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Architectural concepts of contemporary skyscrapers

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ABSTRACT

Nine thousand years of architectural history were marked by human efforts to build tall structures, as evidenced by the remnants of the Egyptian pyramids, the Tower of Babel, pagodas in China and Japan, minarets of mosques in the East, etc. The explosive growth of the urban population has led to the emergence of megalopolises / megacities, large urban agglomerations. Megalopolises have become symbols of our urban age. It is impossible to imagine a megalopolis without its third dimension represented by the skyscrapers. Regardless of their content or primary function, skyscrapers have been named differently throughout history. It is very hard to say why one decides to use one term instead of another: tower, skyscraper, high-rise building, etc. Today, skyscrapers are becoming increasingly popular in rich countries, as well as in the large city centres. They are built not only in order to save space, but are also considered to be symbols of cities, i.e. of the economic power, like temples and palaces were in the past. Skyscrapers are architecturally dominant features, markers in the urban area. They represent their owners' concentration of power and money in today's metropoles. They not only define the horizon, but also help define the city identity. By constructing skyscrapers, the struggle for supremacy and records in achieving heights reaches its peak in the modern, global capitalist society. Today, skyscrapers represent a great achievement of modern technology and cannot be a priori rejected. This article attempts to explore the architectural concepts of modern skyscrapers, the need for high-rise structures, as well as their utilitarian and symbolic aspects.

Keywords: skyscraper, architectural concept, forms.

Introduction

Given the wide range of skyscrapers (towers) usage from their very beginnings until today, it is hard to define them accurately. In addition to the height, as its main characteristics, a high-rise building is denominated according to its construction and typological determinants, according to its use, function, designers, investors, owners, etc. The naming itself is based on the tradition of identifying buildings in architecture and art, spontaneity and acceptance of colloquial identification and recognition. Regardless of their content or primary function, skyscrapers have long since been given different names and it is very difficult to say why one decides to use one term among the others: tower, skyscraper, high-rise building, etc. Some architects believe that a tall building is the building whose main dimension is height and which dominates its surroundings. According to this theory, a church in a village with only two-storey houses which is 18.2 meters (60 ft.) tall, is indeed a tall building, but a 61 meters (200 ft.) tall skyscraper built in a business city centre is not, because it loses one of its essential features - dominating its surroundings among other buildings. Regardless of how we name the skyscrapers today, whether we like them or not, they do cause increasingly frequent controversies and discussions. In addition to the controversy related to the naming of skyscrapers, controversy and discussions on building skyscrapers and living in them emerge. However, regardless of the existence of these polemics, there will always be reasons for and reasons against building skyscrapers.

Historical overview

Construction of the first modern skyscrapers was triggered by the American entrepreneurial spirit and technological achievements (steel structures, elevators). Their instant spread in the city centres is a result of mutual interaction between two factors: the need for a growing concentration of people and a large increase in land prices. Despite the fact that the economic factors and the imperative for a continuing increase in urban density will remain the main actors

in the skyscrapers story, their considerable symbolic potential cannot be neglected. Thousands of workers have been working on the pyramids of ancient Egypt, European cathedrals and countless other towers, all in an effort to create something awe-inspiring.

Ego and grandeur sometimes play a significant role in the building process, just like in the ancient civilizations. People have always aimed to build facilities as tall as the technical possibilities had enabled. A lot of skyscrapers in today's metropoles represent a concentration of power and money belonging to the modern global capitalist society. The first modern tall building originated in Chicago. The architect of the first "skyscraper", the Home Insurance Building, was William Le Baron Jenney.

This was the first building created by means of new possibilities of using steel with the simultaneous invention of the vertical transportation device - the elevator. The Home Insurance Building is an example of the Chicago School of Architecture. At the end of the 19th century, basic prerequisites for the construction of skyscrapers and solving complex technical and static problems were met in America.

Economic interest had inevitably led to construction of taller and taller buildings, since the increase in land prices in the city centres, which the US economic activity was focused on, demanded exploiting every square meter of land parcels and solving problems of high-rise building construction

