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THE INFLUENCE OF LOUIS H. SULLIVAN ON THE CHICAGO SCHOOL OF ARCHITECTURE

• **Dr. Ezgi BAY ŞAHİN***

ABSTRACT

Chicago has been an active city since it started to attract people for new opportunities in the 1830s. After the city experienced the Great Fire in 1871, the primary concern was to rebuild the city. The absence of fire-protective materials, fragile soil conditions, and the need for multistory commercial buildings with structural stability were serious challenges. Many prominent architects and engineers not only rose to them but also created the "Commercial Style". Thus, the time witnessed the emergence of the Chicago School. This paper addresses the influence of Louis Henry Sullivan on the Chicago School of Architecture. Looking at the remarkable ideas in materials and construction techniques employed at the time, it is aimed to answer how a city is built on its dynamics on a different scale. It provides an in-depth analysis of the period's problems related to building construction via literature review, drawings, and photographs. As the method of the study, tall building innovations were investigated using Sullivan's five buildings which express the idea of contemporary high-rise buildings and technical solutions of the period. The study will contribute literature answering how these buildings' designs responded to the theory behind the Chicago School of Architecture.

Keywords: *Louis H. Sullivan, Steel framed system, Chicago School of Architecture, Commercial Style, Building technology.*

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LOUIS H. SULLIVAN'IN ŞİKAGO OKULU ÜZERİNDEKİ ETKİSİ

• Dr. Ezgi BAY ŞAHİN*

ÖZET

1830'lardan itibaren canlı bir kent olan Şikago yeni fırsatlar için insanları çekmeye başlamış ve aktif bir iş merkezi haline gelmiştir. 1871'deki büyük yıkımla sonuçlanan Büyük Yangın'dan sonra, şehri en kısa sürede yeniden inşa etmek tek öncelik olmuştur. Çözümlenmesi gereken birçok problemden biri yangına karşı koruyucu malzemelerin olmamasıdır. Diğeri ise Şikago'nun mukavemet dayanımı düşük zeminine dayanabilecek temel sistemlerinin eksikliğidir. 19. yüzyılın ikinci yarısında, birçok önde gelen mimar ve mühendis, teknolojik gelişmelerin yardımıyla bu problemlerle başa çıkmanın yanı sıra yeni bir akımı ortaya çıkarmışlardır. Bu makale, Şikago Mimarlık Okulu'nun oluştuğu dönemi, Louis Henry Sullivan'ın bu akım üzerindeki etkisini, dönemin gelişen teknolojisi ile bina yapım ilkelerini değerlendirmektedir. Araştırmanın amacı, bu dönemde kullanılan yeni malzeme, inşaat teknikleri ve yenilikçi fikirleri değerlendirerek bir kentin, büyük bir felaket sonrası zorlu koşullar altında, kendi dinamikleri üzerine nasıl tekrar inşa edildiğini ortaya çıkarmaktır. Yöntem olarak dönemin yapım sistemleri ile ilgili zorluklar ve bu süreçte geliştirilen teknikler Louis Sullivan'ın beş binası kullanılarak, literatür, çizimler ve alan çalışmalarında çekilen fotoğraflar üzerinden analiz edilmiş ve bu yapıların Şikago Mimarlık Okulu'nun ardındaki teoriyi nasıl yansıttıkları işlenmiştir.

Anahtar Kelimeler: *Louis H. Sullivan, Çelik taşıyıcı sistem, Şikago Okulu, Ticari Tarz, Yapı teknolojisi.*

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1. INTRODUCTION

In the last years of the nineteenth century, high-rise building construction was booming (Landau and Condit, 1999). With the results of technical progress, structures have reached spectacular heights and strength in metropolises all around the world. There have been many arguments about high rise because of industrialization and urbanization which create an inseparable dialectical process and problematic issues. However, the importance and need for high-rise buildings are not only connected to inevitable results of economic factors. As Hamlin (1897) mentions, doing several economic and urbanistic activities in a minimum space is as essential as the value of the land. Hamlin sees the great height of structures as "a consequence of American hurry, of not wasting time". There are turning points in building types, techniques, and forms in architecture. These may also be affected by catastrophic events due to the need for rebuilding. Chicago is a great example to start explaining a significant turning point in architecture as the birthplace of the Chicago School of Architecture after a disruptive event: The Great Chicago Fire of 1879.

