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URBAN SKYSCRAPERS:STRUCTURAL BEHAVIOR AND FUNCTIONALITY

CANDIDATO
Sara Seracchioli

RELATORE:

Chiar.mo Prof. Marco Savoia

CORRELATORI:

Chiar.mo Prof. Patricia J. Culligan
Chiar.mo Prof. Rene B. Testa

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PART I:

Functional analysis of Urban Skyscrapers

Introduction

Between all the kinds of building, the skyscraper is considered unique in its genre. Its structural shape, dominated by the capacity to distinguish this tall building flying over all the other types of structures, is not only the result of engineer or architectural studies, but also the establishment of new technologies and social and economic developments.

In fact, starting from the 1990s, with the economic growth new central and more concentrated business areas were born in the principal cities of the United States. As a consequence of that, the offices moved away from their locations, creating concentrated business spaces in the city center. Then the land values of those areas increased and the research in more and more advanced and technological materials followed the development. So all these aspects created the first ideal concept of skyscraper.

Skyscraper implies first of all a relationship with the sky, as well as the implied relationship with the earth. Also the advancement in the elevator technology arose with the global development of the tall building structure, trying to always better ensure a reliable and safer method of travelling vertically.

In 2002, William Pedersen defines the "skyscraper" in the preface of Eric Howeler's book “Skyscraper: Vertical now”:

> *“Throughout the world all major cities are now dominated by the tall building. However, only a relatively small percentage of these tall buildings can indeed call themselves ‘skyscrapers.’ Absolute height is not in itself a determinant or a qualification of the term. A proportional relationship of height to width, pointing to the very slender, is a more useful indicator. Even this is not a guarantee. Rather, for me, a skyscraper is defined by an aspiration, one that intends to link earth and sky. Therefore, by this definition, a relatively short building, such as the Woolworth Building, is a skyscraper. To my eyes, Hong Kong has more skyscrapers than New York. I view central Hong Kong almost as a fertile valley surrounded by mountains. The tall buildings appear to be growing like plan material from the forest floor, each striving like mad for the light and sky.”* [1]

The aspiration to connect earth and sky it is viewed as the construction of a vertical bridge, using the body of the tall building to combine the resources of both the city on the ground level and the “reachable” height of the sky.

But, as Pedersen said, skyscrapers are not only a matter of structural height.

In fact, a lot of other different terms are used within the description of the tall building construction and function. In order to simplify some correlations between them, it is tried to give a description of the most important ones. For example, within the definition of skyscraper’s function and use, a distinction between community and neighborhood can be made. The world “community” is defined more by shared culture and method of social interaction between a certain number of people without put a particular indication about the location in which this interaction is taking place. For instance, it can be considered community also the networks of many web sites which connect people from all over the world. The definition of the word “neighborhood” is more like physical manifestation of a community which wants to identify itself in a specific environment. Neighborhood is then characterized by a sense of proximity and vicinity.

Then, the vertical neighborhood is going to define a new extension of the city, giving to the skyscraper a different agglomeration of people’s form, including different facilities and public spaces, all in conformity with the respect of the surrounding environment.

In this research this argument will be treated in a detailed way, considering not only the social impact that a skyscraper can have within a city, but also its more practical connections with the city itself and the environment in terms of sustainability of the tall building. The function of the skyscraper and its history will be also discussed in the research.

Premises for a vertical theory

Following the development of this last age, along with the continuous and fast growth of the population and the need of meeting the more and more popular demand, many cities felt the exigency to upgrade their urban system. In order to do that, New York, Los Angeles as well as Chicago and London, are only examples of cities that have tried to redefine their inefficient existing urban plan into a new more high-dense, mixed-use, vertical and sustainable one. Across the world, cities which are not really known for their high rise buildings are now changing into a more urbanized and compact design of the city proper thanks to them, so the tendency for which the tall building is famous, which is gather all the people and their interest in a concentrated place, now becomes the same tendency of the whole city, with the idea that the tall building would help the city in reaching the intent to create a perfect new regulated urban plan. So the skyscraper is seen as the new element of the urban city transformation and, in relation to that, there is a try in getting past the more traditional officer, commercial and living quarters to a more unique stylish and up to date habitat.

Moreover, the first concept of tall building structure is still existing in the present, and although engineering has become more advanced and technical and it has helped in the development and construction of many of these buildings, the basic function and shape of them is not changed a lot from the realization of the first ones, in the 1880s, until the 1950s and the boom of the Modernism. More of them are merely a sequence of structural elements just piled one on the top of each other, without considering a possible design to accomplish the inhabitant's need, but only in a way to match the maximum profit. The end result being a skyscraper of the lowest quality, which did not

satisfy their occupants, but only put the financial investors money back in their pocket at a fast rate.

Consequently, there is the calling for a new and improved urbanized structure in the sky that will do more than keep the occupants within it but also make them happy, both in their work place and their residences. This structure has to offer all the facilities which can satisfy all people wants and needs and at the same time it does have to attract them. So it does not have to be repetitive, modular and without care about its spaces design, but for example it has to give the feeling to stay in open space or park, even though in the reality of facts people are thirty storeys above the ground.

The skyscraper is then a complex structure which has the difficult task to move up into the upper floors everything that can be done on a ground level, maintaining the same feeling of normalcy. In a certain sense, it would or could be a city above a city, more urbanized and much different from the existing high-rise buildings that now occupy with the basic look and functions the principal business districts of the most important cities.

With the tall building there is the possibility to build in the vertical direction, in a way that the residential and business districts upraise and become visibly more compact, avoiding the more and more persistent problem of the city sprawling caused by the continuously increment of population. So the verticalism becomes the innovative element of the new urban design.

So what went from considering the verticalism as an idea to urbanize a district is no longer just an idea, but the new way to build. In this new urbanized way of thinking, the “idea” is and would be a prerequisite for more urbanized skyscrapers, a vertical addition to the already existing “skyscrapers upper city”.

In order to result really effective, the vertical skyscraper design requires to be viewed thoroughly from every aspect and standpoint. While at the same time make sure it can and effectively will accurately accommodate our generation, as well as the future one, to come and still meeting the needs of urbanization. Moreover, social, economic and environmental factors have to be considered, as well as the effects and the benefits that the structure can have on all the surrounding area.

These many channels that make up the building process have many regulations which serve as requirements that must be met to begin the construction. For example the urban designed skyscraper should:

- Have a preliminary drawing with detailed patterns of floor unlike any other.
- Give a sense of connection between all the spaces within it and between these and the outside environment.
- Access to essential areas that contain appealing and attractive meeting points, both indoor and outdoor spaces.
- Easy accessibility with the proper direction to or from the prosperous area without generating confusion or overcrowding.
- Have really simple maps of rooms function and location in order to render itself more understandable and adaptable to other functions in the case there is the need to satisfy other needs.
- Create more different options than possible, like different kind of facilities, offices and size of houses, in order to emphasize the mix-use and to take advantage of more and more alternative choices.

With urban creativity comes also the responsibility of providing enough space for the high rise building as well as good access to the surrounding streets. Then the skyscraper's design influences all the area around the building itself, determining how enjoyable can be the whole zone.

For instance, the combination of multiple tall buildings one next to each other can also create an uncomfortable environment into which have a walk or simply spending time. For example, if a skyscraper is really close to another one, the width of the street that separates them can determine how much shade will be in the area or how the sunlight may reflect from structure to ground.

The proposed explanation is very much needed, especially because the increase in population is unstoppable. The skyscraper structure is famous for providing so much more space.

Instead of taking up a whole city block with private homes it is possible to take each resident and move him into skyscraper floors and so create more horizontal areas for other activities. Also, looking at the interior space of the tall building, the areas can be utilized and optimized in many ways in order to accommodate a huge number of people. With the option of maximizing instead of minimizing the amount of space in the structure, the creative control would vertically have no limits.

Instead of having the same repetitive look, the designers can now give to each floor something different as well as new. It is possible to have some floors that serve the public needs and other floors may be business or residential, and at the same time very original and unique in their design.

What then happens with the new design proposition is that everything it is possible to find on the ground level is all incorporated into the skyscraper. With their newest innovative design, skyscrapers would have multiple parks on different floors, with open air spaces in the same way as on the ground level.

The high rise building would in a sense create a world within itself. It could create a neighborhood inside a neighborhood, in which everyone knows each other on a first name basis. It would give its inhabitants the feeling to belong to a real community.

So what it has been looking for is an efficient design that meets the needs of the oldest skyscrapers, but given it a twist or an added flavor, something that can change how the previous skyscrapers are built. In the past, most of skyscraper designs could not offer anything more than walls and rooms of no substance but just a living or an office space. The designers were focused on satisfy the real estate financial needs, instead to build the structure and at the same time be very creative taking advantage of all the vertical space available to them. They usually designed one floor plant and they repeated it for all the level of the tall building, without think if it really was the best way to occupy the entire space offered by the structure. Moreover, after that the most important elements of the floor plant were established, like the elevator core, the stairs and the structural grid, the design was already considered satisfactory and very few attentions were given to details and design variations which could qualify the generic tall building.

So instead of the focus being kept on the building and making it better and better, it was just about the initial investment. As well as securing tenants to occupy the building. The building then became the average skyscraper instead of a new more refreshing style

which would also drive more people to the building itself and not only grab their attention but keep it as well.

Nowadays things are different. Designers make projects about the future skyscrapers which have to provide quality of life and vitality also in the upper floors of the cities, giving the possibility to people to socialize as they usually do in a square or in a plaza of the city center.

Therefore, much attention is given also to the organization and the correlation of the functions within the same building. For instance, in order to render more desirable making use of the tall building, a communal office cannot be placed on the top floor of the skyscraper, because people feel more uncomfortable to reach it. Instead, the residential houses can be easily placed on the upper levels to maintain the privacy of their inhabitants.

Also, the sense of the aesthetic is becoming more and more relevant for the design. In fact, on the contrary to popular belief, when one takes notices of a beautifully constructed skyscraper with remarkable facades, they also believe that in this structure there is a world which is hidden from them, that they are curious to explore.

After a series of analysis the question now becomes:”does this skyscraper meet up with the imagination?” Is this “vertical world” urban enough? Does it offer the basic facilities? Does it accurately meet the needs of its occupants? A building of this magnitude would need everything that the skyscraper of old did not possess as well as what it already possesses. The urban skyscraper would have and need to exude life.

Skyscraper geography

Geography is one of the most important analyses which can provide the interdisciplinary interpretation of skyscrapers interventions in the urban context. The versatility of geography provides a series of critical perspectives that might explain the prevalence and significance of skyscrapers. This is because the geographic study of the high-rise building usually considers not only its location (the distribution of tall buildings in the different cities of the world), but also the quintessence of everyday life around it, the space usage, and the analysis about its financial and physical flows, providing a motivation for the existence of the building itself.

From some studies related to that definition of skyscraper's geography, it is possible to analyze three principal aspects: the economic one; the interaction between the tall building and the infrastructures and how they can create more mobility and flow around the building itself; the social condition of the people that make use of the building.

As it is possible to deduce, these regard primarily the geographical location of the city in which the skyscraper had to be built, the social status of the people that were living in the city, the general economy of the place and the environment of the area.

Economic aspect

Since their first realization, skyscrapers have always been seen as a typical building with the residential use as its main purpose. In all the countries of the world, this kind of building maintains the same aim over the years, until 1930's, when they started to have also commercial and office use.

According to the objective point of view of the modern era, whatever kind of use destination the building actually has, the economy of a metropolis related to a specific high rise building beats about the amount of people that the structure can host and so about the density of occupation that the tall building can provide.

As a matter of fact, nowadays it is more and more difficult to increase the dimension of a city outside its external boundaries, and there is the need to create more central nodes of attraction in the city center. Consequently, the skyscraper is the structure that permits to densify the heart of the city without occupy large horizontal areas of it.

Considering for example the office destination, the densification of working areas permits to connect a lot of offices and to easily run from one to another in a more efficient way, obtaining information and creating meetings faster and promoting the collaboration of the groups. This clearly leads to an economic improvement, not only for the workers, but also for the city itself.

What is also very important to underline, is the economic value that the tall building can possess. If the tall building is able to manage its destination of uses and to offer new opportunities for living the city, it will attract more and more people, and consequently it would acquire a bigger real estate value. Then, the economic value of the structure increases the one of the surrounding area, and of the city itself.

With important and captivating centers of interest as can be the skyscrapers, the worth of the whole city can grow and catch the attention also of foreign investors and business manager, or residents that want to make sure to have an apartment in one of the most flourishing city areas of the moment.

A clear example of that is the city of Dubai. There, after the evident decreasing revenues given by the oil and gas reserves, the investors realize that the only way to increase the city economy was based on the tourism and on investing money into the construction of enormous and fabulous structures, which have no connection with the surrounding environment but that, at the same time, they could attract a lot of foreigners thanks to their magnificence. The result of that are the construction of the tallest hotel in the world, the Burj al arab, and of the Burj Khalifa, the largest skyscraper of the world still under construction.

Figure 2- Burj Khalifa, Dubai

Figure 1- Burj Al Arab, Dubai

Moreover, with the same intentions, Dubai also created a complete artificial archipelago, called the Palm Islands, whose residential properties over the Persian Gulf were already sold out even before the start of the project also by famous actors and international jet set people.

Figure 3- Palm Island archipelago, Dubai

Thanks to these mega construction design and projects, Dubai is now considered one of the most attractive and innovative places in the world. The proof of that are its data about the increasing tourism, which is giving to the city a revenue growth of the 37 per cent in the last five years. Nowadays, the real estate and construction investments represent the 22.6 per cent of the whole Dubai's economy (the bigger percentage respect all the other parties, like trade, financial services, gas revenues and others), and this can be an explanation of how the skyscraper's structure can be really involved in the whole city economic development.

Connections and infrastructures

The skyscrapers usually have complicate connections with the surrounding areas. As they are defined as important nodes of attractions for the city, not only simple roads, but often highways and the principal subway's lines connect the structure with all the parts of the city. The skyscraper has to be reachable from everywhere and in different ways. So the existence of a skyscraper clearly modifies a lot the regulation traffic plan of the city itself.

However, it usually happens that not all the different kinds of connections can be used by all the population, which is characterized by different social status and needs. So, for example, if the highways have a toll price, they are used only by an inner circle of people. The idea of the last urban planners is to try to collect people through an underground infrastructural system, which can be considered not expensive for the major part of the people and at the same time it can reduce the congestion on the ground level of the building, increasing the value of the structure itself and of the surrounding area.

A possible example of that can be the connection of " La Defense" with the center of Paris. La Defense represents the main business district of the city, and it holds many of the tallest buildings of the whole urban area. It is like a compact concentration of business skyscrapers, which raises up in the middle of the more lower traditional Paris neighborhoods. Its global urban planning emphasizes the reason why the district is considered the largest purpose-built business district in Europe.

Figure 4- La Defense district, Paris

Considering its connections, La Défense is less than 15 minutes from the heart of Paris. The exceptional level of service that the designers planned for this connection explains the success that this business district is enjoying with a growing number of companies. Thus, 85 percent of people working daily in La Défense use public transport - the business district has an exceptionally dense network of means of transport. La Défense is accessible by an efficient metro line system, which crosses Paris from east to west, and which has two stations in La Défense district. This accounts for about 100,000 passengers a day. Also, the RER (High Speed Network), which also provides an east-west link at the regional level directly connects La Défense to the Etoile district in Paris in less than 10 minutes. Moreover, in addition to the common road and tram paths, there is also the SNCF Train “Transilien”, which connects the Paris Saint-Lazare station to the hubs of western Paris via La Défense.

Another example of good infrastructural connections relating to the skyscraper is in the city of London, where the projects of new high-rise building areas required only the minimum space for parking space and consequently they try to move all the congestion to the underground subway infrastructures. Recently permitted and constructed London schemes such as the Pinnacle, have sought to integrate pedestrian routes through the sites which reflect the distinctive pattern of alleyways that characterize the City, connecting them with the principal subway stops nearby.

In conclusion, it usually happens in some cities of the world that a skyscraper or a high rise building district, as an important nodal point of attraction for the city, can have a proper subway stop or sometimes even a proper highway exit.

The main consideration that it is possible to deduce is that the relation between skyscrapers and infrastructures within a city urban plan is a kind of cross-correlation: if a skyscraper becomes a nodal point of attraction for the city, then it will need much more number of connections towards itself; on the other hand, the infrastructural connections towards the tall building are one of the principal elements which actually render the building an attractive nodal point for the whole city, facilitating people into reaching the building itself.

Social aspect

The economic aspect of the skyscraper and its connections analysis can be correlated with the different kinds of people that make use of it. As it has been said before, especially in this age the high rise buildings have been seen as important nodes that

connect the most important parts of the city one to each other. They are neuralgic points of attraction, usually linked by highways or subway' lines that cross the metropolis from one side to the other, which need to be reachable from each part of the city itself. However, the major part of the times, not all the people are able to easily arrive to the building. In fact, because the major part of times the building is built for important economic and financial companies, the worth of the building is elevated and consequently the main and more advanced infrastructures that connect it with the rest of the city are not tax-free. This leads to the fact that the most favored users, the ones with a higher standard of living, can better make use of it.

However, while tall buildings structures are often viewed as the more frequent habitat of the elite social class, such as luxury hotels and penthouses, they have also been associated with humbler forms of social housing, underlining its alternative more democratic design, the one that was often used as a justification in the development of the high-rise public housing form.

There are many other reasons why it is important to consider the relation that the skyscrapers have with the society.

For instance, even if the general idea about the skyscrapers is that they are one of the best representations of the capitalist system, there is also another general way of thinking by which tall buildings give both a sort of identity to the cities through their skyline, and a clear disposition of the main elements of the city, which can provide orientation for walkers and drivers. Considering the social view of the tall buildings, they have played an important role in the visual history of the twentieth and twenty-first

centuries, also for what regards their continuous presence in films, postcards and announcements.

Therefore, when a tall building is finally opened to the public, from the social point of view it gives a lot of visibility not only to the designer and the owner of the building itself, but also to the companies that have constructed and maintain it.

The skyscraper and its different interpretation

In according with different societies coming from all the parts of the world, the idea of the skyscraper has been changed during time and it has been reinterpreted in different views.

During the Expressionist era for example, the center of Europe gave at the skyscraper a new style. The European designers stopped to think about the high-rise building as a unique stately building block and they attributed to it a new shape, in order to overthrow the idea of rationalism that all the past high rise buildings had and try to give them a soul. Their forms were then distorted to provoke an emotional effect, and some Romantic elements were introduced to remind the power of the Nature for the human being, like lighting and crystal and rock formations.

On the other hand, during the Functionalism period of the Modernist Era important urbanists and architects thought about the high-rise building as the standard and fundamental element of new cities. Le Corbusier for example stated the skyscraper as a unique modulus which has to be repeated a lot of times one next to each other in order to create a schematic city under the idea of the standardization production.