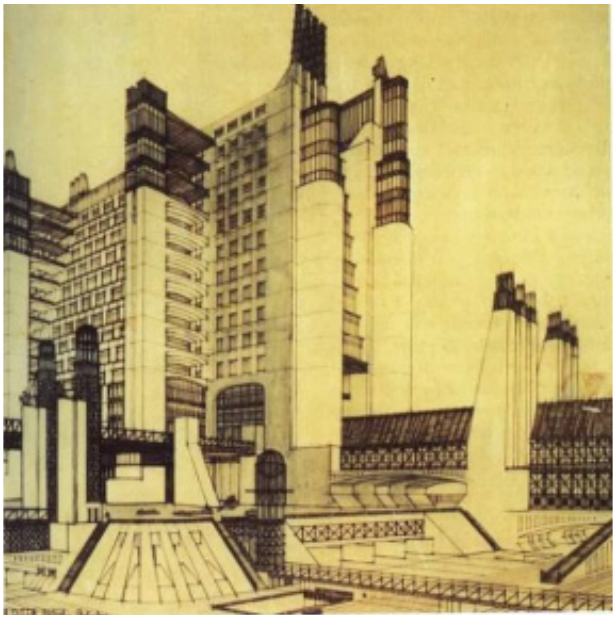


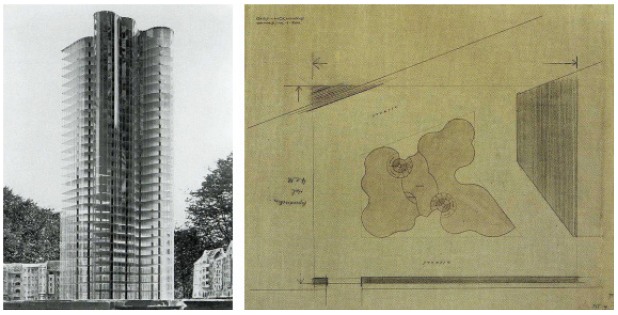
Figure 1: A city according to Antonio Sant'Elia

brought about extraordinarily large amounts of money on the real estate market. On the other hand, there is a considerable reserve towards the construction of skyscrapers in Europe. Although their elegant form can represent a manifestation of optimism, openness and economic vitality, they are usually associated with urban anonymity and uniformity as well. However, the biggest complaints are caused by the environmental insensitivity.

Although skyscrapers occupy several times less land than low-rise buildings of the same volume, much more energy is spent on their construction and exploitation. The difference between the American and the European type of skyscraper construction is the fact that the American architects had carte blanche, while their colleagues from Europe were always facing bureaucratic "problems" in the design of skyscrapers. Antonio Sant'Elia was among the first ones who thought of high-rise building construction.

In 1914, he dreamt of a concentrated city full of towers linked with traffic infrastructure on several levels. In 1921, Le Corbusier made a project for a city with one million inhabitants, 24 skyscrapers, each having 60 storeys with 95 % of spare land. He justified the introduction of skyscrapers into residential zones with the possibility of preserving large areas of free green spaces.

In 1922, in an unknown location in Berlin (it is considered to be a city square or a traffic roundabout), Ludwig Mies van der Rohe envisioned a skyscraper with a glass facade (Friedrichstraße). The geometry of the "crystal" skyscraper, Friedrichstraße, was a biomorphic plant project with a core and three wings. Given the circumstances and possibilities of building this skyscraper at that time, the project was unmanageable. Since then, and until today, the idea of constructing the vertical city did not die.



Figures 2 and 3: Mies van der Rohe's Friedrichstraße skyscraper's facade and plan

Construction, design and form

Several technological advances, which had occurred in the late nineteenth century, enabled the design and construction of skyscrapers. These include mass production of steel, the invention of a safe and efficient elevator and the development of improved techniques for measuring and analysing structural loads and stresses. During the 1920s and 1930s, the development of high-rise buildings was further improved by the discovery of the electric arc welding device and fluorescent lamps. In the traditional construction method, the building walls supported its structure, while the larger structures required thicker walls.

Sixteen buildings that were constructed in Chicago in 1891 had a wall thickness measuring 1.8 m in the base (ground floor). The need for building thick walls was eliminated by the invention of steel structures (frames), in which the rigid steel skeleton supported the construction's weight. The first building made by using steel structures was the Home Insurance Building, built in Chicago in 1884.
Each skyscraper represents a unique structure designed in accordance with the physical limitations. It is determined by factors such as geology, climate, the needs of the tenants and meeting aesthetic goals of the owners and the architects. Therefore, both the construction and the design of each skyscraper are unique. At the beginning of high-rise building construction, the design was conditioned by the construction of the building itself, while today these relationships are much more flexible.

