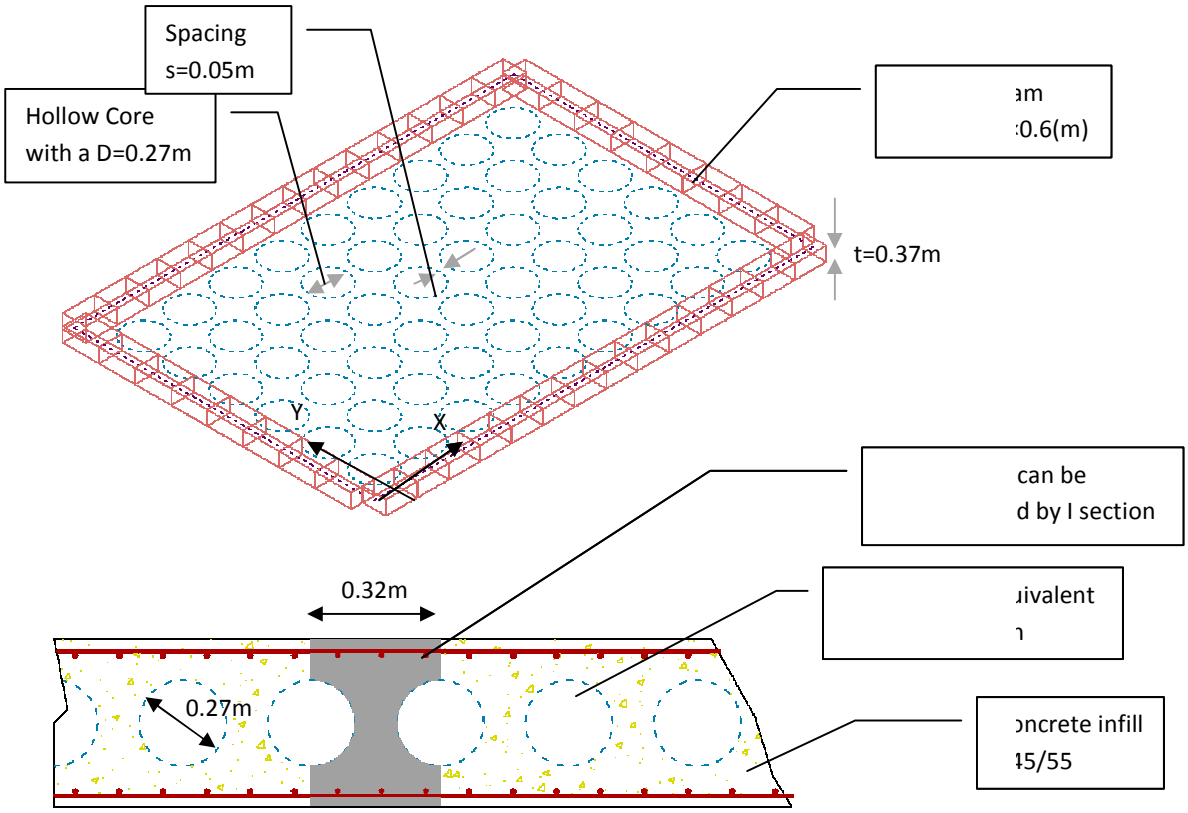
According to EN1991-1 [6.3.3] value of actions on garages and vehicle traffic areas, we define area in -3F and -2F regarding their design purpose as Category F.

Category of traffic areas F, for traffic and parking areas for light vehicles, examples: garages, parking areas.
Value of action as is specified in the subsequent Table 6.8: $q_k = 1.5 \text{to} 2.5\,\text{kN/m}^2$. To be conservative, here we choose $2.5\,\text{kN/m}^2$.

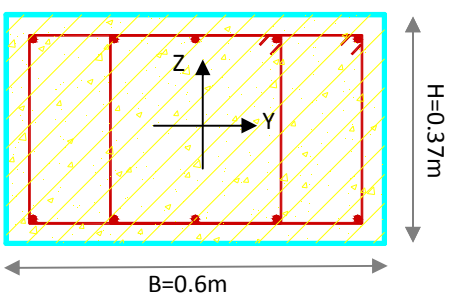
Category for roofs is also defined in EN1991-1 [6.3.4]: Roofs shall be categorised according to their accessibility into 3 categories as shown in Table 6.9.
As for the specific use: roofs not accessible except for normal maintenance and repair, we may choose category H for the loaded area.
Check Tale 6.10 [Imposed loads on roofs of category H], we get $q_k = 0.4\ \text{kN/m}^2$ as recommended.

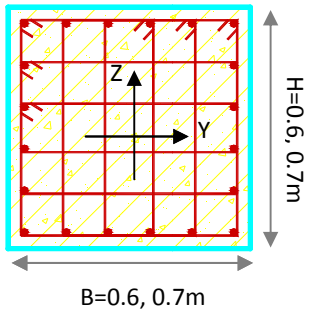
Section Types and Dimensions

-Plate Section



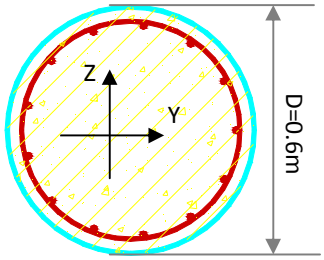
-Beam & Column Sections





Primary Beam Section

Internal Column Section

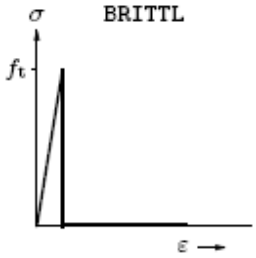


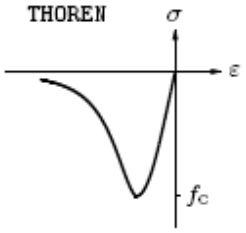
External Column Section

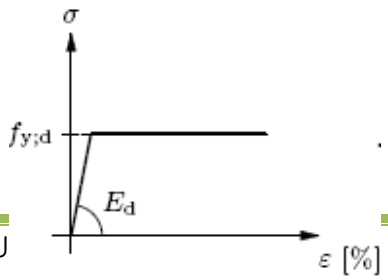
Item	Beam ▭	Rec.Colum □	Cir.Colum ○	Unit
Area	2.22E-01	3.60E-01	2.83E-01	m^2
Asy	1.85E-01	3.00E-01	2.54E-01	m^2
Asz	1.85E-01	3.00E-01	2.54E-01	m^2
Ixx	6.24E-03	1.82E-02	1.27E-02	m^4
Iyy	2.53E-03	1.08E-02	6.36E-03	m^4
Izz	6.66E-03	1.08E-02	6.36E-03	m^4

Detailed Property Table.

Materials.







Concrete C45/55→

Compression→

$f_{ck} = 45\text{Mpa}$

$a = 0.85$ (shrinkage and creep)

$\gamma_c = 1.5$ (partial factor)

$f_{cd} = af_{ck}/\gamma_c = 25.5\text{Mpa}$

$E_c = 38.2\text{Gpa}$

Tensile →

$f_{ctm} = 3.8\text{Mpa}$

$f_{ctk,0.05} = 2.66\text{Mpa}$

$a_{ct} = 1.0$

$f_{ctd} = a_{ct} \cdot f_{ctk,0.05}/\gamma_c = 1.773\text{Mpa}$

Concrete C60/75→

Compression→

$f_{ck} = 60\text{Mpa}$

$a = 0.85$ (shrinkage and creep)

$\gamma_c = 1.5$ (partial factor)

$f_{cd} = af_{ck}/\gamma_c = 34\text{Mpa}$

Concrete C90/105→

Compression→

$f_{ck} = 60\text{Mpa}$

$a = 0.85$ (shrinkage and creep)

$\gamma_c = 1.5$ (partial factor)

$f_{cd} = af_{ck}/\gamma_c = 45.33\text{Mpa}$

Steel S460 N/NL→
$f_{yk} = 460\text{Mpa}; \gamma_s = 1.15$
$f_{yd} = f_{yk}/\gamma_s = 400\text{Mpa}$
$E_s = 200\text{Gpa}$

Load Combination.

According to Eurocode [6.4.3.2], Combinations of actions for persistent or transient design situation (fundamental combinations). The general format is written as:

$$E_d = \gamma_{Sd} E\left\{\gamma_{g,j} G_{k,j}; \gamma_P P; \gamma_{q,1} Q_{k,1}; \gamma_{q,i} \psi_{0,i} Q_{k,i}\right\}$$
$$j \geq 1; i \geq 1$$

In our case, the actions are uniformly distributed pressure force on the slab, and simplified as below:

$$p = \gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \psi_{0,1} s$$

where

ψ is combination coefficient (reduction factor) take into account that all the unfavourable effects may not achieved at the same time.

γ_g partial factor for permanent load

$\gamma_{q,1}$ partial factor for primary variable load

$\gamma_{q,2}$ partial factor for secondary variable load, here is snow load "s"

$g_k; q_k$ characteristic value of dead load & live load.

ψ value as recommended in EN1990[Tale A1.1], for different building types & categories

Category A—domestic, residential areas ψ_0=0.7
Category B—Office areas ψ_0=0.7
Category C—Congregation areas ψ_0=0.7

For snow loads see EN1991-1-3 [Table 4.1]
For Region of "Reminder of other CEN member states, for sites located at altitude H<1000m above sea level", choose ψ_0=0.5

Using Static Equilibrium (EQU) for building structures should be verified using the following design values,

$\gamma_{q,1} = \gamma_{q,2} = \gamma_{q,i} = 1.5$(UNFAVOURABLE)

=0 (FAVOURABLE)

γ_G may choose between superior value and its inferior value 1.15~1.35. Here we may choose 1.35. Apply a 1.0 factor to both favourable part and unfavourable part does not give a more unfavourable effect.

As a result, $\gamma_G = 1.35$

Calculation of g_k of the slab.

(distributed area load, in kN/m^2)

- Volumetric density $\rho = 25\ kN/m^3$
- thickness for weight, Area of 'I' section is $0.0611 m^2$ with a width 0.32m, as a result:

$t = 0.191m$

$\rightarrow$

$g_k = \rho \cdot t = 25 \times 0.191 = 4.775\ kN/m^2$

Floor Finishes $= 1.8\ kN/m^2$

Total $g_k = 6.575\ kN/m^2$

Load Combination (area load, uniform distributed, kN/m^2)

Using EQU rule: $p = \gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \Psi_{0,1} s$

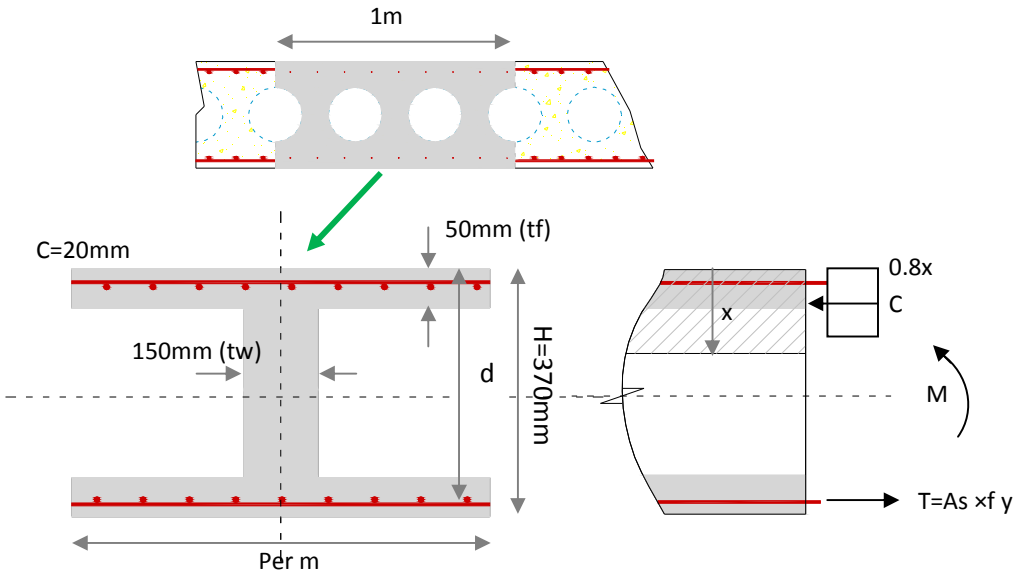
Type	Cate.	g_k kN/m²	q_k	s	Comput.	Computation.	P (G) kN/m²	P (Q) kN/m²
Roof	H	6.575	0.4	1.28	1.35×6.575	1.5×0.4	8.9	0.6
Top2	C1	6.575	2.5	-	1.35×6.575	1.5×2.5	8.9	3.8
Resi	A	6.575	2.0	-	1.35×6.575	1.5×2.0	8.9	3.0
office	B	6.575	2.5	-	1.35×6.575	1.5×2.5	8.9	3.8
public	C3	6.575	3.0	-	1.35×6.575	1.5×3.0	8.9	4.5
garage	F	6.575	2.5	-	1.35×6.575	1.5×2.5	8.9	3.8

SLAB DESIGN

Slab beam between1- 2 and A – F is considered for design.

1. Equivalent slab section.
Simplify the existing slab section with hollow sphere in it by adopting similar "I" section. Principally, the moment of inertial around 2 axis & section area of the representative "I" section

should be the same as the original section. Here, we simply the cross-section by consider a flange of 0.05m thickness while converging the web region within 1m's range into one single web, and thus form the equivalent "I" section. And it's on the safe side in design.



Choosing a concrete cover 20mm thick, and the slab has the same sectional property in XZ

and YZ plane. Compression zone is indicated by x measured from top of the edge, we may calculated for moment resistance M+ & M-.

Formula.

For x<50mm

$\sum F = 0 \rightarrow .8xbf_{cd} = A_s f_{yd}$ (neglect As')

$$M = f_{cd} bx\left(d - \frac{.8x}{2}\right) = A_s f_{yd}\left(d - \frac{.8x}{2}\right) \approx 0.9dA_s f_{yd}$$

For x>50mm

$\sum F = 0 \rightarrow f_c t_w(.8x - t_f) + f_c b t_f = A_s f_{yd}$

$$M = f_{cd} t_w(.8x - t_f)\left(\frac{H}{2} - \frac{.8x}{2} - \frac{t_f}{2}\right) + f_{cd} b t_f\left(\frac{H}{2} - \frac{t_f}{2}\right) + A_s f_{yd}\left(\frac{H}{2} - c\right)$$

We may start with EuroCode minimum requirement for reinforcement. If it's not able to resist given load during the following analysis, we will increase reinforcement ratio.

Since we have a large b=1m, x value is usually small. First try rebar **ø10@200**, which have As =392.7mm^2

→

X=7.7mm<50mm

$M_R(+)=M_R(-)=67.13\ (kN \cdot m)/m$

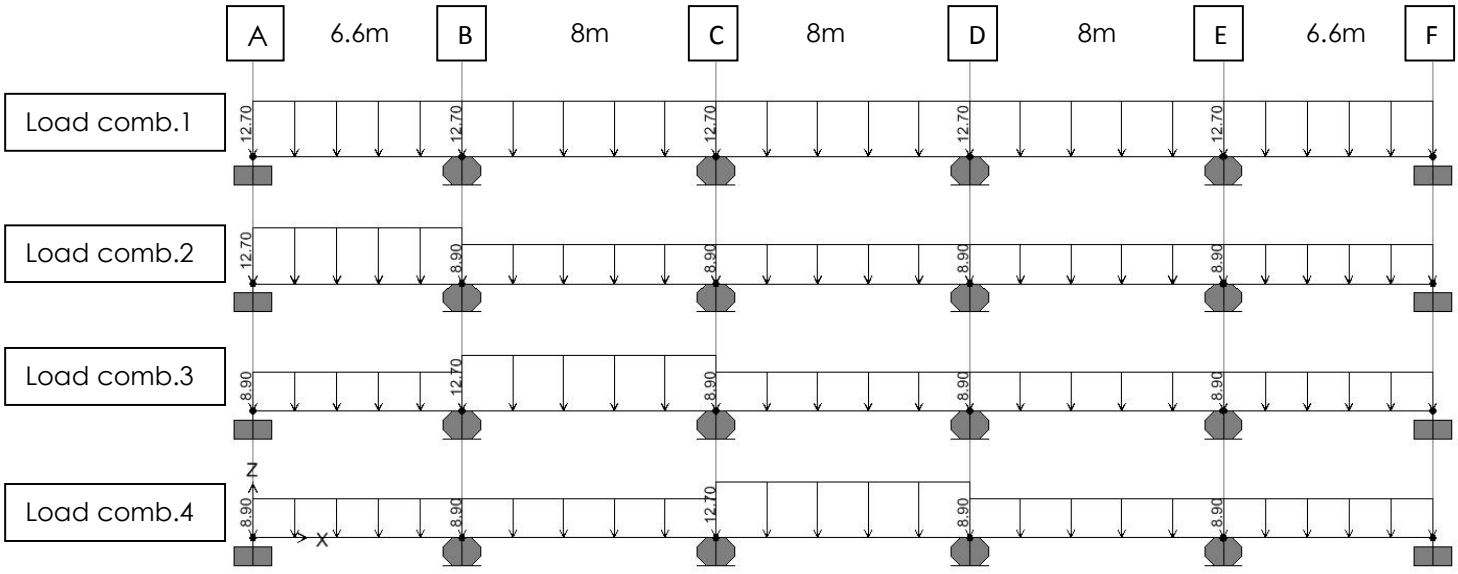
M_E for Slab beam between1- 2 and A – F.

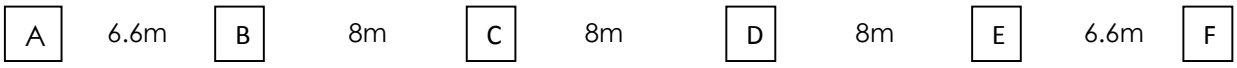
Top2, Office and Garage floors.

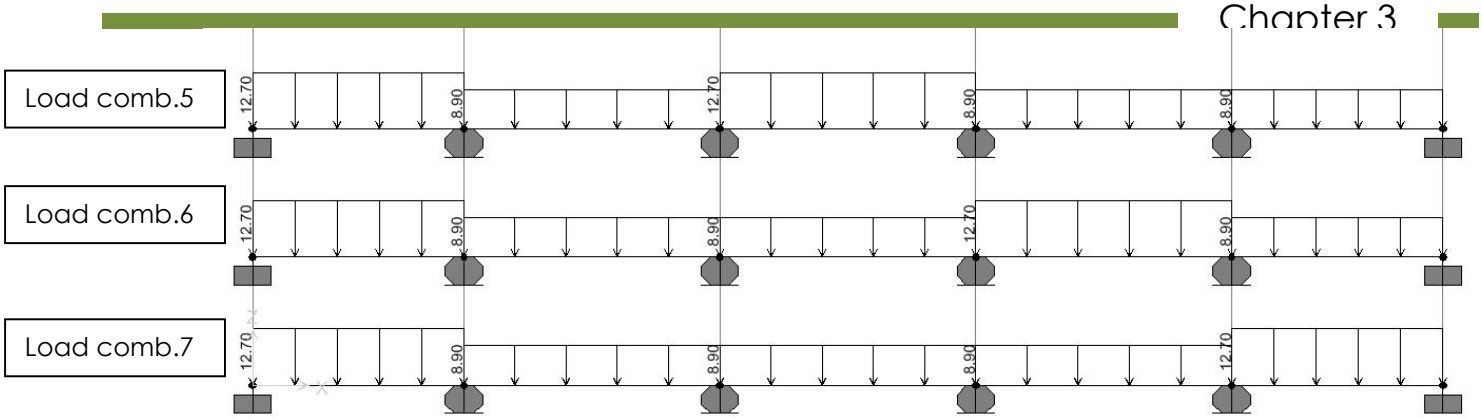
P (G) = 8.9 kN/m

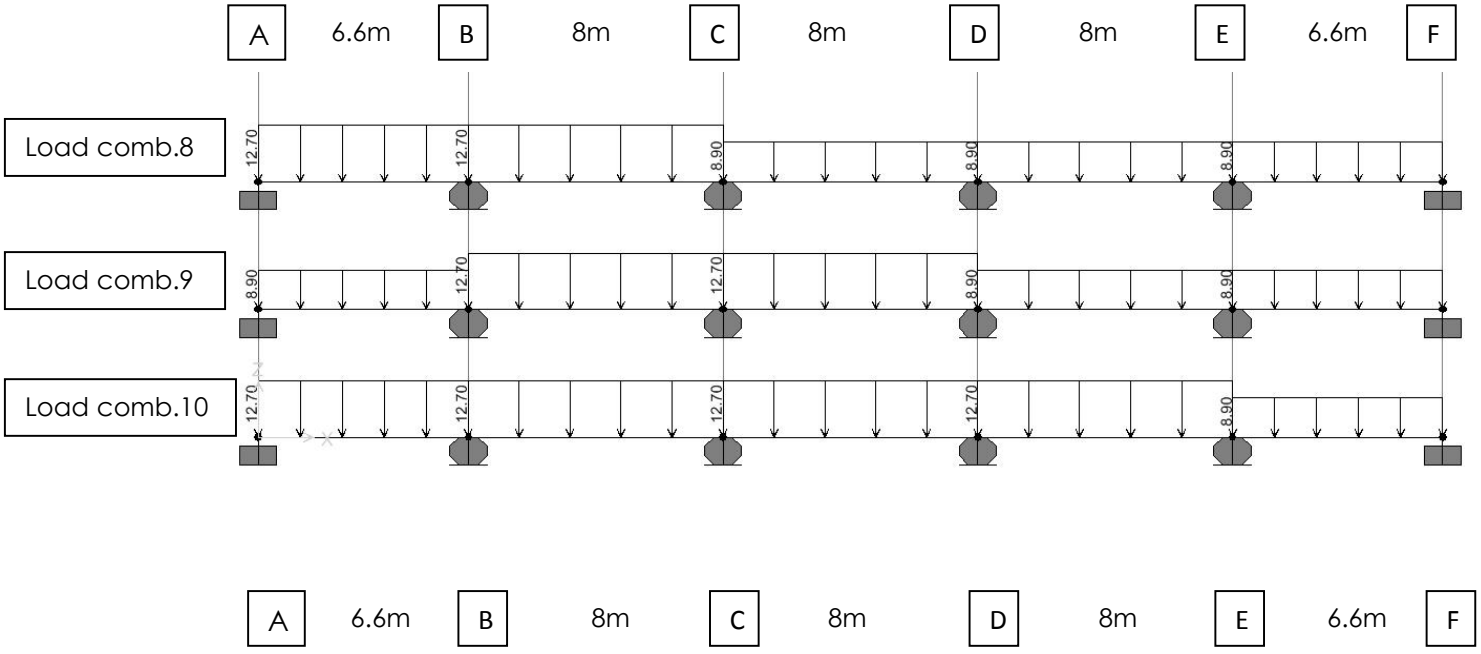
P (Q) = 3.8 kN/m

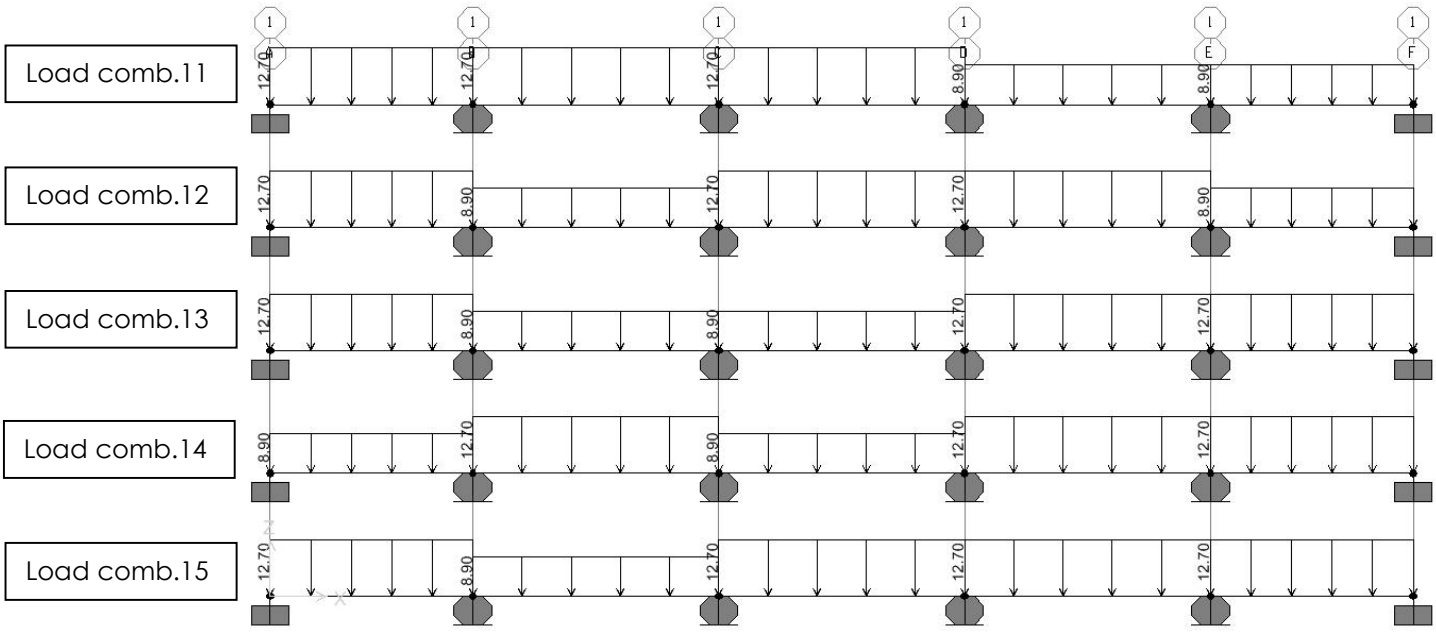
To analyze the slab beam different load combinations are adopted, which are shown below,






Load comb.5
Load comb.6
Load comb.7
12.70
8.90

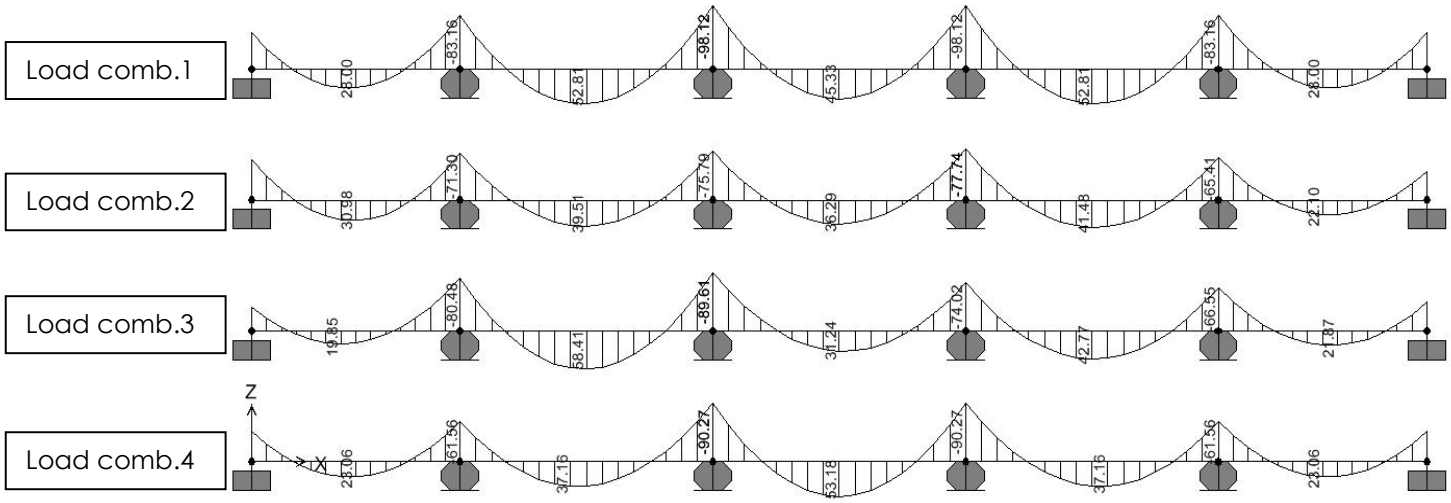

A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.8
Load comb.9
Load comb.10
12.70
8.90

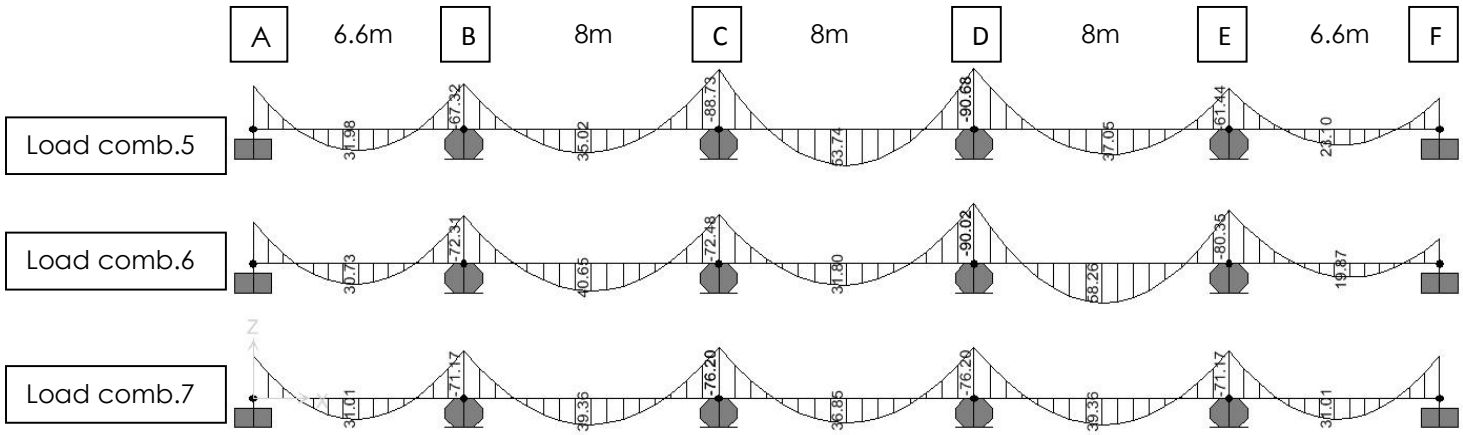


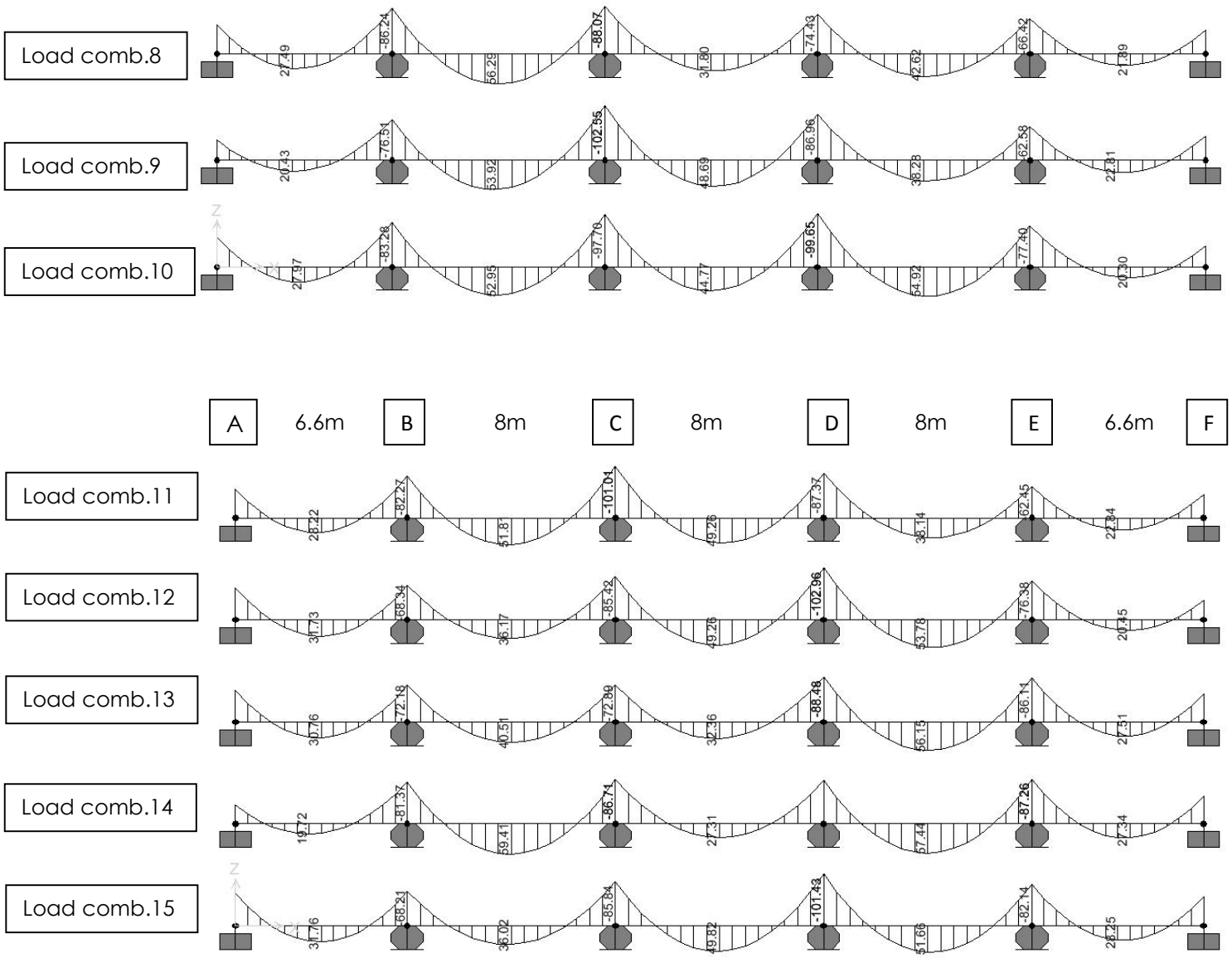
Remaining load combinations are symmetric with above mentioned combinations.

The maximum bending moment is obtained by analyzing the bending moment diagrams produced by different load combination.

A 6.6m B 8m C 8m D 8m E 6.6m F


Load comb.1
Load comb.2
Load comb.3
Load comb.4
Z
X


A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.5
Load comb.6
Load comb.7
Z



The maximum moment obtained by these load combination is,

$M_E(+)$= 59.41 kN.m (Load combination 14)
$M_E(-)$= 102.96 kN.m (Load combination 12)

$M_R(+)=M_R(-)$=67.13 kN.m For $M_E(+)$ ***ok***

But for M_E(-), Reinforcement should be revised

Try rebar **Ø10@100**, which have As =785.4mm²
→
X=15.4 mm<50mm
M_R(-)=134.27 $(\mathrm{kN}\cdot\mathrm{m})/\mathrm{m}$ now its **ok**

CHECKS
For positive bending moment.
X/d ≤ [∈ $cu1$/(∈ $cu1$+∈ yd)]

7.7/342 ≤ [3.5/(3.5+2)]

0.022 ≤ 0.636 **OK!**

According to Eurocode, EU2 – 9.2.1.1. Expression 9.1, The minimum requirement of area of steel.

$$A_{s,min} = 0.26\left(\frac{fctm}{f_{yk}}\ bd\right)$$

but not less than 0.0013bd.

$$A_{s,min} = 0.26\left(\frac{3.8}{460}\ bd\right)$$

$$A_{s,min} = 734.55mm^2$$

$$A_s = 392.7\ mm^2$$

A_s =392.7 mm^2 < $A_{s,min}$ =734.55mm^2 Not OK
But, 0.00214bd > 0.0013bd. **OK!**

For Negative bending moment.
X/d ≤ [∈ $cu1$/(∈ $cu1$+∈ yd)]

15.4/342 ≤ [3.5/(3.5+2)]

0.045 ≤ 0.636 **OK!**

According to Eurocode, EU2 – 9.2.1.1. Expression 9.1, The minimum requirement of area of steel.

$$A_{s,min} = 0.26\left(\frac{fctm}{f_{yk}}\ bd\right)$$

but not less than 0.0013bd.

$$A_{s,min} = 0.26\left(\frac{3.8}{460}\ bd\right)$$

$$A_{s,min} = 734.55mm^2$$

$$A_s = 785.4\ mm^2$$

A_s =785.4 mm^2 > $A_{s,min}$ =734.55mm^2 **OK!**

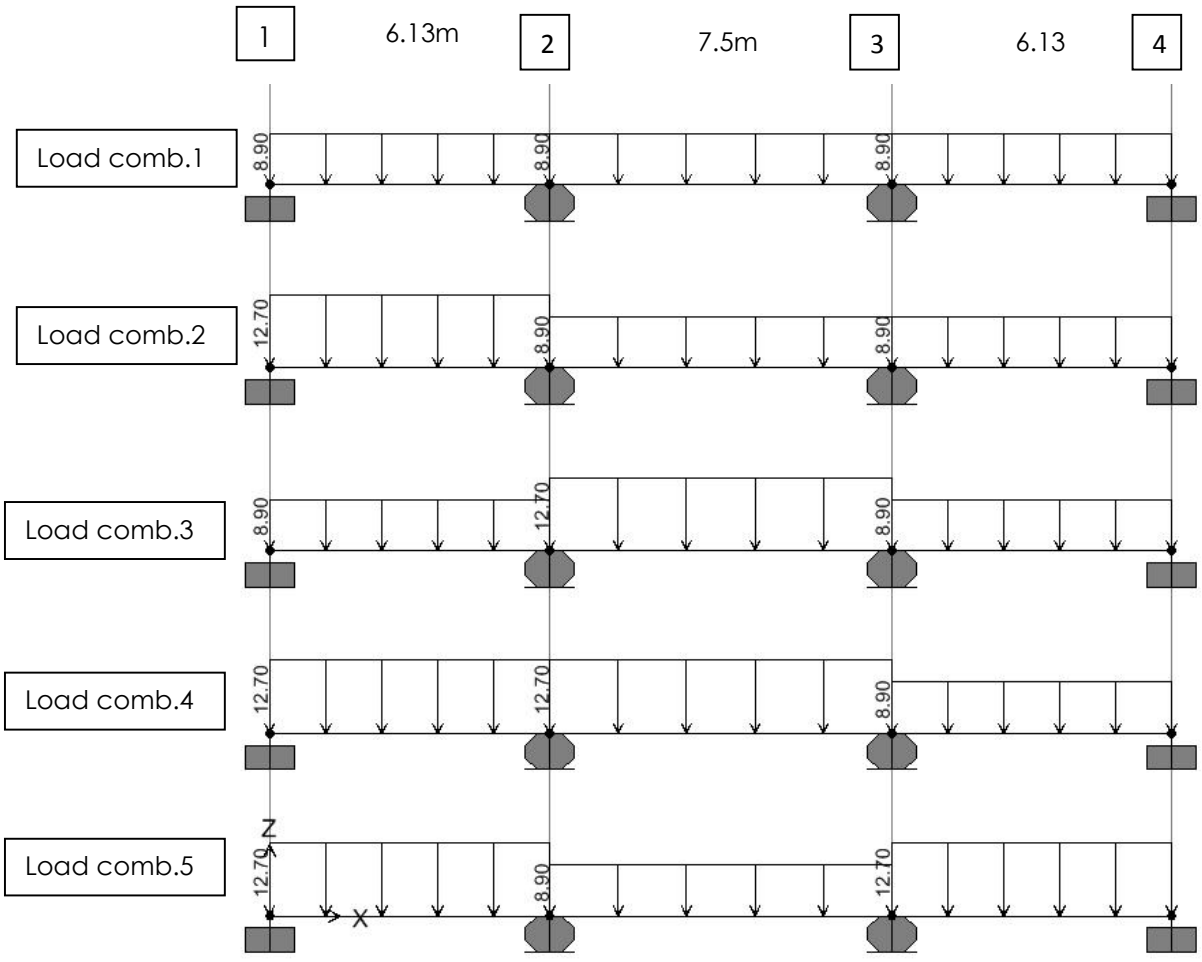
0.00214bd > 0.0013bd. **OK!**

Slab beam on shorter side (A and 1 – 4).

M_E for Slab beam atA and 1 – 4.

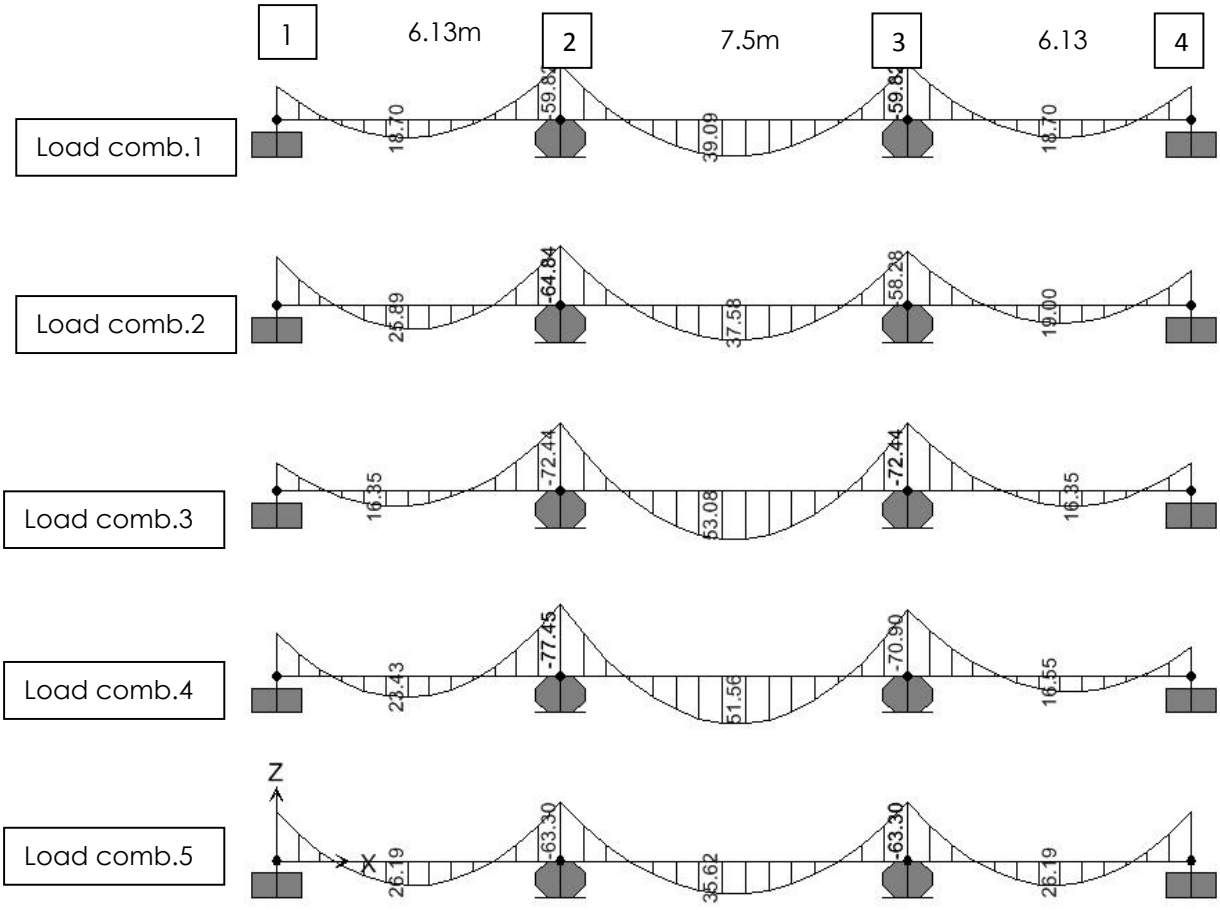
Top2, Office and Garage floors.
P (G) = 8.9 kN/m
P (Q) = 3.8 kN/m

To analyze the slab beam different load combinations are adopted, which are shown below,



Remaining load combinations are symmetric with above mentioned combinations.

The maximum bending moment is obtained by these load combination is as follow,



The maximum moment obtained by these load combination is,

$M_E(+)$= 53.08 kN.m (Load combination 14)
$M_E(-)$= 77.45 kN.m (Load combination 12)

$M_R(+)=M_R(-)$=67.13 kN.m For $M_E(+)$ ***ok***

But for M_E(-), Reinforcement should be revised

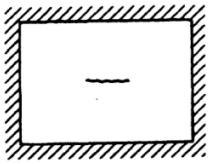
Try rebar **Ø10@100**, which have As =785.4mm^2
→
X=15.4 mm<50mm
M_R(-)=134.27 $(kN \cdot m)/m$ now its ***ok***

Extra conceptual study of Slabs behaviour.

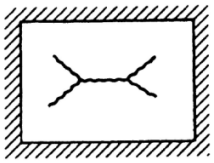
2.Theory of Yield-Lines Method
-A method of upper bound approach
This method is an upper bound approach, since:
(1) the ultimate load is evaluated by postulating a collapse mechanism (compatible with the boundary conditions)
(2) equilibrium is enforced via the Principle of Virtual Works, by equating the work done by the external loads to the work (= energy) dissipated along certain particular lines, called yield lines.
(3) Being an upper bound approach, this method gives ultimate loads that
are either correct or conservatively higher.
(4) For a generic mechanism, the bending moment at the generic point of the slab is not below the resisting moment of the slab section (= M_{Rd}).

-Propagation of yield lines
Consider a reinforced concrete slab that is progressively loaded to failure:
(1) prior to cracking, the distribution of bending moments is as according to linear elastic theory;
(2) after cracking the distribution of the bending moments changes due to the decrease in flexural rigidity of the cracked portions;
(3) with further loading, yielding of tension steel occurs, and the slab undergoes a redistribution of the bending moments (with the moments at the yield locations remaining practically constant).

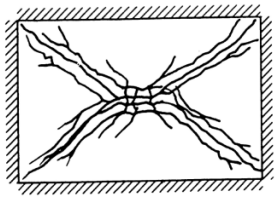
(4) As the load on the slab is further increased, the lines of intense cracking (across which the steel has yielded) will propagate until a sufficient number of lines is attained, for a collapse mechanism to be formed. These lines are referred to as yield lines.
(5) The yield line distribution at collapse is called a yield line pattern.
(6) The first yielding of the tension steel generally occurs at the location of the maximum bending moment; however, the final yield line pattern depends on a variety of factors (reinforcement arrangement, boundary conditions, type of loading).
(7) A yield line is an idealization for a band of intense cracking across which the tension steel has yielded; for the purpose of analysis, the band is represented by a single line at the centre of the band.
(8) It is clear that, for the collapse load to be reached, the yield line must have a sufficient plastic rotation capacity (= ductility).