Other past ideas ridiculed the structure of the skyscrapers, underlying their too impressive magnificence and opulence, because they dealt with new urban plans with small residences which were claiming the peaceful old rural everyday life.

Seeing from different world high territories

If on one hand it is possible to notice the different aspects that the structure of the skyscraper had assumed within the course of the history, on the other hand in the existing Era the high-rise building has faced with some issues that regard also the connections between different countries.

In fact, in the last century the designs and the projects of the most famous skyscrapers belonged to the United States. These buildings were built under the guide of American companies, which simply copied the skyscraper structure in other cities of the world, like London, Capetown, Mexico City, Honolulu and Sydney, with the aim to aid many regional markets. This is what happened for example with the construction of the Hilton chain of Hotels, in which there wasn't a particular characterization of the buildings related to the specific country where they were erected. But the form of the building was almost the same and it respected the wishes of the American owner.

Nowadays things are different. The typical form of the American high rise building has been exported in other countries, and even if its principal elements remained the same, other particular structural aspects of it change in relation to the social geography of the interested country. Moreover, the American architects are not the only ones that guide the project anymore, but a good collaboration between them and the local architect is established in many countries. In this way there is a particular attention to the specific

position where the building is built, the historical background, and the different social goals that people could have respect the American population.

One example can be given by the regions of the South East Asia, which consider the figure of the skyscraper as the symbol of their national modernization.

The Petronas Towers of Kuala Lumpur, in Malaysia, were built by an American architect, Cesar Pelli, who tried to characterize the structure with typical Islamic elements, according with the Malaysian religion. These are primarily the pinnacles, which terminate the towers on the top, and the building plan. As it is possible to see from the figure below, the floor plan is based on Islamic geometric squares creating a shape of eight-pointed stars.

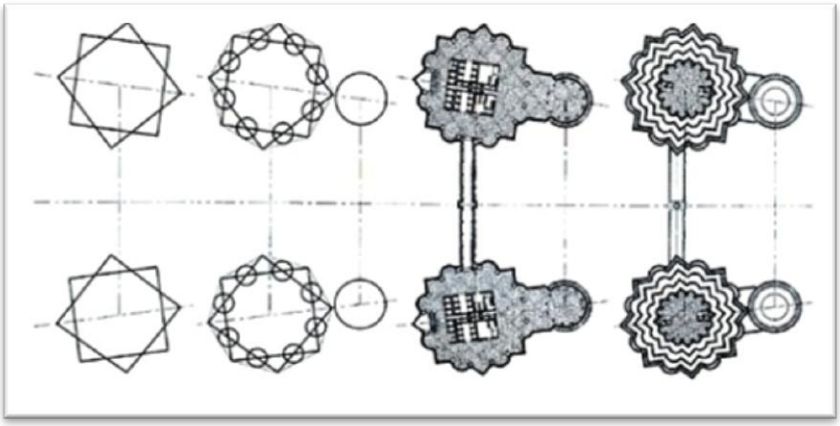


Figure 5- Petronas Tower Floor Plan

In this way, the towers have been seen like an important symbol that underline the modernity of the country maintaining at the same time the characteristic spirituality of the people. The traditional religious elements became together with the high rise building the new symbol of the Malaysian modernism.

Another example concerns the Chinese skyscraper design. This follows the rules of the American one, but at the same time it is revisited with feng-shui elements that emphasize the local traditional aesthetic.

Moreover, high rise buildings coming from the Eastern part of the World, have to face with strong natural issues, like the wind and the seismic action. Clearly these heavy lateral loads that the structure has to carry on the ground level change not only the construction details but also the shape of the building itself, which has to be more flexible rather than the tall buildings located in less seismic zone.

After these examples, it can be concluded that even if the base of the principal skyscraper's design has been exported from the United States, at the same time all the countries had tried during years to change the structural and architectural characteristics of the tall building in relation with their needs and their traditional cultures, taking into account also the regional environment characteristics.

So there is not a unique precise typical structure of the skyscraper that can be consider as a modulus for all the cities of the world, in contrast with what was suggested by Le Corbusier.

As a consequence of that, even if the skyscraper has always been seen as a solid, monolithic mass without particular imagination and creativity in its structural design, it is strange to think about this concept after the description of numerous examples of artistic and original high rise buildings in the world. For that reason they are usually considered an important issue when they have to be built in a new urban plan of the city, because all the construction companies and the financiers see it like a pure gain instrument, a vertical object, and they don't want to spend money in its aesthetic, while

the designers and the architects think about it as a new marker place that can characterize the city in relation with the local residents customs and uses. A very interesting case regards the Twin Towers in Manhattan. In fact, if before the 9/11 they were seen as simple financial tall buildings within the New York skyline, while after that date they become one of the most important symbol of New York and American history. They are considered now as the characteristic element of the city that signed the loss of a lot of human lives after the terrible terroristic attack of 2001. So they are not considered only an impressive vertical object from the structural and social point of view anymore, but they are one of the principal monuments of the country itself.

Figure 6- Twin Towers New York, 2000

Figure 7- WTC New Design Project

Figure 8- 9/11 Memorial & Museum

Of course, by analyzing the concept from another point of view, the decision to build a high rise building in an existent big city that didn't have tall buildings in the past can change the habits of the people who live there. For example, the introduction of the residential skyscrapers in the eastern region of Australia was very appreciated from the local residents, and with the years they pass from living the Australian beaches to living the view and so to enjoying the panorama of the Ocean thanks the optimum panorama offered by the tall building.

Then, the skyscraper does not always represent the social aspect of the city in which it is erected. For example, the Petronas Towers of Kuala Lumpur do not underline the climate of poverty that characterize the city for a lot of decades until now. As a matter of fact, in numerous scenes of films that want to show the real social and economic condition of the city the towers are not present.

Skylines

Figure 9- Hong Kong Skyline

Within the evaluation of a new skyscraper's influence in a city, there is the need to analyze not only the simple tall building in itself, but also the entire scenario that will be performed around it, especially if it is forming a real skyline with other nearby high rise buildings. The skyline represents the essence of the skyscraper's majesty. In fact, if you are walking on the street you are fascinated by the magnificence of a single skyscraper

simply looking up, while you can observe the magnificence of an entire skyline only if you are very distant form it, like for example the view of the New York's skyline from the Brooklyn Bridge Park. The first skylines were created at the beginning of the 20th century. Before that period, only the ancient cathedrals and bell towers characterize the city with their impressiveness. The construction of the skyline was at first saw as making ugly the city. This is what happened in cities like London, with the St Paul's Cathedral, or in New York, with the St Patrick's Cathedral, which have been surmounted and hid by new tall buildings. Nowadays the skyscrapers influence in the city is changed, and they are seen as important symbols of the modern city's opulence. In a certain sense, these new structures can also be seen as a consequent historic development of the old monuments dominance in the city.

Conclusion

After this analysis, it is possible to say that skyscrapers have always been studied as important elements within the urban history. They can be examined in a comprehensive manner, which regards not only engineering and architectural challenges but also the economic progress of the city, its infrastructure development and last but not the least its population and culture.

Numerous publications have been written about that argument, in which it is underlined how the tall building can be built within a city for a lot of different reasons. Starting from the mere ambition of the economic all-powerfulness of the business magnates, like Donald Trump who wanted to emphasize his dominance with the impressive

construction of towers, until the tentative to represent the essence of the city's culture in the skyscraper itself.

These leads to involve a lot of different figures around a skyscraper project, from the designer to the politicians and governors of the city. In relation to that, it is clear that when you are designing a skyscraper also other important factors are needed to take into account during its realization, like the land value, the technological innovations of the city, the availability of materials in their surrounding areas, the development of the class society, the environment. All these factors are essential and at the same time interrelated, and for this reason it can be concluded that the social geography of the city is one of the fundamental aspects within the skyscraper's realization.

The tall building typology and Cities

The tall building typology is studied as one of the best form of building made for the intensification of land.

The high-rise built forms are thought as the remedy for the spatial problems of urban growth, or as the inevitable consequence of an increasing of urban density. During the last years, the number and size of cities and the rate by which many of them are growing suggest that most people find them more attractive than the countryside's residences.
Nevertheless, at the same time people continue to really appreciate the playground style of life, thinking it would be more familiar than other styles. Here is the challenge of the new designers, trying to recreate this kind of habitat also in very dense and populated cities.
But, trying to use this kind of layout, the problem arises in the city center, where there is not enough space to develop a courtyard and it is impossible to expand the boundaries of the city center itself. In this sense the structure of the high-rise building is proposed as a valid solution to compensate the more conventional courtyard way of life within the inevitable use of the restricted space of the city center.

Research on demography of urbanization indicates that the 70-80% of the world's urban and rural populations is living in its cities and urban conglomerations. Then, from these data it is not hard to understand that for the most part of the times the skyscraper is not an eventual structural proposal, but it is a necessary element that needs to satisfy all the accommodation demands. In the next thirty years, also the cities that are not considered metropolis in the present time and that host less than one million of inhabitants will

incorporate half of the future urban. Moreover, even if it will be probable that this urban increment will depend on economical business location, and consequently even if this last one will be outside the boundaries of the city and it will provide a decreasing in urban population, until now is also true that the most important metropolitan cities, like New York City and Los Angeles, have both built a huge number of skyscrapers and created a lot of jobs still in the city center and aggregate payrolls at the same time.

The current worldwide interest in the high-rise built form is still more and more increasing. Urban areas throughout the world continue to expand upwards. City authorities continue to pursue interests toward the skyscraper typology or the tall building's form as the apparent inevitable solution to urban growth, although now with greater concern for security and safety.

Many people think about the expansion of their cities as an optimization of the city's metropolitan land area in the most viable economic and ecological aspect. Some examples of that are in Europe, where cities like London, Frankfurt, Stuttgart and Cologne are planned with the proposal to intensify their Central Business Districts, and construct railway lines and other infrastructures in order to well connect them with the suburban areas of the city. Also, it was studied that if the level of the city's urbanization is great and well organized, then the energy consumption through transportation starts to decrease, resulting as an economical benefit for the city. In a better way, it is possible to say that transportation provides an essential explanation for the dense building development and for an increasing in urbanization.

In conclusion, the avoiding of sprawlness and the following tentative to reach a dense urban form concentrated in the “sky-city center” is a key point for a lot of cities. As a

matter of fact, it does not only increases residential areas and so the number of residents, but at the same it is the starting point for the economic, social, cultural development of the city. Moreover, the same concept of the city center intensification, and so of the concentration of the facilities and the urban functions, leads to a more sustainable style of life also from the environmental point of view. This compactness allows the design of residential areas near the city center and the Central Business District, in a way that it is possible for the residents to reach the proper job location and every facility in the best way as possible.

Therefore, high-rise development can undoubtedly decrease the traffic caused by congestion and can create more point of attraction that require a good access to public transportation. From here, there is the consequent need to connect all these principal structures with a good transport service, like for example a subway system or an efficient bus line system, in order to give the possibility to reach the proper place of interest in the more efficient way, also from the environmental point of view.

Then the future cities will be better designed so as to obtain a good urban system, developed to host more and more people and try to give them the better way of living from all the points of view. At the same time, more people means more different ethnic groups, ages, classes, and so more mixed-use population then the past generations. The skyscraper is considered the best structure to face with this urban evolution.

Urban design framework and Vertical Land-Use mapping

It is clear that in all the old cities the major density of residents was in the centre of the city itself. Since the Roman Era, the city was planned starting from two principal orthogonal streets, the "cardo" and the "decumano", and then it grew up around them. Until this last century all the metropolis have been designed like that. However, in the last century the things have been changed. Cities had ampliate their peripheries until create a lot of small suburbs around them, which have taken more and more importance up to become new very important nodes for the cities themselves. Then a new form of city development started to be generated, the one that can be modeled has: city center node- surrounding area, external nodes. This phenomenon is caused by the difficulty to arrange an accomodation for all the city residents that are continuosly increasing, and it is not considered a good aspect for the urban city design. Consequently, instead of enlarge the city dimension horizontally, it starts the idea to use the skyscraper as the building structure that can satisfy the needs of a vertical expansion, not only in the city core but also in the new outsider points of attraction.

In a general sense, it has also been shown in the last urban designs how the city is not able anymore to develop itself in an even more bigger area because of its density, but it has to create a volume in a potentially buildable vertical space. This concept is called verticalism, by which the urban design and the city expansion is not treated anymore in double dimension, but it is seen from a tridimensional point of view considering also the height of the buildings. In a better way, the verticalism planning is no longer focused on the ground plane, but on the all spatial zone that is placed vertically above the site. If for example it has been considered a city’s Central Business District with an area of 25 acres

and a limit height for the buildings of 40 storey, which corresponds to 520 feet with a typical floor height of 13 feet, then the total Business area is represented by the entire three-dimensional spatial matrix, so 25 acres x 520 feet. This is an approach that is clearly based on the different levels of space that exist above the street level, introducing the tridimensional view of the city. The tridimensional concept is not a system of zoning, but it is a scheme that tries to combine different uses of premises all together. For this purpose the most useful type of building is the skyscraper, and also its importance in adding volumetric dimensions to the urban space is certainly one of its major contributions.

The problem with who this new tridimensional concept had to face up was the lack of connection with the usual urban life. In the 1950s, when the first ideas of verticalism where produced, the urban life was planned essentially horizontally and through low-rise buildings. The first consequence of that was that all the high-rise buildings which contained different uses of premises where essentially removed from the ground street life, creating the consequent risk to destroy the integrity of the usual urban life. Moreover, there was the skepticism that these news structures did not represent anymore the real urban life of the city and consequently the residents of it. This risk was actually connected with the possible lack of the high-rise buildings in creating an integrated community.

As years go by, the verticalism tried to solve this problem trying to include the skyscrapers in the integral scheme of the urban city plan, not only with the design of a strong connection between the ground level and the sky-level, but also with links design between all the buildings one to each other. Nowadays, the study of the verticalism's

form is extended until all the purposes. In fact, the links and the connections are attempts that regard also vertical parks, squares, sky courts and open spaces, which can be seen as fundamental spaces for the new vertical community.

So as it is possible to design an urban plan for the city in the horizontal dimension, then it is also possible to do the same in the vertical dimension with skyscrapers. Uses of different floors usually have a different number and variety of people every day, and so different space requirements, considering also all the adjoining facilities, like the open spaces, restrooms and other amenities.

Diversification of vertical land use

As it has been said before, the articulation of the internal space of the skyscrapers became a fundamental aspect that has been studied during these last years. In particular, the more the population of the city increases the more there is the need to articulate the usual urban life in all its features. In fact, the principal idea above that regards the fact that if a resident lives in a city centre he would like to have the functional amenities of everyday life as close as possible to his habitation. This is not only referred to his work place, but also to all the others amenities of daily living, like for example the supermarket, the commercial stores and the open spaces.

In many cities today the integrity that should be created by assembling all these different uses is not adequate because there is the tendency to create entire neighborhoods only for a specific function (residential, commercial, occupational).

Another aspect to take into account is that, in an usual big city, people usually don't have their work close to their house and they are forced to leave their home very early in the morning and to come back late in the night. The result of this is that for the most part of the day the residential zones of the city remain empty while all the working areas are trafficked, and the contrary is during the night. Moreover, there is also the problem to reach the interested places: the physical distance between the habitation and the office within a city can also be about hours and this can provoke discontent in the people that are bound to waste time in the traffic, becoming everyday more and more stressed.

Here there is the concept of the skyscraper as a new building that can recreate the integrity of a community. With its different land uses, there is the possibility to provide a new recreational high-rise space that can clearly advantage the people living in it, but also can create a lot of benefits to the city itself. In fact, if it is possible to recreate within the skyscraper a new mixed use habitat, the chaotic traffic will be tremendously reduced, the number of cars can decrease and the people can reach their interested places by walking distance.

Similarly, the new urban planning designs argue that this difference of uses has not only to be considered simply with the new skyscraper building structure, but also by analyzing all its levels starting from the ground floor until the sky level. In fact it is necessary to create a mixed use zoning also within it. If the commercial area is designed only on the ground level for example, the distinction between the different uses of the building levels is evident and the concept of an integrated community may fail. To explain in a more clear way, the resident who lives at the thirtieth floor should have the

commodity to reach an open space located two or three floors away from him, or a worker should by his lunch food in a store located at the same distance.

This lead also to create strong interconnections between the traditional bidimensional urban zoning and the tridimensional one: if a supermarket is placed at the upper level of a skyscraper, people are forced to reach it and consequently to interact with the building.

To demonstrate this, some studies have shown that people satisfaction is directly correlated with their everyday life and their social integration. And with this new design, residential, commercial, leisure and educational uses can be combined in a very short distance one from each other, allowing a new interacting community.

Another important aspect to underline is the relation between the different use of high-rise buildings and the average age of the actual citizens in the big cities. Especially in North America, residents in the city centre are getting younger and younger because older people tend to move away from the city traffic and noise. Young people have different needs, starting from the residence to the University, and from the shopping area to the entertainment one. This combination of different uses leads to create a wide variety in the core of the city, which helps the integration of the activities and the balance between them.

Public Realms and Place-Making in the sky

The combination of different uses within the skyscraper introduces another important argument: the idea of the high-rise building as a new fundamental encounter point for people. In all the cities, the number of meeting places is the characteristic that defines a city in itself respect to a simple town or village. Especially in the metropolis, the idea of making places to create meetings and event spaces is continuing to increase, starting from the simple idea of plazas, streets and boulevards, until the new form of future meeting place: the skyscraper. In fact, the connections that can be created between the skyscrapers and the ground level of the city and between the skyscrapers themselves are fundamental elements for the urban process of interaction. The possible designed links can be for example sky courts, elevated squares and streets in the sky. Here it is relevant the challenge that the designer has to face with. Especially in these last decades, people tend to live by themselves as a direct consequence of all the new mass media and innovative technology skills that give the possibility to interact with other people simply staying in the proper house. Moreover, people that usually live in the high-rise buildings tend to have a sort of nostalgia of the ground plane and they feel themselves like decentralized from the common horizontal community development of the city. Therefore, most of the current skyscraper buildings consist of a series of compartmentalized spaces, vertically joined together. Inside, the skyscraper is strictly layered and stratified: it is composed by closed and definite rooms, which often don't have open windows. This description can lead to think about the high-rise building as a segregated space. Moreover, the horizontal floors are no longer linked or interactive, but the most part of the time are isolated. The sense of isolation causes feelings of social

alienation in the inhabitants of the building. So the rigid boundary of spaces may persuade to think about the skyscraper as an inadequate built form and unpleasant environment for its functions and uses. One example of that can be furnished by the workers, whose office locations are considered total artificially closed spaces because they are located in very tiny places, one next to each other in few square feet, and by the residents, whose many of their apartments have no the possibility to recycle the air during the day and to have an open contact with the external environment itself.

As a consequence of that, the designer has not only to create new public spaces in the skyscrapers from a structural and urban point of view, but also tempting people to exploit them, creating good connections between all the high-rise building principal spaces and with the ground level.