The emergence of the world's tallest building forms is closely related to the technical advances that had enabled the implementation of creative solutions as architectural landmarks of cities. Since the late nineteenth century to the present day, the development of skyscraper forms has followed the style and development conditions. It resisted the crisis situations and served to achieve the objectives of modern society, following the dynamics of its development. Tied to strict building regulations of cities, these buildings often took shape of land parcels. Yet, some of them were in contrast with land parcel forms, but almost each of these projects carried its own message, a symbolic instance, urban and architectural uniqueness. Taking into account the emergence of skyscraper forms in the past and the trend in rapid growth of land exploitation in the cities, as well as progress in terms of structural design and building materials in the construction industry, we can expect the emergence of unique, freer and architecturally more complex structures in the near future.

Case study 1 – The Home Insurance Building, William Le Baron Jenney, Chicago 1885

Enabled by the discovery of new building techniques and the invention of the elevator, the first skyscraper was built in Chicago, in 1885. The Home Insurance Building was designed by William Le Baron Jenney. The improved steel structure ensured inner support, which meant that, unlike before, the external walls no longer needed to carry the self-weight of the floors. The building had 10 floors, was 42 meters tall and weighed one-third of the weight it would have had, if it was constructed using standard materials, such as stone.

Despite the fact that it rested on the skeleton system as the primary load-bearing structure, later studies discovered that one part of the load had had to be transferred to the external walls and other building elements. The building was demolished in 1931, but it is still considered a pioneer in the development of the world's skyscrapers, because its architecture and structure had triggered a rapid development of ideas about the possibilities of high-rise building construction. From then on, the administrative buildings, business city centres, housing and multifunctional facilities with skyscraper form have become new architectural landmarks of cities.

Primary purpose	The building was made for an insurance company (people and property insurance)
Spatial organization	Square-shaped building plan, vertical communications are placed in the core, office spaces are arranged around the vertical communications
Structural concept / structure	Simple, prism-shaped building was the basis for future skyscraper construction; the skeleton structural system was resting on stone pillars
Architectural and technological aspect	First building made from steel structures and using an elevator

Figure 4: The Home Insurance Building

Case study 2 – The Chrysler Building, William Van Alen, New York, 1930.

We can state that, at the beginning of skyscraper development, buildings used to inherit the stylistic characteristics of movements prevalent in the world at the time. Thus, the Chrysler Building in New York was built in the Art Deco style, which found its inspiration in the archaeological discoveries from Egypt. The form of this building contains various elements that mimic parts of Chrysler cars.

The facade finish contains numerous geometric elements. The shape of the building is prismatic in majority of its mass, from ground level to the top, while only the upper zones are semi-oval shaped, pulled toward the vertical axis of the building, narrowing down to the top, i.e. the car heater – shaped lance. The upper zone windows are triangular-shaped and follow the oval shape with their positioning on the facade. The rhythm on the facade is achieved by coupling windows and grouping them vertically, while the facades are symmetrical.

Figure 5: Spatial diagram, The Home Insurance Building, 42 m

Primary purpose	Car manufacturer company office building
Spatial organization	Square-shaped building plan, vertical communications are placed in the core, office spaces are arranged around the vertical communications
Structural concept / structure	Simple, prism-shaped building with semi-oval surfaces on the top; steel skeleton structure consists of two cores (the inner core made of steel and the outer core made of concrete)
Architectural and technological aspect	Innovative solutions with stainless steel facade surfaces

Figure 6: The Chrysler Building

Figure 7: Spatial diagram, The Chrysler Building, 319 m

Case study 3 – The Seagram Building, Ludwig Mies van der Rohe, New York 1958.

The Seagram Building skyscraper had a great influence on American skyscraper architecture. Alike almost all skyscrapers at that time, it was constructed using skeleton type steel frames with non-structural hanging glass facades. This skyscraper has a distinctive style through which its external structure is articulated. The style is actually a mixture of the functional and decorative structure pertaining to the load-bearing elements. The architect of the Seagram Building, Mies van der Rohe, strived both for the visibility and the decorative role of the structural elements. He wanted to make all steel (load-bearing) frames visible, but the American building regulations did not allow it (steel must be coated with fire -resistant materials – usually concrete). However, he wanted to avoid covering it with concrete at all costs. Therefore, for the first time in the history of skyscraper construction, he used non-structural bronze stressed pillars, visible from the outside. The Seagram Building was the most expensive skyscraper at that time due to the use of expensive, high-quality materials and interior elements.

Primary purpose	Office building
Spatial organization	Square-shaped building plan, vertical communications are placed in the core, office spaces are arranged around the vertical communications
Structural concept / structure	Prism-shaped building, steel frames structure with bronze exterior columns
Architectural and technological aspect	Use of bronze as non-structural exterior facade and space ventilation

Figure 8: The Seagram Building

Case study 4 – The Sears Tower, Skidmore, Owings & Merrill (SOM), Chicago 1974.

