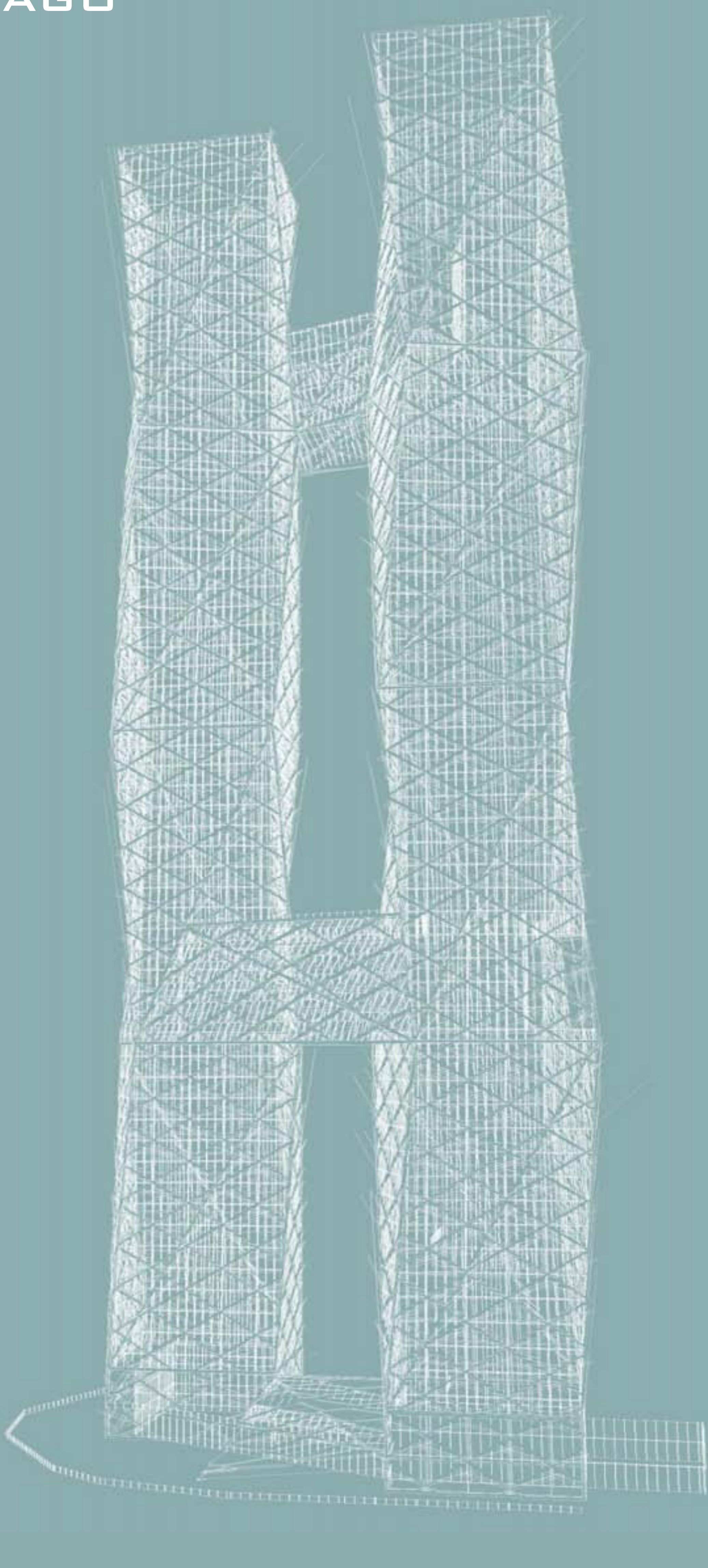
TWIN TOWERS

At Wolf Point, Chicago

STRUCTURE AS A KEY DESIGN ELEMENT



MASTERARBEIT

Twin Towers at Wolf Point, Chicago

STRUCTURE AS A KEY DESIGN ELEMENT

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Thanks to ...

my family: My mum, my brother and my grandma for always being there for me and their support during my university years.

my aunt Michaela, not only for improving my thesis, but above all for listen to my fascinations about those skyscrapers.

Special thanks to my native speaker Annie for her support at reading and improving my diploma thesis.

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3.DESIGN

Preface

I was always interested in skyscrapers, but ever since the first time I stood in front of the Empire State Building, the fascination grew.

On a foggy day, New York City seems different. The clouds hang low and the top of the skyscrapers are no longer visible. The apartment where I stayed in during my research in Chicago, was on the 49th floor. On a rainy day, I was above the clouds, seeing only the top of the highest buildings around me. Experiencing such a view is the reason why the word “skyscraper” is still wisely chosen.

Amongst the historical buildings and the glass towers, the buildings with the visible structure on their façade always attracted my attention. The Hearst Tower in New York City and the John Hancock Center in Chicago were the reasons why I wanted to write this thesis. I decided to choose those two cities because Chicago is where the first skyscraper was built and New York City is still associated with the most popular skyscrapers in the world. I once again flew to New York City and Chicago to do the research and also to analyze the buildings. It occurred to me that especially these kinds of buildings have a high recognition value.

There are a lot of buildings in those to cities, whose structures have key design elements. The way I see it, the following skyscrapers are archetypes in handling the structures on their façades.

With the research as a basis I wanted to design a skyscraper that combines the elements of the chosen examples with my ideas of a skyscraper at Wolf Point, Chicago.

Introduction

Skyscrapers are some of the most impressive creations in history. Gigantic structural elements of steel and concrete support the weight of thousands of tons of equipment, floors and people. High rises are able to withstand high winds with the destructive force of hurricanes and also strong earthquakes. These enormous structures confirm the skills of architects, engineers and scientists.

But why build high rises? On one hand, they are practical. They seem like small towns where thousands of people work, live and spend their free time. On the other hand, the plot of land is limited and also very expensive in busy cities like Chicago and New York. It is necessary to build upwards because of the growing population and the lack of space. Only skyscrapers offer enough space for living and working.

The skyscrapers are often so high that they seem to disappear in the clouds. Thinking about Chicago or New York City the skyline is well known because many buildings are part of sightseeing. The skylines and the skyscrapers are the face of many cities.

However, the towers are not only the pride of their temporary owners, but of their cities as well. They are symbols of economic success. Therefore, there is a worldwide competition for the highest skyscraper, since the first one was built.

STATE OF RESEARCH

BOOKS

Overview

Generally there are a lot of books written about skyscrapers. Those give an overview of the first skyscrapers to the current ones. Sometimes there is a special chapter with skyscrapers, which are not even built. Here, the book “Wolkenkratzer” by Herbert Wright should be mentioned. It stands out with great pictures and short and concise, but helpful information. Herbert Wright did not only write about the early and existing buildings, he also wrote about unbuilt skyscrapers, which are all illustrated with renderings.

Specific Skyscraper

These books contain a lot of specific information about one single skyscraper. Most of these books were written during the development of the skyscraper until its finish. In these books it is possible to find pictures from inside the building, which are almost impossible to get without special permission today. The books “Sears Tower” and “John Hancock Center” by

Ezra Stoller should be mentioned because they contain important information about the concept, design, materials, development, structure, construction and many more, which were very helpful for this thesis.

Architects And Their Work

These books contain the life and work of architects. The titles of the books promise a lot, but in these books, the buildings play a minor role. They are primarily informing the reader about the life of the chosen architect. Although the buildings are included and described in some parts, most of the information is not relevant to this thesis.

NEWSPAPER ARTICLES AND REPORTS

Newspaper Articles

The chosen newspaper articles contain facts, which could not be found in books. In those articles it was possible to find specific information about the structure and the façade. The "New York Times", the "Chicago Sun-Times" and the "Chicago Tribune" are probably the most famous newspapers of the used ones, but there are also a lot of great and very helpful articles from other newspapers.

Reports

The reports of the Commission of Chicago Landmarks are about several buildings in Chicago. These reports were very helpful for this thesis. They contain essential information about the design, the construction and the façade. In those reports it is possible to find a floor plan, but only one or two pictures. The reports contain a lot of information, which is hard to find elsewhere. Here, the "IBM Building", "860-880 Lake Shore Drive" and "Inland Steel Building" should be mentioned, which are a huge benefit for this thesis.

METHOD of the Research

This research is based on two visible methods. First the use of the visible structure on the façade of the skyscrapers and the second one on the fact how people are affected by those buildings. So it is not necessary to be an architect to understand why the buildings are compared like this.

CRITERIA OF THE LIMITED AMOUNT OF SKYSCRAPERS

In New York City and Chicago, there are many buildings, where the structure is visible on the façade. Those, however, would go beyond the scope of this work. Thus the skyscrapers had been reduced to 60 skyscrapers before the local inspection. The amount of the high-rises was limited again as walking through the cities. Many buildings, even though their structure is visible, are covered with various materials, e.g. with marble, so the real significance gets lost. Some skyscrapers would have also supported the research, but they had to be eliminated, because of the small amount of information.

Thus, the research is limited to 11 skyscrapers, which are representative for this theoretical part of the thesis, where the structure is used as a key design element on the façade. The Willis Tower, 330 North Wabash, the 860-880 Lake Shore Drive Apartments, the Inland Steel Building and the Federal Center are located in Chicago. The Seagram Building, the Hearst Tower, the Lever House, and the New York Times Building were built in New York City. Furthermore, it is significant that the skyscrapers are distributed over a large period of time. It is important to show that this type of structure design on the façade is neither new, nor is it copied from previous years. It is also necessary to demonstrate that there is a desire in the future for skyscrapers, whose structure is a key design element on the façade. That’s the reason why the proposed Tower Verre was included into this thesis.

STRUCTURE OF RESEARCH

The criteria for these classifications were the visual perceptions of the structures on the façades. There is a distinction between vertical elements and diagonal braces, in view of the fact that buildings with dark vertical elements are perceived differently from the ones with bright vertical elements.

The advantage of this classification of structures is that buildings of different epochs can be compared to each other. Based on this method, it is possible to analyze how differently or similarly architects design their buildings, even with the same type of structure. If buildings show some affinities in the structure of the façade, does that mean that they have the same structure system?

The choice of the buildings led to five architects and their offices: Skidmore, Owings and Merrill, Ludwig Mies van der Rohe, Sir Norman Foster, Jean Nouvel and Renzo Piano. There was no intention to limit the architects to these five, but history showed that there had never been as much competition in building high-rises like today. SOM (short form for Skidmore, Owings and Merrill) and Ludwig Mies van der Rohe were some of the few architects, who used structure as a key design element on the façade at the beginning of the 1950's. Sir Norman Foster, Jean Nouvel and Renzo Piano are architects of our time. SOM is still successful, but they had taken a different direction in the recent decades.

Definition of Terms and Explanation

In the American language, the words "**structure**" and "**construction**" have different meanings compared to British English. In this thesis, the American sense of these words is used.

In this thesis the "**Twin Towers**" are not associated with the destroyed World Trade Center. Here the original meaning of twin tower is used. Twin Towers are two or more skyscrapers, who look alike.

Construction and structure

Construction is a process. People are performing construction to create a structure. The word "structure" is synonymic with a static system. In this thesis, the particular attention is on the structure as a key design element, visible on a skyscraper's façade.

Skyscraper

There is no absolute definition of what constitutes a "skyscraper".
The CTBUH (Council on Tall Buildings and Urban Habitat) created Height Criteria's for tall buildings, which are:

a) Height Relative to Context

It is not just about height, but about the context in which it exists. Thus, whereas a 14-story building may not be considered a tall building in a high-rise city such as Chicago or Hong Kong, in a provincial European city or a suburb this may be distinctly taller than the urban norm.

b) Proportion

Again, a tall building is not just about height but also about proportion. There are numerous buildings, which are not particularly high, but are slender enough to give the appearance of a tall building, especially against low urban backgrounds. Conversely, there are numerous big/large footprint buildings, which are quite tall but their size/floor area rules them out as being classed as a tall building.

c) Tall Building Technologies

If a building contains technologies, which may be attributed as being a product of "tall" (e.g., specific vertical transport technologies, structural wind bracing as a product of height, etc.), then this building can be classed as a tall building.

Although the number of floors is a poor indicator for defining a tall building due to the changing floor to floor height between differing buildings and functions (e.g., office versus residential usage), a building of perhaps 14 or more stories – or over 50 meters (165 feet) in height – could perhaps be used as a threshold for considering it a “tall building.”[1]

Grid

“A grid is an orthogonal network of lines, used as a principle of arrangement and design to create cities and buildings.”[2]

A grid can also be defined as a “standard size of a design construction. The space of geometric parameters and components are the basis of a specific module.” [3]

Façade

The façade is the “exterior face or wall of a building. The term implies ordered placement of its openings and other features and thus seems inapplicable to a wall without design. Any freestanding structure may have four or more facades, designated by their orientation (e.g., north façade); a building flanked by other buildings on either side generally has only a front and a rear façade.”[4]

Curtain Wall

“The introduction of steel and reinforced concrete frame construction resulted in a number of important changes in the methods of external wall construction. It now became possible to divide the load bearing, enclosing, and heat-insulating functions, which until then had been performed by the conventional solid wall, among separate structural components specifically designed for these purposes. The task of providing structural support is performed by the framework and thus is concentrated at a limited number of points on plan, while the actual wall consists of thin cladding units and has only enclosing and insulating functions. This separation between structural and nonstructural materials was to become one of the central features of modern architectural aesthetics. The development of the curtain wall in commercial structures was a major breakthrough in reducing the size and weight of enclosing walls. As currently used, the curtain wall has come to mean that which

[1] http://www.ctbuh.org/TallBuildings/HeightStatistics/Criteria/tabid/446/language/en-US/Default.aspx, retrieved 2012-04-28
[2] PEVSNER, Nikolaus; HONOUR, Hugh; FLEMING, John; *Lexikon der Weltarchitektur*, 2nd Edition, Prestel, 1987, p. 523
[3] KADATZ, Hans-Joachim, *Seemanns Lexikon der Weltarchitektur*, 3rd Edition, Seemann, 2009, p.205
[4] http://encyclopedia2.thefreedictionary.com/Facade+%28Architecture%29

divides space, is controllable, and supports nothing but itself. Strong, flexible, light, and thin, the curtain wall logically followed the development of the skeleton frame."[5]

Steel building frame

"Steel building frames are generally orthogonal grids of columns, beams, and girders. They are stabilized against lateral forces by systems of diagonal bracing, shear walls, or rigid, moment-transmitting connections. Connections between members in a steel frame are made by bolting, welding, or combinations of the two."[6]

Zoning Regulations

"Zoning ordinances and building codes are legal limitations on construction enforced under the police powers of the state. Although in most cases the regulations are minimum standards, in effect they become the normal standards for construction.

Zoning refers to the legal designation of land for specific uses. In the United States, the legal right to enforce zoning is reserved to the States, and may be delegated to a governmental area or community. Zoning is adopted by ordinance, and includes a zoning map of the affected area. Zoning represents the physical aspect of master plans recorded on a zoning map.

A typical section of the zoning ordinance includes a definition of the zone, permitted uses, and limitation on use. Once these requirements are met, the zoning ordinance describes the minimum lot size, maximum building height, yard requirements, and other structures on the property." [7]

BAY

A bay is a "portion of a plan or of a building contained between adjacent piers or columns."[8]

[5] WILKES, Joseph A., *Encyclopedia of Architecture: Design, Engineering & Construction*, Volume 2, John Wiley & Sons Inc, 1989, p.599
[6] WILKES, Joseph A., *Encyclopedia of Architecture: Design, Engineering & Construction*, Volume 2, John Wiley & Sons Inc, 1989, p.120
[7] WILKES, Joseph A., *Encyclopedia of Architecture: Design, Engineering & Construction*, Volume 4, John Wiley & Sons Inc, 1989, p.514-515
[8] SALOR, Henry H., *Dictionary of Architecture*, John Wiley & Sons Inc,1952, p. 18

HISTORY

1. HISTORY

1. HISTORY

There is no specifically determined height that defines a "skyscraper". Generally speaking, most people perceive a building as tall, if it is taller than the buildings in the surrounding area. The tower has to be at least two or three stories taller than those around it, otherwise it is not noticeable that the building is really taller. The criteria of height had changed many times since the first tall building was built.

The construction of tall buildings has altered since the beginning and as a result, the form and design were modified. The taller the buildings became, the more the horizontal forces and load-bearing structure had to be considered.

1.1. OVERVIEW ON THE AMERICAN HISTORY OF SKYSCRAPERS

(1871–Now)

At the end of the 19th century, the first large office buildings were built in Chicago. The wish to build high became a competition to build higher than someone else. Until the 1970's, New York City and Chicago had followed a further and steady typological development. No other cities in the United States, or around the world, had such influence on the construction of skyscrapers.

FIGURE 1: THE TOWER OF BABEL, PAINTED BY PIETER BRUEGEL THE ELDER, 1563

It is to be assumed that the human being always wanted to come closer to the sky, which is also often symbolized by the concept of reaching God in heaven. According to the bible, the people of Shinar had built a city with a tower, whose top would rise up into heaven – the Tower of Babel. Many paintings and stories tell that if the Tower of Babel really existed, it was about seven stories high. The symbol of reaching God had changed and opened the way for the natural behavior of humans challenging each other.

ELEVATORS

The invention of the elevator was one reason why it was possible to create higher buildings. Although it was technically possible to construct buildings taller than six floors in the 19th century, without an elevator, no one would have gone up so many stairs.

The safe machine powered elevator was invented in 1852 by Elisha Graves Otis. Before that, elevators were powered by animals, water or even humans. Five years later, Otis installed his first elevator in New York. The uniqueness about Otis´ invention was that a serrated guide rail was attached on each side of the elevator shaft. These four guide rails were able to hold the cabin of the elevator in case of emergency, should a safety rope fail. More than 2,000 elevators were installed before 1873.[1]

FIGURE 2: OTIS´ FIRST ELEVATOR, NEW YORK, 1857

The first electric elevator was invented by Werner von Siemens in 1880. Elevators today are still electric. With towers getting higher, the elevators will have to keep up.[2]

GREAT CHICAGO FIRE

The Great Chicago Fire was one of the worst disasters of the 19th century. It is not known exactly what caused the fire. The fact is that the fire started in a barn on October 8th, 1871 and raged for two days. The reasons for the rapid and uncontrollable spread of the fire were the wooden walkways and buildings. The level of destruction was so huge that there were doubts if Chicago could be rebuilt again. The fire claimed the lives of 300 people and destroyed more than 17,000 buildings.[3] During the rebuilding of Chicago a new style came up which was called the “Chicago School of Architecture”.

1.1.1. THE BLOCK AND THE TOWER

In the 1880s, the development of modern high-rise construction began, as intended by commercial and residential institutions. The first and foremost purpose of tall commercial buildings was to combine business activities at the city center. As a consequence there was a lot of pressure at the city center to get these available sites. Among other things a tall commercial building was developed in the city center for business organizations as symbols of notability. The commercial building created a characteristic landmark in the city at the same time. The growing mobility of the tourists and business community opened the way for a new section of tall buildings, the hotel accommodation in the center of the city. The steady increasing urban population, combined with pressure on restricted space, clearly had an influence on residential building development. The residential buildings multiplied because of the high cost of land, the desire to escape hectic, everyday life, and the "need to preserve important agricultural production". Usually, economic and functional factors create high-rises with a similar shape, but the skyscrapers between the last decades of the 19th century and the first half of the 20th century developed in a different way. The reasons for that are, among other things the local conditions, like the city´s historic grid, municipal regulations, and zoning. [4]

THE BLOCK – CHICAGO

The first big office "skyscrapers" in Chicago did not live up to their name. Although the buildings consisted of skeleton structures of cast iron and wrought iron, they did not look like they would ever reach the sky. The tall buildings appeared heavy through the use of natural stones in the façade and bricks in the horizontal structure.

The sites in Chicago were generally large, and so the standard type was a rectangular box penetrating the center or rearing a large light court.

FIGURE 3: MARQUETTE BUILDING, 1895
HOLABIRD & ROCHE, CHICAGO

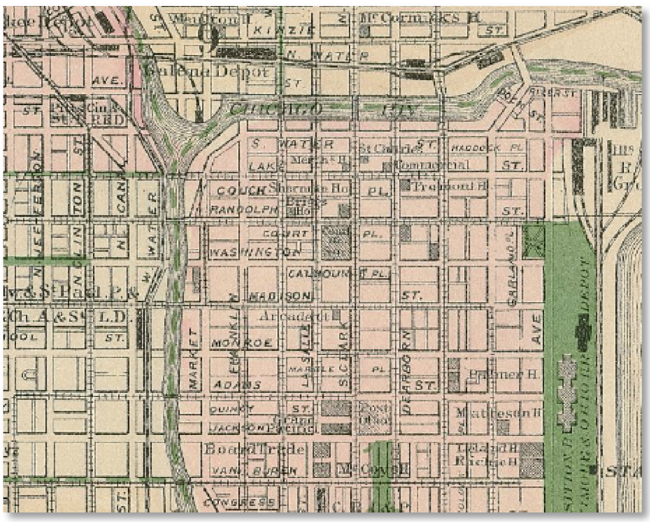

FIGURE 4: MAP SECTION OF CHICAGO, 1888

Louis H. Sullivan (1856-1924) and John Wellborn Root (1850-1891) created the principals of architecture as the first tall office buildings were built in Chicago. Thus it is possible to say that Louis Sullivan was maybe the first theoretician of skyscraper aesthetics.

This movement was called the “Chicago School” and was the first step into modern movement where structure became a form-giving element.[5] Louis Sullivan created regulations for designing skyscrapers, like the tripartite division. He thought that a skyscraper had to be divided into three sections – base, shaft and capital, which are perceptible on his tall building designs.

As the real estate boom began, buildings were allowed to be 200 feet high. But only five years later, in 1893, a new law limited the height of skyscrapers to 130 feet, because of the high vacancy in the new buildings. As a result, Chicago had lost its leading role in skyscraper construction and development to New York City.

THE TOWER – NEW YORK CITY

The skyscraper towers of New York City had distinguishing shapes. The lots in New York City were generally small and there were no height regulations. Thus, the tall and slight tower, where the floor plan was organized around the core, was the most profitable way to build during the first period.[6]

FIGURE 5: SINGER BUILDING, ERNEST FLAGG, 1908

The new way was to create skyscrapers in an historic style, like Gothic, Romanesque and Beaux Arts. Therefore, the tall buildings do not differ that much from the old buildings, so maybe it was a way to convince people to be prepared for something new.

Ernest Flagg created a new tower for the already existing 14-story Singer Building, in 1908. The tower, which was 41 stories high, made the Singer Building the tallest office tower in the world and as a result, the most famous building in America. It became a tourist attraction with its viewing platform, but was demolished in 1968. Gothic elements supported the verticality, which was a suitable way to create the façade of a skyscraper.[7]

The skyline of Manhattan was bristled with towers, while the buildings in Chicago were comparatively low, uniform and had flat tops, in the early 20th century. The skyscraper, architects, clients and especially the city itself had gotten a lot of attention. The skyscraper was established in the architectural language and the public acknowledged the high-rise buildings.

1.1.2. Elaboration of Law

FIGURE 6: EQUITABLE BUILDING BY ERNEST GRAHAM, NEW YORK, 1915

As clients and architects began to misuse the plots by creating extreme lengths, New York City shifted back again to tall block constructions, as they reached the "Golden Twenties"[8]. The transition was initiated by the Equitable Building and the public protests afterward. Such developments would have destroyed the cityscape and neighbors would not have had any rights.

On the basis of zoning resolution the building forms in both cities changed noticeably, in the 1920s. The new types were formed by the regulation, and the buildings combine a big base and a small tower. The New York zoning law of 1916 created the "wedding cake" setbacks, while Chicago´s zoning law in 1923 allowed a tower to rise above the height limit, but limited its total volume.

Zoning Resolution of 1916 – the "Wedding Cake"

As a logical consequence, the Zoning Laws of 1916 prohibited skyscrapers like the Equitable Building. The future buildings had to be stepped inward, which meant the higher the building, the narrower it became at the top.

The result was that the law would determine a building's appearance. An example of the effects by the Zoning Laws of 1916 is the Barclay Vesey Building. This led to the "wedding-cake style", which was created by tall structures with three different sections and an extended top.

FIGURE 7: BARCLAY VESEY BUILDING,VOORHEES, GMELIN AND WALKER, NEW YORK, 1926

Even with the Zoning Law, it was possible to build higher than before. If the floor spaces were reduced to a quarter of the site area by stepping them inward, the skyscraper could rise up to even greater heights.

Two of the probably most famous skyscrapers in the world, the Chrysler Building and the Empire State Building, were built at the beginning of the 1930's. William van Alen created the Chrysler Building, which was the highest building in the world, until the Empire State Building was finished, one year later. The Empire State Building designed by Shreve, Lamb and Harmon finally reached the limits of the proven steel-skeleton structure with a height of 1250 feet. For over 40 years the Empire State building held the title “tallest building in the world”. The Empire State Building is since then the perfect skyscraper example.

FIGURE 8: CHRYSLER BUILDING, NEW YORK, 1930

FIGURE 9: EMPIRE STATE BUILDING, NEW YORK, 1931

THE INTERNATIONAL STYLE

The Golden Twenties and additionally the phase of the skyscrapers were ended by economic crises. This did not change until the competition for the Chicago Tribune Tower, in 1922. Even though the designs of the representatives of German Bauhaus architecture and De Stij movement in Holland, Gropius and the three Dutchmen Bijvoet, Duiker and Zandvoort had only little chance to win, they had created a new style of architecture. Their design showed a new requirement to technology, functionality and clear lines. They had paved the way for Modernist architecture and their architects.

The Harvard University offered Walter Gropius a job in 1937 and the new Bauhaus was founded by Laslo Moholy-Nagy in Chicago in the same year. One year later Mies van der Rohe became director of the Illinois Institute of Technology.

FIGURE 10: RCA BUILDING, ROCKEFELLER CENTER, NEW YORK, 1940

The RCA Building at Rockefeller Center was designed during the Second World War by Hood & Foulhoux, Hofmeister, Corbett, Harrison & Mac Murrey. The building was completed in 1940 in New York City.

In 1932, Howe and Lescaze designed the PSFS Building in Philadelphia, which was one of the first attempts using elements of the International Style – a new movement to the American skyscraper.

FIGURE 11: 860-880 LAKE SHORE DRIVE APARTMENTS, CHICAGO, 1947

After the Second World War, Mies van der Rohe created the Lake Shore Drive Apartments in Chicago. These buildings with their curtain-wall façades and their clear lines became an example for the new modern movement of skyscrapers, called the “International Style”. The Lake Shore Drive Apartments were built between 1949 and 1951. Mies van der Rohe was able to create a perfect archetype of a high-rise building, because the buildings do not vary significantly from each other. The buildings were designed as a simple cubic form, but with an interest for details.

The Seagram Building became the prototype for a modern office tower and was planned in collaboration with Philip Johnson. Later, a lot of duplicates were built all over the world, but such copies did not accomplish the quality of the original buildings.

ZONING RESOLUTION OF 1961- OPEN SPACE

As history shows, the building´s top lost its importance and a new style of skyscrapers developed. The high-rise buildings in New York City now have open plazas in the front of them. The 2nd Zoning Law in 1961 allowed taller buildings if public plazas were created. The Seagram Building in New York City, designed by Mies van der Rohe is a perfect example how the Zoning Law of 1961 worked. This new legislation caused a building boom. But as several buildings were constructed with one right next to the other, plazas ran into each other uninterrupted. As a result, they created quite an inadequate urban setting, where the property line disappeared.

1.1.3. POSTMODERNISM

The new search for different types of stereotypical buildings began during the 1970's and 1980's. The design of the International Style was reduced to the essential, but the architects of the postmodern times changed their buildings into sculptural constructions, decorated with ornaments. Again they began to add decorative details on the façade or hide the functional components and structures behind historical facades.[9]

FIGURE 12: AT&T BUILDING, NEW YORK, 1984

The AT&T Building, now known as the Sony Building, was designed by Philip Johnson and John Burgee in 1978. The building also became known as the “Chippendale skyscraper”, because the top looks like an 18th century Chippendale clock.[10]

The tripartite elevation again became very important in the postmodernist high-rise architecture. The postmodern skyscrapers had a conspicuous foundation with a tall building above.

New York City´s new legislation in 1981 allowed setting the foundation back in certain streets, no more than ten feet, in order to maintain the property line. The city also encouraged that the new buildings create public access routes. The buildings needed two different zones with public facilities in the base and private office spaces above.

This legislation changed the whole city and became a standard to create skyscrapers all over the world. The law was implemented into high-rise buildings with communication areas, atriums, shopping areas and other attractions. The higher the tower gets, the more it becomes a mini city in itself. The John Hancock Center, shows us that super-tall buildings can work as multipurpose towers. Restaurants or commercial space on the bottom floors became common in planning a skyscraper. But investors still have little interest in giving the public an opportunity for a great view, as on observation floors or restaurants on the penthouse level in such high buildings.

At the same time, it is becoming increasingly clear that the skyline of the city and additionally the representative appearance are becoming more and more important.[11]

The styles were developing parallel to each other and since then, Europe and Asia have caught up or rather overtaken the development of skyscrapers. The construction boom showed that over the last 150 years, the architectural design and the building's performance created some of the most spectacular skyscrapers in the world.

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[1] http://die-wolkenkratzer.de/wolkenkratzer-geschichte.html, retrieved 2012-02-24
[2] http://www.allaboutskyscrapers.com/construction/skyscraper_elevator, retrieved 2012-02-24
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[4] SMITH, Bryan S., COULL, Alex, *Tall Building Structures: Analysis and Design*, John Wiley & Sons, 1991, p.1
[5] EISELE, Johann; KLOFT, Ellen, *High-Rise Manual: Typology and Design, Construction and Technology*, Birkhäuser, 1999, p. 8-14
[6] WILLIS, Carol, *Form Follows Finance*, Princeton Architectural Press, New York: 1995, p.23
[7] GRAY, Christopher, "Once the Tallest Building, but Since 1967 a Ghost", in: *New York Times,* January 2nd, 2005
[8] Author´s note: In the *Golden Twenties* the society became huge power and they were participated in economic the first time. Mass production and productivity had increased and the growing consumer products industry created a consumer society.
[9] EISELE, Johann; KLOFT, Ellen, *High-Rise Manual*…, p. 8-14
[10] http://ci.columbia.edu/0240s/0242_3/0242_3_s7_3_text.html, retrieved 2012-02-26
[11] EISELE, Johann; KLOFT, Ellen, *High-Rise Manual*…, p. 8-14

1. HISTORY

1.1. Overview on the American History of Skyscrapers

(1871-Now)

1.2. Structural Systems of Skyscrapers

1.2. STRUCTURAL SYSTEMS OF SKYSCRAPERS

The structural system of a building is designed and constructed to support and transmit the applied gravity and lateral loads safely to the ground without more than the tolerable stresses in its components. The superstructure is the vertical extension of a building above the ground and includes all columns, beams and load-bearing walls. These elements are supporting the floor and roof structures. Not one single element is responsible for the supporting structure, but the combination of members together with the configuration of joints.

1.2.1. STEEL FRAME STRUCTURE

This kind of structural system is not something new, the non-bearing walls were traditionally cladded with stone and brick. It was a combination of architectural design and visual element to express window and door surrounds, and to articulate vertical and horizontal division.

Such characteristic skyscrapers with a base, middle, and top looked solid and classical. Often very tall buildings would incorporate several lower floors faced in rusticated masonry to convey the feeling that the building rested on solid foundation although the masonry on the lower floors carried no more load tan the masonry on the penthouse. The modernists felt that this traditional masonry vocabulary was no longer acceptable for a steel-frame building, and the newer system attempted to exploit the intrinsic qualities of steel cage and of pre- fabricated materials.

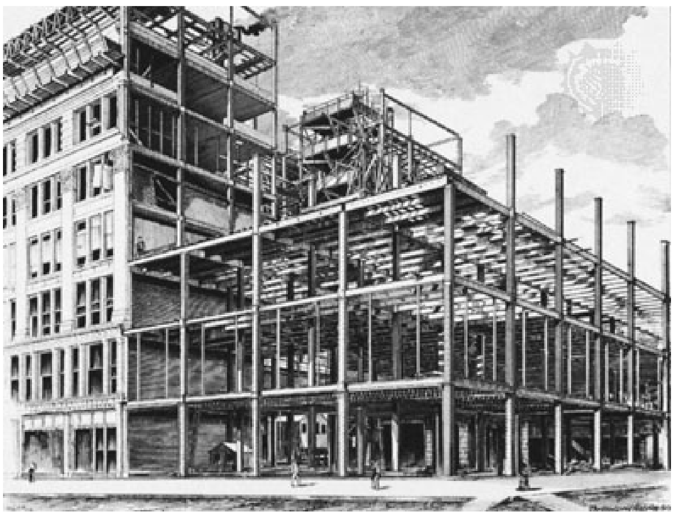

FIGURE 1: CONSTRUCTION OF THE FAIR STORE, WILLIAM LE BARON JENNEY, CHICAGO, 1891–92

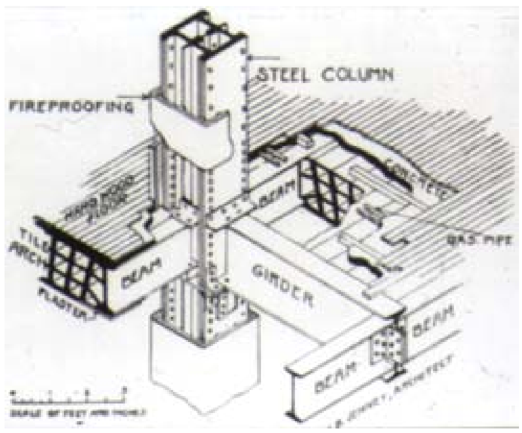

FIGURE 2: FAIRE STORE, STEEL FRAME AXONOMETRIC

The rectangular grid is one of the important requirements of this structure. The steel columns are standing about 20 to 30 feet apart. The floors, walls and the roof of the skyscraper are all connected to the frame.

The architecture movement by Ludwig Mies van der Rohe influenced whole generations of architects. The 860-880 Lake Shore Drive Apartments in Chicago by Mies van der Rohe and the Lever House by SOM in New York City could be understood as archetypes of this time. Both buildings opened a new way for structural forms by reducing the building to essentials and using the structure as a key design element.[11]

FIGURE 2: LAKE SHORE APARTMENTS UNDER CONSTRUCTION, CHICAGO

Core and Frame Structures

The combination with a core and frame structure can reach 30-40 stories. Generally, cores are situated in the center of a building. The advantage of this is on one hand to get as much daylight as possible and on the other hand to resist shear forces effectively. The core is not always in the center. It could also be situated on the outside of the building, but has to be symmetrically located.[12] The core of the Inland Steel Building, for example, is situated on one side of the building.

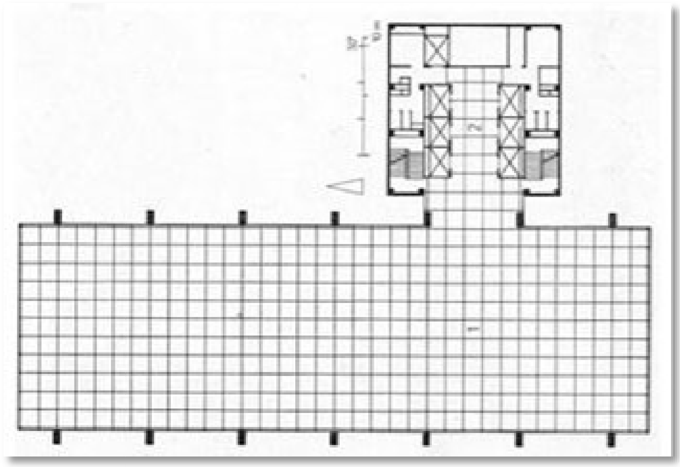

FIGURE 3: INLAND STEEL BUILDING, CHICAGO, FLOOR PLAN

1.2.2. Tube Structure

The choice of the system, the materials and the measurement of cross sections increases in importance the higher the building gets. The requirement specifications are the horizontal and vertical loads, as well as the earthquake loads.

The tube structure is a new addition to the structural systems. Fazlur Khan, engineer of SOM, is generally credited with its invention in the 1960s. It is defined as "*a three dimensional space structure composed of three, four, or possibly more frames, braced frames, or shear walls, joined at or near their edges to form a vertical tube-like structural system capable of resisting lateral forces in any direction by cantilevering from the foundation*."[13]

That means that with this framed tube construction there are no interior columns necessary, like they are in other conventional skyscrapers. The materials of such buildings were steel, composite steel elements and reinforced concrete. With early computer programs it was possible to show engineers that this framed-tube construction used less steel, created larger interior spans and made skyscrapers more economical than ever. In the USA the tube structure system was an ongoing development, where a whole series of tube combined systems were created, such as the braced tube structure and the bundle tube structure.[14]

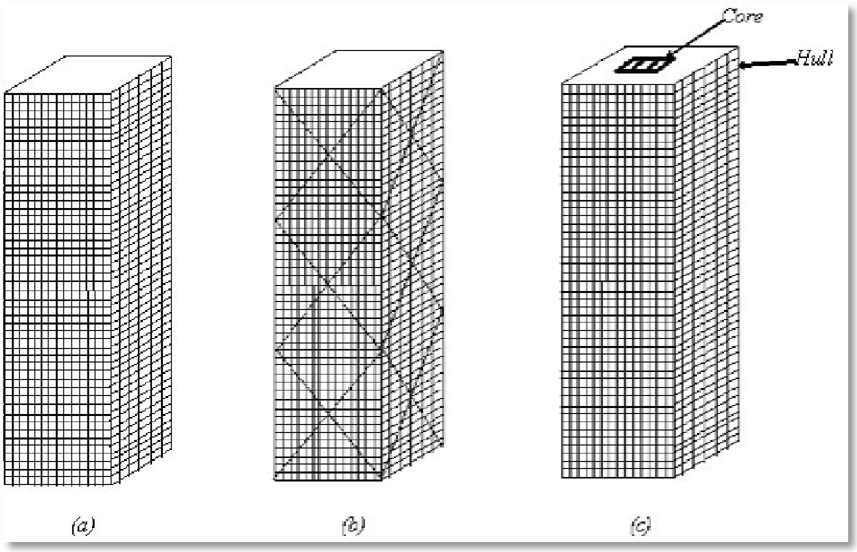

FIGURE 4: (A) FRAMED TUBE (B) BRACED FRAME TUBE (C) TUBE-IN-TUBE-FRAME

BRACED TUBE STRUCTURE

The braced tube structure is also known as trussed tube structure. This structure is basically the same as the frame tube structure. The exterior columns are more separated from each other and as a consequence they can be reduced. To replace the missing columns, steel bracings or concrete shear walls are established along the exterior wall.[15]

The system of the John Hancock Center is a braced tube structure and was created by Fazlur Khan in cooperation with the architect Bruce Graham. Both of them worked for the Chicago office of Skidmore, Owings and Merrill. In the 1960s the wind was more a psychological problem than a structural one. The high winds were no subject in the construction of a skyscraper earlier. But the lightweight flexible John Hancock Center had to sustain horizontal winds. The problem was that there were no studies how long a tower like the John Hancock Center could endure before it became disturbed and how much sway people would tolerate. There was no budget to make a psychological research on this subject, but fortunately the problem solved itself "*on a Sunday afternoon during family outing to Chicago´s Museum of Science and Industry."* [16] *Fazlur Khan and his daughter Yasmin Sabina Khan stood on the rotating section of the floor and Fazlur "noticed a slight jerk on his hand as he hold mine* [Yasmin]*, caused by the floor´s motion*. "[17] SOM was allowed to use the exhibition for their research. Khan and eight volunteers wrote down their level of discomfort as they stood, sat and lay on that floor. The result was that there was no reason for worry about the wind and its forces against the building. The John Hancock Center was the first building with this braced tube structure.[18]

BRACED FRAME TUBE STRUCTURE

The structure system of the Hearst Tower, for example, consists of triangular braces along all four sides of the building. Every four stories the nodes of the diagonal grid emerge and so a second system was necessary in the service core area. These braced frames were asymmetrically attached to one side of the building. A total of 84 similar prefabricated nods were required to connect the diagonal grid columns and the spandrel beams. The columns and spandrel are cladded in stainless steel.[19]

At the New York Times Building the core was also braced, but in addition to that two-story high diagonal braces were attached to the façade. Due to the fact that the Tower Verre did not exist yet the detailed information how the system would be implemented was kept back.

But it could at least be said that these towers have one thing in common – the combination of the braced structure with the frame tube structure. The braced frame tube structure became a popular and common system to create high-rises.

BUNDLED TUBE STRUCTURE

The bundled tube structure is easy explained by the example of the Willis Tower, where the first of its kind was built.

The bundled tube structure consists of nine tubes and each one is a rigid steel frame of columns and beams. Each tube is 75 feet long on each side and tied together along their common sides. The Sears Tower is clustered in a 3×3 matrix, where every tube is 75 feet long.

That forms an overall square base with 225-foot sides and an overall floor area of 3.7 million square feet. As already mentioned one set of beams and columns are used by two tubes next to each other. The connections between columns and beams are fully welded. The tube has three levels were the columns are incorporated with trusses. Those can be found on the 30th floor, between 64 and 66 and also on floor 89.

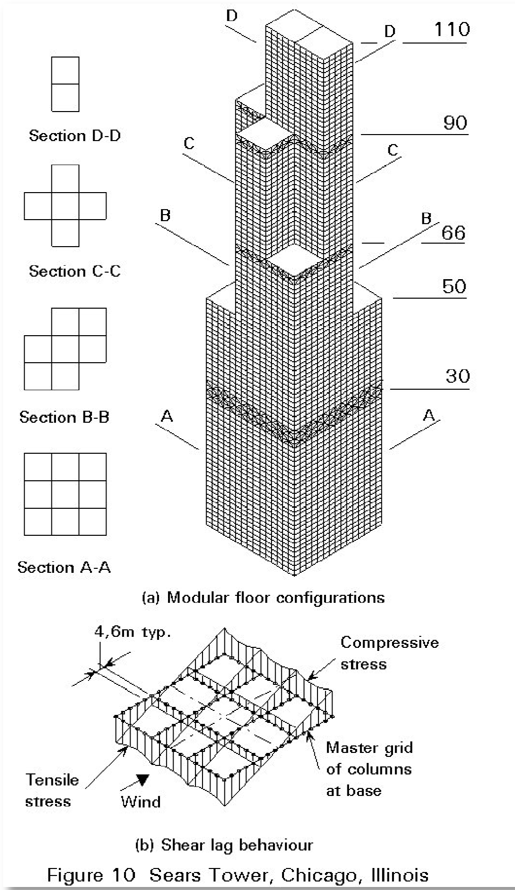

FIGURE 5: BUNDLED TUBE STRUCTURE, WILLIS TOWER

Sixteen 40-inch wide steel columns are 15 feet apart on the outside of every tube. On each floor level the columns are braced by 42 inch deep beams. That means that 75 feet on each side is free of columns because of the recently mentioned supporting steel on the outside.

A series of 3-foot trusses and floor beams connect the levels to each other. The elevators, washrooms and plant rooms are arranged in the center of each floor to provide more free attractive office spaces, which are easier to organize.[20]

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[11] EISELE, Johann; KLOFT, Ellen, High-Rise Manual: Typology and Design, Construction and Technology, Birkhäuser: 2002, p. 77, 78
[12] http://www.slideshare.net/chuhonsan/l5-vertical-structure-pt-3-3341134, retrieved 2012-02-28
[13] KHAN, F. R.; RANKINE, J., *Structural Systems, Tall Building Systems and Concepts, Council on Tall Buildings and Urban Habitat/American Society of Civil Engineers*, American Society of Civil Engineers, 1980, p. 42
[14] EISELE, Johann; KLOFT, Ellen, High-Rise Manual…, p. 77, 78
[15] http://www.slideshare.net/chuhonsan/l5-vertical-structure-pt-3-3341134, retrieved 2012-02-28
[16] STOLLER, Ezra, *The John Hancock Center*, New York (Princeton Architectural Press), 2000, p.2
[17] STOLLER, Ezra, *The John Hancock Center* … , p.7
[18] DIXON, John Morris, *The tall one: John Hancock Center*, Forum, 1970, p.37-46
[19] TARANATH, Bungale S., *Structural Analysis and Design of Tall Buildings: Steel and Composite Construction*, CRC Press: 2012, p. 507
[20] ZUKPWSKY, John and THORNE, Martha, *Skyscrapers: The New Millennium*, Prestel, 2000, p. 24-25

STRUCTURE

2. STRUCTURE

2. STRUCTURE

2.1. DARK VERTICAL ELEMENTS

The following skyscrapers show a lot of similarities. But the most obvious is the use of dark vertical elements as a key design element. The following buildings are a few classic examples. Often, dark vertical elements on the outside of a façade can be seen when walking through the cities of New York and Chicago.

2.1.1. SEAGRAM BUILDING (OR 375 PARK AVENUE)

Joseph E. Seagram and Sons Corporation wanted to celebrate their 100th anniversary with a new headquarters. They wanted to hire the best possible architect. Mies van der Rohe was preferred because they believed he would not let his ego take over the project. He had a specific vision and was trustworthy, so he was hired to build their office building.[1] Since Mies van der Rohe did not have a license to build in New York City, he asked Philip Johnson to work with him and they rented an office together in the City as a solution. The major task was to coordinate between the New York office and Mies' office in Chicago.[2] But since the Four Seasons Restaurant was designated for the Seagram Building, Mies asked Johnson to design it and he was responsible for the lobby design as well.

LOCATION

The site on the Park Avenue in New York City is 200 feet wide and 300 feet deep. It is located between 52nd and 53rd Street. At that time, many American corporations settled down on the famous Park Avenue, like the Lever House.