For what regards the specific design of the open spaces inside the building, it has to be taken into account that people usually live in regular apartments, with small rooms, especially in a big city. The consequence of that is the designer cannot create open spaces within the skyscraper, but he has to correlate the dimensions of it with the scale and the shape of the rooms of the buildings and of the building itself. This is in accordance with the idea of integration of uses, not only from a physical point of view, but also from a visual point of view, convincing the people that the high-rise building can be a good example of new community space which comprehends all the different uses. The architect must then create a new style of life for people who live inside the building and at the same time also a new futuristic and sustainable structure which is considered to be a "city within the city".

Starting from the neo realism era, lot of studies had been made in order to get ideas and suggestions for these new structural forms. The discovery of new materials and the basic concept of the compartmentalization of the spaces and of the Rationalism ideals have been adapted to the present period and consequently to the needs of the current inhabitants of the modern cities of the last century. Within the new tall building structure, all the elements that characterized the past Aldo Rossi's European design movement have been redesigned, like the yard, the arcade, the square, the quarter and the colonnade; everything inside the skyscraper is planned starting from the classical elements that formed a city in that period: the center of the city, which now corresponds to the core of the structure; the nucleus, which now is represented by the important nodes of the structure, like the most important meeting places; the crown, that now is seen as the external part of the building, which has the role to integrate the structure with the outside world and environment, thanks also to links and connections as bridges and stairs. Clearly, all these aspects have been reinvented in relation to the twenty first century design requirement.

So it is possible to deduce that nowadays the high-rise building can arise with these features from the typical form of a complex urban fabric:

"The urban fabric is the physical form of towns and cities. In walkable communities, the urban fabric encourages walking as the primary mode of transportation by ensuring that most people's needs are within walking distance, and providing an environment which is safe and pleasant for pedestrians. Walkable communities are only technically and economically feasible when an infrastructure of quality transit services is provided. With good planning, transit infrastructure can be well integrated with the urban fabric."

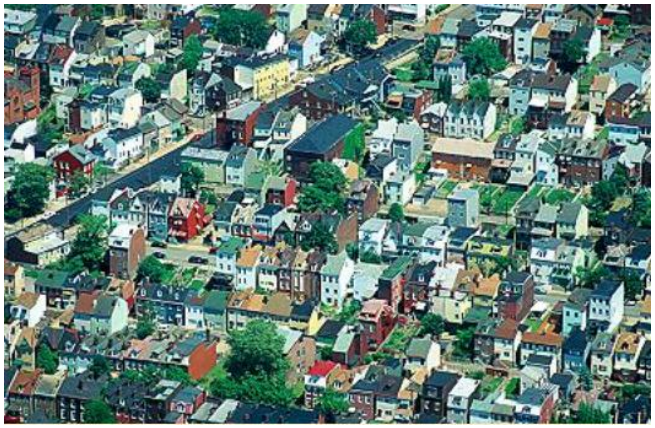


Figure 10- Portland Urban Fabric

In Fig. 9, it is possible to see how in Portland city the project of urban fabric requalification was able to create very dense and mixed use neighborhoods, with a very efficient and organized transport system and with all the facilities and services that people need contained in a small area.

Looking in a more detailed way at the architectural movements of the past decades, in the 1960s and 1970s, some architects of the Neo-Empiricism have studied a method to solve the damaging impact that the Modernist Design have had on the American cities. Then Kevin Lynch, Jane Jacobs and Christopher Alexander tried to make the urban plant of the city more clear and simplified. They criticized the way in which the Modernism completely destroy the sense of human dimension within a city and they tried to do that with the principal aim to restore the social and symbolic function of the street and other public spaces, supporting the point of view of the city's inhabitants.

Among others, Lynch developed the theory for which people usually chose their living places and the relative neighborhoods depending on five principal characteristics:

- paths : the connections between the residence and all the other functional spaces (work or commercial locations)
- edges : the boundaries of the residence and of the proper district, so how the zone is circumscribed in terms of walls, shorelines and other buildings
- districts : analysis of the neighboring in all its aspects
- nodes : central points of attraction next to the residence. They can be important public transport stops, squares or commercial center buildings.
- landmarks : important reference points for the resident. They can be physical, like a hill or a mountain, or not physical, like a statue or other important symbols of the city.

According to Lynch's theory, Boston can be a perfect example of diversification of land uses and contemporaneously of a good correlation between the five elements described above.

In particular, in one of his notes, Lynch described this city as:

"[The] South End . . . is the strongest in physical qualities, though I am less sure of its boundaries than for Back Bay and Beacon Hill . . . There is a strong differentiation in its gridiron street system: n-s streets are residential, narrow, highly traveled; e-w streets are more commercial, have fewer . . . apt. bldgs . . . and are very heavily traveled . . . As I walked through this area it seemed like . . . a visible symphony: a theme and constant beat, or rhythm, with a thousand variations within the theme. The stronger variations are expressed in groups of 5-15 houses . . . suggesting the periods and different builders involved. Other variations, like brightly painted doors, individualistic planting, etc., are expressive of the people who live in each house. To me, this is the ideal of urban

neighborhoods: an imposed discipline and order, strong enough to bind together but not so strong as to blot out the individual's self-expression." (November 17, 1955)

So as for the cities, also the skyscraper can be analyzed as a particular reinterpretation of the "visible symphony" Lynch's concept, so as a particular urban design form, because all the characteristics that the building must have are the same of the ones that must have a good urban plan for an entire city. In fact, as for a more complex urban plan, there are a lot of aspects that needed to be taken into account also in the tall building design and in the organization and connection of its spaces. But these aspects can be judged positive or negative for a tall building structure in different way respect on which they can be considered for an urban city design.

For instance, if the goal to create public spaces on the skyscrapers remained equal to the old tendency of urban horizontalism and it is to create a public integrated community, from the practical point of view the scenario and the advantages that could be taken from the high-rise buildings are multiple. In fact, the public spaces of these last ones are for the most part indoor, so it is possible to make use of them in every season and with every kind of weather. Moreover, reducing the physical horizontal space, the need of heating space is lower and at the same time there is the possibility to get more benefits from the solar energy. All these aspects have a great impact in the global economy of a big city.

Conclusion

All the aspects treated in the study of the urban plan for the big cities can be related to the new form of skyscraper's building.

Analyzing all the elements, it is possible to say that the tall building structure can create connections with the surrounding area, becoming a fundamental part of the city centre community; at the same time it can define its boundaries, in the sense that its structure can well define clear spaces which are separated respect the exterior; and thanks to the new structure's diversification of uses, it is possible to define a sort of district distinction also inside the structure; this leads to consider the skyscraper as an important central node of the city and a new reference point of activity for the community.

Creating neighborhoods in the sky

In order to create a successful vertical neighborhood, the basic idea is trying to replace in the sky the efficacious concept of horizontal neighborhood of the city, considering the structural high rise building constraints. Starting from 1961, new generations of planners stated that diversification of uses is fundamental to the success of a tall building, if it is able to be understood as an extension of the urban living in the sky.

The neighborhood is defined as a “geographically localized community within a larger city, town or suburb. Neighborhoods are often social communities with considerable face-to-face interaction among members”. The definition underlines that this word does not mean a small town or a suburb which is clearly separated from the town or the city,

but it is an element that contributes to the culture and the identity of the city itself. Then the tentative to form a successful community is a complex issue, which not regards only the objective to obtain an effective and captivating urban design, but also the wish to satisfy all the needs that residents, dealers and commuters have for themselves and for their units.

The social problem regarding the skyscraper is the sense of isolation that people usually feel while living within it. The strict imposition of the fragmented floors underlines the loneliness of its inhabitants. Generally the basic social interaction in the building takes place in the lift lobbies, entrance halls and passage ways. These zones have to be large as possible to emphasize the concept of community. Consequently, the design of the high rise building must recreate as best as possible the ideal neighborhood community of the ground plane, basing his plan on local institutions, cafes, shops and stores. These have to be located along all the height of the building as the first step to create social interaction. Then the ways in which these elements are connected one to each other determine the cohesiveness of the neighborhood inside the tall building, avoiding the separation of spaces. Moreover, the design should permit a multiple choice of shapes and forms for spaces, in order to show the different uses that they have. In fact, as underlined before, diversification of spaces does not mean create bad neighborhoods. In a more general sense, the formation of units with people of different classes, ages, races and styles of life is the ambition for every urban plan design. The benefits that this differentiation can create represent the power of the skyscraper community itself, balancing all the various kinds of people and their needs and avoiding the concentration of the same kind of people in a specific area of the neighborhood, like for example the

formation of a rich class within the skyscraper and the presence of middle class or poor people living all around the building itself, which is often cause of discontent between people and of dangerous situations.

Therefore, having multiple uses inside the building is one of the key element to guarantee the safety of its inhabitants also from another more practical point of view: people can reach all the different facilities at any time also during the night, creating a continues movement inside the high rise building, unlike the horizontal urban design where some blocks remain empty and more dangerous during the night because only commercial or office used.

Moreover, other civic structures, like schools and health centers, can be designed inside the skyscraper, in a way that, combining them with all the other elements, it is possible to provide a more and more integrated community able to easily reach also the most important public facilities.

However, especially for what regards the skyscraper's residents, there is also the need to maintain a proper private space outside of public spaces. This does not mean that dwelling units have to be separated from the community concept, but it simply underlines the fact that people want to have a proper space not sharable with others and, at the same time, they want to have the comfort to have public spaces more close than possible. The skyscraper design can help to satisfy this need with the connections. The basic idea is to have some areas in the floors which are exclusively residential, but also to connect these them with the common halls and facilities with public vertical streets. In this way people can have a proper quite dwelling unit, but at the same time,

once they get off from them, they can feel themselves inside a big community group, as what usually happens in the horizontal urban system of the city.

Adaptable Tower, Rotterdam

A good example of high rise building that puts in evidence the possibility to mix the different environments, even maintaining the privacy of the residence units, is the Adaptable Tower in Rotterdam. The principal characteristic that makes this structure unique is that all the flats and the other spaces can change their dimensions in relation with the needs of people which live there time after time. For example, if one floor has six apartments (look at the Fig. 11) and the families who live there are enlarging in number, it is possible to join the flats and obtain three bigger ones. This leads also to change the dimensions of the nearest restaurants and other facilities of the floor, always in relation with the number and the kind of its inhabitants. In this way, this extraordinary type of building is able to change so fast not only its internal structure, but also its height, its density and its principal functions.

In any case, the capacity of this building to be so flexible is a clear demonstration that helps to understand the concept to live in a good mixed-used community and how this community can governs the physical changes in the environment where it lives in relation with their needs.

Figure 11 - Adaptable Tower Typical Plant

Movement, accessibility and streets-in-the-sky

In order to define a new form of reference and meeting point within the skyscraper, the analysis of the connections between the structure and the surrounding area is fundamental. With the creation of streets in the sky, the transportation becomes not only a problem of city urban planning, but also a difficult concept related to the tentative to attract people inside the skyscraper in the more easily and comfortable way as possible. The high rise building has to be integrated with all the surrounding area and, in order to achieve that, the maximum choice of different paths has to be provided. In particular, thinking about the high rise building as a new focal node within the city center, its connection design are primarily focused on the decreasing in the use of mechanical travels. People should be encouraged to reach the important point of attraction by walk, by bike or by public transportation in order to reduce traffic problems. It is also important to create accessible routes that lead from the building to the out part of the city center.

For what regards the transportation system inside the skyscraper, the types and forms of connections usually determine the shape of the building itself. Starting this kind of analysis, the demand of transportation is a fundamental factor, because it is strictly related to the building's capacity estimation.

Elevator

The first and most important transportation element within the skyscraper is the elevator, which is the fastest way to reach different floors and the more comfortable way to go upstairs.

The elevator itself, rather than other typical structural technologies, is the element that has modestly driven the skyscraper projects since the beginning. And it is innovation in elevator technology that will firstly drive the skyscraper form also in the future construction projects. The issue of rapid verticality between levels has been at the heart of skyscraper form in the twentieth century. A lot of researches and studies have been done on the cinematic and social history of elevators, which underline a growing interest in these specific tall building characteristic elements. The futuristic elegance and glamour frequently associated with the express glass elevators continue to demonstrate the power that these technologies have always had on tall buildings users.

Other connection elements

But if there is the necessity to maintain a good ambient from the environmental point of view, it should be created other possible kind of connections that can persuade people to not use the elevator in favor of more sustainable ways of connection. These can be pedestrian routes, stairs, bridges and also small public transports. In this case, the goal of the designer is to create continuity and to render these paths a unique element with the building structure, avoiding the usual idea that walking routes can create disorientation and parting of the spaces inside of it. In particular, streets must be direct, safe and free from barriers. A well connected plan should have the following

characteristics: frequent points of accessibility into and through the building; great and easily reachable connections of public transports around it; clear signals of path's directions, and easy orientation trough them; connections with all the floors and possible destinations within the structure. Then the complexity of which all the routes inside the building are planned establish not only how to carry the traffic, but also the time spent to cross them, the integration of all the facilities and the presence of disjoined floors of the skyscraper. For instance, with the elevator as the only connection element, it is clear how a high-rise building can be fragmented between its floors. Nowadays multilevel buildings base their transportation on the lift, which consist of the 4-5% of the total cost of the structure. To render the skyscraper walk-able some considerations have to be taken: the pedestrian distances beyond 500 meters may be too great to walk without an alternative ways of movement. These can be moving pavements or travelators, which are still mechanical, but they can accelerate the horizontal pedestrian movement within a floor.

Another important element is the connection circulation. Inside the building, there must be a primary transportation, that usually is identified in the elevator, and that connects all the floors from the ground level until the top level. Then other transport cycles have to be creating in order to give a sense of structural continuity. First secondary circulations that connect only half of the high rise building, secondly third circulation systems that connect only few number of floors. The number of circulation systems can vary until the design of systems that connect only two floors. Besides that, other speed connections can be utilized, as for example high speed elevators that can carry a lot of passengers and that connect directly two important nodes of the building. This basic

concept is not important only from the structural and transportation point of view, but it underlines also the multiplicity of uses inside the building and the diversification of the spaces.

Artificial land in the sky: flexibility and change

The skyscraper structure is usually considered as a mere artificial residential land. One of the biggest problems that regard its first phase of the construction is the land property and the real estate development of the building. These issues can be considered less important rather than the design project of the structure, but in the reality of fact they are an integral part of the project itself and they cannot be treated separately from the urban design of the new form of tall building. As a matter of fact, regulations, codes, the real estate market and the economic policies are all fundamental aspects to be considered. The economic attractiveness of the high rise building is composed by a series of spaces, one above each other, in the sky. All these spaces will become new apartments and they will contribute to the real estate development of the city, without subtract any physical place to the horizontal plan of the city itself. For this reason the skyscraper can be called as a particular artificial land.

Of course, as it has been said before, this artificial land can be seen from the economic and management strategy not only as a series of superimposed lofts, like for example the Rappongi skyscraper in Tokio, but also as a science park, like what happened in the

so called Chinese Silicon Valley with the Zhongguancun Science Park, or as a big shopping center, like the Bluewater in UK.

Above all the possible uses of the skyscraper's area, there is the need to take into account also the surrounding space of the building. For example, there must be a good local environment service, which is able to maintain the streets clean and to provide green parks and an efficient lighting system around the building. Another important aspect is the security: people must feel safe walking in the high rise building area, so a good system of policy and guards might be provided. Then, for an adequate urban plan focused around the building, a competent system of facilities needed to be arranged, like school, hospital and social care infrastructures.

Figure 12- Rappongi building

Figure 13- Science Park, Beijing

Vertical landscaping and open spaces

The vertical landscaping is one of the most important innovative aspects for the skyscraper design. Since the beginning of the twelve century, numerous studies were made about this argument, and if it was simple to think about green walls and green roofs for residential buildings and exclusive hotels, it was not the same for the office and commercial spaces. In fact, at that time, there was no the conception of landscaping as a possible meeting point for the inhabitants of the building, but simply designers had an aesthetical vision about it. Moreover, green sites were expensive and also the construction policies were reluctant to spend money for what was not essential from the economical value of the building. During this last century, designers proved that vertical landscaping is not only an aesthetic concept, but it has a lot of advantages from the practical and profitable point of view.

The first design project of vertical landscaping was The Roof Garden for Rockefeller Center in 1929, New York. Here the architect Raymond Hood suggested the possibility to use roofs as green spaces to attract people but also to increase the value of the building

itself. Therefore, he also proved the idea that using green spaces was an optimum way to attract more people and at the same time increase the value of the other residences around them, because of the increasing in the environment quality. Unfortunately, the project was not carried out, but that concept was the base of the modern vertical landscaping.

Nowadays, vertical landscaping is one of the principal key aspects in the high-rise building design. In particular for what regards the improving of biodiversity. For instance in the new urban plans of big cities, where pollutants and noise are the worst signals of unhealthy living, it is predominant taking into account of the regulation of the environmental system and also to the ecosystem production (in terms of food, raw materials). Then, the optimal use of biodiversity is indispensable for a good quality of life, especially considering a metropolis. Using vegetation in the high-rise buildings can also mitigate the urban heat island effect, through the evapotranspiration cooling and to the shading surfaces of the building. Studies have shown that vertical landscaping decrease wall surface temperature about 17 ° C Celsius and can reduce air conditioning costs from the 25% to 80 %.

There is still the need to develop new construction techniques and maintenance operations about them, like irrigation and drainage for example. Nevertheless, the study of verticalism in all these past years achieved great results. Today it is possible to combine the green spaces with the structural materials thanks to the juxtaposition, intermixing and integration of them. Moreover, green spaces can be planned not only on the building roof or walls, but also on large ramps creating a continuous vertical and ecological corridor between the floors. Also, residences should have front garden

terraces and back garden balconies in order to create a unique element with the open spaces designed for the skyscraper.

Vertical landscapes are built along the facades of the tall buildings. Even if they pass through some obstacles, like windows or balconies, they take the advantage from the building height so they can be placed on a certain big vertical area. They can also be considered as a separate structure from the building's wall, which can green and sometimes support the building itself. In relation to the climate conditions of the city, an optimal selection of the vegetation has to be done. In particular, the choice has to take into account of the sun availability on the different sides of the structure, of the wind speed, of the duration of the seasons and other parameters. So, for instance, also in the same skyscraper the plants that require more sun has to be planted on the top floors of the building, while the plants that require more water can be planted on the lower levels.

Vertical landscaping proposals

Especially starting from the last decades, a lot of designers and architects tried to study new technological forms of vertical landscapes and open spaces. The research is still going on, but there are some of these proposals that are worthy of note.

For instance, the New Zealand architect Tim Stephens idea about Urban Farm Design was based on a blending park and a community garden. With this project, he tried to give a new form to skyscraper, to shape it in order to avoid the frequent idea that this kind of building is always a mere impersonal structure. To demonstrate that, he recreated the tall building top floor, designing particular flower beds inclined in the direction of the sunbeams. All the green areas were connected with paths and sidewalks.