A system of connecting several elements into one mass that is much lighter and more stable in comparison to the monolithic structure of the same usable area, was applied in the design of the Sears Tower skyscraper in Chicago. Taking its form into account, we can say that the building was created by subtracting mass from the major, prismatic mass. In this way, a stepped structure narrowing down towards the top was created making its form appear lighter. The materials used for construction are steel covered with black aluminium and glass with an addition of bronze paint, which creates a hot – cool contrast in terms of colour on the facade.

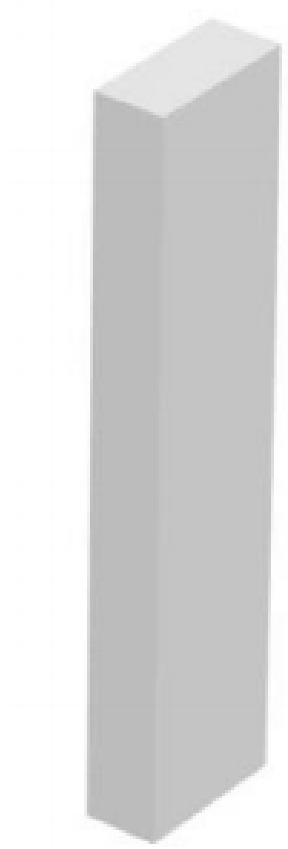


Figure 9: Spatial diagram, The Seagram Building, 157 m

Primary purpose	Large trade corporation office building
Spatial organization	The building plan consists of nine squares with their own communication cores in the middle and office spaces around them
Structural concept / structure	The building was formed by subtracting masses from the main prism-shaped mass; a steel structure covered with black aluminium and glass with an addition of bronze
Architectural and technological aspect	Steel frame with exterior tinted glass coating

Figure 10: The Sears Tower

Figure 11: Spatial diagram, The Sears Tower, 442 m

Case study 5 – Menara Mesiniaga, Kenneth Yeang, Malaysia 1992.

Menara Mesiniaga are the headquarters of IBM in vicinity of Kuala Lumpur. This skyscraper is the result of a ten-year-long research on tall buildings and skyscrapers bioclimatic design principles made by architect Kenneth Yeang. Its structure consists of "green" gardens, ten floors of office space with terraced garden balconies and exterior cooling openings. The skyscraper roof is designed to exploit solar energy (sunroof). A pool through which the solar panels were placed is located on the roof as well. Natural ventilation enabled in the building accounts for its cooling energy savings. Using the environmental design, the architect managed to reduce long-term maintenance costs by reducing the standard energy sources. Apart from large energy savings, Kenneth Yeang managed to keep a high level of the facility aesthetics by designing Menara Mesiniaga skyscraper based on bioclimatic principles. Menara Mesiniaga skyscraper received the Aga Khan Design Award in 1995.

Primary purpose	IBM corporate headquarters
Spatial organization	The building plan is round-shaped; communication core and technical infrastructure are placed along the edge; office spaces are organized in the remaining area
Structural concept / structure	The building is based on two spirals twisted on specific floors to provide shading and visual contrast of steel and aluminium surfaces
Architectural and technological aspect	The world's first bioclimatic skyscraper with a natural cooling system

Figure 12: Menara Mesiniaga

Figure 13: Spatial diagram, Menara Mesiniaga

Case study 6 – The Petronas Towers, Cesar Pelli and Associates, Kuala Lumpur 1998.

The Petronas Towers skyscraper form narrows down towards the top, while the repetition of the horizontal floor module is reduced in number. When analysing the building plan, it is evident that there is analogy with ornaments of Islamic architecture. By analysing the form, we can conclude that the building is symmetrical, balanced and there is a harmony between the individual elements, as well as between the elements and the whole.

Despite being technically well-founded, the form is created with a sense of respect for geometric and mimicking the natural forms. Its plan is developing dynamically along the vertical axis, moving the mass towards the top, so that the building resembles a corncob strongly bonded to the plant stem (i.e. to the ground, in this case).