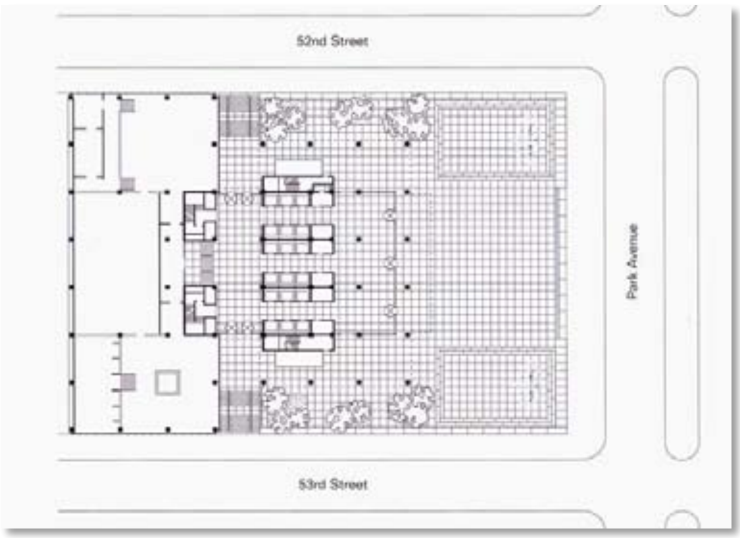

FIGURE 1: GROUND FLOOR PLAN

SHAPE

Seen from Park Avenue, the Seagram Building seems like a high rectangular tower. But the building has a completely different form when viewed from the other sides. An addition to this building was added, that is one bay deep and three bays wide, rising as high as the 39 story Seagram building[3]. The tower also has three adjoining buildings.

FIGURE 2: SEAGRAM BUILDING MODEL

The ten-story high, three bay deep and three bay wide building is located between the others and connects them. The two, four story high buildings are situated on either side of it. Each of them is three bays deep and two bays wide. The two buildings are connected by the middle one. The 39 story high construction connects the look of the main building with the three adjoining buildings.

With this solution, Mies created a lot more floor space, without a complicated design on the site. All the buildings in this complex have matching façades, so they merge to appear as one single tower.

DESIGN

The original Zoning Resolution of 1916 prevented buildings from losing light and air rights because of taller buildings around them. That is the reason why since then, many buildings were stepped back at the top to comply with the rules. In 1961, the Zoning Code was reconsidered and the city introduced, among other things, what was referred to as incentive zoning. If architects incorporated open space into their projects, they were able to add extra floor space.[4]

According to records, Mies assembled a model of Park Avenue at eye level to achieve the perfect proportions of the tower and plaza. The result was that the building was set back 100 feet, which created a great open plaza.[5]

- The world´s most expensive skyscraper at that time
- Construction: 1954-1958

The second floor was elevated with bronze clad columns. The set back lobby enlarges the open plaza and additionally the plaza seems to flow into the building because of the lobby´s floor-to ceiling, glass enclosed façade.

At this time, central air was not state of the art, but it was more readily available. Mies had to separate the structure from the façade to create a vent between them.[6]

It seems like a modern adaptation of a classical temple as one walks from the sidewalk via three steps up to the plaza. There are two identical shallow pools with fountains, one in each corner. The three steps form a bench on each side between the rectangular pools and the sidewalk, which can be used in summertime to relax. The main building, behind the other Seagram buildings, is almost invisible because a tall tree blocks the view.

FIGURE 3: STEPS UP TO THE PLAZA

The dimensions of the tower are; five bays wide by three bays deep. Philip Johnson successfully designed the interior of the lobby and the ground-floor restaurant. The Seagram building cost $36 million and was the most expensive building at that time. An extra $5-million was spent just to create the plaza.

FAÇADE

The Seagram Building´s façade consists of a modular unit, which measures four feet and seven and a half inches.

It is possible to see that the extruded bronze plated I-beam mullions divide the bays. These mullions are mounted consistently across the entire façade. Mies saw the curtain wall for what it was – something which wrapped the building. The miniature I-beams are not a structural element and he wanted to demonstrate that when he allowed them to end just inches from the ground.

> The Seagram Building was the only building Mies van der Rohe designed in New York City

The mullions are only decorative elements, but have the ability to play with light and shade. That leads to the conclusion that the Seagram Building is not as honest with the structure as the façade might signify.[7]

The Seagram Building is 516 feet high[8] and utilizes bronze-tinted glass to minimize the sun´s heat.

STRUCTURE

Until then, Ludwig Mies van der Rohe had never designed such a skyscraper before. Therefore, he never had to deal with wind forces against such a tall building. The shear walls rose on the north and south sides of the structure and he paved these walls with Tinian marble. To maintain a uniform façade, Mies van der Rohe covered the marble with the same curtain wall elements as the rest of the tower. Like other buildings of Mies van der Rohe, this one is also mounted on a grid. From one structural column to the other, it measures 27 feet and nine inches.

The only horizontal lines in alignment with the façade are those of the floor tiles. But it is not possible to see any wind resistant elements, like braces because they are hidden in the walls of the elevator core.[9]

FIGURE 4: SEAGRAM BUILDING

The sculpture in front of the Seagram Building changes every few years. Today the plaza is dominated by a giant yellow teddy bear leaning against a lamp, which is illuminated at night. This 20-ton, 23-foot bronze teddy bear was created by the artist Urs Fischer.[10]

The Seagram Building is a perfect example of Mies´ approach to the minimalistic structure. The tower gained publicity during construction and afterward. The architect Mies van der Rohe and the Seagram Building still receive recognition today. The New York Times journalist Herbert Mushamp referred to it as “the millennium’s most important building”.[11]

The references of the information in the boxes can be found in the footnote.[12]

2.1.2. 330 NORTH WABASH

(FORMALLY THE IBM BUILDING)

The reason for building such a tower was to consolidate all IBM offices in Chicago into one headquarters. The company had to make a tremendous upgrade from tabulating machines to computers. So it was the perfect time to begin such a project. Mies van der Rohe was hired to design a new downtown office building for the International Business Machines Company (IBM) in 1966. By this time, he was 79 years old.

LOCATION

The irregular 1.6 acre site where the IBM building was constructed is located at the north side of the Chicago River and between Wabash Avenue and State Street. Mies van der Rohe was in a wheelchair by then because of arthritis which he suffered from for quite a long time. As he arrived, he was confused, according to an Inland Architect article in July 1972, and asked, "Where´s the site?"

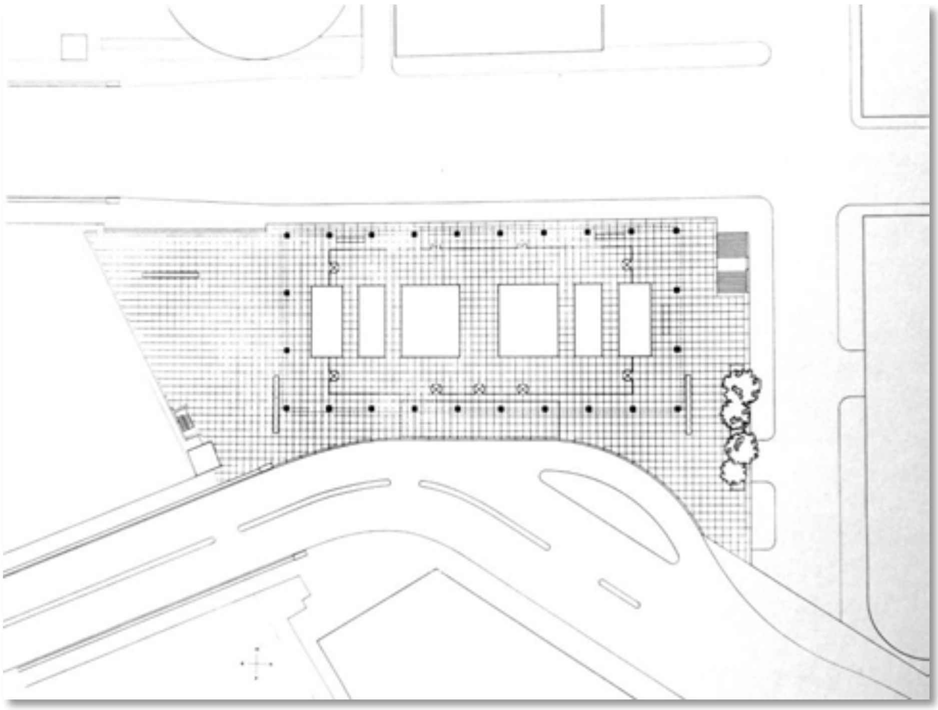

FIGURE 5: 330 N. WABASH, GROUND FLOOR PLAN

This plot was far from being every architect´s dream. There were a few obstacles like the curves of Wabash Avenue, the railroad tracks running underneath the plot and additionally, an existing agreement back then to provide storage for the nearby existing Sun-Times building. Another challenge for Mies van der Rohe and his team was to design a 52 story building, where the surrounding plaza had to be half of the site itself. [13] As the city concurred to modify the outline of Wabash Avenue, the original U-shaped plan was superseded by the current rectangular version.[14]

DESIGN

This building of Mies van der Rohe, is a distinctive one.[15] The black rectilinear box rises 695 feet (670 feet above the plaza). Mies van der Rohe chose dark aluminum and bronze tinted glass for the building. The high-rise building is set parallel to Chicago´s street grid, and the plaza follows the angle of the Chicago River to the south. Because of that, the building does not block the inhabitants' view from the two, concrete, cylindrical towers at Marina City, which are also locally known as "corn cobs".[16]

FIGURE 6: 330 N. WABASH BETWEEN THE MARINA CITY AND THE TRUMP TOWER

FIGURE 7: FAÇADE OF 330 N. WABASH

Mies van Rohe`s buildings are structurally uncomplicated. He followed his motto, "Less is more." But 330 North Wabash is not just another steel and glass box, so there is no harm in trying to examine this more closely. Mies used to say, "God is in the details." Only glass separates the inside from the outside. The floor to ceiling, glass surrounded lobby, extends to a height of 26 feet. The ground floor seems open and almost weightless because the upper floors are supported and lifted up by stilts.

The building is 275 feet long and 125 feet wide. The 32 separate passenger elevators are divided into four banks, and provide transport within the whole building. In case of a major power failure, auxiliary power goes on so one elevator of each bank will still operate.

The regular raster of steel gives the tower a sense of calmness. Depending on weather conditions, the building and mostly the windows, change their colors. On some days the tower seems dark and black and on sunny days the windows are a shimmering blue. A closer look shows that the spandrel panels are recessed and window frames are extruded, unlike most international style buildings.[17]

INNOVATIONS

Sixty percent of the building was available for rent, because IBM only needed space for their 2100 employees. As previously mentioned, IBM switched to computers at that time and that´s the reason why they needed a very sophisticated climate control system. A reverse refrigeration system was developed and the walls were additionally sealed by a plastic thermal barrier.[18] This automatically controlled, heating and cooling system was designed by the associate architects C.F. Murphy.[19] Furthermore a dual-glazed curtain wall was incorporated to preserve the interior humidity.

This tower was the last American office building Mies van der Rohe designed before his death in 1969. He never saw the completed building, because he died just a few weeks after the designs were finished. The IBM tower was completed in 1971 and officially opened its doors in 1972.[20]

- Gross area: 1,780,00 square feet
- Weight: about 125,000 tons
- Start of construction: 1969

Formerly known as the IBM Building, the site was renamed as 330 North Wabash Avenue in 2006, after IBM moved out.[21] In September of 2013 the building will have a new tenant, the American Medical Association. As a result, the building will then be referred to as the AMA Plaza.[22]

The IBM building is not a simple tower after all. There are innovations internally and externally, which make this black steel box so special.

The references of the information in the boxes can be found in the footnote.[23]

2.1.3. THE WILLIS TOWER (FORMERLY THE SEARS TOWER)

A new icon rose in Chicago in the 1970's and became the world's tallest building up until 1998, when the Petronas Towers broke the record. Before One World Trade Center was completed, the Willis Tower was the highest building in the United States.[24]

BEGINNING

The headquarters of Sears Roebuck & Company was a fourteen-story office tower. After World War II, many things had changed. Sears Roebuck and Company was the largest retailer in the U.S., but this required more office space, so the company had to remodel the outdated warehouses to make space for them. Two million square feet were needed right away and speculative diagrams show that thirty years down the road, they would need twice that space.[25]

DESIGN

Sears wasn´t interested in building a monument, but they wanted to build something that was economical. Presumably, that's why they hired SOM.

FIGURE 8: WILLIS TOWER

SOM´s chief engineer Fazlur Khan and chief designer Bruce Graham began their work on the Sears project while the John Hancock Center was under construction. To the Sears Company, it was important not to duplicate this skyscraper, but to build one which is just as characteristic and just as economical. When the clients pursued the single tower concept, they first had to clear an obstacle out of the way to make room for the major skyscraper: a small public thoroughfare on the property on Quincy Street had to be removed. Unfortunately, it was not easy for Sears to buy the property on Quincy Street. Without Mayor Richard J. Daley and his love of skyscrapers, it wouldn´t have been possible to sell this lot to Sears, especially for a bargain.[26]

Some people assumed that the design concept was created one afternoon at the Chicago Club when Fazlur Khan and Bruce Graham were having lunch. The solution to build such a large building would be to cluster the tubes, so all tubes would share walls and support each other. Rumor has it, that the idea hit him when he reached for his cigarettes. Graham took out a handful and held them in his fist. Every cigarette had a different height and Khan understood right away. It was quite obvious that this confirmed the final design concept indicating what the building would look like.

The step-back geometry was necessary for the interior space requirements of Sears. In this lower section of the tower, there was enough space for Sears' current needs. They had their 50,000 square foot floors and if they grew in the future, they could use the smaller floors above. In the meantime, it could be rented by other companies and the smaller, upper floors offer more windows, more corner offices per square foot and create individual floors with different sizes and shapes.[27]

Up to the first 49 floors, all nine tubes are bundled together. At this point, two of the corner tubes end. The remaining seven rise to the 65th floor and again two more corner tubes terminate. The remaining five tubes create a cruciform plan. At the 89th floor, three more tubes terminate and then just two arrive at the 110th floor. On the roof are small penthouses for the cooling towers and the highest wash robot. This geometrical form provides square footage of 12,000 to 41,000 ft² for floors located above the 50th floor.

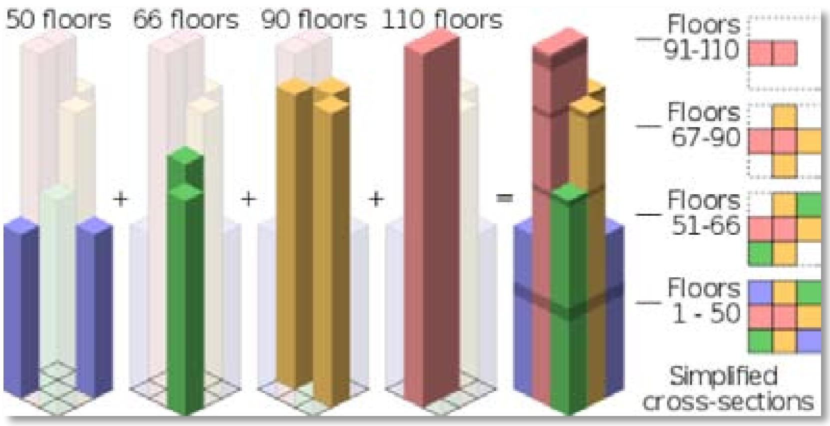

FIGURE 9: WILLIS TOWER, BUNDLED TUBES

Four slotted covers stand out from the rest of the bronze-tinted windows. These are the floors with cross-bracing and mechanical equipment. They are prominent and give the skyscraper an even more characteristic look. They are accommodated on the floors 29-31, 31-33, 64-66, 88-90, 104-106 and 106-109.[28]

HEIGHT

The height of the tower would have been about ninety-five stories based on SOM's calculations for Sears's present and future needs. At the same time, the World Trade Center was under construction and was about to break the world height record. They realized that they were not many stores shorter than the WTC. SOM presented a new scheme, similar to the previous one, to create the world´s tallest building, which reached 1,454 feet and was the absolute limit due to FAA regulations.[29] Gordon Metcalf presented a model for the Sears Tower a few weeks later and told Time Magazine: "*Being the largest retailer in the world, we thought we should have the largest headquarters in the world*".[30]

It started with breaking ground in June of 1971 and was the beginning of one of the most extraordinary projects that anyone involved had ever expected.

- Weight: 223,000 tons –
  Empire State Building weight: 365,000 tons
- Floor area: 3.7 million square feet

CONSTRUCTION TECHNIQUES

The "Christmas trees" were one of the many new construction techniques which had been used the first time on such a scale. These so called "Christmas trees" are 25 foot high columns with 15 foot sections of prefabricated, spandrel, structural units raised up in place.

FIGURE 10: TOWER DURING CONSTRUCTION

The Christmas trees were welded together with special equipment referred to as "electroslag welders". This technique uses electricity rather than a flame to bind metal together.

The typical weight of one Christmas tree is 15 tons. It was only possible to build four stories at once with the four "creeper derricks" hoisted by winches. These plat formed cranes are able to lift themselves up within the steelwork as the structure rises.

The "creeper derricks" also made it feasible to grow eight stories per month, which more than 5,000 trees were added within.[31]

MODERNIZE

In 1982, Sears decided to modernize the lower public areas and spent $20-30 million. They opened up the lobbies and made it easier for workers and visitors to access the rest of the building.

- Induced sway: 7.6 mm per story
- 16,100 bronze-tinted reflective windows
- 28 acres of black-coated aluminum panels
- costs more than $160 million to build

Kmart, Wal-Mart and other discount retailers became keen competition. Sears could not react fast enough because they were so large, when the sales began to slow down. Sears chose to move to a new complex in the Chicago suburbs.

De Stefano and Partners were hired by a real estate developer, to redesign the public areas and lobbies. De Stefano, the former partner of SOM, exposed the interesting structural elements of Fazlur Khan´s tube construction so the spaces would be more open.

The Sears Tower was renamed the Willis Tower in 2009, after London's global insurance broker, the Willis Group. In the same year, a new attraction was installed again by SOM. It was the addition of four glass cubes on the outside of the façade on the 103rd floor.[32]

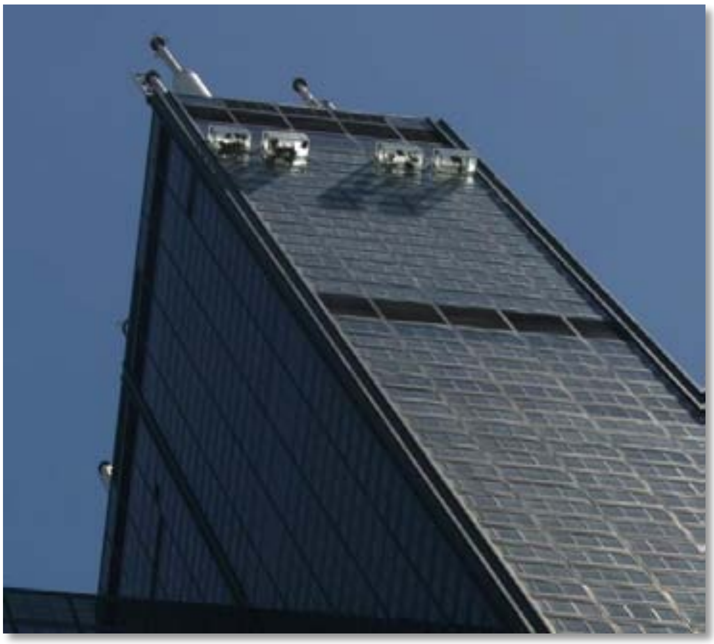

FIGURE 11: GLASS CUBES FROM OUTSIDE

Today the highest building in the world is the Burj Khalifa in Dubai at an astonishing 2,717 feet.[33] Using these examples of super-tall buildings, we see that materials, great architects and engineers with great ideas, and clients who are unafraid of challenge are important in building such magnificent structures. The materials and construction techniques are developing further and this makes it feasible to build higher than ever before.

The references of the information in the boxes can be found in the footnote.

2.1.4. ANALYSIS

The above described high-rises have a lot in common, but by paying attention to detail, there are differences in how they use the structure as a key design element and the effect this has on people.

HEIGHT

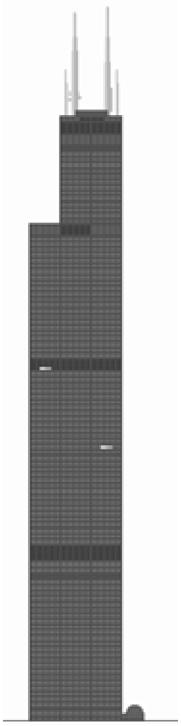

FIGURE 12: WILLIS TOWER

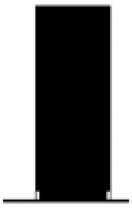

FIGURE 13: 330 N. WABASH

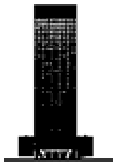

FIGURE 14: SEAGRAM BUILDING

The Willis Tower with its 110 stories, is by far the highest of these three skyscrapers. The dark vertical elements on the façades lead to the same effect. The buildings give the illusion of looking higher than they really are.

The Willis Tower is so high, that it is almost impossible to see the whole building from the street, but there is a good alternative, by boat. The strange thing is that from a distance, the building loses height and it doesn't seem so massive anymore. The Willis Tower looks like an elegant and thin skyscraper, which is the opposite perception from close up. The height of the Willis Tower is almost inconceivable to the human eye.

There are no obstacles in the way when marveling at the Seagram Building's full size. On one hand, the high-rise building is only 39 stories high and on the other hand it was set back from the street, which opens the view to the skyscraper.

The 330 North Wabash building is thirteen stories higher than the Seagram Building, but the Willis Tower is still more than twice as high. Compared to the Seagram Building, 330 North Wabash does not need a huge plaza to be seen in full. The building was constructed on the Chicago River, where people can see the total height from the opposite side.

SITE AND PLAZA

As mentioned prior, the Seagram Building is set back 100 feet from the property line. This was a design solution, caused by New York´s Zoning Law in 1961. Thus, the architect Ludwig Mies van der Rohe was able to build a few stories higher. The rectangular site is 200 feet wide and 300 feet long. The right angle grid, which is an important foundation for Mies van der Rohe, was obviously easy to handle on such a site.

FIGURE 15: WILLIS TOWER PLAZA & ENTRANCE SKYDECK

It became more difficult for the architect many years later when he had to design the new headquarters of IBM in Chicago on the irregular 1.6 acre site. The real problem here was not the asymmetrical lot, but the plaza, which had to be more than half of the site. The 330 North Wabash building is three bays wide and nine bays deep. The terrain drops down in the direction of East Kinzie Street. Mies van der Rohe wanted to have a flat plaza. The plaza behind the building was lifted up and is accessible via stairs from North State Street.

The large plazas of Mies van der Rohe´s buildings are always an important part of the design. The plaza of the Willis Tower is divided into two parts. The smaller one, with a vaulted glass atrium as the entrance, is on the north side, and the other is raised to avoid the “hustle and bustle” of the street. The renovation of this plaza was successful and it became a nice calm place to sit and relax.

The plaza at the Seagram Building is not just large and empty. There are shallow pools with fountains at each of the front corners. The plaza was lifted up three steps and it feels like entering a modern adaptation of a classical temple.

FIGURE 16: SEAGRAM BUILDING PLAZA

The original idea of the plaza, since the 1961 Zoning Law, was to return space to the public. But this thought disappeared and people are not allowed to enjoy the plaza. Tourists can take pictures of the sculpture in front of the plaza, but as soon as somebody wants to get closer to the building, guards with dogs prevent it. Only sitting on the benches is allowed, but those are already on the border of the plaza. The former public plaza became a private one.

SHAPE

Standing in front of them, the Seagram Building and 330 North Wabash might look the same at first, but they are not. The 330 North Wabash building is a rectangular box, but the Seagram Building consists of three adjoining buildings. In between the two, four story high buildings, is a ten story high cube. All are three bays deep, however, the two smaller ones are two bays wide and the one in between, is three bays wide. All of them are connected with the main building by a 39 story high tower. They are only visible from the side, or from behind the building. The buildings look like one, because they have matching façades. From behind the main building, they are almost most invisible.

The shape of the Willis Tower resulted from the bundled tube structure system. The nine tubes are connected to one single tower. The stepped back geometry was also required and created smaller floors. The building's ground floor size is 50,000 square feet and up to the 49th floor, all nine tubes are bundled together. Two corner tubes end there and the remaining seven rise up to the 65th floor, where two more corner tubes end. The rest of the tubes create a cruciform plan. Three more tubes end at the 89th floor. The remaining two tubes rise up to the 110th floor at the very top.

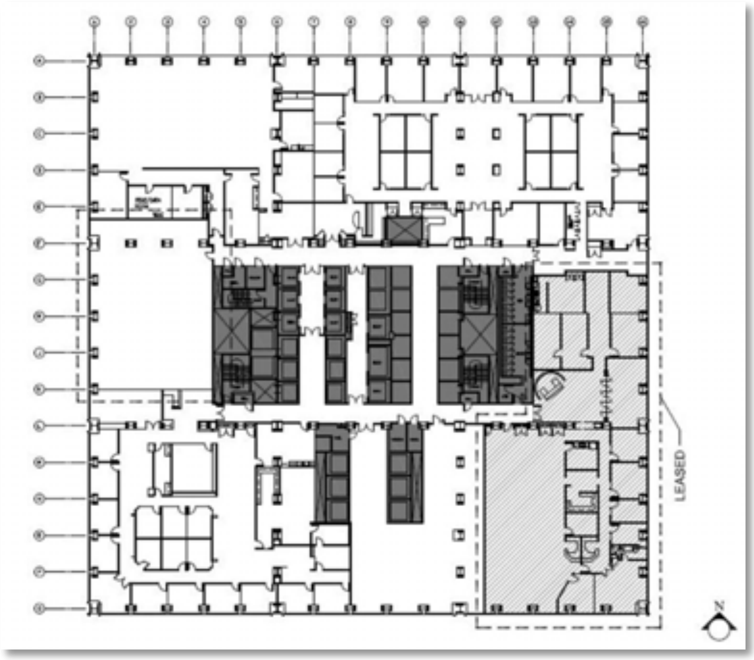

FIGURE 17: FLOOR PLAN, WILLIS TOWER

FAÇADE AND STRUCTURE

Both, 330 North Wabash and the Seagram Building are steel frame structures. The visible, freestanding columns on the ground floor suggest that kind of structure system. The I-beams on the façades of both buildings are just aesthetic elements. The dark vertical elements make the buildings appear larger than they really are.

For years, Mies van der Rohe dealt with the dilemma of positioning the columns in the right locations on the grid. With the steel frame structure, architects had to face the same problem which was encountered at Greek temples. The cross-section of the columns prevents the outer edge of the building from collapsing on the grid axis. If the grid size on the facade is consistent, then either the corner bay in the supporting structure had to be shortened, or a piece of the wall had to be added to the bay. Reducing the bay would result in a greater quantity of façade elements, which would contradict Mies´ logic for steel structure design. The steel construction elements are industrially produced and every superfluity should be avoided.

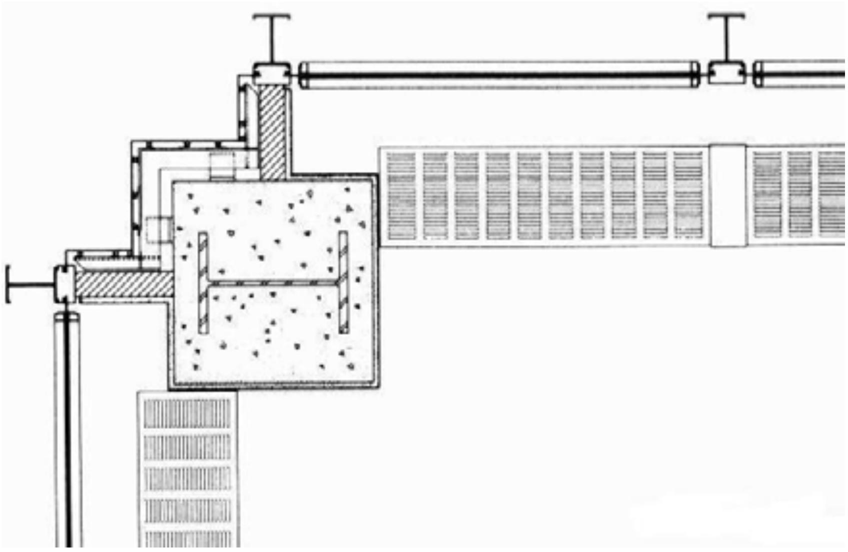

FIGURE 18: SEAGRAM CORNER DETAIL

Mies van der Rohe withdrew the curtain wall from the corner and exposed the supporting structure without covering it. In this execution, the regular grid ends with a frame instead of breaking off abruptly. The frame remains in the background but in a different way, still creates the same effect as the shortened bays at the Greek temple. The negative area creates a new framework, which is not a new element, but becomes an optical phenomenon. The corner solution gives the building a physical unity in the horizontality. This corner solution can also be found on many buildings of Mies van der Rohe, like 860-880 Lake Shore Drive Apartments and the Federal Center of Chicago.

The dark vertical elements are also visible at the Willis Tower. Although the Willis Tower does not need such effects, because of its true height, the clear lines of the vertical elements have a calming effect on the massive building. The dark vertical elements of the Willis Tower create a smooth façade, in contrast to the Seagram Building and 330 North Wabash. They depict depth, while the 3-dimensional I-beams of the two Mies van der Rohe buildings are welded onto the façade. All three buildings have rectangular windows, but the Willis Tower incorporates three windows into one unit, while the other two buildings divide their windows.

That is the reason why the Willis Tower has horizontal window hinges. Thus, the horizontal elements are more pronounced than the vertical ones at the Willis Tower, as compared to the other two buildings of Mies van der Rohe. Through this effect, the Willis Tower seems heavier than the Mies van der Rohe buildings.

FIGURE 19: WILLIS TOWER FACADE

The nine tubes of the structure are visible as clear vertical elements. Each tube is divided into five bays on each side. The three windows previously mentioned, are part of one bay, which means that each side of one singular tube has 15 windows. One side of the lower floors has 45 windows and is divided into 15 bays.

INTERNAL PERCEPTION

The lobbies of 330 North Wabash and the Seagram Building are enclosed in glass and set back. Obviously, high quality materials were used. The spacious lobbies of both buildings were reduced to the minimal necessities, like the plazas on the outside of Mies van der Rohe´s buildings. The clear lines of the structure can also be found inside the building, which gives them a sense of freedom.

FIGURE 20: INSIDE THE SEAGRAM BUILDING

It is easy to imagine that the large 50,000 square foot, lower floors of the former Sears Tower, created an impersonal work atmosphere, provided a cold workplace and had made employee communication nearly impossible, compared with the former smaller and older building. Looking out the window on such large floors had also become almost impossible for many employees. The circulation system was inefficient before modernization. The workers needed half an hour each morning just to get from street-level to their offices. Even though the Sears Tower was state-of-the-art in design and technology, unfortunately, the designers disregarded the people who worked inside. The employees felt disconnected and unhappy in their jobs, which was also because of the new technology. Today, the employees enter the Willis Tower via their own separate entrance and have no connection with the main tourist entrance.

FIGURE 21: INSIDE GLASS CUBE

The Sky Deck Experience on the 108th floor was surely something special at that height, with its fantastic view of the city. SOM installed the four glass cubes on the outside of the Sky Deck to attract tourists again. They are on the side where no tubes are set back, which guarantees an unrestricted view to the ground. People need a lot of courage to step into the glass box, but they never regret it.

Even though the buildings have a few things in common, like the bronze-tinted glass or the dark vertical elements on the façade, they use two different structural systems. Buildings like the Seagram or 330 North Wabash, show perfectly that beams do not have to be a part of the supporting structure. Mies van der Rohe created buildings which might look like copies of each other, but with a closer look, it is possible to recognize that even though they have a few similarities, they also differ from each other. With the creation of the Willis Tower, SOM created a unique building, which became an internationally famous icon of Chicago.

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2. STRUCTURE

2.2. SPECIAL CASE: TWIN TOWERS – DARK VERTICAL ELEMENTS

2.2.1. 860 - 880 LAKE SHORE DRIVE

Mies van der Rohe met Herbert Greenwald, in 1946. He described Greenwald as an idealist who wanted to leave a stamp on the scene by creating great architecture with modern technology.[1]

They started their first project in 1948. Mies van der Rohe designed two variations for the Promontory Apartments in Chicago. One was like the usual concrete structure built at that time and the other had a steel and glass facade, the first example of the curtain wall he would use in future projects. The second project with Greenwald also took place in Chicago, while the Promontory Apartments were under construction.

- Total height: 270 feet
- Four elevators overall (two per building)
- Construction: 1949 - 1951

The design of 860-880 Lake Shore Drive was a combination of an alternative version of the Promontory and drawings of two glass towers from the 1920's. The following year, the construction of the buildings began.

LOCATION

The site is located in one of the most beautiful places in Chicago, right on Lake Michigan. The trapezoidal site is not large and it made perfect sense to arrange the two towers at right angles to one another.[2] The 860-880 Lake Shore Drive Apartments are situated in such a way that most of the residents have a wonderful view of the lake. In the 1950's, the first apartment skyscrapers were built on Lake Michigan. It was a very risky undertaking to create apartment towers with floor-to-ceiling windows, because this allows people to see into the apartments from the city and Lake Shore Drive.[3]

DESIGN

Both towers rise twenty-six-stories high and stand perpendicular to each other. A walkway connects the two buildings. The one bay wide and two story high steel sections on the façade, were prefabricated and welded to the skeleton afterward. [4]

Mies van der Rohe came up with a 21 foot steel frame grid, with the columns mounted at the intersections. He was not the creator of the steel frame structure, but through the use of the grid, this structure was reduced to a minimum so it was considered good quality. [5]

FIGURE 1: 860-880 LAKE SHORE DRIVE APARTMENTS

The short sides of the buildings are divided into three bays and the long side into five bays. Each bay is twenty-one-feet wide. The free standing columns elevate the buildings so it seems like the buildings hover. The lobby at the ground level is set back, which forms an arcade around each building. The seventeen-foot high glass, which encloses the lobby, is divided into four bays, with two outer sections nine inches smaller than the two center glass elements. Mies van der Rohe created this variation as a design element, and it is not a structural requirement. The vertical lines of the towers are more emphasized than the horizontal ones. That includes the pattern of windows and the vertical I-beams, which extend from the second floor to the top. Additionally, these elements support the buildings' height to make them, in the words of Peter Blake, " the most vertical-looking skyscrapers up to that time". [6]

Attaching something that stands out of the façade, can create an effect that changes patterns of shadow and light. From a distance, the buildings appear bright and open but as you move closer, they seem darker and more solid. [7]

FIGURE 2: LAKE SHORE DRIVE, FLOOR PLAN

STRUCTURE

Mies planned his buildings from outside to inside. The main priority was the structure, then the windows and mullions, and later the interior division of spaces. [8]

Two inches of concrete had to be poured all around the steel structure to make it fireproof. Mies could have left the buildings with the concrete exposed, but this would not have created the same effect of height and upward motion. This problem was solved by Mies, with black steel plates. He covered the columns and mullions with them, followed by eight inch deep I-beams welded to the plates. The use of the steel structural element as an ornament, makes sense where the I-beams form the window frames and mullions. [9]

It was important to Mies van der Rohe that the rhythm of the I-beams should continue and spread equally. Apparently, he said that as they looked at the model. It did not look right without the steel section at the corner column. But another reason was that the steel section had to stiffen the plate and the corner column was needed so the plate would not deform. Mies pointed out that the first reason was the real reason, but the other reason was a good one too. [10] Within the skeleton, the floor-to-ceiling windows of glass are set into aluminum frames.

FIGURE 3: LAKE SHORE DRIVE APARTMENTS FAÇADE

APARTMENTS

All apartments were furnished with the same pastel color curtains to achieve a uniform look from the outside. The tenants, who might want to have their own curtains, could hang them inside into the second track. While the buildings show a uniform pattern from the outside, the apartments were planned to be flexible, because of the wide and regular spacing columns. The south building was designed with four, six-room apartments on each floor and in the north building, eight, three-and-one-half-room apartments on each floor. To form larger units, in some cases, apartments had been combined. *Life magazine* printed an article on Mies, which included several photographs of the 860-880 Lake Shore Drive Apartments at night. The photographs show perfectly what Mies' intention was: each apartment could be easily adapted to new use rather than replacing the whole building. [11]

“People Do Live In Glass Houses!” was the title of the *Chicago Tribune* article by Edward Barry on November 14th, 1951. The author was wondering about the psychological effect of living “high in the air with no solid walls to make off one´s living quarters from the abyss outside”. [12]

The buildings were refurbished, by Krueck & Sexton, from 2007 until 2009. The project's total cost was $9 million. [13]

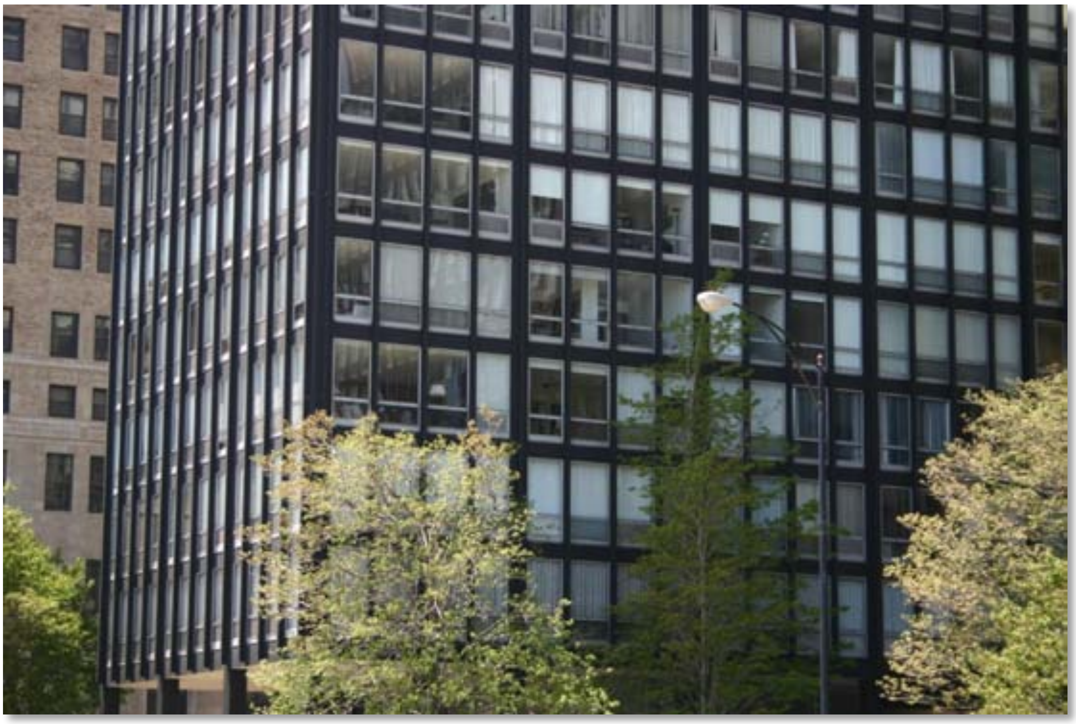

FIGURE 4: LAKE SHORE DRIVE APARTMENTS – "GLASS HOUSE"

The 860-880 Lake Shore Drive Apartments became standards for steel and glass skyscrapers. The buildings seem simple, but that is deceiving. After the towers were built, a colleague of Mies van der Rohe, Walter Peterhans from IIT, wrote "These towers testify to a new, and until now, unknown spirit. They are built out of familiar material, steel and glass, and yet it is as though they introduce the era of steel and glass, as if steel and glass were seen for the first time." [14]

The references of the information in the boxes can be found in the footnote. [15]

2.2.2. THE EVERETT MCKINLEY DIRKSEN BUILDING & THE JOHN C. KLUCZYNSKI BUILDING

The Everett McKinley Dirksen Building and the John C. Kluczynski Building are a part of the Federal Center in Chicago. The third building, the one-story high post office, will be included in the description, but not in the analysis because it is not a skyscraper.

Of course it is cheaper to build a skyscraper with concrete, but to Mies van der Rohe, the Federal Center was an architectural concept and not an engineering choice. Mies had the rare opportunity to build with steel at the Chicago Federal Center.[16]

LOCATION

To make space for the new complex, the old domed, full-block, classical Federal Building, built in 1905 by Henry Ives Cobb, had to be demolished.

The Chicago Federal Center is a group of three buildings on a four-and-a-half acre site in downtown Chicago. These buildings are situated on two different sites, which are separated by Dearborn Street. The forty-two story, general purpose office building and the one story post office are located on the west side of Dearborn Street, while the thirty story high Federal Courthouse building is situated on the east side.[17]

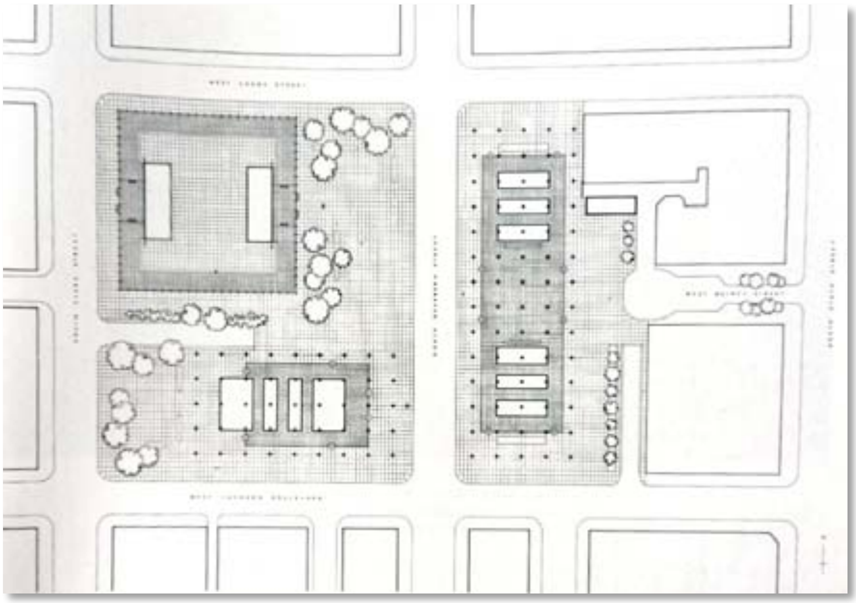

FIGURE 5: FEDERAL CENTER CHICAGO, FLOOR PLAN

DESIGN

Until the new courthouse was finished and opened, the old one on the western site had to remain. So the complex had two phases before everything was completed. That also means that the new courthouse had to be on the eastern site. This site laid the ground for the dimension of the structural grid and as a result, the ground plans for the buildings. The heights of the buildings emerged with a specific floor plan and the calculation of required space for each building. [18]

Mies van der Rohe planned four different kinds of schemes and at last the open-ended scheme was built, except for a small change - the office building was shortened by three stories. This last scheme provided the option to make required modifications during the stage of development, because of its size variations and the asymmetrical arrangements of the buildings. [19]

FIGURE 6: JOHN C. KLUCZYNSKI BUILDING

The two skyscrapers were set orthogonally to each other at the southeast corner and the post office on the northwest. All three buildings were constructed on a twenty-eight foot grid, which includes also the light gray granite in the plaza. [20]

The buildings do not only differ in height and function, but they also differ in their sizes. So it was very important to give the design a visual consistency. Mies achieved that, among other things, when he brought the lobbies and second floors of the two towers up 26 feet to the same height as the post office. [21] The two skyscrapers almost seem to float over the deep set lobbies. The only function of the floor-to-ceiling glass lobbies is to be the entrance space. [22]

Mies van der Rohe also used bronze-tinted glass here to absorb some of the sun´s heat. The steel elements on the façade were coated with graphite, which gives the building its black color. [23]

To get a uniform surface, Mies had a simple idea – he repeated the basic glass and metal pattern at the Federal Center more than 10,000 times. [24]

The forty-two story tower was designed with three levels underground with a height of 562 feet. [25]

STRUCTURE

The design of the new buildings is as simple as other office buildings and stands in contrast to the neo-classical façade of the old Federal Building. The façade of the courthouse tower, with its twenty-one courtrooms, does not distinguish itself from the office building. Only the interior is conformed to a typical courthouse.

If it´s necessary to add or reduce bays, it is possible to do that without consequences to the construction. Symmetry and the conscious perceptions as a whole get created with odd numbers, like 1, 3, 5 and 7. The even numbers 2, 4, 6 and 8 have the ability to split a building in half visually and make it higher than it really is. All numbers higher than 9, regardless of whether they are odd or even, are considered to be “many”.

FIGURE 7: FEDERAL CENTER CHICAGO

The bays between the columns can be counted at the ground floor. It is visible that the office building is four bays wide and eight bays long. The courthouse was built with four bays on the wide side and thirteen on the long side.

The thermal expansion and contraction of steel is a huge problem. A solution to that is to separate the structure from the façade.

The result is that the structure and the façade become equal. This means that the façade has been brought forward, while the structure has been set back – a “curtain wall” façade. [26]

Mies once said, “*Construction is the truest guardian of the spirit of the times because it is objective and is not affected by personal individualism or fantasy*.” [27]

COMPLETION

The first thirty story Everett McKinley Dirksen Building was finished in 1964. It included a Federal courthouse and an office building. After the opening of the new courthouse, the old one was demolished and in 1966 the construction started for the remaining buildings. [28] Gene Summers and Bruno Conterano continued the project, after Mies' death in 1969. The remaining two buildings, the post office and the John C. Kluczynski Building, were completed in 1975. The 53 foot high[29], red steel "Flamingo" sculpture by Alexander Calder, was installed the same year between the office building and the post office. [30]

FIGURE 8: FLAMINGO

It should also be mentioned that this project is not only the work of the architect Ludwig Mies van der Rohe, but it also included Schmidt, Garden and Erickson, C. F. Murphy Associates and A. Epstein and Sons. [31]

The firm of Fujikawa Johnson and Associates, Mies´ successor, designed a fourth building for the complex in the late 1980's, the Metcalfe Building. For this addition, on the southeast corner of Jackson Boulevard, they used the same materials and form to maintain consistency with the existing buildings. [32]

The building was created with a simple structure for a universal space. Buildings have a longer life expectancy than their functions inside. Mies designed the complex with great foresight. Every floor plan is flexible, so that any imaginable utilization is possible.

The references of the information in the boxes can be found in the footnote. [33]

2.2.3. ANALYSIS

The 860-880 Lake Shore Drive Apartments, the Everett McKinley Dirksen Building, and the John C. Kluczynski Building were designed by Ludwig Mies van der Rohe. The Lake Shore Drive Apartments were built in 1951 and the two towers of the Federal Center were finished between 1964 and 1975. Since Mies van der Rohe died in 1969, he did not have the chance to see the John C. Kluczynski Building completed. These Twin Towers are located in Chicago.

HEIGHT AND SHAPE

Mies van der Rohe designed both Twin Towers on grids. The 860-880 Lake Shore Drive Apartments were designed with a 21 foot grid, while the Twin Towers had 28 foot grids.