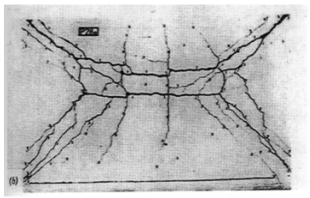


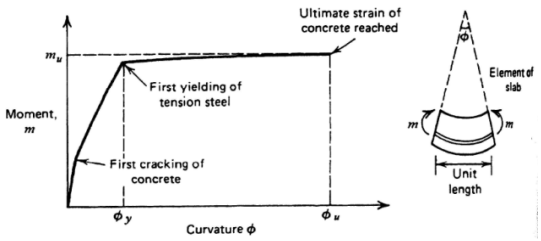
First yielding



Further development of yield lines







-General rule to establish yield line pattern
(1) Once the collapse mechanism has developed, the deformations along the yield lines (= plastic deformations) are much greater than the elastic deformations of the slab between the yield lines (= elastic deformations).
(2) Hence, it is reasonable to assume that, once a mechanism has formed, the slab segments between the yield lines are plane; thus, all additional deformations take place at the yield lines.
(3) This gives three basic rules for the

determination of a yield line pattern:

i. yield lines must be straight, acting as axes of rotation for the rigid slab segments in between;

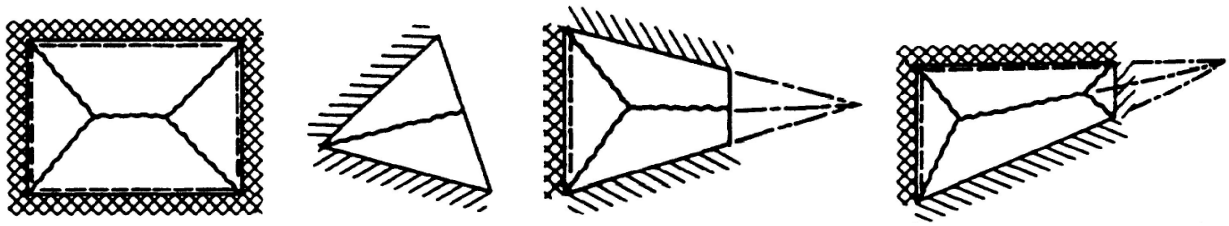
ii. the supported (or clamped) edges will act as axes of rotation;

iii. axes of rotation pass through point supports;

iv. a yield line must pass through the intersection of the axes of rotation of adjacent segments.

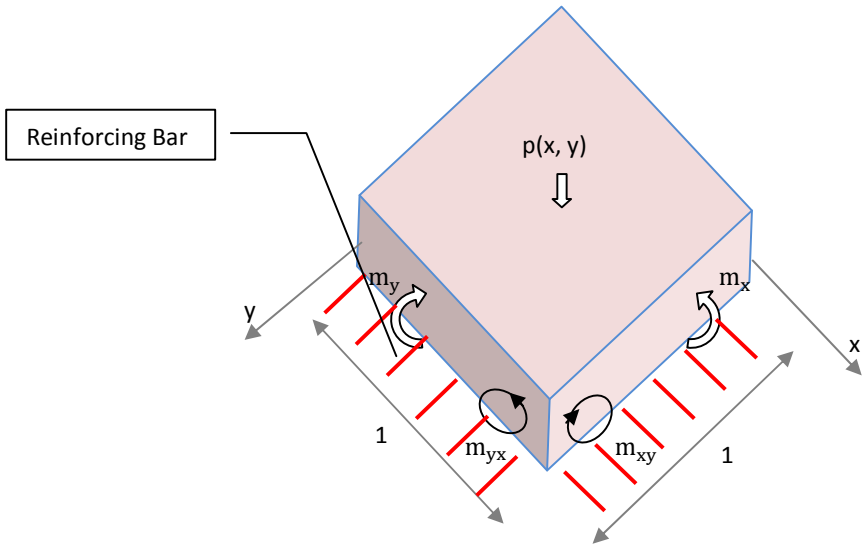
(4) If multiple yield line patterns are possible, the most likely to occur is the one corresponding to the lowest ultimate load.

Yield line patterns used in our case:



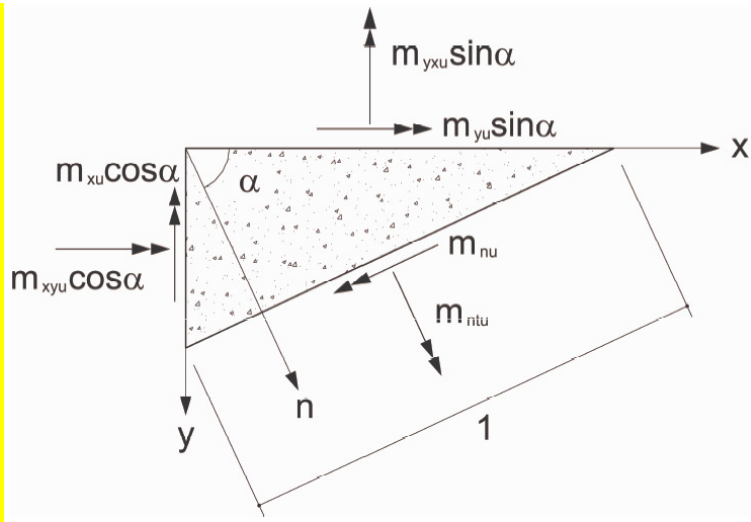
Theory of Calculation of the resisting moment.

Generally, slabs are reinforced by multi-directional reinforcing bars (typically in the x and y directions). Moreover, as in the previous examples, a yield line is not always normal to the reinforcement direction.



The reinforcing bars are assumed to act as wires:
- Their bending stiffness is neglected;
- They can develop only normal stresses;
- Only bending moments are developed (no twisting moments).

Ultimate Moment Calculation.



Governing Equations:

$$m_{un} = m_{xu}\cos^2(a) + m_{yu}\sin^2(a)$$

$$m_{ntu} = (m_{xu} - m_{yu})\sin(a)\cos(a)$$

The slab can develop a torsional moment across the yield line, although the two reinforcement cannot.

Consider the following case:

- $m_{xu} = m_{yu} \Rightarrow$ same amount of rebars in x and y
- $m_{un} = m_{xu}[\cos^2(a) + \sin^2(a)] = m_{xu} = m_{yu}$
- $m_{ntu} = (m_{xu} - m_{yu})\sin(a)\cos(a) = 0$

Such a slab is said to be isotropic, or isotropically reinforced.

When $m_{xu} \neq m_{yu}$ the slab is said to be orthotropic, or orthotropically reinforced; in this case, the ultimate bending moment depends on the orientation of the yield line.

In our case, we apply same amount of reinforcement along two directions, as a result, it's isotropically reinforced.

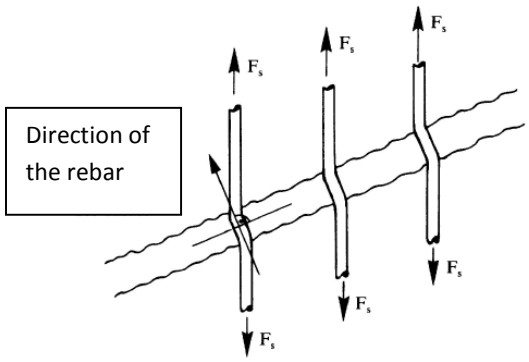
Johansen's yield criterion for calculating the ultimate moment.

This criterion is based on the following assumptions:

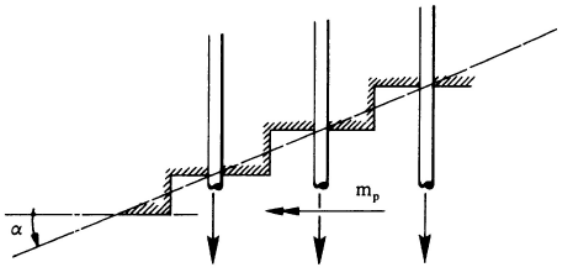
(1). the actual yield line can be replaced by a "stepped" yield line, consisting of small steps in the x- and y directions;

(2). the torsional moments acting in the x- and y-direction are 0;

(3). the strength of the section is not influenced by "kinking" of the rebars crossing a yield line.



Wood's assumption: kinking of rebars



Johansen's assumption: rebars remain straight

Determination of the Ultimate Load: Virtual Work Equation – External Loads.

To analyze a slab by the Virtual Work Principle:

(1) a yield line pattern is postulated.

(2) a convenient point within the slab is chosen, and given a small displacement "d" in the direction of the load.

(3) the resulting displacements at all points of the slab d(x,y), as well as the rotations of the slab segments about the yield lines may be found as a function of d.(4) note that the

support reactions do not contribute, because the supports do not undergo displacements.

(5) the work done by a generic load w(x,y) can be calculated by the following equation:

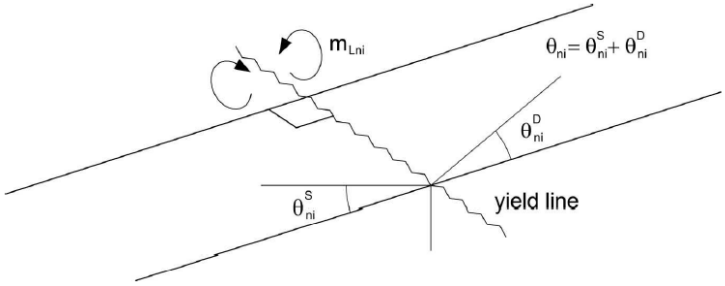
External work = ∫∫w(x,y)d(x,y)dxdy

Determination of the Ultimate Load: Virtual Work Equation – Internal Work.

The work done by the internal actions at the yield lines will be due to only the bending moments, because the work done by the torsional moments and the shear forces is zero, when summed over the whole slab:

(1) this is due to the fact that these actions are equal and opposite, on the faces of the same yield line;

(2) moreover, for any displacement of the yield line, there is no relative displacement between the slab segments adjacent to the yield line (other than a rotation normal to the yield line).



Therefore, the internal work is due only to the bending moments:

Internal work = $\Sigma_i m_{nu} l_i \Theta_{ni}$

By equating the external work to the internal work, the virtual work equation may be written as

$\iint w(x,y)d(x,y)dxdy = \Sigma_i m_{nu} l_i \Theta_{ni}$

When applied to a particular slab, the displacement term cancels from the equation

and the ultimate load is given in terms of the slab dimensions and the ultimate moments per unit width.

Minimum-Load Principle

- In most cases, a yield line pattern cannot be drawn without unknown dimensions locating the yield line positions.
- In these cases, the unknown dimensions will be included in the Virtual Work Equation, which will be expressed in the form:

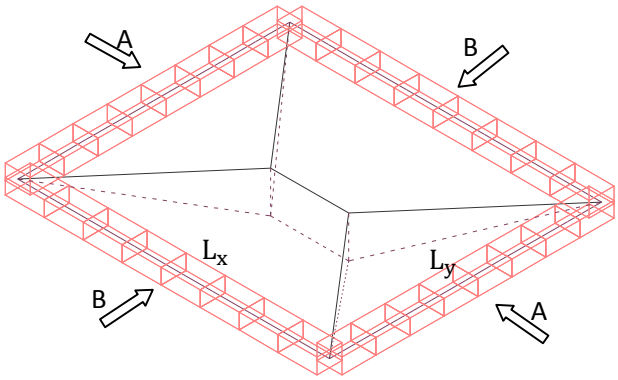
Wu = f(L1, L2, L3…)

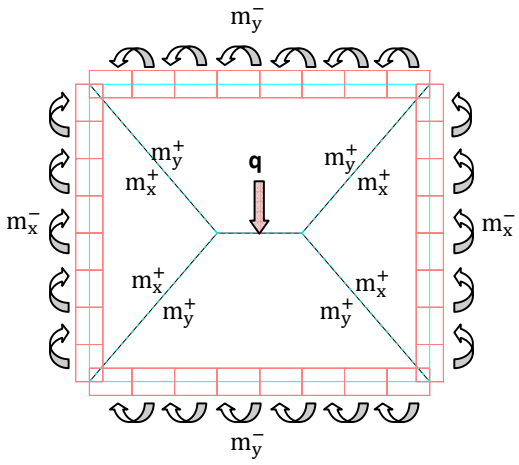
- Since an upper bound approach is used, the values of the unknowns are those that minimize Wu:

$\partial W_u/\partial L_1 = 0;\ \ \partial W_u/\partial L_2 = 0;\ \partial W_u/\partial L_3 = 0\ \ \ldots$

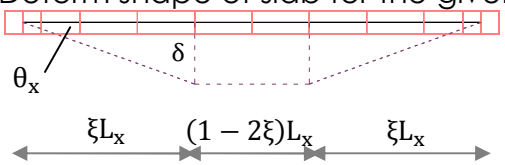
3. Verify the Capability of Slab section using Yielding Line Method

For Slab 1 (7.5×6.54)(m) Shape: Rectangular

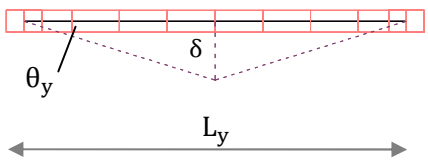




Deform shape of slab for the given yield line pattern



A-A



B-B

Failure Mechanism (upper-bound Approach).
The slab is fix supported in its 4 sides.
Given a typical yield line pattern due to uniform distributed load.
We design the reinforcement and know m_x^+, m_x^-, m_y^+, m_y^-. So the only unknown here is q and ξ.
Bearing Capacity is checked for **q>p**
- p is uniformly distributed external pressure load on the upper surface of the slab whose value is calculated before in the load combination table for different floors and situations.
- q is the maximum homogenous distributed load which the slab can resist. (Design Resisting Value)
- $m_x^+ = m_x^- = m_y^+ = m_y^- = 49.48\ (kN \cdot m)/m$
- L_x=7.5m (longer edge)
- L_y=6.54m (shorter edge)
- As=As'=392.7mm^2

Formula for Calculation→
Internal Energy Dissipation = moment resistance × rotation × yield line length

$$\theta_x = \frac{\delta}{\xi L_x};\ \theta_y = \frac{\delta}{0.5L_y}$$

$$W_I = 2 \cdot m_x^- \theta_x L_y + 2 \cdot m_y^- \theta_y L_x + \left[m_x^+ \theta_x 0.5L_y + m_y^+ \theta_y \xi L_x\right] \times 4 + m_y^+ \cdot 2\theta_y \cdot (1 - 2\xi)L_x$$

$$\text{Volume} = \frac{1}{3} \times \left[\frac{1}{2} L_y \cdot \xi L_x \cdot \delta\right] \times 4 + \frac{1}{2} \cdot \frac{1}{2} L_y \cdot (1 - 2\xi) L_x \cdot \delta \cdot 2$$

$$W_E = \text{Volume} \cdot q$$

Apply $W_I = W_E$, and minimize the load q, in upper-bound approach $q^{UP} \geq q^c$.

Take advantage of Excel working table, there is an option to minimize q by changing the value of ξ.
Then compare this critical q to the actual load p.
If $\mathbf{q^c} > p$, the section is verified.

Result from excel →
Apply Ø10@200 top and bottom in both directions, minimizing q^c, we get:
$\xi = 0.465;\ q^c = 48.758\ \mathrm{kN/m^2} > p$ **OK!**

SECTION INFO.					
f_{cd} (Mpa)	f_{yd} (Mpa)	B (m)	Ø (mm)	S (mm)	D (mm)
25.5	400	1	10	200	350
As1	As	M_{rd} (kN×m)/m			
78.54	392.70	49.48			

Bearing Capacity Check $(\mathrm{kN/m^2})$		
Type	p	q^c=48.758>p
Roof	8.0	q^c=48.758>p
Top2	10.2	q^c=48.758>p
Resi	9.45	q^c=48.758>p
office	10.2	q^c=48.758>p
public	10.95	q^c=48.758>p
garage	10.2	q^c=48.758>p
The slab section is VERIFIED!		

Calculation of critical q			
mx-	mx+	my-	my+
49.48	49.48	49.48	49.48
lx	ly	Θx	Θy
7.5	6.54	0.29	0.31
VirDis		P	
1		NO	
Wi		Vol.	
824.871		16.918	
ratio ξ		**q_c**	
0.465		**48.758**	

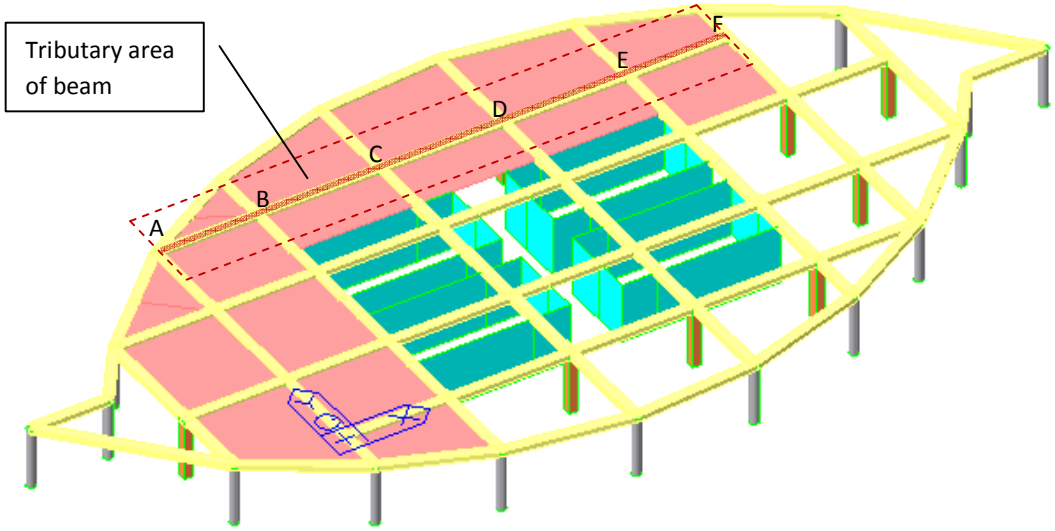
* P is external distributed force
* Wi is internal energy dissipation
* VirDis is Virtual Displacement
* Vol is volume of the prism

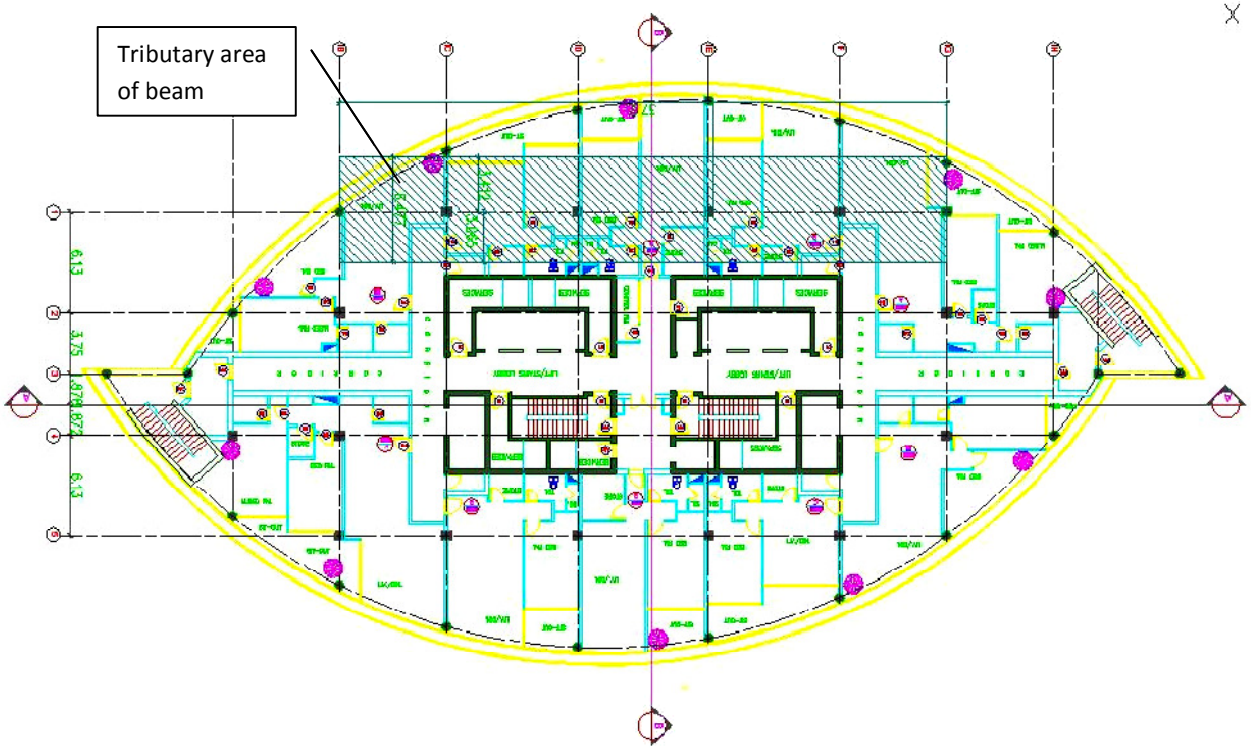
BEAMS DESIGN

Tributary Area

Apply distributed line loads on beams according to the tributary area. Beams are considered as continuous beams.

Tributary area of multi-span continuous beam

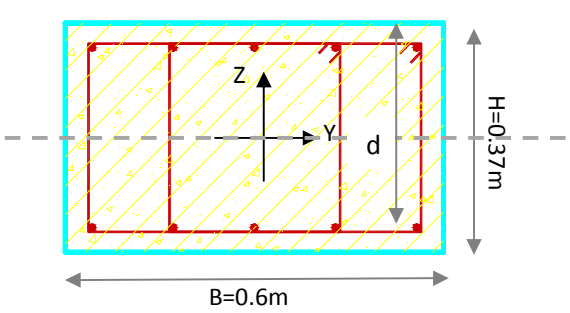


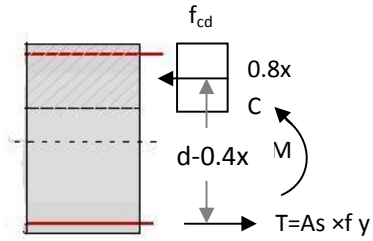


Replace slab with a line loads pattern on primary beams.

Load Combination (area load, uniform distributed, kN/m^2) Using EQU rule: $p = \gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \Psi_{0,1} s$								
Type	Cate.	g_k kN/m²	q_k	s	Comput.	Computation.	P (G) kN/m²	P (Q) kN/m²
Roof	H	6.575	0.4	1.28	1.35×6.575	1.5×0.4	8.9	0.6
Top2	C1	6.575	2.5	-	1.35×6.575	1.5×2.5	8.9	3.8
Resi	A	6.575	2.0	-	1.35×6.575	1.5×2.0	8.9	3.0
office	B	6.575	2.5	-	1.35×6.575	1.5×2.5	8.9	3.8
public	C3	6.575	3.0	-	1.35×6.575	1.5×3.0	8.9	4.5
garage	F	6.575	2.5	-	1.35×6.575	1.5×2.5	8.9	3.8

Line Load on Beam (Load on the beam by tributary method) $p = \gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \Psi_{0,1} s$						
Type	Cate.	P (G) kN/m²	P (Q) kN/m²	Tr.Width m	P (G) kN/m	P (Q) kN/m
Roof	H	8.9	0.6	6.477	57.5	3.9
Top2	C1	8.9	3.8	6.477	57.5	24.3
Resi	A	8.9	3.0	6.477	57.5	19.4
Office	B	8.9	3.8	6.477	57.5	24.3
Public	C3	8.9	4.5	6.477	57.5	29.1
Garage	F	8.9	3.8	6.477	57.5	24.3





Choosing a concrete cover as 20mm thick. Compression zone is indicated by x measured from top of the edge, we may calculated for moment resistance M+ & M-.

Formula.

$$\sum F = 0 \rightarrow 0.8xbf_{cd} = A_s f_{yd} \quad \text{(neglect As')}$$

$$M = f_{cd} b.8x\left(d - \frac{0.8x}{2}\right) = A_s f_{yd}\left(d - \frac{0.8x}{2}\right) \approx 0.9dA_s f_{yd}$$

We start with assumed value of reinforcement. If it's not able to resist given load during the following analysis, we will increase reinforcement ratio.

Since we have a large b=0.6m, x value is usually small.

For Positive moment.

First for the +ive moment, try rebar **15Ø16@4** which have,

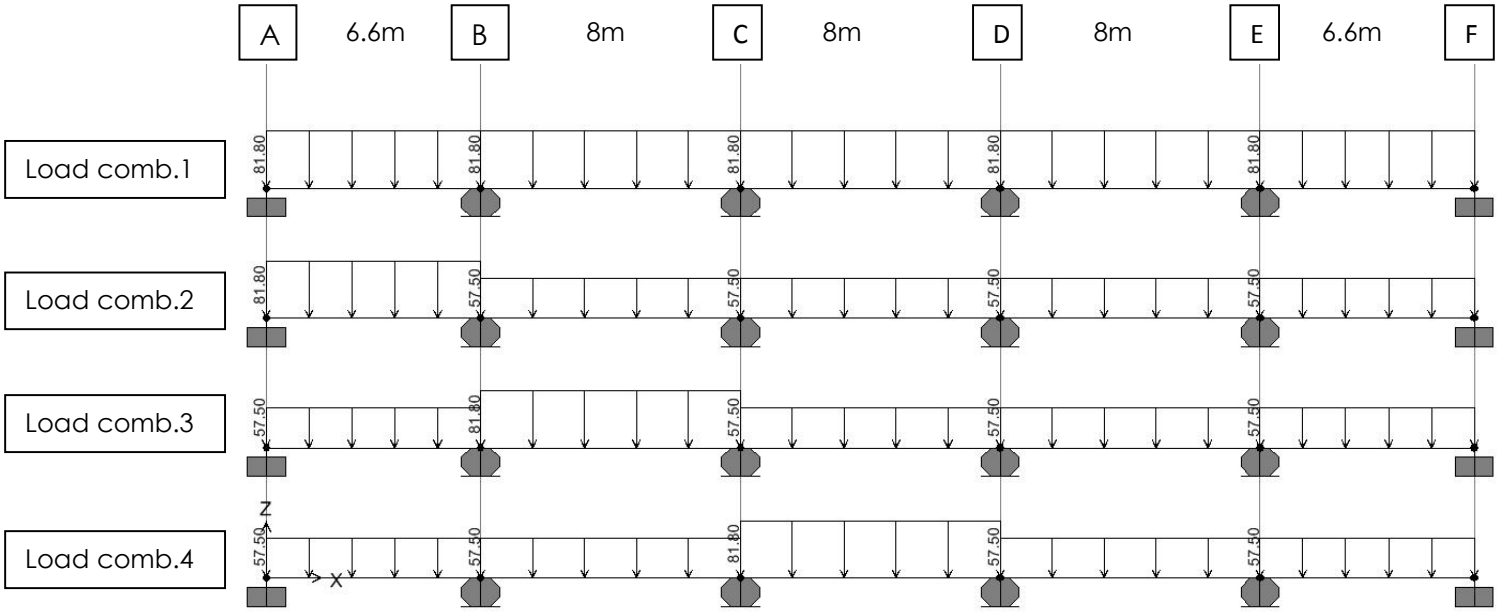
As= 3015 mm^2
→
X=98 mm
d=342 mm

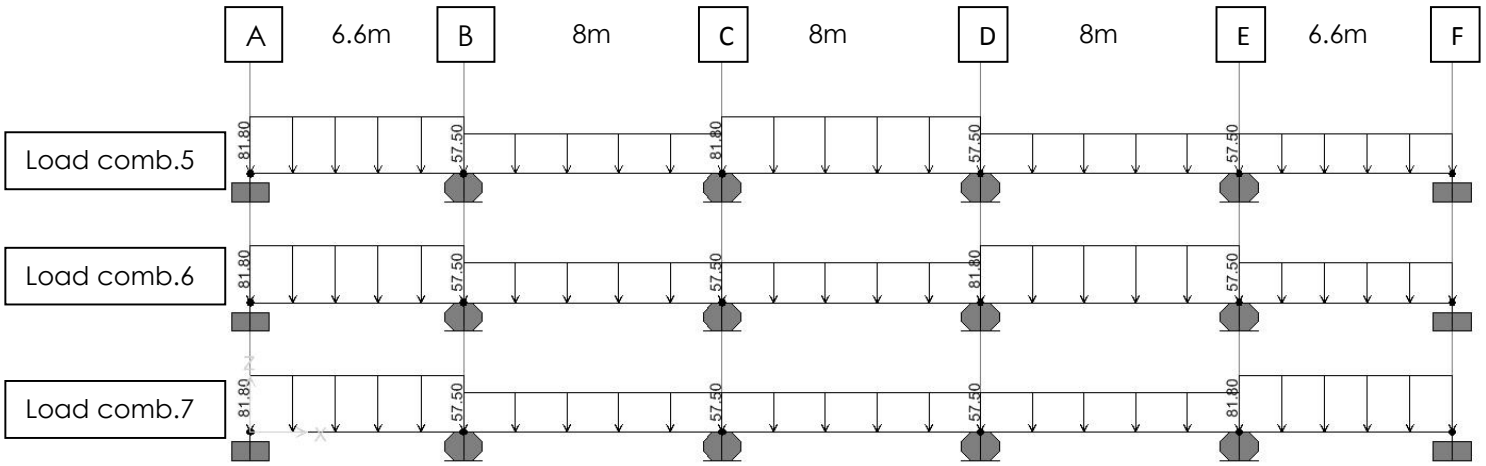
$M_R(+)$=365.17 kN.m **OK!**

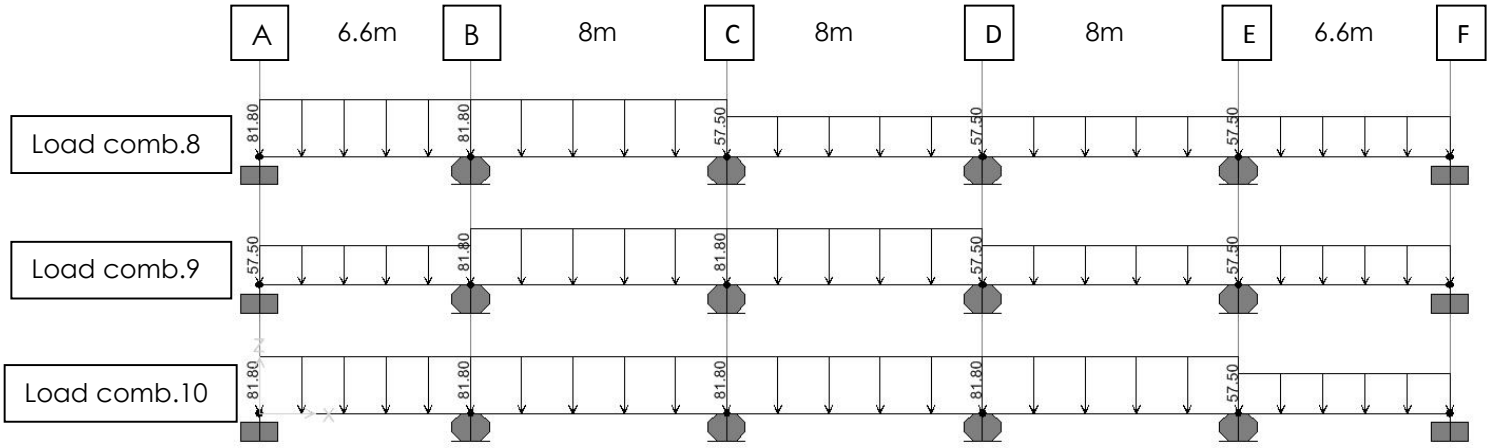
M_E for beam at1and A – F.

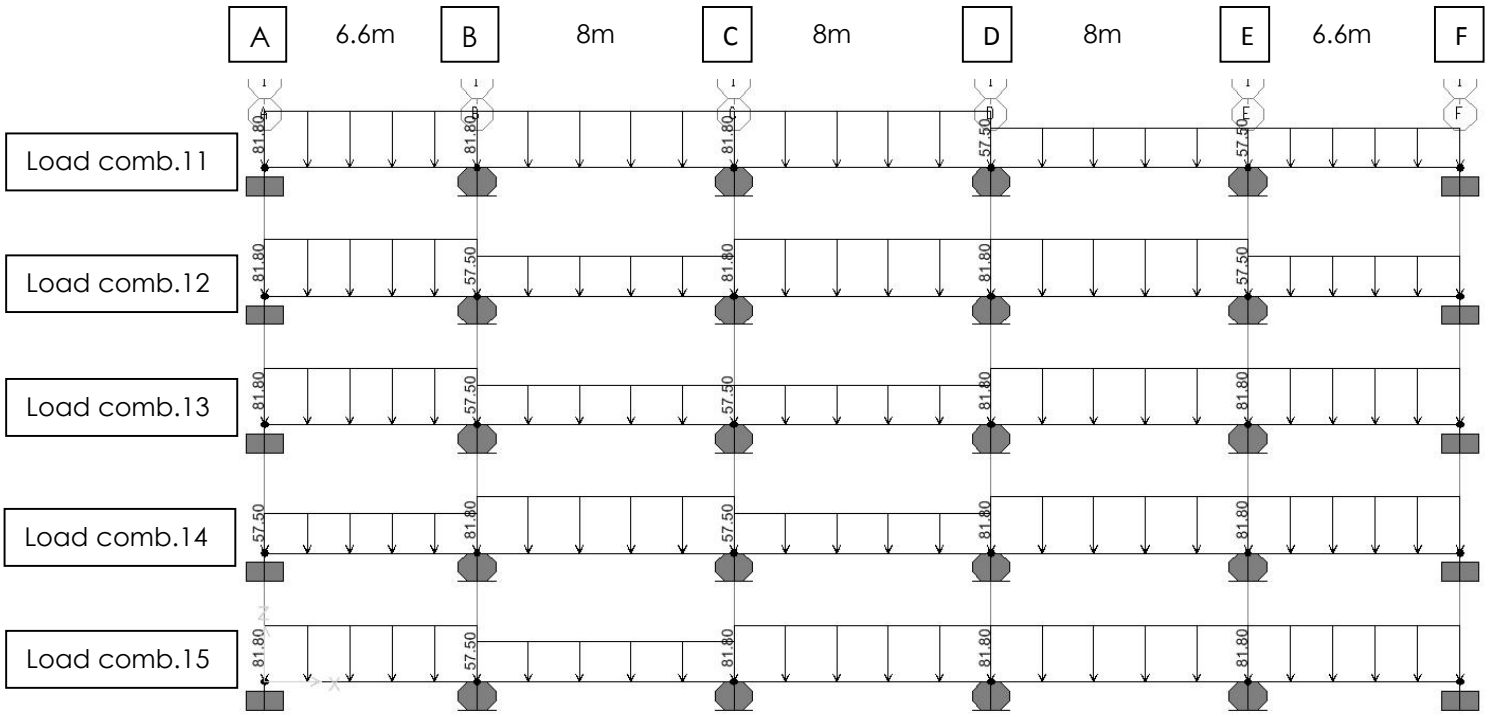
Top2, Office and Garage floors.
P (G) = 57.5 kN/m
P (Q) = 24.3 kN/m

To analyze the beam different load combinations are adopted, which are shown below,



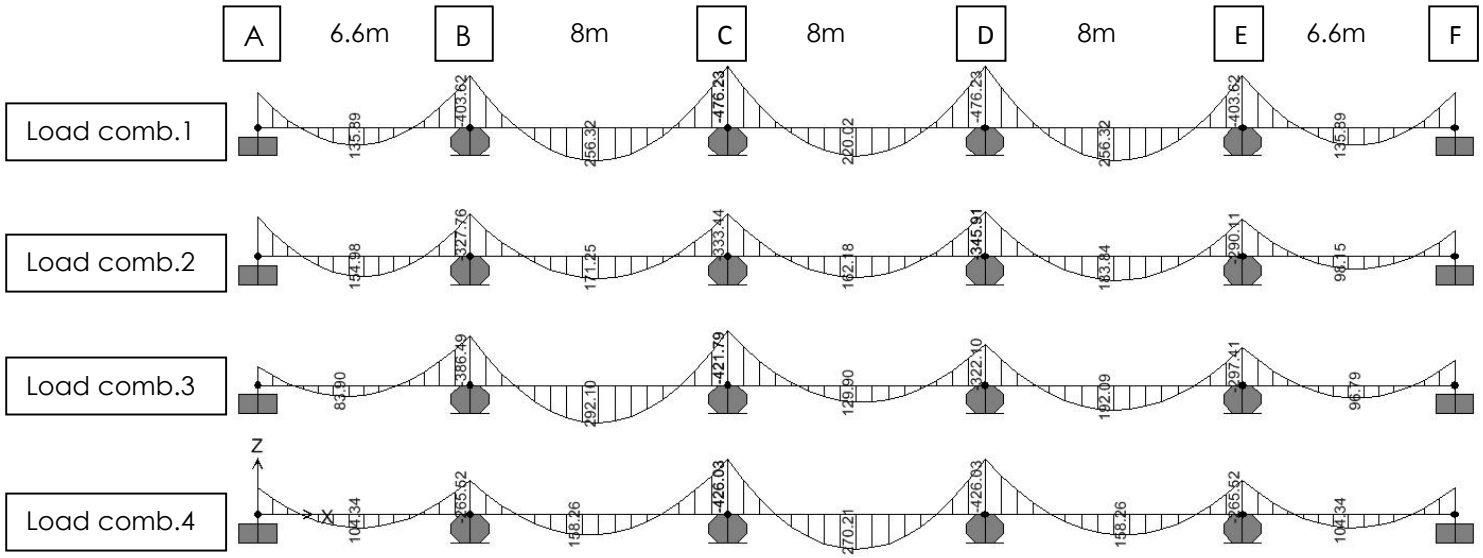

A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.5
Load comb.6
Load comb.7
81.80
57.50

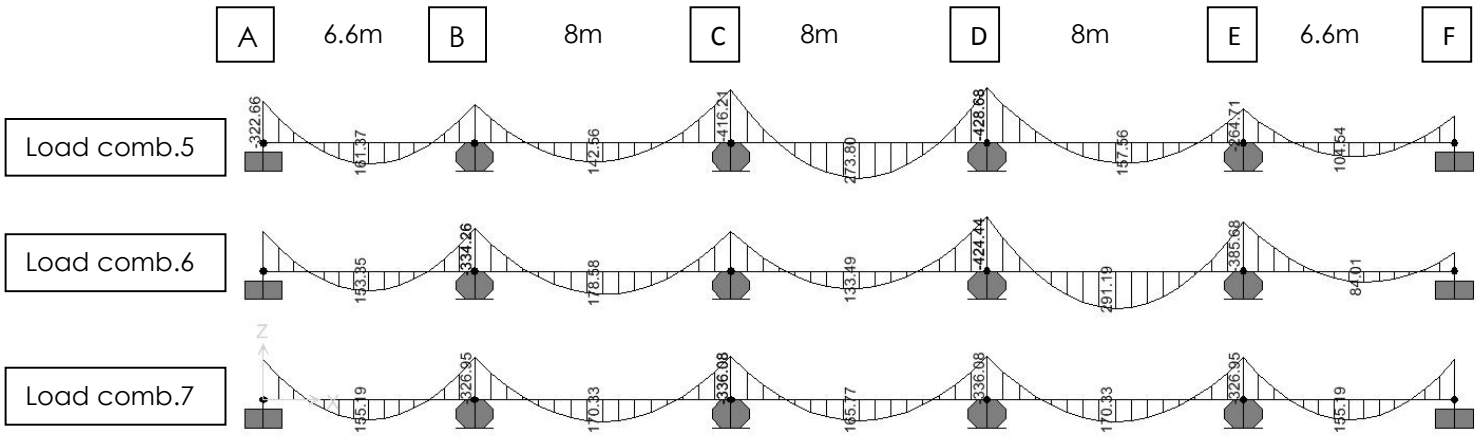

A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.8
Load comb.9
Load comb.10
81.80
57.50

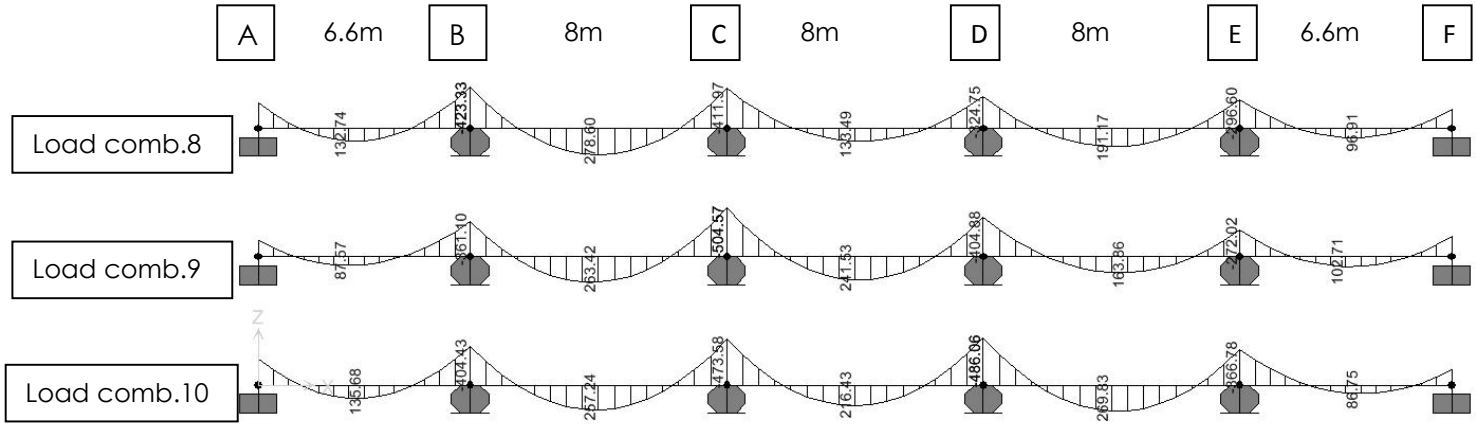


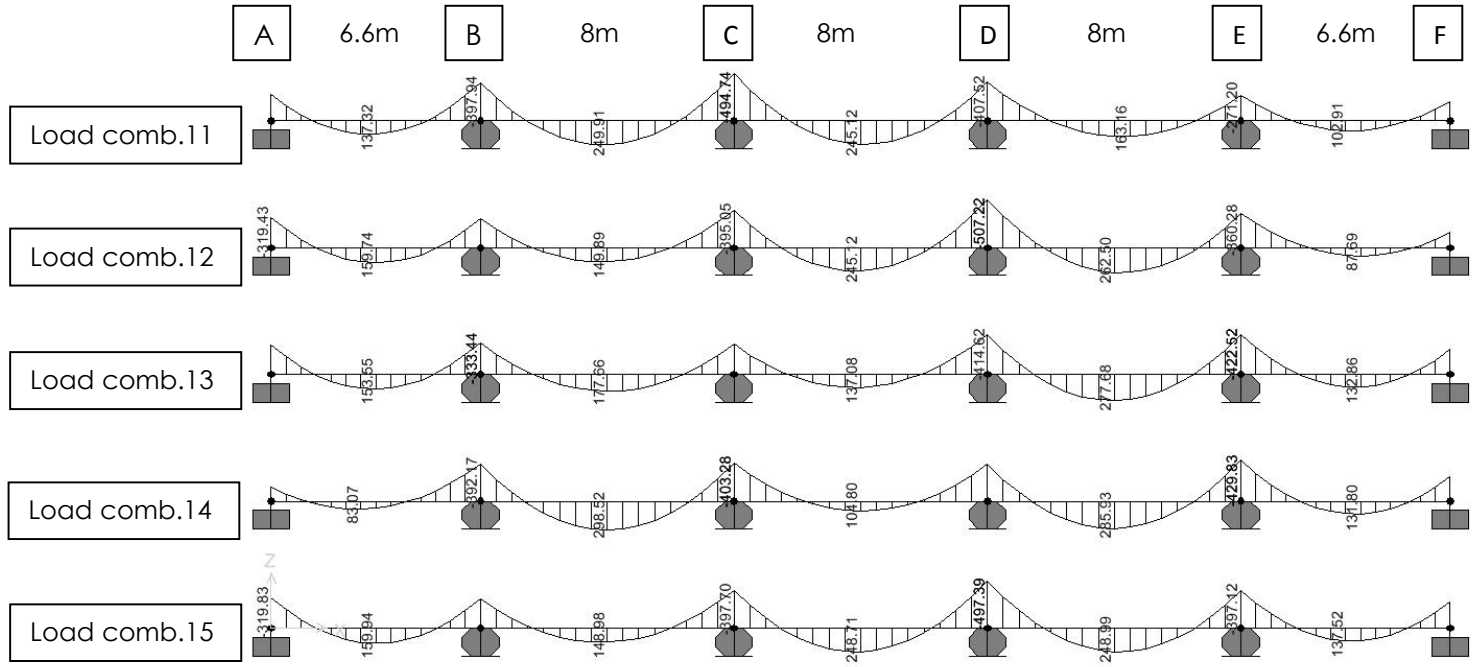
Remaining load combinations are symmetric with above mentioned combinations.

The maximum bending moment obtained by these load combination is as follow,






A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.8
Load comb.9
Load comb.10

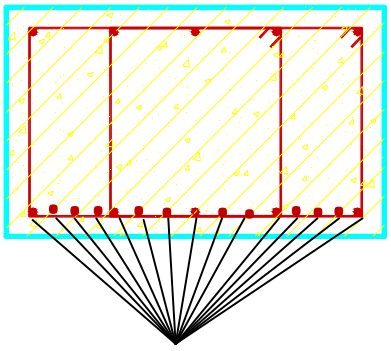

A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.11
Load comb.12
Load comb.13
Load comb.14
Load comb.15

The maximum moment obtained by these load combination is,

$M_E(+)$= 298.52 kN.m (Load combination 14)
$M_E(-)$= 507.22 kN.m (Load combination 12)

$M_R(+)$=365.17 kN.m **OK!**

CHECKS.



15Ø16

X/d $\leq [\epsilon cu1/(\epsilon cu1+\epsilon yd)]$

98/342 ≤ [3.5/(3.5+2)]

0.28 ≤ 0.636 **OK!**

According to Eurocode, EU2 – 9.2.1.1. Expression 9.1, The minimum requirement of area of steel.

$$A_{s,min} = 0.26\left(\frac{fctm}{f_{yk}}\ bd\right)$$

but not less than 0.0013bd.

$$A_{s,min} = 0.26\left(\frac{3.8}{460}\ bd\right)$$

$A_{s,min} = 440.73mm^2$

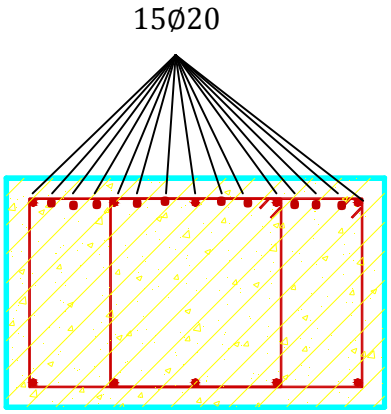
$A_s = 3015.00\ mm^2$

$A_s = 3015.00\ mm^2 > A_{s,min} = 440.73mm^2$ **OK!**

0.00214bd > 0.0013bd. **OK!**

For Negative moment.