After Chicago was taken from the first Native American and French settlers, the population and land prices started to rise in the city. While only 30 people lived around the Chicago River in 1829, Chicago became a town with 350 residents four years later. In 1837, immigrants increased the population to 4,710 and Chicago was declared a city (Hill, 2016). The city population reached 298,977 in 1870 increasing tenfold since 1850 (Condit, 1964). Newly established industries such as meatpacking and brick initiated this growth.

The meatpacking industry in the Union Stock Yards, which was established in 1865, followed the development of agriculture. The Union Stock Yards of Chicago was the center of meat production in the United States. After the invention of the refrigerated railcar, meat could be shipped all over the country and Chicago also became a distribution center. Thanks to major technological changes, the railway network made the city the "national transportation hub" (Roche & Lasher, 2010) and "the principal wholesale market" as the center of lumber and grain distribution (Cronon, 1992).

This environment triggered a real estate boom in Chicago. Thus, the city, which was a big trading center of "fur, flour, skins, jewelry, pipestone, dried meat, fish and alcohol", became a speculative American boomtown. While lots were being sold for $33 in 1829, the prices reached $100,000 by 1836. Cronon explains that these prices were speculators' dreams, and these did not have any relation to the economic reality of that day. Thus, when the real estate market collapsed, selling land became impossible (Cronon, 1992).

Business slowed down by the effect of the Panic of 1837, however, the population growth continued. Dealing with this unprecedented growth, the city experienced the Great Fire in 1871, its consequences, and the emergence of important changes in its recovery. In this environment, the commercial architectural style emerged in Chicago.

This study analyzes the first Chicago school, conditions during its emergence such as the destruction of the Great Fire and efforts to rebuild the city. More specifically, Louis Sullivan's contribution to this influential era as a pioneer architect was reviewed. While Sullivan was called *"the father of skyscrapers", "Form follows function"* (more accurately, "form ever follows function") was attributed to him and guided the innovative architecture in this era. He envisioned the aesthetic possibilities of skyscrapers in urban areas (Bluestone, 2013). His credo became a common doctrine of modern architects. His organic philosophy was adopted by others and triggered the creation of new movements. As an "aesthetic mentor" (Condit, 1964), Sullivan inspired this movement with his work and writing. He influenced many designers and architects such as "George Grant Elmslie, William Purcell, Parker Berry, William E. Drummond, and William L. Steele" (http 1) as well as Frank L. Wright. Architects of the era believed in the connection between designing structures with humanity and the environment. Its characteristics, such as horizontal lines, indigenous materials, integration with landscape, and flat roofs, are common in the Midwestern cities in the United States. Also, they affected other countries in the world.

After analyzing the first Chicago School via technical advances such as skeleton construction, elevators, fireproofing, and Chicago windows in Section 2, the reflection of the Chicago School on the architecture of the period was explained using five case studies. The different and common use of the techniques, the connection between function and appearance, and progress were exemplified through notable buildings of Louis H. Sullivan. Each case study was explained in terms of materiality, structural system, foundation, and exterior features. Ornamental details and interior elements were additionally presented for those structures located in Chicago. The study focuses on the period between the Chicago Fire of 1879 and 1899 via literature reviews, structural documents, and photographs.