The buildings of the 860-880 Lake Shore Drive Apartments have the same height and size. Both towers are 270 feet high. Each of them is three bays wide and five bays long. The two towers of the Federal Center differ in height and size. The Everett McKinley Dirksen Building is 30 stories high and the John C. Kluczynski Building is 42 stories high. Both buildings are four bays wide, but the short one is thirteen bays long and the tall one only eight bays.

FIGURE 9: FEDERAL BUILDING CHICAGO

FIGURE 10: 860-880 LAKE SHORE DRIVE APARTMENTS

The Twin Towers are situated parallel to each other. The Lake Shore Drive Apartments are perpendicular to each other and slightly offset, while the skyscrapers of the Federal Center are perpendicular to form the letter “L”.

They might look like simple black boxes, but with a careful look, the buildings are much more than that.

FUNCTION

Mies van der Rohe wanted to design uniform buildings, because buildings have a longer lifespan than the functions inside of them. The Everett McKinley Dirksen Building is a courthouse and an office building, while the John. C. Kluczynski Building is only an office tower. The Lake Shore Drive Apartments, as the name already suggests, are apartment buildings.

FIGURE 11: EVERETT MCKINLEY DIRKSEN BUILDING FAÇADE

FIGURE 12: LAKE SHORE DRIVE APARTMENTS FACADE

The structural elements and façade don't suggest any particular purpose hidden behind them. The only clear identifications are the curtains behind the façade, suggesting that this is obviously not a typical American office building. These apartments were somewhat of an experiment, since the floor-to-ceiling windows were not used before in apartment buildings. The so-called “Glass-House” was revolutionary because Mies van der Rohe created a new way of living. The advantage of these windows was to enjoy the beautiful view, but the residents have to be free of issues like vertigo or acrophobia, especially because there is only a transparent parapet, unlike other apartments.

SITE AND PLAZA

If an architect chooses to design two or more towers, a few important things have to be considered – how the buildings are connected to each other and how they are situated on the site. The plaza becomes a very important part of the design itself. There are many variations, like the towers in the center of the site with the plaza surrounding them or like Ludwig Mies van der Rohe designed in both examples of the described Twin Towers.

The Twin Towers are both situated on the corner, forming a right angle. Even though the two skyscrapers of the Federal Center are separated by Dearborn Street, it seems like it is only one site. The high-rises create a border on the two sides and in this way they leave the other two sides open. Thus, the plaza seems like a stage where the towers are a piece of the scenery. The plaza of the Twin Towers is very important.

FIGURE 13: LAKE SHORE DRIVE APARTMENT - PLAZA

The arrangement of the Lake Shore Drive Apartment towers on the small trapezoidal site was clearly not an easy one. But Mies van der Rohe designed these buildings with a symmetrical grid. The plaza in the front of the towers seems more private than the plaza in front of the Federal Buildings, because of the trees which are hiding a part of the ground floor. The trees act as a privacy shield compared to the open plaza, which is open to public. The green grass lawn is filled with trees, unlike the almost empty plaza of the Federal Center. The Lake Shore Drive Apartments create a border between the city of Chicago and Lake Michigan. With this arrangement, Mies van der Rohe guaranteed one of the best views of Chicago. Because the buildings are lifted above the plaza and then merge into the deep set lobbies, they create a beautiful transition between interior and exterior. There are four entrances, one on each side of the building. The buildings are connected by a walkway between the third bay on the wide side and second bay on the long side of the opposite building. Despite the small site, the plaza is carefully proportioned, mainly because of the space on the ground floor and the arrangement of the high-rises.

This effect is also visible at the Federal Center, where the plaza merges with the lobby of the John C. Kluczynski Building. Today, there are seating areas along the post office with minimal vegetation. The grid was the basis for the designs of Mies van der Rohe, with the plaza tiles following the same grid. The tile joints are aligned with the axes of the columns and mullions of all three buildings of the Federal Center. But not only there, as this concept is also apparent inside on the lobby, floor and walls. On the other side of Dearborn Street, the courthouse has a plaza hidden behind it. Even though it is separated from the other buildings by a street, it all seems like one site. The sculpture of Alexander Calder was installed a few years after the death of Mies van der Rohe. The red flamingo contrasts with the black buildings behind it. The plaza is also used for events, like the "Oktoberfest" in September.

FIGURE 14: FEDERAL CENTER CHICAGO - PLAZA

The plazas of both buildings are examples of the use of space as a great luxury, which distinguishes the 20th century from the end of the 19th century.

STRUCTURE

The Twin Towers are both constructed as steel frame structures. This particular type of structure utilizes the right angle grid as a significant requirement. The steel frame structure consists of vertical columns and horizontal I-beams. All elements of the building, like the walls, floors and roof are connected to the frame. The perimeter columns are visible at the ground floor, in both towers. Since both buildings have a curtain-wall façade the structure is hidden behind it. The deep set lobby creates a modern arcade, which can also be found in Greek temples. This design with light and space became a standard for future high-rises designed by Ludwig Mies van der Rohe and his supporters.

FAÇADE

The buildings appear higher than they really are. It's the proportion to the surrounding buildings that causes this illusion. The vertical I-beams on the façade also make a considerable contribution. The I-beams on the façade are an aesthetic solution, because they are not structural elements. The Twin Towers both have those I-beams on their façades.

These vertical elements are symmetrically distributed on each façade. They begin a few inches above the second floor and continue to the edge of the roof. The I-beams divide the windows and give the building’s façade a 3-dimensional effect. On a sunny day, they create patterns of shadows and light.

But the façades of those Twin Towers differ from each other. Maybe it is not visible at first glance, but by paying attention to detail, a keen eye will notice that the window frames are painted different colors. While window frames at the courthouse and office tower are black like the rest of the building, they are white on the buildings of the Lake Shore Drive Apartments. This small detail has a strong influence of how the buildings are perceived.

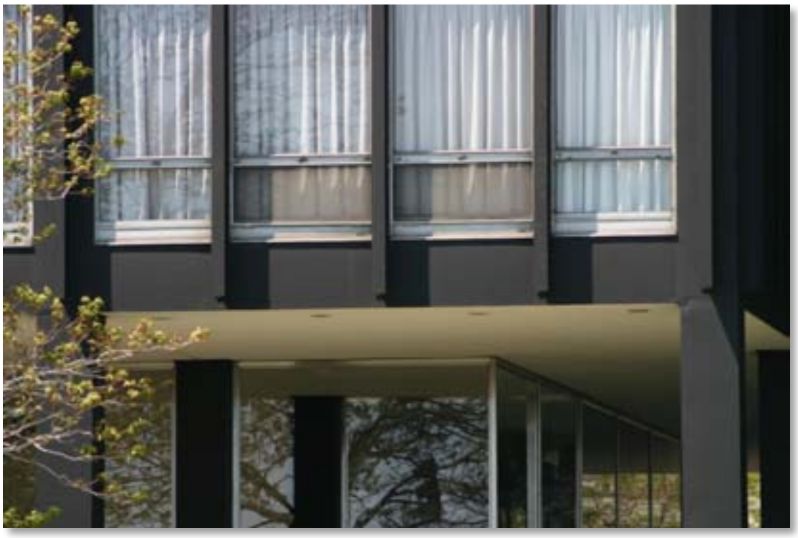

FIGURE 15: DETAIL AT FAÇADE OF LAKE SHORE APARTMENTS

The Twin Towers each have floor-to-ceiling windows, but in contrast to the Federal Center, the Lake Shore Drive Apartment windows have a division by a parapet with a transparent filling. All apartments have the same white curtains, visible from the outside. To individualize the inside of the apartment, the residents have the additional option to hang their own curtains in front of the white ones. Thus a uniform look of the apartments is seen from the outside, even though each apartment looks different inside. The white curtains have furthermore an amazing effect on the building. Although the structure and the steel elements on the façade are black, the Twin Towers appear surprisingly bright. The white frames and curtains give the high-rises an open and unique look. The building´s façade seems to change from time to time, because of the varying habits of residents to close or open the curtains. This makes the towers emerge in different shades of blue, gray, and white on the windows, complimenting the black structural frame. It can be said that the I-beams and the curtains are able to change the appearance of the building from time to time. The Twin Towers both have the same structure as other skyscrapers, but these elements differ from other skyscrapers that Ludwig Mies van der Rohe has created.

FIGURE 16: DETAIL AT FAÇADE OF EVERETT MCKINLEY DIRKSEN BUILDING

The two skyscrapers of the Federal Center have bronze-tinted-glass and all visible elements on the outside are coated with graphite, which gives the buildings the black color. The two Federal Buildings may not have a physical connection, like the connecting walkway between the Lake Shore Drive Apartments, but they are visually connected through the basic, uniform features on both façades. Although the structures of the Twin Towers are both black, the courthouse and the office building seem heavier and more powerful in contrast with the Lake Shore Drive Apartments.

PERCEPTION FROM INSIDE

Due to the fact that the courthouse and the office tower are Federal Buildings it is almost impossible to find pictures of the inside of the buildings. In the course of modernization, a few pictures of the Everett McKinley Dirksen Building were published by the Urban Design Group.

FIGURE 17: COURTROOM

FIGURE 18: LOBBY OF JOHN C. KLUCZYNSKI BUILDING

With these pictures, it is possible to see that the courtrooms are made of high-quality materials. The clear lines and clear forms are noticeable inside the rooms. So one can conclude that the carefully designed grid and clear lines are not only visible externally, but on internally as well. The minimalistic architecture from the outside, mirrors the inside of the courthouse, and vice versa. The lobby of the Everett McKinley Dirksen Building is typical of Mies´ skyscrapers. Everything is minimized to necessity and the luxury of ample, free flowing open space is visible.

FIGURE 19: APARTMENT EXAMPLE OF THE LAKE SHORE DRIVE

FIGURE 20: APARTMENT EXAMPLE OF THE LAKE SHORE DRIVE

The pictures of the inside of the apartments show how bright they really are. As previously stated, the uniform effect is only visible from the outside. Every resident is able to create an individual space for themselves. The apartments in the corners of the buildings have an amazing view on two sides, but as a consequence, there are missing walls. The two pictures show perfectly how the residents really do live in a glass house. People, who are living in such an apartment, have to be as open as the architecture itself. Because of the large windows, it is possible to look inside, but on the other hand, the view is indescribable. After all these years, it still appears as if Mies van der Rohe came back to select and arrange all the furniture himself.

In summary, it can be said that Ludwig Mies van der Rohe designed two buildings that might look the same at the first glance, but are perceived completely differently. However, it is possible to distinguish the buildings' façades from one another, because of small, yet impressive variations. Mies van der Rohe's plazas, lobbies and rooms inside each building radiate calmness and emerge as freedom in architecture.

[1] COMMISSION ON CHICAGO LANDMARKS, *860-880 Lake Shore Drive.* City of Chicago, 1976, p.4
[2] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore …,* 1976, p.9
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[4] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore…*, p.5
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[6] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore …*, p.6,9
[7] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore …*, p.8
[8] BLASER, Werner, *Mies van der Rohe. Lake Shore…* 1999, p.14
[9] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore …*, p.7
[10] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore …* p.8
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[13] http://www.dezeen.com/2010/03/02/860-880-lake-shore-drive-refurbishment-by-krueck-sexton, retrieved 2012-02-07
[14] COMMISSION ON CHICAGO LANDMARKS. *860-880 Lake Shore Drive.* City of Chicago: 1976, p.11,12
[15] http://www.emporis.com/building/860lakeshoredrive-chicago-il-usa, retrieved 2012-02-07
[16] BLASER, Werner, *Mies van der Rohe: Federal Center Chicago,* Birkhäuser, 2000, p. 10
[17] SALIGA, Paulina A., *The Sky's the limit : a century of Chicago skyscrapers*, New York (Rizzoli), 1990, p. 183
[18] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 11
[19] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 12
[20] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 10
[21] MCBRIEN, Judith Paine, *The Loop: Where The Skyscraper Began*, Perspectives Press, 1992, p.33
[22] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 14
[23] SALIGA, Paulina A., *The Sky's the limit : a century …*, p. 183
[24] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 13
[25] http://www.aviewoncities.com/chicago/federalcenter.htm, retrieved 2012-02-14
[26] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 12
[27] BLASER, Werner, *Mies van der Rohe: Federal …*, p. 14
[28] http://www.aviewoncities.com/chicago/federalcenter.htm, retrieved 2012-02-14
[29] http://www.cityprofile.com/illinois/federal-center.html, retrieved 2012-02-14
[30] SALIGA, Paulina A., The Sky's the limit : a century of Chicago skyscrapers, New York (Rizzoli), 1990, p. 183
[31] http://www.aviewoncities.com/chicago/federalcenter.htm, retrieved 2012-02-14
[32] SALIGA, Paulina A., *The Sky's the limit : a century of …*, p. 183
[33] ANONYMOUS, "Architectural Design", Vol. 34, January 1964, p. 10;
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2. STRUCTURE

2.3. BRIGHT VERTICAL ELEMENTS

The following skyscrapers differ in many aspects, but they have at least one thing in common. The bright vertical elements on their façades are among other things, the main reason why they are known all over the world. These three skyscrapers in New York City and Chicago, are only a few examples showing where bright vertical elements on a façade can be key design elements.

2.3.1. LEVER HOUSE

A new wave of American skyscraper construction in the 1950s, created new ideals for modern architects. Since its completion, the Lever House fascinated people all over the world with its crystalline forms and glazed curtain wall. It is known as a key monument in the development of the International Style and plays an important role in the literature of modern architecture.

LOCATION

FIGURE 1: LEVER HOUSE

The Lever House is located on the west side of Park Avenue, between East 53rd Street and East 54th Street in New York City.

The Zoning law, as previously mentioned, permitted a skyscraper to be built without being stepped back under the condition that the building uses only 25 percent of the site.

The Lever House was the first New York real estate venture to take advantage of this Zoning law. [1] Thus, the Lever House broke the traditional "wedding cake" style of skyscrapers which had been common since 1910.

DESIGN

The original requirement for the Lever Brother headquarters, was a building that provided 290,000 square feet of floor space in order to accommodate approximately 1,200 employees. [2] The building had to include a dining room, lounge, auditorium, lobby with reception and support facilities, and an underground garage for the employees, in addition to the office spaces. The Lever Brother's Company had no plans to include additional office space for other companies to rent and they also did not wish to share the commercial ground with tenants. [3]

The architects at Skidmore, Owings & Merrill (SOM) created a unique and modern building, which turned out to be an innovative New York office tower model. The uncharacteristic plan led to a new kind of design for the Lever House. Normally the lobby and commercial spaces are on the ground level, but here they created an open colonnaded space. It flies straight off the walkway with a planted courtyard, open to the sky.

The indoor space on the ground floor occupies approximately 30 percent of the site. It is surrounded only by panels of glass and contains a lobby with a reception, which doubles as an art gallery. The elevator banks and small auditorium are located at the back of the lot. The dining room was originally planned for the second floor, which hovers over the entire lot. The building wraps around a central open courtyard. The slab's glass facades continue along the walls, aligning with the street, which was established by neighboring buildings on Park Avenue and side streets.

The columns on the ground floor are recessed behind the plane of the façade. Due to these supporting columns, the second floor hovers and the building seems almost weightless.

The column foundation remains clear of the underground level and preserves the walls housing the railroad tracks beneath Park Avenue.

An important part of the open courtyard plan is the paving which uniquely repeats the symmetrical grid of the columns.

FIGURE 2: (ABOVE) PLAZA
FIGURE 3: (BELOW) CANTILEVER SECOND FLOOR
SHAPE

The second floor is followed by nineteen office floors, and then three more floors of mechanical equipment. The 24 story high Lever House is clad in glass and stainless steel and rises as a vertical box above a horizontal foundation. The vertical, rectangular tower of the skyscraper is only 53 feet wide and sits perpendicular to Park Avenue. At the western edge, the elevator and service core for the tower are placed at the rear of the slab, creating a solid masonry wall.

STRUCTURE

The structural system of the building is a standard steel frame which supports reinforced concrete floors. This kind of structural system is nothing new as the non-bearing walls were traditionally clad with stone and brick. It was a combination of architectural design and visual elements that defined window and door trim, and to articulate vertical and horizontal division. Such characteristic skyscrapers with a foundation, middle, and top looked solid and classical.

The walls on the outside with the stainless steel mullions, are based on a grid, as well as the structural system on each floor of the Lever House. These mullions hold the various sizes of fixed glass panels in place. The large glass panels are tinted green to absorb heat from the transparent glass, while the small panels are tinted, wired glass and heat the floor slabs behind them.

The curtain wall´s technical aspects were not tested before making this an experiment. Panels had cracked and broken over the years and were replaced by glass of two slightly different shades. The smaller, blue-green panels are double panes behind the transparent panels. These panels provide a horizontal counterpart to the thin and shiny vertical mullions.

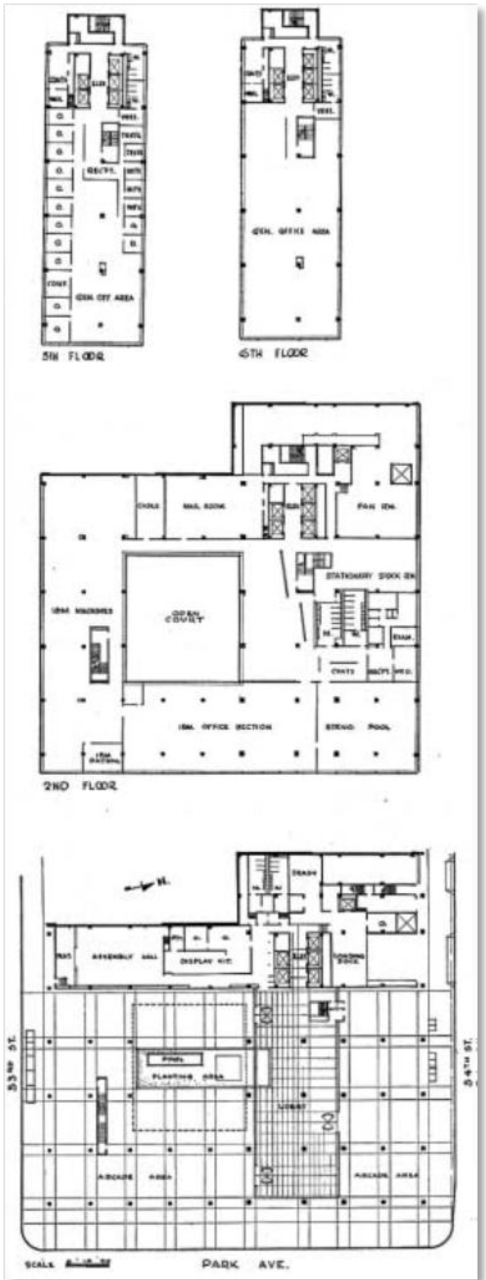

FIGURE 4: LEVER HOUSE, FLOOR PLANS

The mechanical systems at the rear of the spandrels, supply the building with heating and air conditioning. All the ventilation and cooling has to be provided by the mechanical systems, because all the glass in the Lever House is fixed in place. This is possible because the system of forced air ducts is connected to the window sill grilles inside the skyscraper and additionally running above the dropped ceilings on each floor. [4]

The fixed glass walls were economical to build, but furthermore, were supposed to reduce air conditioning and heating costs, and keep the inside of the building free of grime and dust. The architects created a special window cleaning gondola, because fixed windows can only be cleaned from the outside. It could be lowered from the roof and moved on a miniature railroad track behind the parapet. This mechanism attracted the attention of the New Yorkers more than anything else. [5]

2.3.2. INLAND STEEL BUILDING

The Inland Steel Building was finished in 1958, but still stands out for its well-designed modernity after all these years.

FIGURE 5: INLAND STEEL BUILDING

LOCATION

The Inland Steel Building was built in the Loop in Chicago. The building only uses sixty-six percent of the 23,040 square foot site. Along Monroe Street, the first two floors of the office tower are set back twenty feet. The upper floors are cantilevered to the property line. [6]

ORIGINAL PLAN

Skidmore, Owings & Merrill (SOM) were chosen by the Inland Steel Company to design their headquarters. SOM was known for designing “contemporary” styled skyscrapers[7]. Walter Netsch was the original design partner on the project. His idea was to avoid interference with any vertical columns of the supporting structure on the external and internal glass walls. The bright colored ductwork is located between the two glass planes. That means that the skeleton, veins, and skin of the structure would become one. Walter Netsch designed nine columns to divide the façade alongside Dearborn Street. In the original plan, the ground floor was open and contained an outdoor garden with a steel sculpture, but this simultaneously meant that the Inland Steel Company had to accept a small lobby. When Netsch took another project, in Colorado Springs in 1954, Bruce Graham took over and became design partner on the Inland Steel project.

NEW DESIGN

The first things Bruce Graham changed, as he took the commission, were the glass and the columns. He eliminated the outer glass and the attachment of I-beams on the external plane. The double curtain wall was changed into a single curtain wall and the numbers of exterior columns were reduced from nine to seven. One of the few things Graham left was the idea of the supporting columns.

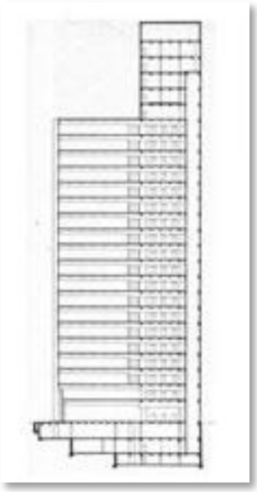

FIGURE 6: (LEFT) INLAND STEEL BUILDING SECTION
FIGURE 7: (RIGHT) INLAND STEEL BUILDING FLOOR PLAN

The horizontal components of the mechanical system, like the distribution system for heating, air conditioning, electricity, and telephone lines are installed underneath the floor, guaranteeing high flexibility of the column-free space. The uninterrupted space of each floor measures 178 feet long and 58 feet wide. The design was simplified by Graham and became more Miesian. The lobby on the ground floor is enclosed to offer a generous space, and can be used for exhibitions or tenant space. A 5 foot, 2 inch grid defines the office floors. The interior, which was designed by SOM as well, can be rearranged as needs change. This kind of “universal space” is based upon the idea of architect, Ludwig Mies van der Rohe and implies that the space can be changed and adapt to different requirements over time. The upper eight floors were originally occupied by the Inland Steel Company.

The glass walled office tower of the Inland Steel Building is located along Dearborn Street and the stainless steel clad service core is placed facing the east. The office building is a rectangular, nineteen story high tower with a height of 252 feet. The service core is twenty-five stories high and therefore 80 feet higher than the office building.

The two story, white brick subsidiary structure is located on the north of the service core. It includes receiving facilities, a mail room, shipping area, and a ramp leading to the basement parking garage.

STRUCTURE

The seven external columns running the length of the office tower, carry the weight of the building. The universal space was made possible by running 60 feet of supportive girders beneath each floor between the pairs of exterior columns. The columns and girders, which divide the windows, are mounted on a symmetrical grid. The building was one of the first where the thinnest curtain wall was used and it was the first major construction in Chicago to utilize steel pilings for its foundation.

The curtain wall´s percentage of glass is sixty-five and the stainless steel is thirty-five. To absorb heat and eliminate glare, the outer glass of the double pane windows are tinted green.

FIGURE 8: INLAND STEEL BUILDING FAÇADE

The columns as well as window frames are clad in nickel chrome stainless steel. The architects used a matte finish to sheathe the service core. The Inland Steel Company and its subsidiaries manufactured all the steel, including structural and clad steel, which was used in the building.

The dull steel finish for the service core and the shiny steel finish of the office tower were simultaneously a reflection of the structural and expressive qualities of the Inland Steel Company itself.

As the building was constructed, it received a lot of attention in the press. The Inland Steel Building was awarded with the Twenty-Five Honor Award by the Chicago chapter of the American Institute of Architects, in 1982.[8]

In the 1990´s the Inland Steel Company sold the building and it is now owned by Capital Properties and star architect, Frank Gehry.[9] Currently, the Inland Steel Building is undergoing restorations, which refurbish and architecturally maintain significant elements while adapting to the work environment.[10]

2.3.3. THE NEW YORK TIMES BUILDING

The New York Times Building´s grand opening was on November 19th, 2007.[11] The 52-story building in Manhattan, constructed by architect Renzo Piano, represents the philosophy of a free press. Even if it is hard to take the whole building in at close range, it´s still possible to see what´s special about this tall building. Renzo Piano found the right words to describe it: "*Each architecture tells a story, and the story this new building proposes to tell is one of lightness and transparency*."[12]

LOCATION

FIGURE 9: FAÇADE, NEW YORK TIMES BUILDING

The public heard about the plan for a new building on Eighth Avenue between 40th and 41st Streets in June 2000. The New York Times Company and real estate developer, Forest City Ratner Companies, wanted to build a new headquarters for themselves and for other world class tenants. That would be the seventh time The New York Times moved since its foundation in 1851.[13] In April 1905, after The New York Times moved to its new headquarters, the formerly known Longacre Square was renamed Times Square. That building is now known as One Times Square where the annual New Year´s Eve ball drops on top.[14] The new headquarters at the famous Times Square tourist attraction site is located in one of the world´s most attractive neighborhoods for diverse companies like law firms or various kinds of media and entertainment.[15]

DESIGN

The New York Times did not want to create a new icon in the New York City skyline. They wanted to have a human building which is economical and at the same time, technologically advanced. To find the right architect for such an extraordinary building, they arranged an invitational competition. Renzo Piano´s plan has that special touch by being different and standing out from the crowd: a curtain wall façade of white ceramic rods with the aim of mirroring the wind, clouds and colors of the sky. This 830 foot high façade was highlighted by an airy, six-story high atrium. Four months after the proposal for a new building, the design was chosen. [16] The new headquarters of the New York Times was created by the Renzo Piano Building Workshop and FXFOWLE Architects. [17] This building was the first one for Renzo Piano in New York City. [18]

It was very important to the publisher that the building adapted to the already existing work processes and not the other way around as was often done prior. A few ideas have been very well implemented, for example, the views, the balance of natural and artificial light, and the illusion of merging the street with the inside of the building .[19]

DOUBLE-SKIN CURTAIN WALL

The curtain wall is made of low-iron, ultra-clear glass and draped with 186,000, 4 foot, 10 inch, white ceramic rods. [20] These elements reflect the weather, so the building appears to change colors. [21]

From the ground level to the roof, the building is 748 feet high. The horizontal ceramic rods rise 92 feet higher and with the mast, the building has a height of 1,046 feet.[22] That makes the building the fourth tallest building in New York and the eighth tallest in the United States.[23] The ceramic rods are on the east, south and west facades.[24]

From the bottom to the top, the spaces are enlarged between the rods and this way the building becomes more and more transparent as it rises.

The steel framing and bracing is clearly shown at the four corner setbacks and a careful observer can also spot the construction hidden behind the rods. The cruciform plan of the tower accents the two different types of the façade.

The top priority when building a highriser, is to figure out how to protect the building from direct radiation of the sun´s rays, because clearly, that causes over heating in the offices which are hard to cool down again, even with air conditioning.

FIGURE 10: CURTAIN WALL DETAIL

Normally architects counteracted that with smaller windows or with heavily coated glass. But with these methods, this building would not be as transparent as stated before. Renzo Piano had to come up with something new and so he brought in the ceramic rods. This curtain wall with a well planned system of spaces between each ceramic rod, allowed creating a floor-to-ceiling façade without affecting the tower´s energy efficiency.

The water white glass[25] façade gives pedestrians the opportunity to look into the building, provides employees with an incredible view of the city, as well as creating an amazing degree of natural light.

EXPOSED CONNECTIONS

Every corner notch is held up by steel rod X-braces. At the 51st floor, a belt truss connects the interior steel with the exterior. The advantage of this is reduced thermal variations affecting the length of the steel. Ascending to the top, the steel narrows from four inches at the bottom, to two inches. [26]

The so called "knuckle" connection is the main exposed connection detail. It had to be like the building itself: light. The usual detail had not been considered because of the high costs. This special detail is very complex because many elements converge here together at one point.

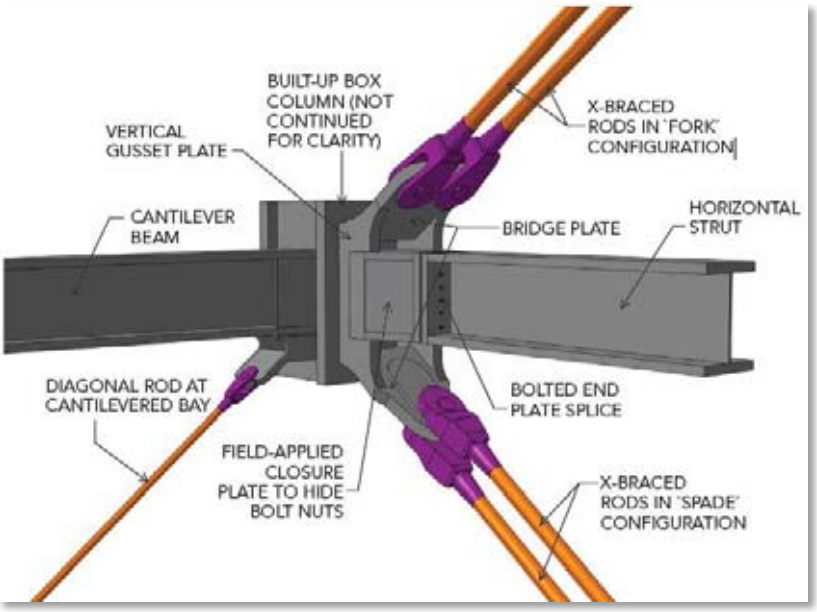

FIGURE 11: "KNUCKLE" CONNECTION

From the notch column, two 3 foot high vertical gusset plates extend, curving up and down the horizontal strut then thin out as they connect with the "bridge plate".

There are two different types of bridge plates: the "fork", the plate above, is connected to the two horizontal rods, and the plate underneath, the "spade" is connected to the vertically oriented rods.

The connecting element between the horizontal strut and the column is a built-up strut and with the help of a bolted end-plate connection, the knuckle fastens together. The thin closure plate hides the bolts and the knuckle looks like one light piece, in accordance with the rest of the building. [27]

SPATIAL CONCEPT

Renzo Piano said: "*I love the city and I wanted this building to be an expression of that. I wanted a transparent relationship between the street and the building. From the street, you can see through the whole building. Nothing is hidden. And like the city itself, the building will catch the light and change color with the weather. Bluish after a shower, and in the evening on a sunny day, shimmering red. The story of this building is one of lightness and transparency*." [28]

This transparency he refers to, begins at the bottom of the building in the lobby, where the street and the building flow into each other. Unlike many lobbies, this one is spaciously arranged with a view 375 feet up through the building which has a welcoming effect on the employees and visitors. [29]

An open-air garden was created on the ground floor and centered in the middle of the building.

It was surrounded by glass [30], measuring 70x70 feet [31], and featured seven, 50 foot birch trees.

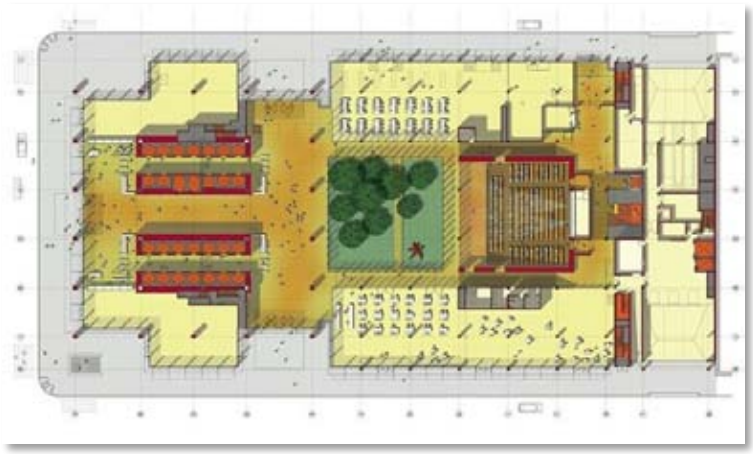

FIGURE 12: GROUND FLOOR, NEW YORK TIMES BUILDING

The spaciousness of the building also affects the floor plan - they could create such big open office spaces because all private offices and other rooms are located by the core. By doing this, the Times Company has the option to offer flexible work space for any quick media or environmental change.

- total area: 1,521,00 square feet
- above- average floor-to-ceiling height of 9'7" and rises to 10'4" at the windows
- building costs $850,000,000

Creating such a large work space, was due to an intention to encouraging communication amongst the employees. Between the New York Times floors are internal stairs in the corners which support the aforementioned too. [32] These stairs are prominent from the outside because the balustrades are painted in an orange-red color standing out against the light grey building.

Between the ground floor and 27th floor, is the new headquarters of The New York Times and floors 29 through 52 are owned by the FCRC (Forest City Ratner Companies). The 28th and 51st floors, as well as 22,000 square feet of retail space on the ground floor, are jointly owned by FCRC and the Times Company.[33] Renzo Piano planned 32 elevators for the building, 24 of them are passenger elevators and with the touchpad in the lobby, the passengers select their destination. The elevator system indicates which elevator will quickly get them to the right floor.[34]

As a special feature, the architect planned an auditorium/performance space. It is possible to enter the 378-seat auditorium from 41st Street through a separate entrance via a lobby as well as from the building´s main lobby.

- the first skyscraper in the U.S with a ceramic sunscreen curtain wall
- the high-riser contains 23,500 tons of steel
- Elevators move up to 1,600 feet per minute speed

Renzo Piano created a wood-paneled hall where the speaker-stage is in front of the glass dividing the auditorium from the open-air garden. By doing this, the audience has the beautiful view of the garden as a backdrop behind the speaker.[35]

It seems like the building works with opposites. It is not only the light, it is also the shadow, and it's not only the hustle and bustle from the street, it´s also the calm and tempting entrance which make the building special. These opposites are also shown on the façade – on one side, the construction is hidden behind the ceramic rods while the other exposes the bracings.

The references of the information in the boxes can be found in the footnote.[36]

2.3.4. ANALYSIS

The New York Times Building, as well as the Lever House, were constructed in New York City, while the Inland Steel Building was built in Chicago. The Lever House and the Inland Steel Building were both built in the 1950's by the architectural firm Skidmore, Owings & Merrill. The New York Times Building was designed more than 50 years later by Renzo Piano. Even though they were constructed in different centuries they have a few things in common, like the bright vertical element on their façades, among other things.

HEIGHT

The office tower of the Inland Steel Building is 252 feet high and with a 332 foot high service core, it is higher than the Lever House, with its height of 307 feet.

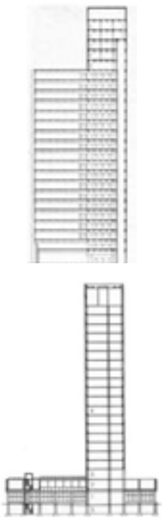

FIGURE 13: INLAND STEEL BUILDING (ABOVE)
FIGURE 14: LEVER HOUSE (BELOW)

FIGURE 15: NEW YORK TIMES BUILDING

Even if putting both buildings one above the other, they would not reach the roof of the New York Times Building at 748 feet. But the façade of the tower is higher than the roof, which gives the building such a distinctive look.

The building's total height, with the antenna is 1,046 feet. The New York Times building, including the antenna, is more than three times higher than the Lever House.

The service core of the Inland Steel Building is 25 stories high and thus only one story higher than the Lever House. There are 52 stories at the New York Times Building, a difference of 33 floors as compared to the office tower of the Inland Steel Building, which has only 19 floors.

SHAPE

The clear lines of the floor plan also reflect the shape of the buildings, but they are totally different from each other. The office tower of the Inland Steel Building is a rectangular, vertical structure, like the tower of the Lever House.

The Lever House differs from the other two skyscrapers, because of its hovering second floor. The second floor is nearly the size of the lot. The horizontal slab with an open courtyard in the center is raised with support columns, which creates an open space for pedestrians on the ground level. On the elevation, above the ground floor, The Lever House forms an upside down "T" shape.

The office tower of the Inland Steel Building is connected to a service core. The buildings are vertically oriented, which is not only visible on the section, but also from the outside. In contrast to the Lever House, the Inland Steel Building´s structure forms a distinguishing shape. The glass box is rectangular like the Lever House, but appears to be different with the columns on the outside.

The tower of the New York Times Building has a cruciform floor plan, but a lower additional building, contains the auditorium, garden and other facilities. The roof is not visible from the street, because the façades reach higher than the flat top. The elevation of the building forms a right angle. Here, it is an "L" shape like the Lever House.

STRUCTURE

At the New York Times Building, each corner notch is held up by steel rod X-braces. The exterior steel is connected to the interior by a belt truss at the 51st floor. In this case, the thermal variations affecting the length of steel are reduced. From bottom to top, the steel narrows from four inches to half of that.

As previously stated, the main exposed connection detail is the "knuckle", which is easily visible on the façade. The steel rods are framed into "bridge plates", between two, vertical gusset plates. The "fork" and "spade" connect the horizontally and vertically oriented rods. The horizontal strut is bolted to a knuckle as an end plate. A cover plate, concealing the bolts, is welded on the strut.

FIGURE 16: BRACES AT NEW YORK TIMES BUILDING

Therefore the knuckle seems to be all one piece. Other than the visible bracing, the core of the New York Times building was additionally braced. The columns behind the ceramic rods are almost invisible, but they show on the first floors of the building. The structure of the New York Times Building seems almost weightless, but the ceramic rods create a virtually opaque, second skin for the tower.

FIGURE 17: CORNER DETAIL, INLAND STEEL BUILDING

The structural systems of the Lever House and the Inland Steel Building are steel frame structures. SOM also had a problem with the corner column with this kind of structure.

Their solution was to have no corner columns, so instead, the upper floors were cantilevered. This made the building seem almost weightless.

The shimmer of both structures varies in intensity, depending on the sun´s position.

The columns of the Inland Steel Building are more exposed than those on the Lever House façade and therefore the building changes its color to red, caused by a natural color shift at sunset. Often skyscrapers' cores are inside the building, usually in the center. But the service core of the Inland Steel Building is located on the outside and contains elevators, washrooms and staircases. With this solution, it was possible to create a column-free, universal space for the offices. The columns on the Inland Steel Building are clad in nickel chrome stainless steel.

Even though the New York Times Building and the Inland Steel Building are mounted on grids, it is only noticeable to pedestrians at the Lever House. The free standing columns lifting up the second floor, create a grid. It is additionally highlighted by the pavement on the ground level.

FAÇADE

The green tinted glass of the Lever House can also be found at the Inland Steel Building. But the Lever House has two different colors on its façade. The blue-green glass panels are behind the transparent panels in double panes. With this feature it is possible to identify the floor levels from the outside. The building can change the pattern of its facade with white window shades. If they are closed, the window color changes to a light green, but appears darker and more transparent if they are open. The Lever House emerges in a different way at night, like all glass clad buildings.

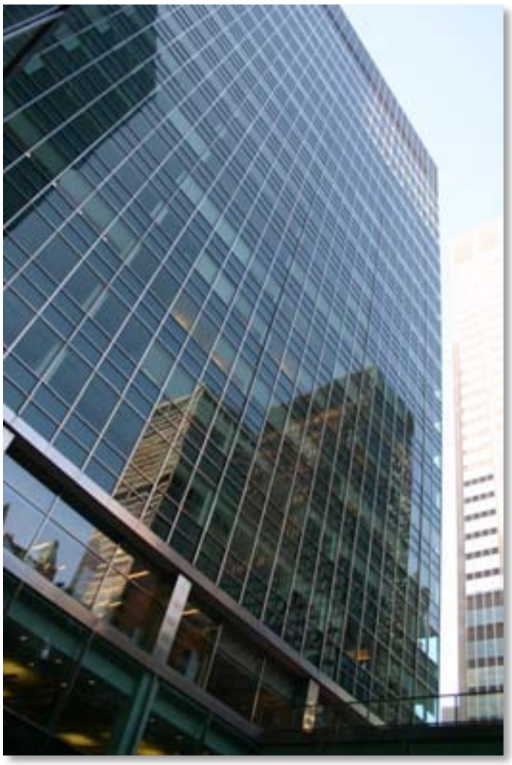

FIGURE 18: LEVER HOUSE FAÇADE

FIGURE 19: LEVER HOUSE AT NIGHT

The window glass reflects sunlight during day, but it becomes completely transparent at night. The spandrels and double panes change to an opaque black, which emerges with the dark of night. The columns and spandrels of the Lever House are hardly visible from a distance. But standing in front of the courtyard, it is obvious that the structure and mullions are an important part of the façade. Most of the structure is hidden behind the curtain wall, except the ground floor and the third floor, where the curtain wall is set back. The windows of the Lever House are vertically oriented and divided by mullions. The blue-green panels stand out with their darker color more than the transparent ones. That provides the effect of horizontality like the hovering second floor.

Compared to the Lever House, the Inland Steel Building appears vertical, because of the dominant columns on the outside. All three buildings have rectangular windows, but the Inland Steel Building incorporates five windows between two columns and thus the windows appear wide rather than tall. The Lever House façade differs from the façade of the Inland Steel Building because the strong "column" element is hidden behind the curtain wall.

FIGURE 20: INLAND STEEL BUILDING, FAÇADE

FIGURE 21: NEW YORK TIMES BUILDING, FAÇADE

The New York Times Building incorporates both elements. At the lower levels, gigantic columns are prominent, but the higher the building gets, they disappear behind the wall. They are visible because the curtain wall was set back on the lower levels. Standing in front of, or near the building, it is possible to see into the building between the ceramic rods. Higher up the building, the ceramic rods merge closer together, and lose their transparent appearance creating an opaque grey façade. This phenomenon emerges at night in a different kind of way. While the building seems opaque during the day, it appears almost transparent when lights are on inside during the night. The architect Renzo Piano wanted to create a transparent glass tower. But the crystal clear glass had to be protected from sunlight, because otherwise it would be too hot and too bright for a comfortable work atmosphere inside of the building. The ceramic rods reflect the sunlight on a sunny day giving the building a certain glow.

PLAZA AND ENTRANCE

Every lobby is surrounded by glass, and space and plays a major role in each of these three designs. The Lever House with its hovering second floor, obviously has the largest entrance area. The columns dominate the ground level and offer a covered area, as well as open space in the center. The columns are mounted on a grid, which is also made visible with the different colors in the pavement. There are a few seating areas and an inviting courtyard garden, which can also be found inside the lobby. Only the glass divides the courtyard garden from the interior, but it feels like the inside and outside merge into each other. Even though it is a large covered area, the plaza is still bright and open. There are no clear lines indicating where the sidewalk ends and the plaza begins, because the grid and pavement extend all the way out to the street.

FIGURE 22: LEVER HOUSE, OPEN COURTYARD

FIGURE 23: NEW YORK TIMES BUILDING, ENTRANCE

There is no real plaza at the Inland Steel Building. The plaza is more like a wide sidewalk for a large entrance area. With 20 feet set back on the first two floors, the building seems lightweight and does not feel overwhelming because of the gigantic steel columns.

The New York Times Building uses nearly the entire site, at least on the ground floor. The corners are used for optional restaurant seating, among other possibilities. The real plaza is inside the building, in the 70 square foot tall, open-air garden, that is surrounded by glass. It is open to the public, but without knowing this, not many people enter, even with the floor to ceiling, glass enclosed entrance.

All three buildings are used as offices. The supporting structure changes from hidden to clearly visible on the façade. The mullion and spandrels between the windows are not structural elements and were merely used to underline the concept of the design. The bright vertical elements automatically create an illusion of a lightweight structure and the building appears shiny and new. Even today, the green tinted glass is something special. The shading inside the Lever House and the Inland Steel Building create different patterns on their unique façades. The New York Times Building distinguishes itself not only from the other two, but also from most skyscrapers in the world, because of the extraordinary shading on the outside. All three skyscrapers are unique in their design, but they are combined by the use of the bright vertical elements on their façades.

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2. STRUCTURE

2.4. DIAGONAL BRACES

These are not the only examples with diagonal braces in New York City and Chicago, but the following skyscrapers use them as a key element.

2.4.1. JOHN HANCOCK CENTER

FIGURE 1: JOHN HANCOCK CENTER

Chicago is not only the city where the world´s first steel-framed building rose. It is furthermore the proper place where the 1,100 feet [11] high John Hancock Center was built. The skyline is not possible to imagine without it and it turns out to be one of the icons of Chicago. The black “obelisk” represents the trust in technology and moreover it is a result of harmonizing aesthetic and economic development.

Even if it wasn´t the first intention to build the highest building in the world, people´s association with glory and recognition have to be considered.

This phenomenon can be seen all over the world. The challenge was at least to build higher than the Empire State Building.

The John Hancock Center was the third building in the world to be taller than 1,000 feet, after the Chrysler Building in 1930 and the Empire State Building in 1931 and therefore the first building of such height outside of New York City.[12] The John Hancock Center is a perfect example of the great collaboration between architect Bruce Graham and structural engineer Fazlur Khan. They had already worked together for the Brunswick Building where Khan created a first-of-its-kind concrete tube structure. This technology made it possible to conceive high-rise construction at the John Hancock Center and the Sears Tower later.

LOCATION

In late 1964 Jerry Wolman, a building-developer, hired SOM to design a building on his site on North Michigan Avenue.

The site is located among the city´s most popular shops and professional offices, on North Michigan Avenue. Hotels, restaurants, luxury apartments and shops can be found in the area. Obviously Wolman bought this site because of the good market conditions at the so called "The Magnificent Mile" to build a multipurpose skyscraper.

The "Magnificent Mile" was designed by Developer Arthur Rubloff in hopes of bringing back the interest in this neighborhood in 1947. But at that time the plot was too far away from commuter railroad stations and the transit lines. That problem had to be solved by the architects, too.[13]

- World´s first multipurpose skyscraper
- Also known locally as "Big John"
- Construction started in June 1965 and ended in 1969

DESIGN AND STRUCTURE

FIGURE 2: FAÇADE - CUTOUT

SOM presented Wolman two alternatives: a two tower and a multipurpose, single tower concept.

A 70-story apartment tower and an additional 45-story office building of the same height were planned at the northeast and southwest corners of the plot.[14]

But the single tower clearly would cover less of the plot area and in this case there would be more open space for pedestrians. In the sole building, the workers and residents would also have a better view because there weren´t any obstacles between the two towers and they would be far enough away from noisy, "hustle and bustle" on the street, too.

It would also be a great profit for Wolman to build the "world´s highest" apartments with this amazing view over the city and lake at this site.