First for the -ive moment, try rebar **15Ø20@4** which have,



As= 4710 mm^2
→
X=153 mm
d=340 mm

M_E(-)= 507.22 kN.m (Load combination 12)
M_R(-)= 525.25 kN.m **OK!**

CHECKS

X/d ≤ [$\epsilon cu1/(\epsilon cu1+\epsilon yd)$]

153/340 ≤ [3.5/(3.5+2)]

0.45 ≤ 0.636 **OK!**

According to Eurocode, EU2 – 9.2.1.1. Expression 9.1, The minimum requirement of area of steel.

$$A_{s,min} = 0.26\left(\frac{fctm}{f_{yk}}\ bd\right)$$

but not less than 0.0013bd.

$$A_{s,min} = 0.26\left(\frac{3.8}{460}\ bd\right)$$

$$A_{s,min} = 1695.13mm^2$$

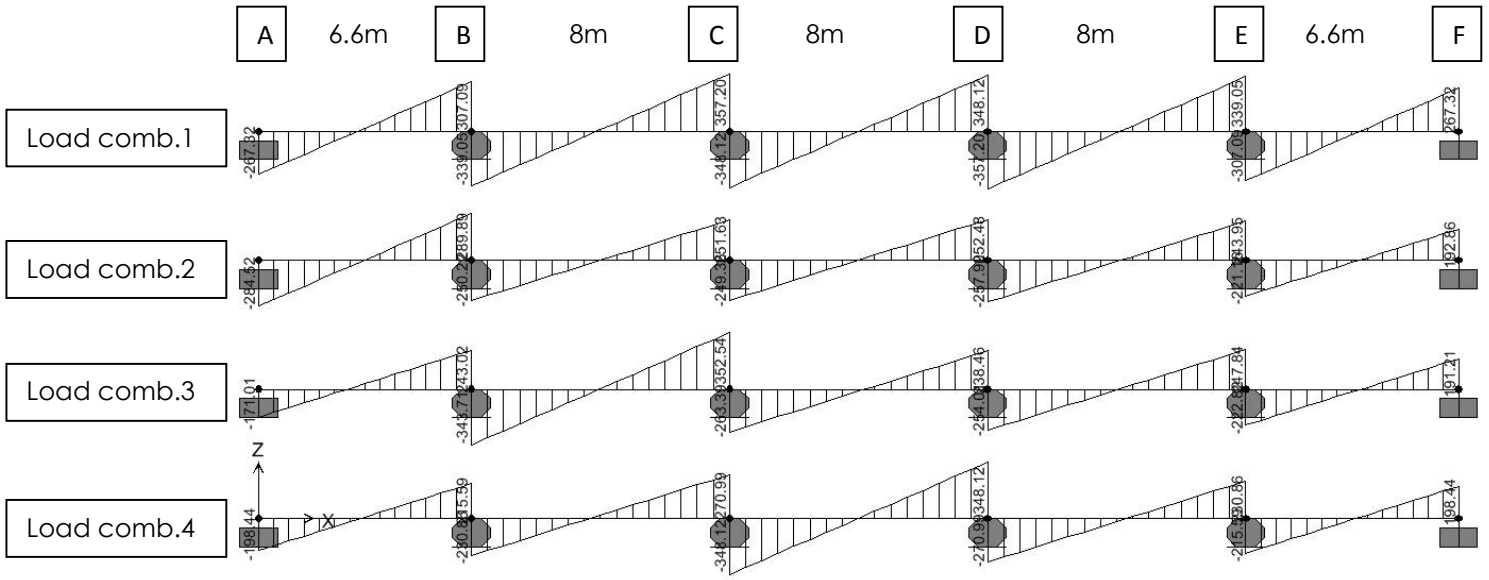
$$A_s = 4710.00\ mm^2$$

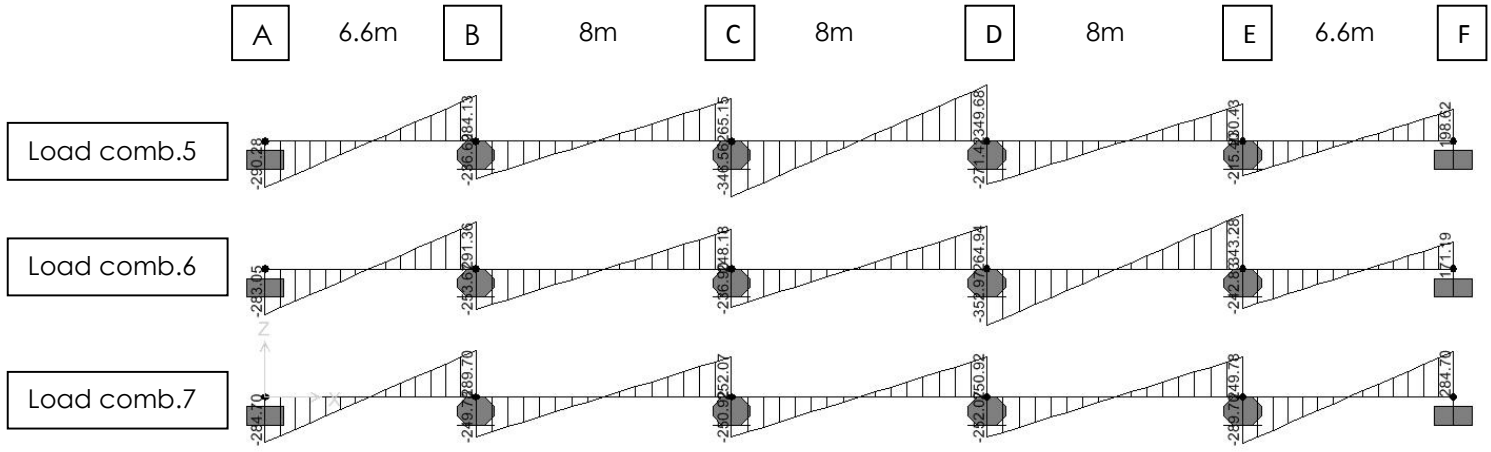
A_s =4710.00 mm^2 > $A_{s,min}$ =438.15mm^2 **OK!**

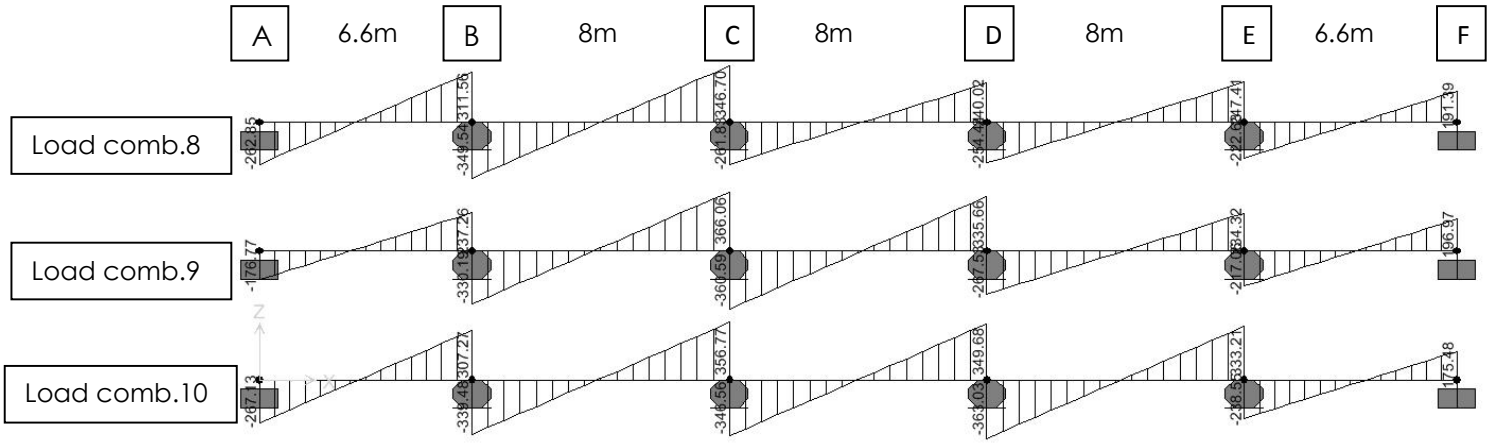
0.00214bd > 0.0013bd. **OK!**

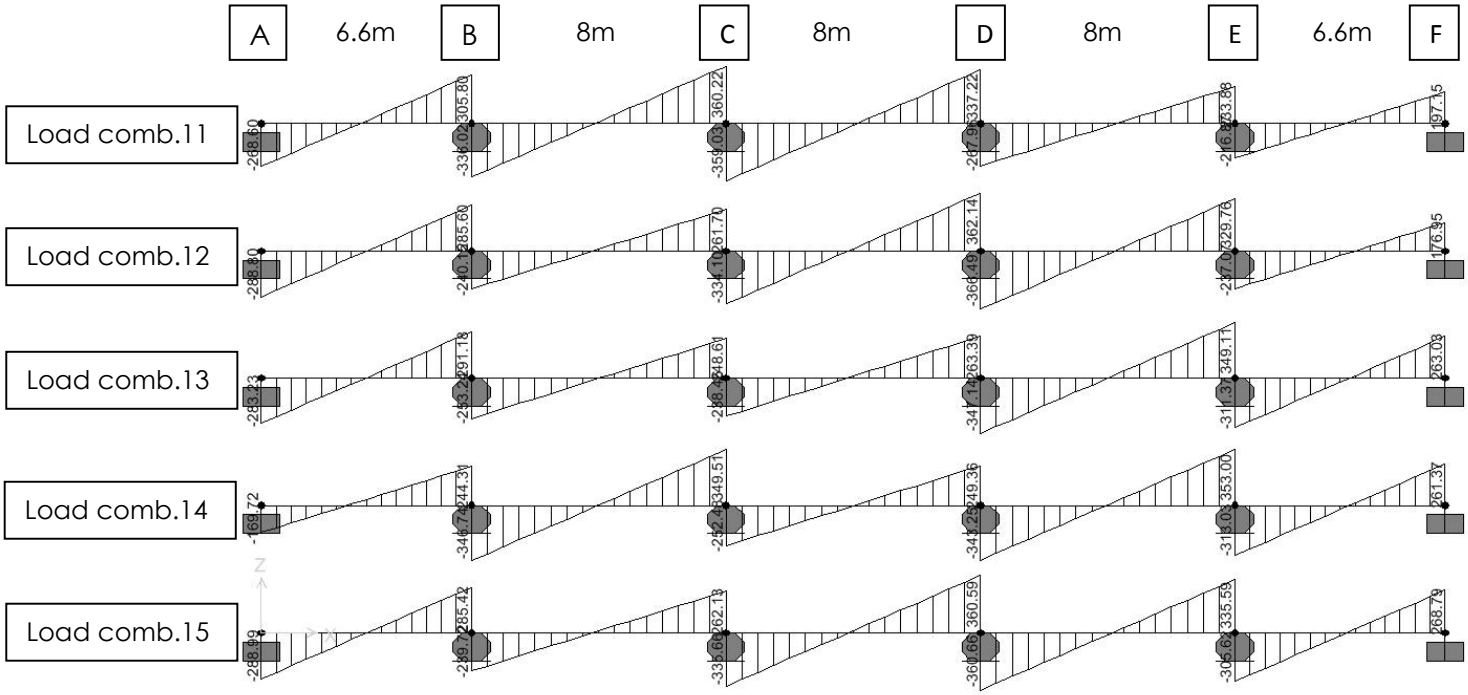
Shear reinforcement design.

The shear force diagrams of the beam A – E for different load combinations are shown below.


A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.1
Load comb.2
Load comb.3
Load comb.4
Z
X


A
6.6m
B
8m
C
8m
D
8m
E
6.6m
F
Load comb.5
Load comb.6
Load comb.7
Z





The maximum shear force obtained by these load combination is,

V_{Ed}= 366.49 kN. (Load combination 12)

According to EC2 – Expression 6.2.2(1), the design value for the shear resistance $V_{Rd,c}$ is given by:

$V_{Rd,c} = [C_{Rd,c}\, k(100\ \rho_1 f_{ck})^{1/3} + k_1\ \sigma_{cp}]\ b_w d$ …. *[N]*

Where:

- f_{ck} is in MPa = 45 MPa
- $C_{Rd,c} = 0.18/\gamma_c = 0.12$ and that for $k_1 = 0.15$.
- $\sigma_{cp} = N_{Ed}/Ac < 0{,}2\ f_{cd}$…assume $N_{Ed} = 0$
- $k = 1 + \sqrt{(200/d)} = 1.76 < 2.0$, with d in mm
- $\rho_l = A_{sl}/bd = 3015/600*342 = 0.0146$
  As=15φ16…(for +M)

Substituting all the values, $V_{Rd,c}$= 174KN

The remaining shear force will be resisted by the stirrups.

$V_{Rd,s} = (A_{sw}/s) z f_{ywd} \cot \theta$.

where:

- $A_{sw,}$ is the cross-sectional area of the shear reinforcement (φ12mm two legs, A_{sw}=113+ 113 = 226 mm^2)
- *S,* is the spacing of the stirrups = 100mm
- f_{ywd} is the design yield strength of the shear reinforcement
- θ, is the angle between the concrete compression strut and the beam axis perpendicular to the shear force = 45°

Substituting all values,

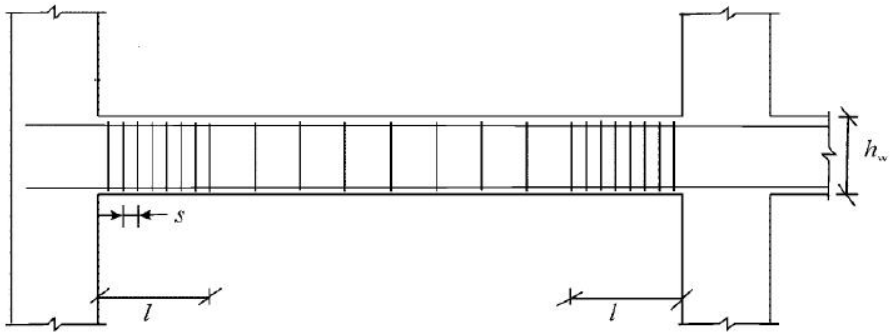
$V_{Rd,s} = A_{sw}/s\ (0.9d) f_{ywd.}$

$V_{Rd,s} = 226/100 * 0.9 * 342 * 400 = 278.25kN$

$V_{Rd} = V_{Rd,c} + V_{Rd,s}$

$V_{Rd} = 174 + 278.25 = 452.25$ kN **OK!**

$V_{Ed} = 366.49$ kN.



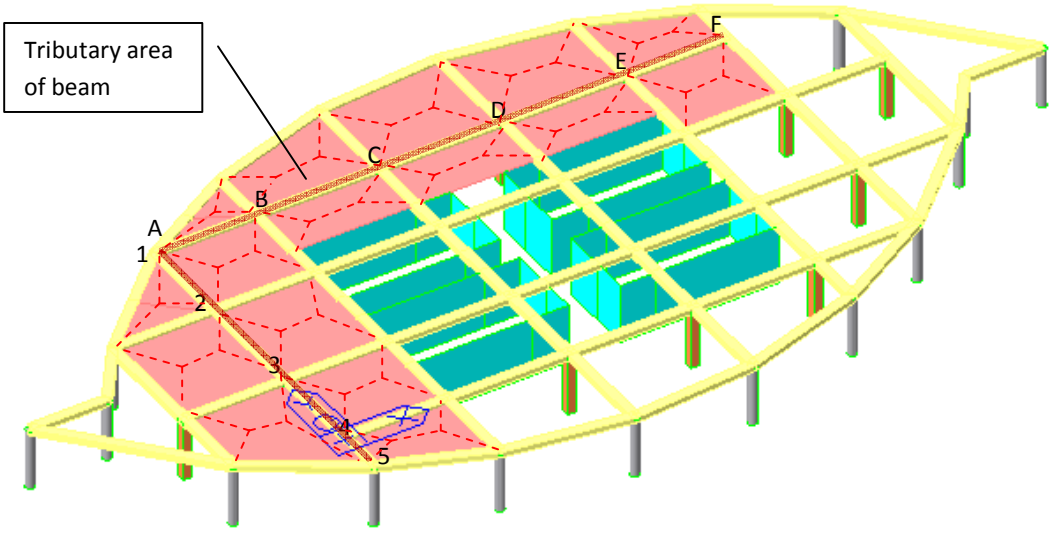
Detail of Shear Reinforcement

EXTRA CONCEPTUAL STUDY OF LOAD DISTRIBUTION ON BEAMS

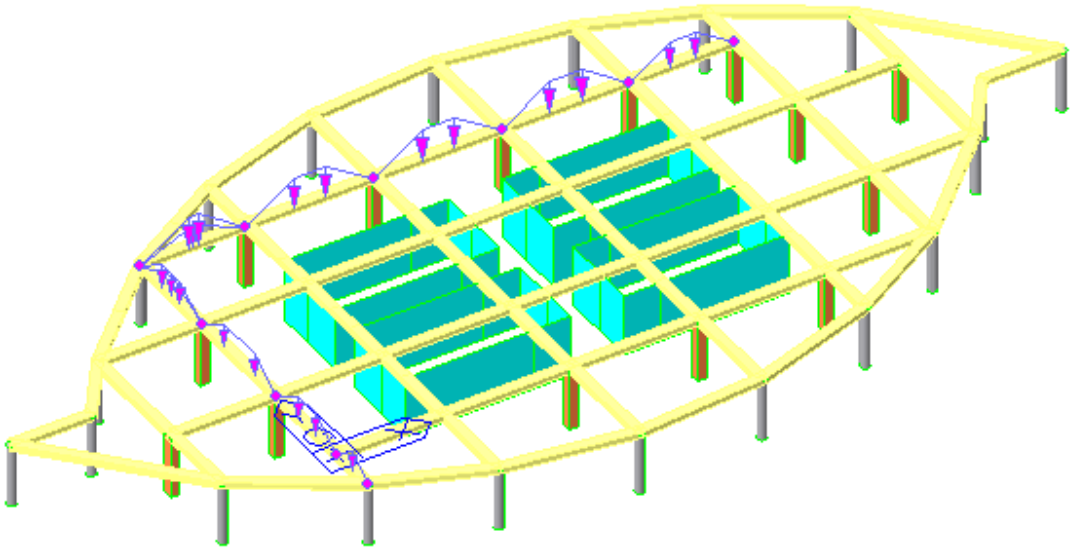
1.Tributary Area

Apply distributed line loads on beams according to the yield line patterns above. Simplify beam column support as simply supported. Beams are considered as continuous beams.

-Tributary area of multi-span continuous beam

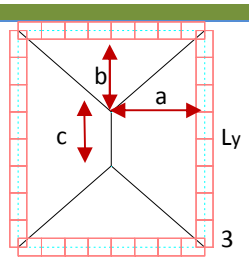
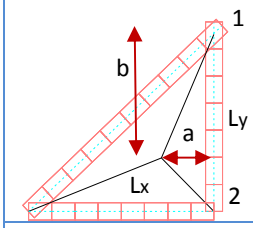
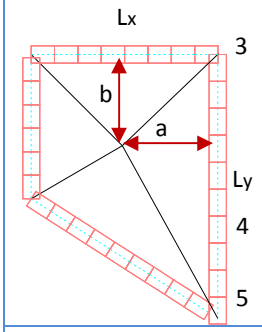
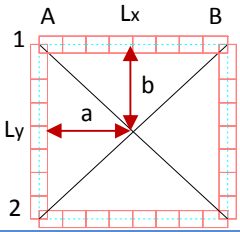


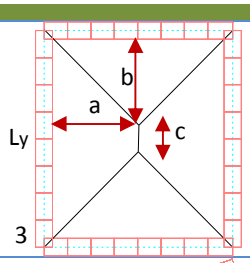
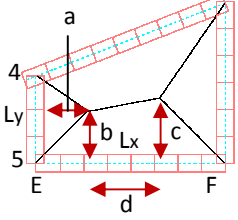
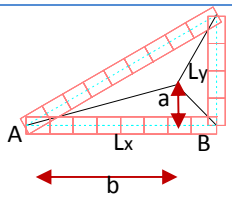
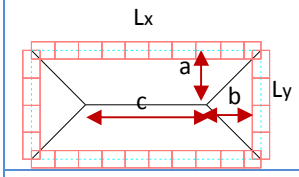
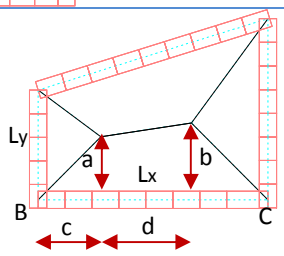
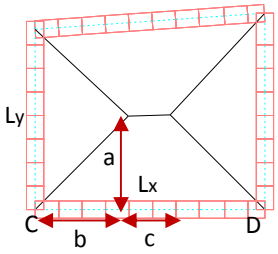
Replace slab with a series of line loads pattern on primary beams in 2 direction.

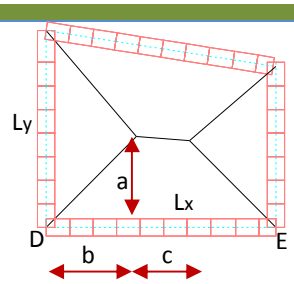


Details of the load pattern, see the table below:

Line Loads on Beams			
SLAB	**BEAM SEG.**	**SHAPE**	**PEAK VALUE (line load)**
SLAB 1 Lx 2	2-3	Trapezoid	$p = (\gamma_g g_k + \gamma_{q,1} q_k + \gamma q,2\psi 0,1s \times a$

 Lx=6.45m Ly=7.5m a=3.225m b=3.26m c=0.98m			γ_g=1.35 (Unfavourable) =1.0 (favourable) $\gamma_{q,i}$=1.5 (Unfavourable) =0 (favourable) $\psi_{0,1}$=0.5
SLAB 2  Lx=6.45m Ly=6.13m a=1.85m b=4.28m	1-2	Triangular	The same as above
SLAB 3  Lx=6.45m Ly=9.19m a=3.35m b=3.17m	3-4-5	Triangular	The same as above
SLAB 4  Lx=6.6m Ly=6.13m a=3.3m b=3.065m	A-B;E-F	Triangular	p=(…)×b
	1-2	Triangular	p=(…)×a
SLAB 5 2 Lx	2-3	Triangular	The same as above

Lx=6.6m Ly=7.5m a=3.3m b=3.225m c=0.98m 			
SLAB 6 Lx=6.6m Ly=3.04m a=1.8m b=1.8m c=2.27m d=2.53m 	E-F	Trapezoid	P=(…)×b; p=(…)×c
	4-5	Triangular	P=(…)×a
SLAB 7 Lx=6.6m Ly=3.8m a=1.39m b=5.21m 	A-B	Triangular	The same as above
SLAB 8 Lx=8.0m Ly=3.78m a=1.89m b=1.89m c=4.22m 	B-C; C-D; D-E	Trapezoid	The same as above
SLAB 9 Lx=8.0m Ly=3.80m a=2.18m b=2.66m c=2.18m d=3.16m 	B-C	Trapezoid	P=(…)×a; p=(…)×b
SLAB 10 Lx=8.0m Ly=6.26m a=3.24m b=3.24m c=1.47m 	C-D	Trapezoid	P=(…)×a

SLAB 11 Lx=8.0m Ly=6.82m a=3.15m b=3.15m c=1.85m 	D-E	Trapezoid	The same as above

2. Model of Calculation

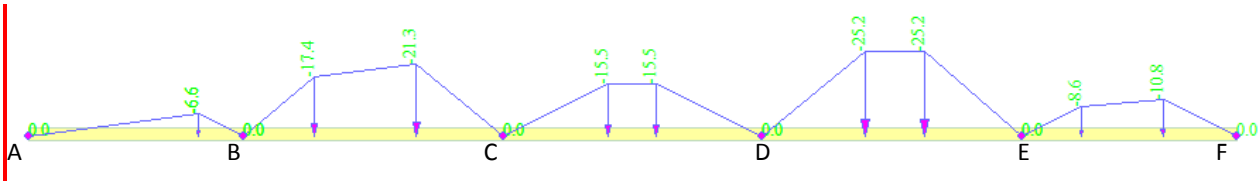
Calculating critical reaction force in node C & negative moment in node C:

RC & MC

Take beam locates on roof for example:

Load transmitted to beam A-F from Slab7,9,10,11,6

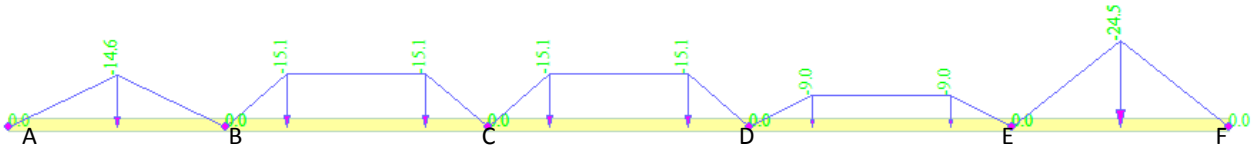
Load patterns should consider favourable and unfavourable coeff. of the dead & live load



RC & MC $p = (\gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \psi_{0,1} s) \times a$ (kN/m)			
Type	A-B (FAV)	B-C (UNFAV)	C-D (UNFAV)
Roof	(1.0×4.775+0×0.4+0.5×0×1.28)×1.39=6.64	(1.35×4.775+1.5×0.4+0.5×1.5×1.28)×2.18=17.4 (1.35×4.775+1.5×0.4+0.5×1.5×1.28)×2.66=21.3	……

Load transmitted to beam A-F from Slab4,8

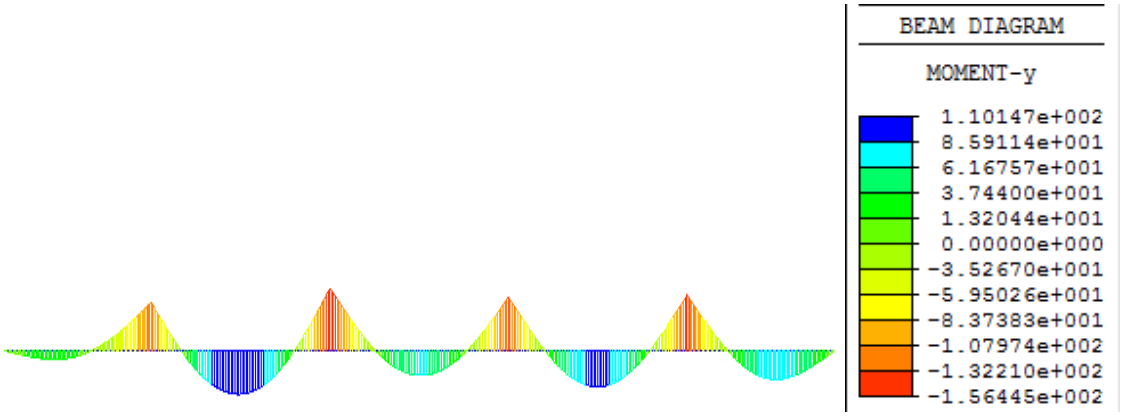
Load patterns should consider favourable and unfavourable coeff. of the dead & live load



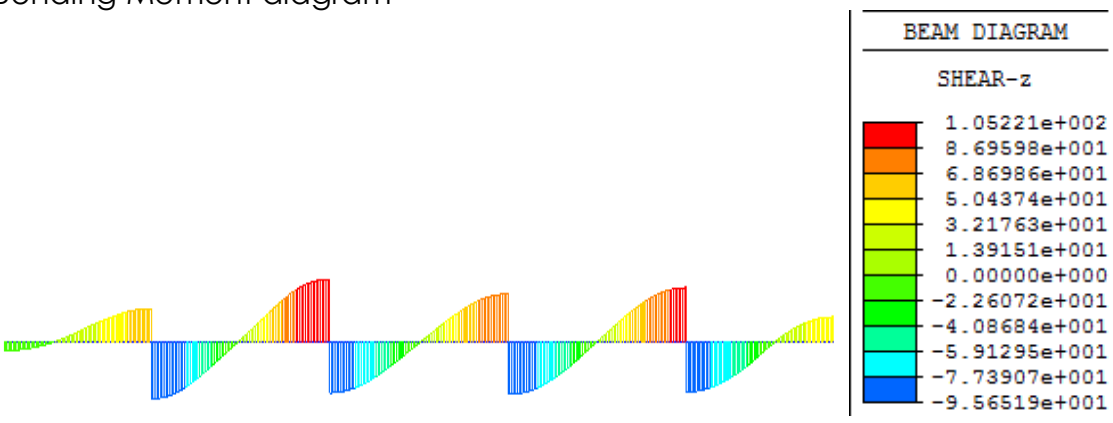
RC & MC $p = (\gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \psi_{0,1} s) \times a$ (kN/m)			
Type	A-B (FAV)	B-C (UNFAV)	C-D (UNFAV)
Roof	(1.0×4.775+0×0.4+0.5×0×1.28)×3.065=14.6	(1.35×4.775+1.5×0.4+0.5×1.5×1.28)×1.89=15.1	……

3.Results

Applying Principle of Super Position for the above2 load cases.



Bending Moment diagram



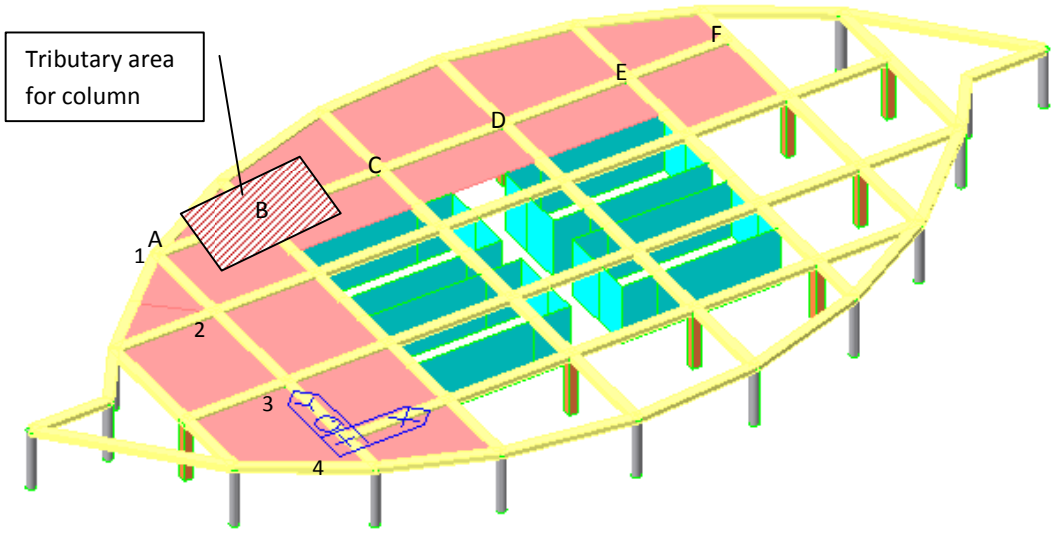
Shear diagram

Reaction force

Critical Moment and Reaction Force for node C is
Mc=-156.45 kN·m
Rc= 190.8 kN

COLUMN DESIGN.

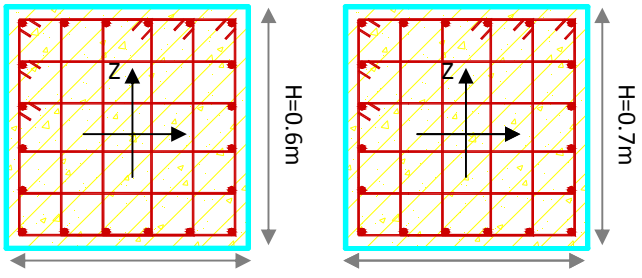
Column at 1-B is taken in to account for the design consideration. The tributary area is calculated by half widths of the surrounding slabs.
The tributary area is = 47.28 m^2



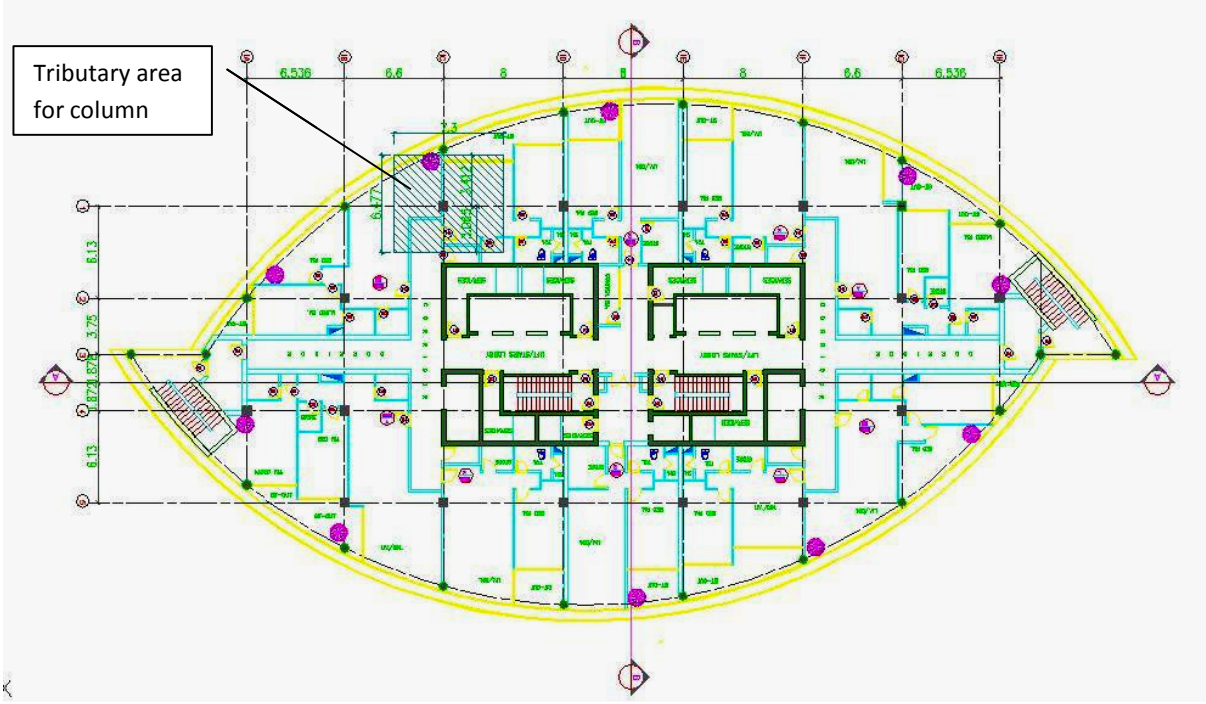
Three types of concrete is used.

f_{ck} =C45/55
f_{ck} =C60/75
f_{ck} =C95/105

Two types of cross sections are used.



Internal Column Section



The load on the column is calculated by multiplying the tributary area with the distributed load.

$P = A_{Tr} \times P_d$ kN

For different floors the value of axial load on the column is calculated as follows.

Axial Load on column (Load on the column by tributary method)
$p = \gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \Psi_{0,1} s$

Type	Cate.	g_k kN/m²	q_k	s	P kN/m²	Tr.Area m²	F kN
Roof	H	6.575	0.4	1.28	10.436	47.28	493.426
Top2	C1	6.575	2.5	-	12.626	47.28	596.969
Resi	A	6.575	2.0	-	11.876	47.28	561.509
Office	B	6.575	2.5	-	12.626	47.28	596.969
Public	C3	6.575	3.0	-	13.376	21.53	287.991
Garage	F	6.575	2.5	-	12.626	47.28	596.969

Axial Load on Column (Load on the column by tributary method)
$p = \gamma_g g_k + \gamma_{q,1} q_k + \gamma_{q,2} \Psi_{0,1} s$

Type	Cate.	F kN	Bxh (mm)	A_c mm²
Roof	H	493.426	600 x 600	360000
Top2	C1	596.969	600 x 600	360000
Resi	A	561.509	600 x 600	360000
Office	B	596.969	600 x 600	360000
Public	C3	287.991	600 x 600	360000
Garage	F	596.969	600 x 600	360000

Self load weight of the column is,
= 0.6mx0.6mx3.9mx25kN/m³ = 35.1 kN
=1.35x35.1=47.38 kN

According to EUROCODE 2, the following limits are applied for the longitudinal reinforcement.

- Technological Limit:
  Columns having a polygonal cross-section, at least one bar should be placed at each corner. The number of longitudinal bars in a circular column should not be less than four

and should have a diameter of not less than ϕ 12 mm. EU2 – 9.5.2 (4) and EU2 – 9.5.2 (1)

- Geometrical Limit:
  The total amount of longitudinal reinforcement should not be less than $A_{s,min}$.
  $A_{s,min}$ = 0,002 A_c whichever is the greater.
- Static Limit:
  The total amount of longitudinal reinforcement should not be less than $A_{s,min}$.
  $A_{s,min} = 0.1N_{ED}/f_{yd}$.
  whichever is the greater, Geometrical or Static limit.

Column Design (Roof and 14 Floors) f_{ck} =C45/55
(Load on the column is including self weight of columns)

Type	Ct	N_{ED} kN	ΣN_{ED} kN	$A_{c0}= N_{Ed}/f_{cd}$ mm²	A_c mm²	$A_{s,mini}$ =0.3 % mm²	$A_{s,min}$ =0.10N_{ED}/f_{yd} mm²	A_s mm²	n⁰ xØ
Roof	H	540.81	540.81	21208.27	360000	1080	135.2	1232.0	8Ø14
Top2	C1	644.35	1185.17	46477.06	360000	1080	296.3	1232.0	8Ø14
2	C1	644.35	1829.52	71745.85	360000	1080	457.4	1232.0	8Ø14
Resi	A	608.89	2438.41	95624.05	360000	1080	609.6	1232.0	8Ø14
2	A	608.89	3047.31	119502.25	360000	1080	761.8	1232.0	8Ø14
3	A	608.89	3656.20	143380.45	360000	1080	914.1	1232.0	8Ø14
4	A	608.89	4265.10	167258.65	360000	1080	1066.3	1232.0	8Ø14
5	A	608.89	4873.99	191136.85	360000	1080	1218.5	2464.0	16Ø14
6	A	608.89	5482.88	215015.05	360000	1080	1370.7	2464.0	16Ø14
7	A	608.89	6091.78	238893.25	360000	1080	1522.9	2464.0	16Ø14
8	A	608.89	6700.67	262771.45	360000	1080	1675.2	2464.0	16Ø14
9	A	608.89	7309.57	286649.65	360000	1080	1827.4	2464.0	16Ø14
10	A	608.89	7918.46	310527.85	360000	1080	1979.6	2464.0	16Ø14
11	A	608.89	8527.35	334406.05	360000	1080	2131.8	2464.0	16Ø14
12	A	608.89	9136.25	358284.25	360000	1080	2284.1	2464.0	16Ø14

Equivalent Area of concrete,
$A_{c2}=A_s*\alpha_e$
α_e=15

Column Design (16 Floors) f_{ck} =C60/75

Type	Ct	N_{ED} kN	ΣN_{ED} kN	$A_{c0}= N_{Ed}/f_{cd}$ mm²	A_c mm²	A_{c2} mm²	$A_s=A_{c2}/15$ mm²	A_s mm²	n⁰ xØ
13	A	608.89	9745.14	286621.84	360000	195251.5	13016.77	14784	24Ø28
14	A	608.89	10354.0	304530.49	360000	195251.5	13016.77	14784	24Ø28
15	A	608.89	10962.9	322439.14	360000	195251.5	13016.77	14784	24Ø28
16	A	608.89	11571.8	340347.79	360000	195251.5	13016.77	14784	24Ø28
17	A	608.89	12180.2	358256.44	360000	195251.5	13016.77	14784	24Ø28
18	A	608.89	12789.6	376165.09	360000	195251.5	13016.77	14784	24Ø28
19	A	608.89	13398.5	394073.74	360000	195251.5	13016.77	14784	24Ø28
20	A	608.89	14007.4	411982.39	360000	195251.5	13016.77	14784	24Ø28
21	A	608.89	14616.3	429891.04	360000	195251.5	13016.77	14784	24Ø28
22	A	608.89	15225.1	447799.69	360000	195251.5	13016.77	14784	24Ø28
23	A	608.89	15834.0	465708.34	360000	195251.5	13016.77	14784	24Ø28
24	A	608.89	16442.9	483616.99	360000	195251.5	13016.77	14784	24Ø28
25	A	608.89	17051.8	501525.64	360000	195251.5	13016.77	14784	24Ø28
26	A	608.89	17660.7	519434.29	360000	195251.5	13016.77	14784	24Ø28
27	A	608.89	18269.6	537342.94	360000	195251.5	13016.77	14784	24Ø28
28	A	608.89	18878.5	555251.59	360000	195251.5	13016.77	14784	24Ø28

Column Design (21 Floors)
f_{ck} =C95/105. Column cross section = 0.70 X 0.70 m²

Type	Ct	N_{ED} kN	ΣN_{ED} kN	$A_{c0}= N_{Ed}/f_{cd}$ mm²	A_c mm²	A_{c2} mm²	$A_s=A_{c2}/15$ mm²	A_s mm²	n⁰ xØ
Offic	B	661.5	19540.	383137.6	490000.	230355.3	15357.0	19296.	24Ø32
2	B	661.5	20201.	396107.5	490000.	230355.3	15357.0	19296.	24Ø32
3	B	661.5	20862.	409077.5	490000.	230355.3	15357.0	19296.	24Ø32
4	B	661.5	21524.	422047.4	490000.	230355.3	15357.0	19296.	24Ø32
5	B	661.5	22185.	435017.3	490000.	230355.3	15357.0	19296.	24Ø32
6	B	661.5	22847.	447987.2	490000.	230355.3	15357.0	19296.	24Ø32
7	B	661.5	23508.	460957.1	490000.	230355.3	15357.0	19296.	24Ø32
8	B	661.5	24170.	473927.0	490000.	230355.3	15357.0	19296.	24Ø32
9	B	661.5	24831.	486896.9	490000.	230355.3	15357.0	19296.	24Ø32
10	B	661.5	25493.	499866.8	490000.	230355.3	15357.0	19296.	24Ø32
11	B	661.5	26154.	512836.7	490000.	230355.3	15357.0	19296.	24Ø32
12	B	661.5	26816.	525806.6	490000.	230355.3	15357.0	19296.	24Ø32
13	B	661.5	27477.	538776.5	490000.	230355.3	15357.0	19296.	24Ø32
14	B	661.5	28139.	551746.4	490000.	230355.3	15357.0	19296.	24Ø32
15	B	661.5	28800.	564716.4	490000.	230355.3	15357.0	19296.	24Ø32
16	B	661.5	29462.	577686.3	490000.	230355.3	15357.0	19296.	24Ø32

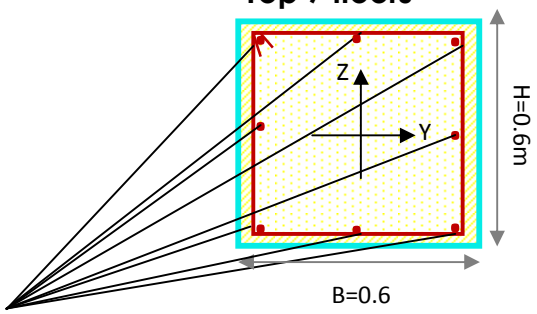
17	B	661.5	30123.	590656.2	490000.	230355.3	15357.0	19296.	24Ø32
18	B	661.5	30784.	603626.1	490000.	230355.3	15357.0	19296.	24Ø32
19	B	661.5	31446.	616596.0	490000.	230355.3	15357.0	19296.	24Ø32
20	B	661.5	32107.	629565.9	490000.	230355.3	15357.0	19296.	24Ø32
21	B	661.5	32769.	642535.8	490000.	230355.3	15357.0	19296.	24Ø32

Column Design (6 Floors)
f_{ck} =C95/105. Column cross section = 0.70 X 0.70 m^2

Type	Ct	N_{ED} kN	ΣN_{ED} kN	$A_{c0}= N_{Ed}/f_{cd}$ mm^2	A_c mm^2	A_{c2} mm^2	$A_s=A_{c2}/15$ mm^2	A_s mm^2	n^0 xØ
Public	C3	661.5	33430.8	655505.7	490000	230355.3	15357.0	19296.	24Ø32
2	C3	661.5	34092.3	668475.6	490000	230355.3	15357.0	19296.	24Ø32
3	C3	661.5	34753.7	681445.5	490000	230355.3	15357.0	19296.	24Ø32
4	C3	661.5	35415.2	694415.4	490000	230355.3	15357.0	19296.	24Ø32
Garage	F	661.5	36076.7	707385.4	490000	230355.3	15357.0	19296.	24Ø32
Garage	F	661.5	36738.1	720355.3	490000	230355.3	15357.0	19296.	24Ø32

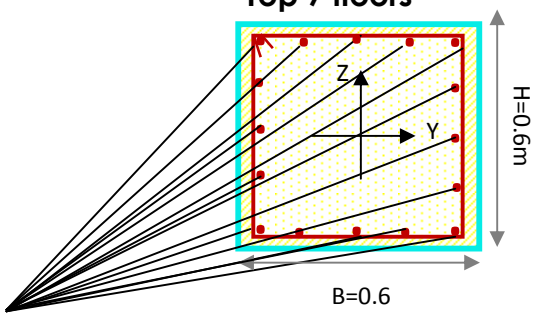
Longitudinal Reinforcement.

Top 7 floors



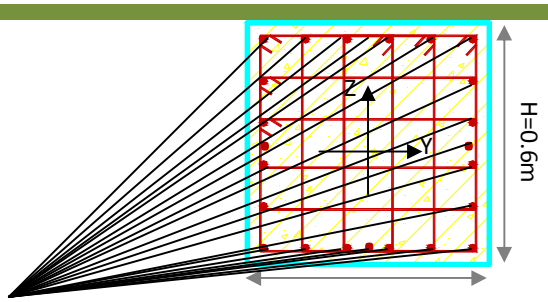
8Ø14

Top 7 floors



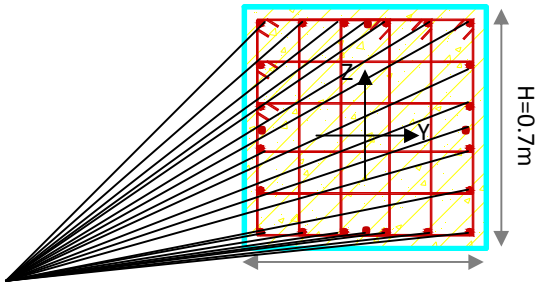
16Ø14

13 – 28 resid floors



24Ø28

Last 27 floors



24Ø32

CHECKS

Ultimate Limit States and Serviceability Limit States are verified as below.
The translational equilibrium of the cross section for SLS is,

$N = \sigma_C A_C + \sigma_s A_s$

Under the hypothesis of plane sections (Eulero Bernoulli, there is same strain in steel and in surrounding concrete

$\varepsilon_C = \varepsilon_s$ SO
$\sigma_s = \alpha_e \sigma_C$

where ratio of modulus of elasticity α_e is assumed equal to 15 in order to take in to account the time dependent (creep) behavior of concrete.