Figure 6- Tim Stephens Design Project

Despite the innovation of the proposal, some aspects remain not well analyzed, like for example the lack of artificial lighting in the floor. In fact, if the garden can be considered another important point of attraction of the tall building during the day, the same is not during the night.

Another important proposal was done by Sejal Bhimjiani. He also tried to use more imaginative and curvilinear shapes for the skyscraper's design and put them into the schematic and rigid urban plant of big metropolis like New York or Shangai. The very innovative aspect of this project is the tentative to create a real and proper park along all the height of the skyscraper. The tall building will have then the function of a huge and green meeting place on the open air, where people can talk in the squares located at each level of the structure, can do jogging and play sports.

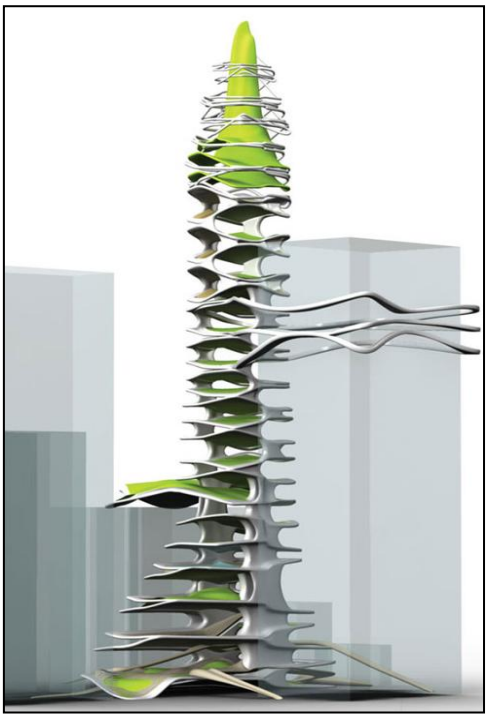


Figure 15 - Bhimjiani Project Design

In particular, in the following picture (Fig. 16), it is possible to understand better the project in all its aspects. It has been considered from the architect the possibility to maintain a certain separation between the urban space and the not-urban private space, and also a clearly separation of the ambient between the public and the residential ones (see space and program distribution); moreover, the tall building was designed taking into account also the climate variations of the seasons and the daily activities (see temporal diagram). Finally, it is possible to see how, despite the unusual primarily function of the building, the mixed-used development is maintained with the presence of touristic, residential and office areas (see user group diagram).

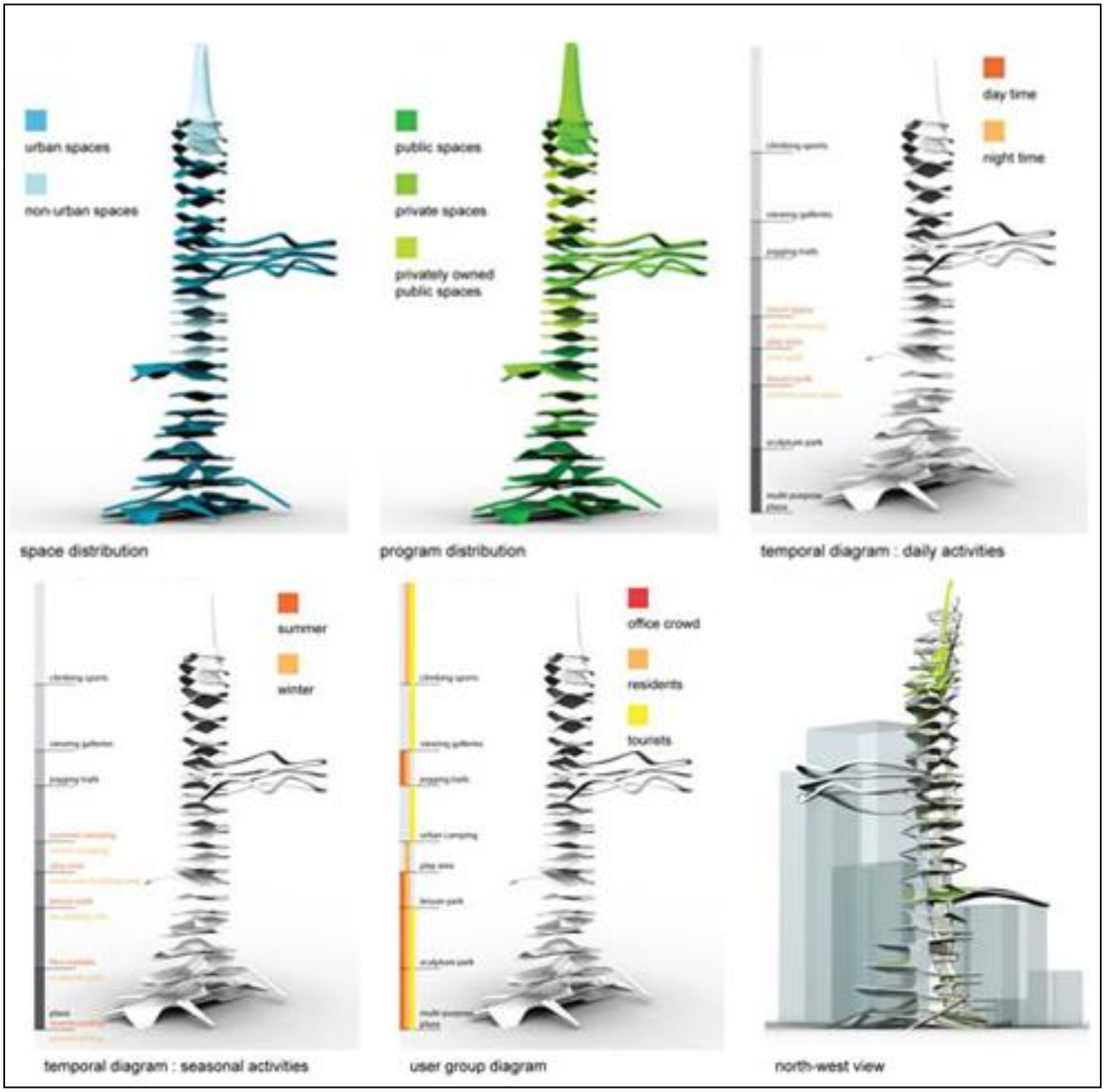


Figure 7- Design Project Schemes

The skyscraper as a urban ecosystem

The urban ecosystem is generally defined as the "cities, towns and urban strips constructed by humans". In particular, its study regards the possibility of the city to become a real and proper ecosystem thanks to the improvement of sustainable approaches, which are able to decrease the negative parameters of the city environment.

Sustainability is an argument that is becoming more and more important in these last decades. The principal idea for the new urban plans and for the most recent skyscraper's design project is to utilize renewal materials, which are created thanks to the recycling of the residuals and waste products of the same urban system.

Numerous definitions about the word sustainability have been provided. The main one was presented by the *Report of World Commission on Environment and Development WCED* in 1987, which stated that: *"sustainability is the development which meets the needs of the present without compromising the ability of future generations to meet their own needs".*

The theory of a sustainable system concerns three major concepts:

- Right to fairness in the years, which primarily regards what will be left to the **future generations**. This concept is part of the long term stability of the environment and of the earth's resources.
- Adequate and right **use of present resources.** The natural resources have to be used in the optimal way, taking into account that they are not always renewable and that sooner or later they are going to run out. So they need to be conserved

as much as possible and there must be assured an alternative reserve, with a competent use of the territory, in the case they are not available anymore. Moreover, this concept, is focus on the local stability of the urban system, requires the replacement of the natural resources with other ones when they are not renewable, promoting the biodiversity.

- The possible **relations cause-effect** that can exist **between two nearby cities.** For example, this concept of local stability involves the air pollution, the garbage disposal and the global warming problems, which can be lead to more important economic and social issues between the cities.

Consequently, the new skyscraper design must be guided by the form of urban ecosystem that the future cities want to acquire. The new high-rise building must become part of the urban ecosystem itself, and it will help to maintain the balance of natural resources and the biosphere conservation.

In order to obtain that, the tall building has to be built with more natural resources than possible, so an artless fusion will be created between the building and the surrounding urban area. Moreover, the high rise building has to avoid more than possible all the design processes that can cause air pollution on the surrounding environment, encouraging the capacity of the ecosystem to regenerate itself.

Technical Advices for an Eco-Sustainable Skyscraper

Considering the structural aspect of a tall building, the suggestions and the aspects to analyze in order to make it sustainable can be described in a more detailed way.

What is important to consider at first is its energy conservation and efficiency, the indoor air quality, with resource and materials efficiency inside the building, and the life cycle of the structure, including design, site work, operation and demolition. As a matter of fact, skyscrapers are very difficult structures to govern in terms of environment quality. For instance, they consume large volumes of energy and materials in all their different phases of life-cycle due to their significant volume, and they play an important role in the problem of environment pollutant because of their high-density and their consequent huge amount of waste discharge.

In order to better face with these issues, in June 1993 the *Declaration of Interdependence for a Sustainable Future* was prepared during the World Congress of Architects meeting. The declaration stated the new paradigm to follow for the skyscraper Eco-Sustainability: energy efficiency, sustainability concept, holistic approach. In a better way, the new paradigm stated that a high rise building should develops the following characteristics:

- Embodied Energy : environment-friendly materials should be chosen for the building construction.
- Energy Efficiency : minimizing the energy consumption, especially for light, heating, cooling and ventilation without limiting people's comfort.
- Bioclimatic Approach: support the use of passive techniques (climate) to reduce energy.
- Recyclability: support the use of renewable resources, like solar energy, wind energy and biomass energy, and avoid or at least reduce the use of non-renewable ones, like mineral or water resources.

- Flexibility and Adaptability: during the entire life of the structure, estimated to be about one hundred years for the most common tall buildings types, mix-use and reusable resources can give adaptability and flexibility to the structure also in relation to the future generation.
- Toxicity: govern and constant control fresh air circulation and gas emission, like formaldehyde, that are possible to be generated from the interior parts of the high rise building.
- Comprehensiveness: check all the interactions and the exchanges between the building and the environment

Eco-Sustainable Skyscrapers' Examples

Some examples of Eco-Sustainable skyscrapers can be given by the building designs of the last decade.

The first one built in New York that is considered having significant environment-friendly characteristics is the 4 Times Square, built in 1999 by Fox & Fowle Architects. The building is mixed-use, it was designed for a low energy consume, it follows a recycle program for the utilized resources and it was constant monitored during the construction phase in order to control gas emission come from the materials.

Figure 17- 4 Times Square in New York

Then, the EDITT Tower of Singapore, built in 1998 by T.R. Hamzah & Yeang, presents a design life of almost one hundred and fifty years and an efficient program of waste recycling and on-site energy production.

Moreover, the Skyscraper Project, built in FrankFurt in 1997 by Prof. Schweger is famous for its natural system of ventilation, which basically consists of a cylindrical tower and a square placed inside the building. Also, the facades contribute to the natural ventilation giving an advantageous shading and glare protection and at the same time avoiding huge expenditures for their construction.

Figure 18- Helicoidal Skyscraper

Therefore, the Helicoidal Skyscarper of the Architect Prof. Manfredi Nicoletti, which is the unique skyscraper to utilize the aerodynamic principles in order to

result environment-friendly. Thanks to them, the shape of the tall building is accurately analyzed with organic principles and the volume and weight of the structure are notably reduced. But is also important to underline is the effect that the helicoidal shape gives to the building and to the surrounding environment. In fact, it usually happens that, for more general skyscrapers' forms, the wind effect goes down through the building's height until arrive on the ground floor, causing unpleasant micro-climate within it and increasing air pollution. Instead, with this new particular helicoidal shape, the building reacts to the wind action with a vertical force, which prevents the risk of air pollution on the lowest floors and redirects part of the wind action upwards. Moreover, after thermo graphic analysis conducted by the New York University, it has been shown that this effect is increased by the conviction currents created by the solar-thermal distribution on the facades.

All these examples demonstrate how eco-sustainability has to be considered not only a general characteristic of the skyscraper, but a fundamental criteria of the whole tall building design, construction and maintenance.

Conclusion

The skyscraper has assumed a familiar presence in modern urban landscapes. Socially, it allows people to come together in greater density. Structurally, it is able to accommodate clustering of companies. Urbanistically, it provides more room for open spaces and helps maximize the efficiency of travel networks (e.g., the New York subway). Being particularly suited to locations close to public transport nodes, they also have a positive impact on the environment, by reducing the need for car use. Moreover, skyscrapers also use way less energy per capita than people in single-family dwellings.

An underlying theme in the arguments presented here, examines the relationships between the skyscraper and the natural world, the community and the city. Some important issues to be considered when visualizing its future involve the effectiveness of the space organization, how it can best accommodate the needs of current inhabitants and those of the generations to come, as well as the challenges and advantages of building an eco-friendly structure. Another aspect of the skyscraper closely associated with its materiality (i.e., mass, form, etc.), is its attractiveness, the charm and character that it adds to the skyline of a city.

Associated with the idea of limited land, a city can only reach its potential through the proper use of its territories. While it may never offer some of the amenities of suburban life — namely, space, its tall structures can compensate for this loss by creating a place that's equally comfortable, relatively affordable, and considerably more efficient.

PART II:

Structural Behavior of Urban Skyscrapers

Introduction

Skyscraper History: how tall buildings changed their shape with time

The historical evolution of the skyscrapers is characterized by different development of the structure under many points of view, in relation to the particular period at which the tall building was referred.

The first consistent skyscraper proliferation occurred between the 1880 and the 1900 in Chicago. The city was becoming the neuralgic and connecting point from which the rail system of transportation should begin to expand westward. After the fire broke out in 1871, the flat area around the Lake Michigan offered a tabula rasa for rapid expansion of the city. The skyscraper was, essentially, the building type for white-collar workers: a direct expression of the labor division between worker and manager. The intention to build vertically came from the desire to focus everyone in a closed loop at the center of the city: an area of only nine blocks long and wide, flanked by the Chicago River and the railroad, but was also born from the desire to take full advantage of individual rectangular plots of land within the urban grid.

The problem was to find appropriate forms for a variety of functions ranging from merchant stores to high office buildings. It was necessary to have cheap and functional buildings, easy and rapid to construct, of flexible use and resistant to fire events. Because of these requirements, rectangular perimeters of the building would have been optimal. In fact, they allowed to maximize the floor plans and at the same time to avoid inner courtyards, considered a waste of space, replacing them by large glass openings that allowed the entry of light and air even in the most interior of the blocks.

Then, a commercial architectural style emerged only after the discovery of an effective way to combine the sculptural tradition of masonry with the essential structural frame. In fact, even if the structural skeleton was covered with protective layers of brick, stone or clay, used as fire insulation or ornament, it gradually became more and more important for the overall shape, for the composition of the facade and for the tectonic stresses analysis in the building. The actual structural frame was made as a sort of visual frame, in which the interrelation between the column, string course, moldings, glass plates, beam and arch offered a new sense of aesthetics.

Among the most famous architects of the Chicago School, Louis Sullivan saw the skyscraper as an inevitable product of technological and social forces, which was considered a completely new typology of tall building directed towards a proper suitable structural morphology. From the Sullivan's perspective, the functionality of the skyscraper had to assume a relevant role also in the design phase, because functionality is the element that specifies the identity of the building itself. In order to better explain his theory, he described the terms of the problem in a pragmatic way. The fundamental elements that needed to be present within the skyscraper were an inferior part for the building's hall and stores, a mezzanine, a succession of floors for an office destination, a top floor for the mechanical system of elevators, a vertical corridor for the ventilation system, and a frame structure. Then he argued that these elements could have been split up in three principal groups, corresponding to the three main subdivisions of the skyscraper: the ground floor, the central part, and the top floor. Sullivan was the initiator idea that the skyscraper would have vertical emphasis.

In the decade between the end of the First World War and the Wall Street stock market crash of 1929, it started the fastest growth of skyscrapers in the cities of the United States, related to the construction boom that characterized this period. New corporations required the opening of offices in the major city centers. They needed a tall building typology of structure, capable of projecting solid and convincing images of themselves and their products.

The typical structural anatomy of that time combined a skeleton frame with a regular grid plan, compartimentalized spaces and glass facades, which could have been appropriate for different uses.

The Plan of New York in 1916, which required setbacks to get light and air to buildings and streets below, also encouraged the use of a stepped pyramid-shaped, often mounted on a tapered tower, which stood on a more wide base.

Then the skyscraper became a typology of building used also in contexts of use. An example of that are the two towers for residential use in Lake Shore Drive, Chicago (1948-51), designed by Mies van der Rhoe. But the destination of use of the whole skyscraper was still only one, even if each tall building was starting to have different use destinations one respect the others. In the development of the tall building after the 1970s, it is possible to notice a gradual diversification of the spaces also within the same high rise building, and then a correspondent diversification in the space dimensions and volumes.

So in the first historical examples of tall buildings the uniformity and modularity of the plant was one of the principal characteristics of the skyscraper. This was expressed by a repetition of floor plans along the facades, which created an overall image of fragmentation and rigidity, a functional expression of internal homogeneity, except for the lower levels which were designed for the lobby or commercial spaces.

Compared to these images of the past century, the contemporary skyscrapers, with a great variety of combined functions and diversification of spaces, are a reflection of a social evolution that has led to new requirements defined within the urban landscape. The skyscraper is reinventing itself thanks to continuous engineering developments, and it is now the type of building that best meets the need for consolidation of multiple functions in large metropolitan cities.

The principal diversification structural element: asymmetry

Asymmetry is one of the most important characteristics that influence the structural behavior of a building. This is particular evident when not only the floor plan of the building present an eccentricity of mass, but also when the same horizontal area change in its dimensions giving an ulterior vertical eccentricity of the center of mass. The result is a combination of torsional effects that needed seriously to be taken into account in the structural design of a skyscraper.

ASCE design criteria evaluation of additional torsion

Torsional behavior of asymmetric buildings is one of the most frequent sources of structural damage and failure during strong ground motions. Plan irregularity of buildings frequently involves the asymmetric distribution of mass which results in rotational motions of the floor slab in addition to the translational motions, even for stiff, strong symmetric systems. As a consequence, both force and displacement demands on vertical resisting elements can be larger then those they would experience in the presence of mass symmetry and of some resisting elements like frames and shear walls. Moreover, asymmetric distributions of mass leed to an

asymmetric distribution of axial forces in resisting elements, presenting different lateral strength capabilities because of the influence of interaction phenomena.

Symmetric tall building: Seagram Building proposed design

Description of the project: location, analysis of the site, period of construction

The Seagram Building is located in New York, Midtown Manhattan, at 375 Park Avenue, between 52nd Street and 53rd Street. The building was the world's first office tower to feature floor-to-ceiling height glazing.

The project of the building started in 1954 and its construction was completed in 1958. For the period in which it was planned and constructed, it stands as one of the finest examples of the functionalist aesthetic and a masterpiece of corporate modernism.