These are a few reasons why the single-tower scheme was the best programmatic solution, but the obstacle was the cost of construction.[15]

The structural costs per square foot would boost up the higher the building became because the forces of wind would require more expensive material. The architects knew that a one hundred–story building might be technically possible, but it might not be financially possible to construct this tower.

It was very important to Bruce Graham and Fazlur Khan that this high-rise exposes the structure in the same way as the Eiffel Tower in Paris.

For some people it was hard to accept the building being finished that way because the façade is made only of black anodized clad steel with tinted bronze glass. They always wondered why the John Hancock Center, the tallest building in the city, was not covered with polished stone.

But the design partner Bruce Graham believes that structure has to be included in the architectural form. SOM was notable for their cost efficiency.

And therefore the only reasonable answer was an accurate structural shape, which made it feasible to create this 100 story building.[16]

The multiple uses and their scale lead Graham and Khan to a new kind of structure: the diagonal tube.[17] There should also be mentioned that the first trussed-tube skyscraper ever built was the John Hancock Center.[18]

STRUCTURE

On the north and south sides the building is reduced by 65 feet and on the east and west by 105 feet, therefore the skyscraper narrows on every side.

The steel tube is composed of spandrel beams, diagonal braces, exterior columns and structural floors. But the primary elements are only the first three of them.

The steel per square foot of a typical floor area was less than thirty pounds, like that of a forty- to fifty-story traditional skyscraper.[19]

FIGURE 3: STRUCTURE ON THE FAÇADE

The inner core bears only a fraction of the floor loads and none of the wind loads. Even if it seems like the big diagonals are non-structural, they are all a part of a structural grid including all columns and spandrel beams. According to this, the façade is a load bearing wall structure. The lateral forces are transferred over the diagonals from windward wall to the opposite side where they are compressed.[20]

FIGURE 4: FIVE AND A HALF X-BRACES

The floors in the structural system are playing a minor role. That means that it was possible to leave floors out whenever double-height spaces were needed. As a matter of fact, the floor plans were designed after the framing was planned and the steel ordered. The only exceptions are the rigid bracing floors located approximately every 18th story.

There are five X´s on every side including a half-X from the 92nd to the 97th floor. The first one can be seen from floors 2 to 20, from 21st to 37th floor the second and third X's go from 38th to 55th floor. The remaining two X's are between the 56th and the 74th floor and 75th and 91st floor.[21]

Every week the workers completed up to three floors. That could be completed so quickly because of the prefabrication and the accurate detailing.

MULTIPURPOSE

Until the twin towers of New York´s World Trade Center were finished, the John Hancock Center had the world´s highest occupied floors. No other taller, multipurpose building existed or was even designed by then.[22]

- Construction cost: $91.000.000
- Floor size decreased from 47,000 sq feet at the base to 17,000 sq feet at the top

The John Hancock Center was designed as a "city within a city", which is a concept of contemporary urban development. These are complexes of one or several buildings, consisting of shopping, entertainment and recreational facilities, offices, restaurants, hotels and residential space. In this tall building the commercial uses are below, offices are in the middle and the residences are above.

Widespread retail stores and the garage could be found in the large lower floors. In the middle of the building are the offices with less floor space and above are smaller floors for apartments. The observatory is located on the 94th floor, the restaurant "Signature Room" on the 95th floor and the "Signature Lounge" could be found above on the 96th floor. On a beautiful and sunny day, it´s possible to see Lake Michigan and nearby states: Michigan, Indiana, Wisconsin and Illinois.

The taper geometry is perfect for this multipurpose tower because each function had different height and space requirements. By observing various heights of stories and wall details on façades, a careful look can indicate which floors could have offices, apartments or maintenance levels.

A building of this size had to have an extraordinary transport system. If you want to go to the office, you have to take the escalator from a second-floor lobby to the office elevators. This solution brought more continuous retail space and separated the workers at rush hour from visitors and customers as well.

At that time there were no other apartments in the world above the 60th floor. Between the 46th and 92nd floors, the apartment layouts had to be changed five times because the floor space shrinks the higher the tower gets. At axes east-west and north-south the floor plans and the bracing are symmetrical.

Behind this solution stands the idea not to block the view by the big diagonal braces in the apartments. At that time 703 apartments were designed to rent, but later changed to condominiums.[23]

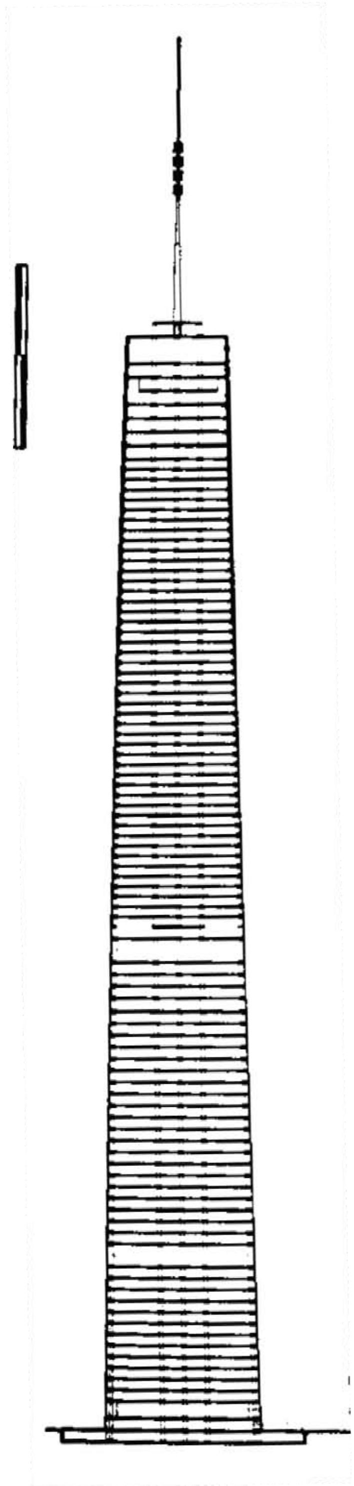


FIGURE 5: SECTION

Another highlight is the "sky terrace" which was planned for one third of the units. These are separated from the interior rooms by sliding glass doors. The high-rise balcony has hopper windows and tile floors.[24]

The office spaces are between the 13th and 41st floor with a total square footage of 825,000.[25] Originally the office lobby, with high ceilings, had been on the second floor and accessible by escalators. In the 1990´s it was moved to the ground level and the old space was changed into retail instead.[26]

In the “sky lobby” on the 44th and 45th floors, the occupants change to apartment-elevators which are situated above the office elevator banks. It´s only allowed for residents to use the special facilities in the sky lobby, which include a restaurant, commissary, swimming pool, health club, shops and other amenities.[27]

The John Hancock Center still has the world´s highest indoor swimming pool of North America.[28]

To solve any possible parking problem, the architects planned a parking area for 750 cars between the sixth and twelfth floors. The car entrance to the parking levels is on the side of the skyscraper using a concrete spiral ramp structure which is connected to the sixth floor.[29]

FIGURE 6: JOHN HANCOCK CENTER AT NIGHT

For winning the award for the tallest structure in Chicago, the twin TV antennas had to be installed on the tower.[30] They rise above the 1,127-foot high penthouse roof to the 1,449-foot ceiling set by the Federal Aviation Administration (FAA).[31]

In the end of 2002, the eastern antenna was considerably increased and now it’s a little bit higher than the roof line of the Sears Tower across town. The antenna also could change color for holidays like Valentine´s Day, St. Patrick´s Day, 4th of July, Halloween and Christmas. At night, a band of white lights are visible around the 100th floor.[32]

The people moved into their residences in late 1969. A resident told the Chicago Sun Times that he had left a home in the suburbs for the tower and that now he has an interest in nature after his move to the city.[33]

- Building area: 2.800.000 sq feet
- 100 floors above ground
- 50 elevators

But there were not only good reviews. The tower was criticized as dehumanizing and sterile. The observers thought that the sunken plaza in the front of the building, including the first base, was visually and conceptually disrupting. One reviewer said that the base of the tower was "unworthy to the tower above"[34]

In the original plan, the sunken plaza was larger and rectangular. It was a public oasis with a 12-foot waterfall, decorated with seasonal plantings and had a pool. The façade with the black anodized aluminum began at the second floor because the façade of the base was surfaced with white travertine tile. Shown in pictures a few years later, this façade was replaced by a darker granite.[35]

FIGURE 7: THE SUNKEN PLAZA THEN…

FIGURE 8: … AND THE SUNKEN PLAZA TODAY.

Other tall buildings followed the example of this special tube structure. The fantastic collaboration between designing and engineering is still noticeable, after forty-three-years. In 2008 the refurbishment of the John Hancock Center was completed and the building could be seen afterward in all its glory again. The John Hancock Center is undeniably one of the most recognizable buildings in the world.

The references of the information in the boxes can be found in the footnote.[36]

2.4.2. HEARST TOWER

ORIGINALLY THE INTERNATIONAL MAGAZINE BUILDING

William Randolph Hearst´s newspaper started his story in the late 19th and early 20th century when he brought the daily tabloid into the American journalism. It played a major role in the moving to support the Spanish American War in 1898 and was read by one in four Americans. Today Hearst is the largest publisher of monthly magazines in the world and owns twelve daily newspapers.[37]

In the early 1920´s William Randolph Hearst hired the Austrian architect Joseph Urban and George P. Post & Sons to build a skyscraper.[38]

FIGURE 9: THE ORIGINAL INTERNATIONAL MAGAZINE BUILDING

The first step was to build a six-story high basement which was completed in 1928 and named the International Magazine Building.[39] It contained 40,000 square feet of space and cost $2 million.[40] Because of the Great Depression, the Art Deco tower with 12 added stories[41] should have only been a proposal.

The promise became acquit nearly eighty years later when the new Hearst Tower addition was completed.[42]

LOCATION

The 1,800 employees were spread out in nine separate buildings in Midtown and their number was going to grow.[43] It was quite an obvious choice to build the new headquarters at the site of the original one. This location has some obvious advantages, such as its history, and close proximity to the Columbus Circle subway station and Central Park.

- 856,000 square feet
- Groundbreaking in April 2003
- Completed in 2006
- Cost $ 500 million

Before they could start, they had a few problems which had to be solved. A few years after the original building had been constructed, it was land marked and therefore they needed an approval from the Landmark Commission.[44] The construction was allowed under the condition that the original façade would be preserved. The subway is located under the building and thus the project had to go by the Uniform Land Use Review Procedure too.

As a result, Hearst added six floors below ground to advance the subway station. Foster also included three new elevators, built a new entrance, added and relocated stairwells and more.[45]

FIGURE 10: THE HEARST BUILDING

DESIGN

In charge of development management was the company Tishman Speyer. Bruce Phillips, senior director of design and construction of Tishman Speyer, and his team, put together a list of possible architects. "Foster's work on the Reichstag and the British Museum,[46] where he brought the old and new together, attracted us." said Brian Schwagerl, senior manager of facilities planning of Hearst.[47]

Above the old, hollowed-out, building, rises the new tower. The 42 story high office tower and its distinctive triangular steel bracing, began at the 10th floor. The only vertical columns, which are visible at the façade, are those on the connection part between the tower itself and the old building. The tower is connected to the old building by transparent glass that provides spaces underneath with natural light. This intermediate item also purports that the actual tower hovers over the original building.

Several mega-columns transfer the loads of the tower from the 10th floor to the foundation. There are no more structural elements left from the old building. All of them, together with the columns and the foundation were replaced. The only thing remaining is the façade at the perimeter of the original building, which had to be maintained.

FIGURE 11: HEARST BUILDING - LOBBY

The entrance is still where the original one was. The three escalators in the lobby are set into a sculptural cascade which flows down as the escalators take employees directly to the third floor. The waterfall acts as an air humidifier in winter and cools the atrium in summer. On the first six floors are the main elevator lobby, the cafeteria, an auditorium and mezzanine levels for meetings and special functions. The facilities are for employees only, but guards allow people to visit the lobby or the so called "Urban Plaza" by Sir Norman Foster.

There are fifteen elevators installed to reach the offices above the lobby. The elevator core is embellished by the 72 foot high fresco called, "Riverlines" which was created by land art pioneer, Richard Long.

DIAGONAL GRID

The four-story diagonal grid, in A-frames, was prefabricated and can be seen from the outside as well as from the inside of the building. This special exoskeleton made it necessary for Foster´s team and structural engineer Ahmad Rahimian, vice president at Cantor Seinuk [48], to work together closely.[49]

Special about this building is that the beveled corners make it possible to have an amazing view, because there are no columns to obstruct it. This triangular bracing on the façade is not something new. It has been done before on the John Hancock Center in Chicago in the 1960´s.

FIGURE 12: THE DIAMOND PATTERN FAÇADE

This diagrid (short for diagonal grid) structural system resists against wind forces. It is able to carry the gravity load and therefore there is no need for concrete walls or additional bracing in the building at all. The Hearst Tower used 20 percent less steel compared to other office buildings of the same size.[50]

With this kind of structural system it is possible to create larger open floor spaces, which was very important for Hearst.[51]

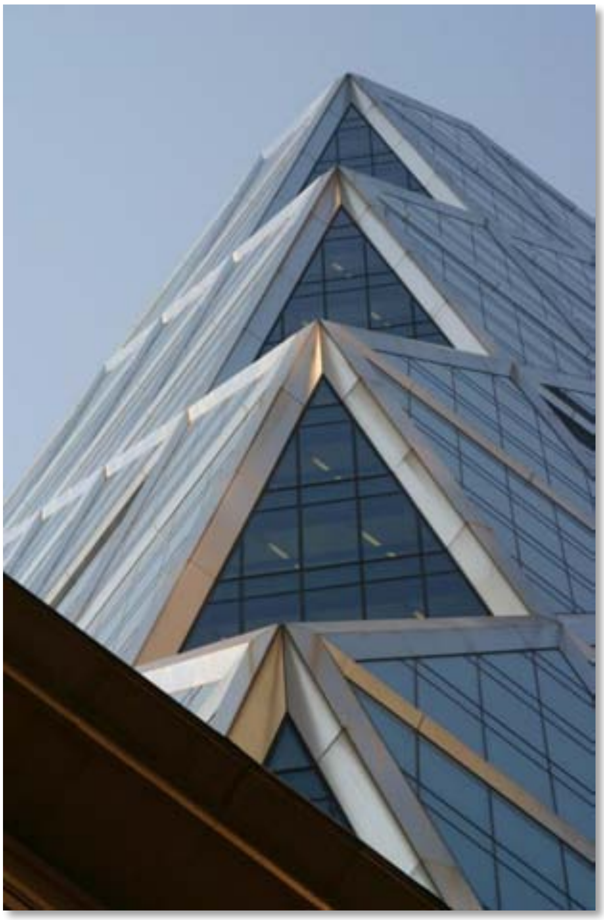


FIGURE 13: BIRD BEAKS - CLOSE UP

Every four floors create the so called "bird beaks"- these are the exterior walls with alternating angles. With these elements, the tower brings the external structure inside.

The tower with its jewel-like façade stands on the western edge of the foundation and that creates more space for events which take place in the atrium.[52]

With the diamond pattern of the façades it seems as if the building is asymmetrical, but it is not.

This building is very significant and by walking through the city it looks like it shifts with every view.

GREEN BUILDING

As to explain clearly what green attributes the Hearst Tower has, it's very important to know what a green building is and what makes a building green. The EPA (US Environmental Protection Agency) defined it as follows: “Green building (also known as green construction or sustainable building) refers to a structure and using a process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. This practice expands and complements the classical building design along with concerns of economy, utility, durability, and comfort.” [53]

The employees of the Hearst Tower work in a building which was created to be energy efficient. In some form or another, about 85% of the construction material has been recycled. Compared to a typical office building in Manhattan, the steel for the structure is 20% lighter, based on the diagrid.

Usually the regulation of temperature requires giant volumes of cool air and huge air conditioning units to provide it, but in this tower, engineers have worked out other solutions. Here are some examples. Almost 90% of the steel which was needed is made from recycled material. The employees here could have natural light and ventilation year round. The lights in the whole building are carefully regulated by electronic sensors, so they turn off automatically if they are no longer required.

FIGURE 14: WATERFALL IN THE LOBBY

Another way to reduce waste is by saving water. On the roof, rainwater is collected and stored in large tanks in the basement.

The water in those tanks supplies half of the buildings' water requirements. The waterfall in the lobby is not only just a sculpture but the water cools and moistens the huge atrium.[54]

Compared to a typical building, this tower was constructed with 26% less energy.[55]

All these attributes reduce costs and the special materials were kept to a minimum.

The U.S. Green Building Council´s Leadership in Energy and Environmental Design (LEED) awarded the Hearst Tower with a gold rating for economical and ecological aspects in this building.[56]

There is no other building in New York City which has ever won this award, even though a few projects have been voted upon.[57] For superior energy performance, the building earned the Energy

Star designation in 2010.[58] The Hearst Tower is from design to construction, the most environmentally friendly or “green” office tower in the history of New York City.[59]

The Hearst Tower was the first building designed by Foster in New York City and the first high-rise building to break ground in New York after 9/11. There is no doubt that this tower is unique. The very first glance at the façade with its diagrid makes it special, but this is not the only reason. The old basement and the new tower do not compete with each other, but rather compliment each another.

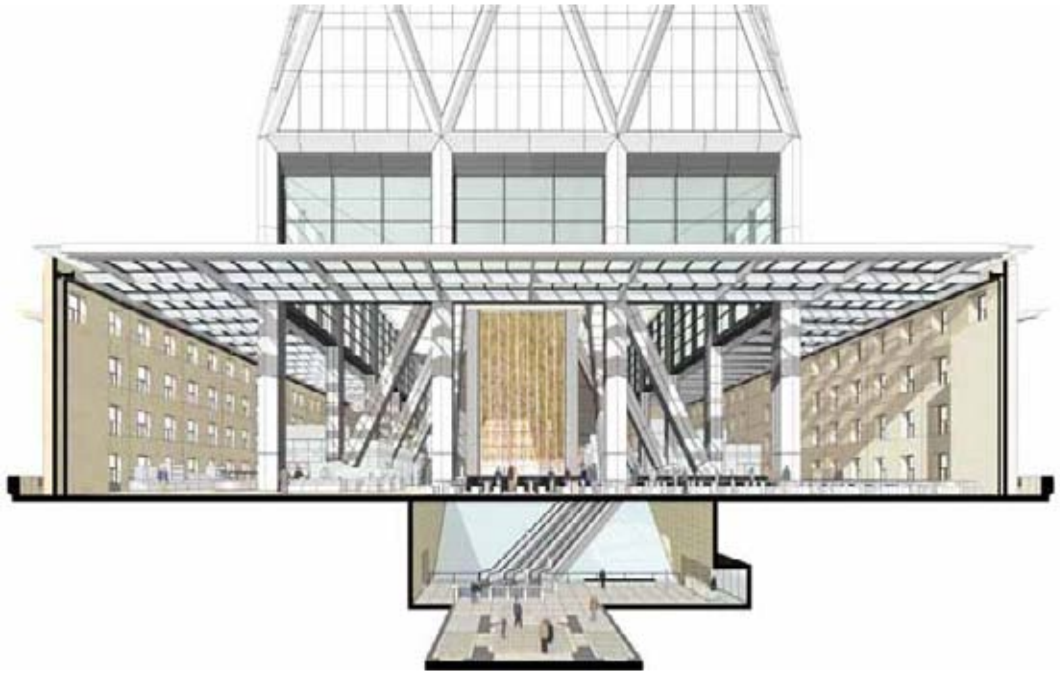


FIGURE 15: HEARST TOWER SECTION THROUGH THE OLD BUILDING

The references of the information in the boxes can be found in the footnote.[60]

2.4.3. TOWER VERRE

Today, the new skyscrapers are getting taller and thinner at the same time. The structure turns out to be more and more important, for example to resist the forces of wind. The Tower Verre should be as high as the roof of the Empire State Building and thus higher than the Chrysler Building.

LEGAL BARRIER

In 2009 the City Planning Commission defeated the original design. After a long period of twisting and turning, the skyscraper had to be shortened from 1,250 feet to 1,050 feet. Nouvel also had to change a couple of things, which included the top of the tower, because apparently it was unacceptable.[61] Afterward Nouvel said that they didn´t have to start from scratch, and the essentials of the structure could remain, but they had to revisit the building design.[62]

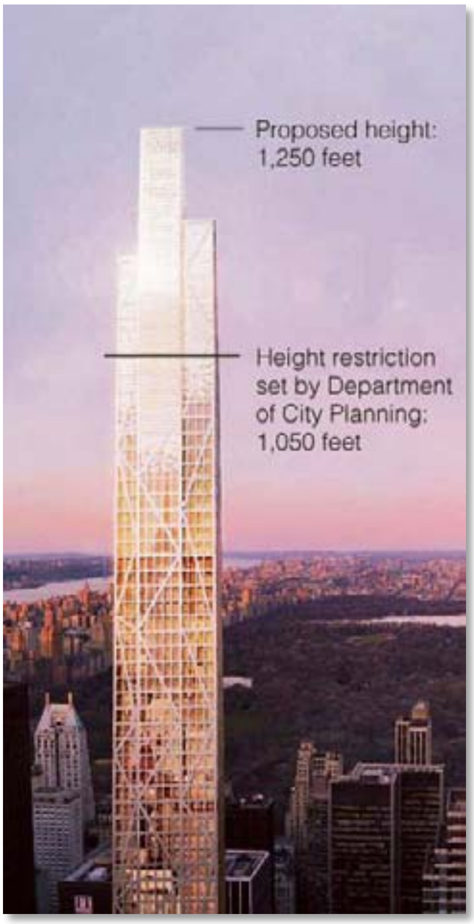


FIGURE 16: LEGAL HEIGHT BARRIER

LOCATION

The new tower, designed by Jean Nouvel, will now only rise up 75 stories.[63] It will be located between 53rd and 54th streets, next to the Museum of Modern Art, in New York City.[64] Therefore, the building is also known as the MoMA expansion tower.[65] Hines, a real estate investment company, bought the site from MoMA for $125 million, under the condition that about 40,000 square feet of gallery space had to be planned inside the building, for the museum itself.[66]

DESIGN

The design takes full advantage of the 17,000 square foot lot. The building's unique shape narrows as it ascends upward. The diagrid structural design dominates the building´s façade. Thus, it is obvious that the main structural materials are steel and glass.[67]

This is a very unusual form compared with the usual ones like the stepped style buildings all over the city. Because of the large proportion of glass in the façade, the building seems to merge the indoors with the outdoors.[68] The machinery and maintenance areas are planned on the top of the building behind blades or louvers, and are not visible from the outside.[69]

FIGURE 17: RENDERING - DIAGRID AT FAÇADE

The floor size gets smaller, as buildings grow higher. Since the big massive central core takes up a lot of space, the rooms are all around the perimeter of the building. [70] Hopefully, future apartment-owners won't suffer from vertigo or acrophobia at such heights.

Often a restaurant is situated on the ground floor, but Nouvel decided to put it one floor below the ground. The restaurant is completely glass-enclosed, so pedestrians are able to take a peek inside.

This multipurpose high-rise will include a 50,000 square foot exhibition space for MoMA, a five-star hotel with about 100 rooms, and 120 luxurious residential apartments, which are planned for the upper floors.[71]

STRUCTURE

The façade is dominated by painted steel elements and non-mirrored glass. From bottom to top, several columns, in different angles, are extended along the building. At the top of the tower, the columns are standing out like sharp needles [72] so that the building would “disappear in the sky”[73], like Nouvel once said. He designed a tower in a dynamic and elegant way to follow the step back rules of New York City. The diagrid as a structure, was considered among other things, to resist the wind forces. Additionally, solar panels and wind turbines are going to be installed the tapered top section.[74]

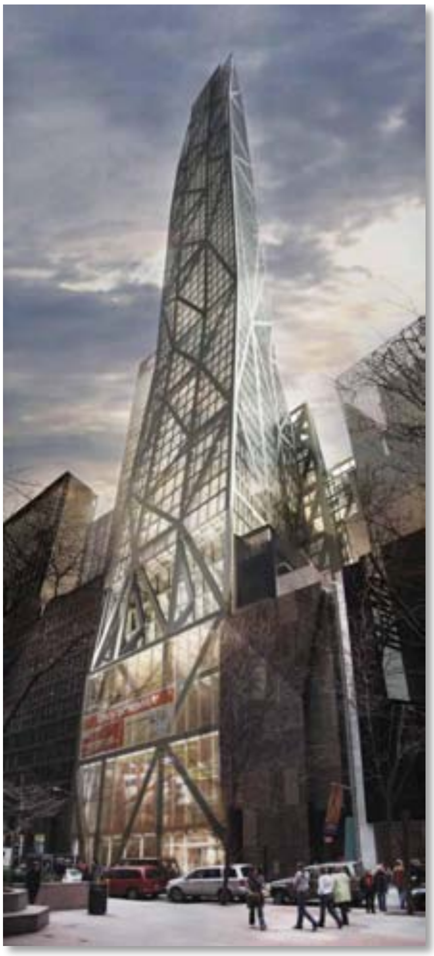


FIGURE 18: RENDERING - TOWER SEEN FROM 54TH STREET

Nouvel was able to create bigger and more open floors because he planned the structural frame on the outside, on the façade.

FIGURE 19: RENDERING – ENTRANCE TOWER VERRE

A part of the building was cut away for a better view through the residential Museum Tower, and steps back to conform zoning regulations at the northeast corner. The outer structure mirrors the inner one, and that means the columns define the rooms inside. The big sloped concrete mullions inside the building are running from the ground to the top, like a tree.[75]

The design of Jean Nouvel is still getting a lot attention. In New York and also all over the world, opinions tend to differ sharply between the ones who are totally against it, and the ones who are thrilled and support the building. New is not always good, but on the other hand, is old always better? It´s fair to say that New York has the most memorable skyline in the world. It is most recognizable with the Empire State Building and the Chrysler Building, and soon again the World Trade Center. Is there not enough space for a new memorial tower?

2.4.4. ANALYSIS

As different as the buildings might look at first sight, they have one essential thing in common: the similarity of structure at the façade. The diagonal structure and the nodes can be found on each of these three towers.

FIGURE 20: JOHN HANCOCK CENTER

FIGURE 21: HEARST TOWER

FIGURE 22: TOWER VERRE

HEIGHT

One of the most striking visual differences is their height variety.

The John Hancock Center is the highest skyscraper of these three, but closely followed by the Tower Verre. If the Tower Verre will be built it will only be 50 feet shorter than the John Hancock Center. The Hearst Tower, with a height of 597 feet, is the smallest of those three high-rises.

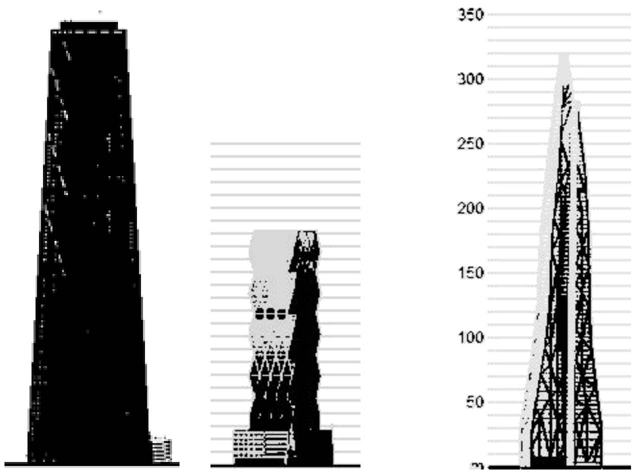


FIGURE 23: HEIGHT DIFFERENCE DIAGRAM

It is shorter than the John Hancock Center by nearly half. Even if you do not know how tall those buildings are, the height difference is noticeable. The John Hancock Center looks like a gigantic black obelisk, which almost disappears into the sky and the continuous narrowing shape augments this effect. Combined with the intention to create the highest building at that time, these effects were well chosen. The same effect can be found in the design of the Tower Verre. The higher the building gets, the more it tapers and the top seems almost invisible. Both buildings seem higher than they really are. The Hearst Tower is clearly a high building, but compared to the others, the edge of the tower is more noticeable.

SHAPE

The structure of these three skyscrapers is highlighted by different kinds of shapes.

FIGURE 24: JOHN HANCOCK CENTER, 3D-MODEL

The John Hancock Center has a rectangular ground floor which tapers consistently to the top. The building had been originally designed with a flat roof. The John Hancock Center looks like a big insect after the two antennas were later installed. The large corner columns are a similarity between the John Hancock Center and the Tower Verre.

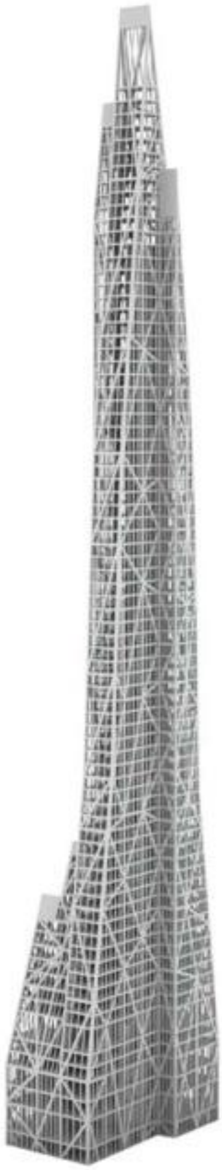


FIGURE 25: TOWER VERRE 3D-MODEL

The Tower Verre follows the step back rules and at the top, the columns stand out like sharp needles. Like at the beginning of the 20th century, the top of the Tower Verre, is also a very important part of the building. The Tower Verre emerges more as a huge sculpture than a skyscraper. But with a closer look, it is possible to see the well thought-out structure system inside and outside the building. In this way, the building doesn't appear to be haphazard.

The Hearst Tower on the other hand, goes straight up and closes up with a flat roof. It is possible to divide the Hearst Tower into three sections - foundation, shaft and capital division. The three sections have distinct design elements. The foundation is six stories high, is only used as the lobby and appears in Art Déco style. The shaft plays a minor role and like the tripartite division by Sullivan, it connects the foundation with the capital. At the Hearst Tower, the shaft is only one story high making a more discreet transition to the capital. At the façade of shaft, the vertical columns on the inside are visible from the outside. The capital is the strongest section of the building with its unique façade structure. The Hearst Tower is not just a simple box. The building has no corner columns, but “bird – beaks” at the corners. These angles alternate back and forth every four floors. The diagrid and the “bird -- beaks” of the tower seem like a gigantic diamond with the old building as a seat for the jewel.

FIGURE 26: THE HEARST TOWER 3D-MODEL

STRUCTURE

Even though all three buildings have the “X” visible on the façade in different ways, there are only two different structures.

The John Hancock Center was constructed to be a 100 story building. The structure had to be cost efficient and sustain the horizontal winds. Fazlur Khan developed the “tube structure” two years before, in 1963. The so called “braced tube structure” was used for the first time in a steel structure at the John Hancock Center. The more highly stressed columns can transfer the axial loads to the lesser stressed columns via the braces. This eliminates differences between the load stresses in the columns.

The Hearst Tower and the Tower Verre have the same structure – the “Diagrid”. Diagrid is the short form for diagonal grid and the structure is designed for large buildings with steel, like the braced-frame-tube-structure. The diagrid creates triangular structures with diagonal support beams. With a regular diagrid structure, large corner columns are no longer necessary. The diagrid can have many different forms as the Hearst Tower and the Tower Verre demonstrate.

The diagrid at the Hearst Tower has a regular grid, while the Tower Verre is characterized by several columns in different angles. This irregular grid at the façade of the Tower Verre made a large column at the corners necessary, after all.

ENTRANCE

The bases of the Hearst Tower and the Tower Verre use the full capacity of the site, in contrast to the John Hancock Center. The sunken redesigned plaza in front of it seems open and welcoming. There are a few shops on the ground floor and cafés and snack bars in the sunken plaza, one floor below the John Hancock Center. The entrance to the observatory is downstairs in the sunken plaza. The dark and long corridor leads to the inner core where elevators carry people up to the observatory. Even though there are shops on the right and left side, the corridor seems more like a tunnel because there is no natural light. But the sunken plaza itself is something special and the colossal staircase invites visitors to sit down and relax.

The Hearst Tower is a beautiful building, but the public entrance is hardly recognizable from the outside. The tower looks like most office buildings with an entry appearing to be for employees only or for those with special permission. But the entrance is open to the public which was, according to the doorman, a special request by the architect Norman Foster. Through a revolving door you reach the entrance area. The entrance is full of natural light from the glass roof above the old building and the shaft. But the first glance falls on the huge cascade where three escalators were installed. It is also possible to sit down and watch the sculptural waterfall at the entrance. The open ceiling design makes it possible to see a part of the in-house lobby above the entrance. The high atrium is bright and spacious, where employees can eat their lunch. It also provides a view of the old building. But sadly, only the outside wall was left over from the old building. Sometimes an architect has to break down the supporting structure, but design and construction in an existing context was not the way Norman Foster handled it. From the outside, it is impossible to see that only the outer wall remained.

The building is still a proposal and because of that, the only references are the renderings. It is not known whether the underground restaurant in the Tower Verre is open to the public or not. On the renderings, the restaurant appears public, because of the non-mirrored glass and the possibility to look down. It would be a pity if the structure on the inside of the building could only be marveled by employees and residents. Maybe someday it will be possible to see the columns and beams inside the lobby of the future five-star hotel.

COLOR

The Hearst Tower distinguishes itself from the other two buildings by preserving the existing building. The structure at the Hearst Tower is highlighted in white, while the façade at the John Hancock Center is black anodized clad steel with bronze tinted glass. The John Hancock Center´s glass and the structure seem to merge together, because they have a similar color. Based on the renderings of the Tower Verre the structure is grey with normal window glass, which also can be found at the Hearst Tower. The steel of the Tower Verre distinguishes itself, because of its dark color, compared to the light glass, which surrounds the building. The structure of the Tower Verre seems like a negative from the Hearst Tower. Both of them have the same effect – the structure gains more importance. The designer and the engineer of the John Hancock Center did that in a different kind of way. They extrude the structure from the façade and the shadows support the depth effect – another way to highlight the X-braces.

USES AND THE VISUAL STRUCTURE PERCEPTION INSIDE

The structure can easily be seen from the outside, but does it have the same strong feeling on the inside?

JOHN HANCOCK CENTER

The John Hancock Center and the Tower Verre are multipurpose towers. The commercial spaces of the John Hancock Center are on the first two floors and one below ground. The office spaces are above and the apartments are at the top.

FIGURE 27: X-BRACES ON THE OBSERVATORY

FIGURE 28: X-BRACES AT THE SKYLOBBY

The observatory is on the 95th floor, where you have a beautiful view over the city and Lake Michigan. The black diagonal braces appear inside the observatory as well as on the outside. On a cloudy day, the observatory seems darker because of the dark grey carpet and the bronze tinted glass. But the advantage is, the observatory moves to the background while the view moves to the foreground. With this concept in mind, the observatory makes perfect sense. The only part where the diagonal braces do not appear in black is at the cocktail-corner, where they are white and the floor covering is wood.

The observatory does not distinguish itself from the apartments and the offices below. This impression leads to the assumption that it is more somber, compared to the apartments and offices. But this can also be a good thing, especially for working on the computer. Through the bronze-tinted glass, a large part of the sun´s heat and light is blocked. The advantage is that the offices and apartments are not over heated , but as a consequence they lose a lot of sunlight.

The X-braces of the John Hancock Center are so big that they are not visible from some apartments, offices and commercial spaces. But other spaces in the building display the structure as well as the columns and vertical mullions, which divide the windows.

HEARST TOWER

Compared to the John Hancock Center, the Hearst Tower is only an office building, but it has certain amenities. The entrance is on the ground floor and the private lobby is on the third floor. The lobby includes a cafeteria and an open space for galleries or events.

FIGURE 29: X-BRACE INSDE THE HEARST TOWER

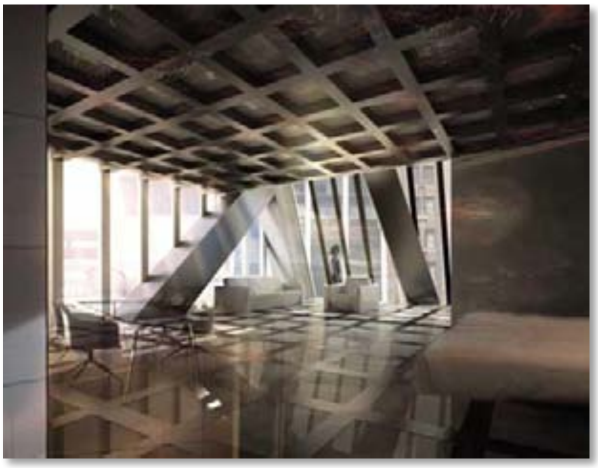
FIGURE 30: "BIRD BEAK" FROM THE INSIDE OF THE HEARST TOWER

Based on the pictures, the offices emerge bright. Like at the John Hancock Center there are no inner columns on the upper floors. The diagonal braces extend over four floors and that´s the reason why the structure is not visible from every office. But the Hearst Tower needed additional columns inside the building, because there was no more structure left from the original building, which is a distinguishing feature compared to the John Hancock Center. These large columns and the atrium give the lobby an impressive atmosphere. The vertical columns of the base extend to the 10th floor, where they are visible in the atrium and outside at the connection shaft.

The walls between the different offices or working areas are situated in a right angle to the window framing. The diagonal grid appears as a highlight in those bright rooms and fits in its picture. The offices get a positive impact through the diagonal grid. The black window framing is in contrast to the white diagrid and enhances the interior space. The disadvantage of this non-mirrored glass is that the sun heats up the offices. Compared to a tinted glass, the offices are filled with light and as a result, less artificial light is needed. The shading of the windows is only possible from the inside, which blocks the sunlight, but not the heat.

TOWER VERRE

As mentioned, the Tower Verre is designed as a multipurpose building. It will include a hotel, apartments and exhibition space for the Museum of Modern Art.



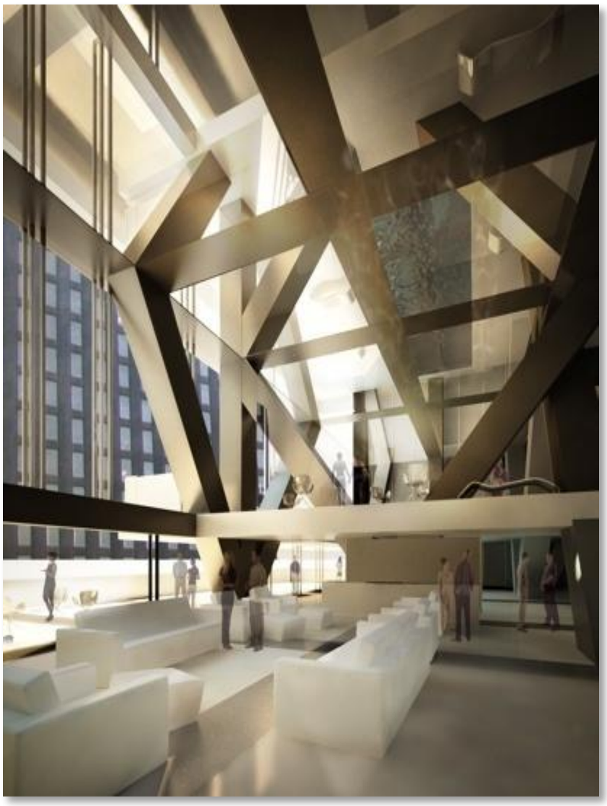


FIGURE 31 (ABOVE): HOTEL ROOM IN TOWER VERRE
FIGURE 32 (BELOW): CEILING OPENING

FIGURE 33: COLUMNS AND BEAMS INSIDE THE TOWER VERRE

The renderings of the lower levels look like a tree. A few of the concrete columns of the Tower Verre, inside the building, are connected with those at the façade. There are a lot of columns and beams at different angles, which seem to hover over one´s head. These impressive rooms could probably make people feel threatened by those massive columns and beams. But the higher the building gets, the more it tapers and therefore a smaller amount of columns is necessary.

In the upper apartments and hotel-rooms, no more inner columns are required and the beams are hidden inside the ceiling. Thus, those rooms seem calmer, because the structure will only be visible on the façade. The renderings of the Tower Verre show that there are similarities with the other two buildings. The diagrid – structure is also visible from the inside. Like at the other two towers, the structure on the façade cannot be seen from every room.

The renderings show openings in the ceilings, which will create unique rooms, with a lot of light.

The Tower Verre apparently will have non-mirrored glass, like the Hearst Tower. Like the Hearst Tower, the rooms will be full of light, but also with heat.

If somebody chooses to live or work in such buildings, the structure has to be an important part of the room inside, otherwise it is just like an ordinary building.

Normally diagonal braces are found inside of walls. But these three skyscrapers perfectly show that the structure is not something which needs to be hidden. The John Hancock Center was built in 1969, the Hearst Tower 37 years later and the Tower Verre is still a proposal. Even though some years lay between them, they are good examples of how architects, engineers and people change. The requirements and the structure of the building have also been developed. The Hearst Tower was the first green building in New York City and set new standards for an “environmentally friendly” building. Even though it was built only six years ago, the Hearst Tower is associated with New York City. The building is not the highest in New York City, but has a high recognition value, with its extraordinary façade. As the John Hancock Center was built, people saw it as an unfinished skyscraper. At that time it was still something new, and over the years it became one of the most recognizable skyscrapers in the world. The John Hancock Center was a pioneer by using less steel with this new kind of tube structure. The Tower Verre is controversial like the John Hancock Center in its time. It is not known, if the Tower Verre will also be designed as a green building. This building should not only be a proposal but maybe it has the chance to go down in history as a new, breathtaking and revolutionary high-rise building, like the John Hancock Center and Hearst Tower.

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2. STRUCTURE

2.5 CONCLUSION

The steel frame structure is based on a grid and therefore the buildings look alike. It is also easier to recognize what kind of structure was designed. It becomes more difficult with newer buildings constructed after the 1970's.

With the tube structure, there are more possible variations. The braced frame tube, for example, can be constructed as a regular grid or, asymmetrically like at the Tower Verre. The Hearst Tower is also based on a grid, like the steel frame structure buildings. Compared to those buildings, the Hearst Tower has its visible grid on the façade rotated by 45 degrees. The grid of the described buildings of International Style is recognized by the consistent spacing of the free-standing support columns. The tube structure is commonly used in skyscrapers today. Compared to the steel frame structure, the tube structure is often combined with another type of structure. Therefore, it is possible to create buildings like the John Hancock Center and the Hearst Tower, whose only similarities seem to be the nodes on their façades.

The significant point here is also the visual perception. The structure of the Hearst Tower is highlighted in white as compared to the black X-braces of the John Hancock Center, which appear to merge into the rest of the building. The green tinted glass of the Lever House and Inland Steel Building creates a beautiful contrast to the shiny stainless steel.

Ludwig Mies van der Rohe created buildings that have been reduced to their essential necessities and look alike. Without paying closer attention, it looked like Mies van der Rohe had no intentions of creating anything new, because all his buildings shared similarities. His designs are well planned, down to the tiniest detail, especially his corner solution, where Mies van der Rohe withdrew the curtain wall from the corner and exposed the supporting structure. With this execution, the grid does not break off abruptly but ends with a frame instead. Therefore, he was able to uniquely create the effect of the shortened bays at the Greek temple.

The Lever House and the Inland Steel Building have the same structure as the Mies van der Rohe buildings, but the architects of SOM have different ways of approaching the design concept of a building. The designers gave up the corner column and let the side of the building cantilever. Therefore, the architect does not have to deal with the corner issue. The buildings seem almost weightless and the shimmering stainless steel contributes to that effect. The Lever House is also a perfect example how different ways of handling the façade and structure can create variations on a façade. The support columns stand out in the open on the ground floor, are hidden on the second floor, yet are visible on the third floor, and again hidden behind the curtain wall on the upper floors.

Like the I-beams of the façades of the Mies van der Rohe buildings, the mullions are not structural elements but only used for aesthetic purposes.

The Willis Tower shows how important the window division is for visual perception, because in this instance, the further apart the columns are, the more horizontal the building appears.

Even though the dark vertical elements of the Willis Tower give a soaring effect on the building, the horizontality of the huge distance between the columns is more emphasized.

The Inland Steel Building with its huge, shiny, support columns, distinguishes itself from the other skyscrapers described in this thesis. Here, the whole structure is on the outside of the building. Even though the columns are thick and tall, the building itself does not seem heavy.

To Mies van der Rohe, the open and universal space was an important part of his design, which has also been incorporated by SOM. During the design period, Mies van der Rohe expected that the building would have a long lifespan, so he created a multipurpose space that was adaptable to versatility. The generous open spaces are also visible from the plazas and ensuing entrances of his buildings. The 860-880 Lake Shore Drive Apartments, the Everett McKinley Dirksen Building and John C. Kluczynski Building, are examples for the strong connections between buildings by creating such a plaza. The glass enclosed, set back lobby is a trademark of Mies van der Rohe. At the Lake Shore Drive Apartments, he created the option of changing a façade with white curtains behind the windows. The same idea had been implemented into the Lever House design. The Ceramic rods in front of the New York Times Building are another way to block sunlight.

A very important element, that deserves recognition, is glass. This material allows the option to create a different perception of a building, depending on its transparency or color. The green tinted glass at the Lever House shows high transparency at night, where the structure merges into the darkness. The lights behind the bronze tinted glass, appear in a warm orange from outside the Seagram Building, whose effect is also transmitted into the skyscraper. Renzo Piano created a transparent building for the New York Times, where the structure is a key design element. The combination of the ceramic rods and transparency of the glass, turn the building into a distinctive skyscraper.

Based on the research, a building's structure is quite an important part of the façade and yet the architects still have the opportunity to create it in a unique manner. However, to design and create such buildings, not only the brilliant architects are necessary but also the engineers from the first day on. The structure, the façade and the shape, are closely connected with each other and it is impossible to design one part without knowing what the others look like.

The visual perception of buildings plays a major role in the recognition of skyscrapers. This can be achieved through the structure itself, the glass, shape, height, color, and the surrounding plaza.