$N = \sigma_c (A_c + \alpha_e A_s) = \sigma_c A_{ie}$
$\alpha_e A_s$ = Equivalent area of concrete

So,
For f_{ck} =C45/55
$\sigma_c = N / A_{ie} \leq \sigma_{c\,adm} = 0.6\, f_{ck} = 0.6*45 = 27$ N/mm^2

For f_{ck} =C60/75
$\sigma_c = N / A_{ie} \leq \sigma_{c\,adm} = 0.6\, f_{ck} = 0.6*60 = 36$ N/mm^2

For f_{ck} =C95/105
$\sigma_c = N / A_{ie} \leq \sigma_{c\,adm} = 0.6\, f_{ck} = 0.6*95 = 57$ N/mm^2

For Verification only roof and top 14 floors columns are considered

Column Design (Roof and 14 Floors) f_{ck} =C45/55

Type	Cat	ΣN kN	A_c mm^2	A_s mm^2	A_{ie} mm^2	σ_c N/mm^2	$< \sigma_{c,\,adm}$
Roof	H	425.4	360000.0	1232.0	378480.0	1.1	yes
Top2	C1	889.6	360000.0	1232.0	378480.0	2.4	yes
2.0	C1	1353.7	360000.0	1232.0	378480.0	3.6	yes
Resi	A	1794.3	360000.0	1232.0	378480.0	4.7	yes
2.0	A	2234.8	360000.0	1232.0	378480.0	5.9	yes
3.0	A	2675.3	360000.0	1232.0	378480.0	7.1	yes
4.0	A	3115.8	360000.0	1232.0	378480.0	8.2	yes
5.0	A	3556.4	360000.0	2464.0	396960.0	9.0	yes
6.0	A	3996.9	360000.0	2464.0	396960.0	10.1	yes
7.0	A	4437.4	360000.0	2464.0	396960.0	11.2	yes
8.0	A	4877.9	360000.0	2464.0	396960.0	12.3	yes
9.0	A	5318.5	360000.0	2464.0	396960.0	13.4	yes
10.0	A	5759.0	360000.0	2464.0	396960.0	14.5	yes
11.0	A	6199.5	360000.0	2464.0	396960.0	15.6	yes
12.0	A	6640.0	360000.0	2464.0	396960.0	16.7	yes

Table. SLS verification

The translational equilibrium for ULS is,
$N_{Rd} = A_c f_{cd} + A_s f_{yd}$

Column Design (Roof and 14 Floors) f_{ck} =C45/55						
Type	Cat	N_{Ed} kN	A_c mm²	A_s mm²	N_{Rd} kN	N_{Rd}/N_{Ed}
Roof	H	540.8	360000.0	1232.0	9672.8	17.9
Top2	C1	1185.2	360000.0	1232.0	9672.8	8.2
2.0	C2	1829.5	360000.0	1232.0	9672.8	5.3
Resi	A	2438.4	360000.0	1232.0	9672.8	4.0
2.0	A	3047.3	360000.0	1232.0	9672.8	3.2
3.0	A	3656.2	360000.0	1232.0	9672.8	2.6
4.0	A	4265.1	360000.0	1232.0	9672.8	2.3
5.0	A	4874.0	360000.0	2464.0	10165.6	2.1
6.0	A	5482.9	360000.0	2464.0	10165.6	1.9
7.0	A	6091.8	360000.0	2464.0	10165.6	1.7
8.0	A	6700.7	360000.0	2464.0	10165.6	1.5
9.0	A	7309.6	360000.0	2464.0	10165.6	1.4
10.0	A	7918.5	360000.0	2464.0	10165.6	1.3
11.0	A	8527.4	360000.0	2464.0	10165.6	1.2
12.0	A	9136.2	360000.0	2464.0	10165.6	1.1

Table. ULS verification

Transverse reinforcement.

According to Eurocode the requirement for the transversal reinforcement are as following,

- The diameter of the transverse reinforcement (links, loops or helical spiral reinforcement) should not be less than 6 mm or one quarter of the maximum diameter of the longitudinal bars, whichever is the greater. The diameter of the wires of welded mesh fabric for transverse reinforcement should not be less than 5 mm.

For longitudinal bar of Ø14, Ø28, Ø40 the stirrup size is,

Stirrup size = ¼* 14 = 3.5 mm but 8 mm
Stirrup size = ¼* 28 = 7 mm but 8 mm
Stirrup size = ¼* 32 = 8 mm but 10 mm

- The transverse reinforcement should be anchored adequately.

- The spacing of the transverse reinforcement along the column should not exceed $S_{cl,tmax}$.
  The recommended value of $S_{cl,tmax}$ is,
  the least of the following three distances:
  - 20 times the minimum diameter of the longitudinal bars (20*14 = 280 mm)
  - The lesser dimension of the column (600 mm)
  - 400 mm
  So the $S_{cl,tmax}$ is 280 mm for ***top 14 floors***
  And 400 mm for ***all remaining floors.***

  - The maximum spacing required should be reduced by a factor 0,6:

(i) in sections within a distance equal to the larger dimension of the column cross-section above or below a beam or slab; (600mm)
(ii) near lapped joints, if the maximum diameter of the longitudinal bars is greater than 14 mm. A minimum of 3 bars evenly placed in the lap length is required.

- Where the direction of the longitudinal bars changes, (e.g. at changes in column size), the spacing of transverse reinforcement should be calculated, taking account of the lateral forces involved. These effects may be ignored if the change of direction is less than or equal to 1 in 12.
- Every longitudinal bar or bundle of bars placed in a corner should be held by transverse reinforcement. No bar within a compression

zone should be further than 150 mm from a restrained bar.

For top 31 floors.

Stirrups Ø8@280 will be provided along the columns, whereas at the bottom and the top of column for a distance of 600 mm stirrups Ø8@150 will be provided.

For remaining floors below.

Stirrups Ø10@400 will be provided along the columns, whereas at the bottom and the top of column for a distance of 600 mm stirrups Ø10@225 will be provided.

4.1. Hot zones in China

According to the Chinese Standard GB 50176-93,China has five hot zones.

1. Severe Cold Zone
2. Cold Zone
3. Hot Summer and Cold Winter Zone
4. Temperate Zone
5. Hot summer and Warm Winter Zone

Climate Zone	Mean Temperature in			
	Coldest Month	Hottest Month	HDD °18	CDD °18
Severe Cold	≤ −10 °C		3800 — 8000	
Cold	−10 — 0 °C		2000 — 3800	100 — 200
HSCW	0 — 10 °C	25 — 30 °C	600 — 1000	50 — 300
HSWW	>10 °C	25 — 29 °C	≤600	>200
Temperate	0 — 13 °C	18 — 25 °C	600 — 2000	≤ 50

Source: Lin, 2008; Huang and Deringer, 2007

The northern part of China is located in the severe cold and cold zones, where space heating is the predominant end use for buildings. The Hot Summer and Cold Winter Zone covers the central part of China, where space heating and cooling are both required for comfort in buildings. The southern part of China, which falls in the Hot summer and Warm Winter Zone, has seen increasing energy demand for cooling during hot summers.

Hot-summer and cold-winter zone is the transient climate region between the cold and the hot zones in China.

It includes the whole of Hubei, Hunan, Jiangxi,

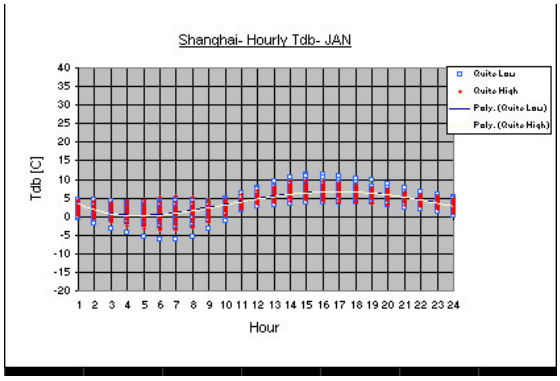
Anhui, Zhejiang provinces, Shanghai and Chongqing two municipalities, the eastern part of Sichuan and Guizhou provinces, the southern part of Henan, Jiangsu, Shanxi and Gansu provinces, and the northern part of Fujian, Guangdong and Guangxi provinces. The zone includes an area of 1,800,000 km2 (694,984 sq mi) with a population of 550 million people. This region is the most populous and economical-developed area of China, producing 48% of the gross domestic product (GDP) of the whole country.

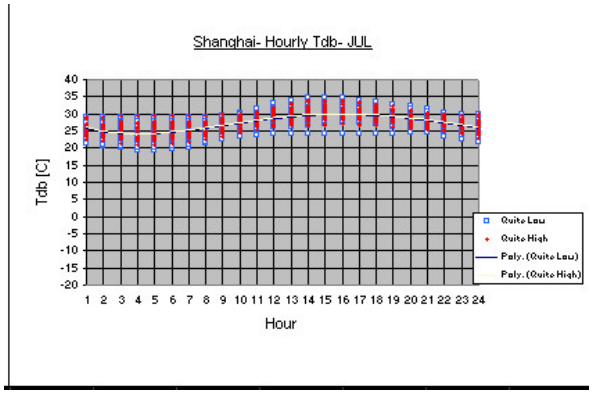
The main bother of hot-summer/cold-winter zone is hot, humid summers and cold, humid winters. The temperature difference between day and night is normally small. The precipitation in an average year is large. Sun radiation is relative weak due to cloud cover.

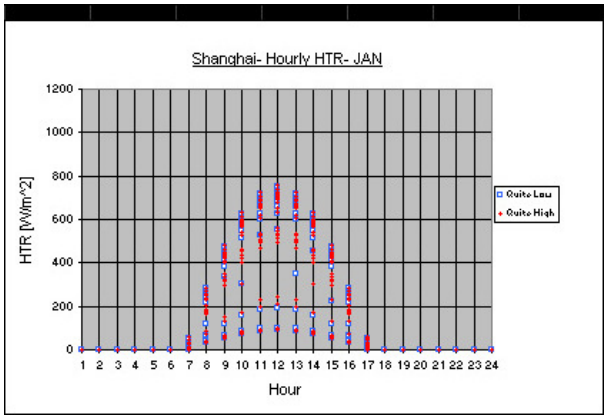
The most durable time you will ever have outside during the hottest summer month is 25–30 °C (77–86 °F), with peak temperatures above 40 °C (104 °F). The average outside temperature during the coldest winter month is 0–10 °C (32–50 °F), with lowest temperatures below 0 °C (32 °F).

For historical reasons, the residential buildings in this zone don't have central HVAC systems and are not well insulated or otherwise weatherized. With the recent and rapid economic development of this region, demand for better indoor environments is rising.

Many residents install 'minisplit' air conditioners to improve their thermal comfort. But electrical energy consumption is rising accordingly and is taxing the generation capacity. The Chinese government has created new national design standards and other efforts to lower the energy consumption while also constructing new power generating stations.





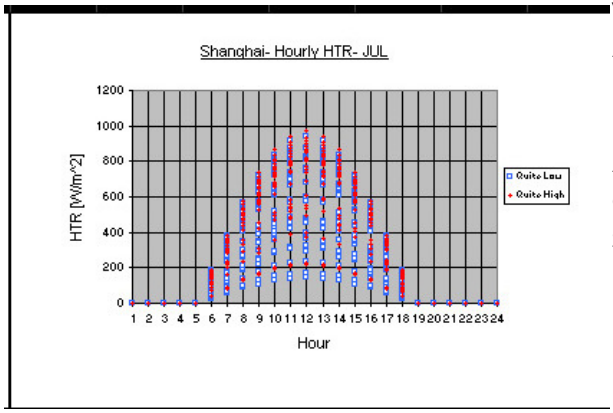


4.2 Shanghai Climate study

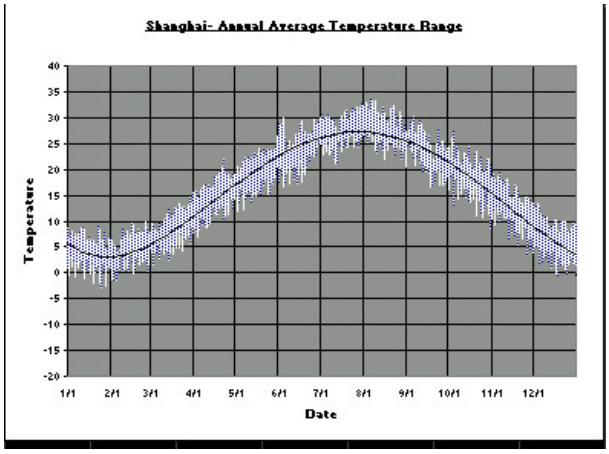
A building's location and surroundings play a key role in regulating its temperature and illumination. For example, trees, landscaping, and hills can provide shade and block wind. In cooler climates, designing buildings with a south facing windows increases the amount of sun (ultimately heat energy) entering the building, minimizing energy use, by maximizing passive solar heating. Tight building design, including energy-efficient windows, well-sealed doors, and additional thermal insulation of walls, basement slabs, and foundations can reduce heat loss by 25 to 50 percent.

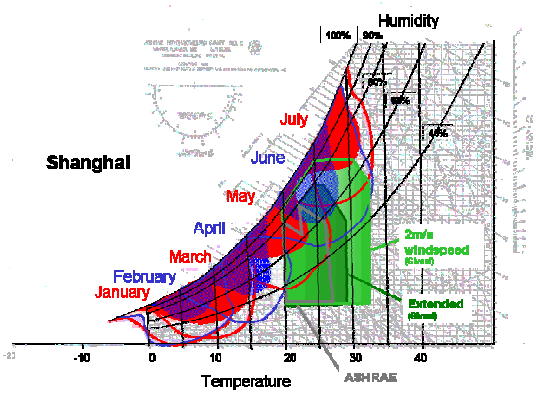
The analysis of the climate is the starting point for a design that maximizes comfort and minimizes the energy consumption for heating and cooling. One possibility to show the distribution of temperature and humidity over a whole year is to plot hourly climatic data in a psychometric chart. The horizontal axis of a psychometric chart shows the dry-bulb-temperature. The vertical axis shows the absolute water content of air in g of water per kg of dry air. Air can take up water up to saturation. The 100% relative humidity line corresponds to saturation of air with water. The warmer air is, the more water it can take up.

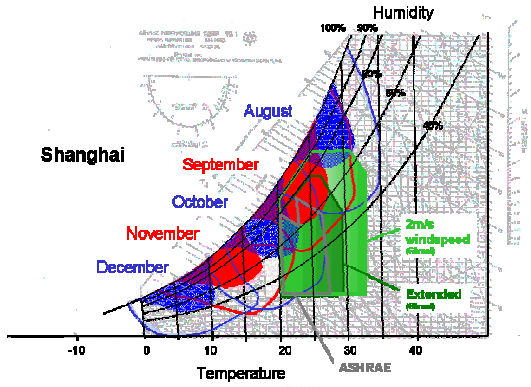
The weather data generator "Medpha" from Tsinghua University creates hourly weather data for a full year. There is a statistical probability that a year is warmer or colder than an average year. We used a "high" and a "low" year to cover a wide range of possible weather situations for Shanghai. However, an extreme year may have "very high" or "very low" climatic data, but this is statistically a small possibility, so it is not considered as a scenario in our studies.

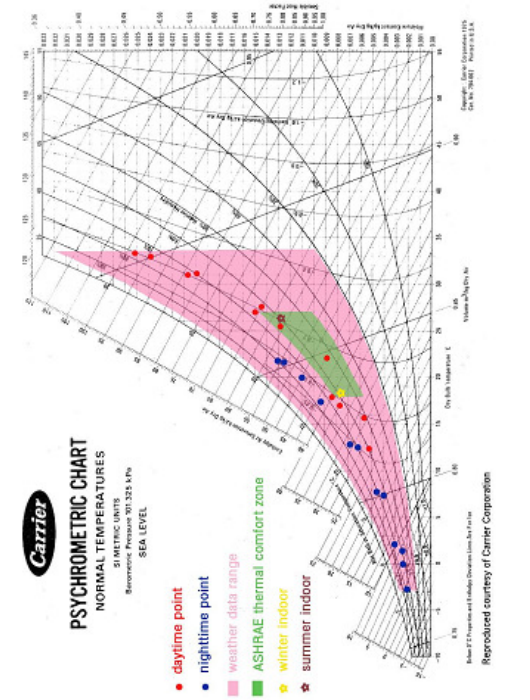


we plot the climatic data into four graphs- Average Hourly Temperature categorized by months, Average Hourly Horizontal Total Solar Radiation, Annual Temperature Range and Annual Relative Humidity Range. From the graphs we are then able to determine the specific climatic characteristic of Shanghai.









To summarize the climatic data for the whole year, we made a scatter plot with hourly data into a psychrometric chart for each month. The zones with a high density of scatters are colored . The rest of the scatters in each month are contained in the zone delimited by the solid line.

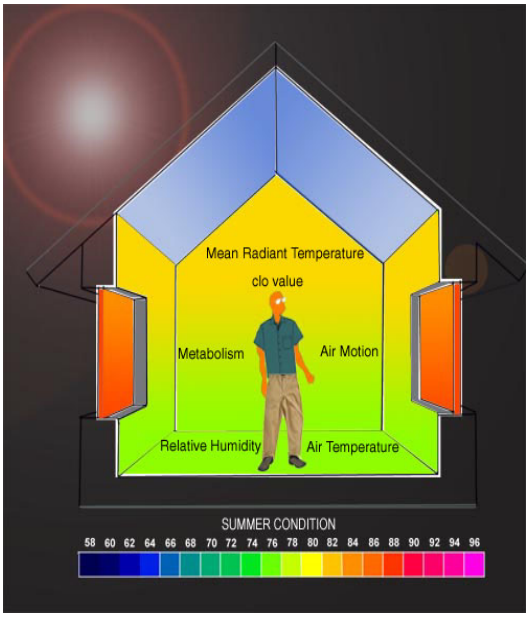
Weather data showing on psychometric chart and thermal comfort zone, Our design goal is trying to give people thermal comfort as much as possible.

Human thermal comfort is defined by ASHRAE as the state of mind that expresses satisfaction withthe surrounding environment. Maintaining thermal comfort for occupants of buildings or other enclosures is one of the important goals of HVAC design engineers. Thermal comfort is affected by heat conduction, convection, radiation, and evaporative heat loss. Thermal comfort is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. Any heat gain or loss beyond this generates a sensation of discomfort.

It has been long recognized that the sensation of feeling hot or cold is not just dependent on air temperature alone. In different areas of the world, thermal comfort needs may vary based on climate. In China there are hot humid summers and cold winters causing a need for efficient thermal comfort. Energy conservation in relation to

thermal comfort has become a large issue in China in the last several decades due to rapid economic and population growth. Researchers are now looking into ways to heat and cool buildings in China for lower costs and also with less harm to the environment.

It can be seen from the graphs that in Shanghai, the climates cover a wide range on the temperature scale. In winter Freezing occurs. Shanghai has only has a few hours of temperatures below freezing. The summers are hot and humid. The maximum temperatures are somehow higher in Shanghai. Shanghai has a very high humidity level during the summer.



Comfort Equation:

$$M - W = H + E_c + C_{res} + E_{res}$$

$$E_c = 3.05 \cdot 10^{-3} \cdot \left[5733 - 6.99 \cdot (M - W - P_a)\right] + 0.42 \cdot (M - W - 58.15)$$

$$C_{res} = 0.0014 \cdot M \cdot (34 - t_a)$$

$$E_{res} = 1.72 \cdot 10^{-5} \cdot M \cdot (5867 - P_a)$$

H is either measured directly or calculated from the equation in Appendix A.

What to estimate

MET - VALUE (Metabolism)
CLO - VALUE (Clothing level)

What to measure

Air Temperature + Mean Radiant Temperature + Air Velocity + Humidity

OR

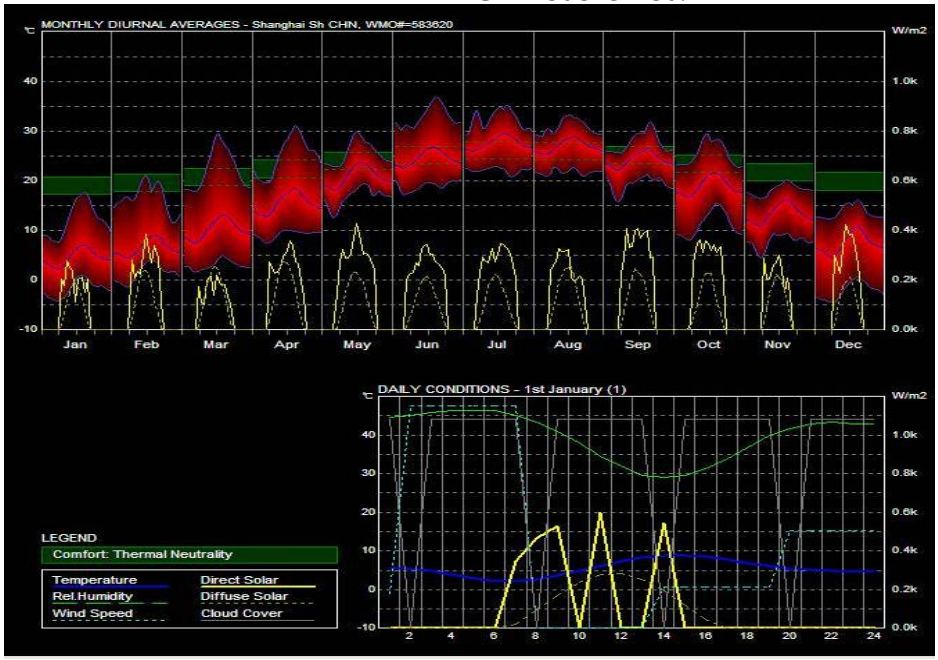
Operative Temperature + Air Velocity + Humidity

OR

Equivalent Temperature + Humidity

4.2.1.Temperature ,Relative humidity study

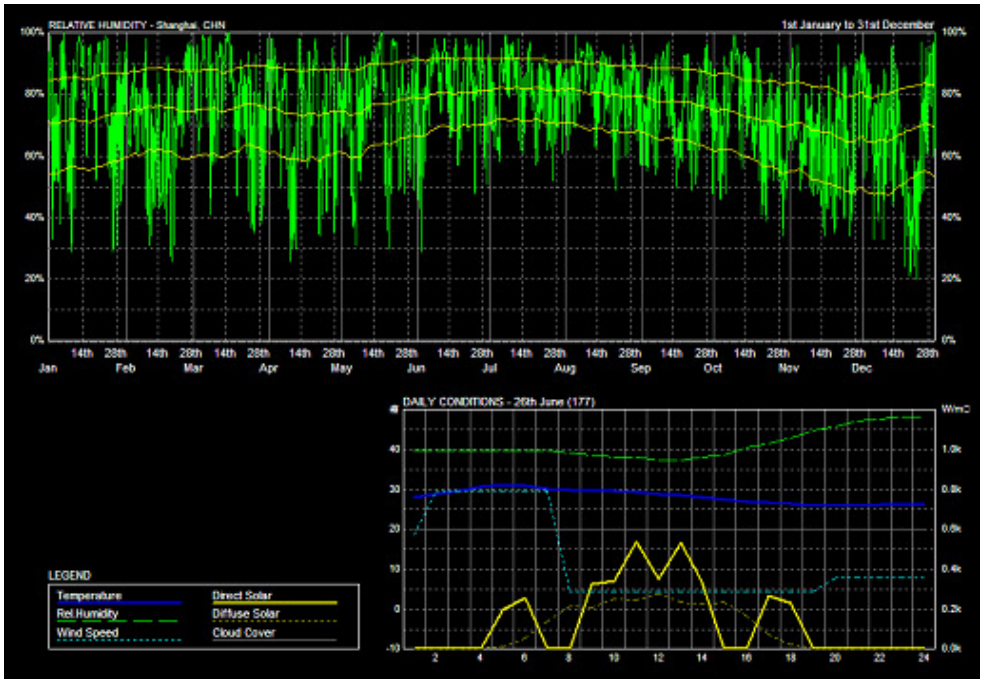
There is a wide range of climatic conditions in China. The northern parts of China, such as Beijing and Tianjin can be cool. In these cold regions, the temperature drops well below zero in the winter. The centre part of China, such as Changsha, is extremely hot in summer. The southern part and coastal strip of China, such as Shanghai, is warm and humid. Therefore, it is worthy to study thermal neutral temperature in Chinese cities.



Weather during November to April is the coldest and temperatures range between 3.5oC to 13.7oC (38.3oF to 56.7oF). Weather in May, June, September and October is cooling, ranging between 18.6oC to 23.5oC (65.5oF to 74.3oF). Climate in July and August starts to turn warm and temperature can go up to 28oC (82.4oF).Also we can see the temperature difference between summer and winter is dramatic.

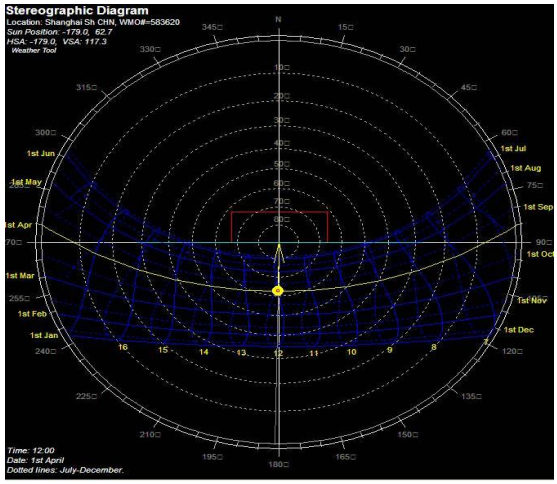
The problem in Shanghai is that the air is humid, so a large amount of energy is used not to heat or cool the air, but get rid of the humidity. This is

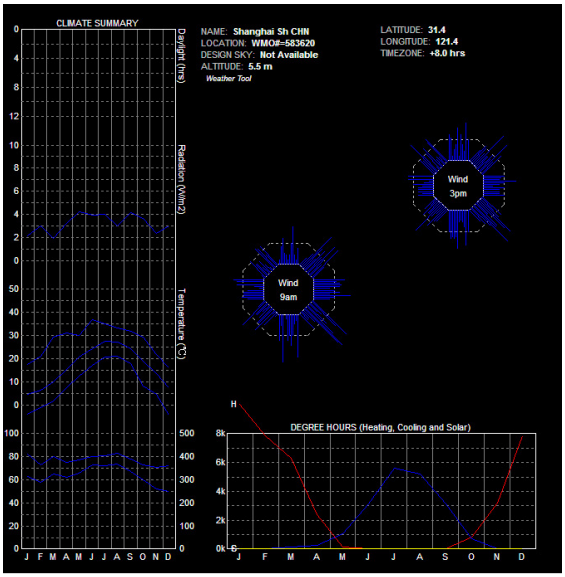
also a typical character in Hot Summer and Cold Winter Zone



4.2.2..Sun path Diagram

The sun goes via south side of all the buildings in Shanghai. In winter time, there will be no direct sun light at 5pm. From these information, we were able to design the windows and shading properly accordingly.



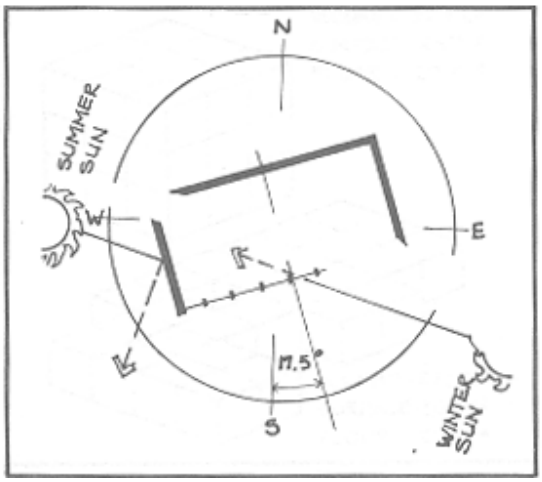


4.2.3.Summery Data

A brief summery is listed to show the Daylight,Radiation,Temperature,wind ,design hours(heating,cooling,solar).The detailed analyses will be listed below.

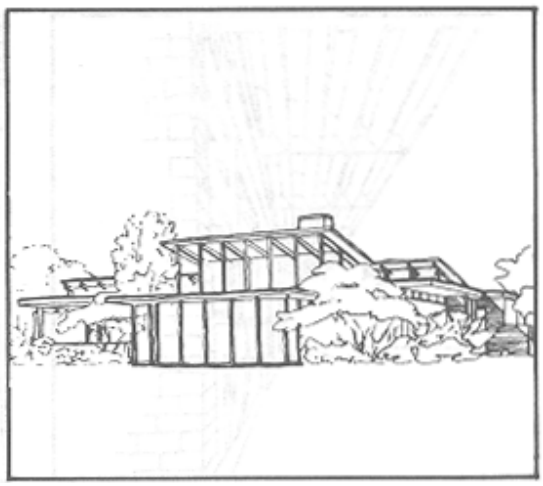
4.3 Proposed Design Strategies

From our study of the climatic data generated by "Medpha", we are able to suggest a few design criteria that aim to enhance the thermal comfort level in buildings for Shanghai. We divided these design strategies into four categories: **Orientation**, **Building Envelope**, **Thermal Mass** and **Ventilation**. Most of the design strategies suggested are in general applicable for Shanghai according to its specific climatic characteristics.

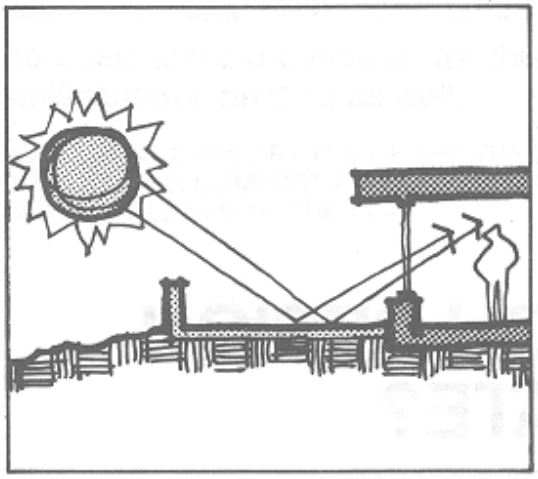


The four factors will be taken into our special consideration for skyscraper .

Proper orientation lets the warming winter morning sun in and keeps the hot summer afternoon sun out.

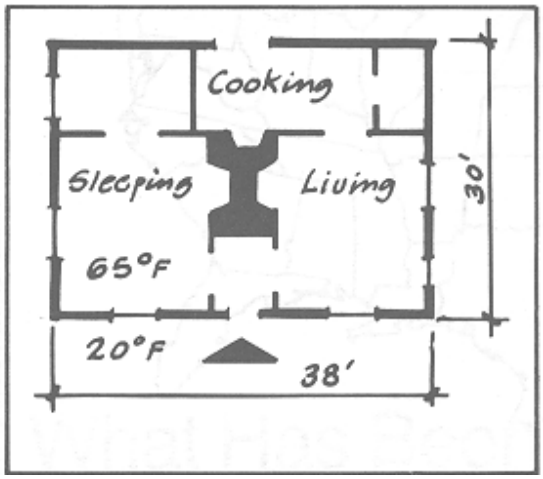


Vertical Southern Windows collect the most winter sun and can be easily shaded against high summer sun.Insulate against loss with shutter,drapes,and even triple glazing.



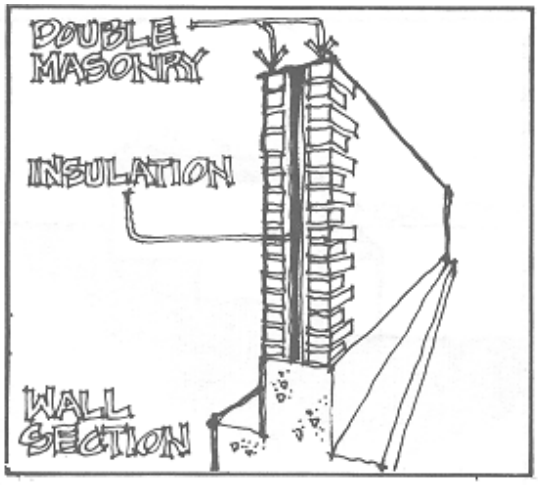
Balconies in front of south windows should be paved with light colored materials to reflect sunlight and heat into the house

Use shutters to keep the sun out of the living space on east and west facades,where the sun is low in the sky.

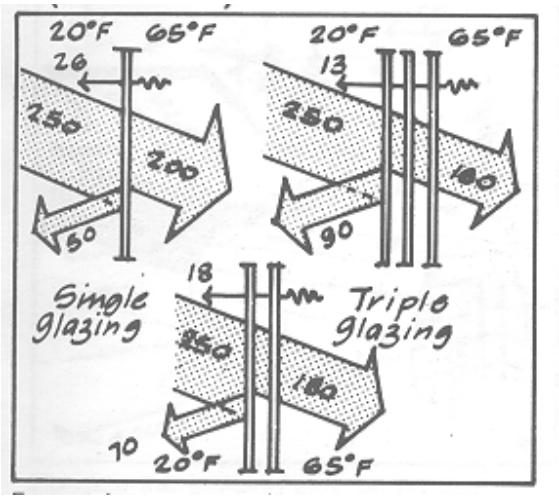


Build compact homes with snug floor plans to minimize exposure and retain heat.

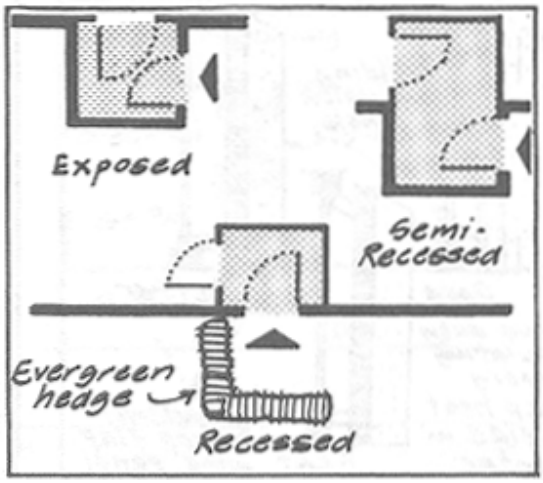
Building homes together. Shared heat can be the most energy efficient way to live(Skyscraper)



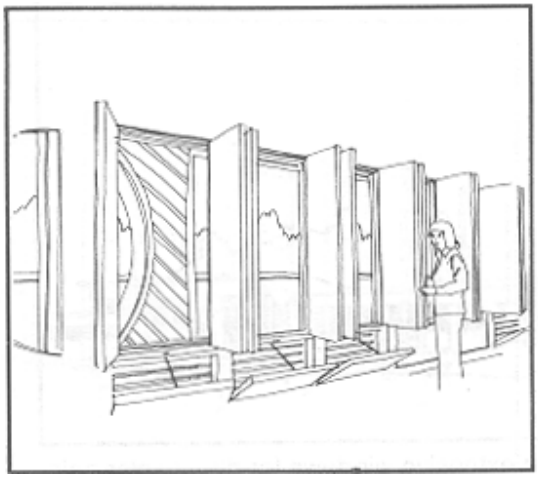
Use massive materials for thermal capacity, holding daytime heat until nighttime hours, This should still be combined with resistance insulation to keep the cold out.



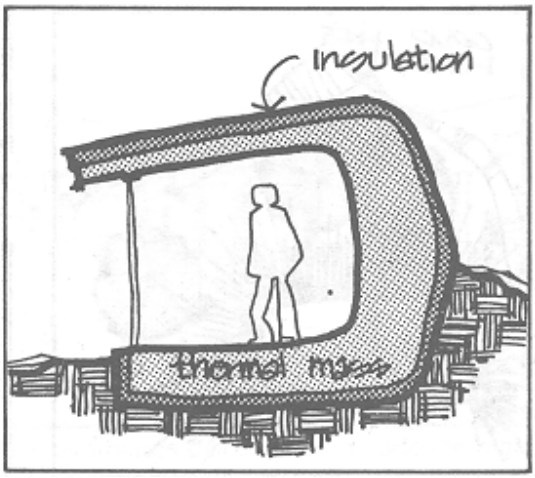
For maximum protection, use double glazing ,and ,in some instances ,triple glaze window openings.



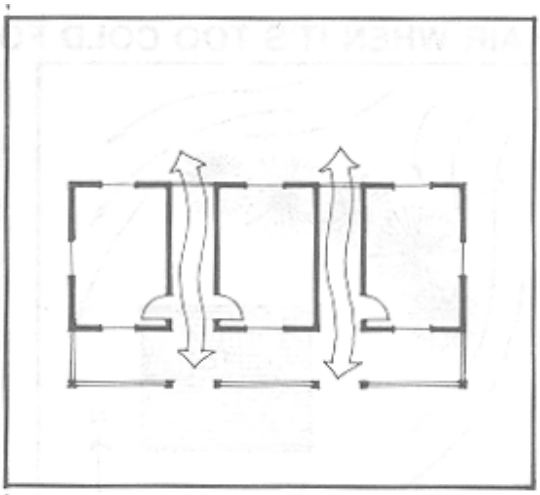
Use a traditional air-lock entry to stop cold air form rushing through the house.



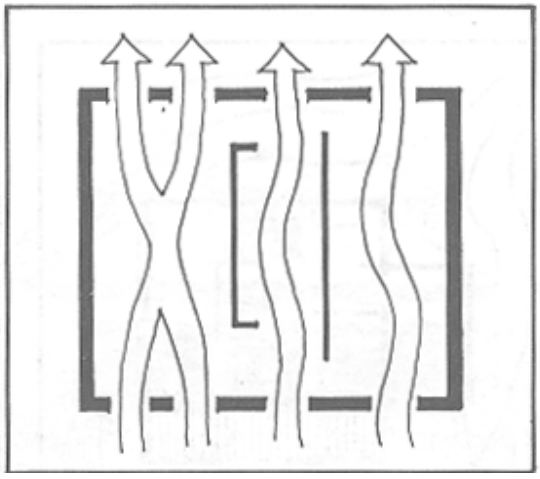
Use operable insulated shutters and triple-glazed windows.



Use massive, heavy building materials such as stone ,brick ,concrete or adobe to store internal heat gains and temper outside temperature extremes, Use lots of insulation, close to the exterior surface of the building ,and try to make it continuous.

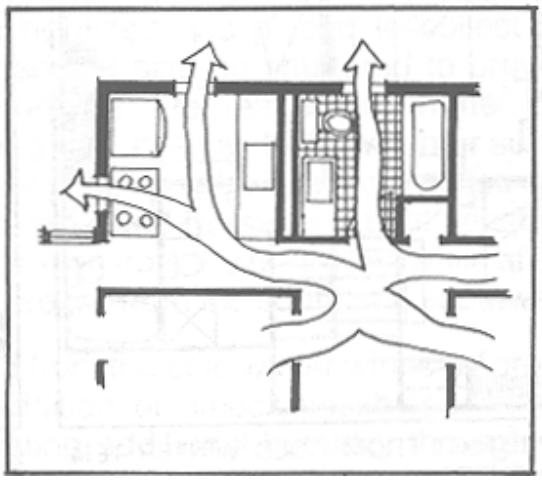


Plan front-to-back windows between rooms to allow cross ventilation through louvered shutters at both ends.

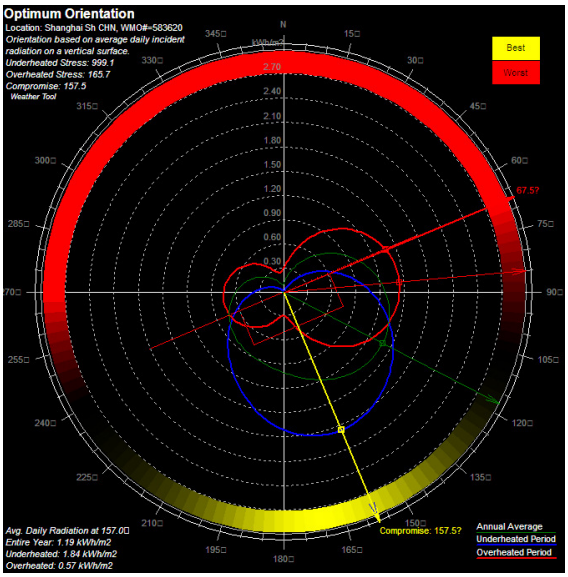


Use open interior planning to allow air movement.

In summer, remove plants from direct sunlight to reduce evaporation.

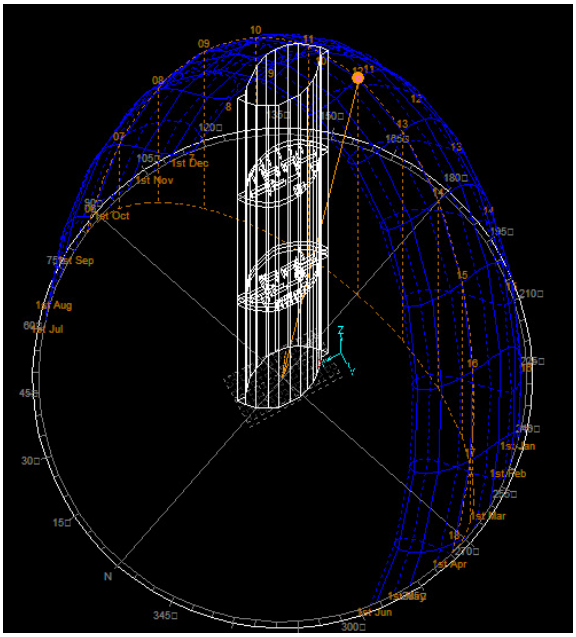


Ventilate kitchens, baths and laundry rooms in order to exhaust humid air.



4.4.Best Orientation

We hope to make full use of solar energy in winter and to reduce the heat gain in Summer, therefore we try to find a balance between the two demands. If the orientation of the building can take advantage of this point, our energy consumption will be largely reduced.



4.4.1.Sun path of the building

From the picture, we can see our buildings will have sufficient nature light., both summer and winter .The day light analysis will be listed below.

4.5 Building Envelope

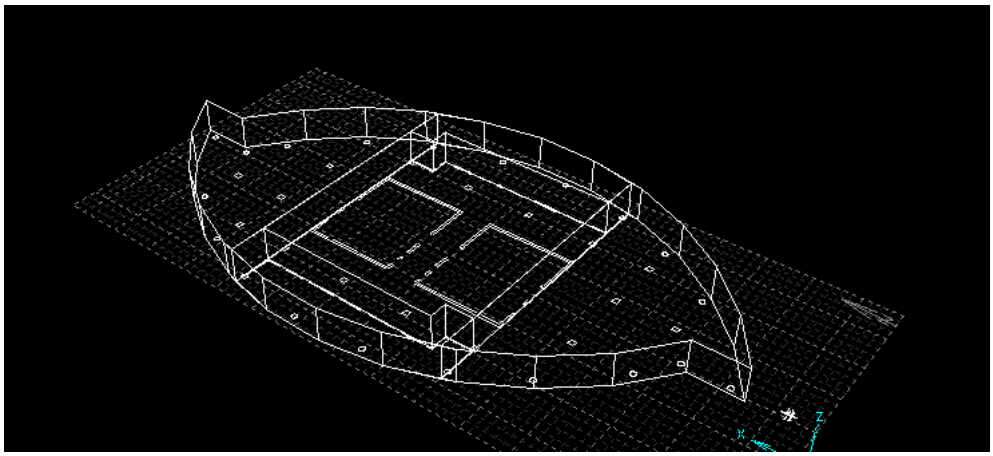
The building envelope is the interface between the interior of the building and the outdoor environment, including the walls, roof, and foundation. By acting as a thermal barrier, the building envelope plays an important role in regulating interior temperatures and helps determine the amount of energy required to maintain thermal comfort. Minimizing heat transfer through the building envelope is crucial for reducing the need for space heating and cooling. In cold climates, the building envelope can reduce the amount of energy required for heating; in hot climates, the building envelope can reduce the amount of energy required for cooling. A substantial part of "weatherization" includes improvements to the building envelope, and government weatherization programs often cite energy and energy bill savings as a primary rationale for these initiatives. The overall design can help determine the amount of lighting, heating, and cooling a building will require. Architects and engineers have developed innovative new ways to improve overall building design in order to maximize light and heat efficiency

Building envelope is also very important for our skyscraper. We start to analyze our façade using two different structures. Single-façade and double-façade, We will get the heating and cooling load, peak load, and time for the peak load. At the same time, the daylight factor will be studied. What is more important is that we will find the dominant factor for the load. After getting this result, we will choose our corresponding design method to reduce our energy Consumption, a HVAC system will also be designed.

Division of the thermal zone.

Judging from orientation ,we decide to divide our floor into five different thermal zones.

South zone,
North zone,
West zone,
East zone.
Core zone.