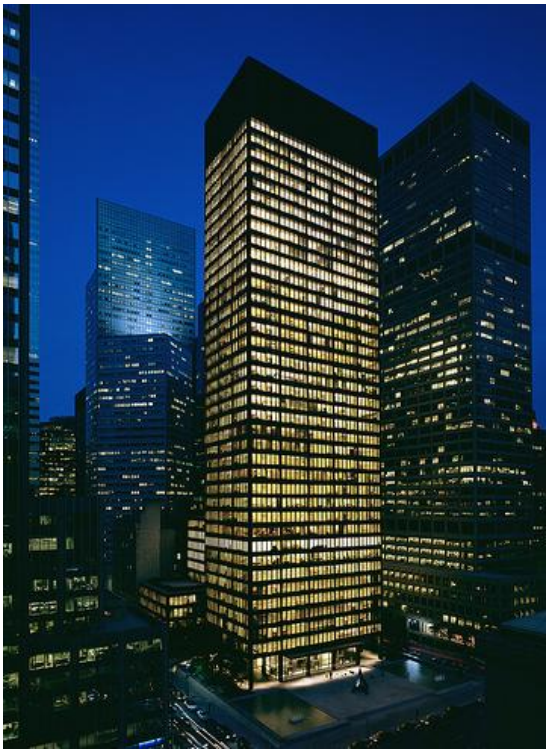


Figure 19- Seagram Building

Designed by the famous European architect Ludwig Mies van der Rohe, who immigrated to the North America at the beginning of World War II, this building epitomizes the importation of modernist ideals from Europe to the United States. In its monumental simplicity, expressed by the structural frame and rational use of repeated building elements, the building perfectly embodies one of the most

famous aphorisms of the Architect: "structure is spiritual and less is more." In fact, he believed that the more a building was pared to its essential structural and functional elements, and the less superfluous imagery is used, the more a building expresses its structure and form.

One of the style's characteristic traits was to express or articulate the structure of buildings externally. It was a style that argued that the functional utility of the building's structural elements when made visible, could supplant a formal decorative articulation; and more honestly converse with the public than any system of applied ornamentation.

This important structure, and the International style in which it was built, had enormous influences on all the future American architecture. Consequently, it is very interesting to better understand in which way the history of the skyscraper design has been changed with the past of the years, starting form this particular building until the more technologic and innovative ones.

Life Analysis

Space Dimensions

The internal organization of the Seagram building is very simple and repetitive as the Modernist Period of the 1950's was claimed. Therefore, as explained before, the function of the building is for office use and then also this fact demonstrates how there was no very much need to change the space of the room one respect the other. In fact, all the office works cells are characterized more or less by the same area and except for the main lobby and meeting area the dimensions of the spaces do not change so much even in the building height. This means that not only the floor plant

is composed by equal rooms, but also that the same floor plant is repeated with its same spaces along all the height of the building. In Figure 20 it is possible to see one general example of the Seagram's floor plant.

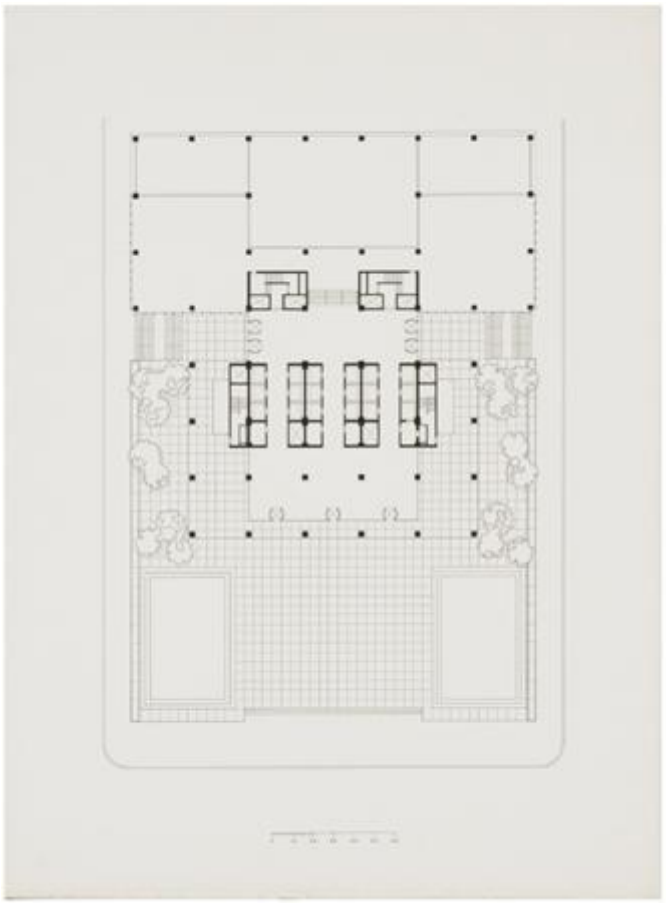


Figure 10- Seagram floor plan

The detailing of the exterior surface was carefully determined by the desired exterior expression Mies wanted to achieve. The metal bronze skin that is seen in the facade is nonstructural but is used to express the idea of the structural frame that is underneath. Additional vertical elements were also welded to the window panels not only to stiffen the skin for installation and wind loading, but to aesthetically further enhance the vertical articulation of the building.

Height

Another interesting feature which draws on the constant and repetitive Design concept of the Seagram Building is the window blinds. As was common with International style architects, Mies van der Rohe wanted the building to have a uniform appearance. One aspect of a façade which Mies disliked, was the disordered irregularity when window blinds are drawn. Inevitably, people using different windows will draw blinds to different heights, making the building appear disorganized. To reduce this disproportionate appearance, Mies specified window blinds which only operated in three positions – fully open, halfway open/closed, or fully closed.

Lighting

Lighting is a very important issue for this building. Because of its rectangular and modular structural shape and the particular location in which it rises up, during its design it has been challenging find a way in which it was possible to illuminate proportionately each floor plan and consequently each office space.

As a matter of fact, the tall building has an important concrete central core, which raises along all the building length. It is obvious then that the natural light found some difficulties to properly light all the spaces.

Moreover, the particular position of the skyscraper does not help the lighting as well. As it has been already written before, the tall building location is at 375 Park Avenue, between 52nd Street and 53rd Street in Midtown Manhattan, New York City. Here, it is interesting to analyse the inclination of the natural light during the daily hours. As

Manhattan island has a very rigid street plan, composed by streets and Avenues perfectly orthogonal ones respect the others, the whole road network is inclined of some grades in the north-east direction respect the general daylight path. The following Figure shows in a more detailed way this aspect. The natural light starts from the north-east part of the building, continues during the daily hours illuminating the north east façade and the north-west façade, and then illuminates the south-west part of the building during the last daily hours.

Figure 11- Seagram natural lighting

Other aspects that have to be considered are the urban architectural elements around the building and the geographic position of the tall building itself. In fact,

building a skyscraper in Manhattan is different respect building a high rise structure in any other city or town. In Manhattan, the density of people is very high, corresponding to 71'000 pople per square mile, and the increasing percentage of skyscrapers in the island is a direct consequence of that. Hence, the possibility of the skyscrapers to acquire natural light becomes more and more difficult due to the tall building that have been erecting one in front of each other.

In this particular case, the Seagram building is loocated in one of the most important Business and Finance areas of the whole city, and so it has a lot of important other high rise buildings around itself. In fact, on the east and north side the Seagram building borders with the City Group buildings, which consist in two skyscrapers, one of fortyone floors and the other one, considered one of the tallest of Manhattan, of fiftynine floors. Also, on the west part it is located the Park Avenue Plaza Building, with its 45 floors, just in front of the Seagram Building entrance. Then it is easy to understand how the Seagram Building can suffer the lack of natural light due to the nearby other tall constructions, especially during the earlier and last daily hours in relation to the biggest light inclination.

Trying to find the best solution for these problems related to the Seagram building, the office spaces above the lobby, furnished by Philip Johnson which collaborated with Ludwig Mies van der Rohe in the project, were then designed with luminous ceiling panels. Moreover, in order to catch more natural light than possible, these floors had also exterior being glass panes of gray topaz that provide floor-to-ceiling windows for the office spaces. The gray topaz glass was used also for sun and heat protection.

However, in the building facades there are also Venetian blinds for window coverings which could only be fixed in a limited number of positions so as to provide visual consistency from the outside.

In conclusion, it is then possible to say that, even if some strategies have been applied to gurantee a consistent amount of natural light within the building spaces, the lighting problem still remained not completely solved.

Structural Analysis

The building stands 516 feet tall. The structure combines a steel moment frame and a steel and reinforced concrete core for lateral stiffness. The concrete core shear walls extend up to the 17th floor, and diagonal core bracing (shear trusses) extends to the 29th floor.

According to Severud Associates, the structural engineering consultants, the Seagram Building was the first tall building to use high strength bolted connections, the first tall building to combine a braced frame with a moment frame, one of the first tall buildings to use a vertical truss bracing system and the first tall building to employ a composite steel and concrete lateral frame.

The concrete core and steel frame system has a central concrete core surrounded by steel framing. This design incorporates the strengths of both structural materials into an efficient solution to resisting against lateral loads in which they act together to prevent the sway of a tall building. In terms of structural

and cost efficiency, the concrete core and steel frame system is perfect for moderately tall high rises, such as the 600' tall Eleven Times Square building.

Steel compared to concrete has higher strength and less weight, which makes it the ideal material to build skyscrapers because as a building's height increases, the amount of load from its own self weight increases, thus using a material that has a high ratio between its strength and weight would be most effective. While a steel framed building is very efficient vertically, horizontally it lacks lateral stability. One way of providing this stability is by introducing a rigid core that decreases the effects of deformation and torsion from external lateral forces. Other techniques that are used to provide stability include using braced frames, moment connections, and exterior shear walls. However, when compared to a central rigid core, they each have their own drawbacks. For example, diagonal bracing can interfere with usable floor space and exterior windows. Moment connections between beams and columns are very labor intensive and can drive up construction costs a considerable amount. Exterior shear walls are also require more labor and can also be excessively heavy.

Using reinforced concrete shear walls has been a common way of stabilizing structures against lateral loads from winds and earthquakes. In a concrete core system, the shear walls are grouped in the center of a building, surrounding the elevator shafts and stairwells. The core walls are designed to cantilever out from the foundation, transferring bending, shear, and torsional stresses from winds and earthquakes as well as the stresses from gravity. To ensure that the walls work together, multiple core walls can be coupled via link beams within the ceiling or shear coupling walls, which can be one to two stories high. The more shear walls

that are coupled together the stiffer the overall building becomes. Because the overall mass increase is much less, the natural frequency of the building increases, which can be a positive effect, such as for achieving acceptable wind induced vibrations for occupant comfort.

The steel framed concrete core system is an efficient hybrid design for tall buildings. The steel and concrete work together and bring about desirable effects that neither one could accomplish alone as successfully. With the rigidity of the central concrete core along with the strength and lightness of the steel perimeter framing, this structural scheme can easily become the overall most efficient design for the project's office high rise requirements.

Stability

The base reactions, shown in Figure 22, were estimated using an approximate factored load value of 200 psf for a concrete building acting concurrently with a uniformly distributed wind load of 40 psf. This wind load corresponds to the design wind speed of 160 ft/s. The wind load was assumed to be acting on the widest face of the building to produce the largest overturning moment.

The base reactions were calculated through static equilibrium as follows:

$$W = 200\ psf * 125' * 155' = \ 3{,}875\,\frac{kip}{floor}$$

$$P_d = 40\ psf * 155' = \ 6.2\,\frac{kip}{ft}$$

$$M = \ P_d * \frac{H^2}{2} = 1{,}412{,}000\ kip - ft$$

$$V = \ P_d * H = 4{,}185\ kip$$

$$N = W * 49\ floors = 190{,}000\ kip$$

Using the moment value already shown, the required cracked inertia of the core can be computed to satisfy maximum sway requirements at the top floor.

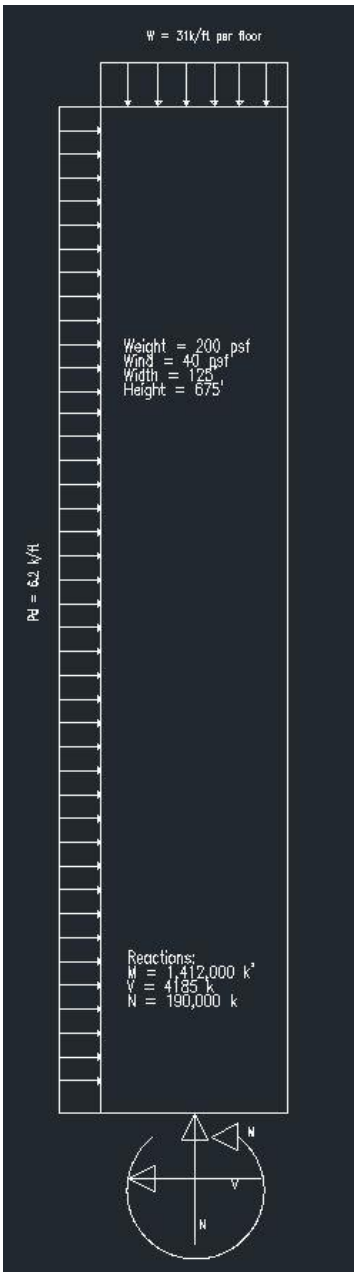


Figure 12- Seagram base reaction

The concrete is taken to be 10 ksi strength with a corresponding modulus of elasticity of 5700 ksi. This is found through:

$$E = 5700 * \sqrt{f_c'(psi)}$$

The maximum sway is required to be less than L/400. Therefore:

$$\Delta_{max} = \frac{L}{400} = 20.25"$$

To find the required moment of inertia of the concrete core, set this maximum sway equal to the deflection caused by the uniform wind pressure. The concrete core is assumed to deflect like a cantilever, shear deformation is not considered.

$$\frac{L}{400} = \frac{P_d L^4}{8EI}$$

$$I_{req} = \frac{50 P_d L^3}{E}$$

The core is composed of several reinforced concrete elements working together to resist the effects of the lateral loads. Depending on the design of the reinforced concrete link beams joining these elements of the core, the elements in the core will act somewhere between completely composite and completely independent.. As an upper-bound calculation the moment of inertia for a completely composite core is:

$$I_X = \sum I_{x,elements}$$

$$= 4 * (t * \frac{(45' * 12)^3}{12} + 16 * \left(10' * 12 * \frac{t^3}{12} + 10' * 12 * t * \left(\frac{45}{2}\right) 62\right)$$

$$I_X = 160 * t^3 + 1.62x10^8 * t$$

$$I_{X,required} = 2.41x10^9 in^4$$

$$t = 25\ inches$$

Similarly, the following bounds are calculated for complete composite action and completely independent response:

Response	Required t_X (in)	Required t_Y (in)	Initial t used (in)
Composite	25	6	30
Independent	60	400	

A uniform thickness is used throughout the core. The value is chosen based on constructability and the intent to design the link beams to sufficient stiffness to maximize efficiency of material used. This preliminary calculation for the horizontal system thickness has identified the relative weak axis for both cases. The calculation has also highlighted the importance of the performance of the link beam.

Vertical System and Ventilation

Gravity loads are resisted by the building's concrete core and steel frame. The load path for the building starts at the concrete slab that acts compositely with a steel deck and steel beam framing which resists live loads and dead loads through bending. The composite beams resist the loads around them based on a tributary area method. Half of these loads are assumed to be taken by the concrete core while the other half is taken by the perimeter columns.

The perimeter columns resist these loads through axial compression. This load path is shown below in the figure to the right.

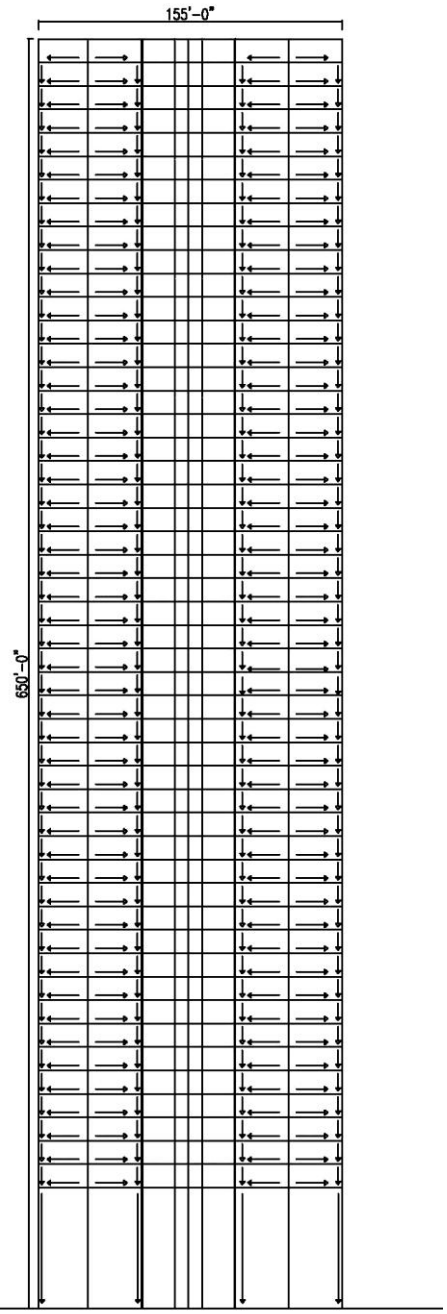


Figure 13- Seagram vertical load system

Wind Load Analysis Seagram Building

Following the Wind Design Requirements for Building Structures of ASCE 7-10, a wind analysis has been performed along any lateral direction of the high rise building. This analysis has been amde with sperimental data of the building, in order to correlate the results with the wind analysis given by GID Program.

Wind Parameters

The specific structure is an enclosed tall building, with the following characteristics:

Fundamental Period	T	4.75	s

Basic Wind Speed	V	110	mph
Wind Directionality	Kd	0.85	
Importance Factor	I	1.15	
Surface Roughness category		B	
Exposure class		B	

Height of the structure	h	675	ft
Height above the ground level	z	0	ft
Single Floor Height	hx	13.5	ft

Base of the building	B	155	ft
Lateral dimension	L	125	ft
Elastic modulus	E	5700	ksi
Damping ratio	β	0.02	

The base of the building is considered orthogonal to the wind direction, while the lateral dimension is parallel to the wind direction.