DESIGN

3. DESIGN

3.1. Wolf Point
- 3.1.1. History
- 3.1.2. Surrounding Area
- 3.1.3. Site Plan

3.2. Tower Design
- 3.2.1. Concept
- 3.2.2. Multipurpose Twin Towers

3.3. Structural Design
- 3.3.1. General Conditions
- 3.3.2. Structure System

3.4. Landscape
- 3.4.1. Access
- 3.4.2. Tower Park
- 3.4.3. Sky-Garden

3.5. Plans
- 3.5.1. Floor Plans
- 3.5.2. Sections
- 3.5.3. Elevations
- 3.5.4. Details

3.6. Renderings
- 3.6.1. Renderings Outside
- 3.6.2. Renderings Inside
- 3.6.3. Renderings Landscape

3.1. WOLF POINT

3.1.1. HISTORY

The site, which extends into the river at the Y-junction of the North Branch and the main branches of the Chicago River, is called the Wolf Point. Before the 1820s and 1830s only the west bank of the river at the Y-junction was called "Wolf Point" and afterwards the entire area of the site get its name. In the development of early Chicago the plot and the fork in the river are historically important.

FIGURE 1: A VIEW OF WOLF POINT LOOKING EAST IN 1875
COURTESY OF DOWNTOWN CHICAGO

The Wolf Point was also the place of Chicago's first hotel "Sauganash Hotel", its first three taverns, ferry, drug store, church, and the first bridges across the Chicago River.

The significant "Y-figure" of the Chicago River had been adopted as a logo. The "Y" represents the three branches of the Chicago River as they come together at Wolf Point. All around the city on many municipal, commercial and industrial buildings it is possible to find this symbol, which is also known as the Chicago Municipal Devise.

FIGURE 2: Y-FIGURE

There are many theories about the name “Wolf Point”. One says that it possibly derives from a Native American Chief whose name was translated to wolf. The Wolf Point property was owned by the Kennedy family, since the 1940s.

Today the Wolf Point is used as a parking lot as it has for many years, but in the latest years there have been many discussions, plans and visions.[1]

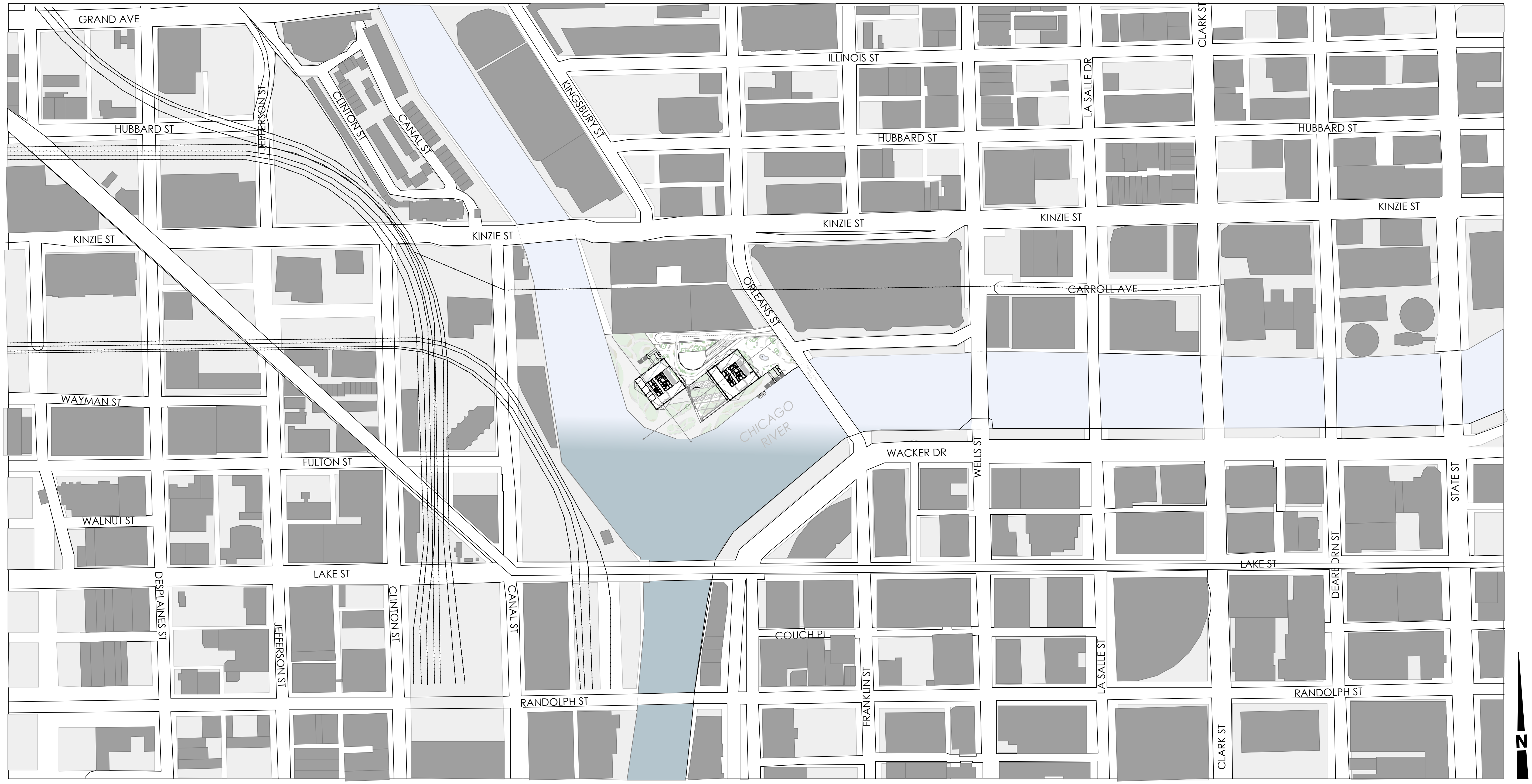
FIGURE 3: PARKING LOT - WOLF POINT

3.1.2. SURROUNDING AREA

FIGURE 4: GOOGLE MAPS – SURROUNDING AREA OF WOLF POINT, CHICAGO

[1] http://friendsofwolfpoint.com/about/, retrieved 2013-03-21

3.1.3. Site Plan



3. DESIGN

3.2. Tower Design

3.2.1. Concept

Due to the huge size of the site it had been decided to design two towers. Although there would have been enough space on the plot for more than two towers, it had been decided not to fill out the site with buildings and have enough space for free areas and landscape.

Shape and Geometry

Every skyscraper of the research and also most of the towers in Chicago and New York City have a rectangular or square floor plan.

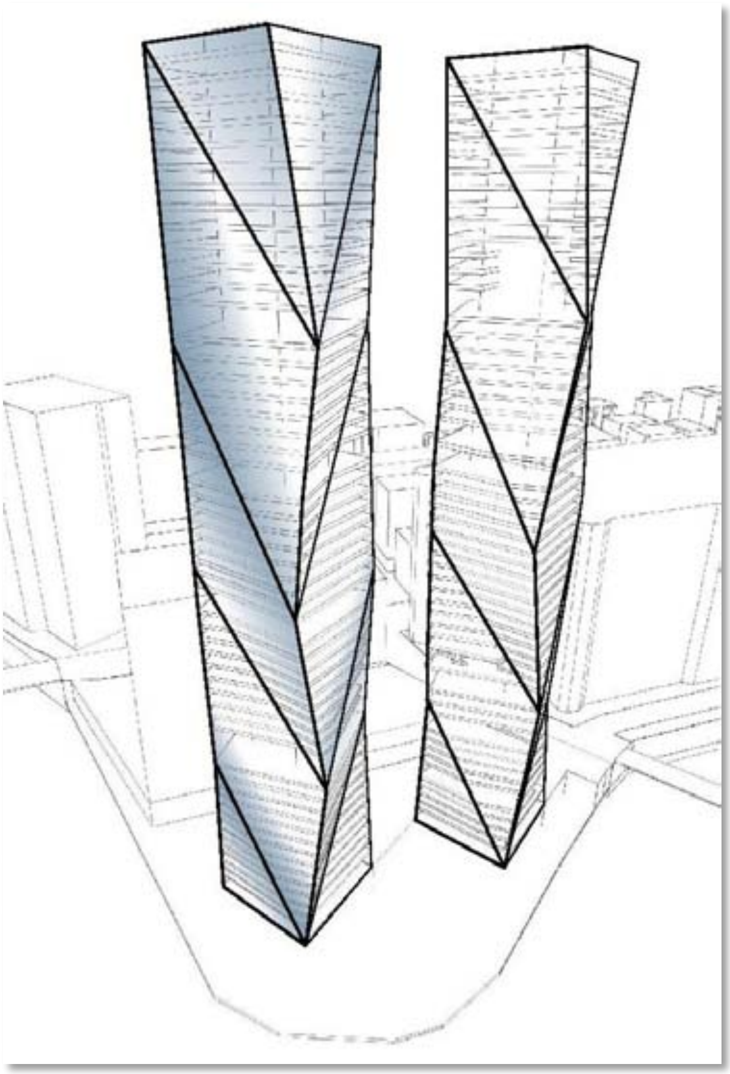


Figure 1: Twin Towers Shape

Thus, the basis for the design was a square floor plan. The square was extruded and each of the four walls was divided by a diagonal line. There are two different façade shapes, because of the direction of the diagonal line. One runs from the lower left to the upper right corner.

Here the diagonal line was pulled out. The other one runs from the lower right corner to the upper right corner and in contrast to the other façade the diagonal line was pressed into the building.

This element was stacked on top of each other four times and rotates in 90 degrees. That means that the façade folds itself in and at the next element out and so on. The whole tower rotates additionally in 90 degrees from bottom to top and so it seems like the tower changes its façade, depending on the viewing direction. The second tower is an exact copy – a twin - of the first one, only a few feet away. The main entrances of both towers are situated on the plaza level and additionally at the sunken plaza.

SKYBRIDGE

Furthermore there are two Skybridges, which connect one tower to the other. That means that with these Skybridges it is possible to move between the towers without leaving the building. The Skybridge is not only a gateway between the two towers, furthermore it's the place of different amenities for hotel guests, employees and residents.

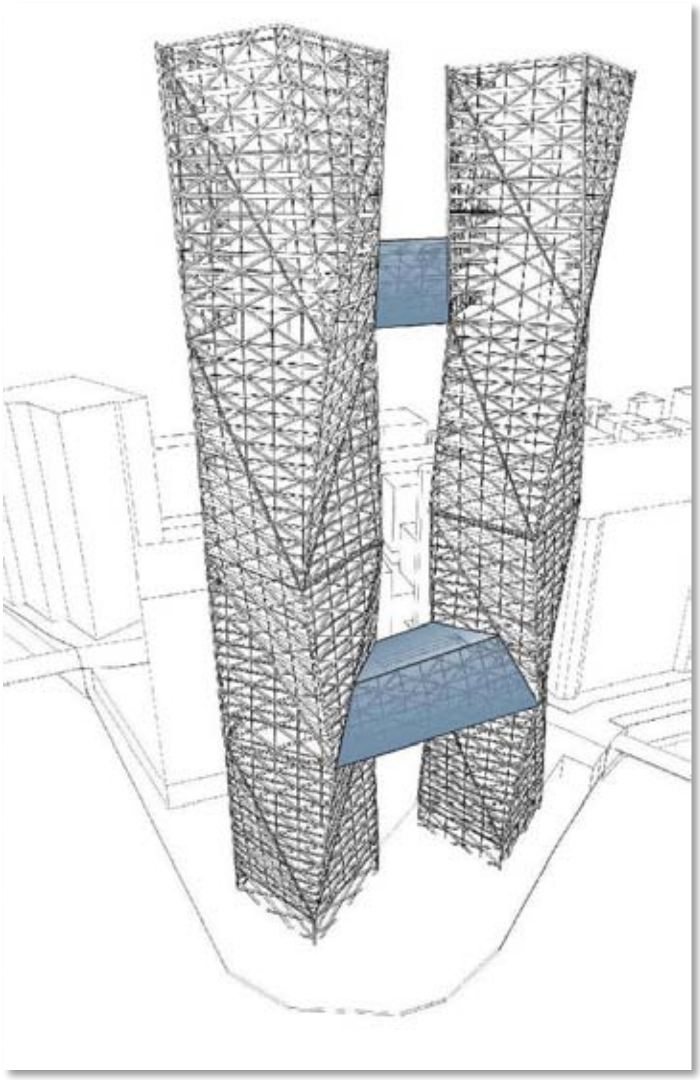


FIGURE 2: SKYBRIDGES

BRIGHT AND DARK

The structure is the key design element of the towers façade. The main part lies on the diagonal grid, which extends over two storeys. The full ceiling-to-ceiling high rectangular windows give the building a straight extension, while the horizontal orientated diagrid affects the width of the skyscrapers. This contrast is also noticeable within the different colors of the structures. While the diagonal grid is shown in a bright color to the foreground, the window frame is set back and dark colored. Through this color difference the facades of the buildings get an additional three dimensional effect. The detailed description of the structure system design can be found in Chapter 3.3. *Structural System Design*.

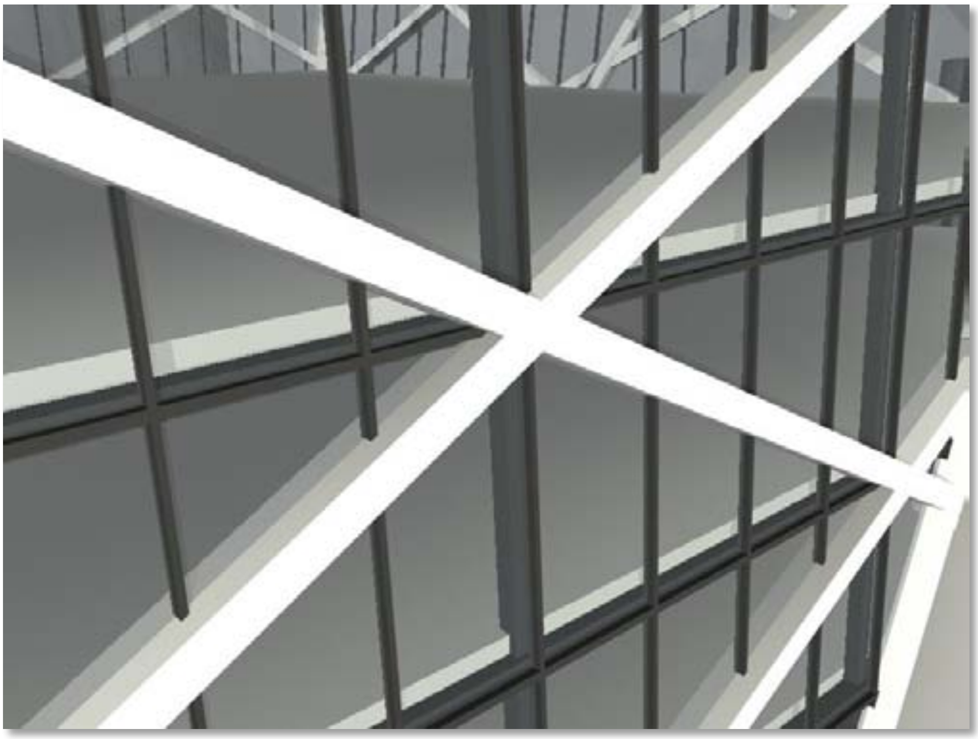


FIGURE 3: FAÇADE BRIGHT AND DARK STRUCTURE

CORE

The core has a square floor plan and is extruded to the full height of each tower. The Twin Towers look alike, thus the core is the same in both towers. The core is available from two sides, which are across each other. There are 4 express elevators, 6 local elevators, two fright elevators and one firefighter elevator. The express elevators stop … times, at every skylobby. Here you change to the local elevators to get to your destination. In case of fire there are two emergency stairs. The women´s and men´s restrooms are also located inside the core, to get free and flexible floor plans without restrictions. The restrooms are omitted, because they are not needed and instead a Service Room and a Garbage Room was added. At the Apartment-floors the space was used for a Service

Room and two additional elevators. The building services and the electrical system are hidden in the shafts inside the core.

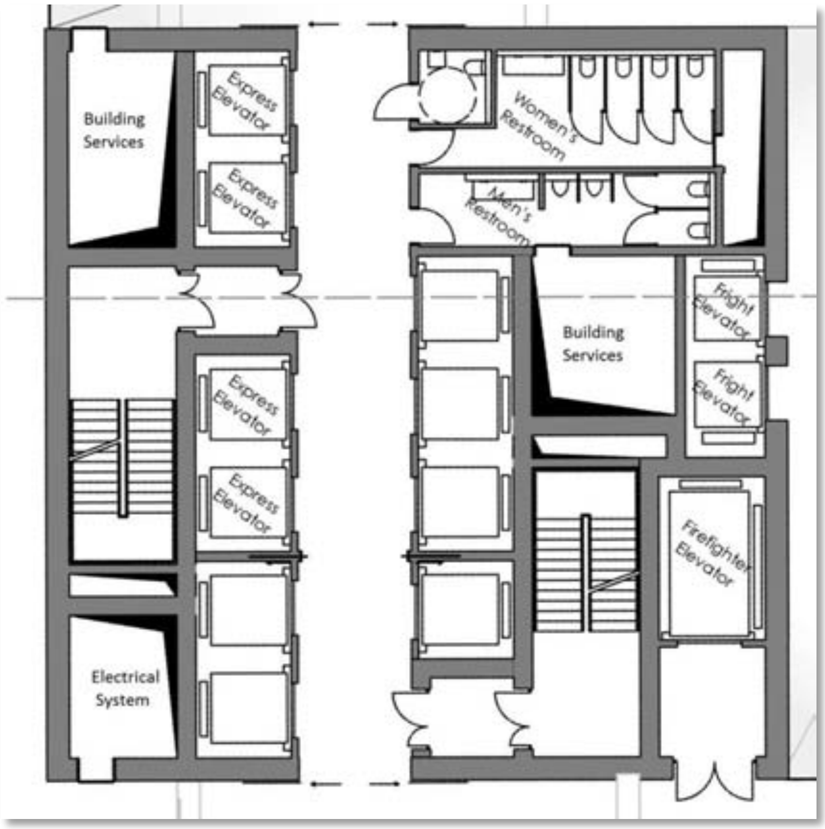


FIGURE 4: CORE

3.2.2. MULTIPURPOSE TWIN TOWERS

The historical importance of the property was, among other things, the reason for incorporating a few features to the functional and spatial program. This includes for example the first ferry, first hotel, first taverns and the first bridges over the Chicago River.

Thus, a pier for ferries and boats was designed on the south-east of the property, near the Franklin Street Bridge, along the Chicago River. The first historical bridges over the river are re-interpreted for the design and appear as Skybridges, which connect one tower to the other. The hotel, restaurants and bars are also a part of the design of the Twin Towers. Furthermore, offices and apartments are added to the design.

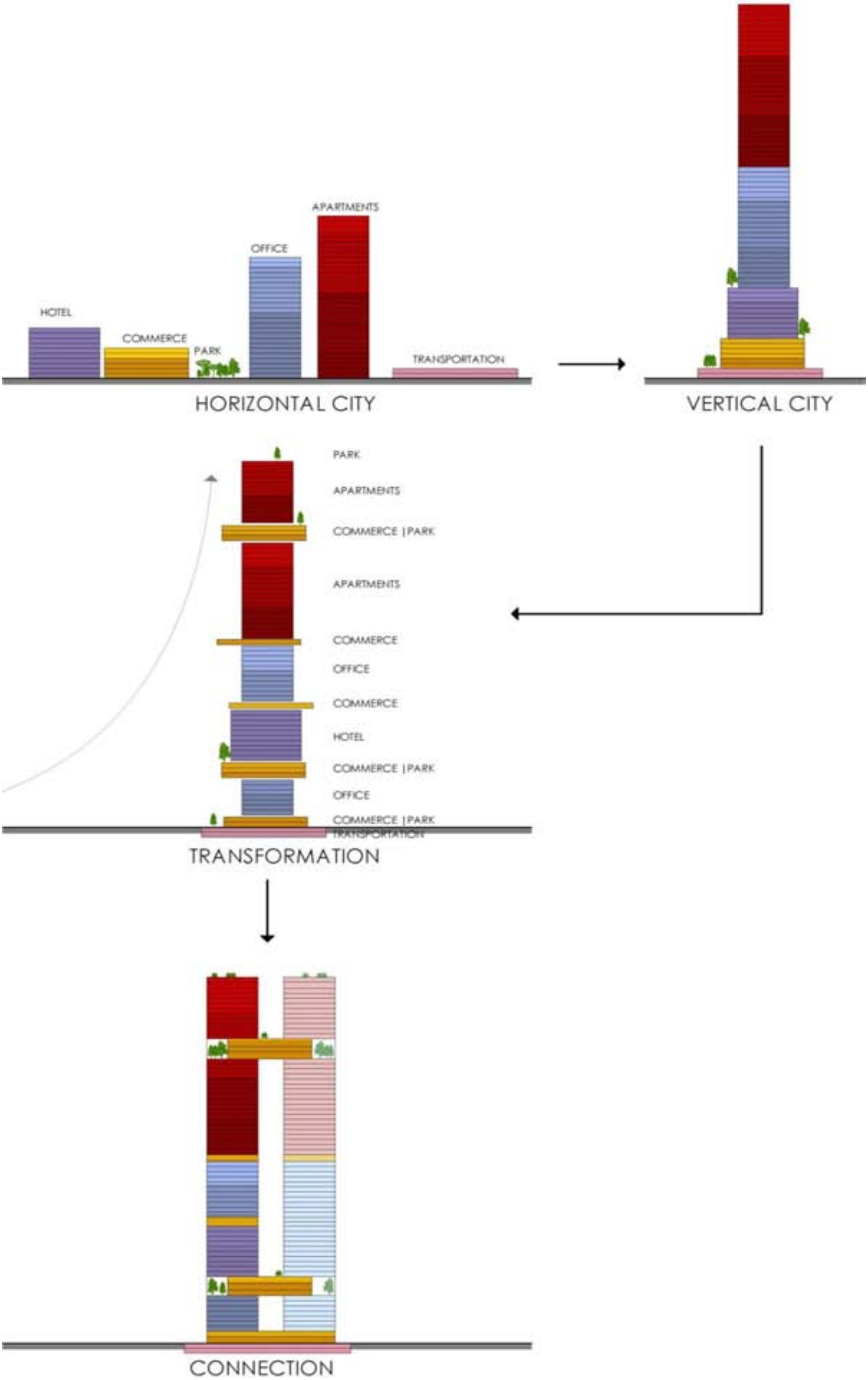


FIGURE 5: CONCEPT DIAGRAM

OFFICE

All in all there are 28 office floors, thereof 17 in the West Tower and 19 in the East Tower. Altogether there are 7 office spaces, which are extended over two floors. These are suitable for larger companies and/or for open office space. The regular window partitions allow flexible and easily transformed individual offices. For new users a new arrangement change is possible with little effort. Due to the rotation of the tower, there is no standard floor, resulting different square feet on floor plans. Thus, each company has the possibility to find the right office in the right size to rent or buy. The core is accessible from two opposite sites, which make it possible to share the office space with more than two companies.

APARTMENTS

The apartments are situated in the upper floors of each tower. All in all there are 33 apartment floors. The apartments vary in size and in the number of bedrooms. It ranges from studio apartments to 2 bedroom apartments. Because of the regular window partitions it is also possible to combine apartments to get larger ones, or split the larger ones to get several smaller units. The so called wet-cells with bath and/or toilette are oriented towards the core. Thus, nothing blocks the beautiful panoramic view. At the apartment floors two additional elevators are added to guarantee a faster and fluently access.

STUDIO APARTMENT

The studio apartments are approximately 45-57m². They include a kitchen, dining and living area, combined with a sleeping area. The bathroom is equipped with a shower, sink and a toilet. The entrance is separated from the living and sleeping area by an anteroom. There is also a niche for a wardrobe or closet.

FIGURE 6: STUDIO APARTMENT

1-BEDROOM APARTMENT

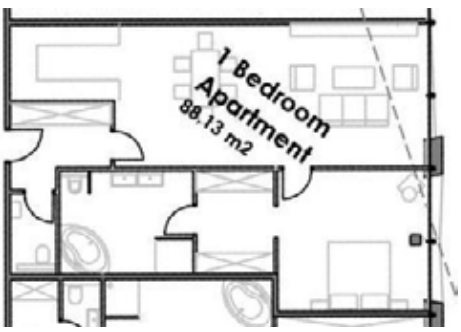


FIGURE 7: 1 BEDROOM APARTMENT

The 1 bedroom apartments are approximately 75-85m ². The entrance area has space for a wardrobe or a closet. From the anteroom you are able to get to the bathroom and to the living room. The spacious living area includes a kitchen, a dining area and a living area. From there it is possible to enter the master bedroom with a walk-in wardrobe. The master bathroom is furnished with a corner bathtub, a shower and a double sink.

2-Bedroom Apartment

The 2 bedroom apartments are about 95-115m². On one hand the 1 bedroom Apartment differs from the 2 bedroom by size and on the other hand by an additional bedroom. The 2 bedroom apartment`s living area is also planned more generously than the smaller apartments. The master bedroom, the walk-in closet and the attached master bathroom have the same equipment as the 1 Bedroom Apartments. Depending on the size and the location of the apartment the second bedroom has also an appended bathroom equipped with a shower, sink and a toilet. Otherwise, a separated bathroom is planned, which will be used from all residents of the apartment. It is equipped with a corner bath, shower and double sinks. A separate toilet is planned and accessible from the entrance area.

FIGURE 8: 2 BEDROOM APARTMENT

HOTEL

The hotel is located in the East Tower and reaches over 8 floors. The hotel reception with the restaurant and the bar are situated on the 16th Floor, by the skylobby of the West Tower. The lower Skybridge, which connects the East Tower with the West Tower, is also located on the 16th Floor. The hotel rooms and suites are above the Skybridge at the 21st floor, where you have an amazing few over the Chicago River. The amenities in the Skybridge can also be used by the hotel guests. All in all there are 129 rooms and suites in the hotel.

Reception

The Reception is located on the 16th floor at the first level of the lower Skybridge. A luggage room, a staff area, a meeting room and a seating possibility are added to the reception area. From the reception area it is possible to get out to the small park of the building.

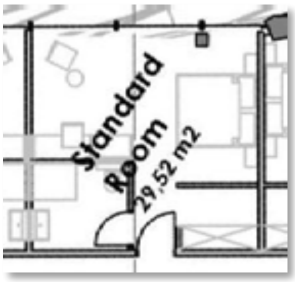
Luxury Suites

The Luxury Suites are located on the 21st floor, just above the amenities/ Skybridge, where you have a beautiful view over the city and also to the outdoor pool on the roof of the lower Skybridge. On this floor you can find the Presidential Suite, an Executive King Suite and an Executive Queen Suite. The Luxury Suites consist of the following rooms or areas: a Master Bedroom, a bathroom, a spa, sauna, a lobby, a living Room and a library.

HOTEL ROOMS AND SUITES

The hotel rooms and suites are located on the 22nd up to the 27th floor. On each floor there are 21 hotel rooms. Whereof five different types of rooms and suites:

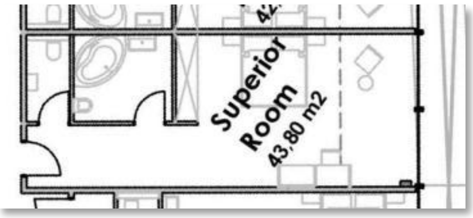
- Standard Room



The Standard Room is a typical hotel room with a king size bed, a desk, a closet and a bathroom with a shower, a sink and a toilet.

FIGURE 9: STANDARD ROOM

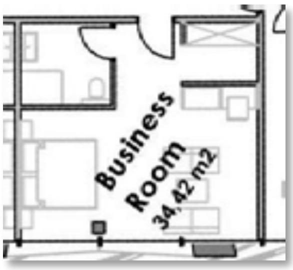
- Superior Room



The Superior Room has a separated toilet and a bathroom with a bidet and a bathtub.

FIGURE 10: SUPERIOR ROOM

- Business Room



The Business Room has additional space for a small living room area.

FIGURE 11: BUSINESS ROOM

- Junior Suite

  The Junior Suite is more spacious than the Business Room.

- Deluxe Suite

The Deluxe Suites are situated in the corner of the East Tower to have the best possible view, from two sides, over the city. It has a niche for the kitchen and a living and dining area. The spacious bedroom has an open bathroom, where you can enjoy the beautiful view from the bathtub in the middle of the bedroom.

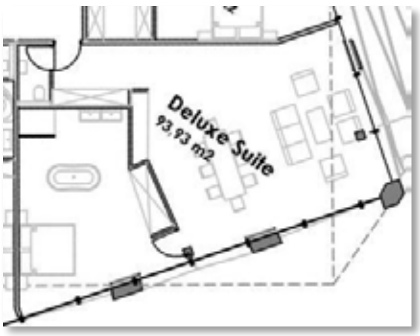


FIGURE 12: DELUXE SUITE

Restaurant| Bar

From the reception you can get to the restaurant and bar area of the double-height skylobby. The restaurant and bar will mainly be used by the guests of the hotel. But it is also open for employees and residents of the Twin Towers.

LOBBY| SKYLOBBIES

Lobby

The main lobby level is the first floor – the ground floor. The lobby is available through the front plaza. The main lobby extends over three floors, which include the first floor and two basement levels. All lobby levels have double-height floors. From the first floor level it is possible to get to the first basement level via escalator by elevators. The lobby height varies from 6m to a maximum of 14 m, because of the galleries.

Skylobby

The skylobbies are on the 1st, 16th, 20th, 30th and on the 44th floor. They are used to change from one elevator to another, from express elevators to local elevators and reverse. The 16th floor Skylobby, as well as the 44th floor Skylobby differs from the others because of two recreation parks in the corner of the buildings. The Skylobby in the 20th floor is also the access to the outdoor pool on the roof of the lower Skybridge.

AMENITIES

The amenities are located in the upper and lower Skybridges. The lower Skybridge and the amenities can be used by employees and hotel guests. The amenities include a Spa, a Gym and on the lower Skybridge an outdoor pool on the roof. The amenities are connected through the core and additionally by two separated elevators and stairs.

Spa

The Spa is located on the 18th floor. It includes changing rooms, showers, toilets and the spa area with 10 warm and hot pools with different depths and heights. Two pools are separated from the others by walls like grottos to relax. A few other pools are featured with massage jets and a swimming pool. There are lying areas to rest and relax, which are also separated by walls with 4.3 feet height.

The spa level includes a sauna area with four sauna rooms, a relaxing area and a cold pool. The cold pool is located outside the spa, with a view to the open park area.

GYM

The gym is located on the 19th floor and includes changing rooms, showers and toilets for the users. Behind the desk of the reception you can find a staff area, an office and a first-aid room. The gym includes a cardio area, a strength area and a Juice Bar with a seating area to relax. There are also two exercise rooms for aerobic, yoga and so on, as well as storage and a stretching area. Around the fitness area runs a 689 ft track, along the façade inside the building, which is separated by a glass wall.

The gym area also contains a Massage Center with five massage rooms, one couple massage room and two therapy bath rooms.

OUTDOOR POOL

The outdoor pool is located on the 20th floor, on the roof of the lower Skybridge. This floor is also a Skylobby floor. Therefore the pool is open to hotel guests, employees and residents.

BASEMENT LEVELS:

SHOPS

The shops are located on the first and the second basement levels. The main access is from the sunken plaza, but they are also available from the main plaza on the first floor level by the escalators. The shops are designed as open warehouses, with open shops and the possibility to pay the items on both levels.

BAR|LOUNGE

The bar and the lounge are located on the first basement level. The sloping roof of the bar brings more light into the bar and through the roof it is possible to look up to the towers. A terrace was added to the bar, to sit outside on warm and sunny days. The bar can be accessed from the shops, the lobby, or from outside, where the basement-façade is set back.

PARKING

There are four parking levels (3rd to 6th basement level). Every level has 358 parking lots, whereof 5 are for disabled people. The parking levels can be accessed by vehicles from the main plaza at the first floor. Inside the buildings footprint are rooms for bikes, service rooms and technical rooms.

3. DESIGN

3.3. STRUCTURAL DESIGN

The structure is the key design element for the design of the Twin Towers. Therefore, it was necessary to do this research to find the right structural system for these towers. Not a single element but rather the combination of the members together with the configuration of joints is responsible for the supporting structure. The visible structure on the facade is just one part of the whole structural system.

3.3.1. GENERAL CONDITIONS

WIND FORCES

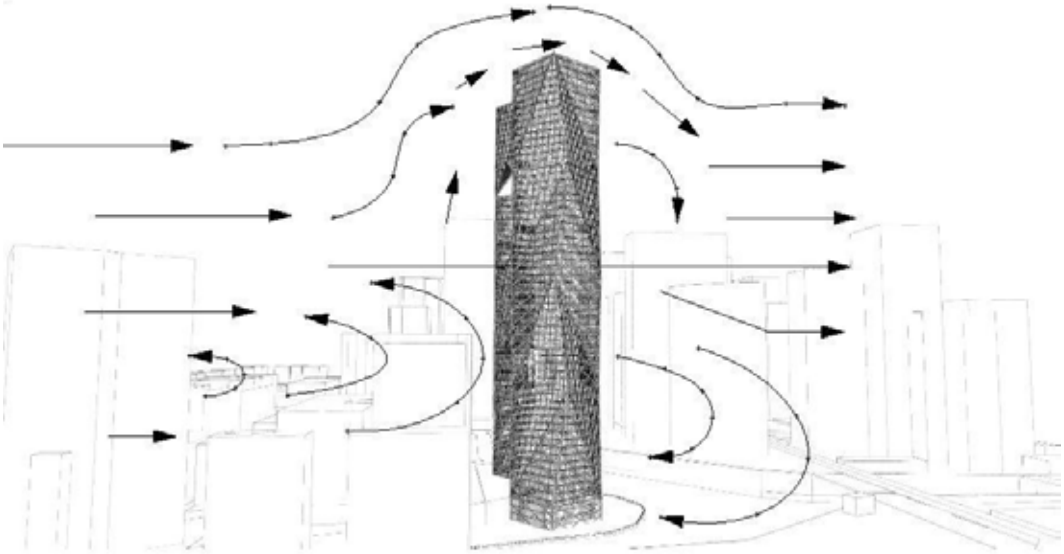


FIGURE 1: WIND FORCES ON TWIN TOWERS

Since there could not be found any geological results for this plot, an already developed site area had to be used for this thesis. For this thesis the same conditions were used as it had been for the Trump International Hotel & Tower, built in 2009 by SOM. The Trump International Hotel & Tower was built nearby, east of the Wolf Point, also at the Chicago River.

GEOTECHNICAL CONDITIONS

Below the existing ground there are layers with about 10 to 20 ft of sand and urban fill underlain by soft Chicago blue clay. Underneath the soft clay, at 75 ft in depth, are layers of hardpan, which is a very hard till that was consolidated by the glaciers over 10,000 years ago. Further down the hardpan turns into layers of very dense silty sand and a very dense to extremely dense silt and water under pressure.

The Dolomite Limestone Bedrock can be found in approximately 110 ft underneath the existing ground.

These special subsurface conditions are characteristic for properties in downtown Chicago.[1]

3.3.2. STRUCTURAL SYSTEM

Such towers, like these Twin Towers, have a tremendous weight, which means that the structural design is heavily influenced by geotechnical conditions.

FOUNDATION

A rock-socked caisson construction is a good choice if these geotechnical conditions occur combined with the plan to design Twin Towers with such heavily loaded structures. That means that both towers are supported by rock-socked reinforced concrete caissons, with permanent steel casings, while the plaza, the retail portions and the parking levels are supported by hardpan belled caissons. The caissons are drilled to the top of the rock. Afterwards a permanent steel casing is added and drilled into the Bedrock to seal the caisson shaft from groundwater. The steel casing is screwed into the Dolomite Limestone Bedrock, and sealed with grout.[2]

The rock socket depths of the Towers are 6 ft long. This length was measured from the top of the sound rock, because of the typical layers of weathered limestone or broken rock and gravel on the bedrock.

This is a typical procedure for the rock caisson construction in Chicago.

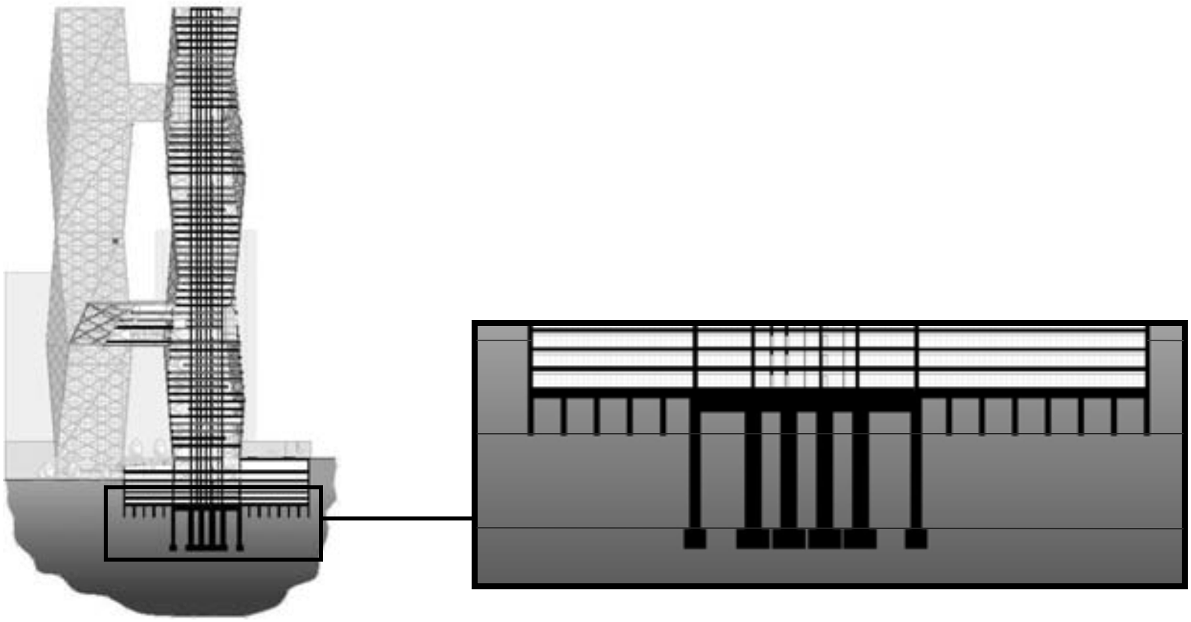


FIGURE 2: SECTION TWIN TOWERS WITH FOUNDATION DETAIL

Each highly loaded core of the Twin Towers is supported by a 13 ft thick reinforced concrete mat, which transfers the tremendous load of the core into 16 rock caissons, each with a diameter of 10 ft.

The outrigger columns and the diagonal grid are supported by 24 individual rock caissons with diameters of 6.7 ft. They are connected to each other by a series of caisson caps and grade beams.

TUBE STRUCTURE

For this design the tube structure was chosen, because there are no interior columns necessary, like they are in other conventional skyscrapers. This allows open floor plans which can be easily redesigned if necessary.

The structure of the Twin Towers consists of a core, slabs, a diagonal and a secondary grid. This means that a braced frame tube structure, which was previously explained, was used to design these Twin Towers.

CORE

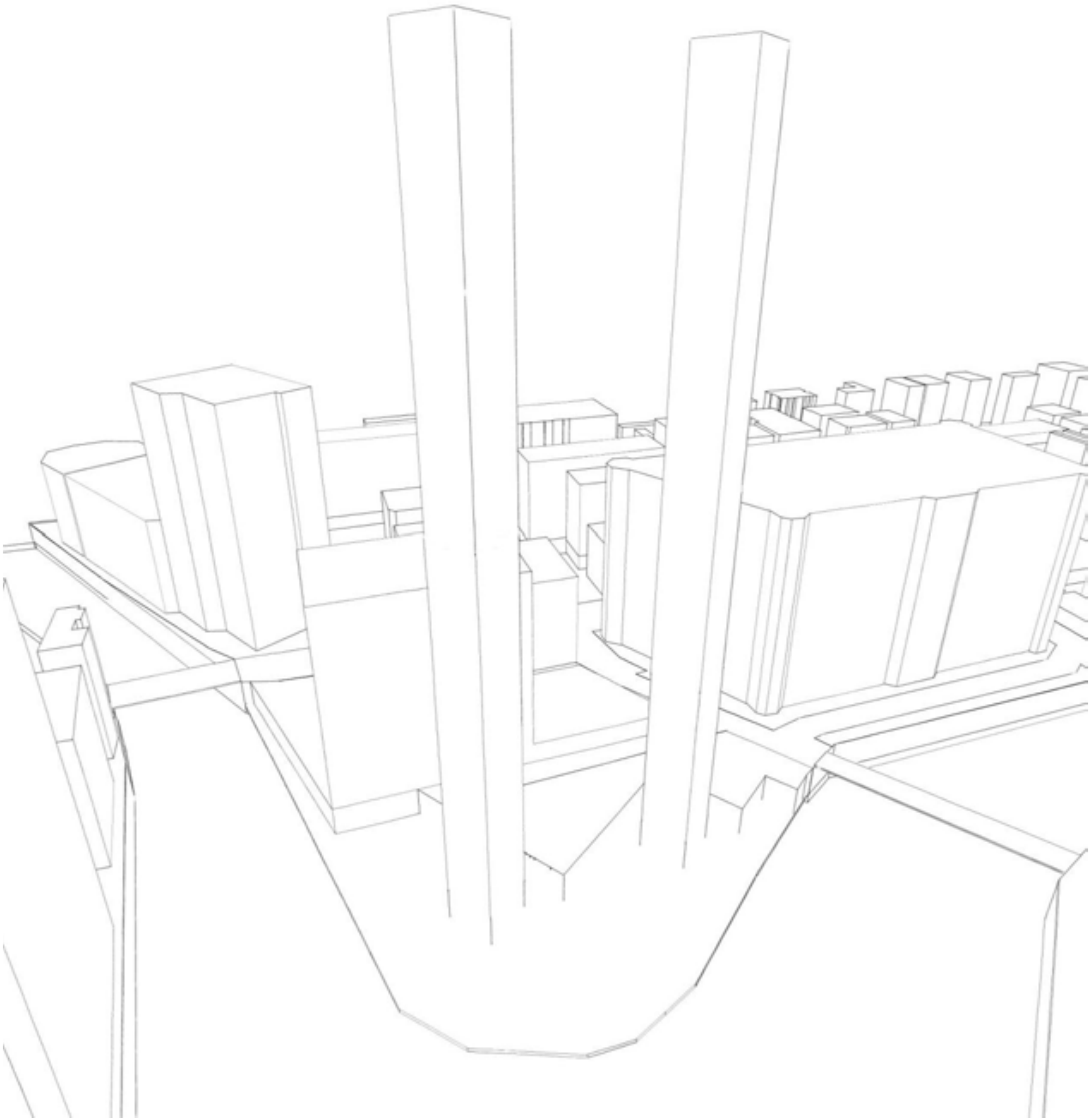


FIGURE 3: CORES OF THE TWIN TOWERS

The core is located at the center of each tower and consists of 2 feet thick walls on the lower floors and tapers to 1 foot thick walls at the upper floors. The cores have a rectangular shape with the dimensions of 65.3 feet to 64.3 feet and reach the total height of the Twin Towers.

SLAB

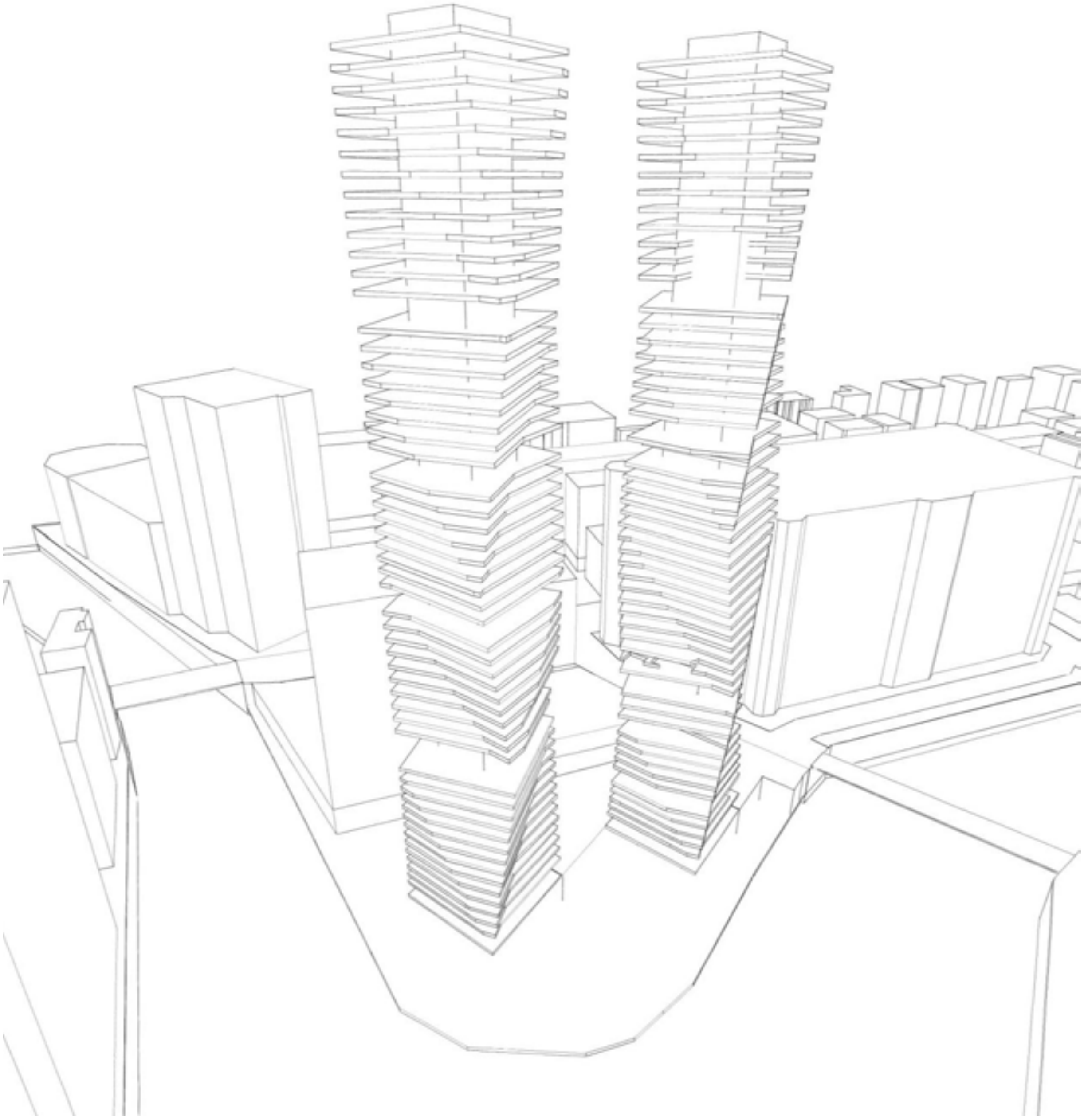


FIGURE 4: SLABS ATTACHED TO THE CORES OF THE TWIN TOWERS

Attached to the core are the composite slabs with integrated steel beams. The main beams are HEB 700 (*german describtion*) and the secondary beams are HEB 360 (*german describtion*), both up to a maximum length of 32.8 feet. In the following pictures it is possible to see that the main beams are connected to the nodes of the diagonal and the secondary grid. The main I-beams are forming an inner (connected to the core) and an outer frame (connected to the outrigger system).