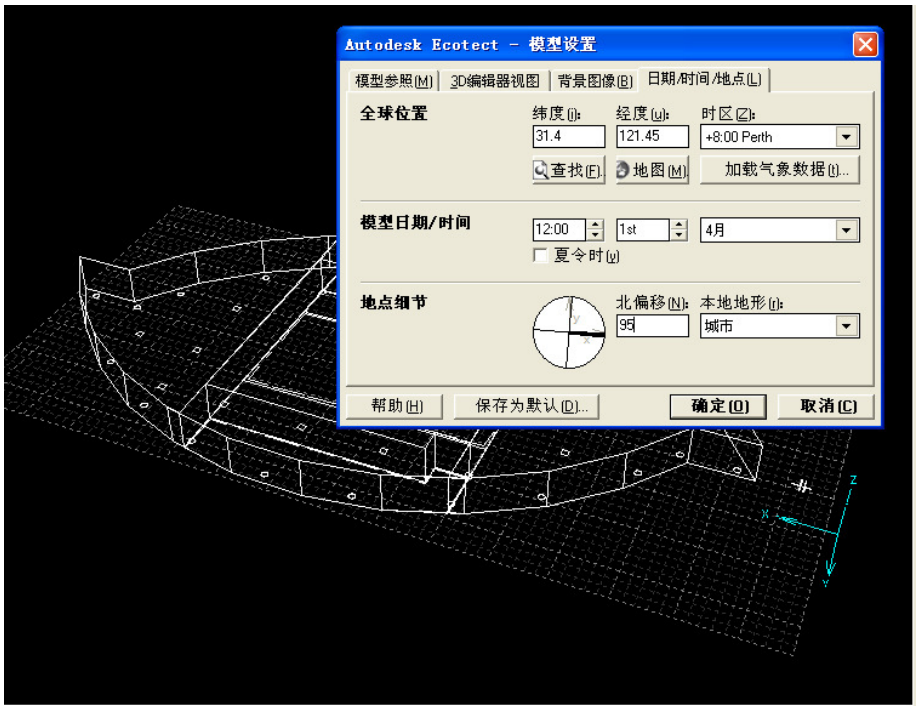


We will use Ecotect to realize our experiment. Only one floor will be tested as almost all the layout for each floor is more or less the same. The upper floor and ground will be in constant temperature ,also have no heat transfer as no temperature differences exist.
We choose two types of façade:

1. Single glass façade

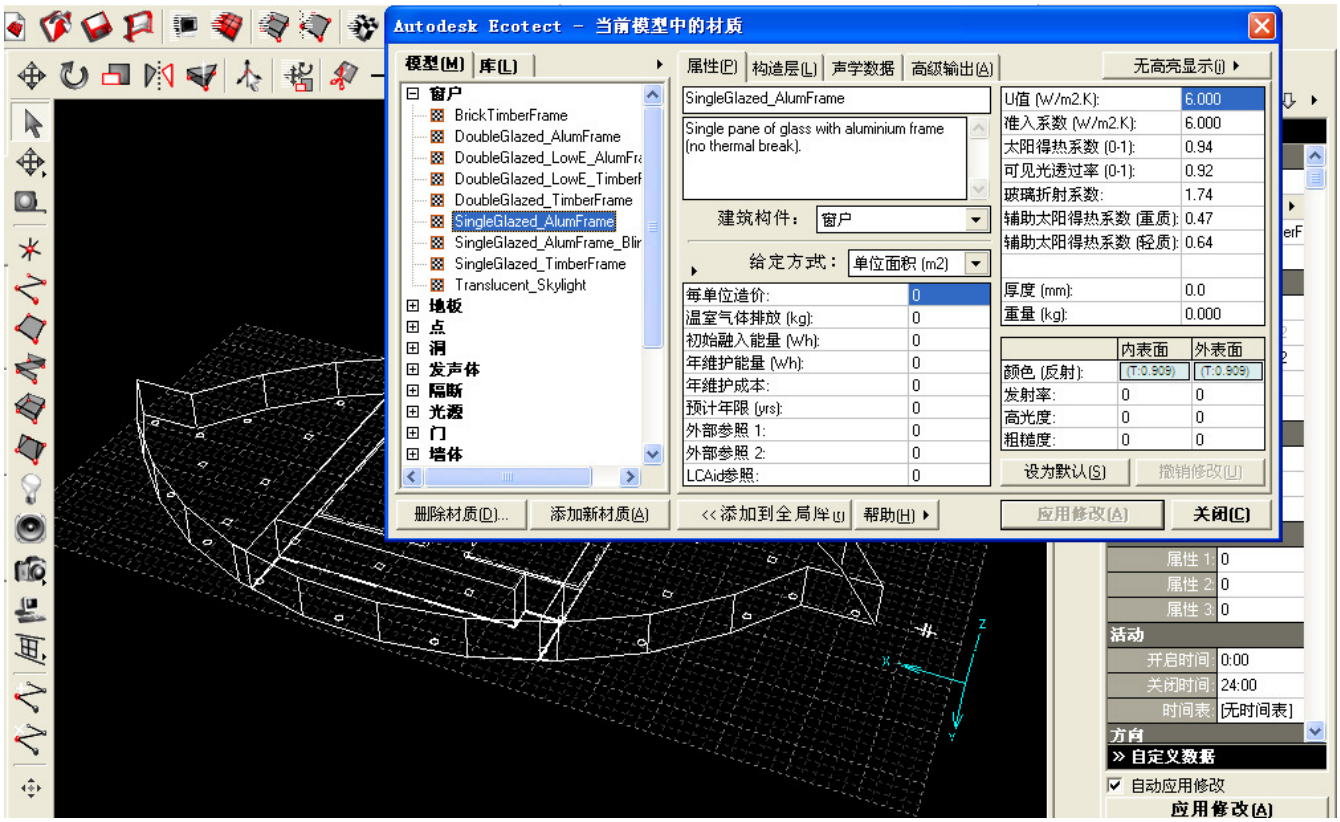
2. Double glass façade

We choose the orientation of building ,the location of the building.



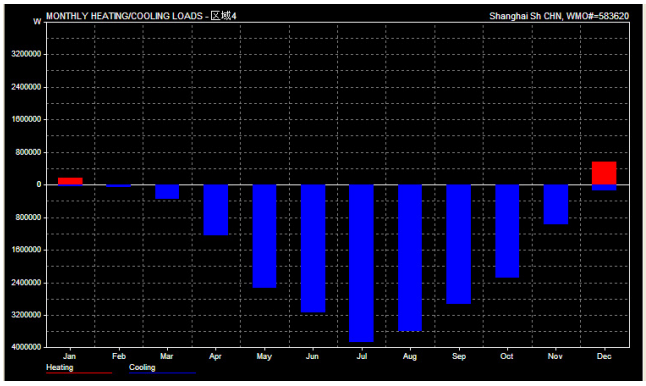
4.5.1 Single glass façade

The property of this façade is shown below.And all the surroundings of the building ,except the floor and ceiling(set U=0), will be equipped with this texture.



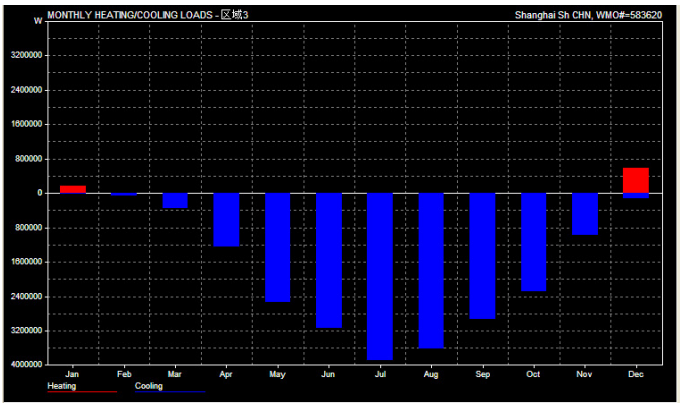
We choose this floor to be a standard office area and will be provided both heating and cooling,the temperature will be controlled between 18°to 25°.

The simulation is shown below



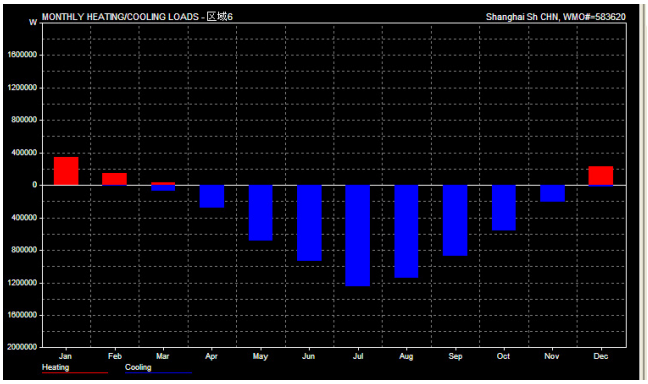
For the north thermal zone.

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	1002580	12537	1015117
Feb	0	48086	48086
Mar	0	304396	304396
Apr	0	992739	992739
May	0	2496503	2496503
Jun	0	3195352	3195352
Jul	0	3874637	3874637
Aug	0	3619364	3619364
Sep	0	2961024	2961024
Oct	0	2055599	2055599
Nov	0	678114	678114
Dec	987123	51290	1038412
TOTAL	1989703	20289642	22279344



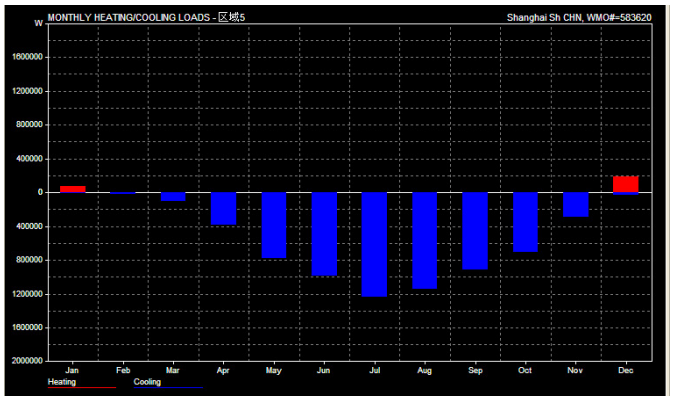
For the South thermal Zone

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	1134362	14131	1148493
Feb	52070	41081	93151
Mar	0	300899	300899
Apr	0	981595	981595
May	0	2493975	2493975
Jun	0	3202681	3202681
Jul	0	3889283	3889283
Aug	0	3631214	3631214
Sep	0	2964356	2964356
Oct	0	2049068	2049068
Nov	0	665830	665830
Dec	1055404	44928	1100333
TOTAL	2241836	20279042	22520878



For the east thermal zone

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	700364	2303	702667
Feb	352067	8056	360123
Mar	98779	70804	169583
Apr	0	249968	249968
May	0	746903	746903
Jun	0	1007892	1007892
Jul	0	1254674	1254674
Aug	0	1161937	1161937
Sep	0	941870	941870
Oct	0	628612	628612
Nov	1454	162592	164046
Dec	392790	6986	399776
TOTAL	1545453	6242598	7788050

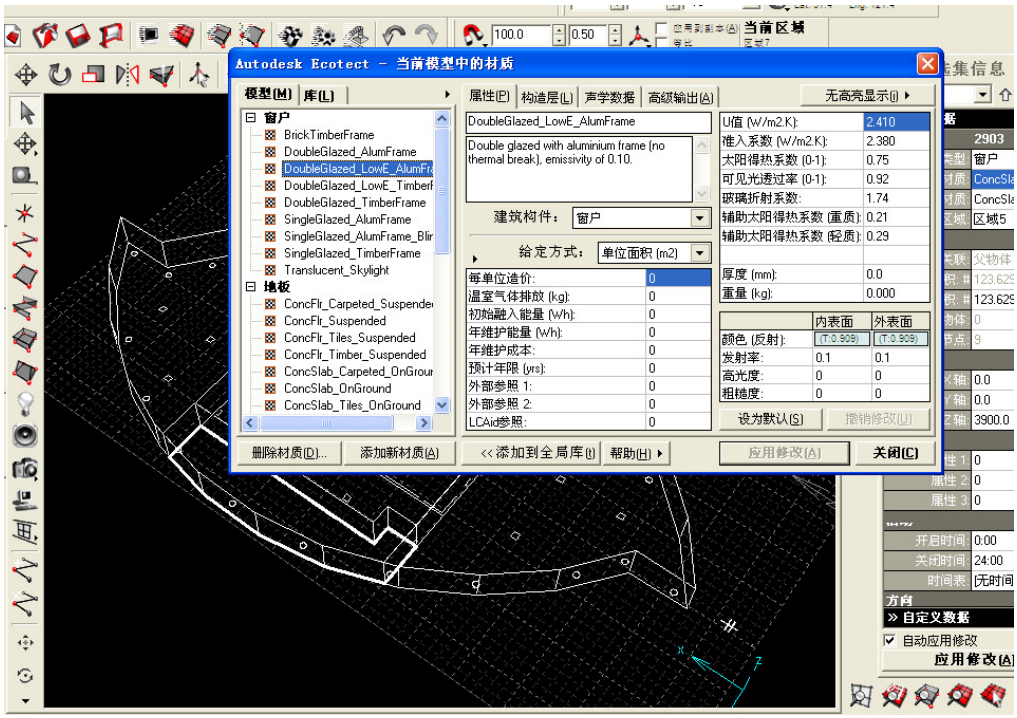


For the west thermal Zone

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	512153	2224	514377
Feb	266481	10180	276660
Mar	50920	73905	124826
Apr	0	272298	272298
May	0	750377	750377
Jun	0	995518	995518
Jul	0	1231339	1231339
Aug	0	1138971	1138971
Sep	0	918774	918774
Oct	0	614294	614294
Nov	0	180332	180332
Dec	311633	9445	321078
TOTAL	1141186	6197656	7338843

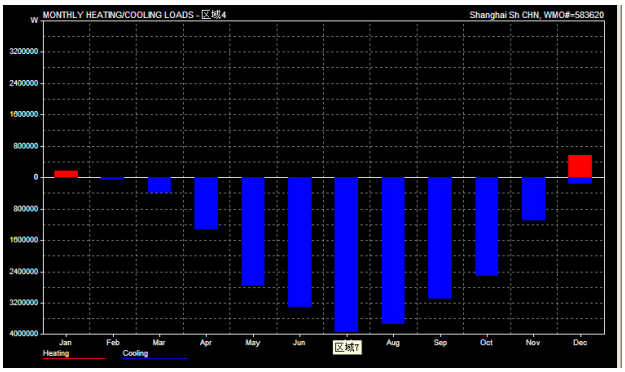
4.5.2 double glass façade

The property of this façade is shown below.And all the surroundings of the building ,except the floor and ceiling(set U=0), will be equipped with this texture.



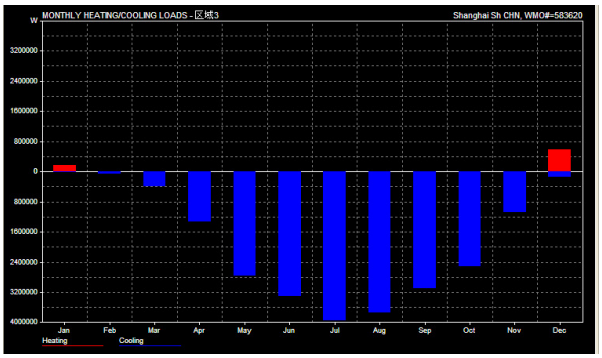
We choose this floor to be a standard office area and will be provided both heating and cooling,the temperature will be controlled between 18°to 25°.

The simulation is shown below r the north thermal zone.



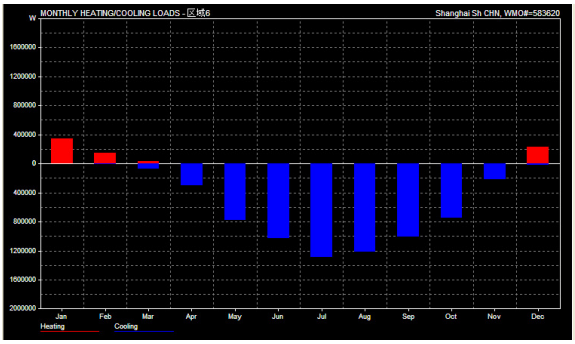
MONTH	HEATING	COOLING (Wh)	TOTAL (Wh)	(Wh)
Jan	163170	30316	193486	
Feb	0	61948	61948	
Mar	0	394624	394624	
Apr	0	1337925	1337925	
May	0	2759900	2759900	
Jun	0	3295607	3295607	
Jul	0	3939864	3939864	
Aug	0	3732871	3732871	
Sep	0	3100968	3100968	
Oct	0	2522431	2522431	
Nov	0	1099207	1099207	
Dec	566612	158646	725258	
TOTAL	729782	22434310	23164092	

For the South thermal Zone

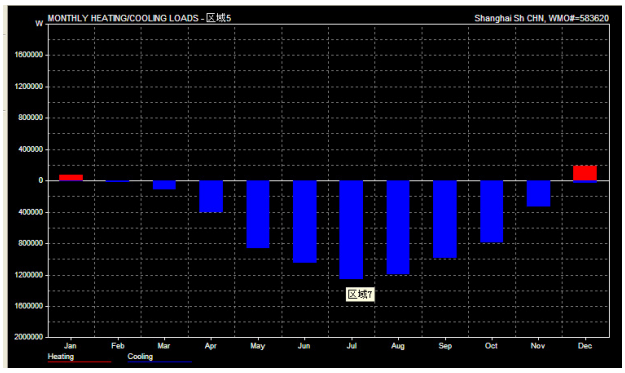


MONTH	HEATING	COOLING (Wh)	TOTAL (Wh)	(Wh)
Jan	169246	28036	197283	
Feb	0	60752	60752	
Mar	0	392136	392136	
Apr	0	1328744	1328744	
May	0	2759386	2759386	
Jun	0	3301892	3301892	
Jul	0	3953783	3953783	
Aug	0	3743551	3743551	
Sep	0	3103022	3103022	
Oct	0	2517908	2517908	
Nov	0	1089475	1089475	
Dec	585704	141303	727007	
TOTAL	754950	22419988	23174938	

For the east thermal zone



MONTH	HEATING	COOLING (Wh)	TOTAL (Wh)	(Wh)
Jan	344074	4438	348512	
Feb	142351	12124	154475	
Mar	29272	74345	103618	
Apr	0	300111	300111	
May	0	780686	780686	
Jun	0	1024920	1024920	
Jul	0	1285196	1285196	
Aug	0	1215281	1215281	
Sep	0	1006961	1006961	
Oct	0	752098	752098	
Nov	0	223088	223088	
Dec	226841	24679	251520	
TOTAL	742539	6703928	7446466	



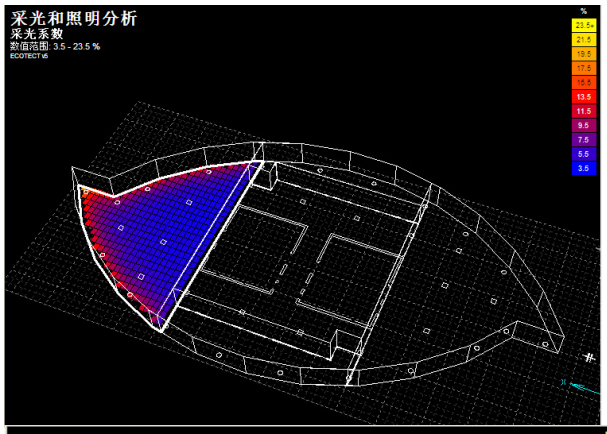
For the west thermal Zone

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)	(Wh)
Jan	74139	5595	79734	
Feb	0	17511	17511	
Mar	0	116003	116003	
Apr	0	409651	409651	
May	0	861716	861716	
Jun	0	1045693	1045693	
Jul	0	1261863	1261863	
Aug	0	1192775	1192775	
Sep	0	984661	984661	
Oct	0	790885	790885	
Nov	0	332548	332548	
Dec	188948	35847	224794	
TOTAL	263086	7054749	7317835	

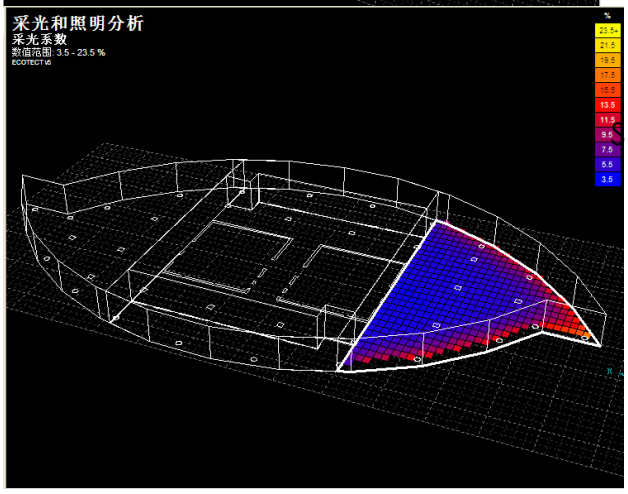
4.5.3 The analysis of daylight factor.

Daylight admitted into a building through `holes' in external fabric (windows, roof lights, etc.), which in adverse climates generally incorporate glass or an alternative transparent material to heat loss and/or inclement weather spaces. The amount of light received inside a building is usually only a small fraction of that required - because of modifications imposed by the size and position of openings - and will also constantly vary owing to the influences imposed on the `whole sky', illumination level by clouds, buildings and/or other reflecting planes. Therefore, it is impracticable to express interior day lighting in terms of the illumination actually obtainable inside a building at any one time, for within a few minutes that figure is liable to change with corresponding changes in the luminance of the sky.

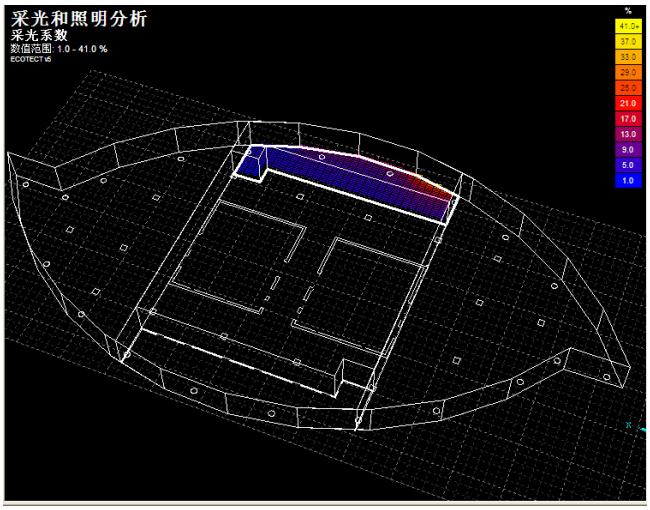
For practical purposes, use is made of the daylight factor. This is a percentage ratio of the instantaneous illumination level at a reference point inside a room to that occurring simultaneously outside in an unobstructed position.



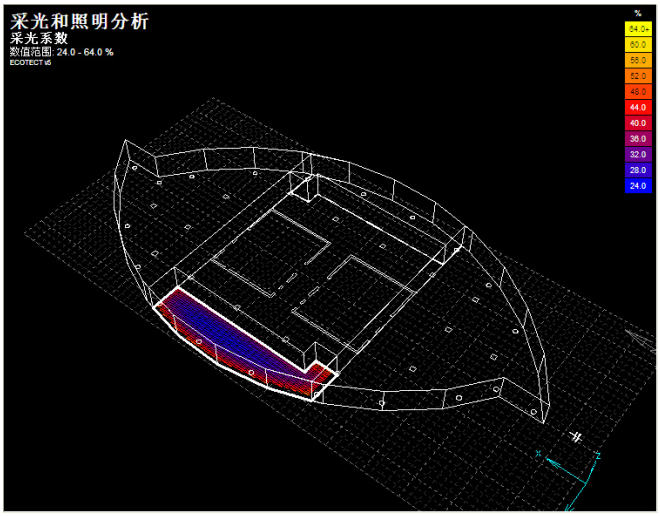
north thermal zone.



South thermal zone



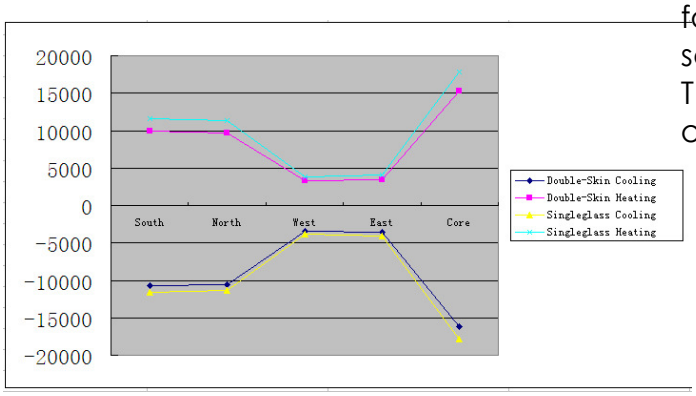
East thermal zone



West thermal zone

4.5.4 Comparison of the simulation

We can see the there are not major differences between the double-glass façade single-glass façade. However, double-glass façade does save energy respect to single-façade system. Therefore, we choose double-glass façade as our envelope.



	Double-Skin Cooling	Double-Skin Heating	Singleglass Cooling	Singleglass Heating
South	-10680	9945	-11634	11634
North	-10574	9715	-11377	11377
West	-3438	3258	-3807	3807
East	-3569	3466	-4014	4014
Core	-16239	15288	-17843	17843

	Double-Skin Cooling	Double-Skin Heating	Singleglass Cooling	Singleglass Heating
South	14:00 on 29th June	05:00 on 10th January	14:00 on 29th June	06:00 on 20th December
North	14:00 on 29th June	05:00 on 10th January	14:00 on 29th June	06:00 on 20th December
West	14:00 on 29th June	05:00 on 10th January	14:00 on 29th June	06:00 on 20th December
East	14:00 on 30th June	05:00 on 10th January	14:00 on 30th June	06:00 on 20th December
Core	14:00 on 29th June	05:00 on 10th January	14:00 on 29th June	06:00 on 20th December

The next step is to analyze which is the dominant factor of our load. We choose one thermal zone ,and calculated the ventilation load. We get the statistics below. The ventilation is occupying around 60% of the heating and cooling load. The way to reduce the ventilation load is to design a high-efficient HVAC system.

ANNUAL LOADS TABLE

ventilation - Qv- monthly

HOUR	JAN (Wh)	FEB (Wh)	MAR (Wh)	APR (Wh)	MAY (Wh)	JUN (Wh)	JUL (Wh)	AUG (Wh)	SEP (Wh)	OCT (Wh)	NOV (Wh)	DEC (Wh)
00	-81350	-65559	-53104	-24250	-1345	2477	5989	4257	0	-8905	-32747	-69310
01	-84388	-71154	-54385	-24474	-2337	2304	5584	3936	0	-10170	-36143	-71161
02	-86667	-72245	-56235	-26280	-4225	2207	4936	3635	0	-11144	-38143	-73814
03	-89426	-73574	-58085	-27809	-5433	2199	4787	3629	-331	-12409	-40387	-76928
04	-92101	-74625	-59018	-28535	-4563	2594	5112	3921	-568	-13399	-42159	-79696
05	-93454	-75156	-57886	-27141	-2510	2939	5904	4673	-379	-13589	-42953	-80958
06	-92141	-73972	-54674	-23681	-1053	3428	7362	5962	-95	-11383	-40145	-79644
07	-80027	-71021	-51134	-22242	-565	4425	9785	8211	288	-8532	-33107	-75219
08	-75864	-67255	-46670	-18204	-275	5795	12441	10769	1497	-5986	-27438	-70208
09	-71434	-63911	-42944	-14826	370	7331	15159	13081	2871	-4095	-22643	-64520
10	-67226	-60757	-39208	-12063	1095	8910	17617	15265	4001	-2732	-18689	-58648
11	-63450	-57603	-36078	-9981	1818	10332	19625	17102	4779	-1677	-15556	-53099
12	-60562	-54622	-34276	-8785	1817	11346	21120	18388	5370	-1056	-13127	-48446
13	-64226	-50589	-33548	-7067	1170	12189	21604	17219	5695	-728	-11599	-46241
14	-63696	-48981	-33004	-6993	722	12665	22244	16703	6374	-625	-11516	-45362
15	-65540	-50156	-34274	-8550	384	11799	21326	15067	5501	-1383	-13704	-47843
16	-68704	-53103	-36515	-10801	18	10339	19238	13059	4148	-2799	-17204	-52137
17	-72143	-57046	-39738	-13314	-150	8618	16307	10756	2722	-4595	-20930	-57122
18	-75396	-61184	-43298	-15404	-102	6913	13133	8429	1411	-6406	-24781	-61728
19	-75933	-61296	-44776	-17335	-14	5439	11009	7292	409	-7438	-26938	-63091
20	-77228	-63004	-46385	-18788	-152	4576	9505	6482	135	-8208	-29118	-65357
21	-78209	-64097	-47528	-20126	-217	3910	8483	5825	0	-8619	-30874	-66715
22	-79211	-64717	-48348	-21430	-387	3389	7562	5140	37	-8795	-32224	-67694
23	-80292	-65292	-49484	-22777	-804	2979	6791	4467	37	-8874	-33354	-68580

4.5.5 Condensation

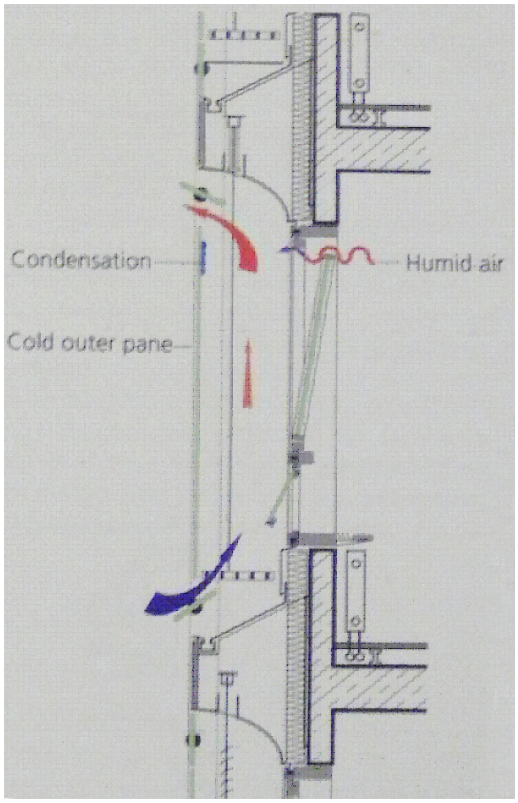
Shanghai is a city troubled by humidity. Large amount of energy is used to get rid of the humidity instead of simply cooling or heating air. Condensation problem is also a major issue that worth of better consideration.

Condensation in the façade cavity

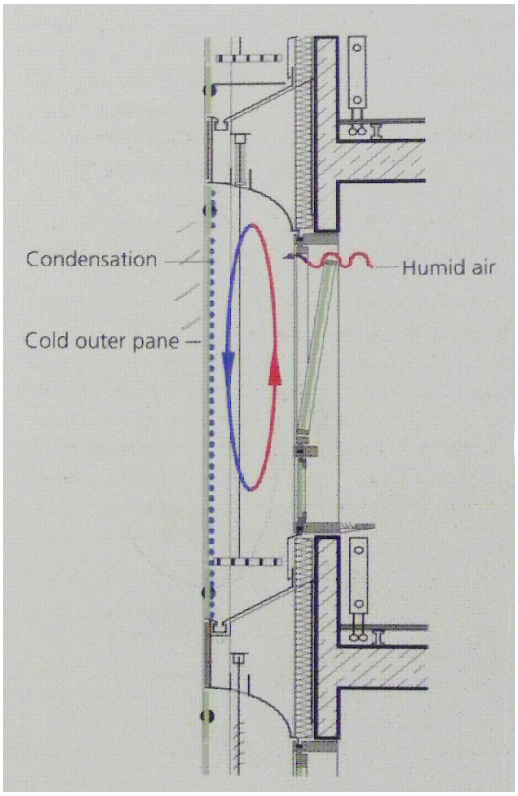
If a closable façade has too tight a seal, condensation can form on the inside face of the external skin for more than just short periods. This can impair the view through the façade in both directions ,as if a pane of translucent glass had been installed in the outer skin. This effect is undesirable for a number of reasons, however, not just because of the visual disturbance it causes and the interruption of contact with the outside world .

In principle. condensation can form in the cavity space during the cold periods of the year-independently of the ventilation-when humid air from the internal spaces comes into contact with surfaces whose temperatures lie beneath the dew point of the humid air. The dew point, or rather the dew-point temperature contained in the air corresponds precisely with the maximum moisture-absorption capacity of the air; when the air is saturated with moisture or has a relative humidity of 100 percent. If the air is cooled below this dew point, moisture is precipitated in form of rain ,mist ,condensation or frost.

A single glazed outer façade skin can cool down quite rapidly at night if efficient thermal insulation in the inner façade layer prevents virtually any heat escaping from the building to the outer face and if ,at the same time,there is a clear night sky and wind or radiation result in great heat losses. no
condensation or frost will be formed on the outer face of the façade.



Route taken by moist room air when the façade intermediate space is ventilated.



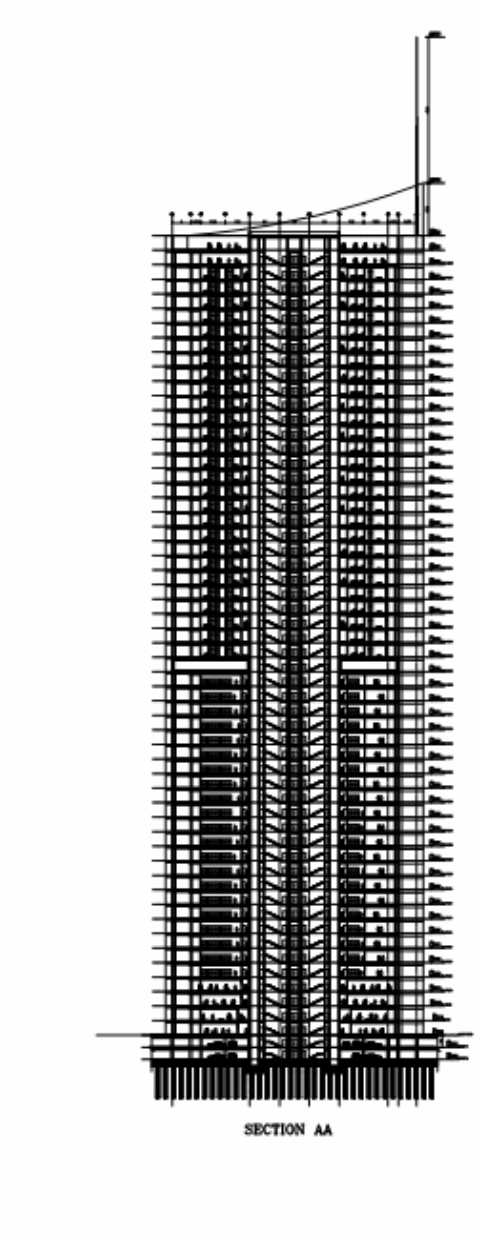
Route taken by moist room air when the façade intermediate space is closed.

4.6 HVAC system design

High rise complexes have air conditioning needs unlike any other building. These buildings have unique challenges. As most people know, hot air rises and cool air remains close to the ground. This makes finding and utilizing the perfect HVAC system for a high rise complex incredibly challenging. Many high rise complexes are not equipped with the proper air conditioning unit. This is generally due to poor planning or lack of knowledge of what type of system should be installed. As a result, the need for maintenance and the frequency of unexpected repairs dramatically increases. Therefore, it is imperative that the proper system be installed.

Finding the proper A/C unit for a high rise building is one of the most challenging and time consuming tasks of owning and operating a high rise complex. It is very highly advised that planning for the HVAC system be started during construction of the building. This allows for planning to be made in advance and for the most appropriate unit and system of ducts be installed from the very beginning. This avoids the need for changes in construction later on. This is preferable because any changes made to the HVAC system of a high rise will almost always involve some level of construction. Not only is this incredibly costly, but it is very time consuming and can leave part, or all, of the high rise without air conditioning during the construction.

Start shopping for the perfect air conditioning system long before construction begins. Preferably, shopping for the system should occur around the same time that the plans for the building are being designed. This allows for the architect to make any adjustments that may be necessary to accommodate the required A/C unit and duct system.



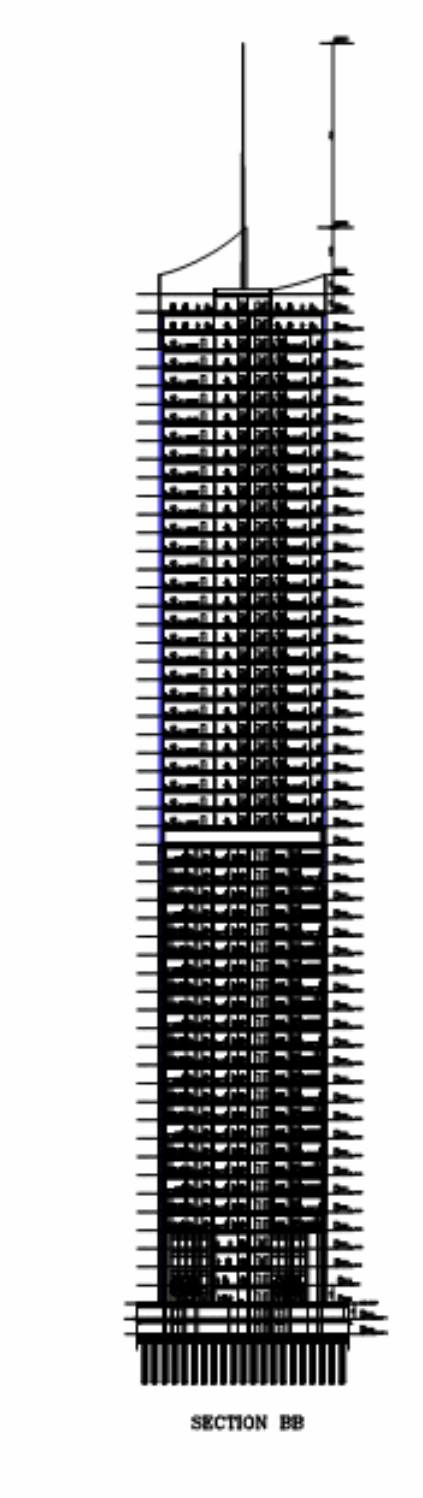
4.6.1 facility &evacuation floor

First of all ,we decide to use one floor, totally, as a facility &evacuation floor.

The reason for this is that:

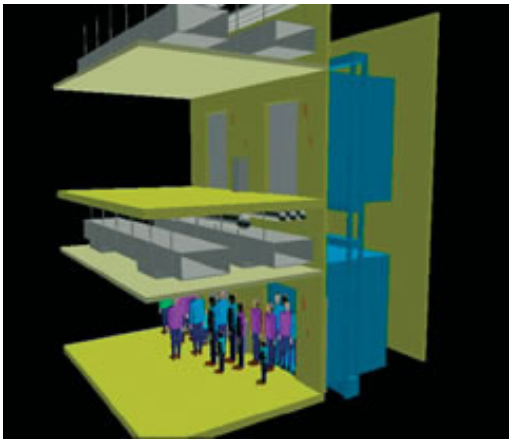
Several recent fires in high rise buildings have awakened renewed interest in fire safety on the part of the public, and in particular, apartment dwellers. Since most high rise buildings are of fire resistive construction and possess reliable enclosed stairways, fires are generally confined to individual office furnishings or possibly the contents of one floor.

Thus, it is important first of all to understand that fire in a high rise building is not necessarily a cause for panic. Nevertheless, it must be realized that if a fire occurs within a building, it will most likely be necessary to seek refuge as soon as possible. Therefore, it is extremely important that the occupants become well acquainted with the location of stairways provided in buildings and with the procedures to follow in case of fire. If a floor dedicated to evacuation is provided, the refuge will have a much bigger chance to survive . Also in high rise buildings with a large number of occupants, it would take an excessive length time for occupants to evacuate if a single staged total building evacuation is initiated. Therefore, an alternative phased evacuation has been proposed to facilitate the evacuation of Sky Tower occupants most at risk. occupants on the fire floor and immediate vicinity. This means the queuing time into the staircases is reduced and occupants can leave the fire floors more quickly because there is nobody else in the stairs. The remaining occupants of the building are evacuated subsequently as necessary.



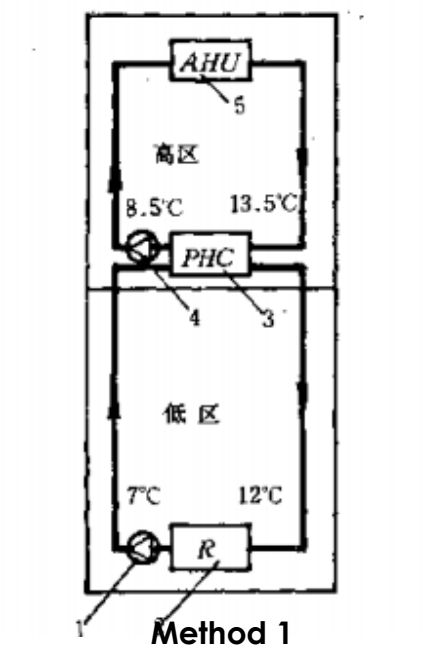
Except from that ,we decide to use the protected/hardened lifts .In fact, lifts have already become a means of evacuating mobility impaired occupants since it is not realistic to expect fire service personnel to carry people to safety down stairs. When lifts are used in conjunction with stairs, it reduces the building evacuation time.

A refined lift evacuation strategy which consists of combining stair evacuation from a group of occupied floors to a protected area on a transfer floor followed by lift evacuation from the transfer floor to street level is proposed. The lift evacuation strategy is for occupants on each floor to evacuate via the stairs to the protected transfer area first. The occupants can then choose to travel down to the street level by using shuttle lifts or stairs. This refined lift evacuation strategy has also been adopted and approved in super high rise buildings designed such as the 492m Shanghai World Financial Centre and 439m Kingkey Finance Centre in China.



On the other hand ,using totally one floor as an evacuation floor is "luxury" in Shanghai,a city where real estate market is rising dramatically. We consider ,using the evacuation floor as a facility floor for our HVAC system during normal operation.

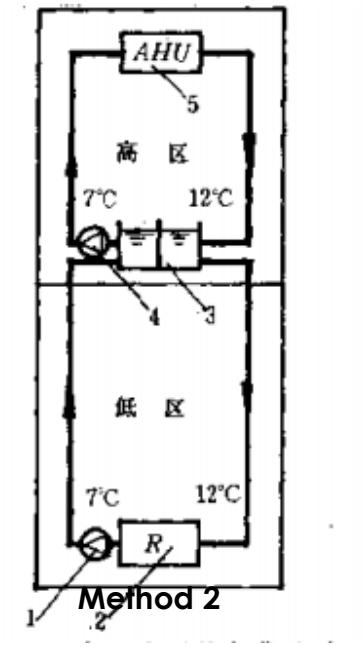
4.6.2 Choosing system



Method 1

Normally ,for the facility floor ,which will be located the HVAC equipment, we have two different choices

For method 1(1.pump 2 refrigerator 3. Plate heat exchanger 4, pump 5 air handling unit) ,the benefit is that simple and operational fee is relatively low .the disadvantage is that it does exist an temperature difference in the high-pressure zone, which reduce the efficiency of the air handling unit.

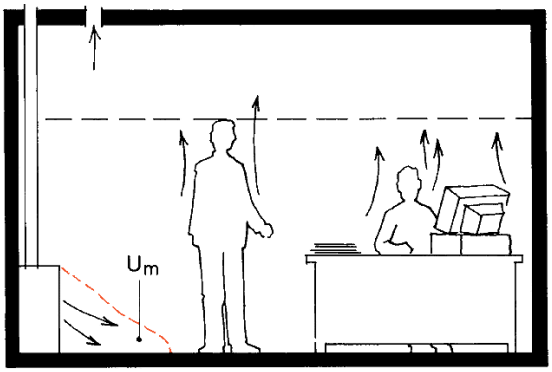


Method 2

For method 2(1.pump 2 refrigerator 3. water storage tank 4, pump 5 air handling unit) .the advantage is that there is no temperature difference but on the other hand, it is more complicated and running cost is much higher. The design of the tank is very difficult not only in terms of design but also in management.

Both of the methods are applicable in the evacuation floor. But after considering all the factors stated above, we decided to use method 1.

4.6.3 Displacement ventilation for office



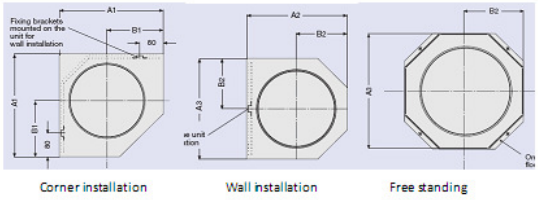
As we have a mixed building ,we decide to use the Displacement ventilation for office and Radiant panel for the residential.

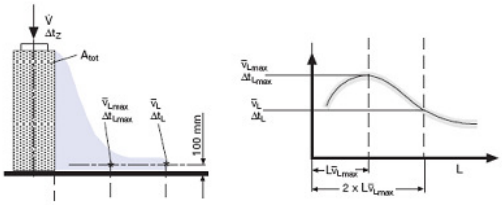
The reason we must have mechanical ventilation is that if not we will only have water system, no air system, so there will be no fresh air supply. Another reason is since radiant heating/cooling has no air movement, which will make occupants feeling uncomfortable, while ventilation can compensate this. The four factors affecting people's comfort indoor are: air temperature, moisture, air velocity and mean radiant temperature. So we have to take care of the air movement indoor. We assume 10 occupants in an office cubic , and 90 m3/h fresh air for every occupants, then the total fresh air quantity is 900 m3/h. Due to the villa's air□conditioned volume is 333 m2 x 3.3 m = 1100 m3. So the air change rate is 900/1100=0.8 1/ h . We used this number in Ecotect HVAC load calculation. And the fresh air is chilled down to the dew point so it can bring the over humidity away. We notice that this is a very small amount of fresh air supply, and one good way to supply a low rate of air is displacement ventilation.

Displacement ventilation is characterized by naturally generated stratification in density (thermal) and scalar concentration (pollutant). It discharges supply air of low velocity near the floor and cool supplied air spreads over floor and forms pool of conditioned air. When this cool air meets a heat source, due to the temperature difference and resulting buoyant force, convection is generated through warmed and polluted air goes upwards to the ceiling where it exits.

Displacement ventilation systems supply air directly to the occupied zone. The air is supplied at low velocities to cause minimal induction and mixing. This system is used for ventilation and cooling of large high spaces, such as auditoria and atria, where energy can be saved if only the occupied zone is treated rather than trying to control the conditions in the entire space.

The displacement outlets are usually located at or near the floor with the air supply designed so the air flows smoothly across the floor. Where there is a heat source (such as people, lighting, computers, electrical equipment, etc.) the air will rise, pulling the cool supply air up with it and moving contaminants and heat from the occupied zone to the return or exhaust grilles above. By doing so, the air quality in the occupied zone is generally superior to that achieved with mixing room air distribution. If air mixing is encouraged at the floor level, this type of floor-to-ceiling room air distribution is known as underfloor air distribution; if mixing is discouraged, it is displacement.



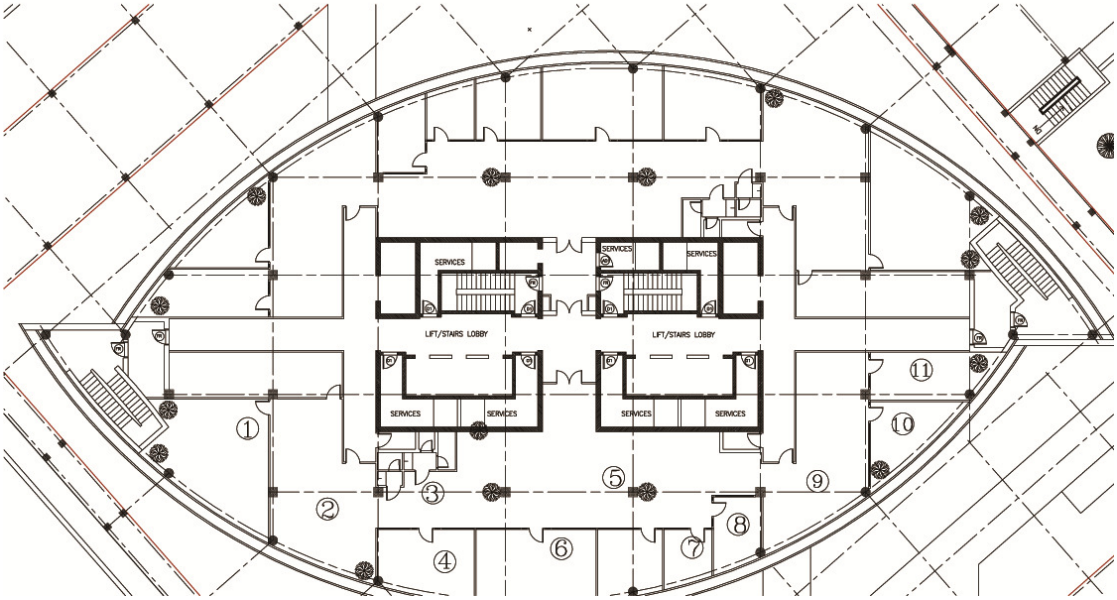


Displacement room airflow presents an opportunity to improve both the thermal comfort and indoor air quality (IAQ) of the occupied space. It also takes advantage of the difference in air density between an upper contaminated zone and a lower clean zone. Cool air is supplied at low velocity into the lower zone. Convection from heat sources creates vertical air motion into the upper zone where high level return inlets extract the air. In most cases these convection heat sources are also the contamination sources (e.g., people, equipment, or processes), thereby carrying the contaminants up to the upper zone, away from the occupants.