The building natural frequency is:

$$n_1 = \frac{1}{T} = 0.2105\ Hz$$

Gust Effect Factor

The gust effect factor for flexible or dynamically sensitive structures is calculated from:

$$Gf = 0.925 \cdot \left(\frac{1 + 1.7 \cdot Iz \cdot \sqrt{g_Q^2 \cdot Q^2 + g_R^2 \cdot R^2}}{1 + 1.7 \cdot Iz \cdot g_v} \right) = 0.8841$$

Where all the parameters, obtained from Table 6-2 of the code, are shown below:

Equivalent Height $\bar{z}$	**405**	**ft**
c	0.3	
Turbolence intensity $I_{\bar{z}}$	**0.197529**	
g_Q	3.4	
g_v	3.4	
g_R	**2.64027**	
ℓ	320	ft
ϵ	0.333333	
Integral length (scale of turb.) $L_{\bar{z}}$	**738.1257**	**ft**
b	0.45	
α	0.25	
Mean hourly wind speed $V_{\bar{z}}$	**135.8851**	**mph**
N	1.143575	
Rn	0.122302	
η for Rh	4.810565	
Rh	0.186271	
η for RB	1.104648	
RB	0.540494	
η for RL	2.982395	
RL	0.279232	

The background response Q is:

$$Q = \sqrt{\frac{1}{1 + 0.63(\frac{B+h}{L_{\bar{z}}})^{0.063}}} = 0.7719$$

And the resonant response factor is:

$$R = \sqrt{\frac{1}{\beta}\text{RnRhRB}(0.53 + 0.47\text{RL})} = 0.6380$$

Velocity Pressure

The formula used for the velocity pressure computation at each floor is:

$$q_z = \rho K_Z K_{zt} K_d V^2 I$$

The coefficients used for the velocity pressure computation are taken from Table 6-2 of the code:

Air Density	ρ	0.00256	lb/ft^3
zg value (Table 6.2)	zg	1200	ft
α value (Table 6.2)	α	7	
Windward Wall	Cp	0.8	
Leeward Wall	Cp	-0.5	
Side Wall	Cp	-0.7	
Uplift	Cp	-0.9	
Enclosed Building	Gcpi	-0.18	

In particular, for a more detailed analysis of the velocity pressure, considering also the four sides of the building, look at the Appendix (section Wind Analysis).

From the computation of the q_z values it is possible to obtain also the shear forces and the overturning moments for each floor of the building, as shown in the following table:

Floor	z	K_z	K_{zt}	K_d	**qz (lb/ft^2)**	F (k)	Shear V (k)	Mom (k ft)
0	0	0.700591	1	0.85	**21.2132267**	50.84674	4033.473488	1489238.33
1	13.5	0.700591	1	0.85	**21.2132267**	50.84674	3982.626747	1435472.87
2	27	0.700591	1	0.85	**21.2132267**	50.84674	3931.780006	1382393.84
3	40.5	0.763313	1	0.85	**23.1123951**	53.65776	3880.933265	1330001.24
…								
28	378	1.444961	1	0.85	**43.752041**	84.20719	2079.733513	316037.666
29	391.5	1.459521	1	0.85	**44.1929094**	84.85973	1995.526326	289098.061
30	405	1.473727	1	0.85	**44.6230487**	85.49639	1910.666595	263304.062
31	418.5	1.487599	1	0.85	**45.043065**	86.11807	1825.170201	238664.264
32	432	1.501154	1	0.85	**45.453512**	86.72559	1739.052126	215187.061
…								
48	648	1.685533	1	0.85	**51.0363061**	94.98887	286.299167	3871.06434
49	661.5	1.695492	1	0.85	**51.3378598**	95.43521	191.3102977	1288.37532
50	675	1.705307	1	0.85	**51.6350492**	95.87509	95.8750888	0

Note that the average value of qz over the 50 floors comes out to 40.29 psf which is almost exactly equal to the uniform design wind load of 40 psf. These same results are shown in the following diagrams:

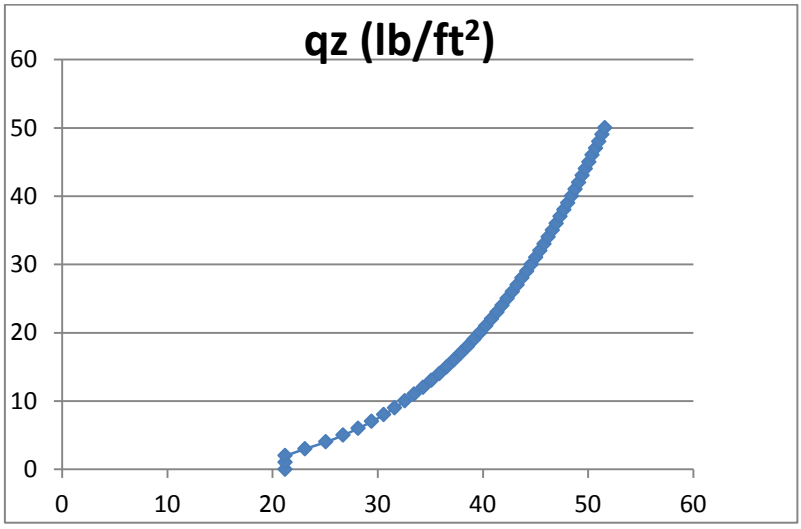
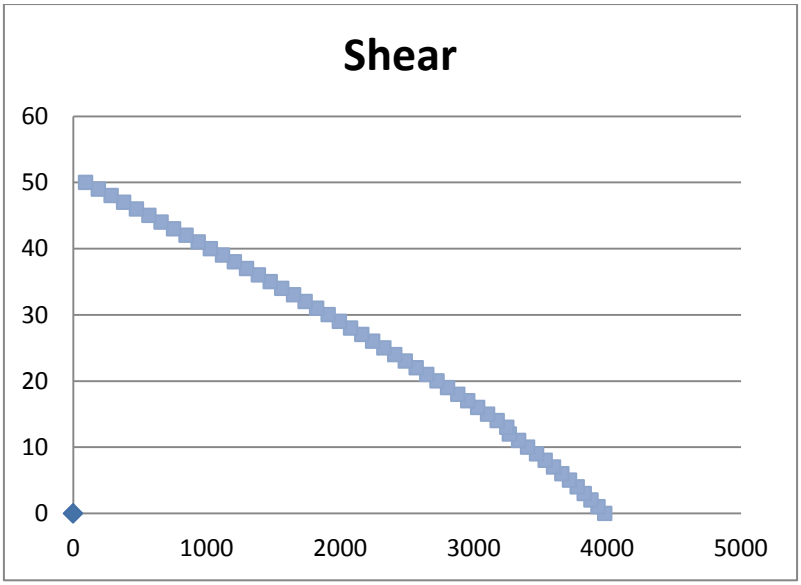


Table 1- velocity pressure diagram



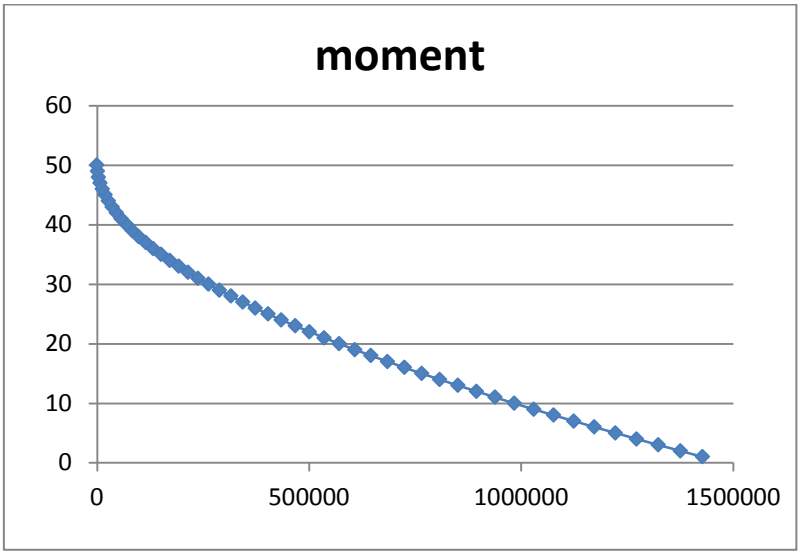


Figure 14- Shear and Moment diagrams

Inter- story Drifts Verification

A structural analysis of the building under wind loads is performed in order to compute the inter-story drift for each floor:

The moment of inertia of the building is considered composed, for simplicity, by the moment of inertia of two typical floors:

$I_{type\ 1} = 127255\ ft^4$

$I_{type\ 2} = 11248\ ft^4$

Consequently, the two main stiffnesses of the typical floors of the building are:

$k_{type\ 1} = 509438946.5\ \ k\ ft$

$k_{type\ 2} = 45029030.45\ k\ ft$

Then the inter story drift of each floor is computed by:

$$\Delta i = \frac{V_i}{k_i}$$

The deflections undergone by elastic analysis are then computed. In conclusion, the amplified inter story drifts need to be verified with the code requirements:

$$\Delta i < \frac{3}{8}\ in$$

The following table shows the computation:

Floor	Δ (ft)	< 3/8 in	δ (ft)
1	7.71789E-06	< 0.03125	7.72E-06
2	7.61808E-06	< 0.03125	1.53E-05
3	7.51827E-06	< 0.03125	2.29E-05
…			
28	4.0824E-06	< 0.03125	0.000169
29	3.91711E-06	< 0.03125	0.000173
30	3.75053E-06	< 0.03125	0.000177
31	3.58271E-06	< 0.03125	0.000181
32	3.41366E-06	< 0.03125	0.000184
…			
48	5.61989E-07	< 0.03125	0.000215
49	3.75531E-07	< 0.03125	0.000215
50	1.88197E-07	< 0.03125	0.000215

These same results are expressed in the following diagrams:

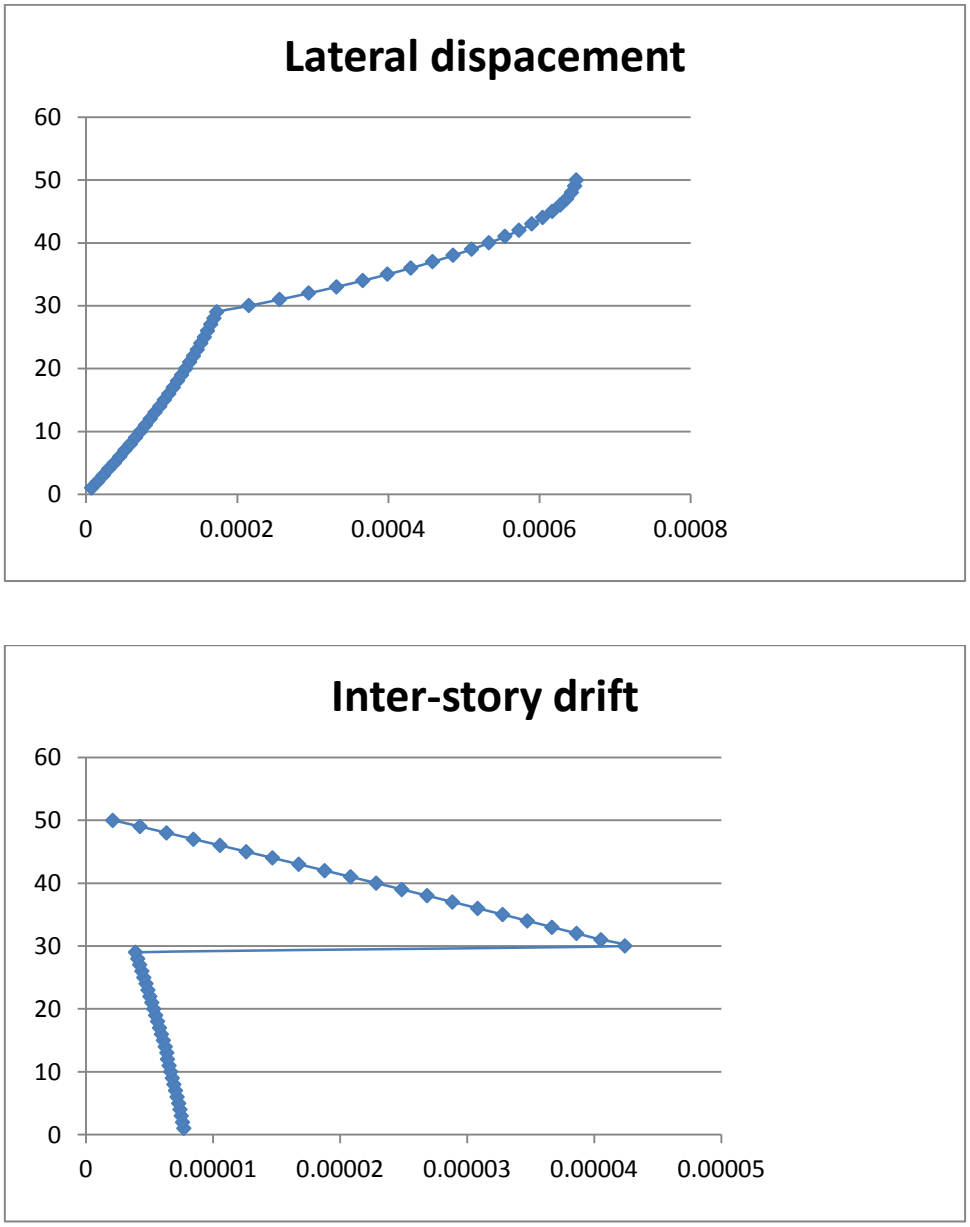


Figure 15- Seagram Inter-story Drifts and Lateral Displacements

The lateral displacements and the inter-storey drifts, considered as the final results of this analysis, can be considered complitely verified and in accordance with the Wind Design Requirements for Building Structures.

Construction

Materials Specification

The material used ofr hte construction of the tall building are divided in two parts, related respectively to the core and the construction of the other structural elements.

For what regards the construction of the core, it has been used the *Cement- type III.* This material, characterized by high early strength, is specified not only for the construction of the core wall but also for the foundations.

Insetad, for what regards the other parts of the structure, the *Cement-type I* has been used. This is an ordinary Portland cement, which has been selected for the Seagram for all the other concrete works which not comprehend the core.

Moreover, the construction of the building followed the idea of Mies van der Rohe Project, by which the structural elements of the building itself should be visible even when the cosntruction period is over. The Seagram Building, like virtually all large buildings of the time, was built of a steel frame, from which non-structural glass walls were hung. So the idea of the architect was based on the fact that the steel frame should have been visible to all. However, American building codes required that all structural steel be covered in a fireproof material, usually concrete, because improperly protected steel columns or beams may soften and fail in confined fires. So at the end, Concrete hid the structure of the building even if Mies was completely not agree. Anyway, in order to maintain his structural design, Mies used non-structural bronze-toned I-beams to suggest the structure's construction elements. The beams are visible from the outside of the building, and run vertically, like mullions, surrounding the large glass windows. This method of construction using an interior reinforced concrete shell to support a larger non-structural edifice has

since become commonplace. As designed, the building used 1,500 tons of bronze in its construction.

Construction method

Slip-form construction techniques will be employed in the construction of the core. Concrete is continuously poured into a form which rises in a continuous, slow motion. The concrete form is surrounded by a platform on which workers stand, placing steel reinforcing rods into the concrete and ensuring a smooth pour. Generally, the slip-form rises at a rate which permits the concrete to harden by the time it emerges from the bottom of the form.

Slip-form construction relies on the quick-setting properties of concrete, and requires a balance between quick-setting capacity and workability. For this reason, Cement-type III (with high early strength) has been specified for the construction of the core wall to facilitate and speed up the rate of construction.

The benefits for using this construction technique are as follows:

- Reduction in construction time and necessary processes
- Highly cost efficient form of construction
- Reduction in necessary costs associated with formwork
- Minimization of the risk involved in the construction process

In order to ensure the maximum speed of construction, a basic timeline schedule is considered. First of all, each single floor of concrete will be set and ready to be

loaded in two weeks (15 days). On the other hand, a story of steel framing is estimated to be constructed in 5 days.

The objective is to create a schedule such that the part of the project concerning the concrete pouring and the one of the steel erection will finish approximately at the same time. This can be done thanks to the type of cement used (Type III High Early Strength). The result that it is possible to deduce after some analysis, presented also in the following page, shows that the steel erection shall start 490 days (approximately 1 year and 4 months) later than the pouring of the footings.

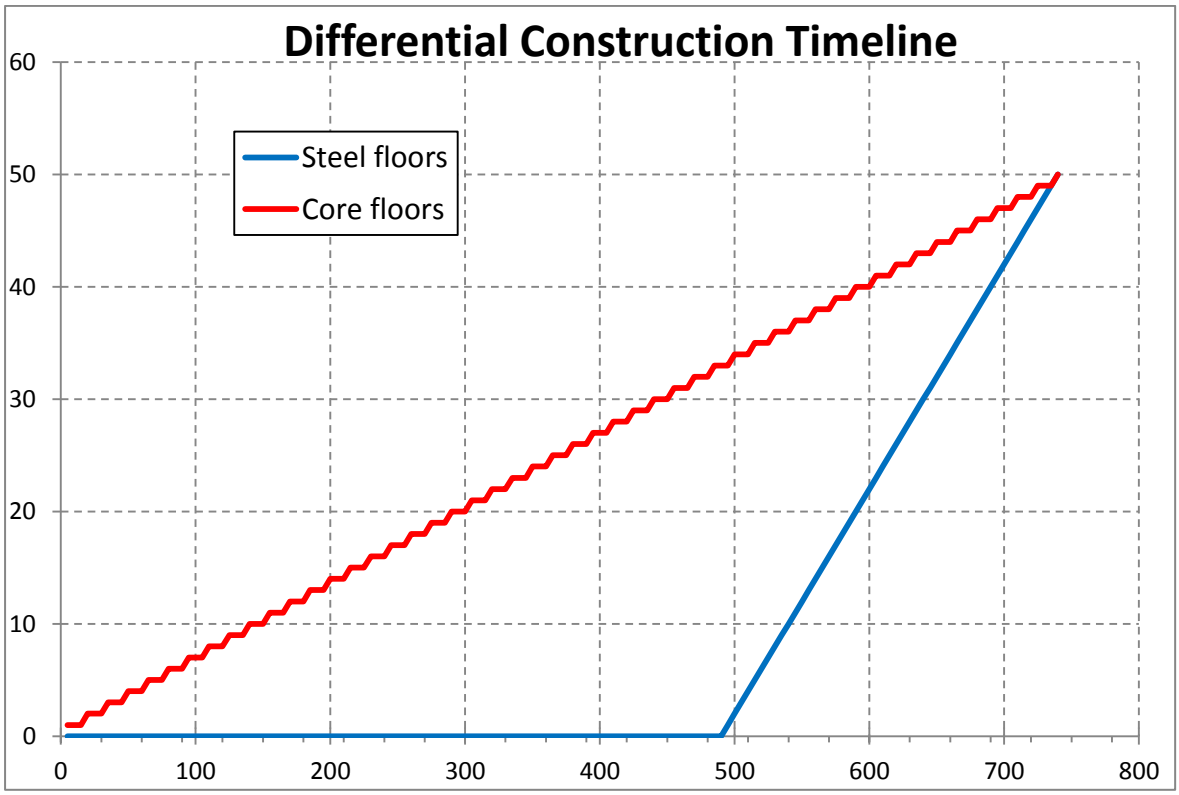


Figure 16- Seagram Timeline Construction

Eventually, with more available information, is possible to synchronize the floor construction progress with the MEP works and interior installations. It's interesting

to note that this schedule considerably increases the effect of creep deformation on the structure as we will see in the following section.