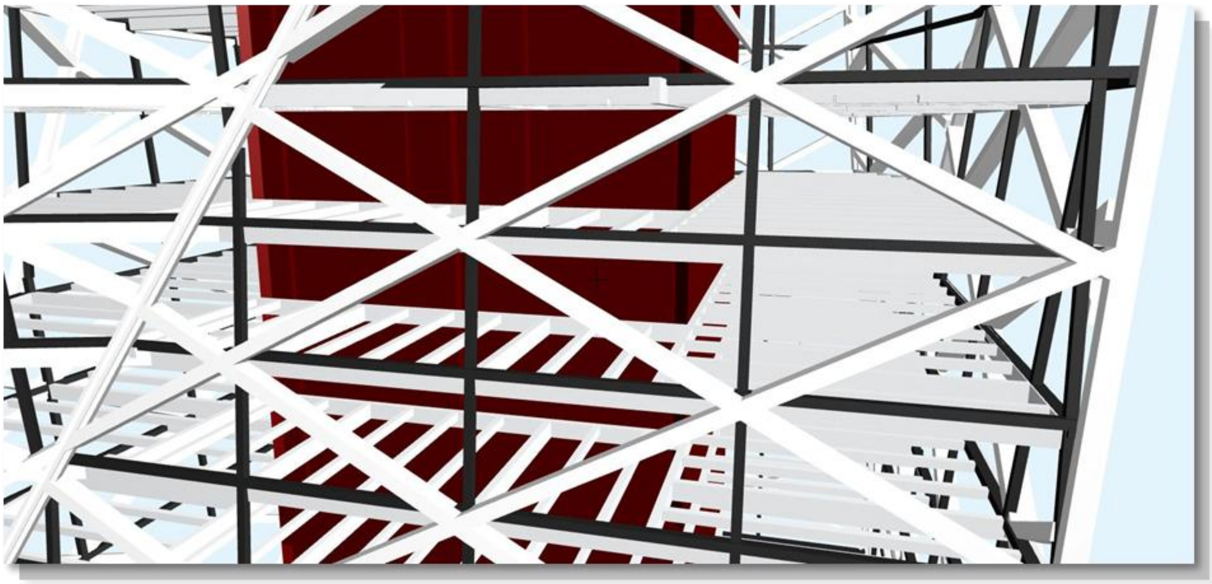


FIGURE 5: STRUCTURE MODEL WITH MAIN AND SECONDARY BEAMS INSIDE THE SLAB

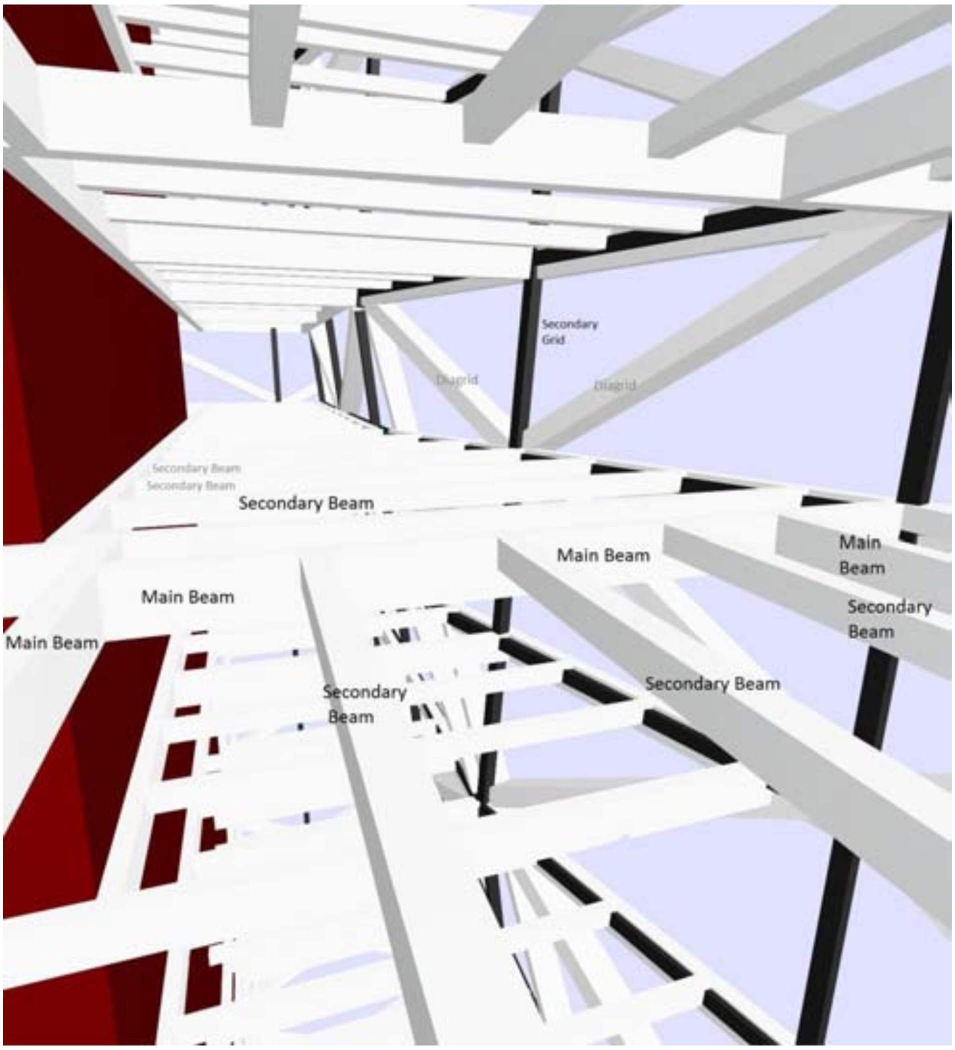


FIGURE 6: STRUCTURE MODEL WITH MAIN AND SECONDARY BEAMS INSIDE THE SLAB

DIAGONAL GRID

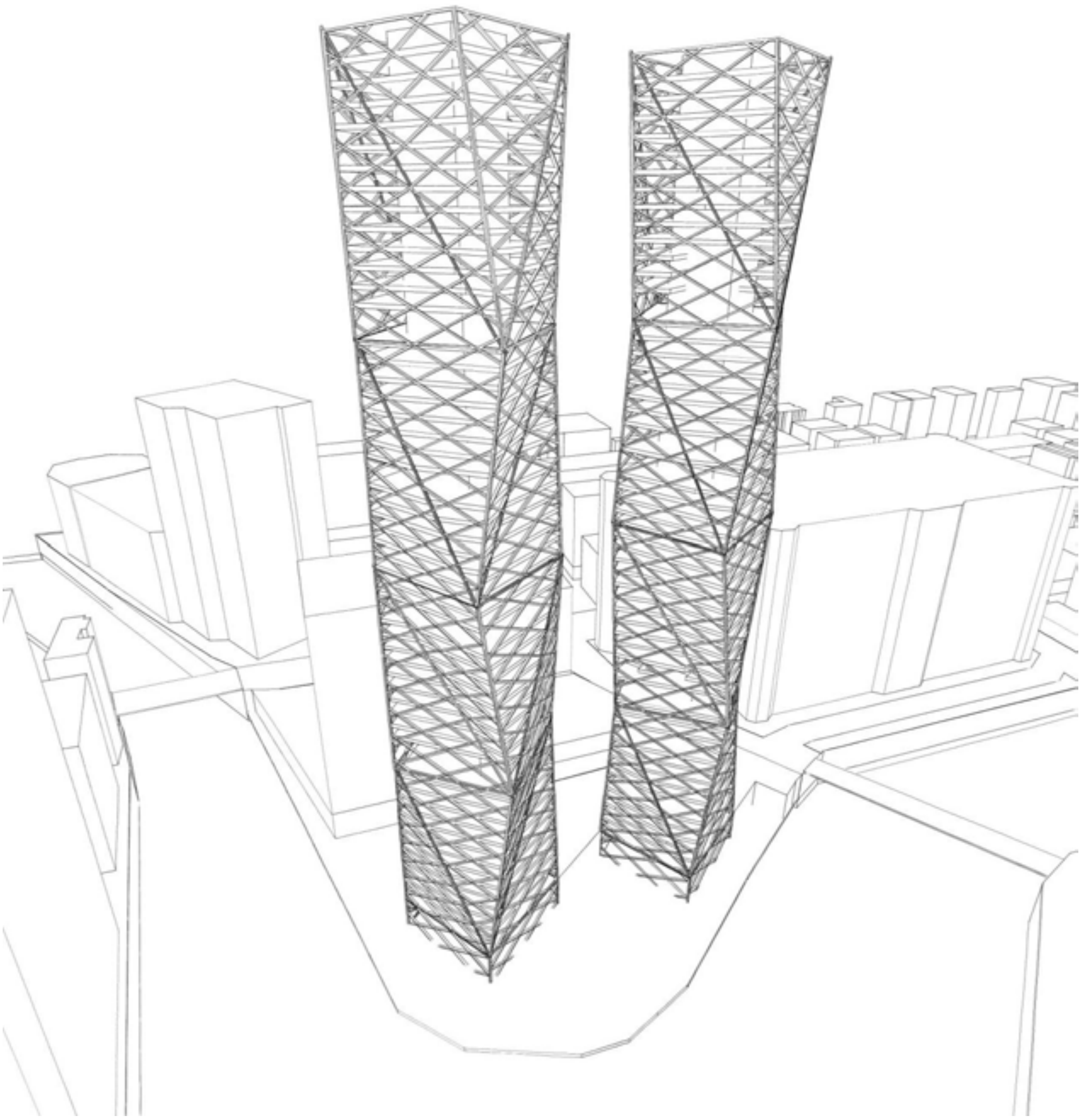


FIGURE 7: DIAGONAL GRID OF THE TWIN TOWERS

The lateral system consists of a core and an outrigger system. At the mechanical levels the diagonal and the secondary grid are connected to the core to increase the Tower´s lateral stiffness as well as its resistance to overturning due to wind.

The diagrids form a network of a triangulated truss system interconnecting all four faces of each tower, thus creating a highly efficient tube structure. The diagrid nodes are formed by the diagonal elements and the shape of the tower itself.

These nodes are key design elements both structurally and architecturally. Structurally, they act as hubs for redirecting the member forces. The nodes are on a 29.5-foot module and placed at two floors apart creating the diagrid system.

SECONDARY GRID

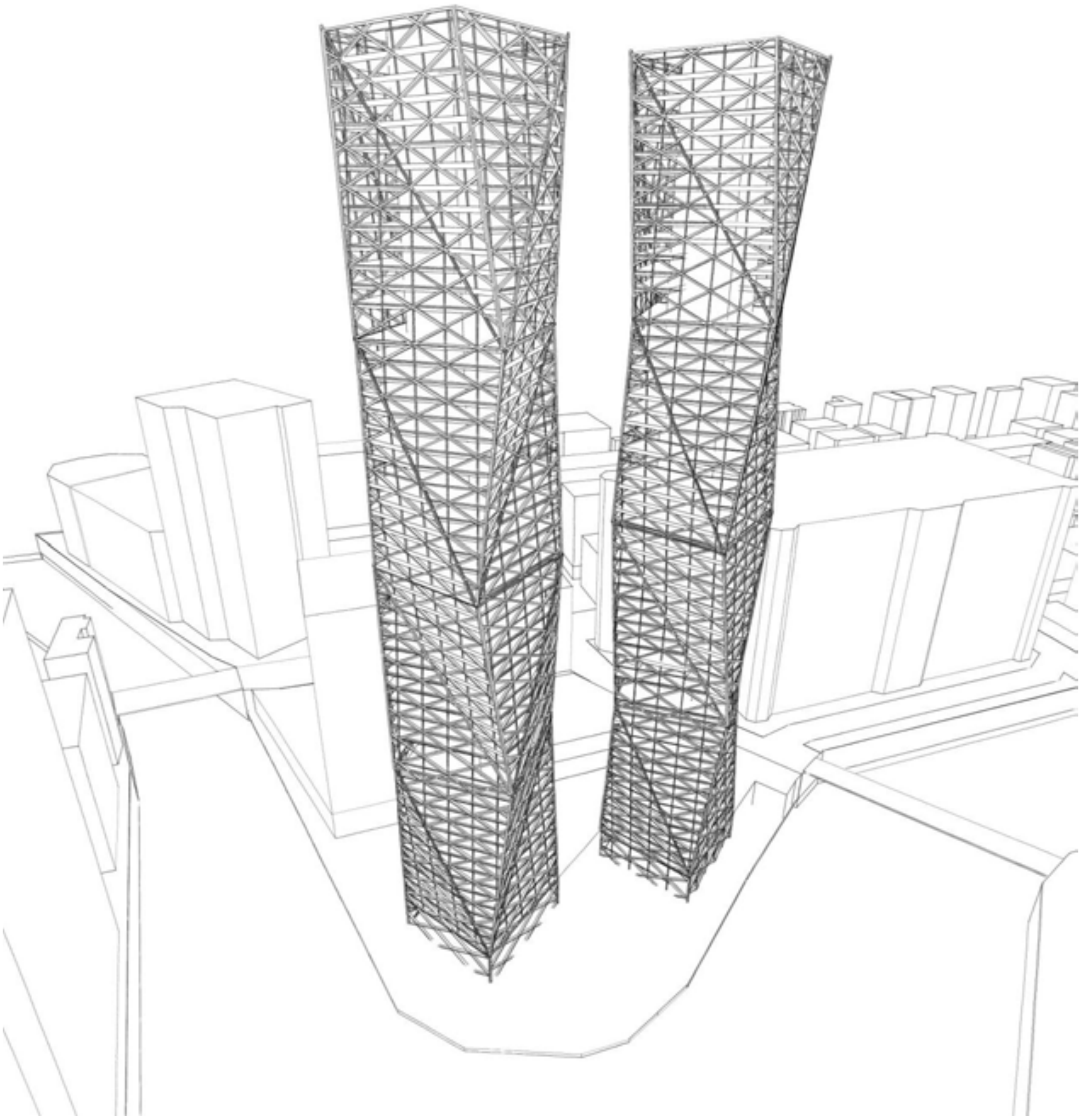


FIGURE 8: SECONDARY GRID OF THE TWIN TOWERS

The secondary grid is necessary, because of the diagonal grid´s span length of 59 feet. Without the secondary grid it would not be possible to span the slab between the diagonal grid and the core. The columns of the secondary grid are connected to the nodes of the diagonal grid with an additional horizontal I-beam on each floor, which was already explained.

SKYBRIDGE - SLABS

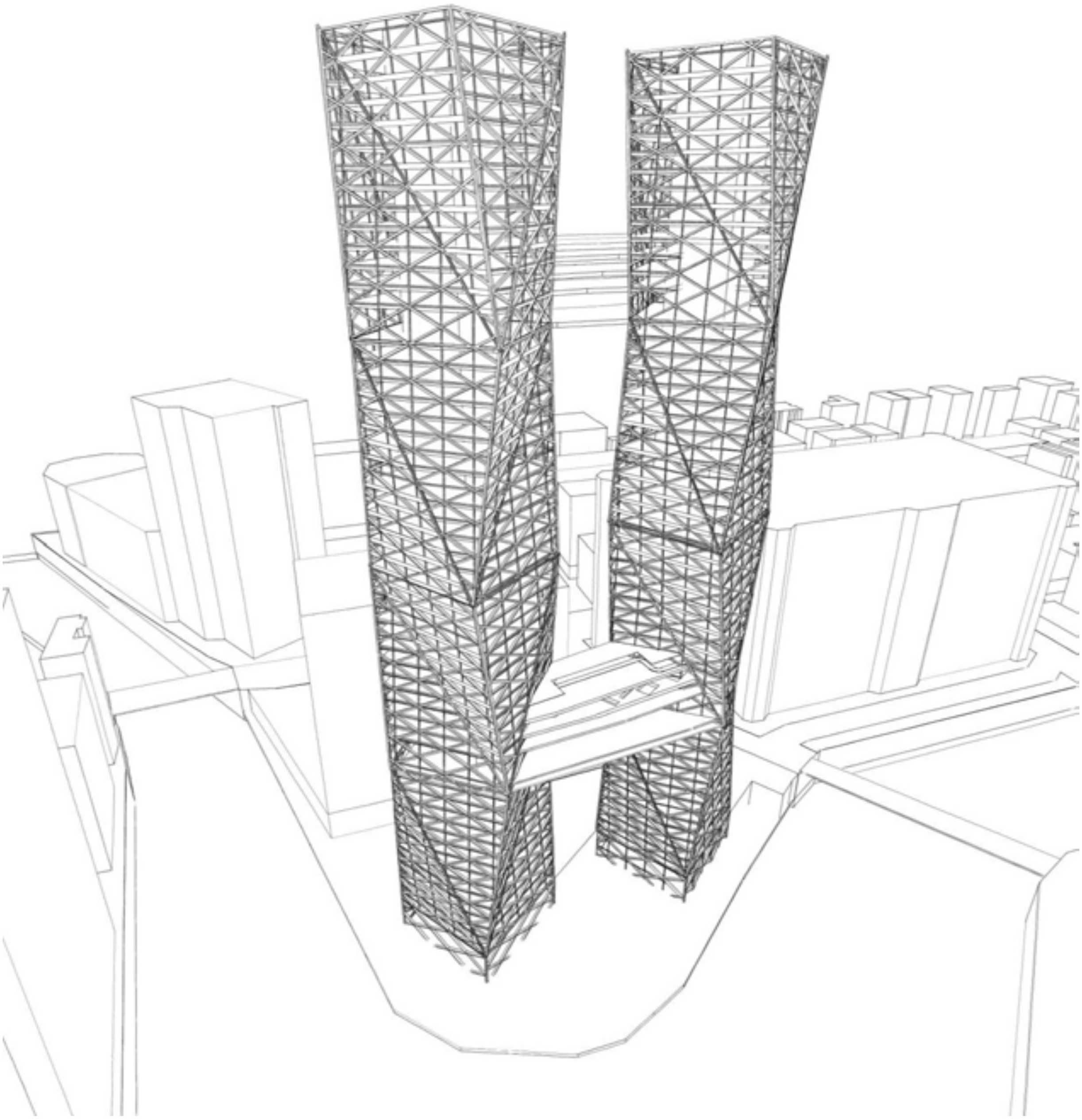


FIGURE 9: SKYBRIDGE SLABS CONNECT TO BOTH TOWERS

The slabs of the Skybridge differ from those of the towers. The beams have to span 78 ft and up to 255 ft. Therefore, huge I-beams up to 5 ft are necessary. The slabs are connected to the outrigger system, where the loads are supported.

SKYBRIDGE – DIAGONAL GRID

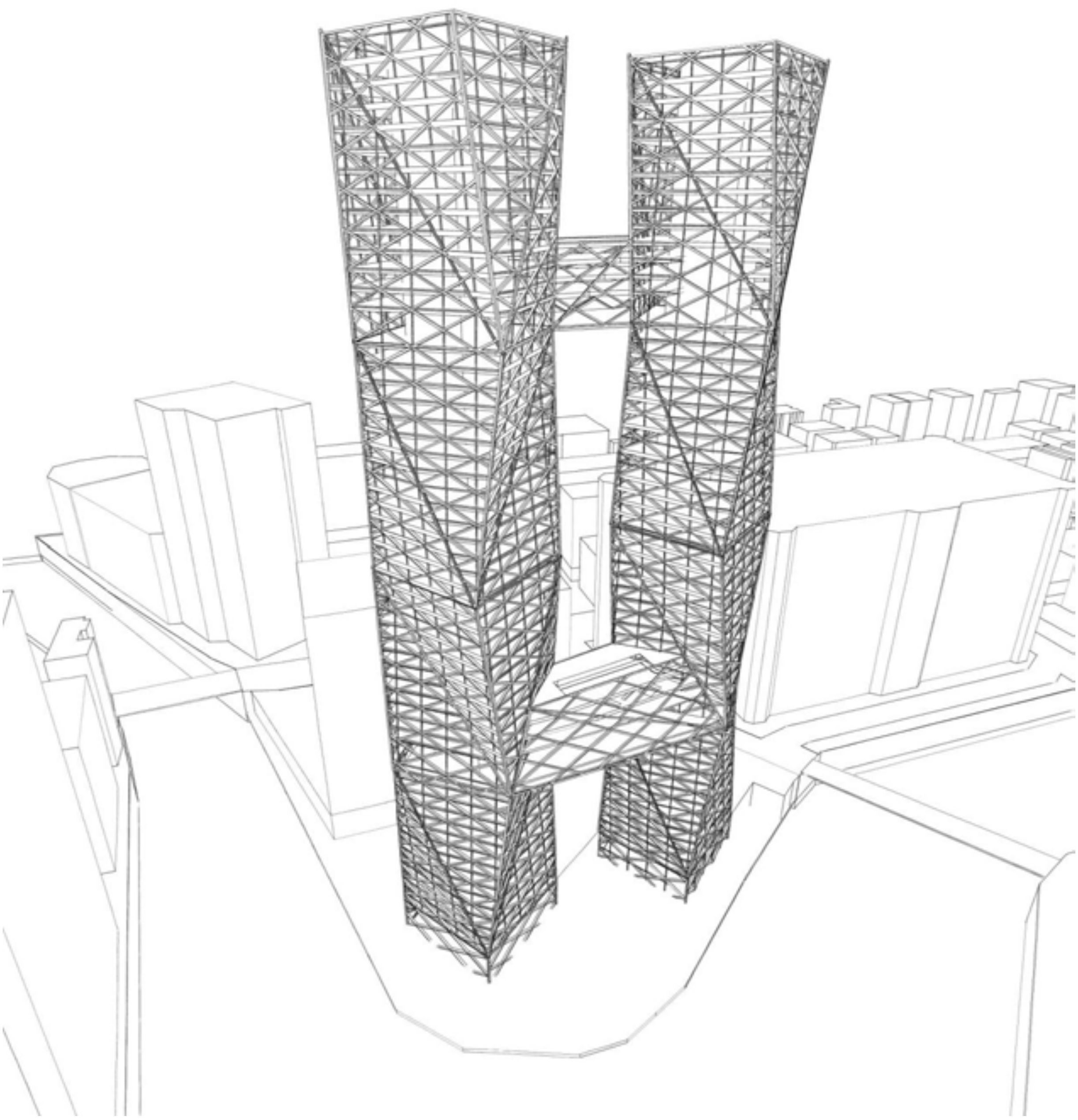


FIGURE 10: SKYBRIDGE WITH THE DIAGONAL GRID

The diagonal grid and the secondary grid (figure 11) at the Skybridge have to withstand the same requirements as the towers.

SKYBRIDGE – SECONDARY GRID

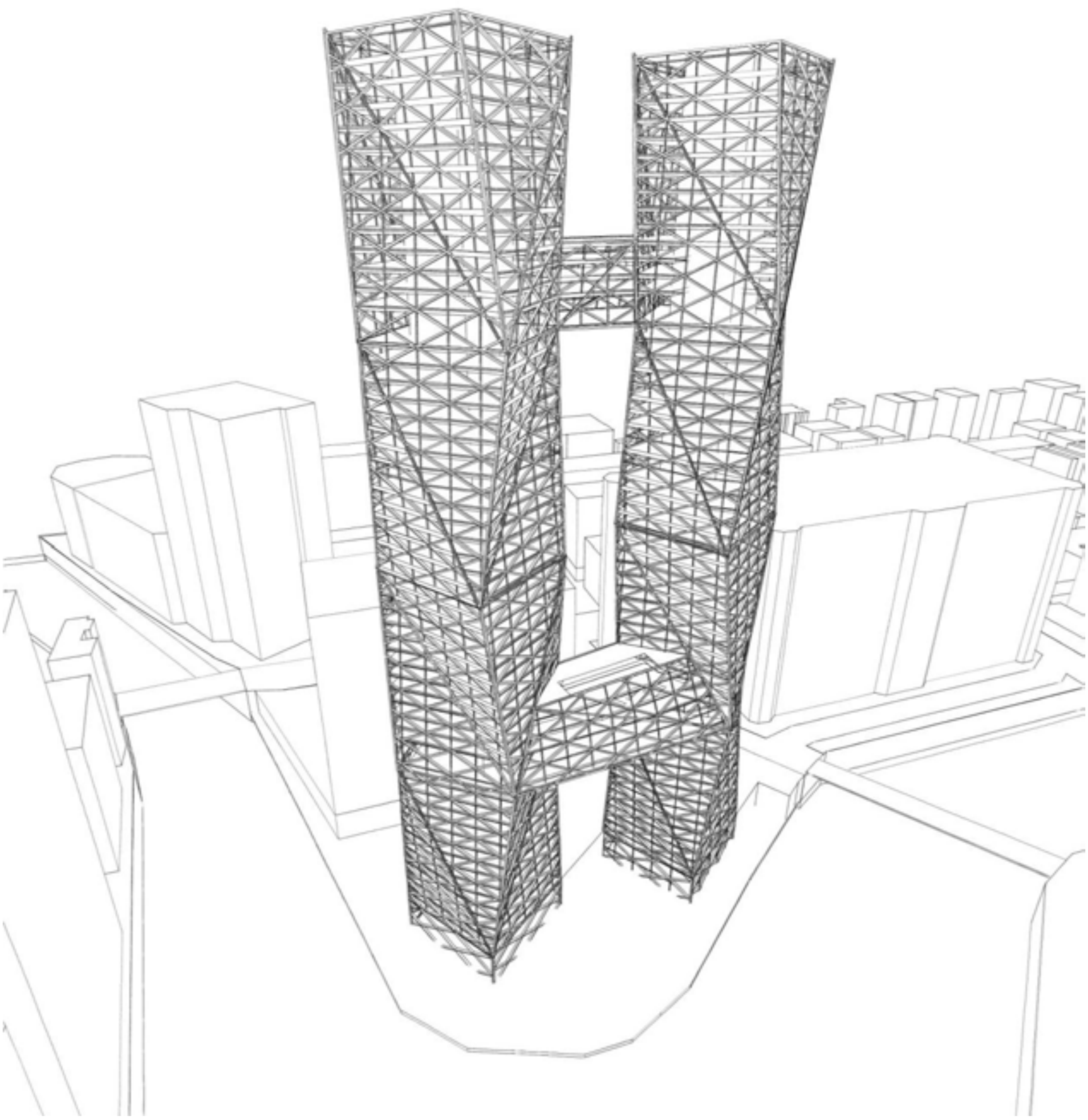


FIGURE 11: SKYBRIDGE WITH THE SECONDARY GRID

The nodes of the secondary grid and the diagonal grid on the Skybridge do not differ from those of the tower.

[1] DEEP FOUNDATIONS INSTITUT, *Trump International Tower and Hotel: A Deep Foundation in a Challenging Urban Site,* The Magazine for the Deep Foundations Institute, Fall 2009, p. 8-11

3. DESIGN

3.4. LANDSCAPE

The idea behind the landscape design was to be a contrast to the Twin Towers. Thus, the landscape design has very organic curved forms. The landscape and the Twin Towers with their structure should not be apart from each other, rather interconnected.

3.4.1. ACCESS MAIN ENTRANCE PLAZA AND SUNKEN PLAZA

From Orleans Street you get to the main entrance plaza. There are three possible ways to get from the main plaza to the sunken plaza and the water. The first one is on the East, where you can get by stairs or by elevators to the sunken plaza. There you have also the possibility to get to the first basement level. The other option is in the North-west, on the right corner of the West Tower. Here you can also get by stairs or by elevators to the sunken plaza and the first basement level. The third access is in the middle of the Twin Towers. By ramp or stairs you reach the sunken plaza over the sloping roof of the café. The access to the ferry is on the east branch of the site.

All accesses are orientated towards the Chicago River and the beautiful view.

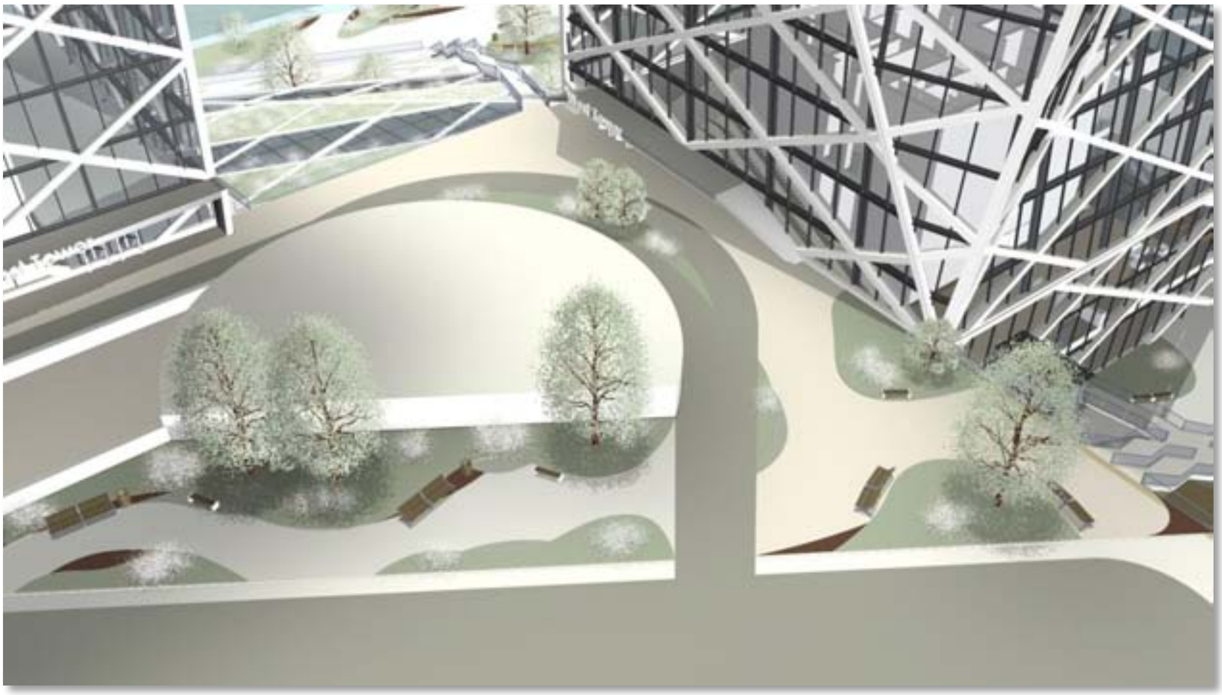


FIGURE 1: MAIN PLAZA

3.4.2. Tower Park

As already mentioned, the landscape is not limited to the main entrance plaza and the sunken plaza. Inside the Twin Towers there are four Tower Parks, located at the corners of the first level of each Skybridge, which reach up to 22,5m height.

FIGURE 2: TOWER PARK

3.4.3. SKY-GARDEN

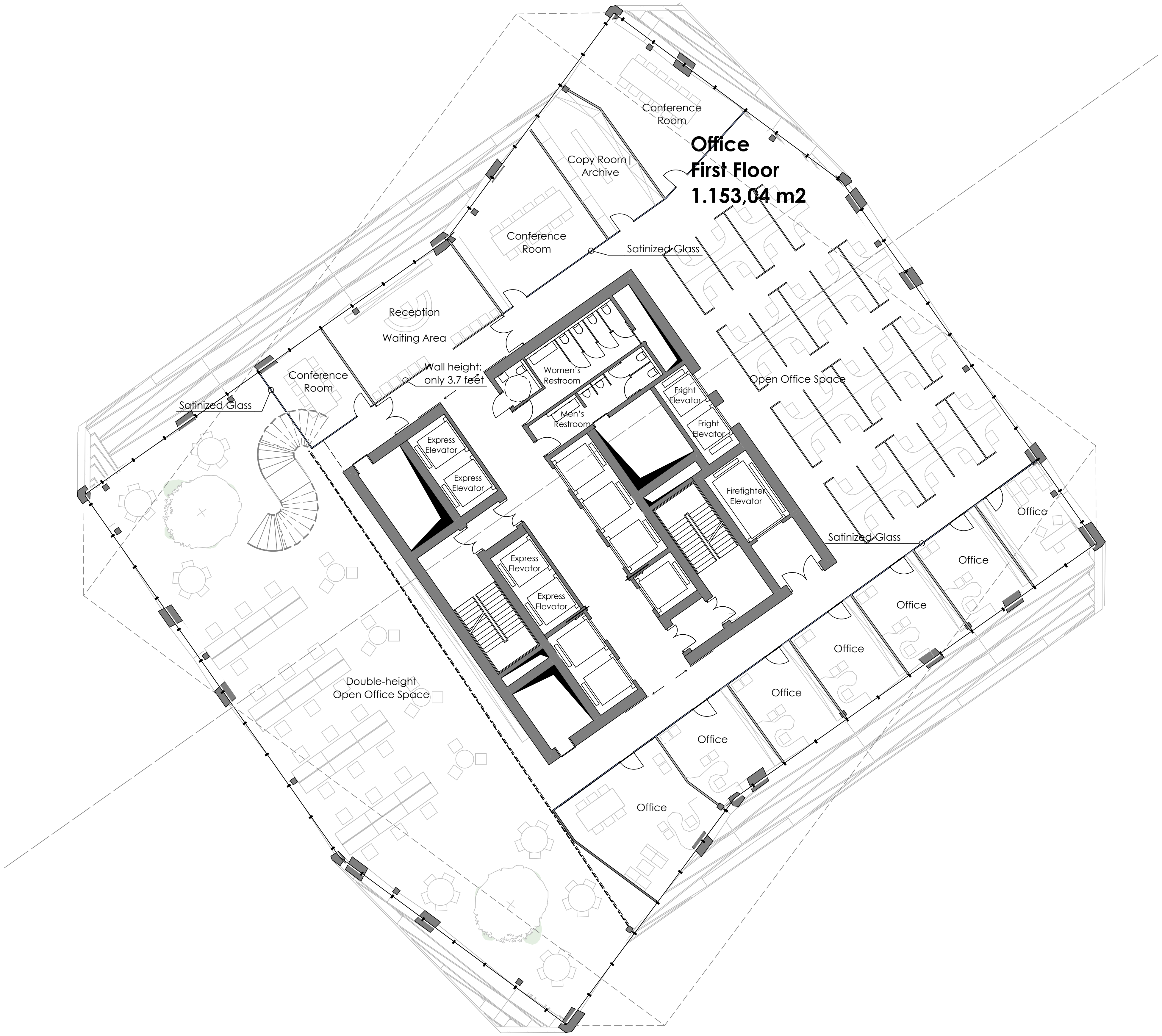
On the top of each Tower there is a sky-garden, designated for the residents to relax. The façade reaches up to 4,5m to minimize the forces of the wind on the roof.

FIGURE 3: SKY-GARDEN

3. DESIGN

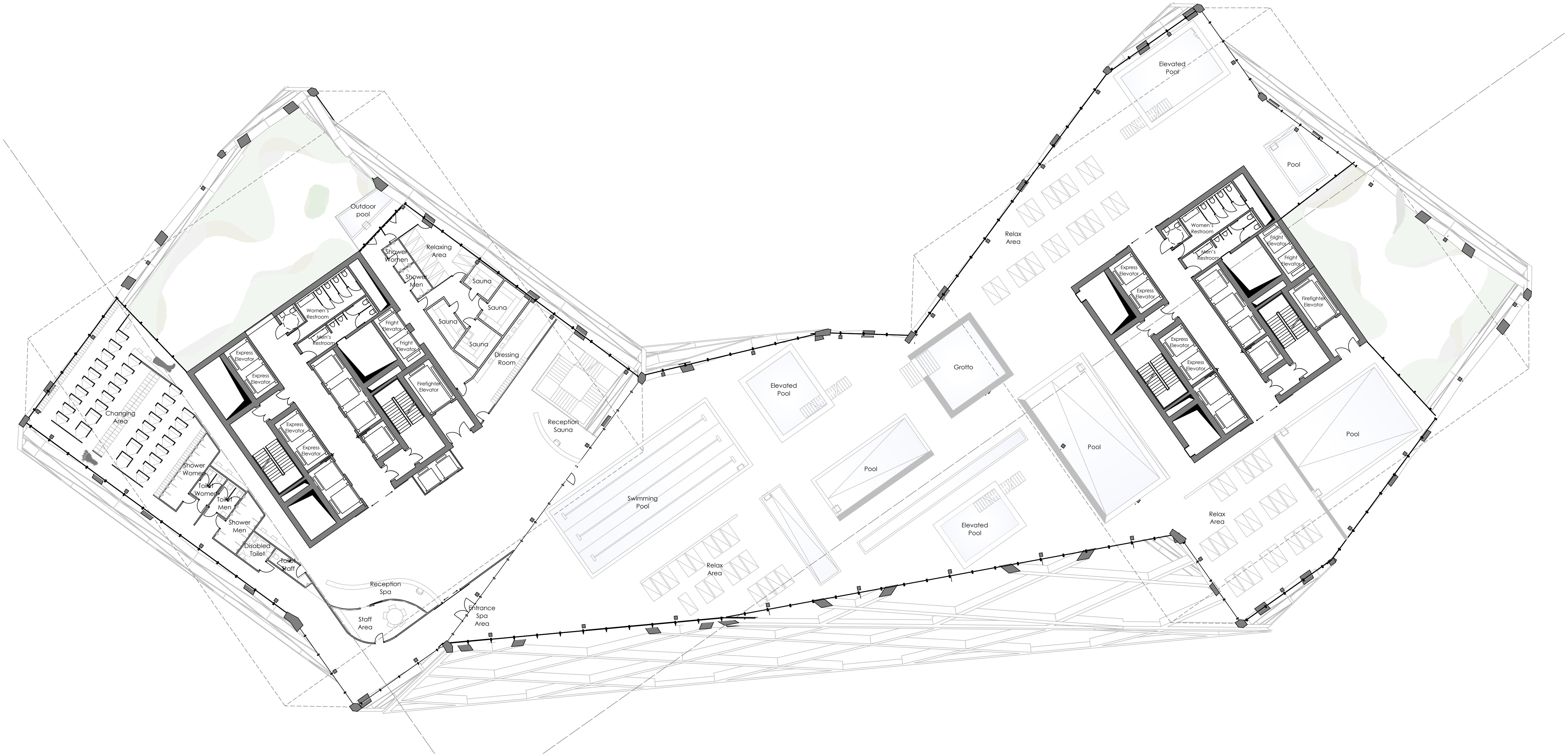

"Chicago Sun-Times Building"
Sidewalk
Access Road
Turn Around
Access to Twin Towers
Orleans Street
Park
Access to Basement Levels
MAIN PLAZA
Access to Parking Levels
Access to Street from Parking Levels
Rooftop of ramp
Roofing
Entrance East Tower
Entrance West Tower
Fountain
Administation
Staff Area
Office
Lobby
Lobby
717,46 m2
Info-Point Doorman
Escalator to 1. Basement Level
Terrace Bar 1. Basement Level
Roof of Bar 1. Basement Level
View to 1. Basement Level
View to 2. Basement Level
Access to 2. Basement Level
CHICAGO
RIVER

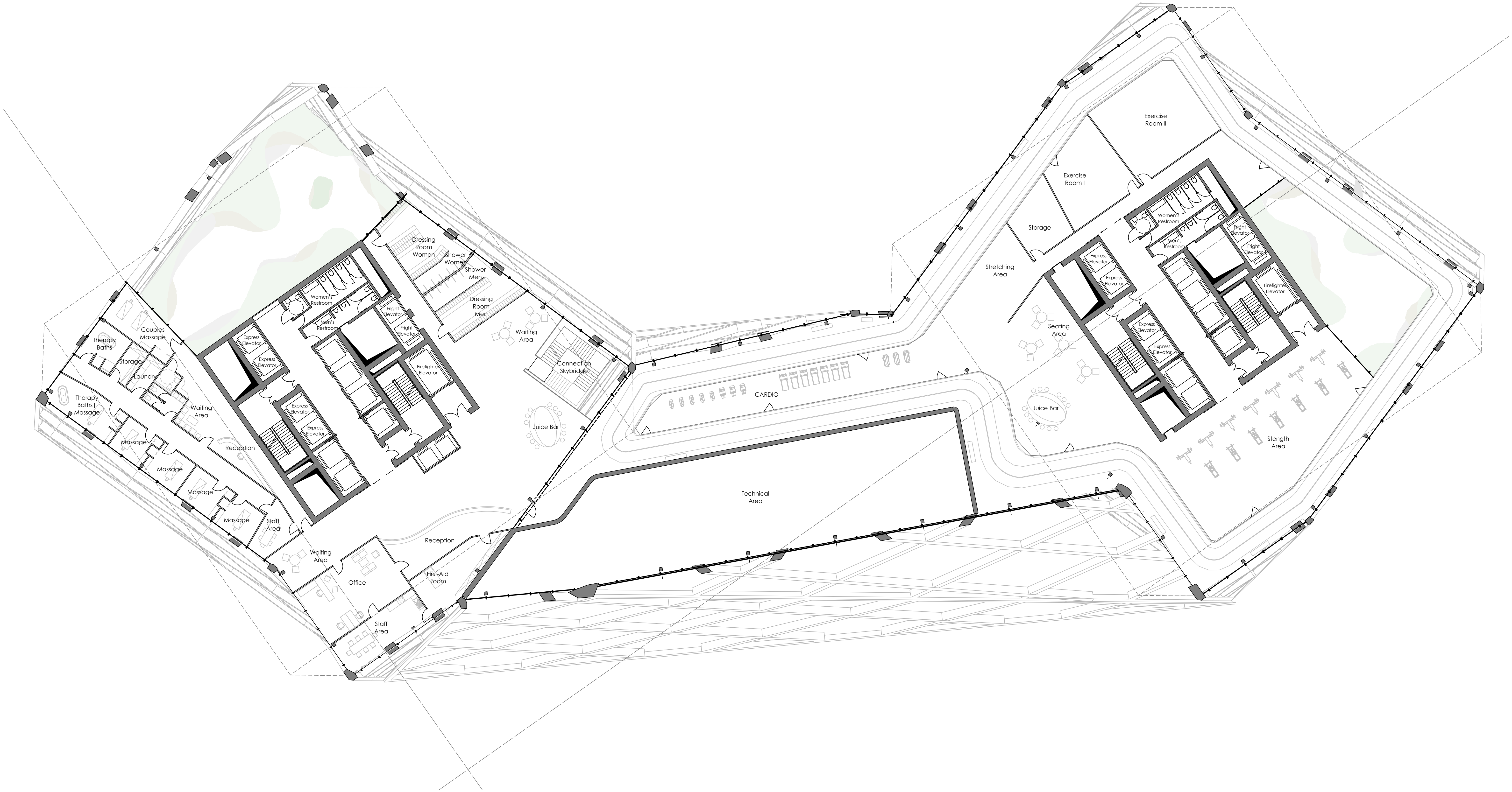

Office
1.163,94 m2
Office
Office
Office
Office
Skylight at
7.2 feet
Office
Meeting-|
Communication
Area
Office
Skylight at
7.2 feet
Office
Women's
Restroom
Fright
Elevator
Fright
Elevator
Men's
Restroom
Office
Office
Express
Elevator
Express
Elevator
Recreation
Area
Office
Secretary
Skylight at
7.2 feet
Office
Firefighter
Elevator
Satinized Glass
Presentation
Room
Express
Elevator
Express
Elevator
Office
Skylight at
7.2 feet
Secretary
Office
Satinized
Glass
Office
Wall height:
only 3.7 feet
Office
Meeting-|
Communication
Area
Waiting Area |
Reception
Office
Skylight at
7.2 feet
Waiting
Area
Office
Conference
Room
Secretary
Office


Office
First Floor
1.153,04 m2
Conference Room
Copy Room | Archive
Conference Room
Satinized Glass
Reception
Waiting Area
Wall height: only 3.7 feet
Conference Room
Satinized Glass
Women's Restroom
Men's Restroom
Fright Elevator
Fright Elevator
Open Office Space
Express Elevator
Express Elevator
Express Elevator
Express Elevator
Firefighter Elevator
Satinized Glass
Office
Office
Office
Office
Office
Office
Office
Double-height Open Office Space