Since the conditioned air is supplied directly into the occupied space, supply air temperatures must be higher than mixing systems (usually above 63 °F or 17 °C) to avoid cold draughts at the floor. By introducing the air at supply air temperatures close to the room temperature and low outlet velocity a high level of thermal comfort can be provided with displacement ventilation.

4.6.4 Ventilation system terminals design

We choose displacement ventilation diffusers fro m TROX company, the type QLV□90, QLV□180 and QLV□360. The detailed parameters are:

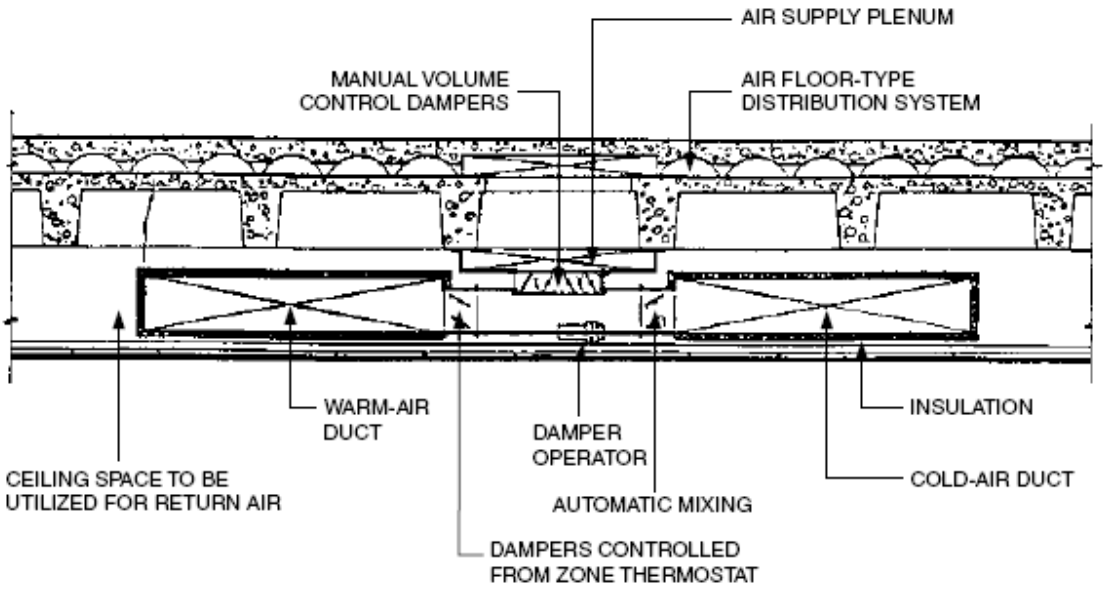


Room	Diffuser NO.	Type	Flow rate (m3/h)	ΔT (K)	Outlet area (m2)	Velocity (m/s)	Height (mm)	NW (mm)
1	2	QLV - 180	142	2	0.39	0.1	800	160
2	2	QLV - 90	74	2	0.21	0.1	600	160
3	2	QLV - 90	74	2	0.21	0.1	600	160
4	2	QLV - 90	74	2	0.21	0.1	600	160
5	3	QLV - 360	138	2	0.38	0.1	600	160
6	2	QLV - 180	142	2	0.39	0.1	800	160
7	2	QLV - 90	74	2	0.21	0.1	600	160
8	2	QLV - 90	74	2	0.21	0.1	600	160
9	2	QLV - 360	138	2	0.38	0.1	600	160
10	2	QLV - 180	142	2	0.39	0.1	800	160
11	1	QLV - 90	74	2	0.21	0.1	600	160

4.6.5 Radiant panel

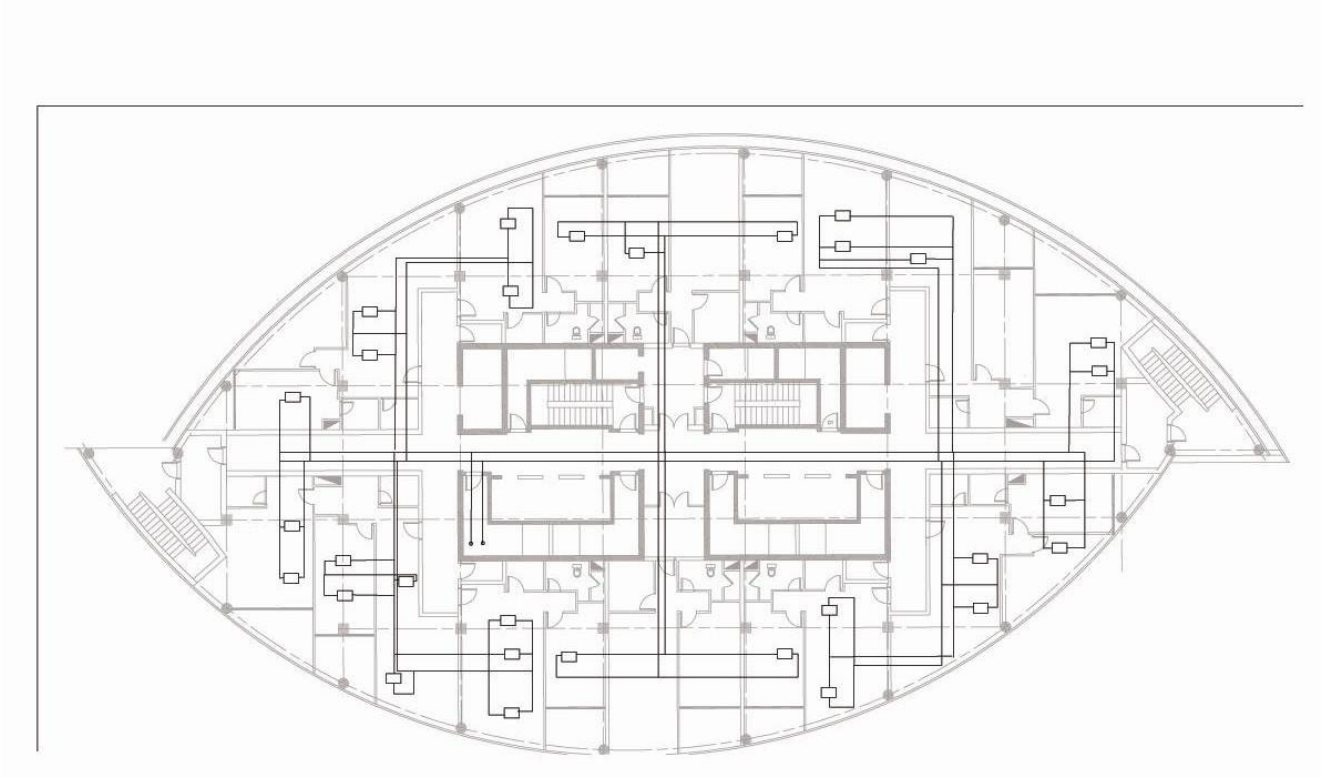
For the residential area, we decide to use the Radiant panel.The advange of radiant panel is that it saves the space(important for a city congested like Shanghai) and almost invisible. Even in some Chinese eyes, it means fashion. Also It is flexible and easy to install.

The detail of the radiant panel is shown.Section showing air-conditioning distribution system.



We choose ceiling radiant panel product from Chatsworth company. This product is surface mounted, elegant and flexible installed. Its size is 600mm x 600mm x 40mm. There are two rating watts, 200W and 300W types.

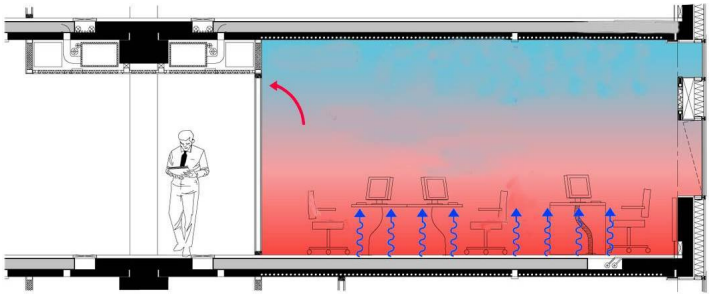
The possible radiant panel in the residential area is:



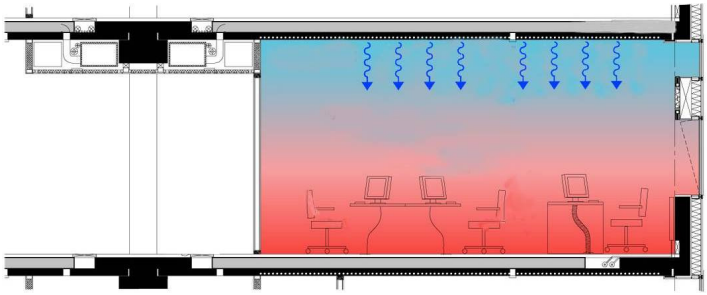
4.7 Thermal Mass Effect

since the thermal mass will absorb heat when the surroundings are hotter than the mass, and give heat back when the surroundings are cooler. the mass of the building provides "inertia" against temperature fluctuations, like the concrete ,is an ideal material to be used for this effect.

For the office ,we use the displacement ventilation. Also by using this method, the slab could be cooled during the day. And at night, when there will be no workers, without using the HVAC system, the slab will absorb the heat from the surrounding, thus in the second day, the start-up load of the HVAC system will be much lower. We use different strategies for different time of the year.

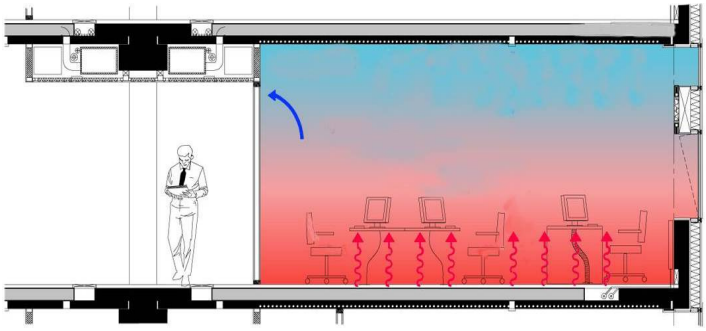


Summer daytime

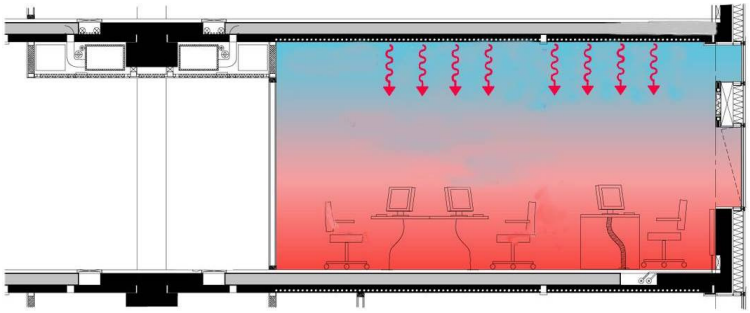


Summer night

On the contrary ,in the winter, the slab will absorb the heat during the day and emit the heat during the night., when there will be no people and no heating provided.

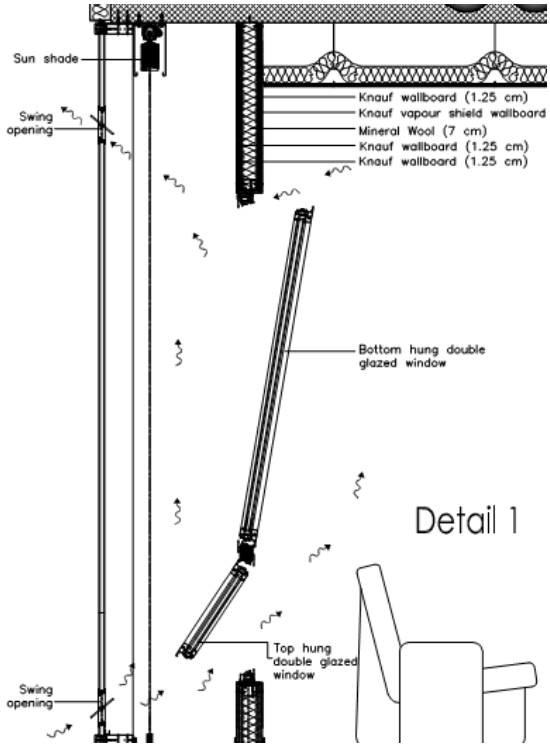


Winter daytime

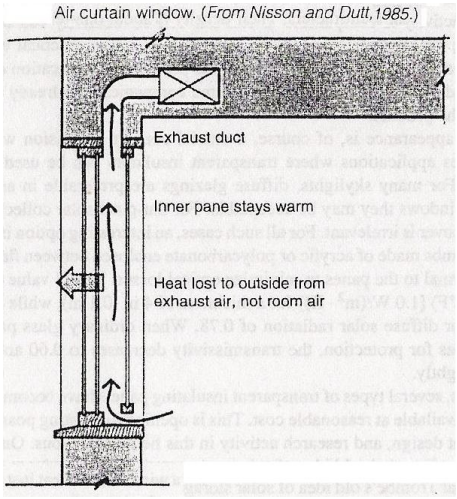


winter night

4.8 Ventilation control in the residential area and office area



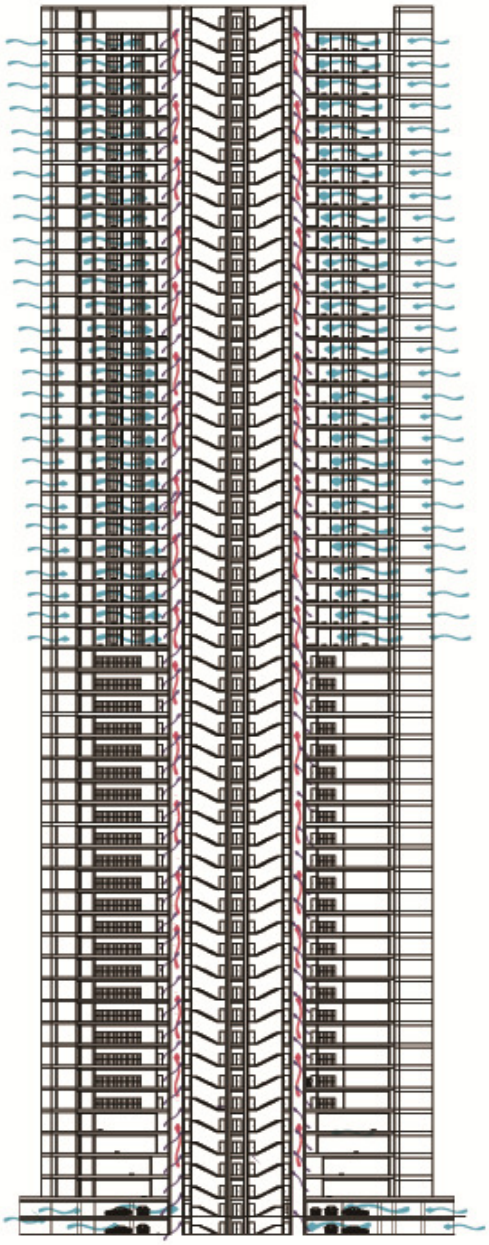
For the residential area, we choose the nature ventilation in the transition season if it is possible. The bottom and upper part of the window can be opened. And between the double-skin ,shading is provided in case of strong sunshine. The people who are living in can choose to open or close it. The details will be shown below.



Air curtain window. (*From Nisson and Dutt,1985.*)

For the office area, we have a concept shown left. No direct air is conduct between the inside and outside, but the air will recirculate within the cavity to keep the indoor space comfortable. The ventilated cavity acts like a buffer zone .The air will also be conducted through the mechanical duct. The details will be shown below.

As we have a inner empty space within our skyscraper. We use the ventilation strategy like the drawing shown. The office area will be provide with mechanical duct, but the residential ,nature ventilation is allowable.

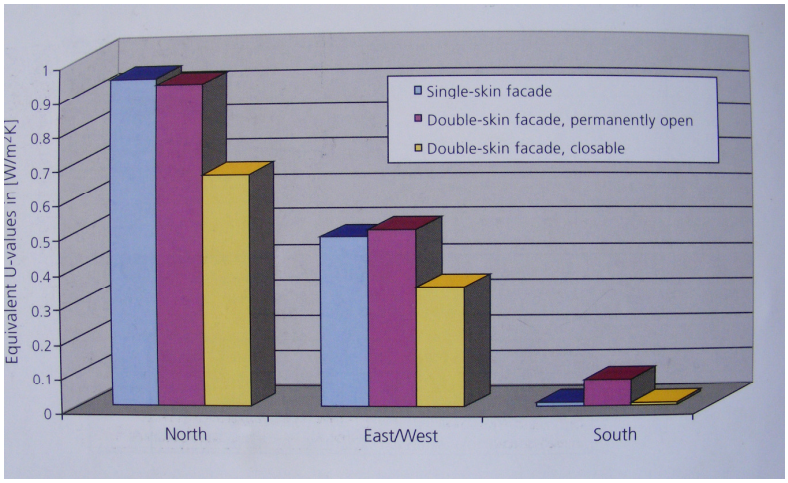


4.8. Double Skin

4.8.1.U value

Equivalent U-value as defined in the thermal insulation regulations currently valid in Germany/T16/,dating from 1995.The coefficient of the of thermal transmission for a single-skin façade or for the inner layer of a double-skin façade is below. Different orientation also has different U value.

Within a pane of insulation double glazing ,where different temperatures prevail inside and outside the building ,the air in the cavity between the panes of glass will be warmed on one side and cooled air sinks on the bottom .The result is a cyclical motion, whereby the heated molecules of air are initially borne upward before giving off there heat to the cooler panes of glass and sinking again. To reduce this transport of heat through free convection, double glazing unites are no longer filled with air nowadays, but with inert gas.



4.8.2 Double Skin façade Construction

The most remarkable characteristic of our Tower is the use of glass double-skin on all of the facade. Since its inner skin consists of pair glass, the tower has virtually a triple glass shell. It is with the double-skin facade that the natural ventilation of the high-rise was actualized, and the transparent and energy-saving building was made possible.

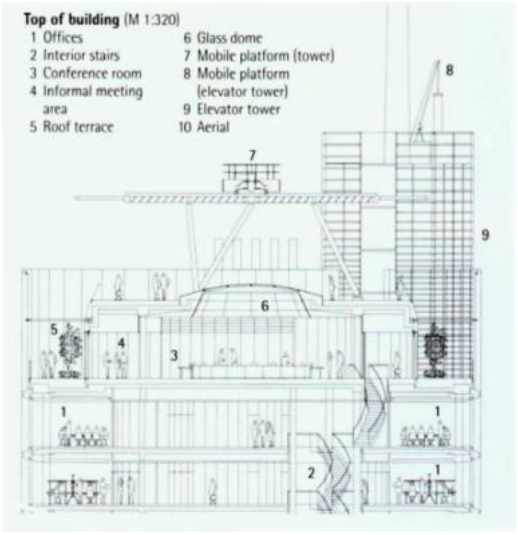
We choose double-skin facades because that the outer skin provides greater thermal insulation both in summer and winter.The buffer effect ,with which one is familiar from conservatories and glazed loggias,can result in a considerable saving of energy .Similarly,it is argued,the facility for accommodating sunshading in a protected position in a well-ventilated intermediate space between the inner and outer skin means that the construction of all-glass facades presents no problems.

4.8.3 Case study of RWE Tower in Essen, Germany

4.8.3.1 Design of fish-mouth

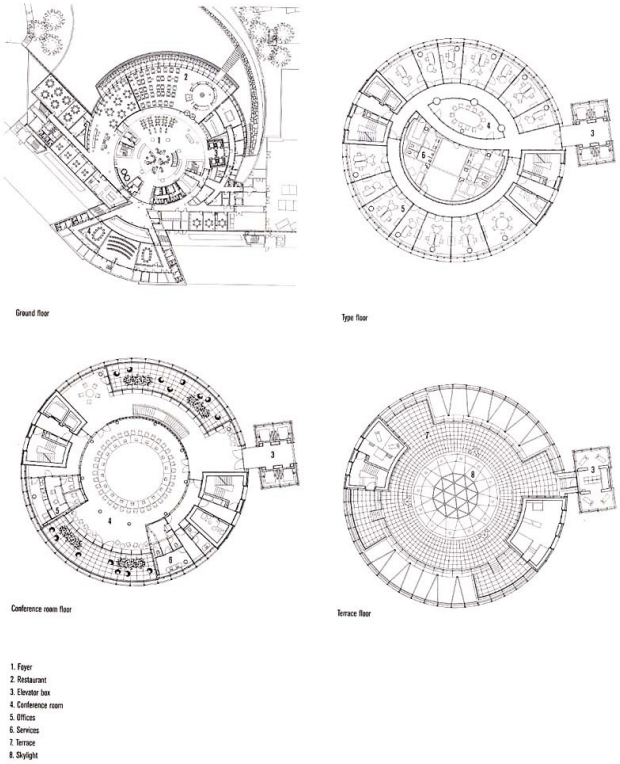
As is widely known, in Europe any new building is required to blend in with the other buildings in a street.

The RWE Tower has the main building set back from the street, along with the pergola the height of which is aligned with the eaves of neighbouring houses. There was still need to obtain the special sanction of the municipal authorities to construct the skyscraper. As Achim

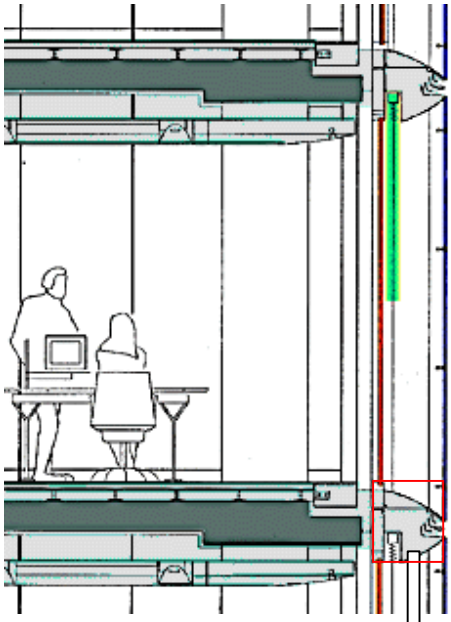


Nagel, one of the IOK architects, explained, churches dating back to ancient times were the only tall buildings. The 162m height of the tower, including an aerial on the top, is the highest point in North-Rhine Westphalia, but does not look isolated, when it is seen from anywhere in the city. Its abstract and clear external appearance is essentially in harmony with the row of stores and houses in the street.

The main concern of the design of this 31-storey cylindrical tower is natural ventilation. This is achieved by its double-leaf facade, which is intended to provide good natural ventilation for perimeter office areas. The space inside the facade is supplied with outside air through a meandering arrangement of intake and exhaust louvers.



The double skin allows the RWE Tower to "breathe". It consists of an exterior sheet made of fixed glass panels - 2 x 3.6m modules that permit air circulation through corresponding slots, and an interior sheet with operable panels. A solar protection system is installed between both layers, which are 50cm apart. Strips, placed on the setting lines for the exterior facade modules, are perforated on the right side and solid on the left side, at the lower level. The disposition is reversed on the upper level, next to the roof, which guarantees a minimum diagonal of ventilation and prevents the return of recently evacuated air back into the spaces. The interior layer of the double skin is a conventional facade, insulated by collapsible panels that can be controlled manually.

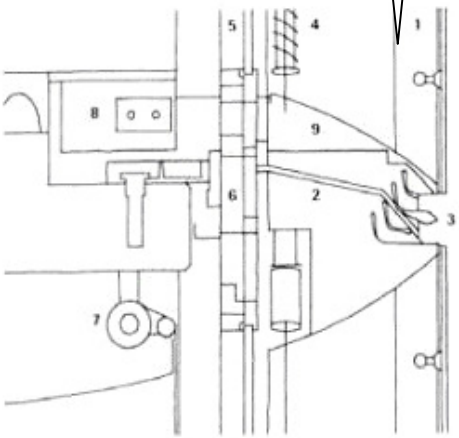


Between the inner and outer facades, separated a distance of 50cm, a set of louver blinds, consisting of 80mm-wide aluminum strips, is installed and can be remotely-controlled. The blinds are protected by the outer facade from wind and rain, and prevented by the inner facade from transmitting the heat to the room, so as to maximize their shading and heat-reflecting effects. Also, a set of roller shades made of fireproof cloth are fitted inside the inner facade.

The composition of the facade

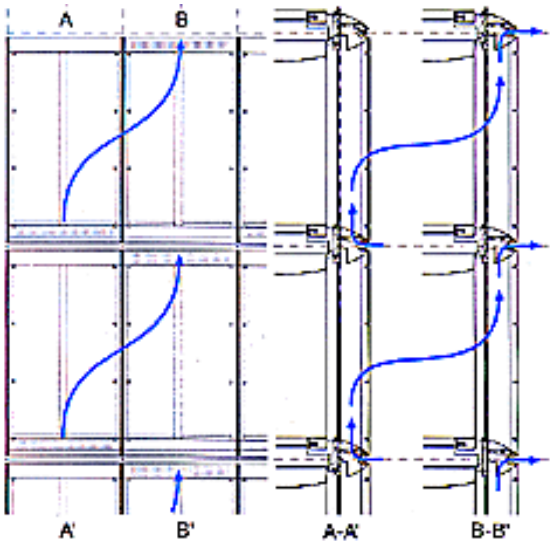
Notes		
Inner Facade	louvre blinds	Outer Facade

1 façade construction
2 façade segmentation
3 Supply and extracted vent
4 Sun protect blind
5 Sliding window
6 Thermal separation
7 Anti-glare device
8 Convector
9 Walking Platform



Detail of fish-mouth

The 50cm-deep space between both skins can be partitioned by a glass panel at the partitioning wall of each individual cell, as indicated in the detailed floor plan. Hence, the wind circulating in the cavity can be controlled, and in addition, the transmission of sound between the cells can also be restricted. a special sash called a "fish-mouth" designed to absorb and exhaust outside air is built-in between stories, as mentioned in detail above.
The parts that support the outer facade as well



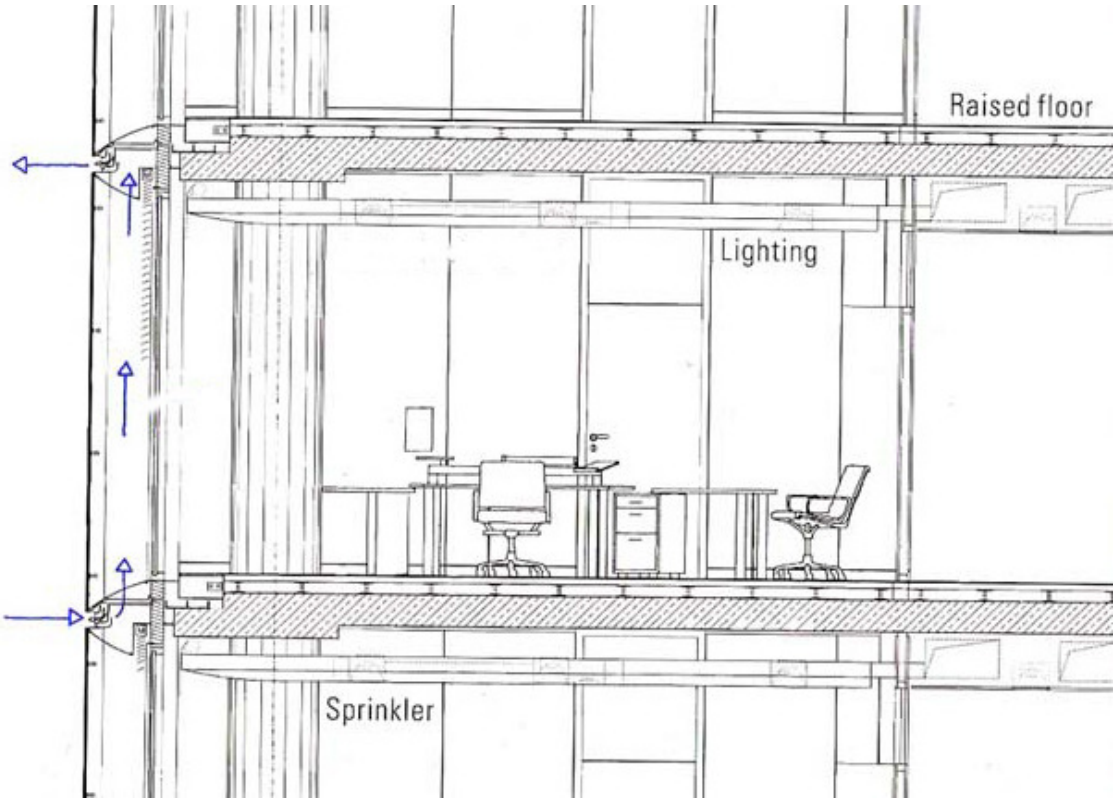
as absorb or exhaust air are called "fish-mouths" , which are responsible for both the intake and outtake of air in the double-skin.
This is a pair of sashes, where one carries a "fish-mouth" with small holes on its upper part exclusively for intake, and another has a "fish-mouth" with small holes on its lower part exclusively for outtake, as indicated in the plan. Due to such a composition, the outside air from the intake "fish-mouth" is warmed inside the double-skin and diagonally ascends to be exhausted from the outtake "fish-mouth" at the neighboring sash. If both the "fish-mouths" had been laid out vertically, exhaust air would take the shortest path up to the floor above and enter it in the place of fresh environmental air. If this happened, air quality would decrease with every subsequent floor.

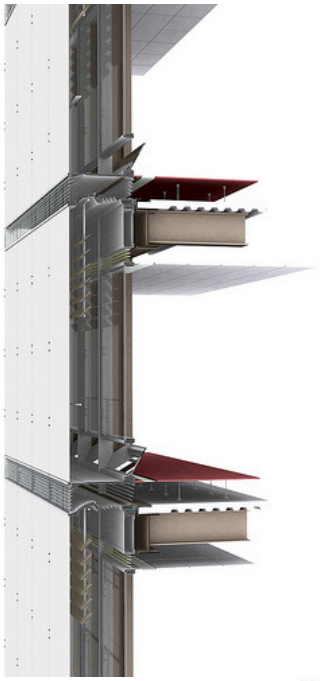
The upper fish-mouth open

When absorbed, the air stream is adjusted to a suitable speed, by going through the "fish-mouth." It is made slower in case the wind velocity is too great, whereas it is made faster in case their is no enough wind. Of course, no rain enters through the "fish-mouth." The sensors fitted to the aperture inform of the aerial conditions.

The upper fish-mouth closed

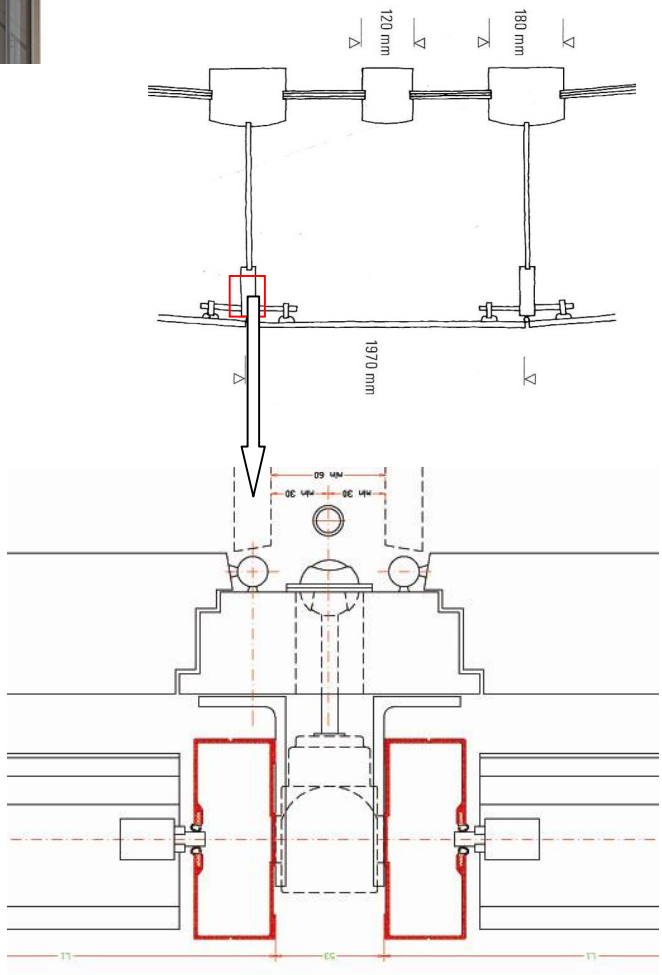
As mentioned above, the "fish-mouth" can also be used by raising its cover as a footplate for cleaning, and is effective in preventing fire from spreading to upper or lower levels. Also, its gently curved bottom side is formed to reflect sunlight moderately and to take in solar energy to the maximum extent. Incidentally, because the air conditions, including the wind velocity, vary according to the altitude, there is a difference in size between the "fish-mouths" in different floor





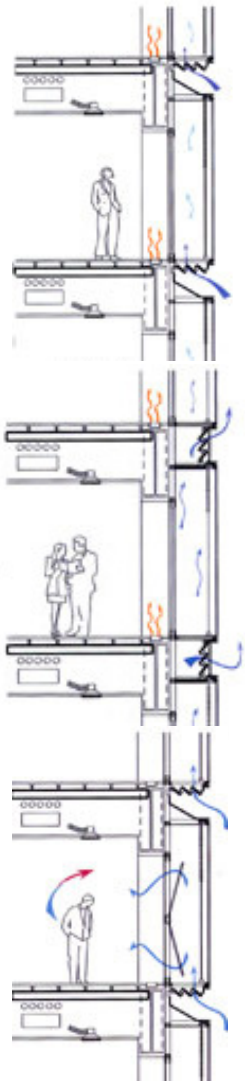
3 D view of the double-Skin facade

Vertical dividers in the facade seal the individual axes from one another and dampen the sound carried within the facade cavity, in effect creating a box window.



4.8.3.2 hybrid mechanical and natural ventilation with double skin façade

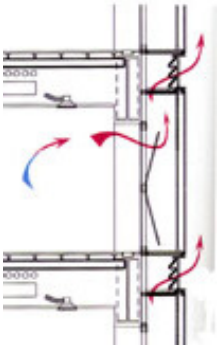
Ventilating is the process of "changing" or replacing air in any space to provide high indoor air quality (i.e. to control temperature, replenish oxygen, or remove moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide). Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior building air circulating, and to prevent stagnation of the interior air.



Displacement ventilation and winter air in

Displacement ventilation and winter air out

Mid-Season air in through the adjustable inner facade



Mid-Season air out through the adjustable inner facade

4.8.3.3 louver blinds design

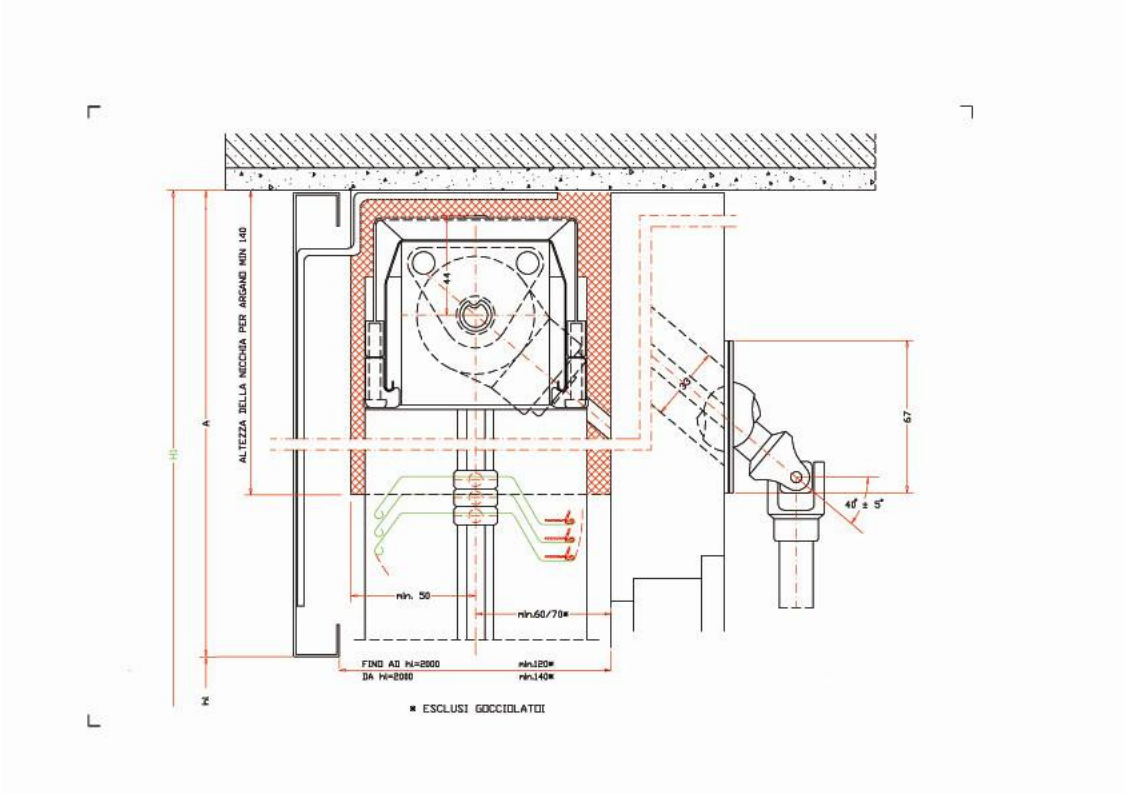
The louver between the double façade is also an very important for the automatic or manually control of the tower in terms of sunlight.

There are many different reasons to want to control the amount of sunlight that is admitted into a building. In warm, sunny climates excess solar gain may result in high cooling energy consumption; in cold and temperate climates winter sun entering south-facing windows can positively contribute to passive solar heating; and in nearly all climates controlling and diffusing natural illumination will improve delighting.

Well-designed sun control and shading devices can dramatically reduce building peak heat gain and cooling requirements and improve the natural lighting quality of building interiors. Depending on the amount and location of fenestration, reductions in annual cooling energy consumption of 5% to 15% have been

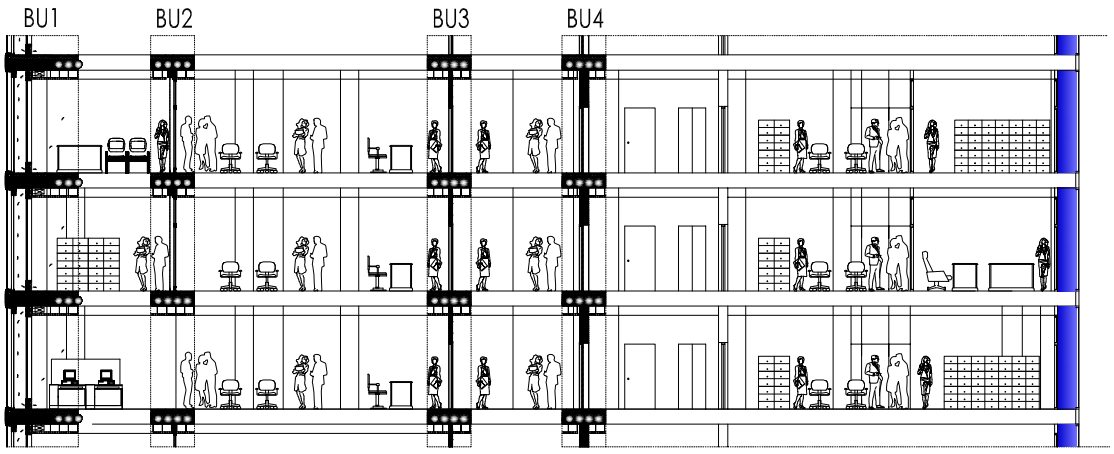
reported. Sun control and shading devices can also improve user visual comfort by controlling glare and reducing contrast ratios. This often leads to increased satisfaction and productivity. Shading devices offer the opportunity of differentiating one building facade from another. This can provide interest and human scale to an otherwise undistinguished design.

The detail is shown below, it is dual control ,both manually and electronically. In case during the holiday ,someone forgets to turn off the louver ,the room will not becoming a hot pot thanks to the automatic control of the building.

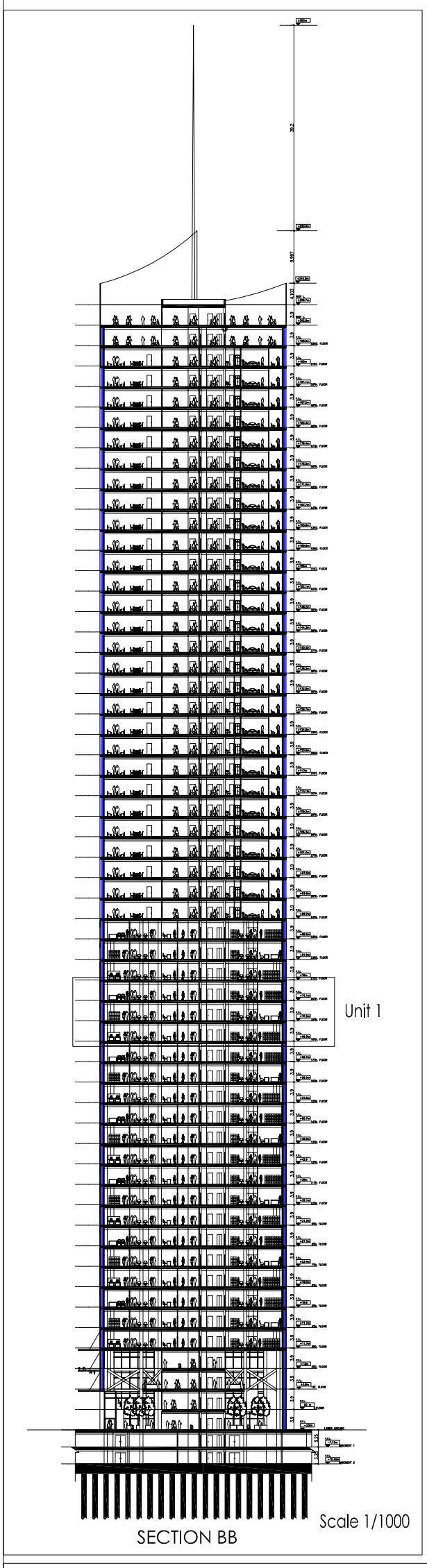


4.10 Details for Expo'10 Green Tower

EXPO'10 GREEN TOWER SHANGHAI.