Cost of Design and Construction

After the completion, the construction costs of the Seagram building made it the world's most expensive skyscraper at the time, due also to the use of expensive quality materials and lavish interior decoration including bronze, travertine, and marble. The interior was designed to assure cohesion with the external features, repeated in the glass and bronze furnishings and decorative scheme.

The cost of the building is estimated using a unit cost method. This method lumps together the cost of fabrication, transportation and erection based on a unit "weight" of the material. For steel this "weight" is the actual tonnage of steel used while for concrete it is the volume used. The formwork unit is the surface area of the concrete which is being formed. Note that this price is assumed to take only standard formwork into account. The quantities of materials of steel, concrete and form work are obtained based on the design presented in this paper.

In conclusion, considering also the other expensive materials used for its realization, the total cost of the Seagram Building was about 41'000'000 $, including the five million Dollars cost of the building parcel.

Asymmetric building: Leadenhall Building

Description of the project: location, analysis of the site, period of construction

Figure 17- Leadenhall Building

The Leadenhall Building is located at 122 Leadenhall street, in the middle of the Business district of London, the City. The project of the building started in 2002 and it is still under construction. As for the Seagram building at its own time, nowadays the Ledenhall building represents one of the finest examples of the functionalist aesthetic and the perfect symbol of the most advanced and efficient skyscraper's architecture.

This 50 storey tower opposite Lloyd's of London rises to a height of 802 feet (224.5 meters), its slender form creating its own distinctive profile within an emerging cluster of tall buildings in this part of the City of London. In fact, 122 Leadenhall Street will be a stunning addition to the emerging 'eastern cluster' of tall buildings in the City and will improve the skyline from important static views and London panoramas.

The redevelopment involved the demolition of 122 Leadenhall Street, a 14-storey office tower built in 1969.

Transport for London is concerned as to how the existing site will be demolished and how the new building will be erected and believes that a construction methodology and statement identifying impacts to the highway network and

measures that will mitigate these risks should be in place. Transport for London would also like a risk assessment to be included with this statement.

The building's tapering profile is prompted by a requirement to respect views of St Paul's Cathedral, in particular from Fleet Street.

The architect of the project, Richard Rogers, has followed the comfortably standard of the 'World Class' architecture, creating at the same time a beautiful and engaging final building, defined a "delight to the eye" from London's residents. The proposal will play an important part in supporting London's World city role by providing a stunning modern mixed-use building with floor space capable of being deployed flexibly to meet the needs of high value tenants.

Life Analysis

Space Dimensions

Analyzing the spaces dimensions of the building, it is clearly possible to understand why this building is considered one of the most important examples of the optimization and diversification of spaces of the existing Era.

In fact, the building's envelope expresses the diversity of what it encloses, reinforcing the composition and providing legibility to the primary elements. The architect Richard Rogers situates at the back of the building all the vertical transport and services for the building, keeping the floor space clear from obstruction and additional building structure which ends up in a net to gross ratio of 77%.

Although the tower occupies the entire site, the scheme delivers an unprecedented allocation of public space: the lower levels are recessed on a raking diagonal to

create a spectacular, sunlit seven-storey-high space complete with shops, exhibition space, soft landscaping and trees.

Anlyzing the straordinary diversification of spaces of this building, it is possible to note how the structure is not only designed for different uses, but it is also projected with different dimensions, considering both the floor area and the height of each floor. The following Figures express this concept in amore detailed way:

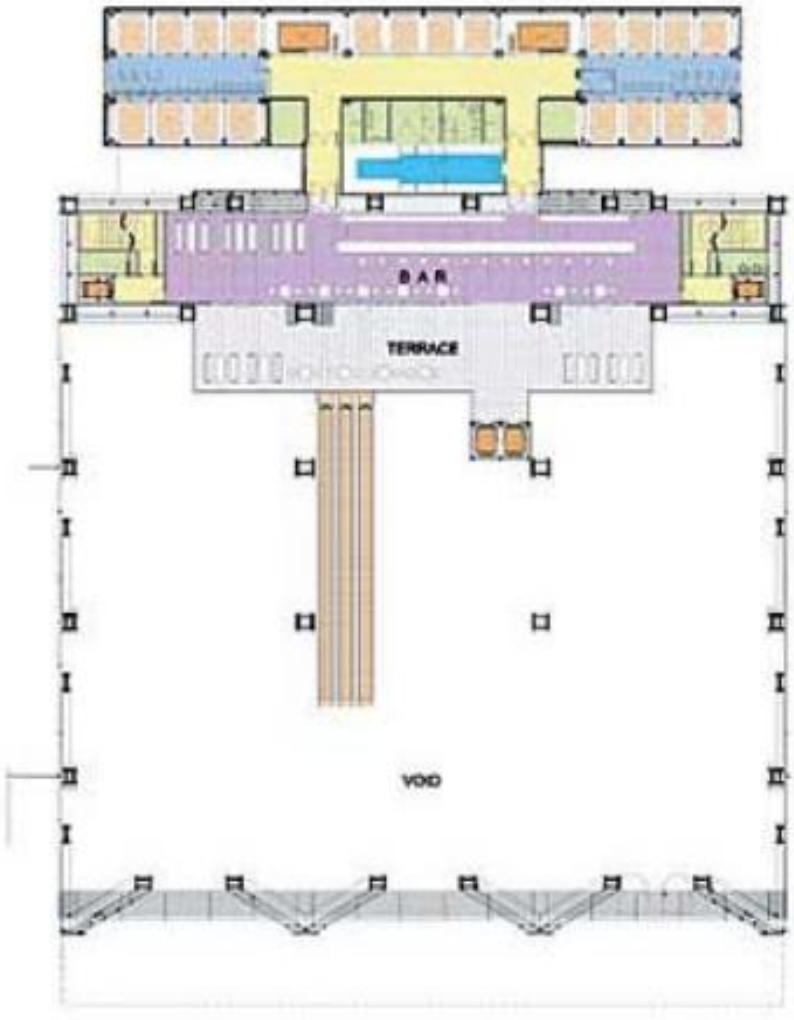


Figure 18- Leadenahll second floor plan

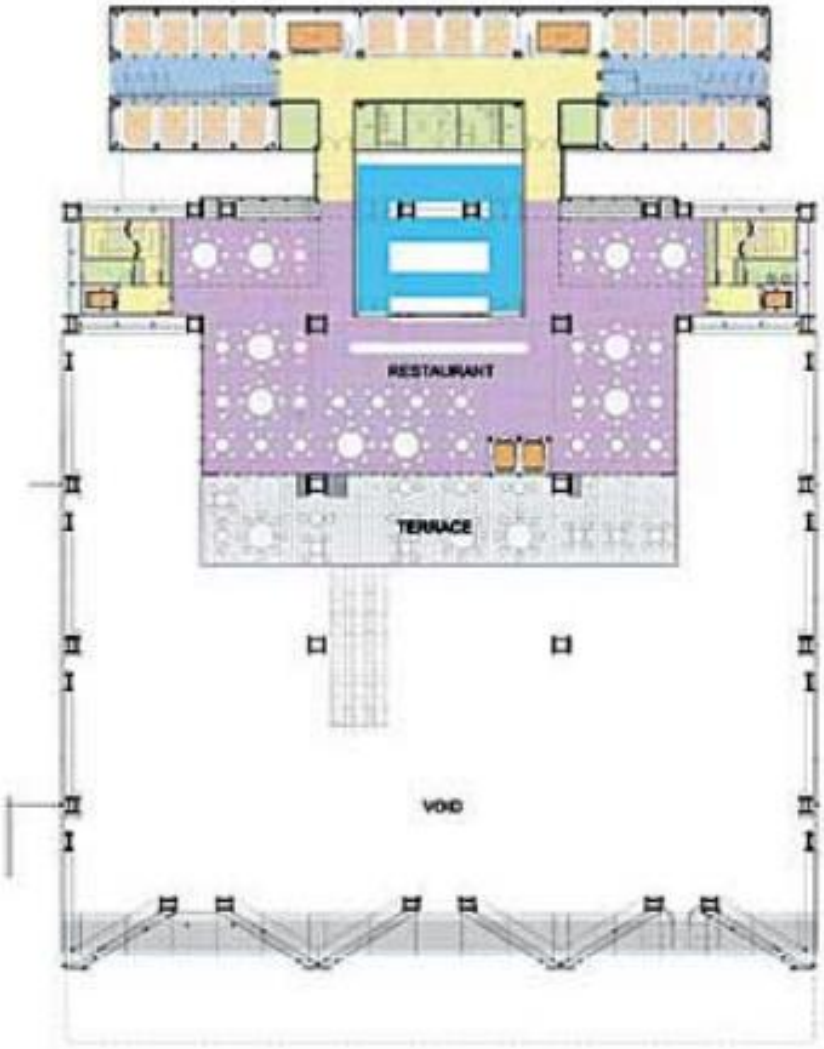


Figure 19- Leadenhall third floor plan

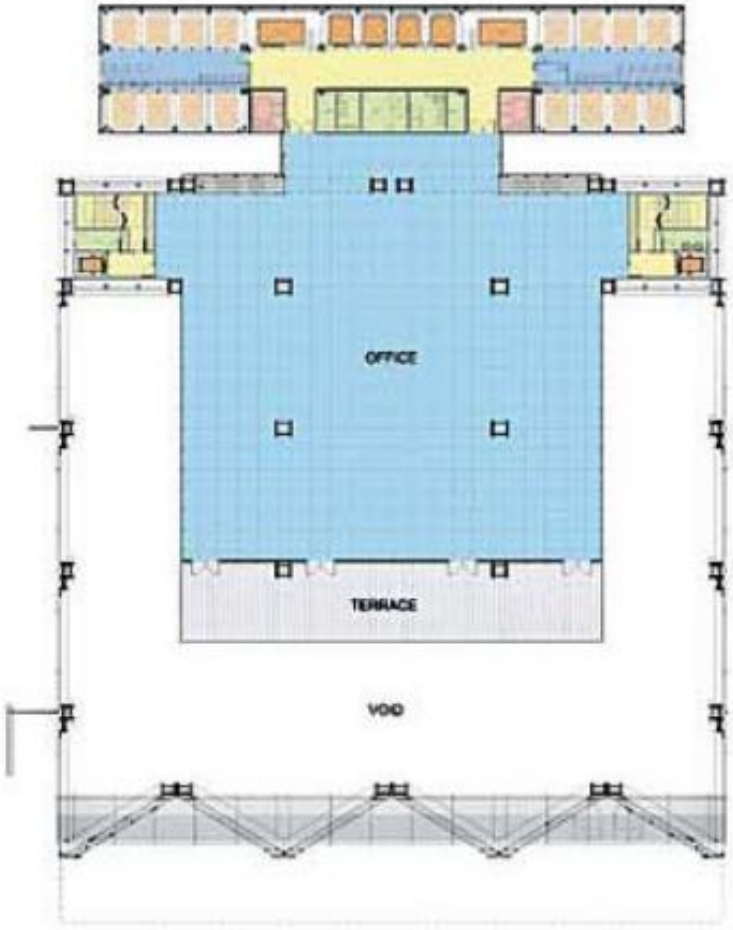


Figure 20- Fourth floor plan

The proposed floor space is:

- Offices 82,722 sq.m (gross)
  53,571 sq.m (net)
- Retail 2,150 sq.m (gross)
- Car parking/servicing 2,745 sq.m (gross)
- Plant 6,180 sq.m (gross)
- Covered public space 2,182 sq.m (gross)

The floor plates vary in size which allows for great flexibility in providing office space which can be cellular or open-plan. In particular, office floors range from 1,983 square meters net at level five to 583 square meters net at level forty-five.

Mix Use and Public Space

Looking in a more detailed way at the inside part of the building, the diversification of spaces is clearly underlined. The skyscraper is subdivided in:

- a combination of shop and catering retail uses are proposed on ground, mezzanine, second and third floors
- office and retail use from the fourth floor to the fortyfifth
- three levels of basement containing servicing facilities, parking and plant accommodation

The following picture of the building's longitudinal profile shows this space's diversification:

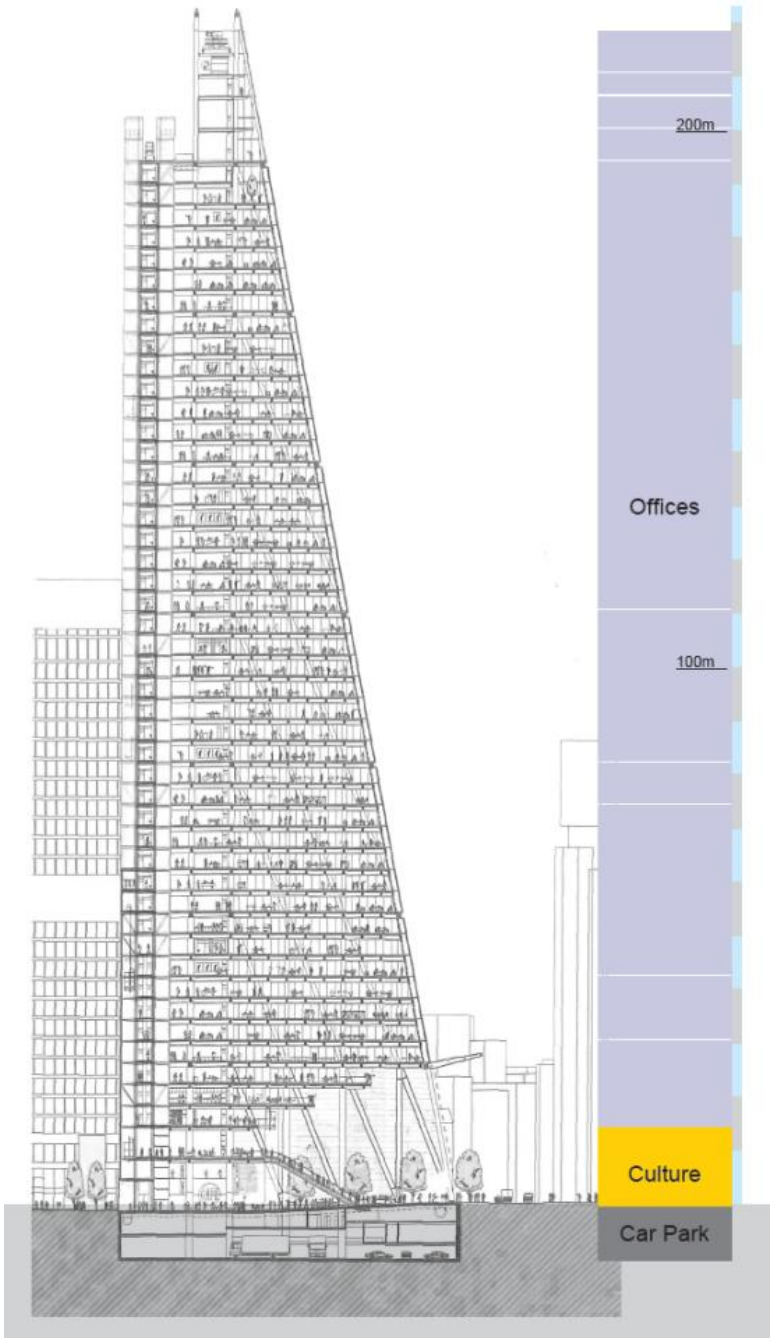


Figure 21- Seagram longitudinal profile

What is really important to underline in this study is the great ability of the Architect into combine, within the same tall building, an office and retail space for workers and professionals with a public space available and reachable from all the London's residents.

For what regards the public space, this is subdivided in more than one floor.

The enclosure is open at ground level to give access from all directions. The ground floor open space under the building provides a pedestrian route from the north to the south side and links eastwards to the remaining plaza, with the potential to link westwards to Undershaft if the opportunity arises. This public space offers a large, gently raked surface which extends for half acre the adjacent St Helen's Square until Leadenhall Street. This new public space will provide a rare oasis within the dense urban character of the City of London.

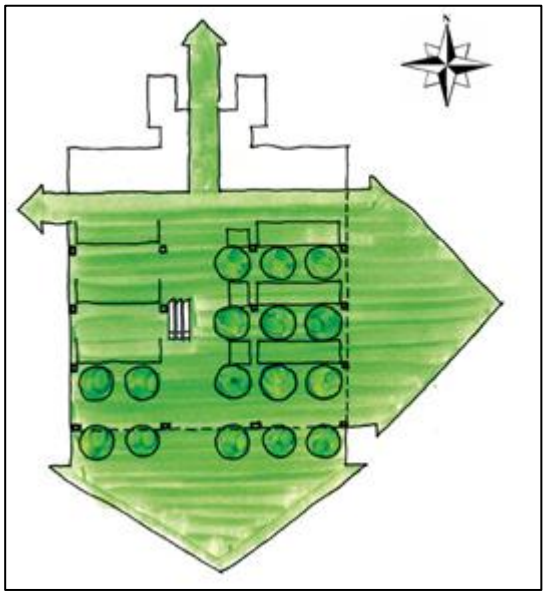


Figure 22- Ground Floor Open Space

More in detail, the ground floor is planned as following:

Figure 23- Ground floor open space

The open space under the building is intended to be landscaped and would include semi mature trees planted in subterranean pits. Other planting includes semi mature trees on St. Mary Axe and Undershaft to assist and mitigate the impact of wind on the microclimate. The application includes illustrative material showing how the landscaping under the building could be extended on to the plaza in front of the CU building if the owners and occupiers of that building agree. Discussions are taking place on this issue between the two land owners.