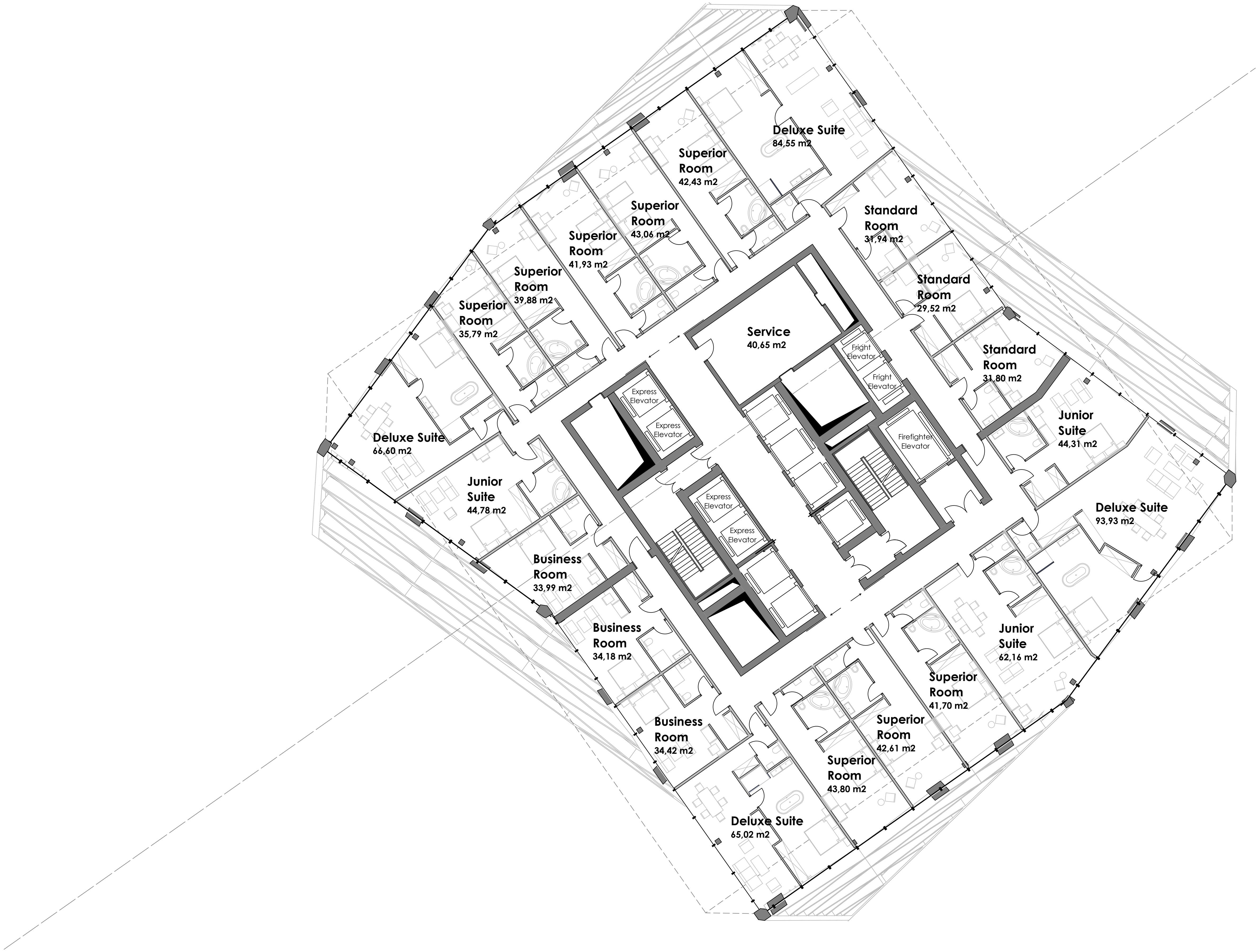

Conference Room
Office
Office
Second Floor
755,13 m2
Skylight at 7.2 feet
Secretary
Reception
Waiting Area
Wall height: only 3.7 feet
Seating Area
Women's Restroom
Men's Restroom
Fright Elevator
Fright Elevator
Open Office Space
Express Elevator
Express Elevator
Firefighter Elevator
Express Elevator
Express Elevator
Meeting Area
Open Office Space

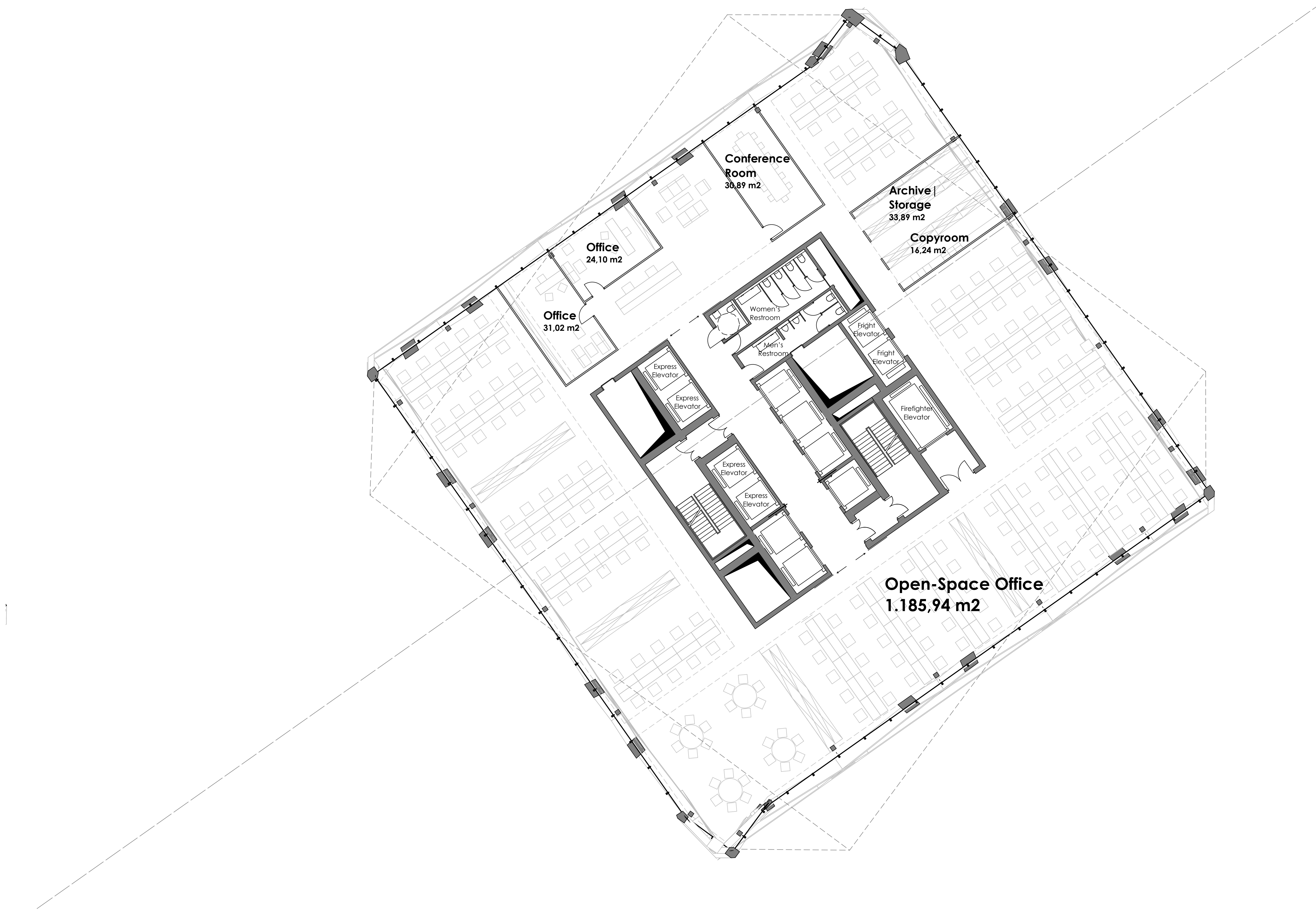

Tower Park
Seating Area
Women's Restroom
Men's Restroom
Express Elevator
Fright Elevator
Firefighter Elevator
Skylobby
890,40 m2
Lounge Seating Area
Restaurant Seating Area
Bar
Buffet
Kitchen
Cooling Storage Rooms
Administration
Clean Zone
Dirty Zone
Staff Area
Women Sanitary & Changing
Men Sanitary & Changing
Meeting Room
Waiter-entrance
Conference Room
Luggage Room
Hotel Reception
Staff Area


Outdoor pool
Relaxing Area
Shower Women
Shower Men
Sauna
Sauna
Sauna
Sauna
Dressing Room
Women's Restroom
Men's Restroom
Fright Elevator
Fright Elevator
Express Elevator
Express Elevator
Firefighter Elevator
Express Elevator
Express Elevator
Changing Area
Shower Women
Toilet Women
Toilet Men
Shower Men
Disabled Toilet
Toilet Staff
Reception Sauna
Reception Spa
Staff Area
Entrance Spa Area
Swimming Pool
Elevated Pool
Pool
Relax Area
Grotto
Elevated Pool
Elevated Pool
Pool
Relax Area
Pool
Pool
Relax Area
Women's Restroom
Men's Restroom
Fright Elevator
Fright Elevator
Firefighter Elevator

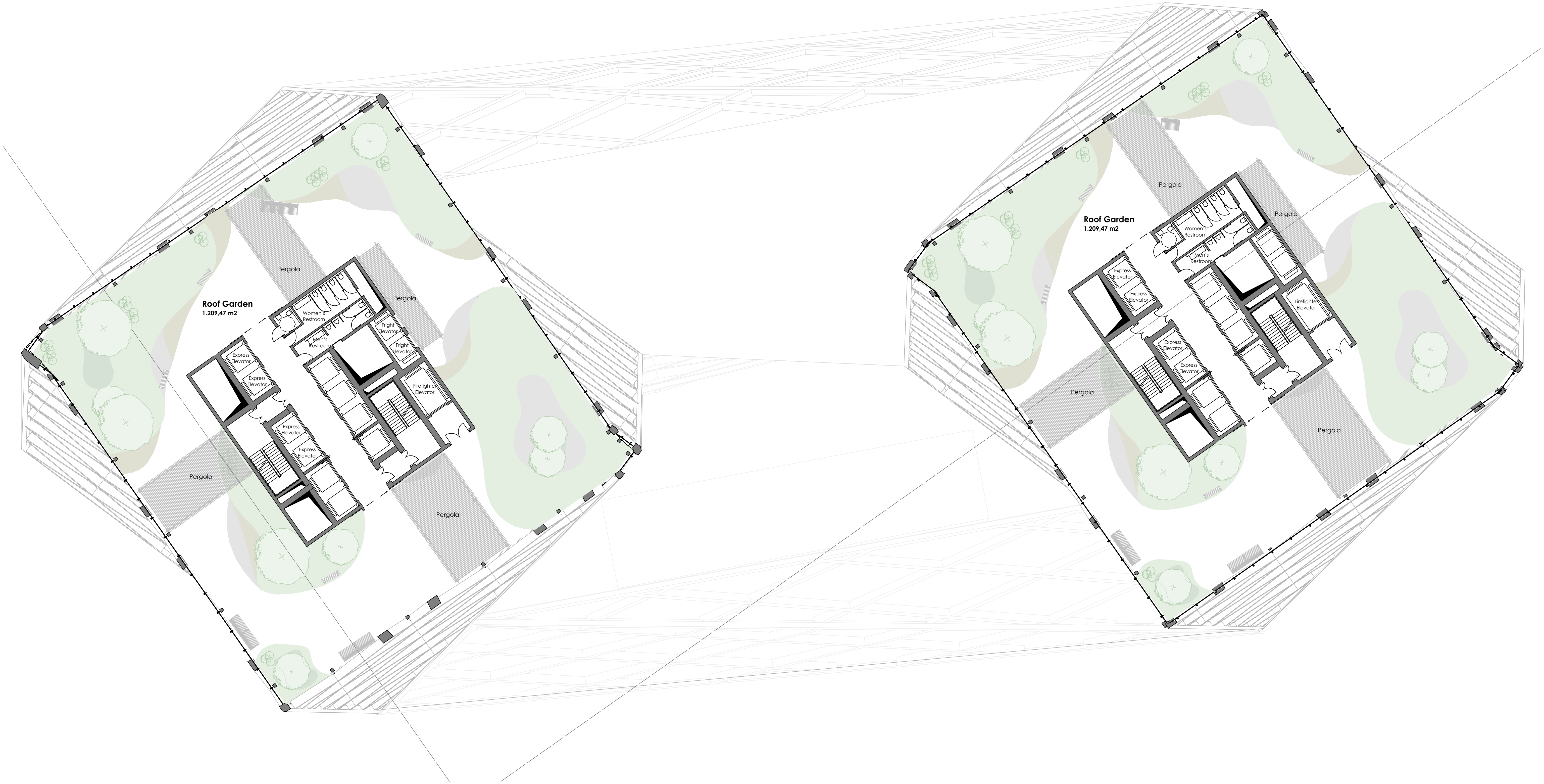

Couples Massage
Therapy Baths
Storage
Laundry
Therapy Baths | Massage
Waiting Area
Reception
Massage
Massage
Massage
Massage
Staff Area
Dressing Room Women
Shower Women
Shower Men
Dressing Room Men
Women's Restroom
Men's Restroom
Fright Elevator
Express Elevator
Firefighter Elevator
Waiting Area
Connection Skybridge
Juice Bar
Reception
Waiting Area
Office
First-Aid Room
Staff Area
CARDIO
Technical Area
Exercise Room II
Exercise Room I
Storage
Stretching Area
Seating Area
Juice Bar
Stength Area


Presitential Suite 435,15 m2
LIBRARY
LIVING ROOM
Executive King Suite 382,01 m2
LIVING ROOM
LIBRARY
MASTER BEDROOM
BATHROOM
SPA
SAUNA
Service 16,20 m2
Fright Elevator
Fright Elevator
Express Elevator
Express Elevator
Express Elevator
Express Elevator
Firefighter Elevator
EMERGENCY EXIT
SAUNA
SPA
BATHROOM
MASTER BEDROOM
LIBRARY
Executive Queen Suite 320,96 m2
LIVING ROOM
SAUNA
SPA
BATHROOM
MASTER BEDROOM

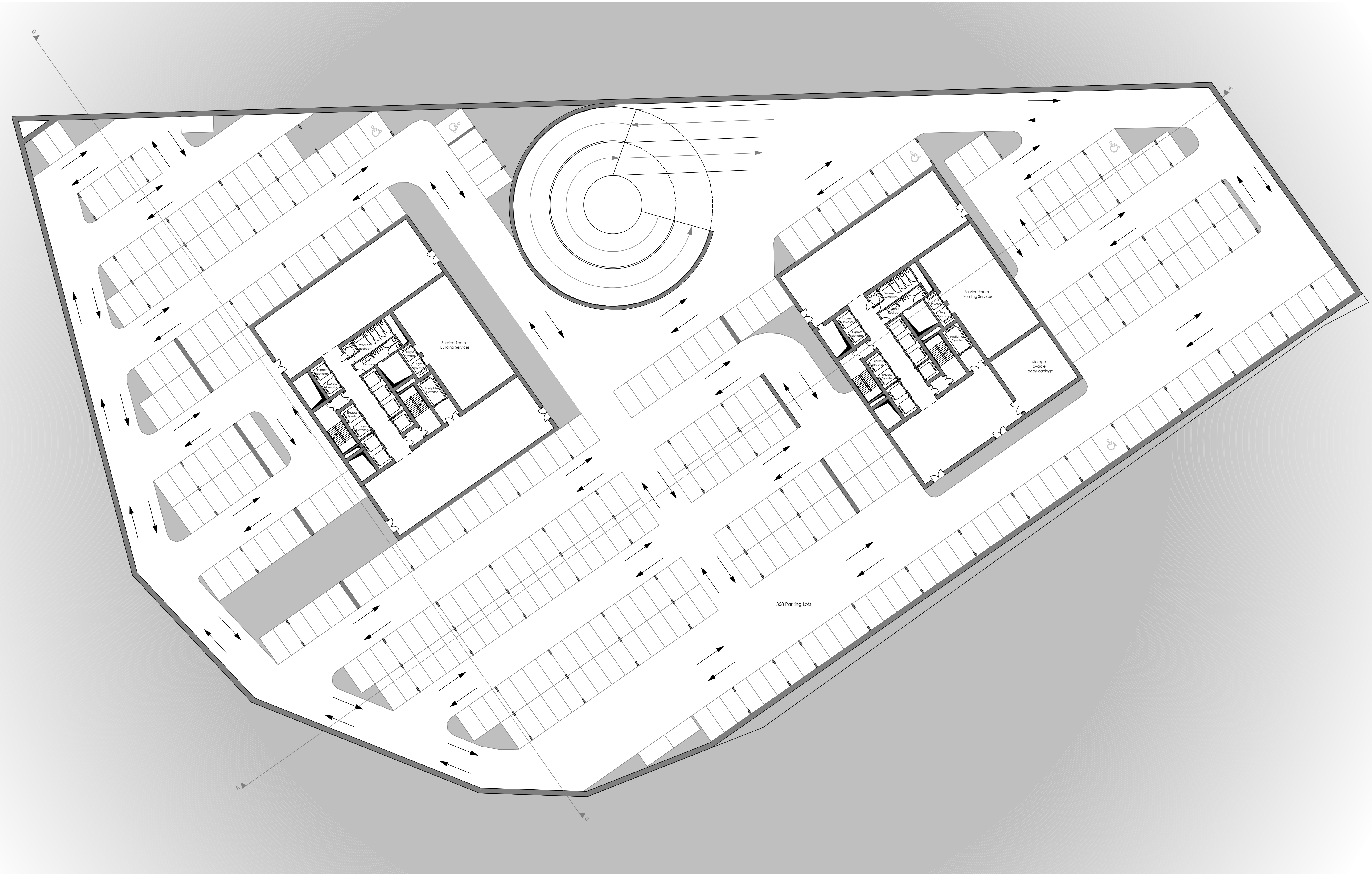

Deluxe Suite
84,55 m2
Superior Room
42,43 m2
Superior Room
43,06 m2
Superior Room
41,93 m2
Superior Room
39,88 m2
Superior Room
35,79 m2
Standard Room
31,94 m2
Standard Room
29,52 m2
Standard Room
31,80 m2
Service
40,65 m2
Fright Elevator
Fright Elevator
Express Elevator
Express Elevator
Express Elevator
Express Elevator
Firefighter Elevator
Junior Suite
44,31 m2
Deluxe Suite
66,60 m2
Junior Suite
44,78 m2
Deluxe Suite
93,93 m2
Business Room
33,99 m2
Business Room
34,18 m2
Business Room
34,42 m2
Junior Suite
62,16 m2
Superior Room
41,70 m2
Superior Room
42,61 m2
Superior Room
43,80 m2
Deluxe Suite
65,02 m2

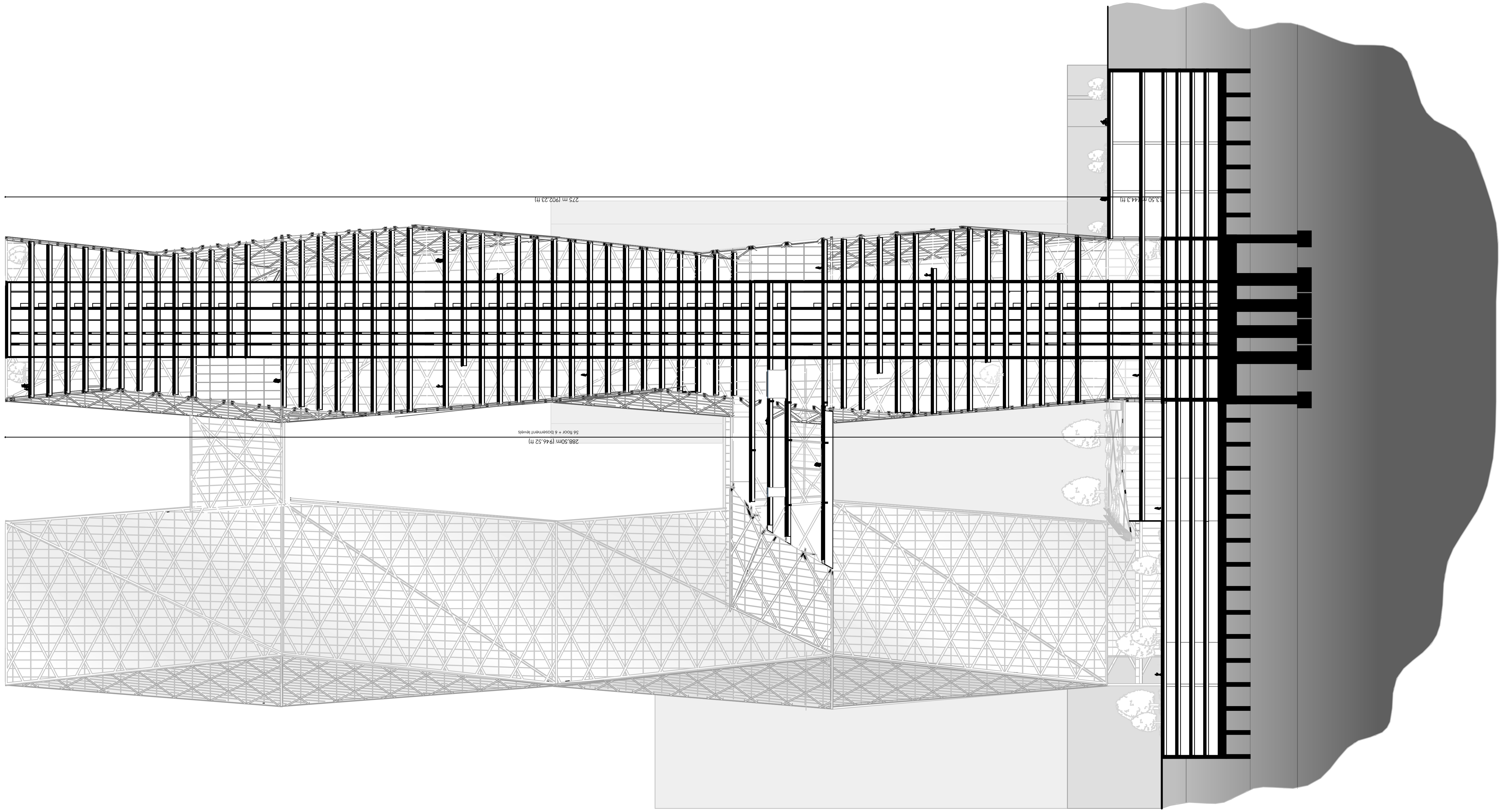

Conference Room
30,89 m2
Archive | Storage
33,89 m2
Copyroom
16,24 m2
Office
24,10 m2
Office
31,02 m2
Women's Restroom
Men's Restroom
Fright Elevator
Fright Elevator
Express Elevator
Express Elevator
Firefighter Elevator
Express Elevator
Express Elevator
Open-Space Office
1.185,94 m2

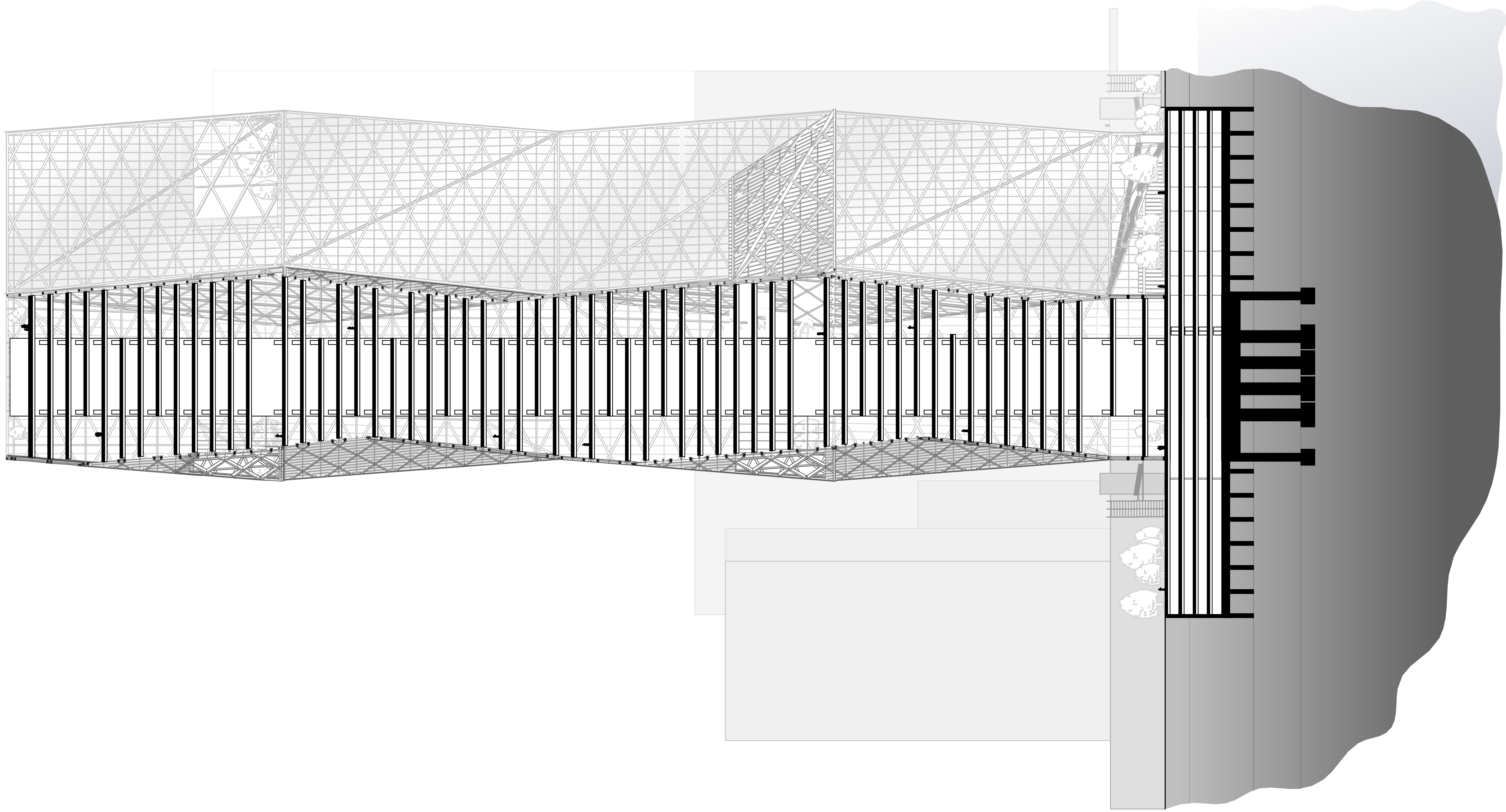

2 Bedroom Apartment 113,45 m2
Studio Apartment 49,26 m2
2 Bedroom Apartment 127,42 m2
Studio Apartment 34,29 m2
Service | Garbage 26,54 m2
Fright Elevator
Fright Elevator
1 Bedroom Apartment 88,13 m2
Express Elevator
Express Elevator
Firefighter Elevator
2 Bedroom Apartment 101,91 m2
Express Elevator
Express Elevator
2 Bedroom Apartment 123,87 m2
1 Bedroom Apartment 81,90 m2
1 Bedroom Apartment 77,93 m2
Studio Apartment 51,31 m2
Studio Apartment 56,64 m2
2 Bedroom Apartment 115,11 m2

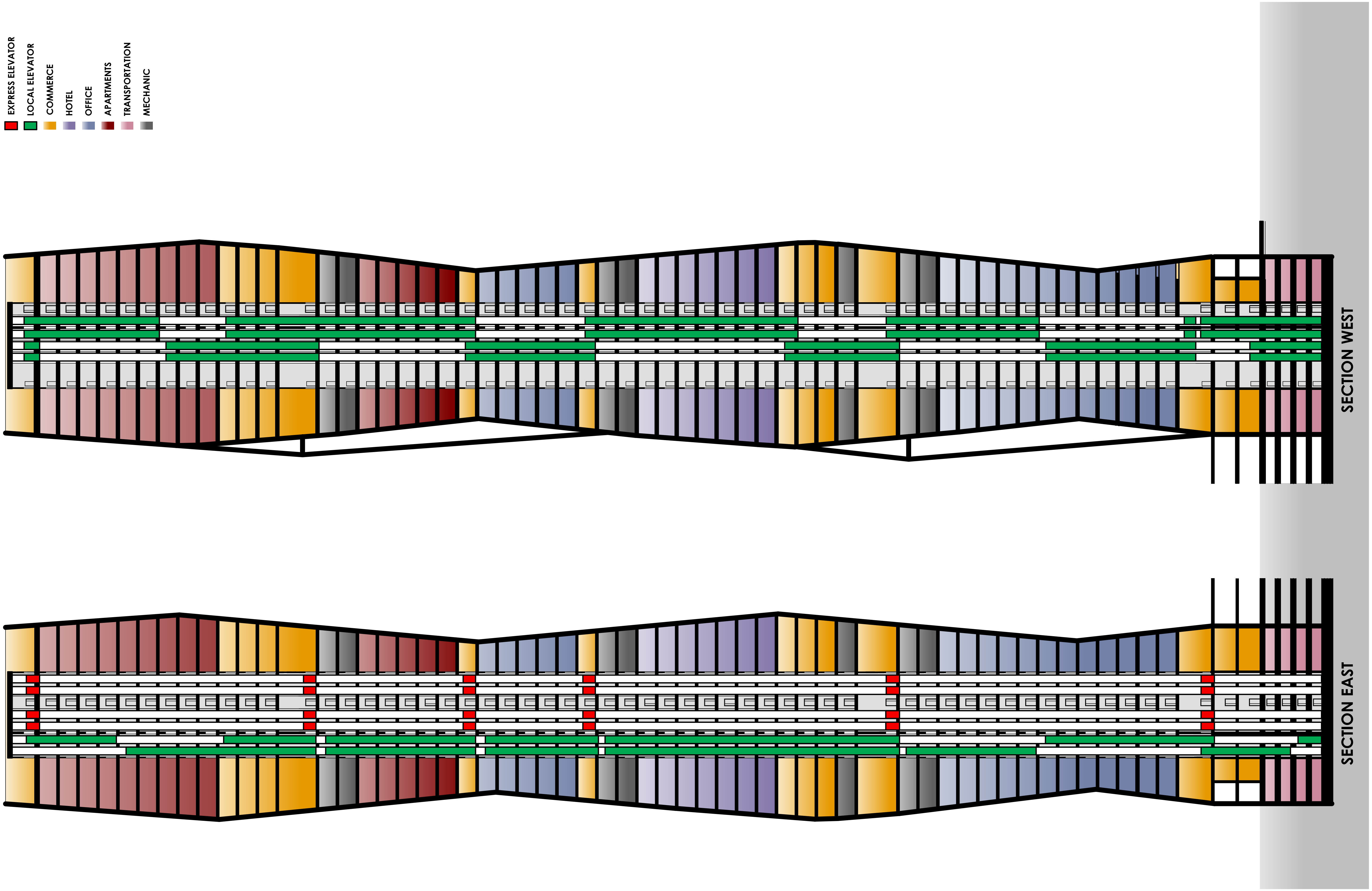

Roof Garden
1.209,47 m2
Pergola
Pergola
Pergola
Pergola
Women's Restroom
Men's Restroom
Express Elevator
Express Elevator
Express Elevator
Express Elevator
Fright Elevator
Fright Elevator
Firefighter Elevator
Roof Garden
1.209,47 m2
Pergola
Pergola
Pergola
Pergola
Women's Restroom
Men's Restroom
Express Elevator
Express Elevator
Express Elevator
Express Elevator
Firefighter Elevator


Riverwalk
Shop
Seating Area
Dressing Room
Entrance from Elevators
Entrance from Outside Stairs
SUNKEN PLAZA AT 2. BASEMENT LEVEL
Lobby
Terrace
Kitchen
Bar
Bar / Lounge
Platform
Access Ferry
Ramp
CHICAGO RIVER


Women's Restroom
Men's Restroom
Express Elevator
Fright Elevator
Firefighter Elevator
Service Room | Building Services
Storage | bycicle | baby carriage
358 Parking Lots

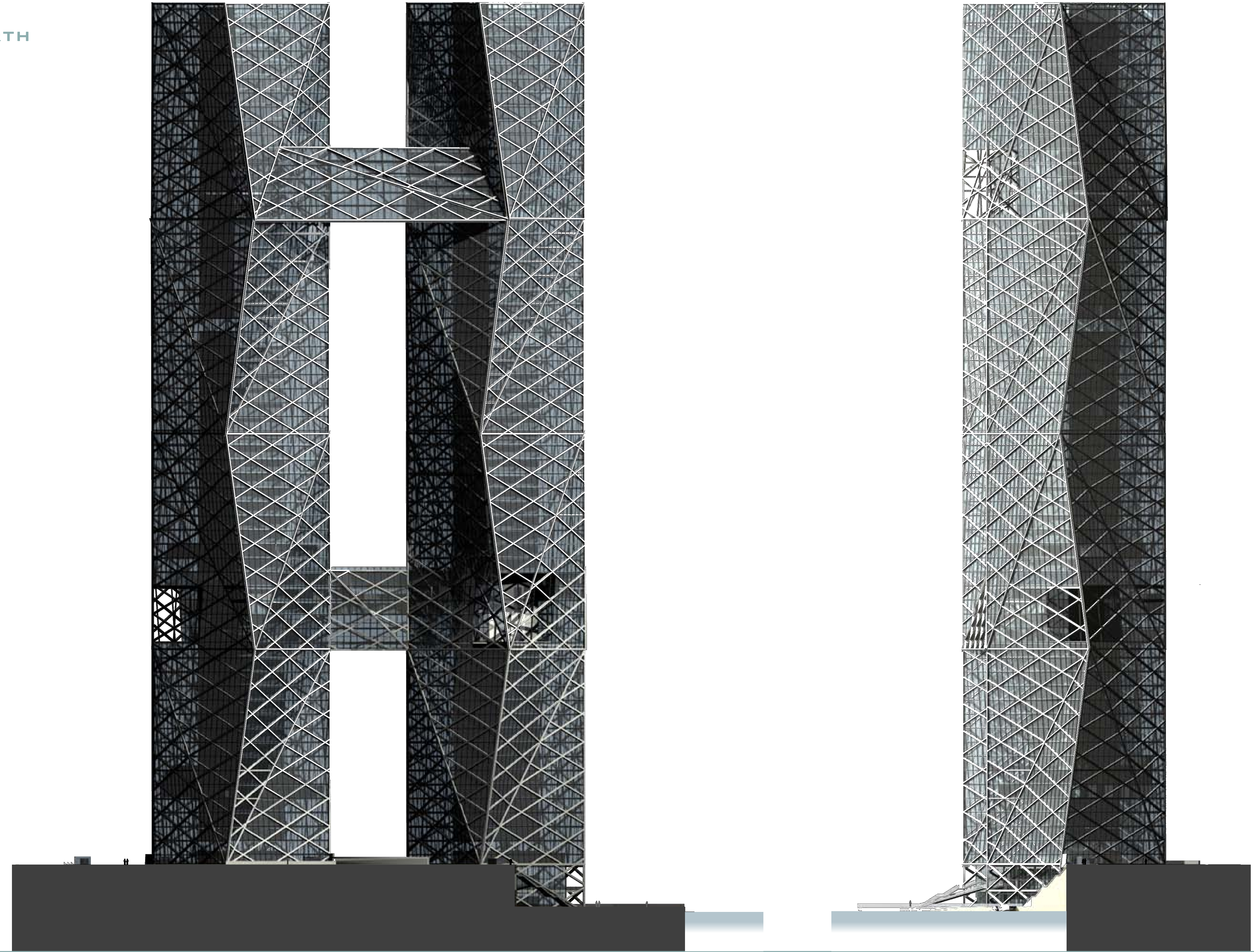

275 m (902.23 ft)
56 floor + 6 basement levels
288,50m (946.52 ft)