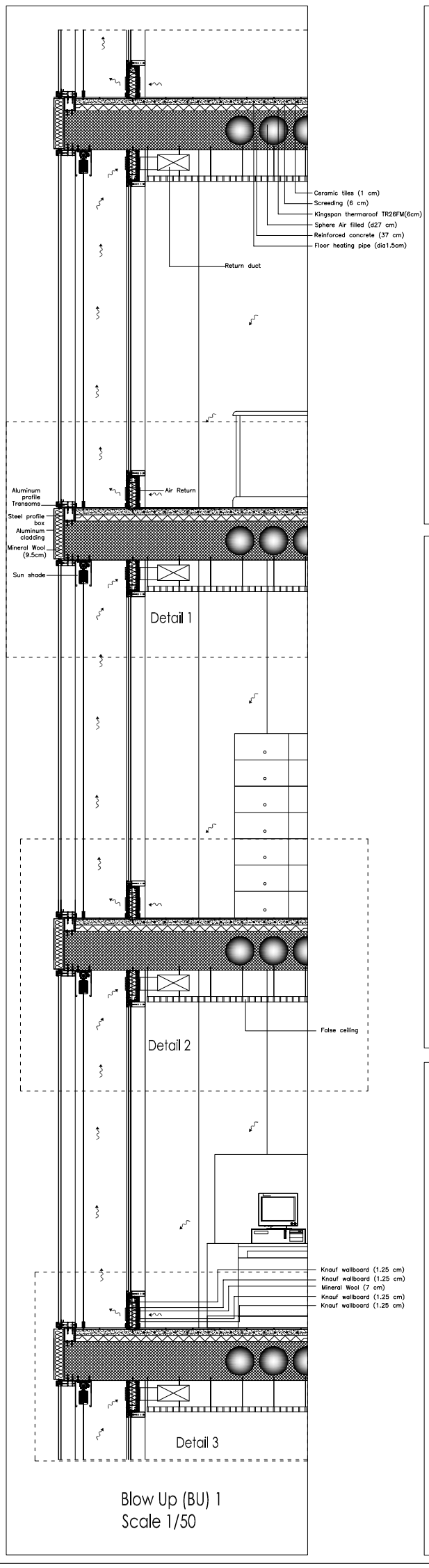


Unit 1
Scale 1/250

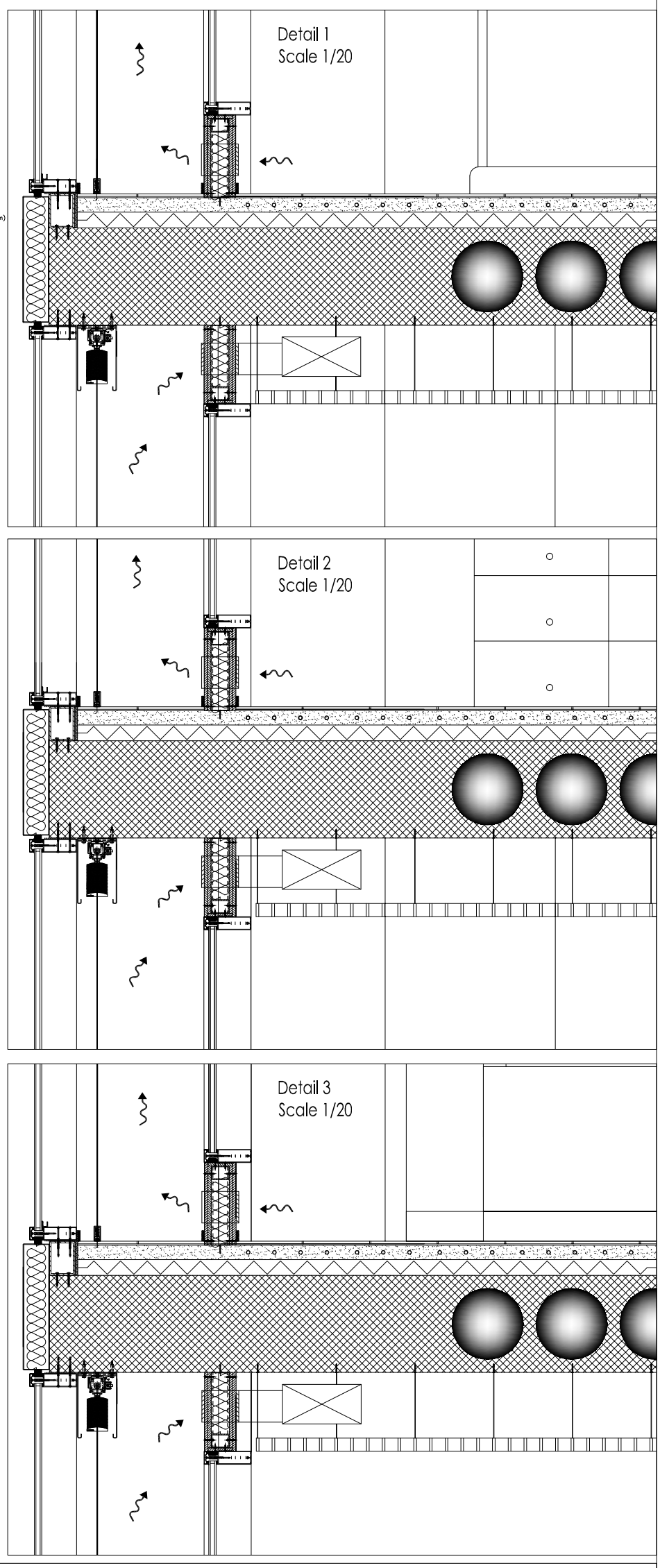


Unit 1

SECTION BB
Scale 1/1000



Blow Up (BU) 1
Scale 1/50



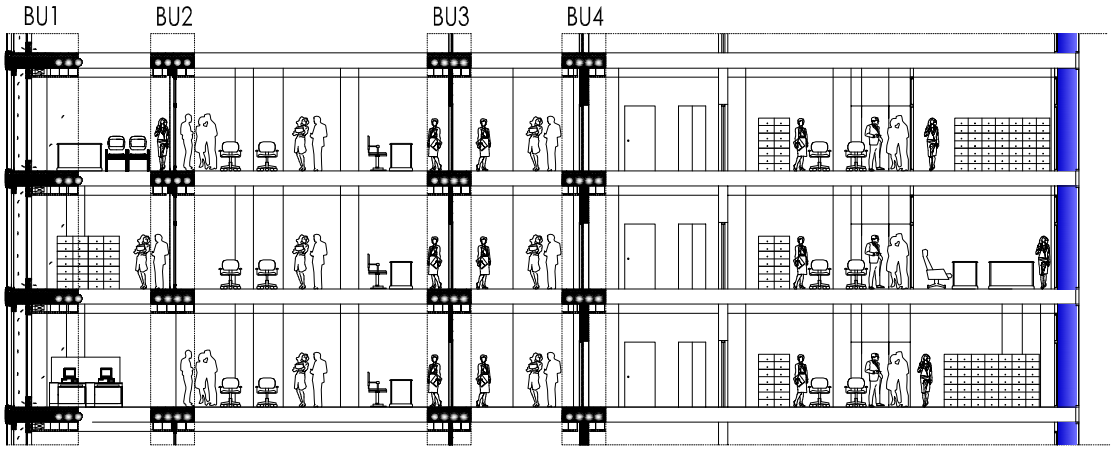
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

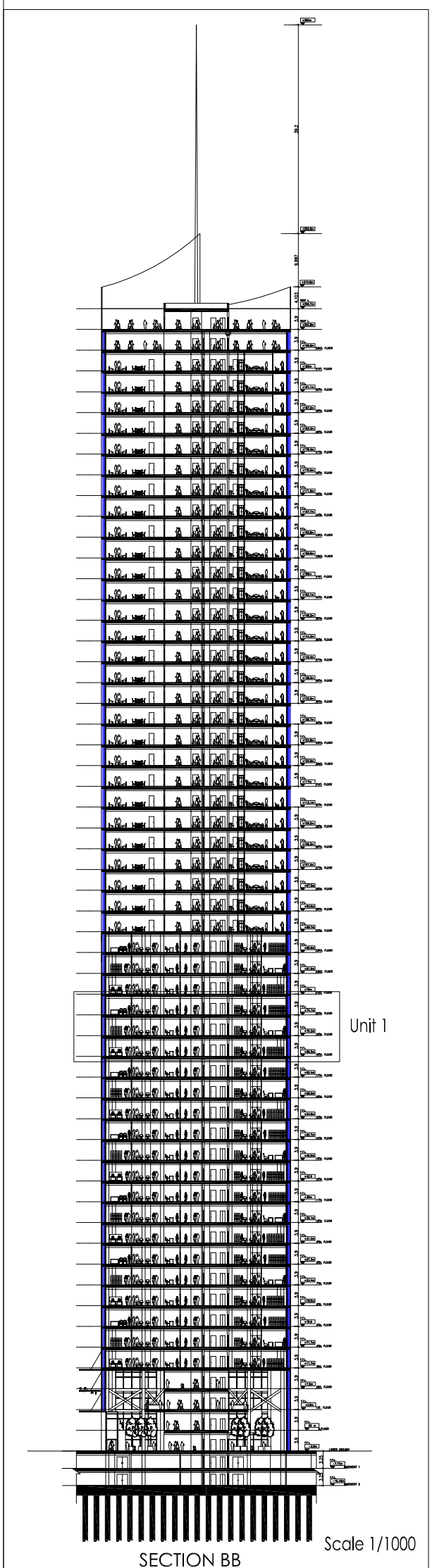
Vertical Blowup Detail 1

Scale: for A3 sheet

EXPO'10 GREEN TOWER SHANGHAI.



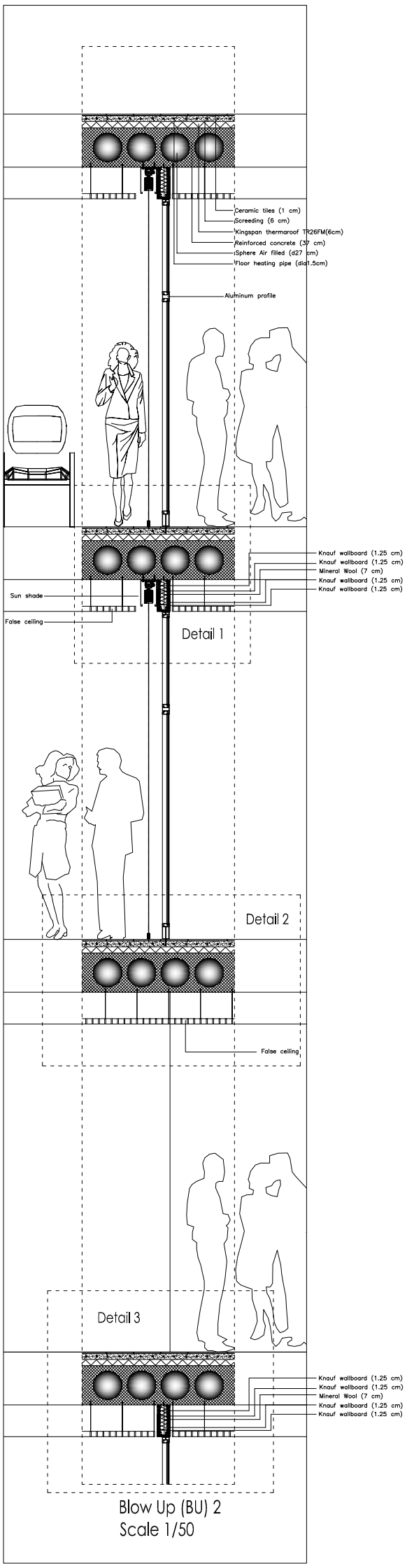
Unit 1
Scale 1/250



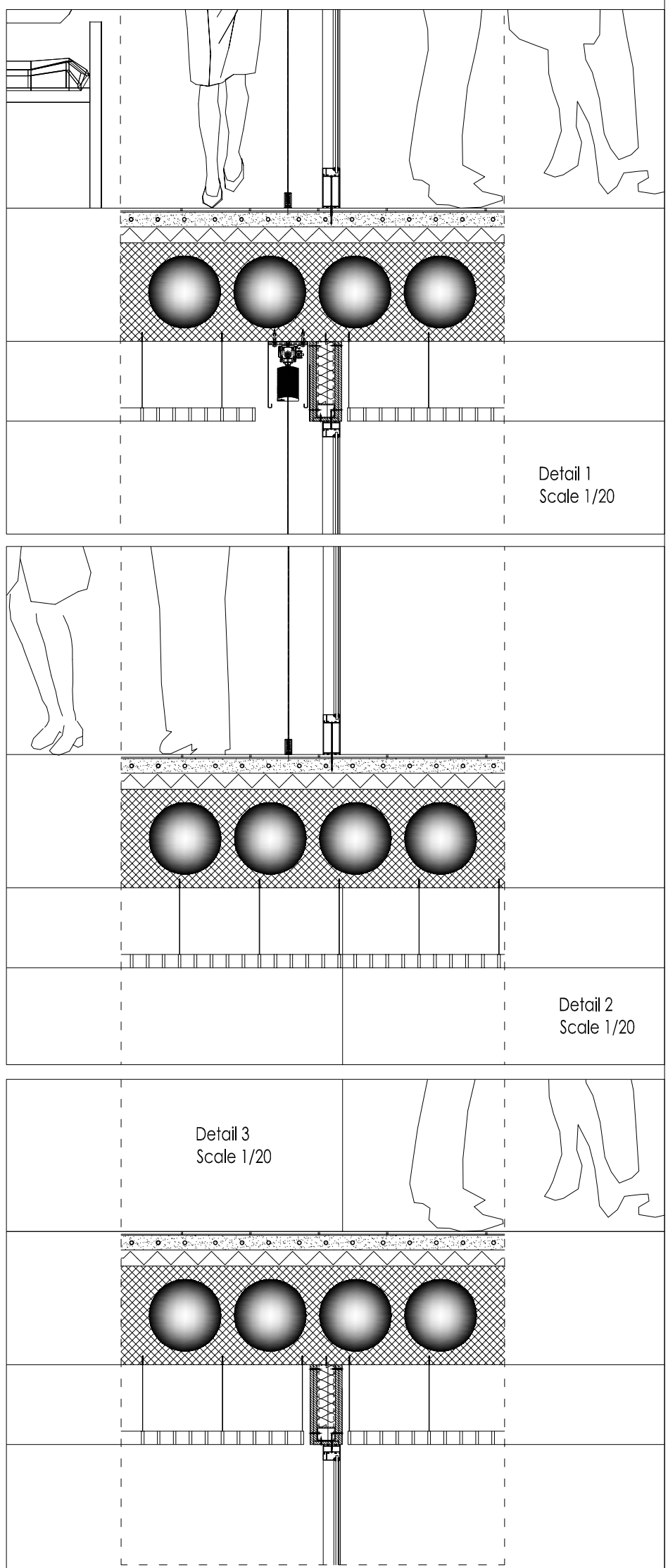
Unit 1

SECTION BB

Scale 1/1000



Blow Up (BU) 2
Scale 1/50



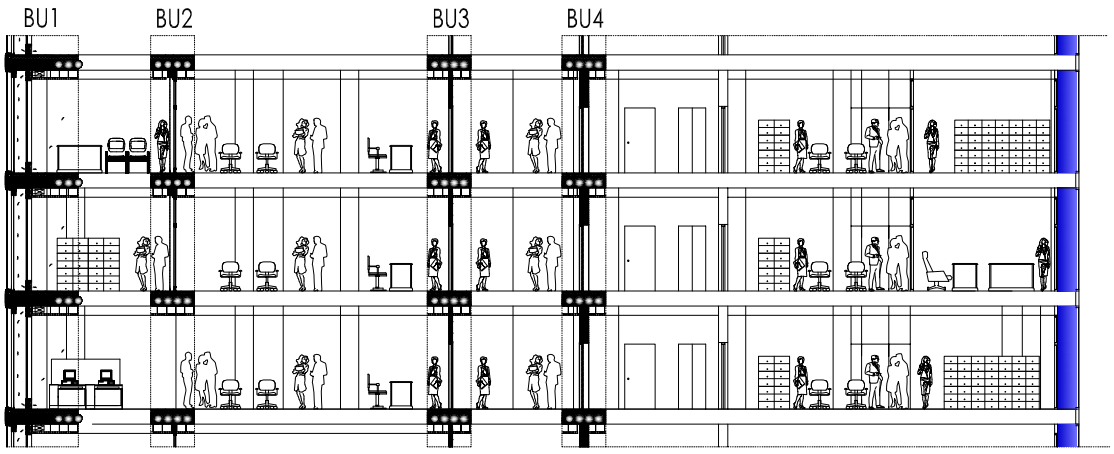
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

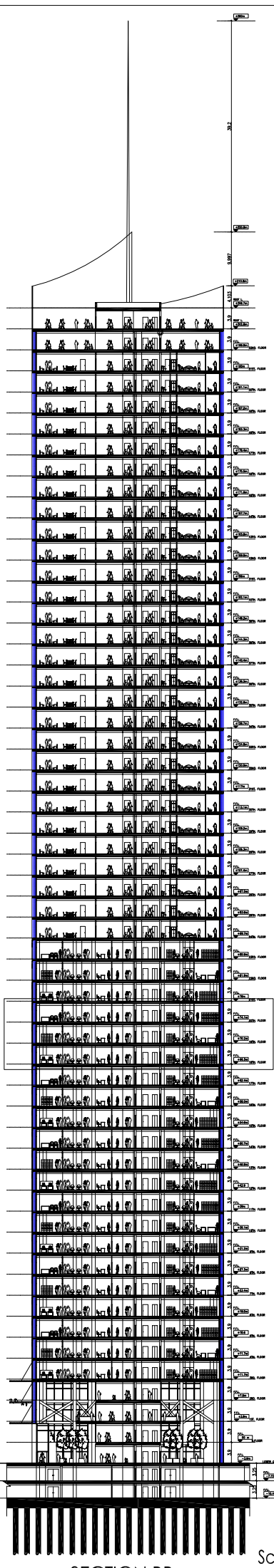
Vertical Blowup Detail 2

Scale: for A3 sheet

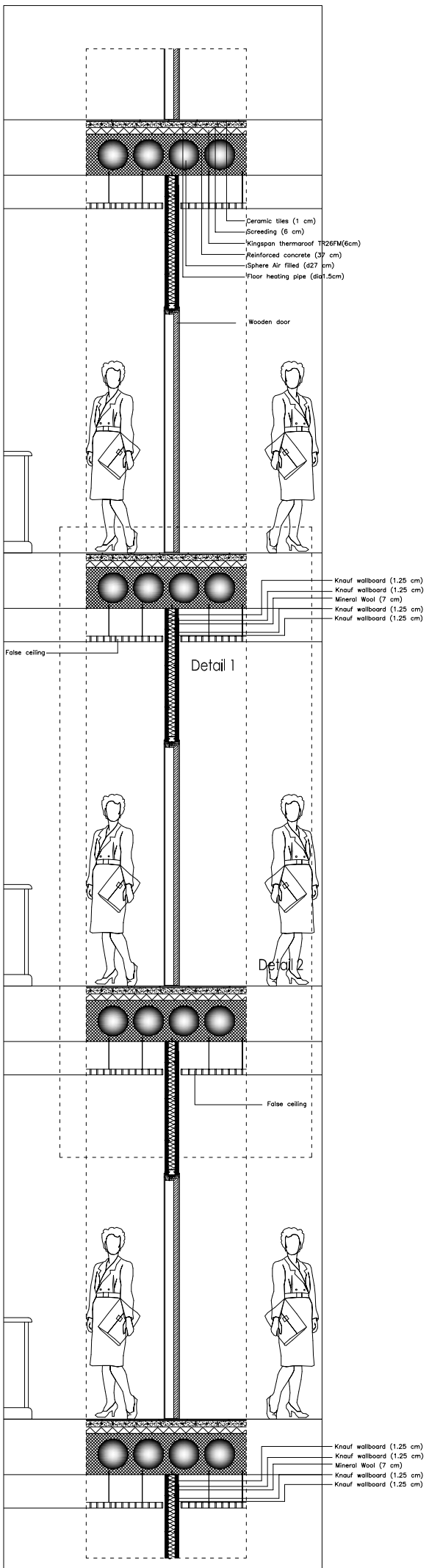
EXPO'10 GREEN TOWER SHANGHAI.



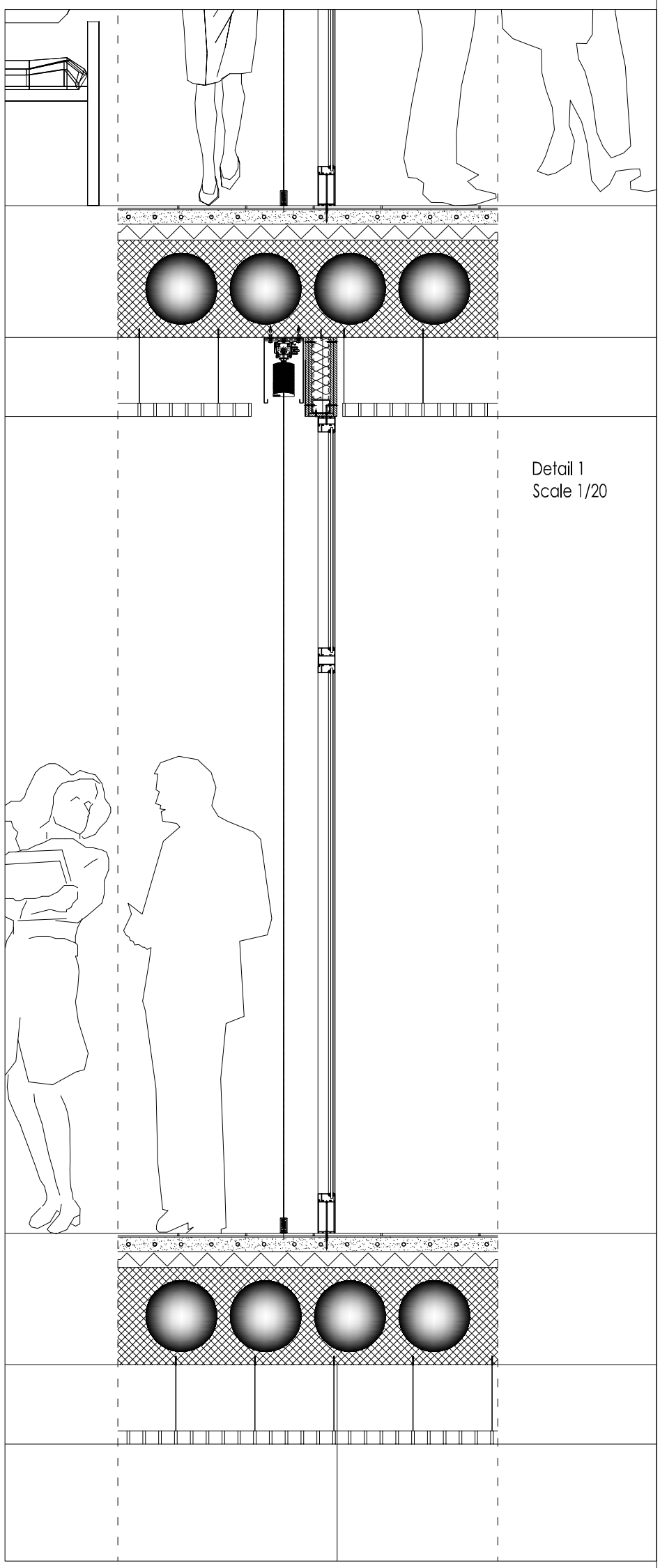
Unit 1
Scale 1/250



SECTION BB
Scale 1/1000



Blow Up (BU) 3
Scale 1/50



Detail 1
Scale 1/20

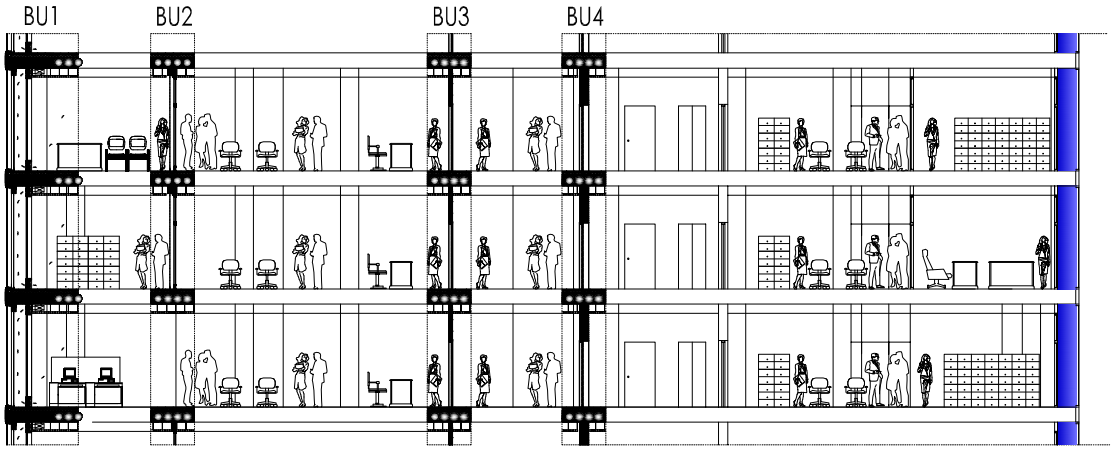
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

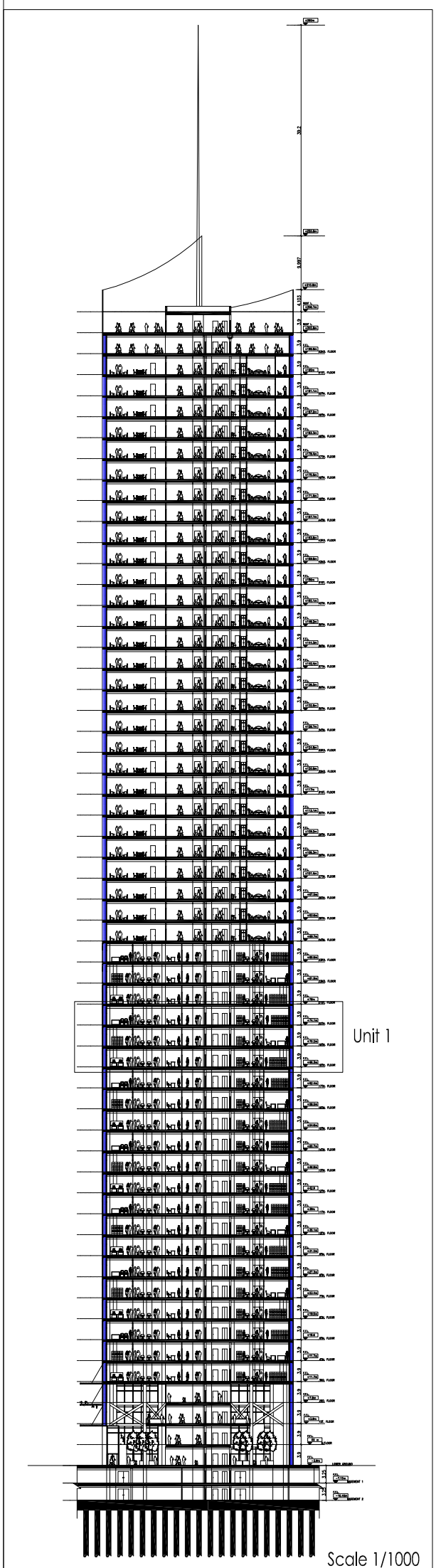
Vertical Blowup Detail 3

Scale: for A3 sheet

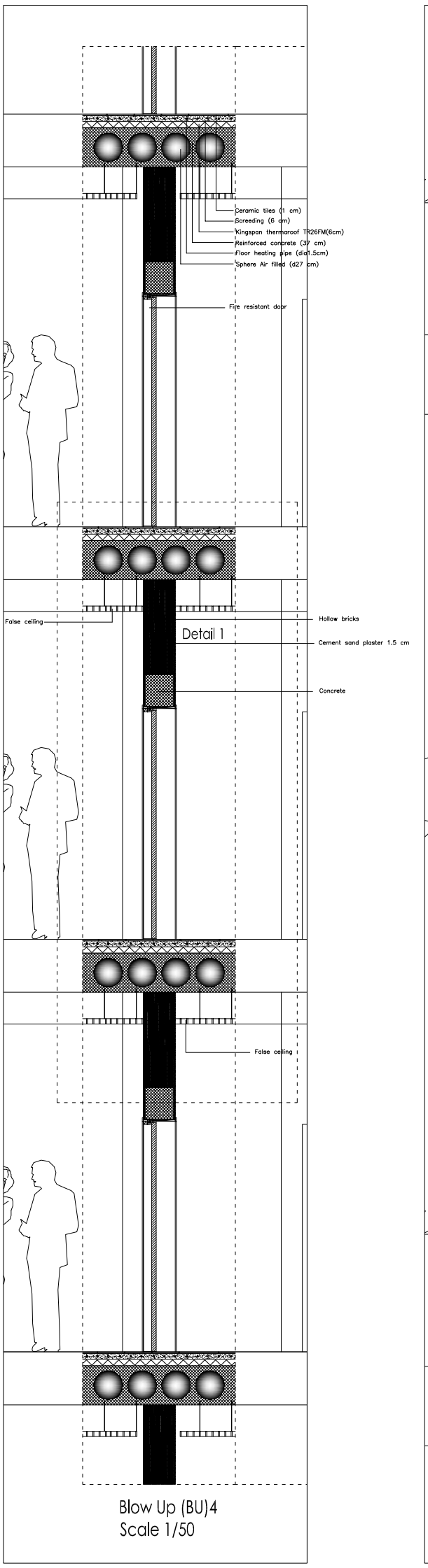
EXPO'10 GREEN TOWER SHANGHAI.



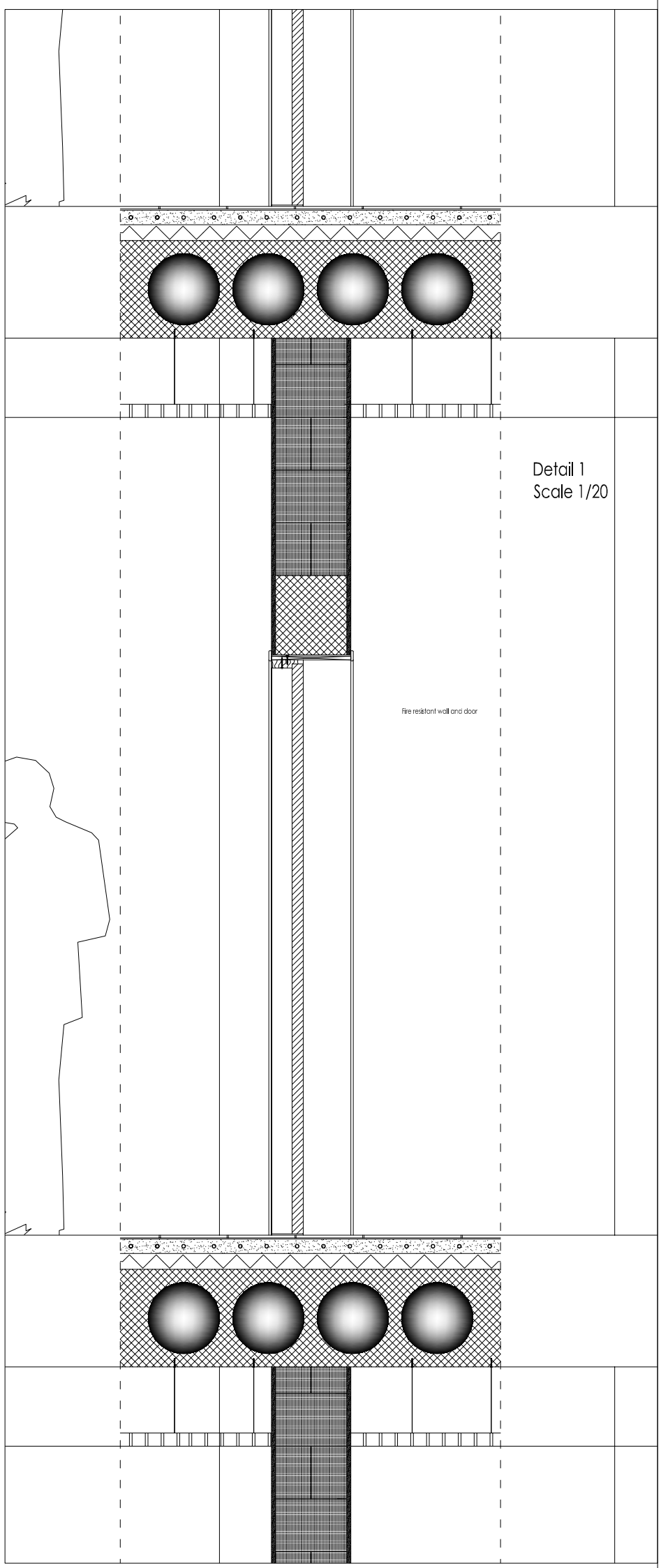
Unit 1
Scale 1/250



SECTION BB
Scale 1/1000



Blow Up (BU)4
Scale 1/50



POLITECNICO DI MILANO

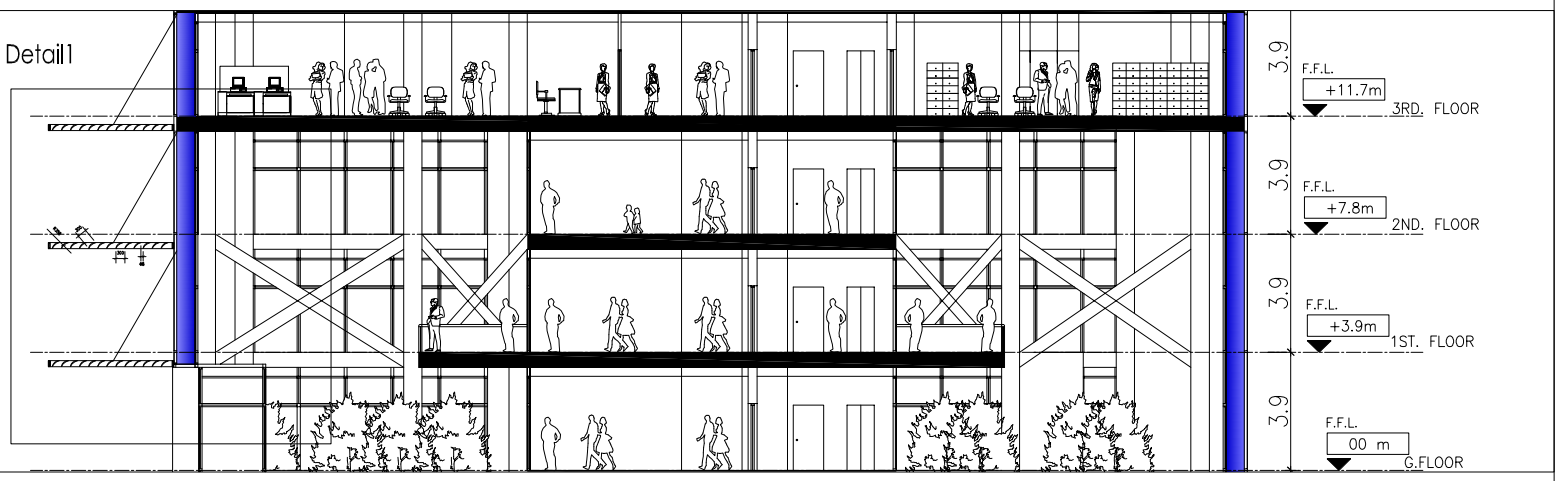
TECHNOLOGICAL DESIGN

Vertical Blowup Detail 4

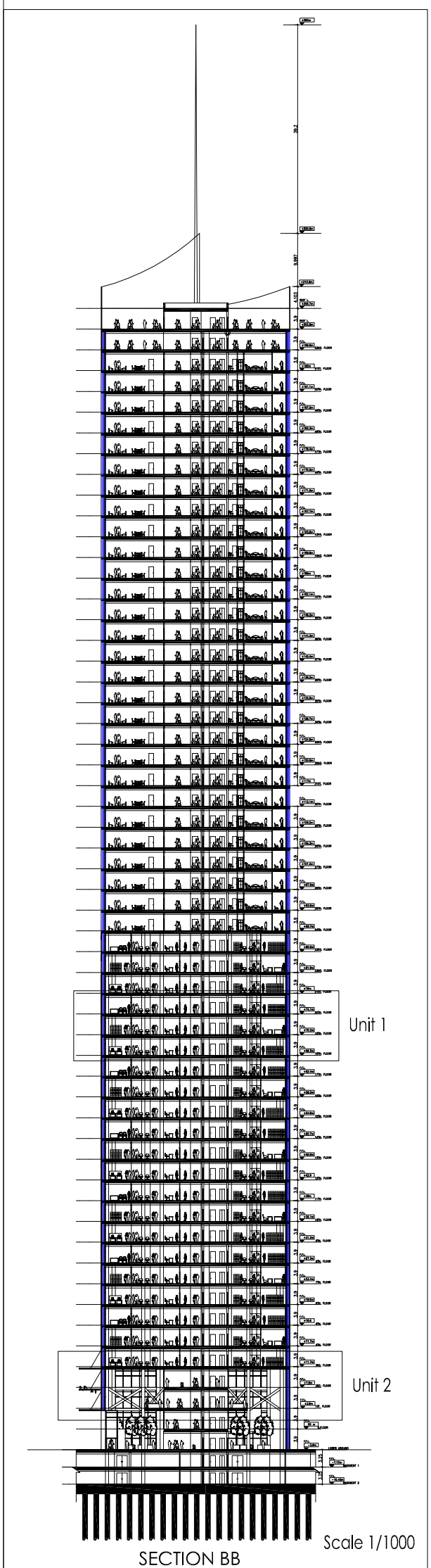
Scale: for A3 sheet

EXPO'10 GREEN TOWER SHANGHAI.

Detail1

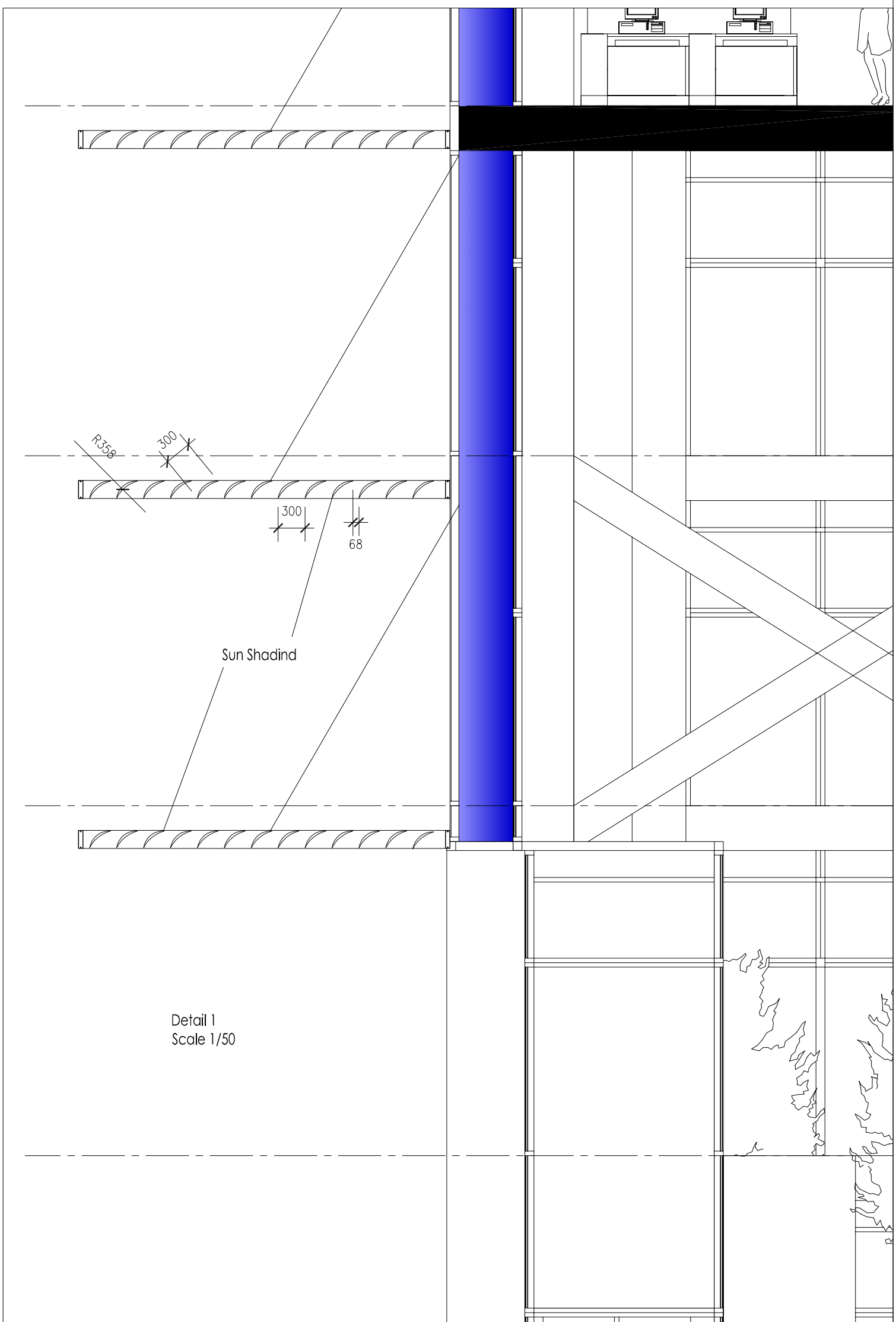


Unit 2
Scale 1/250



Scale 1/1000

SECTION BB



Detail 1
Scale 1/50

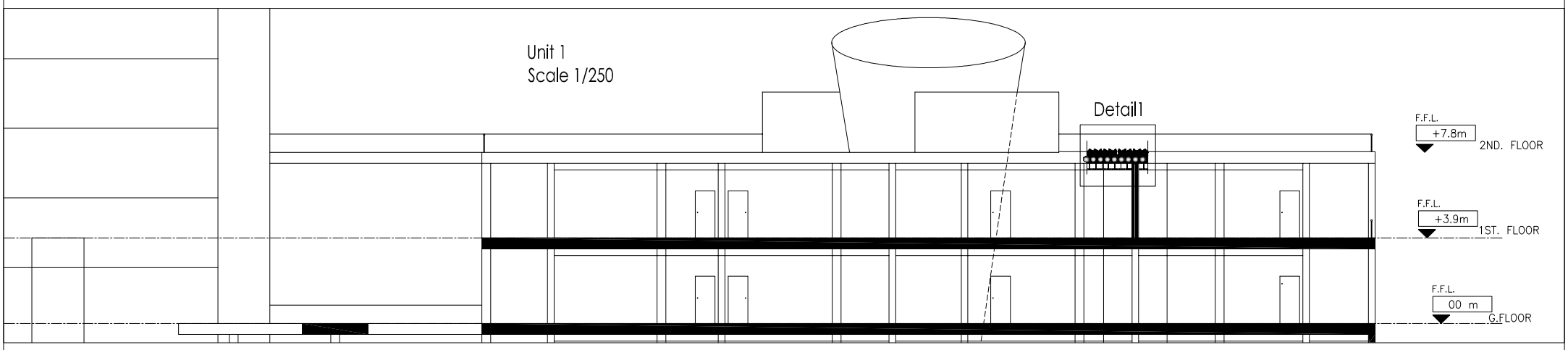
POLITECNICO DI MILANO

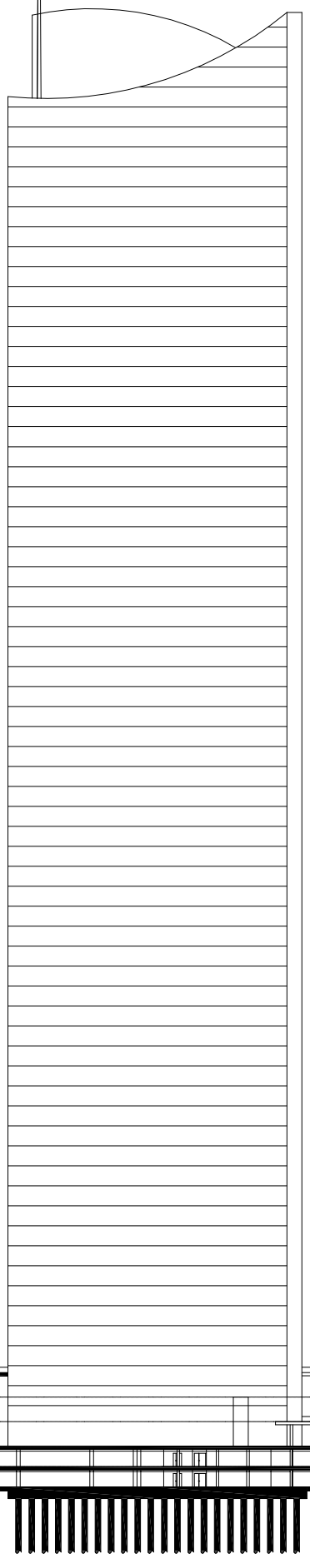
TECHNOLOGICAL DESIGN

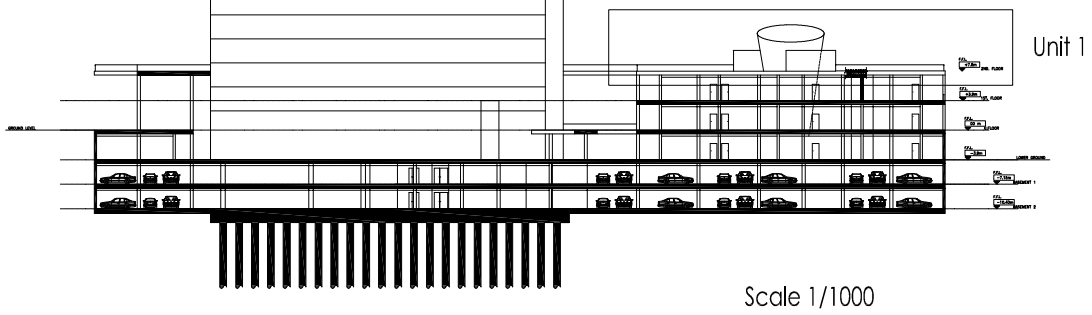
Vertical Blowup Detail 5

Scale: for A3 sheet

EXPO'10 GREEN TOWER SHANGHAI.



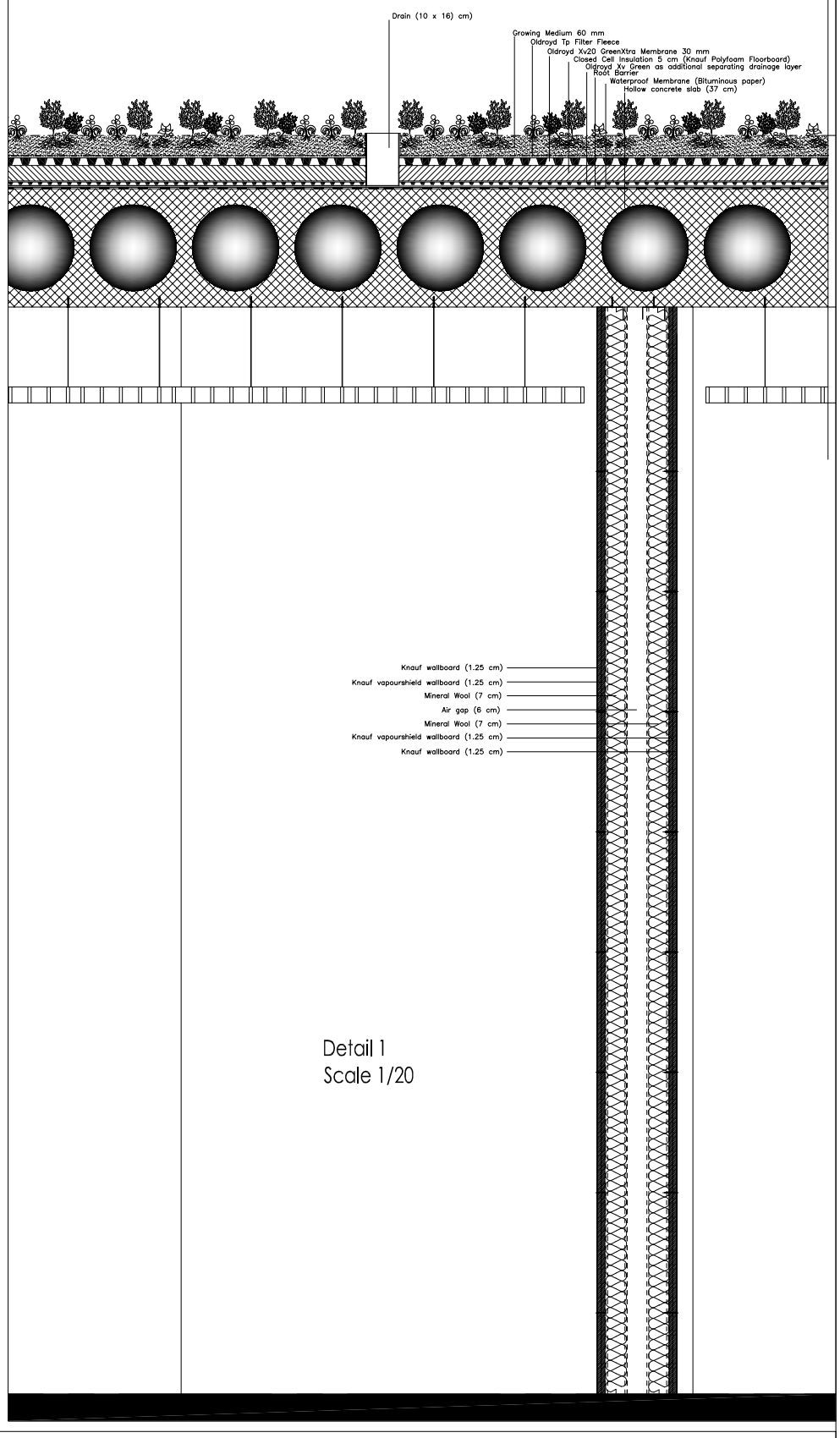




SECTION CC

Scale 1/1000

Roof garden Detail



Detail 1
Scale 1/20

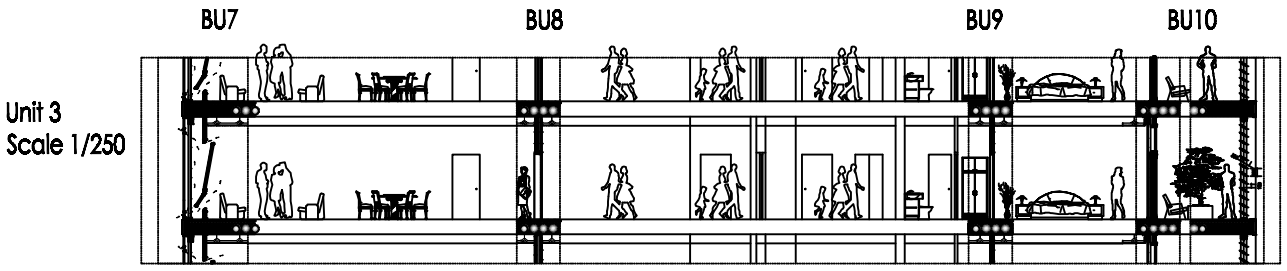
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

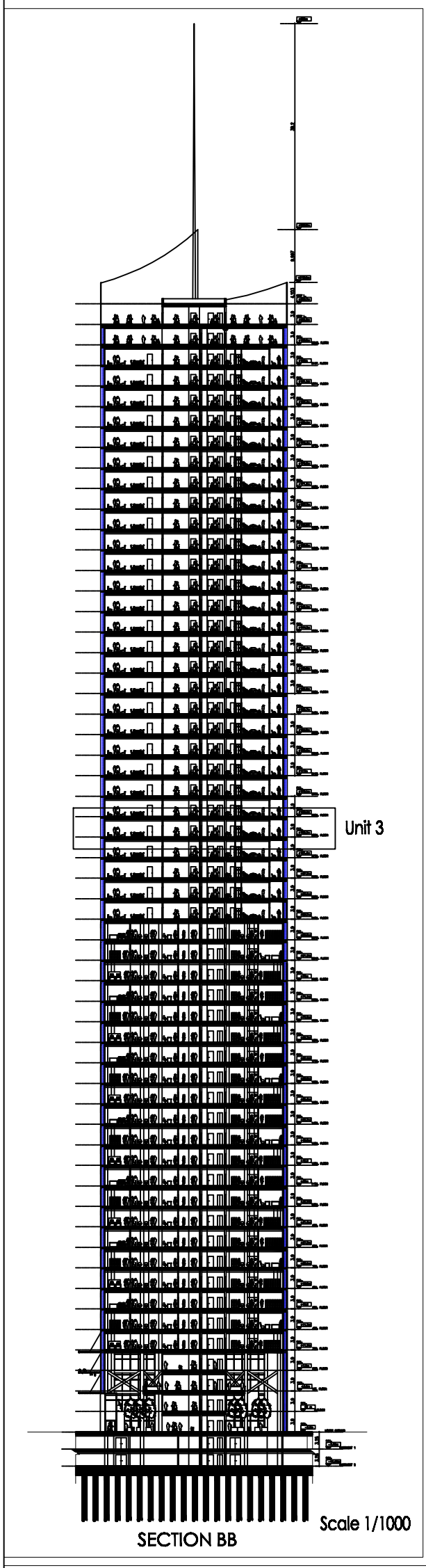
Vertical Blowup Detail 6

Scale: for A3 sheet

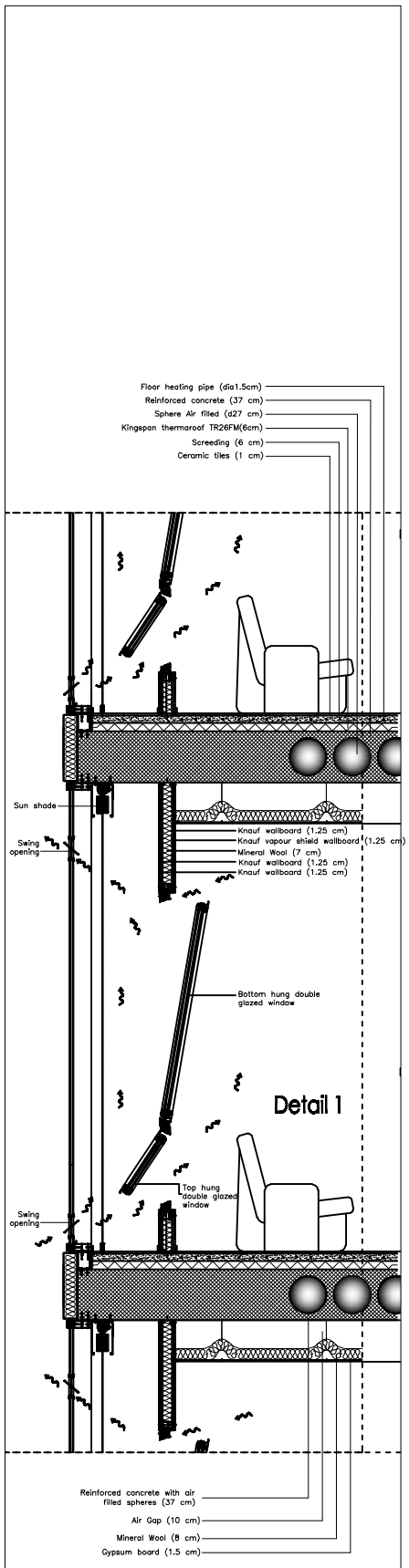
EXPO'10 GREEN TOWER SHANGHAI.