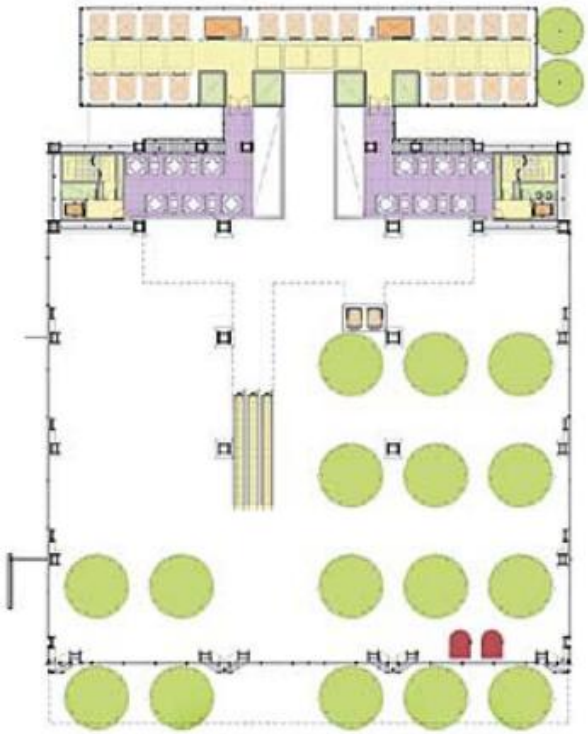


Figure 24- First floor open space

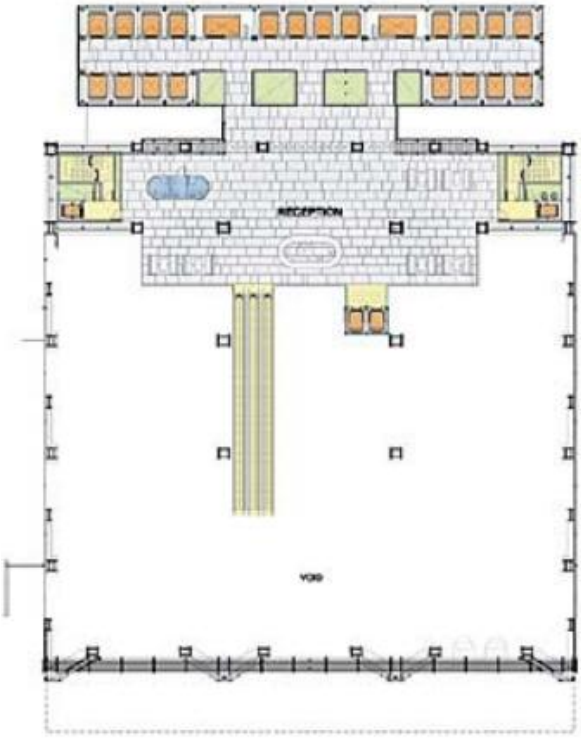


Figure 25- Second floor open space

Moreover, as it is possible to see from the above Figures, in the other two floors of open space, the first and the second one of the building, a public bar, some stores and a restaurant have been placed, which are served by glazed lifts. These public spaces also provide external seating, and both informal recreational and formal

areas where activities or exhibits can be provided. provide animation and views into the public space and beyond.

The open space at the base rises then to other seven storeys.

In conclusion, the lower levels of the building are recessed on a raking diagonal to create a large public space that opens up to the south side. The spectacular scale of the semi-enclosed, cathedral-like space is without precedent in London and will create a major new meeting place and a unique destination in itself.

Public realm

The combination of different uses and spaces within the skyscraper introduces another important argument: make the high-rise building the new fundamental nodal point of attraction for people. The Leadenhall building project tries with its characteristics to create a new community place within the City. This is not only referred to give to the employers working in the district the possibility to have a reference point for their business. In fact, also all the London population can find in this building a new place that corresponds and satisfies their needs.

Figure 26- place making in the sky

Especially in a big metropolis like London, the idea of making places to create meetings and event spaces is continuing to increase, and in this particular case the

connections that can be created between the Leadenhall building and the surrounding area is a great example of community renovation.

As it possible to see from the following Figure, there are a lot of designed links between the tall building and the nearby urban elements of the district. At first, the open space on the ground floor not only concerns the area under the skyscraper, but the whole block in which the building is built. In this way it is explained the extended connection between the close St Helen's square and the building itself. Then if all the surrounding area is analyzed, it is possible to understand the importance of this public space, considering that it will be the only green one able to host a certain number of people guaranting at the same time the quality of the space and of the environment. Then the elevated seven floor plans of the building with public space destiantion of use help to increase the value of the community area, providing with restaurant bar and stores all the comforts requirable from the people.

Figure 27- Leaden building community place

Of course, there are other important issues to take into account for the realization of this important project.

For example, there are concerns that the number of disabled parking bays will fall well short of the area's actual requirement and that the configuration of the basement areas of the building should address the concerns of disabled users. In particular, all of the parking in the new buildings should be safeguarded for disabled users and these spaces should ideally be closer to the lift cores.

Because of the particular structure of the building, there are also concerns regarding noise levels in the foyer and the rake of the floor which are perceived as being difficult for disabled people. It will be important to ensure that the building is responsive to the needs of disabled people and for this reason during the revision of the project it has already been asked that these internal design issues have to be addressed.

Moreover, in order to help mitigate concerns over public transport capacity, it has been expected that the pedestrian environment in the vicinity of Leadenhall Street, Gracechurch Street and Bishopsgate will be improved, including improvements to bus stops and pedestrian crossings in pedestrian routes to and from public transport nodes. This will enhance the access to the public transport network.

Therefore, in terms of resources, the development will bring identified impacts for London's housing market and public transportation system. These are strategic in nature and will require mitigation towards housing and transport over and above the levels envisages in the City Corporation's supplementary planning guidance.

In addition, the development will be located in the Central Activities Zone and as such, a greater emphasis towards mitigation in favor of affordable housing is supported in the specific policy.

Lighting

Lighting is one of the more important characteristics of the whole building project. The shape of the building, as its disposition in the block, were radical design

decisions made in order to acquire more natural light than possible. Also particular structural elements are used to increment the total amount of illumination.

Starting to analyze the whole area around the building, it is possible to say that the condition of tall buildings around it is different from the case of the Seagram building. There are not particular elevated structures which erge in the closer blocks, so the natural light is able to illuminate the Leadenhall building in a easier way also in the earlier and later hours of the day. The only exception is the Swiss Re Building with a circle floor plan, which is located on the west side respect the Leadenhall. Anyway, this building has forty floors, then less than the Leadenhall one, and the other tallest structures in the surroundig area, which are signed in red in the following Figure, have in any case less than twentyfive floors. This is the reason why it has been decided to build the Leadenhall building in the south east part of the block, so in this way the Swiss Building is will be placed in the north west direction respect the Leadenhall and consequently will prevent the Leadenhall lighting as little as possible.

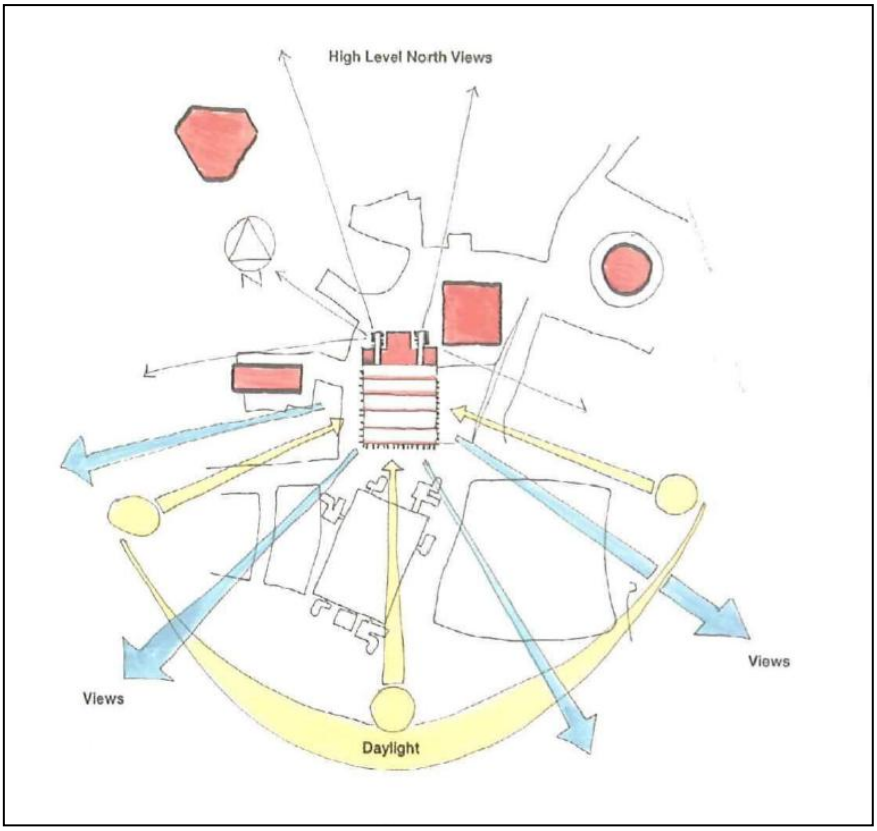


Figure 28- Leadenhall building area daylight

Moreover, the core of the skyscraper is located on the north side, in a way that, as it is shown in the above Figure, all the other sides of the building can be easily illuminated during all the day without encounter any other obstacle.

For what regards the inside design of the skyscraper, the solar gain to the office areas is countered with the incorporation of remotely controlled blinds, which can be regulated in relation to the amount of light required.

Structural Analysis

The proposed tower, designed by the Richard Rogers Partnership is 224.4 meters high (which corresponds to 239.4 meters AOD). The building would be 6.5 meters taller than the Minerva tower, making it the tallest currently proposed in the whole London City. The tower would be rectangular in plan but its south face slopes back to create a tapering form and a distinctive profile. Its structure takes the form of a braced 'tube' which becomes a major visible feature of the building behind its external glazing.

The ladder frame contributes to the vertical emphasis of the building, and encloses the fire-fighting cores that serve the office floors. The frame also visually anchors the building to the ground. At fifth floor level, a full length canopy would cantilever over the lower raking structure and the existing public footway. Below level five the floors are recessed on a raking diagonal under the building to create an open undercroft or galleria with a south facing public space looking onto Leadenhall Street and Lloyds of London. This area will be topped by ceilings 27m above floor level.

The office floors take the form of simple rectangular floor plates which progressively diminish in depth by 0.75 meters towards the apex. Office floors are connected to the structural "tube" at every floor level without the need for secondary vertical columns at the perimeter.

The northern support core is conceived as a detached tower containing all passenger and goods lifts, service risers, on floor plant and lavatories.

Then three groups of passenger lifts serve the low, mid and high rise sections of the building, and are connected by two transfer lobbies at levels tenth and twentyfourth.

The offices reception is at first floor accessed from the open space at the ground

floor by three escalators and a pair of lifts. From first floor, twenty lifts provide access to various parts of the office accommodation. Of the twenty nine total lifts, twenty two are exterior, glass, and fully scenic.

The position of the northern support core, which is separated from the office areas, means that the structure is not required to be over-clad with fire protection, allowing the whole to be designed and expressed as visible steelwork. This articulated steel frame provides clarity to the whole assemblage.

Moreover, as it has previously discussed earlier, the building needs to not face with particular close structural elevated obstacles in ordrer to receive the maximum amount of light than possible, but at the same time, the building itself has to not interfere with the view of the most important historic monuments located in the same area. As a consequence of that, the distinctive wedge shape is designed to virtually eliminate the building intruding into the sight line of St. Paul's Cathedral when viewed along Fleet Street and up Ludgate Hill.

In fact, the tower's design ensures that from this key vantage point the cathedral's dome is still framed by a clear expanse of sky.

Stability

Instead of a traditional central core providing structural stability, the building employs a full perimeter braced tube which defines the perimeter of the office floor plates and creates stability under wind loads. The circulation and servicing core, located in a detached north facing tower, provide an asymmetry in the floor plan of the building. This leads to the fact that, analyzing the floor plan, the center of mass does not coincide with the shear center, creating a torsional action.

Moreover, due to the diversification of the areas along the building's length, the torsion is not only referred to each single floor plan analysis of stability, but also to the whole vertical profile of the building itself.
The double torsion action is the most important structural aspect of the skyscraper's stability analysis.

Vertical System and Ventilation

The vertical circulation is located on the north side, opposite the lobby and main entrance facing the Lloyd's Building.
The building is designed to express all the constituent elements behind a single glazed envelope. Facades to the office areas require the highest comfort criteria in relation to heat loss, daylight, glare control and solar gain. Here, the facade is supplemented with an internal layer of double-glazing, forming a cavity which incorporates the structural frame. The external glazing incorporates vents at node levels to allow outside air to enter and discharge from the cavity. Controlled blinds in the cavity automatically adjust to limit unwanted solar gain and glare. A semplified scheme of the ventilation system along the facades is shown in the following Figure.

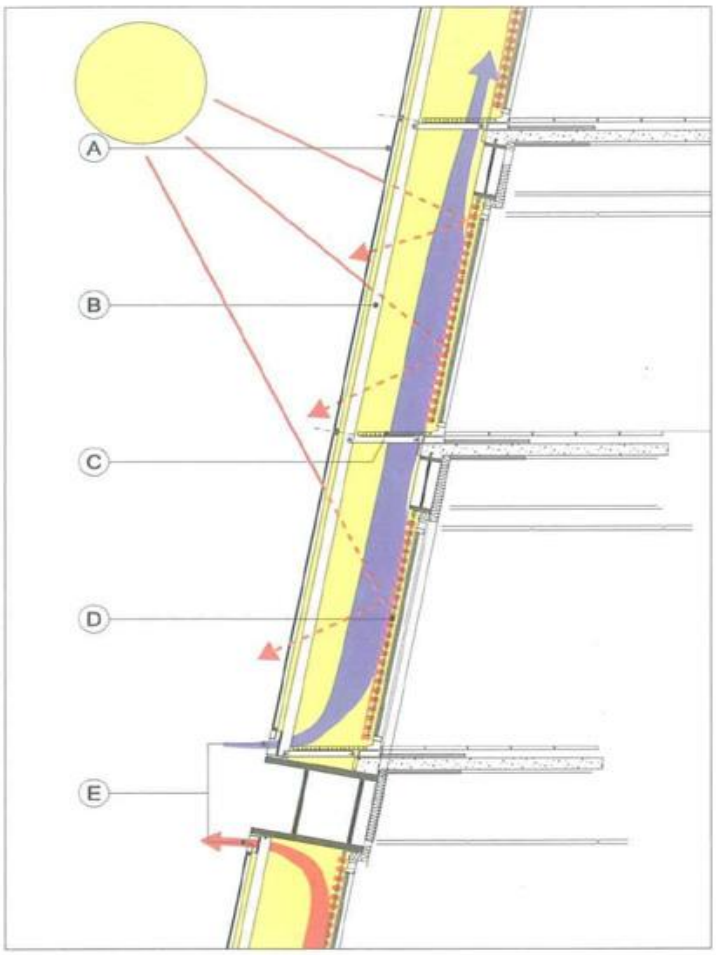


Figure 29- Ventilation system

Cost of Design and Construction

For the cost of the project and its construction it is useful to look at the policy draw by the London Mayor, Ken Livingstone, which was operating in 2004 and signed the full planning report from the London's Corporation.

The mixed use policy does not require residential use on-site within the City of London but, given importance to business and finance sector as a whole, off-site mitigation is considered appropriate. Give this background, it has been considered that significantly more than £30 per square meter (presumed to mean 30% of the planning obligations finance) will be required to mitigate the direct impacts of the

development and to provide an off-site contribution to housing as required by his mixed use policy.

Transport for London requires developer finance to be sought towards the delivery of capacity and accessibility improvements at stations servicing the development. Given the identified strategic impacts, it has also been considered that significantly more than £15 per square meter (presumed to mean 15% of the planning obligations finance) will be required to offset the impacts to the Transport for London network.

The London Development Agency urges the Corporation to secure 5% of any planning obligation finance for employment and skills training to go towards the long-term jobs on the site as well as enabling local access to construction training opportunities. In this way, the development will help tackle social exclusion and improve the capacity of the construction sector.

On the other hand, for what regards the cost of the building's project and construction, it has been estimated 45'000'000 $, even if the skyscraper is still under construction and the total final cost can change in the two next years.

Conclusion

At the end of this study, it is possible to resume all the considerations done for both the tall buildings and then make a comparison between them, in order to better understand advantages and disadvantages of each high rise building.

Seagram Building

Retracing all the analysis on the Seagram building, the conclusions are drawn on the basis of the functional, economic and structural point of view previously discussed. The first important aspect regards the design of the structure. In particular, the symmetries of the shape and the floor plans are very important elements for the building structural analysis. This is because in this way the study on the building's stability can be done without considering important structural aspects, like the torsional effect. The importance of the position of the concrete core needs also to be underlined. In fact, its centrality in the floor plan of the building fits together with the more simple model of skyscraper existing until our days: the central position of the core encourages the modularity of the structure, but most of all, permits a correct and more simple load ripartition in the columns of the vertical system. Moreover, being a modular and repetitive building floor after floor, with not particular structural elements used, the design has been quite linear with the realization of the building itself. In fact, no delays have been presented with respect to the supposed time of completion of the project during the construction phase. Therefore, the repetitiveness of the floor plans and of the rooms, due to the mere office destination, leads to the building compartimentalization. This does not provide the diversification of the spaces, that is one of the most important aspect needed to ensure the view of the Urban skyscraper as the "city within the city".

The second important aspect regards the building's functionality. The single destination office use is an important issue for this building, because it clearly underlines the absence of the mixed-use space, which is another fundamental element to consider the skyscraper as a reference point for the community's activities.

Leadenhall building

As for the Seagram building, some considerations are possible to be deduced also after the analysis of the Leadenhall building.

As for the structural design, the asymmetry of the floor plans and of the entire structure along its heigth represents an important issue for the realization of the tall building. In fact, the additional double torsion (in plan and in the longitudinal profile) is one of the elements that make the building very difficult to build up.

For this reason, there have been a lot of delays during the construction phase of the project, and, although the skyscraper was expected to be open to the public two years ago, it is still under construction.

On the other hand, the efficient technologies and the innovative structural elements used in the building's design express the overall quality of the project. The three glass facades and the accurate studies on the adopted illumination and ventilation systems are the technological elements given by this complex structure that make this skyscraper unique in its genre.

The second important aspect to consider is the Leadenhall functionality. The diversification of the spaces, not only for what regards the designed internal rooms but also the height and the square area of each floor, gives to the tall building a sense of variety of the elements, which is stricly correlated with the thought of people to

consider this skyscraper a place in continuos change, able to offer all the amenities proper of a good quality of life.

Moreover, the mixed-use space is another important characteristic of the skyscraper. The combination of office, residential, commercial and public spaces make the Leadenhall building the effective new nodal point of attraction of the City district of London.

Symmetric and Asymmetric buildings comparison

After structural and functional comparison, it is possible to say that from the economic point of view the two skyscrapers have more or less the same cost. This is obtained taking also in consideration the precious materials used for Seagram building facades and the delays in construction of the Leadenhall building.

So, at a parity of cost, of course each of the two presented skyscrapers has its proper advantages and disadvantages from many perspectives. Despite that, the positive aspects of the Leadenhall building are considered more significant with respect to the Seagram ones. In fact, designing a skyscraper with an efficient and innovative system of lighting and ventilation, which is eco-friendly and at the same time maintains the importance of the function for which it was built, corresponds to the maximum ideal of skyscraper, which is the only type of structure that can be considered the new referiment place for the community.

As a consequence of that, altough the comparison between the old Seagram and the new Leadenhall building describes the presence of more issues in the second one's stability analysis, caused primarily by its particular innovative shape, it is possible to

conlcude that these structural problems have to be anyway faced if the final result is the realization of one of the best examples of Urban skyscraper ever existed.
Then, as the Leadenhall building has demonstrated, the evolution of the tall buildings in their whole history leads to the conclusion that the new skyscrapers forms are more efficient and effective than the previous ones under many points of view. The continuous increasing in the development of innovative skyscrapers' typologies will be able to satisfy more and more the community needs in order to create the best urban plan for the future cities.

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