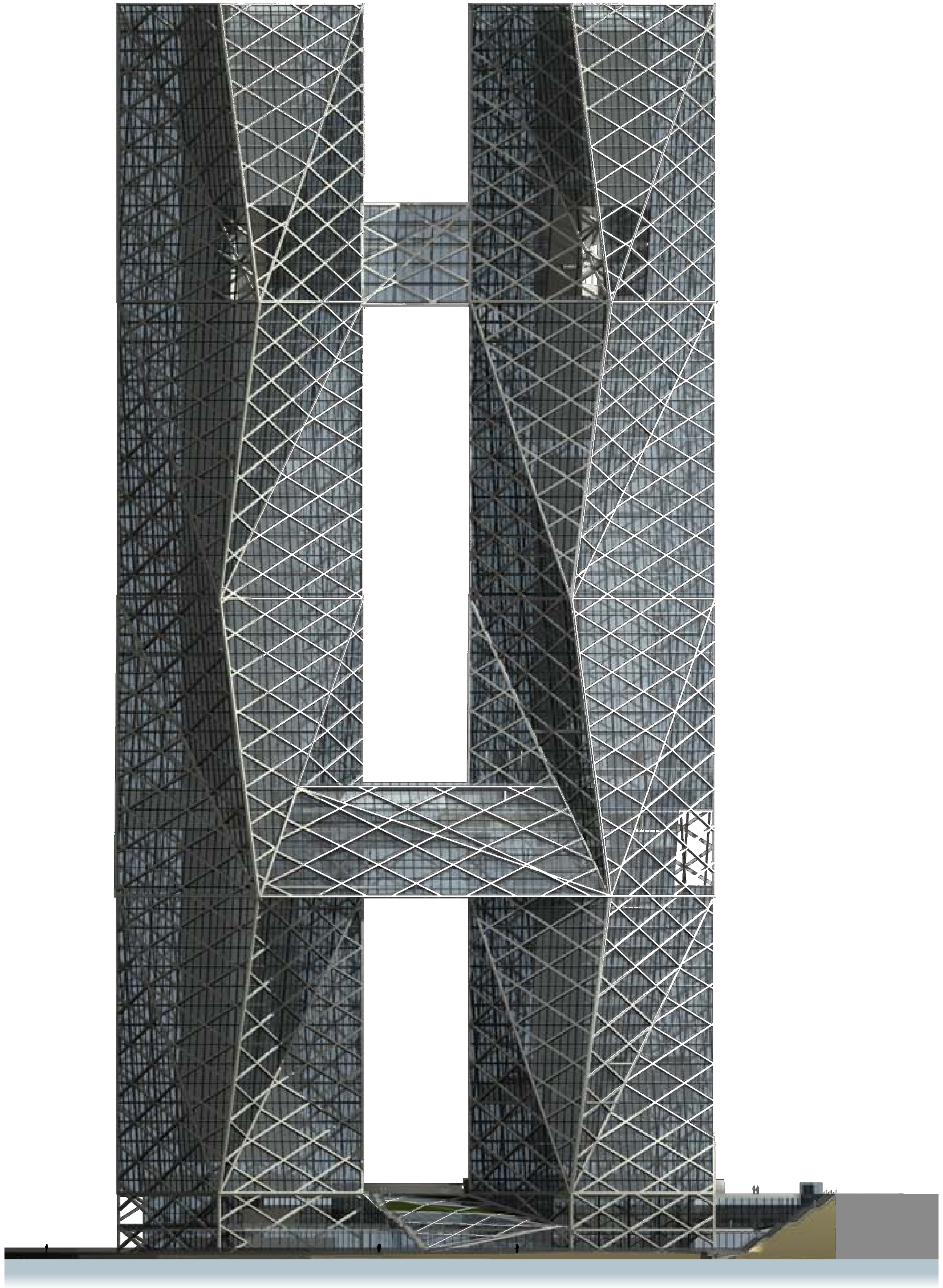

EXPRESS ELEVATOR
LOCAL ELEVATOR
COMMERCE
HOTEL
OFFICE
APARTMENTS
TRANSPORTATION
MECHANIC
SECTION WEST
SECTION EAST

NORTH

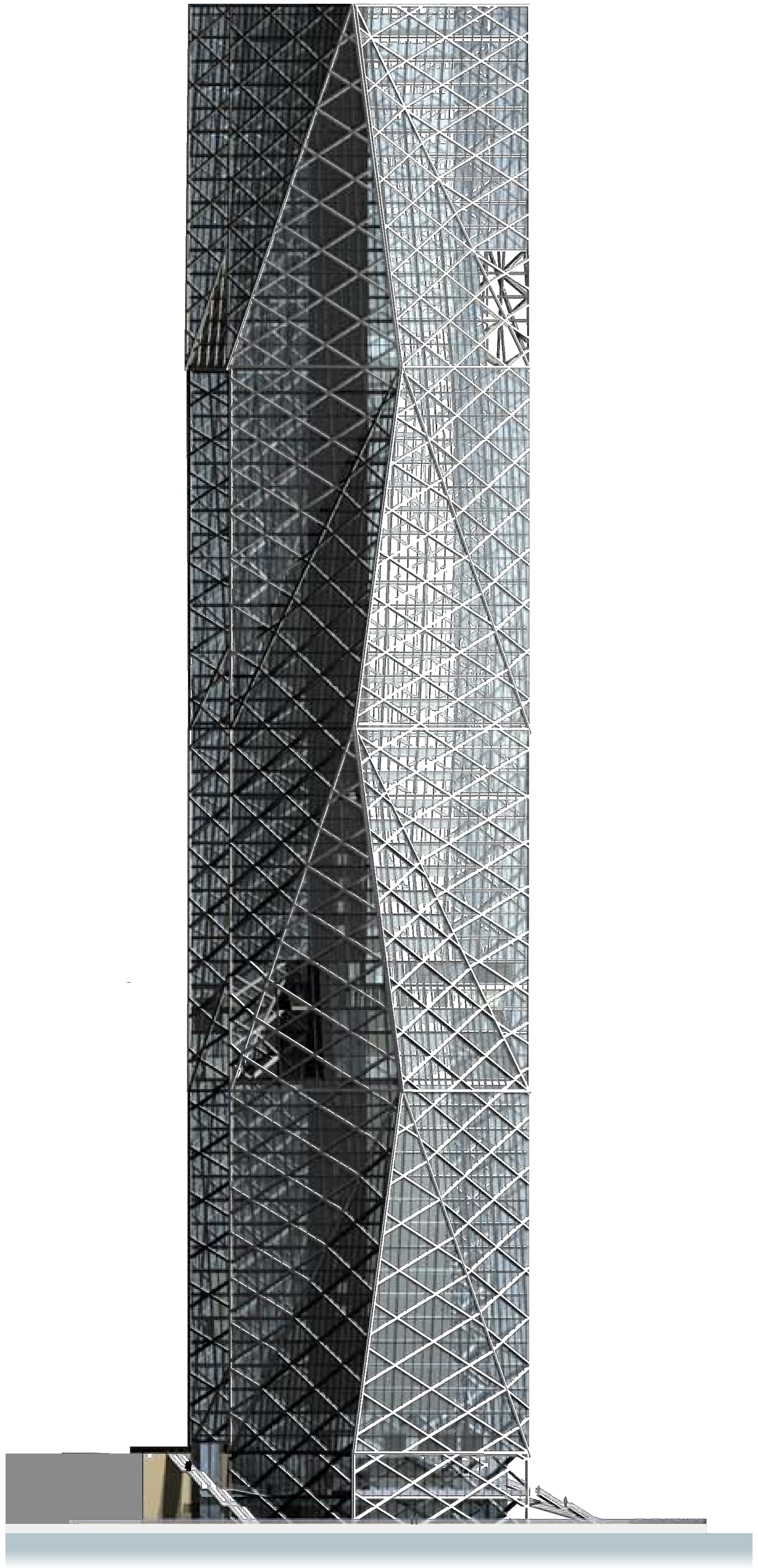
EAST

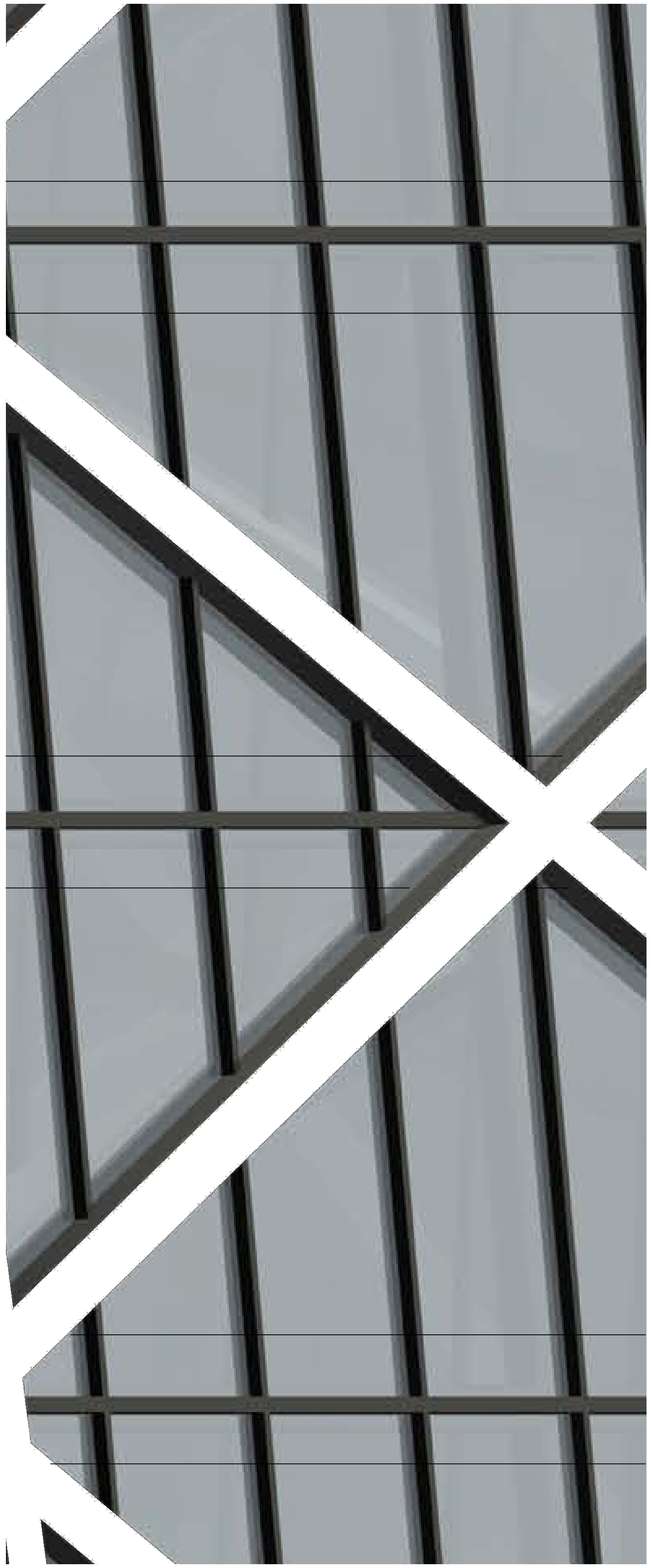


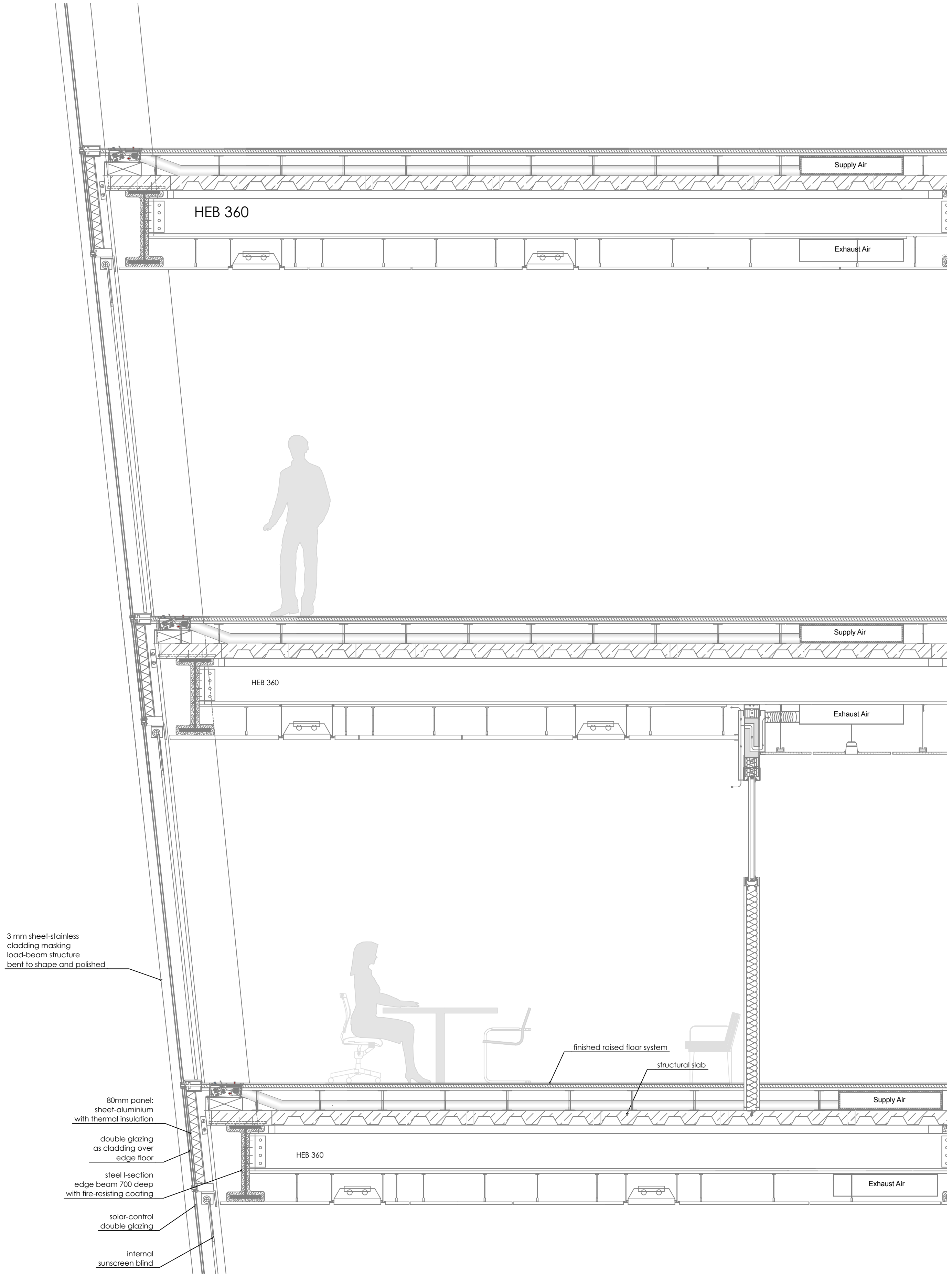
SOUTH

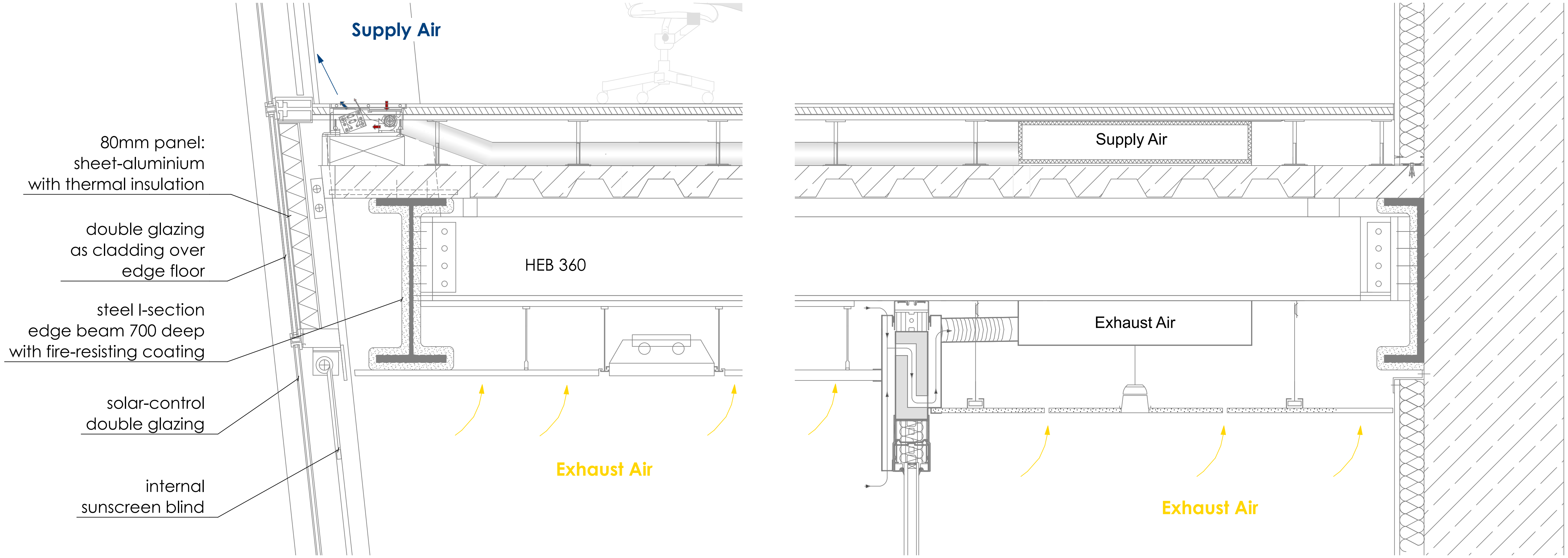


WEST

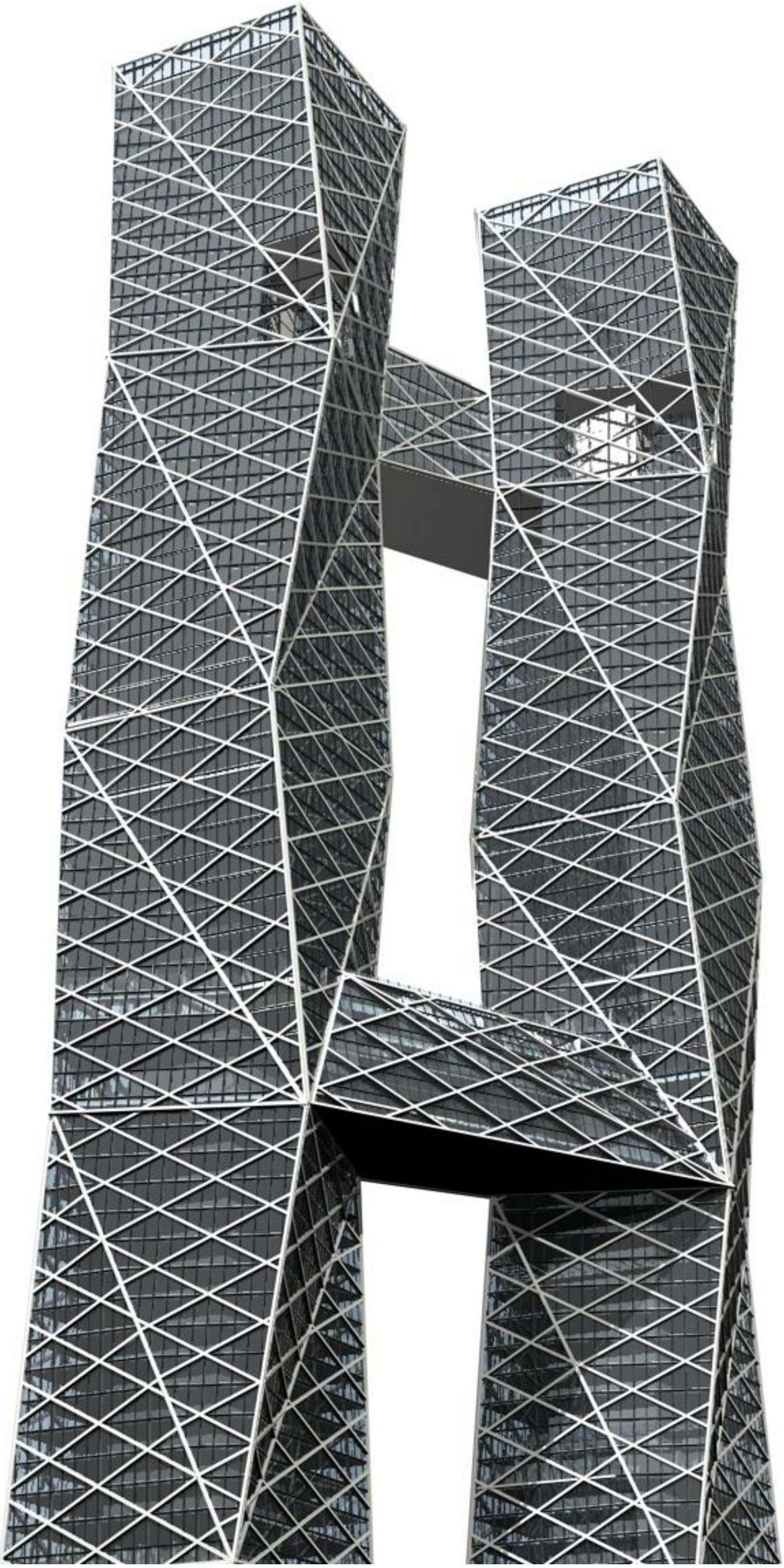


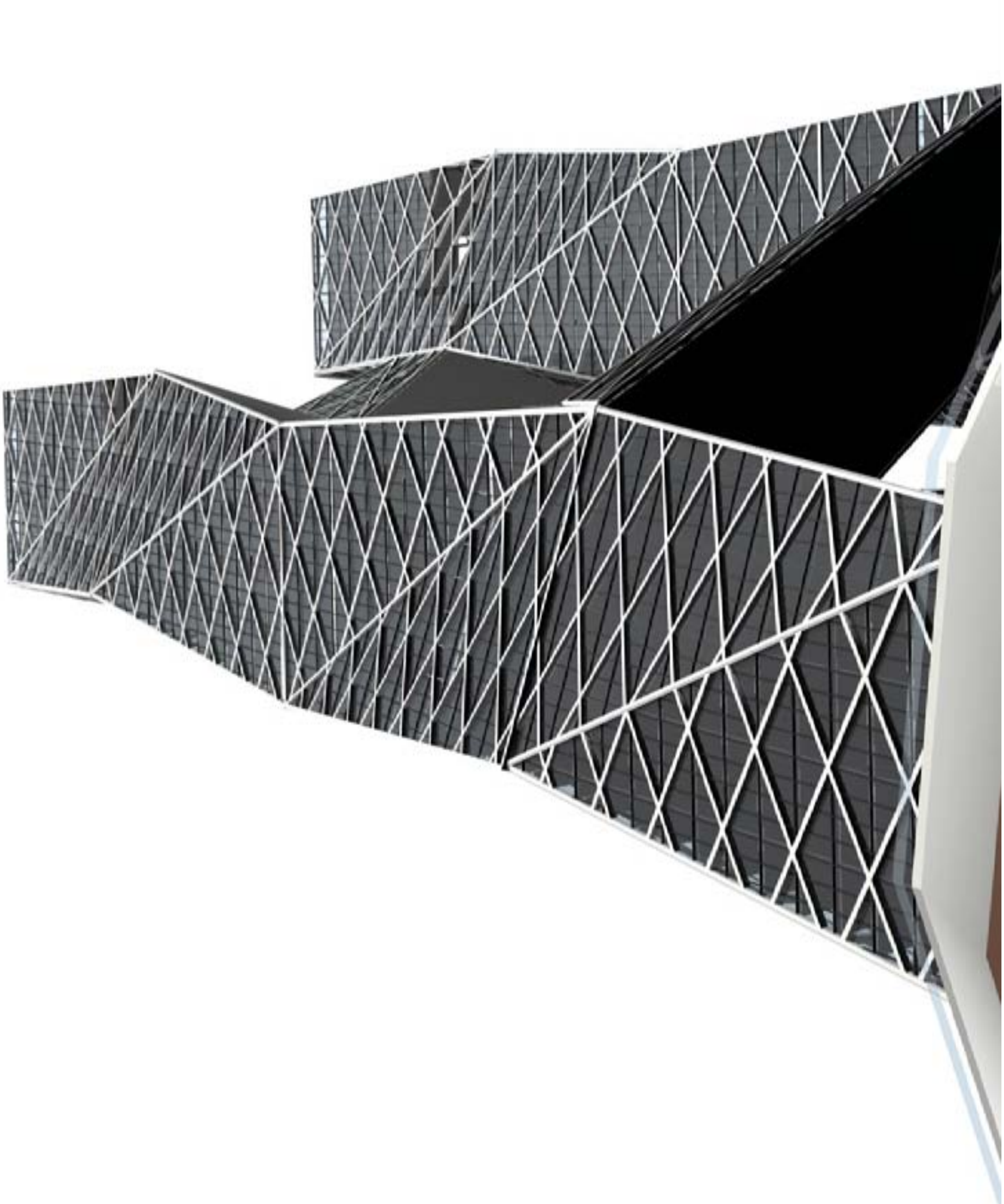


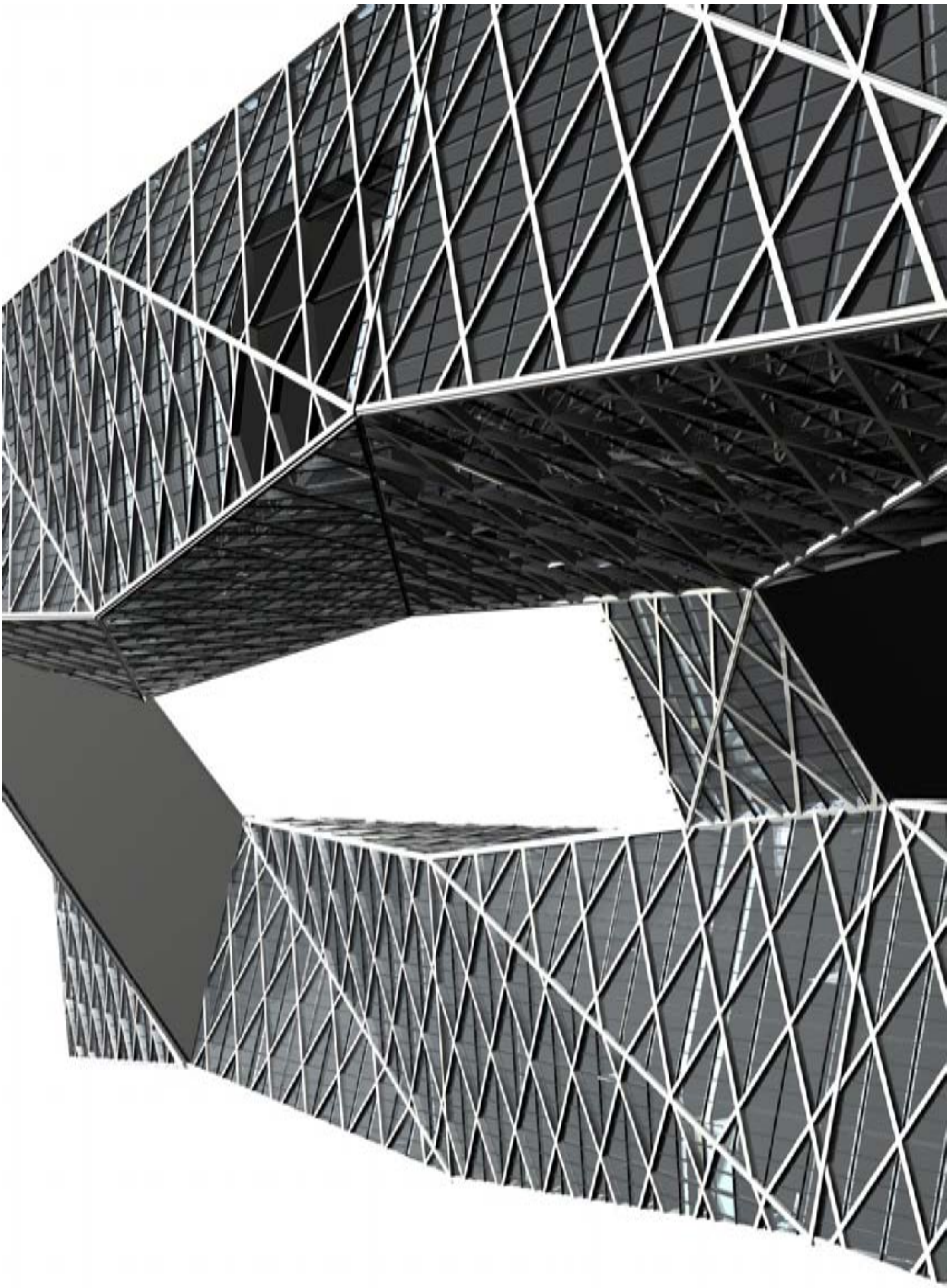

Supply Air
HEB 360
Exhaust Air
Supply Air
HEB 360
Exhaust Air
3 mm sheet-stainless
cladding masking
load-beam structure
bent to shape and polished
finished raised floor system
structural slab
Supply Air
80mm panel:
sheet-aluminium
with thermal insulation
double glazing
as cladding over
edge floor
HEB 360
steel I-section
edge beam 700 deep
with fire-resisting coating
Exhaust Air
solar-control
double glazing
internal
sunscreen blind

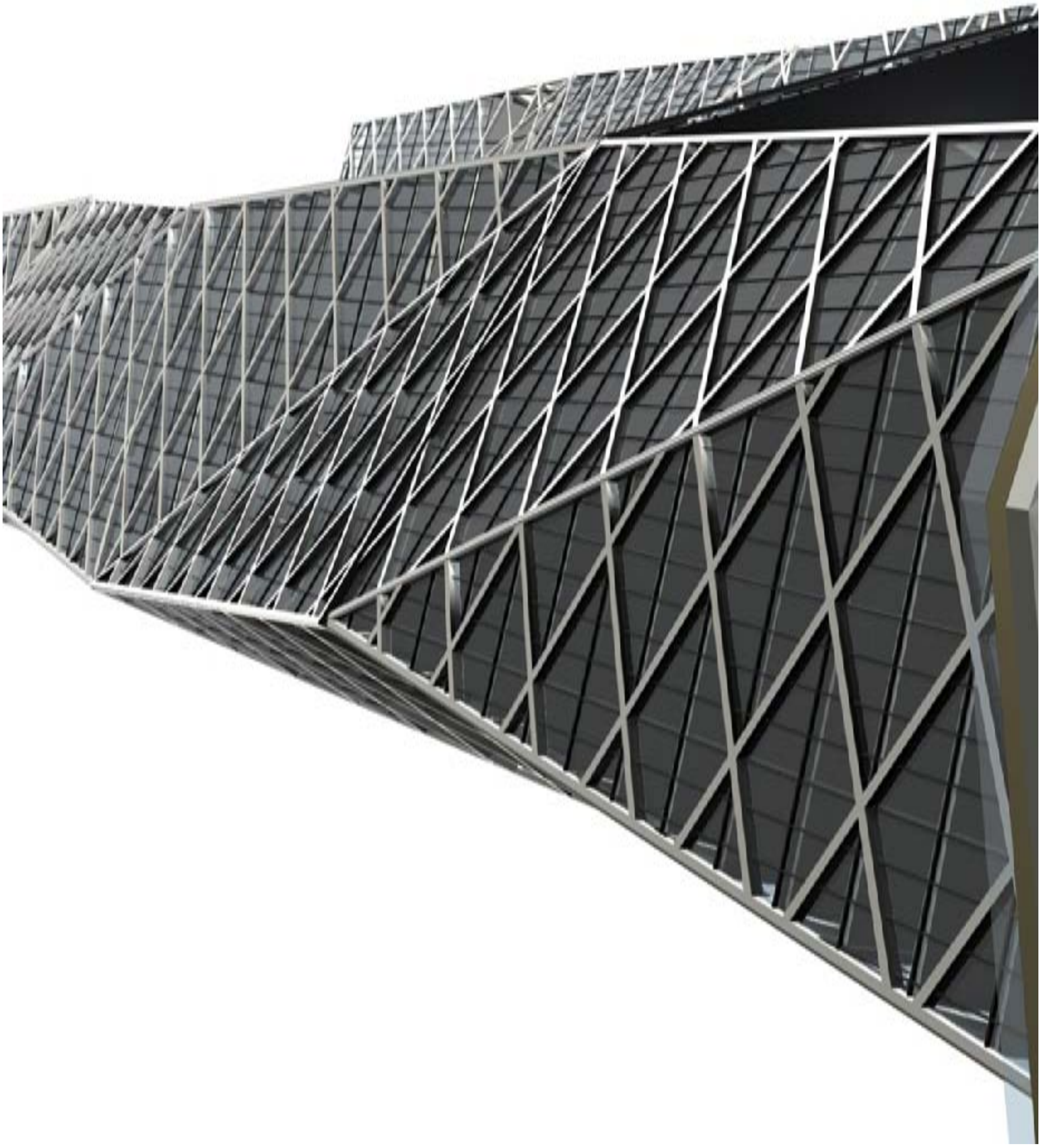

Supply Air
80mm panel:
sheet-aluminium
with thermal insulation
double glazing
as cladding over
edge floor
steel I-section
edge beam 700 deep
with fire-resisting coating
solar-control
double glazing
internal
sunscreen blind
HEB 360
Exhaust Air
Supply Air
Exhaust Air
Exhaust Air

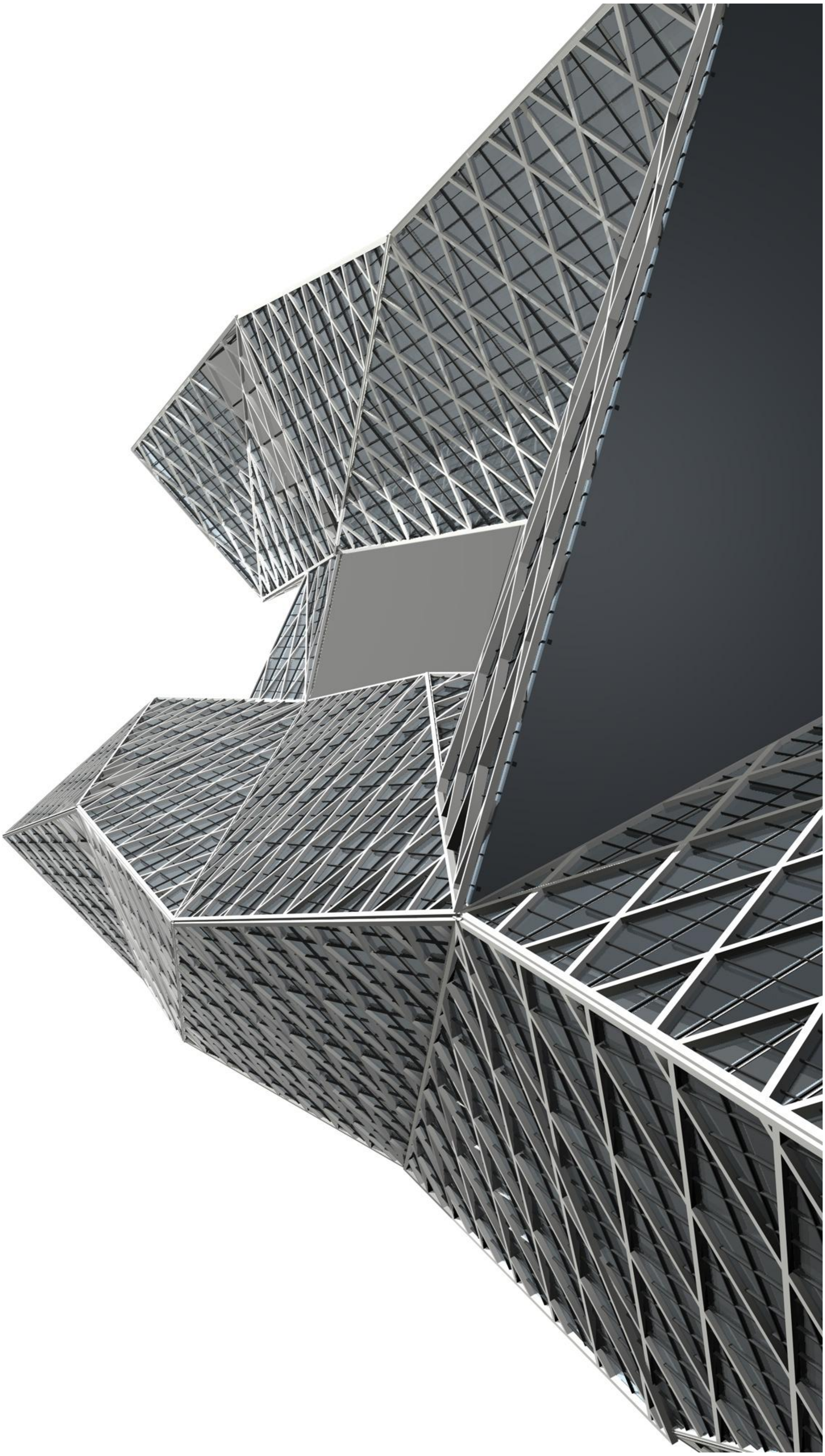
3. DESIGN

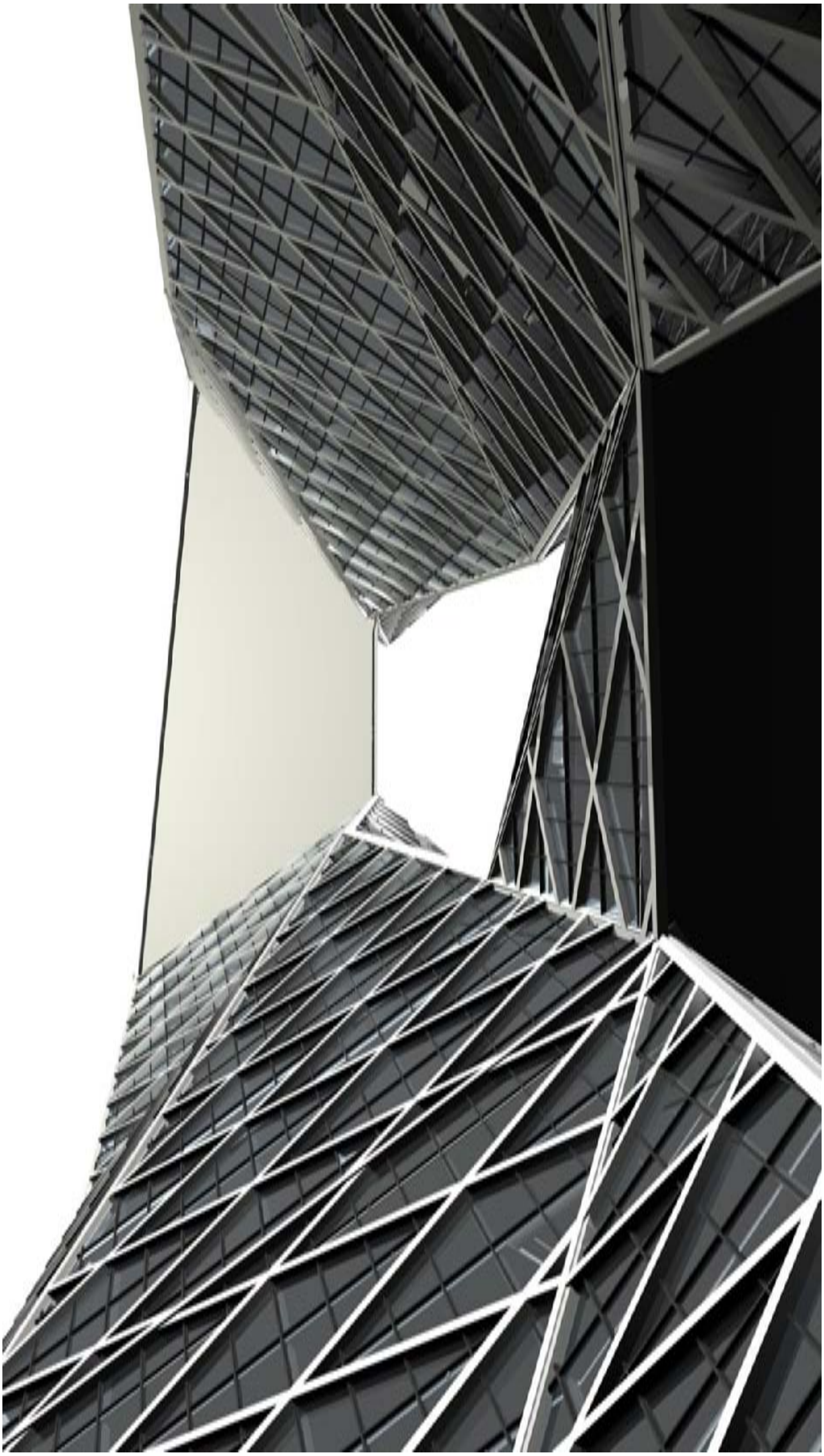


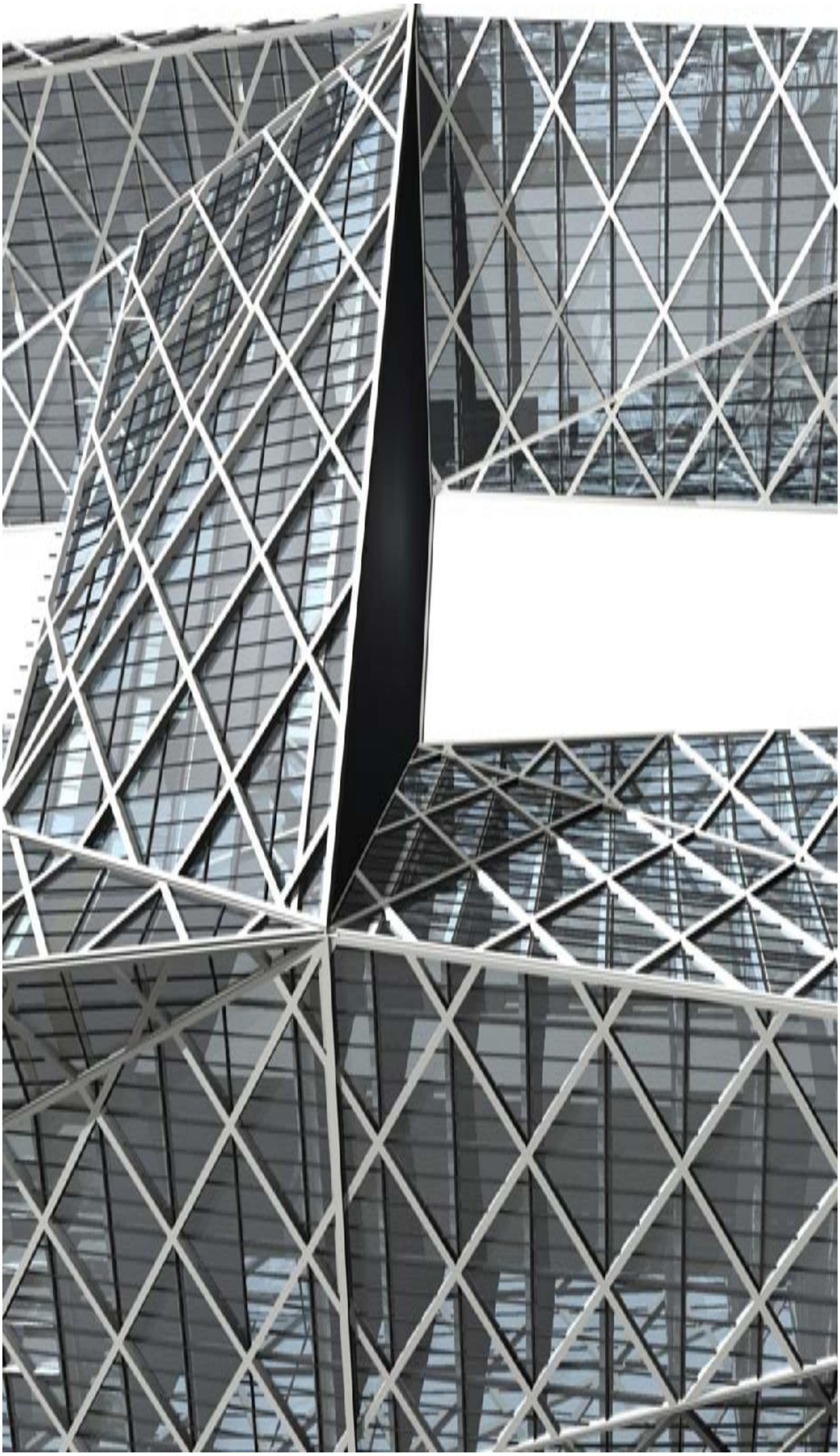


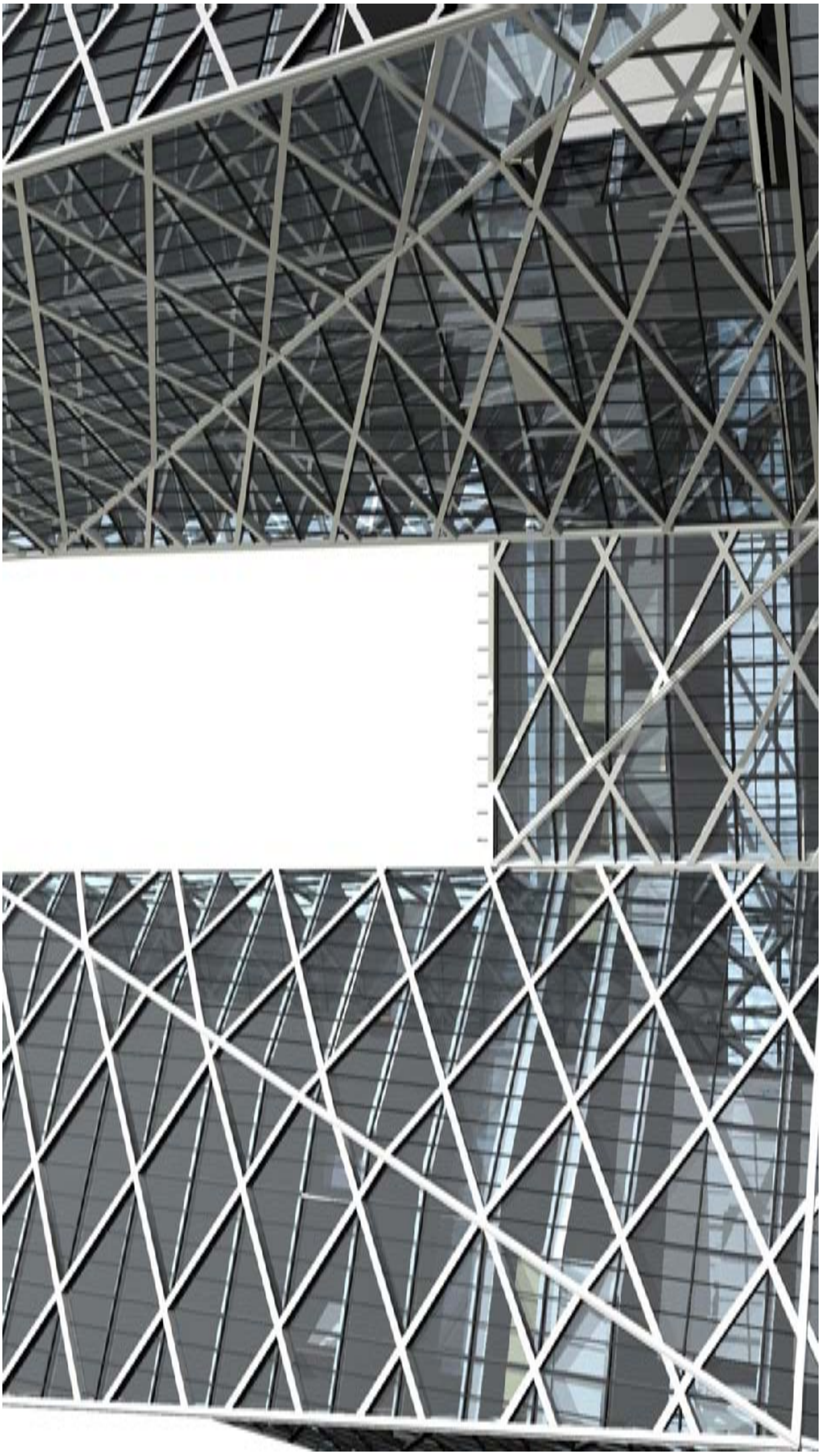


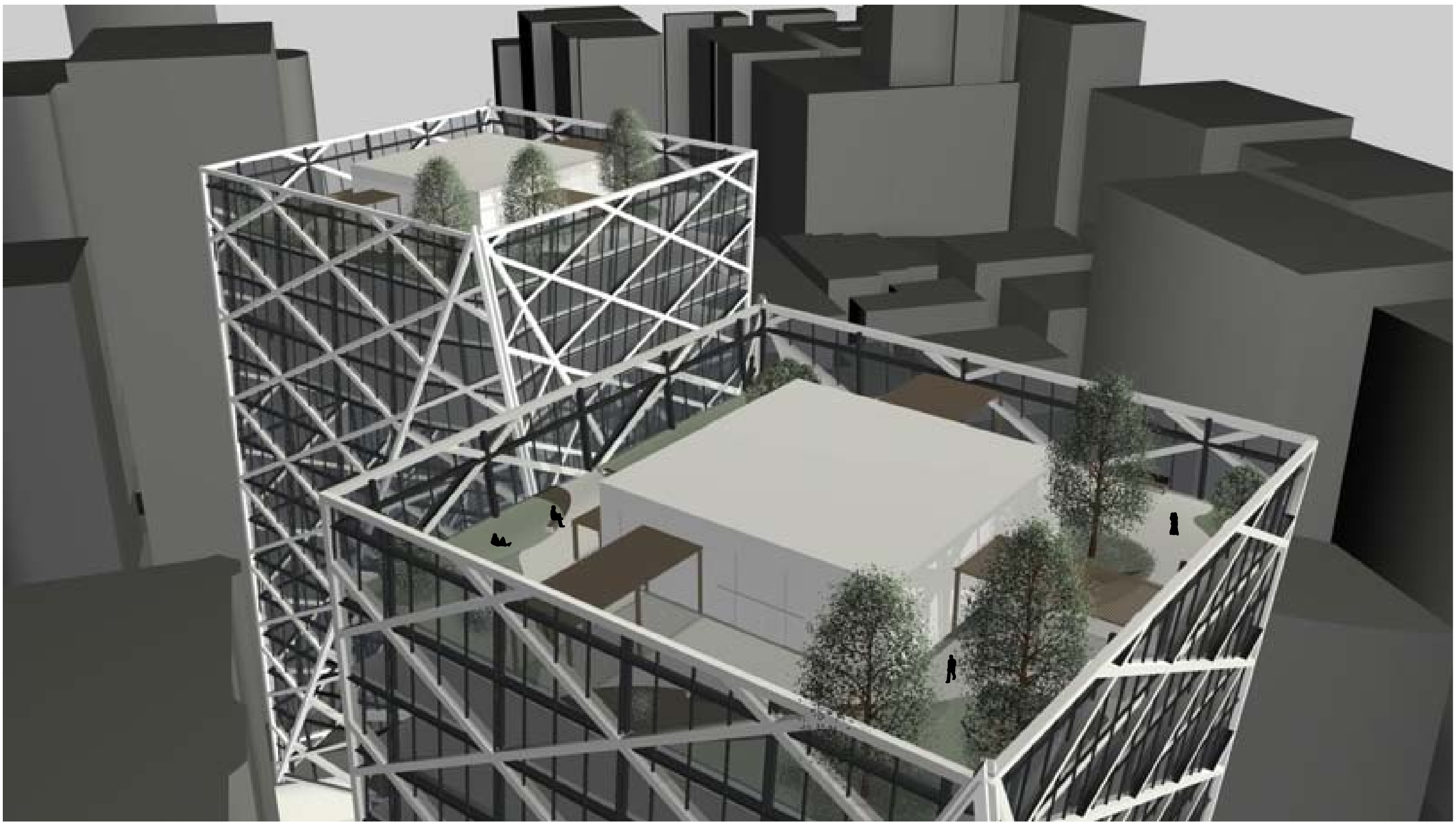


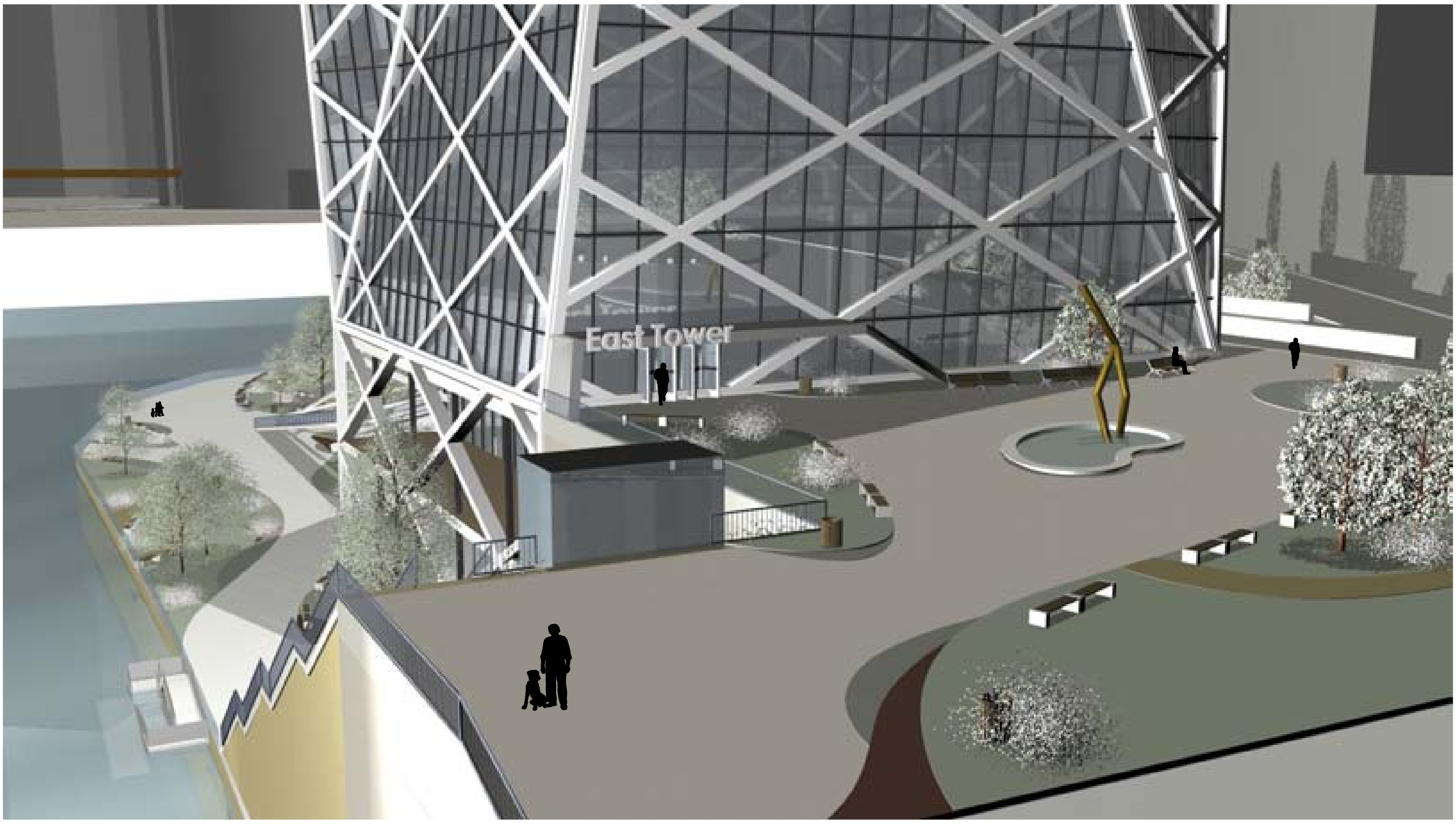











East Tower

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REFERENCES

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1.1. OVERVIEW ON THE AMERICAN HISTORY OF SKYSCRAPERS (1871-NOW)

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1.2. STRUCTURAL SYSTEMS OF SKYSCRAPERS

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http://www.aadip9.net/aras/20091007inland02.jpg

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http://2.bp.blogspot.com/-2UbLdSARe2U/ThgijMfucXI/AAAAAAAAACU/ZVU1dxAV2x0/s1600/Advanced+structural+forms.png

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2.1. DARK VERTICAL ELEMENTS

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http://www.buildyourownnewyork.com/SeagramBldgModel.jpg

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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SPAETH, David, *Mies van der Rohe: Der Architekt der technischen Perfektion,* Stuttgart (Deutsche Verlags-Anstalt), 1994 p. 170

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Photograph by Bianca Ottowitz

2.2. SPECIAL CASE: TWIN TOWERS – DARK VERTICAL ELEMENTS

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

FIGURE 4: LAKE SHORE DRIVE APARTMENTS – "GLASS HOUSE"

Photograph by Bianca Ottowitz

FIGURE 5: FEDERAL CENTER CHICAGO, FLOOR PLAN

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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http://www.urbandesigngroup.com/pages-portfolio/institutional-judi-govt.html#project-dirksen.html

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http://cribchatter.com/wp-content/uploads/2007/10/880-n-lake-shore-drive-_12h-livingroom.jpg

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2.3. BRIGHT VERTICAL ELEMENTS

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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ARCHITECTURAL RECORD, “Lever House, New York: Glass and Steel Walls”, Architectural Record, 111, June 1952, p. 132

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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CALLOW, Jeffrey A., KRALL, Kyle E. and SCARANGELLO, Thomas Z., "Inside Out", Modern Steel Construction, January 2009

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http://www.aadip9.net/aras/20091007inland02.jpg

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http://www.aadip9.net/aras/20091008lever05.jpg

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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Photograph by Bianca Ottowitz

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http://static.dezeen.com/uploads/2007/11/room.jpg

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http://friendsofwolfpoint.com/wolfpoint1875-large.jpg

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

FIGURE 19: 1 BEDROOM APARTMENT

created by Bianca Ottowitz

FIGURE 20: 2 BEDROOM APARTMENT

created by Bianca Ottowitz

FIGURE 21: STANDARD ROOM

created by Bianca Ottowitz

FIGURE 22: SUPERIOR ROOM

created by Bianca Ottowitz

FIGURE 23: BUSINESS ROOM

created by Bianca Ottowitz

FIGURE 24: DELUXE SUITE

created by Bianca Ottowitz

3.3. STRUCTURAL DESIGN

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

FIGURE 6: STRUCTURE MODEL WITH MAIN AND SECONDARY BEAMS INSIDE THE SLAB

created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

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created by Bianca Ottowitz

FIGURE 3: SKY-GARDEN

created by Bianca Ottowitz

3.5. PLANS

created by Bianca Ottowitz

3.6. RENDERINGS

created by Bianca Ottowitz