Primary purpose	The facility was built for the business needs of petro- chemical industry companies
Spatial organization	The building plan consists of two main and two smaller "circles", the central communication core is placed in the middle and other functions are organized around it
Structural concept / structure	The building consists of two main and two smaller towers that resemble a corncob; the basic parts of the structure are steel and concrete with a glass facade which contains elements of Islamic architecture
Architectural and technological aspect	Mastering seismology in skyscraper construction and connecting the two towers at a high altitude

Figure 14: The Petronas Towers

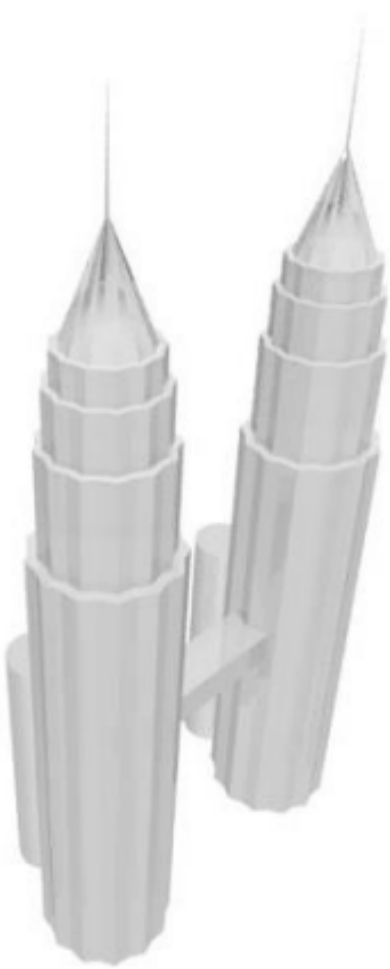


Figure 15: Spatial diagram, The Petronas Towers, 452 m

Conclusion

Whether we like it or not, skyscrapers, regardless of their height, today cause increasingly frequent controversy, polemics and discussions. Despite many existing definitions, it is very difficult to make a general one which would be generally acceptable for skyscrapers, the one that would suit each city, different latitudes, people, etc. Today, skyscrapers represent a great achievement of modern technology and cannot be a priori rejected. During the construction of a skyscraper, factors including specific conditions shaping the design process, social environment and time of construction must be taken into account. Furthermore, we should also note that economic interests have influenced the design of the skyscrapers due to the increase in land price in central parts of cities, which caused exploitation of each square meter of land parcels. The key issue regarding the existence of skyscrapers is the correct choice of location, as well as the appropriate number and arrangement of skyscrapers in the city context. As a symbol, the skyscraper represents a demonstration of power, and is therefore the ideal promoter of the corporate image, as well as a sign of a globalized world economy. In general, we can conclude that the construction of skyscrapers in larger dimensions still seeks the ideal form. However, this search does not include repetition, generally speaking, as each new building adds something new to the history of the skyscraper construction, in technological, aesthetic, or both of these aspects. This article can serve as a starting point for future research on:

- The development of human (green) design of skyscrapers,
- Ideal forms of skyscrapers,
- New designs and new technological developments in the field of skyscraper construction.

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Arhitektonski koncepti savremenih nebodera

SAŽETAK

Devet hiljada godina arhitektonske historije označene su humanim naporom da se gradi u visinu, što potvrđuju ostaci egipatskih piramida, babilonskih kula, pagode Kine i Japana, munare džamija Istoka. Eksplozivni rast gradskog stanovništva doveo je do pojave megalopolisa/megagradova, velikih gradskih aglomeracija. Megalopolisi su postali simboli našeg urbanog doba. Nemoguće je zamisliti sliku megalopolisa bez njegove treće dimenzije koju predstavljaju neboderi. Neboderi bez obzira na sadržaj ili svoju primarnu funkciju, dobile su seriju naziva i vrlo je teško reći zbog čega se čovjek odlučuje da upotrijebi jedan između ostalih: toranj, neboder, oblakoder, soliter itd. Danas su neboderi sve popularniji u bogatim zemljama kao i u centrima velikih gradova. Oni se grade ne samo za „uštedu" prostora, nego se smatraju simbolom grada, tj. ekonomske moći, kao što su bili hramovi i palače iz prošlosti. Neboderi su arhitektonske dominante, biljezi u urbanom prostoru, oni u Današnjim metropolama predstavljaju koncentraciju moći novca njihovih vlasnika. Oni ne samo da definiraju horizont, nego pomažu definirati i identitet grada. Borba za primat i rekorde u dostizanju visine gradnjom nebodera dostiže svoj vrhunac u savremenom, globalnom kapitalističkom društvu. Neboderi danas predstavljaju veliko dostignuće savremene tehnologije i ne mogu se apriori odbaciti. Ovaj članak će pokušati da istraži arhitektonske koncepte savremenih nebodera, potrebu visoke gradnje, njihove utilitarne i simboličke aspekte.

Ključne riječi: neboder, arhitektonski koncepti, forme.