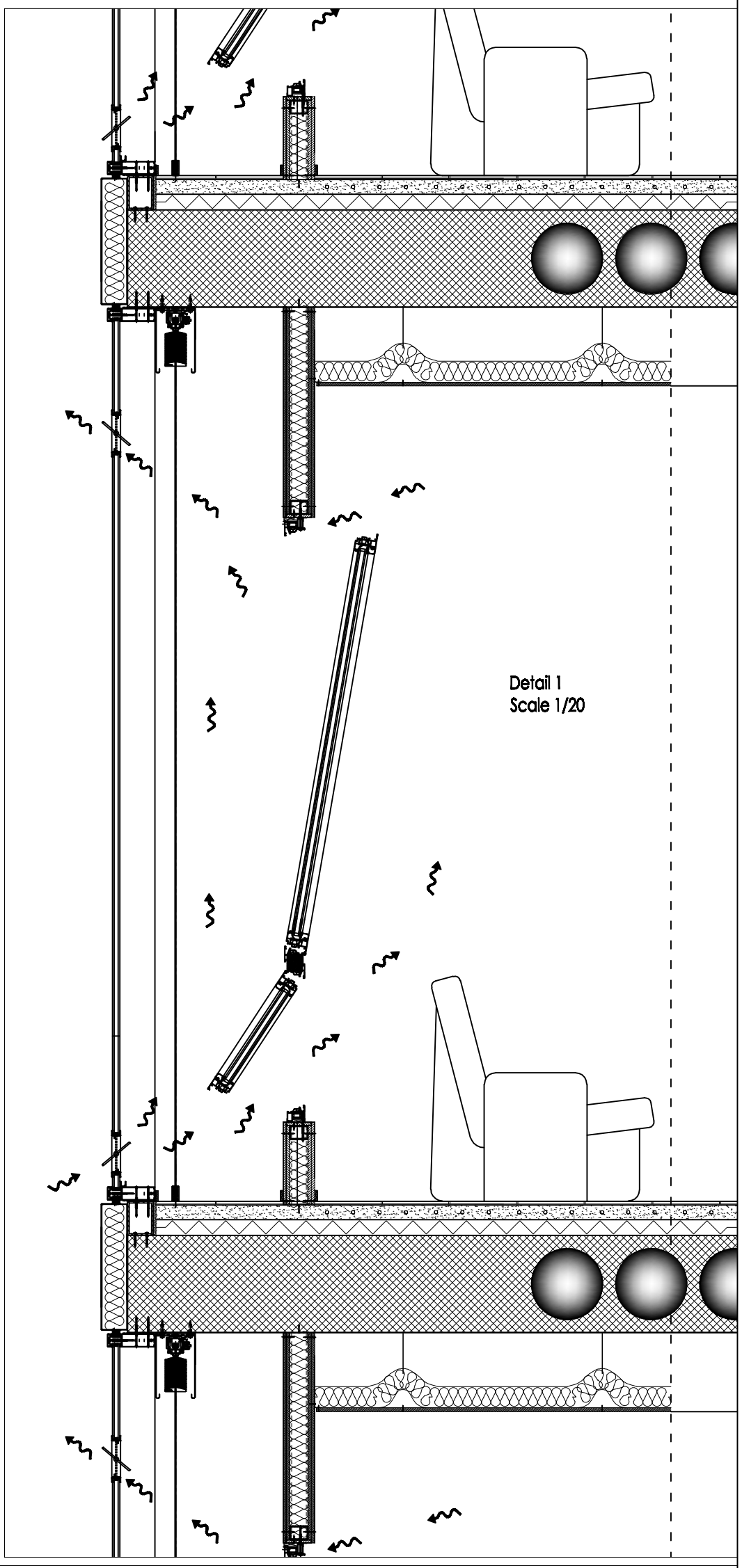
Unit 3
Scale 1/250



SECTION BB
Scale 1/1000



Blow Up (BU) 7
Scale 1/50



Detail 1
Scale 1/20

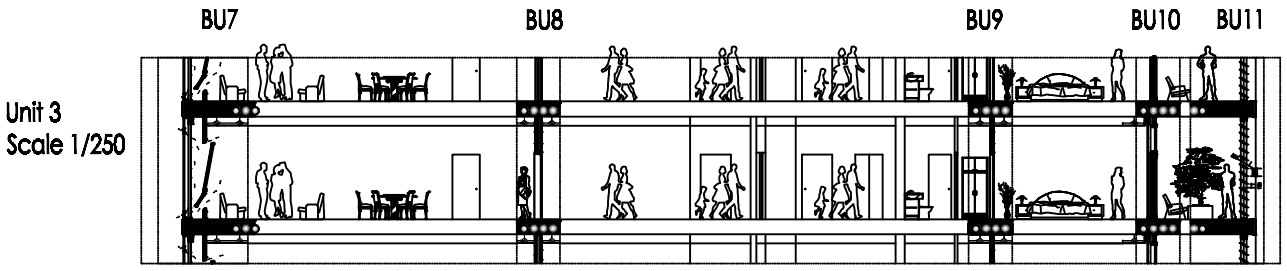
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

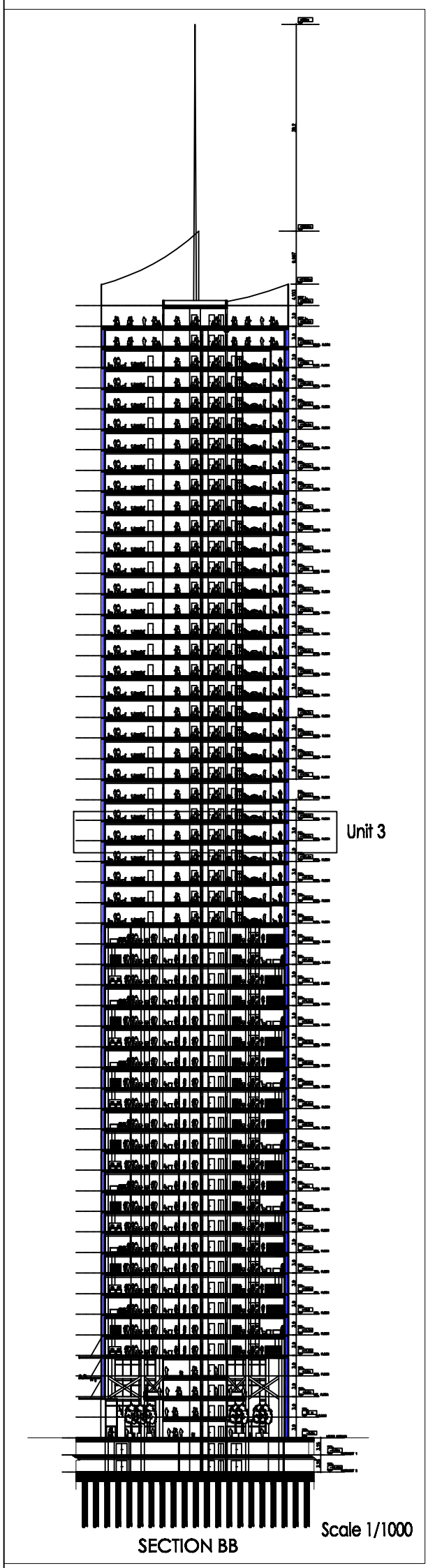
Vertical Blowup Detail 7

Scale: for A3 sheet

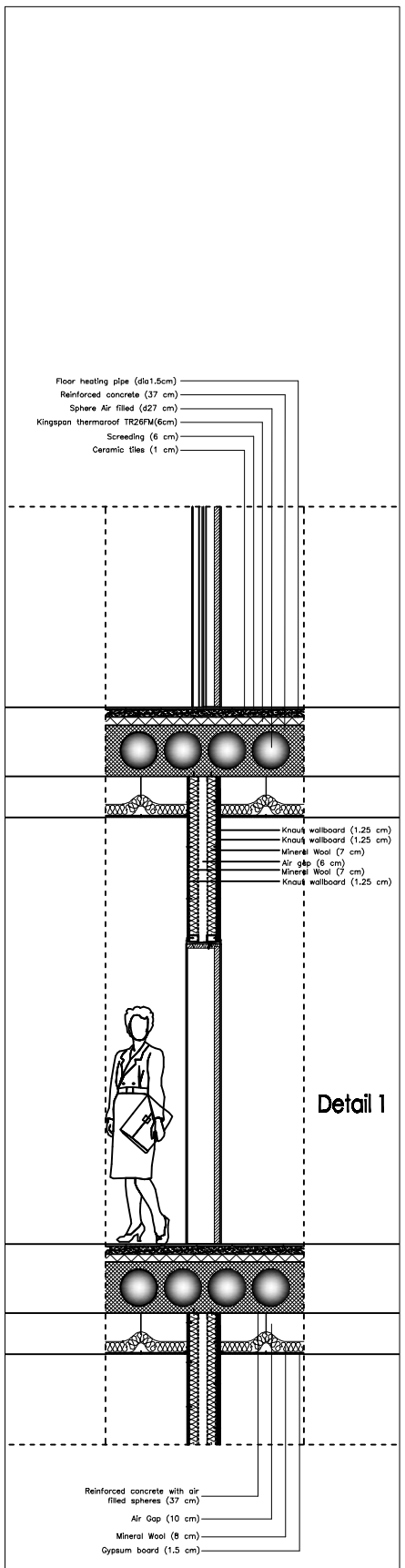
EXPO'10 GREEN TOWER SHANGHAI.



Unit 3
Scale 1/250

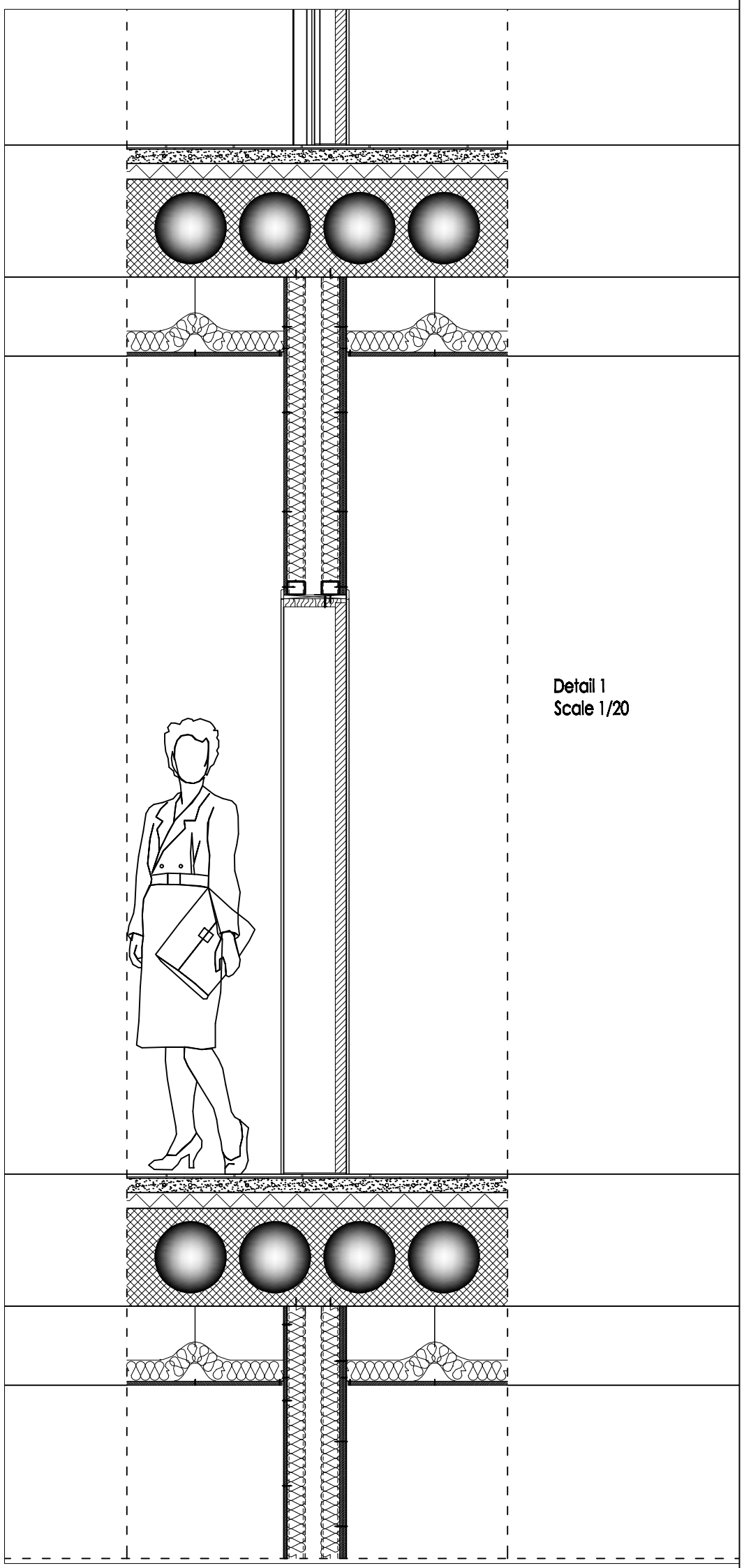


SECTION BB
Scale 1/1000



Detail 1

Blow Up (BU)8
Scale 1/50



Detail 1
Scale 1/20

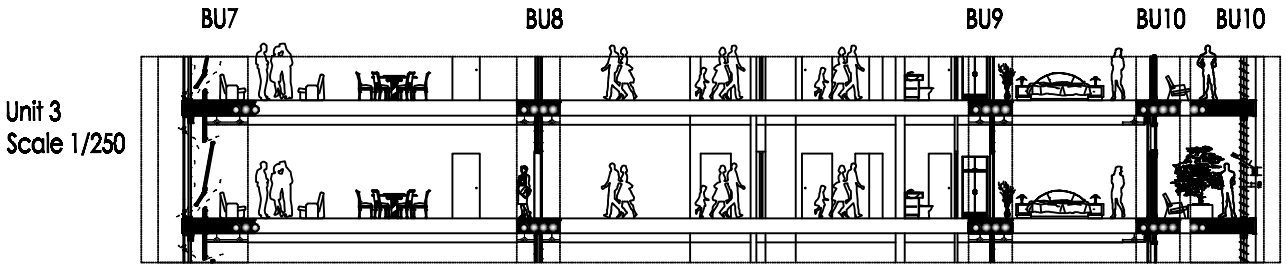
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

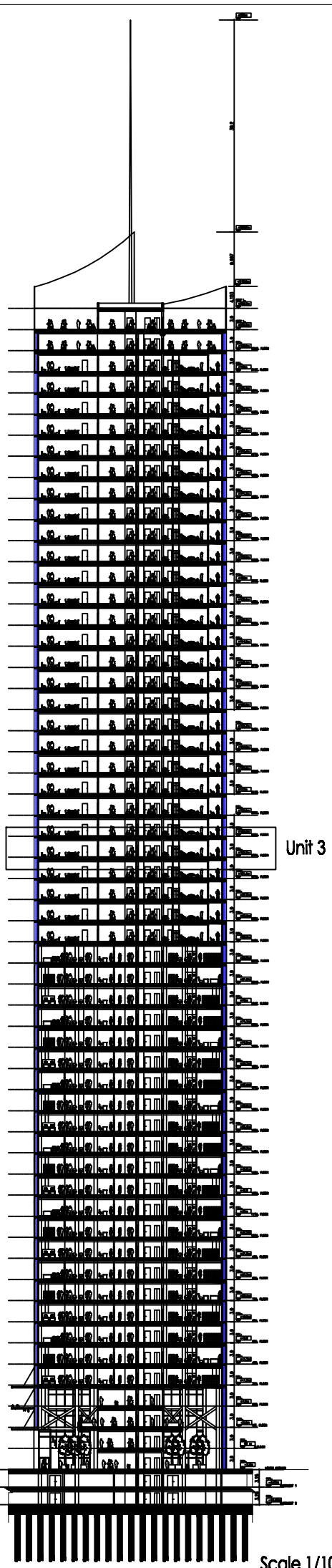
Vertical Blowup Detail 8

Scale: for A3 sheet

EXPO'10 GREEN TOWER SHANGHAI.



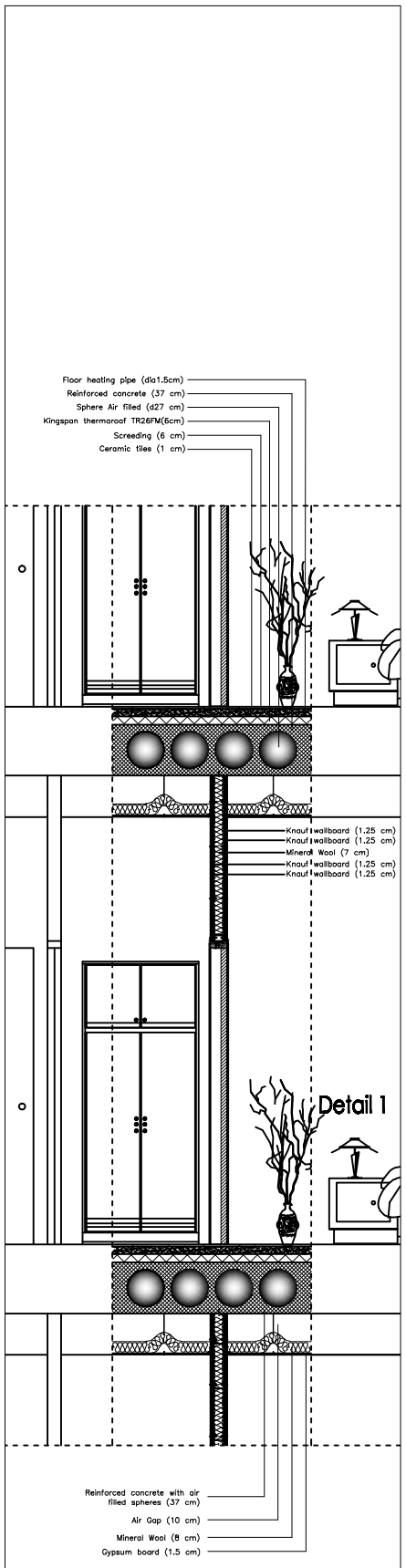
Unit 3
Scale 1/250



Unit 3

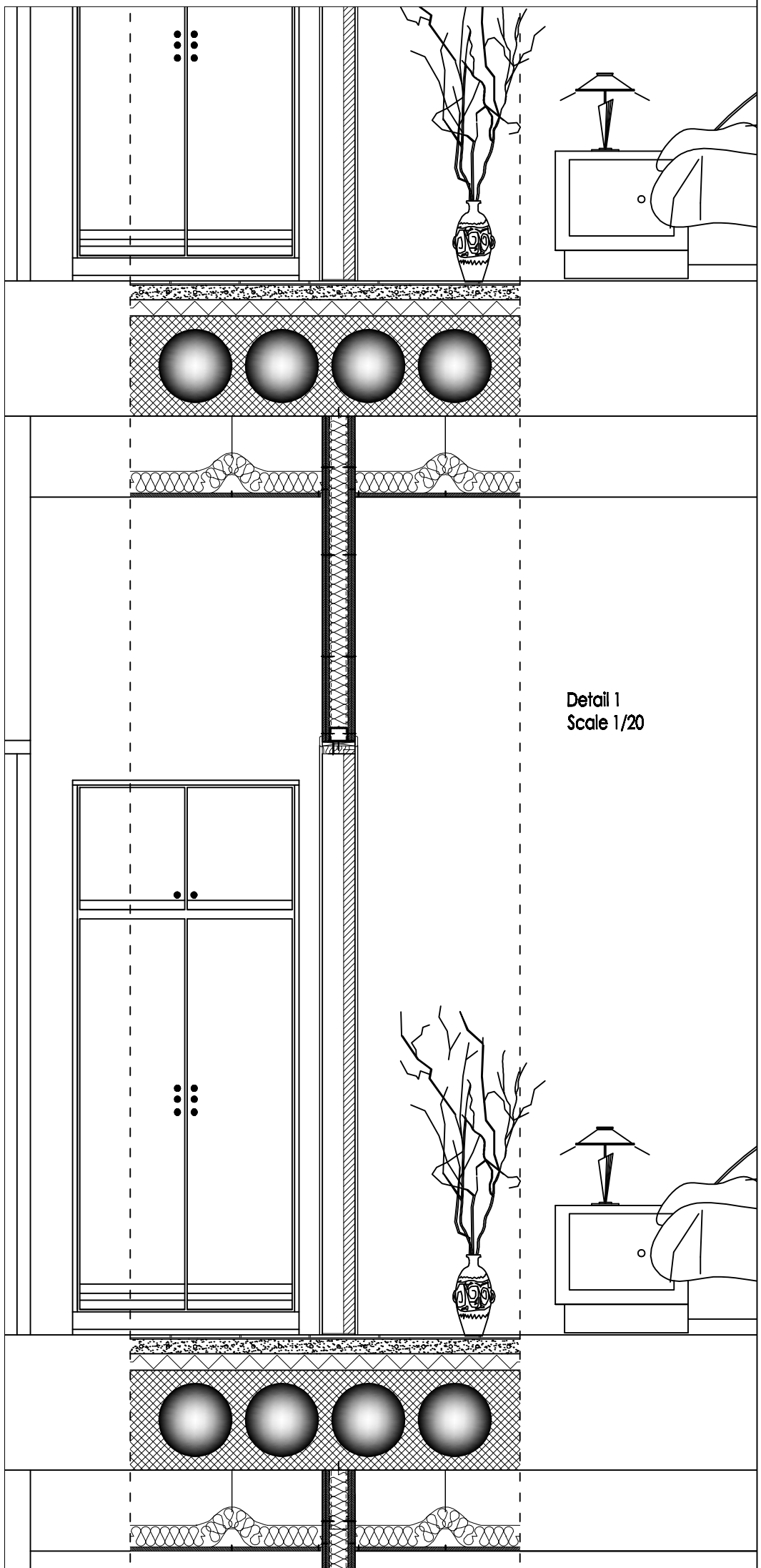
SECTION BB

Scale 1/1000



Detail 1

Blow Up (BU)9
Scale 1/50



Detail 1
Scale 1/20

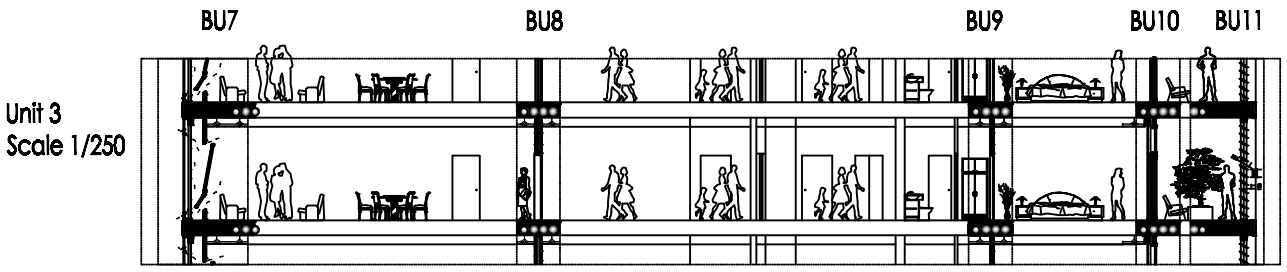
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

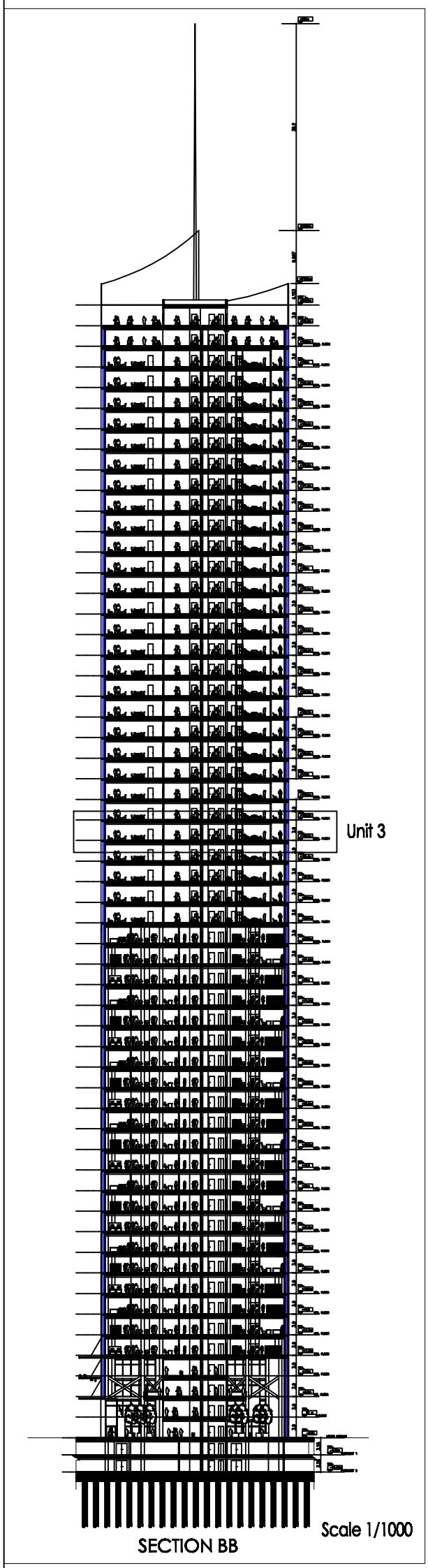
Vertical Blowup Detail 9

Scale: for A3 sheet

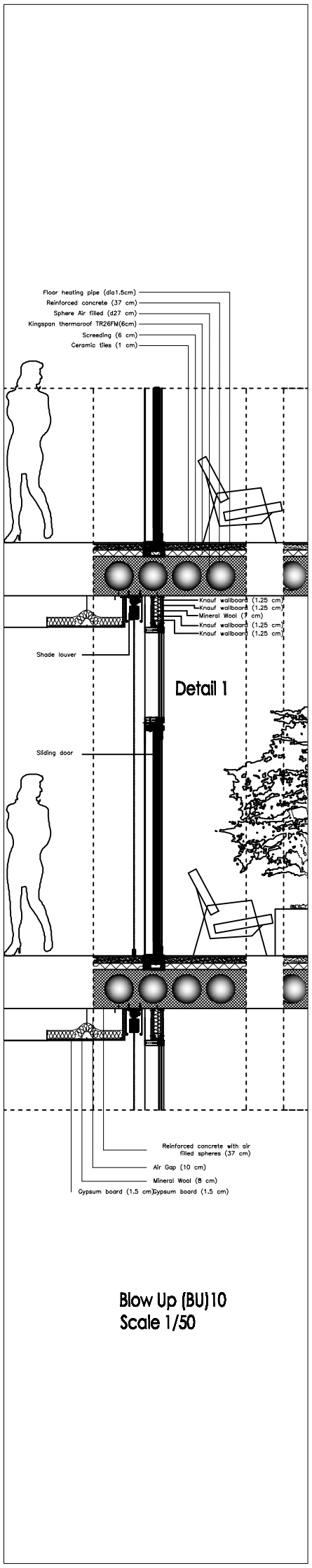
EXPO'10 GREEN TOWER SHANGHAI.



Unit 3
Scale 1/250

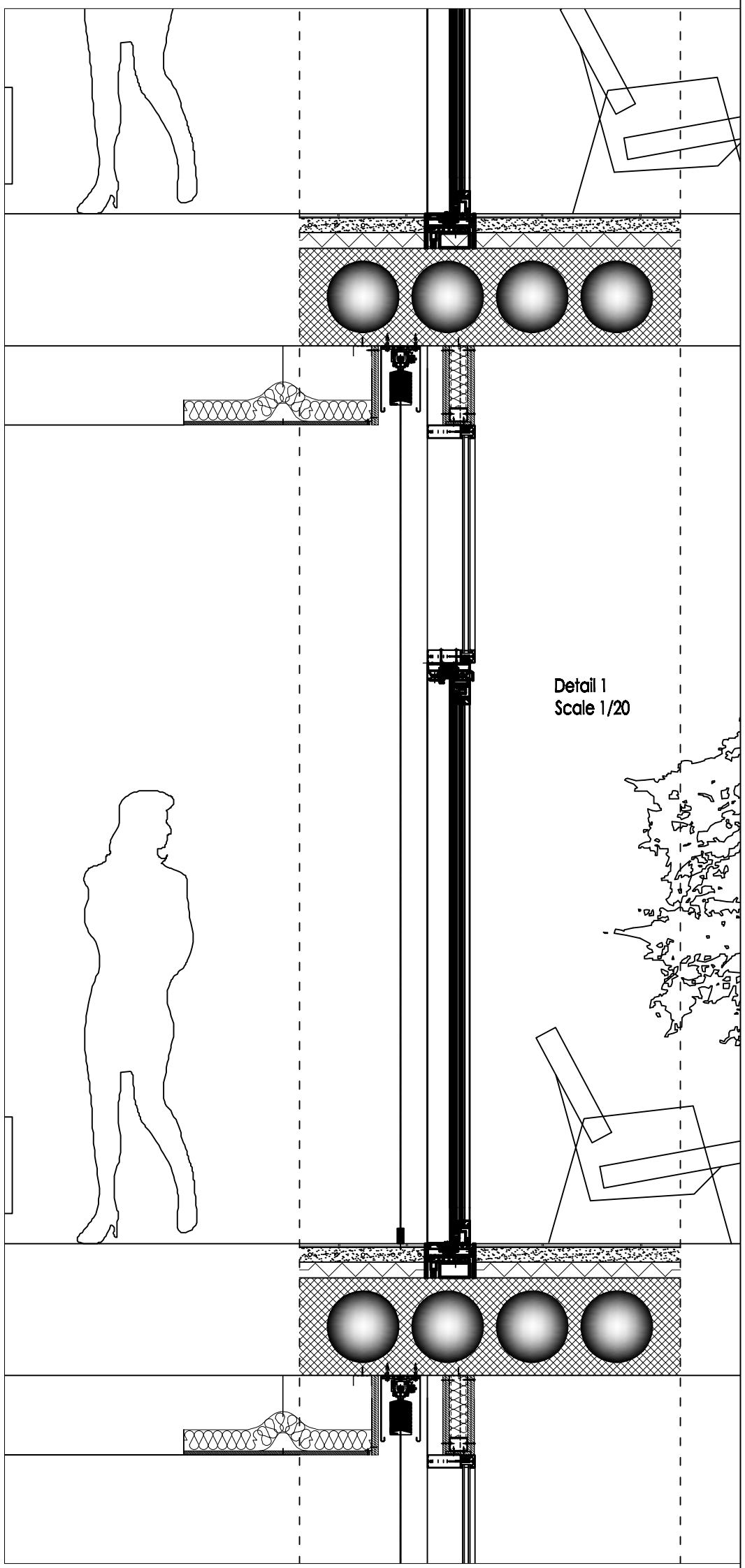


SECTION BB
Scale 1/1000



Detail 1

Blow Up (BU)10
Scale 1/50



Detail 1
Scale 1/20

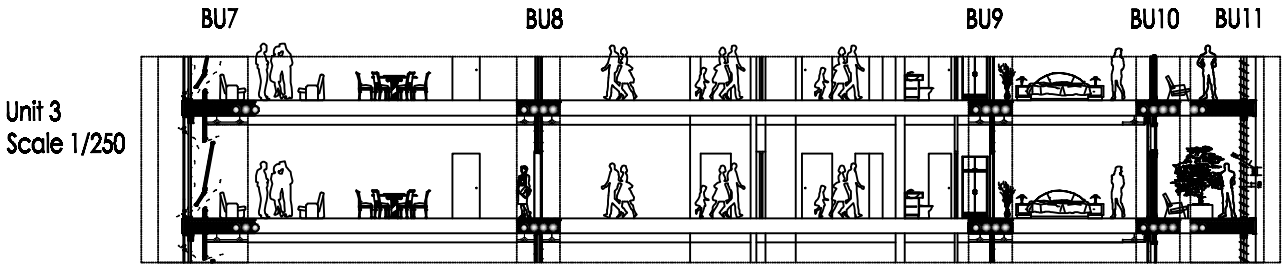
POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

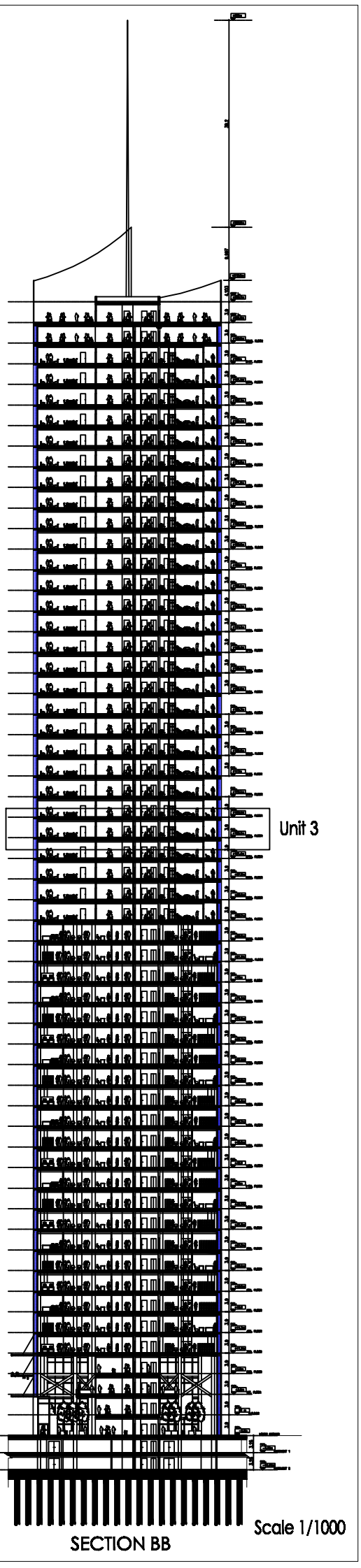
Vertical Blowup Detail 10

Scale: for A3 sheet

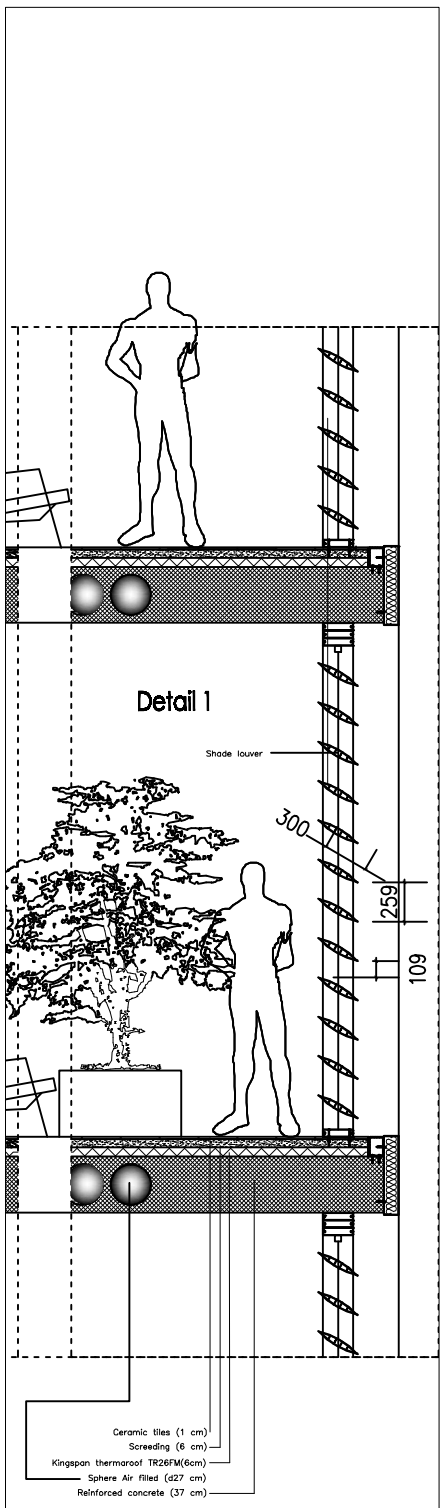
EXPO'10 GREEN TOWER SHANGHAI.



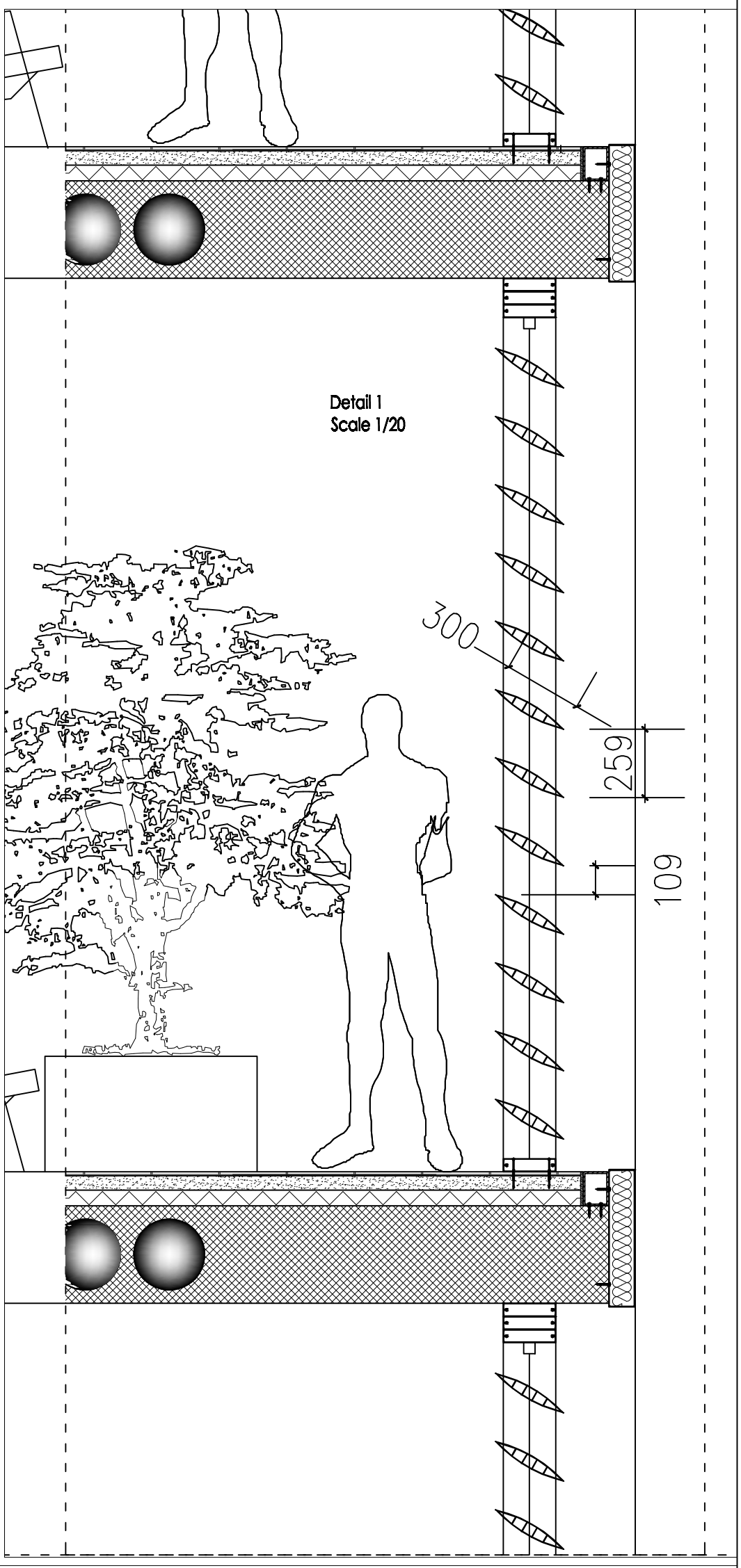
Unit 3
Scale 1/250



SECTION BB
Scale 1/1000



Blow Up (BU)11
Scale 1/50



POLITECNICO DI MILANO

TECHNOLOGICAL DESIGN

Vertical Blowup Detail 11

Scales: for A3 sheet

CONCLUSION

When the Shanghai World Expo closes , its more than 70 million visitors will remember the event as the biggest in the 159-year history of the global fair.
From the sheer scale of the 5.3 sq km site to the largest turnout of visitors, pavilions, volunteers and security personnel, the six-month exhibition was created to break records.

Be it setting a new Guinness record for the world's largest sushi mosaic or claiming the title of the first smoke-free, low-carbon Expo, Shanghai wanted it all. No detail was too small to magnify its moment of glory hosting a global event that once again showcases China's dazzling rise.
In the expo site, a green tower is designed. Starting from analyzing the hot zone in China and Shanghai climate ,several design proposes are raised and put into design practice. Orientation, Building Envelope, Thermal Mass and Ventilation are emphasized ,and double skin façade is used as a main structure of the tower. At the same time, a HVAC system is determined at the early stage ,integrating with the overall design of the tower.

Thanks to technology, the energy consumption of the building is greatly reduce by using displacement ventilation, radiant panel, solar energy ,green roof and green garden etc. The unique ventilation mode is develop in our building, as it is the mixed-use building with lower floor being office and upper floor being residence. Within the office area ,the air is in recirculation between the double –skin façade and ducted to the mechanical system in the end. And in the residential area the windows can be open for nature or mechanical ventilation.

We got our right way for designing thanks to the professors in Politecnico di milano. Thanks to all the professors who helped us.

BIBLIOGRAPHY

High-Rise manual : typology and design, construction and technology / edited by Johann Eisele, Ellen Kloft. - Basel : Boston : Berlin . 2002

Double-skin facades : integrated planning : building physics, construction, aerophysics, air-conditioning, economic viability / Oesterle. 2001

Displacement Ventilation Deisgn Guide. Halton.2009

The HVAC Handbook .McGraw-Hill Professional; 1 edition (July 30, 2004)
Robert Rosaler .Robert Rosaler

Introduction to Building Physics Student litteratur AB (January 1, 2001)

Strategy for Sustainability Adam Werbach .Harvard Business Press (July 6, 2009)

Norman Foster: A Global Architecture Martin Pawley Universe Publishing (December 17, 1999)

Knapp, Ronald G. (2005) Chinese Houses. Tuttle Publishing, Singapore

Sue Roaf, Manuel Fuentes, Stephanie Thomas(1997) Ecohouse . Architectural Press, Ox ford, UK

Thomas Herzog, Walter Lang, Roland Krippner (2004) Façade Construction Manual. Bir khauser, Switzerland

Jianfei Zhu (2009) Architecture of Modern China: A Historical Critique. Routledge, UK

http://chinahousing.mit.edu/english/china/specific/energy_beijing+shanghai/index.h tml

http://www.hillyork.com/hvac-systems/hvac-for-high-rise-complexes.html

http://www.firemiddleeastmagazine.com/pages/issue_6_feature1.aspx

http://www3.hku.hk/mech/sbe/case_study/case/ger/RWE_Tower/rwe_index.html#4.3