2. TOWARD AN INNOVATIVE PERIOD: THE ANALYSIS OF CHICAGO SCHOOL

Representing a leading era in sociology and urban science, the Chicago School refers to a "school of thought" that originated at the University of Chicago in 1892 and their work became prominent during the early twentieth century (Lutters and Ackerman, 1996). While the first main body of research focused on urban sociology, the research concentrated on the urban environment of Chicago also became influential (Parker, 2004). Members of the school have treated this expanding city as a social laboratory to find evidence if urban growth and social mobility cause contemporary social problems. (Wirth, 1928). In architecture, the Chicago School describes a period of experimentation in construction and design and defines a style for mostly the high-rise office buildings in the late 1800s.

When the Great Fire of Chicago destroyed nearly "a third of the city, including commercial downtown and most of the North Side", thousands of people became homeless (Smith, 2007). Wood frames, wood floors, and iron structures failed and collapsed during the fire. So, $192,000,000 of property was burned in Chicago whose population was 334,270 (Randall & Randall, 1999). In this sense, Chicago demanded an architectural transition in terms of techniques and materials. Since rapid construction was required in Chicago's valuable land, the idea of rebuilding the city in the post-fire period attracted many architects and engineers throughout the country. Especially, a group of them converted the city into an experimental place where developed solutions made incredible contributions to the evolution of building construction in the Chicago scene. Commercial buildings were designed by them with flexible plan scheme, wind bracing and non-load bearing walls (curtain walls). They, including Daniel Burnham, William Le Baron Jenney, John Wellborn Root, Dankmar Adler, Louis Henry Sullivan promoted new building technologies and created the "Chicago School of Architecture" also called "Commercial Style" which affected the contemporary architecture.

Figure 1: *Chicago after the Great Fire of 1871 (Photographer George N. Barnard, http 2)*

These significant figures helped the recovery of Chicago when solving numerous architectural and structural problems. For instance, William Le Baron Jenney was the architect of the first fully metal-framed ten-story structure, Home Insurance Building in Chicago (Moon, 2018). John Wellborn Root developed the floating raft foundation system interlacing the concrete slab with steel beams to prevent tall buildings from sinking in Chicago's wet ground (Leslie, 2013). One of the Chicago landmarks, Auditorium Theatre on a massive scale with electric services was built by Adler and Sullivan in 1889 (Randall and Randall, 1999).

As Sullivan advocated an organic theory of architecture via his famous expression 'form follows function'(Ellis, 2021), Chicago's School addressed two main integrated features: *Function and Form*. The first one was the issue of construction that connects with function and structure. The other was the formal which was about aesthetics to create a new style and shape the own character of American architecture. Significant technological advances were made; skeletal frames provided strength, height, and openness in the plan and on the façade. It was made possible through the usage of narrower iron-reinforced brick piers that reduced the spatial disadvantages of large masonry walls and piers.

Furthermore, wind–braced frames began to be used to prevent the strong effects of wind. On the exterior, terra-cotta was used as a fire-proofing material, and glass made buildings' skin lighter and more transparent (Lupkin, 2018; Moon, 2018; Leslie, 2013). This progress in building construction with technological advances enabled Chicago to have leading examples of tall commercial buildings after the Great Fire. Architects and engineers from the Chicago School not just designed buildings in Chicago, but also in New York, Cincinnati, Minneapolis, New Orleans, San Francisco, and other metropolitan areas in the US (Achilles, 2013). These innovations they used are still relevant for today's architecture. Several structures such as tall office buildings, hotels, and residential blocks could be developed with the help of modern techniques.

Building techniques were changed and developed over time while searching for better solutions to architectural and engineering problems. Although new material usage and lighting technologies provided an advantage to commercial architecture, World War I (1914-1918) changed the conditions. Leslie explains this effect on specific materials by giving the example of glass price and availability. "The rise in energy costs around the war more directly affected glass prices than steel, brick, or concrete, and plate glass went from being a luxury material in 1890 to being "cheaper than bricks" around 1895, to again being expensive enough to warrant careful rationing in 1918" (Leslie, 2013).

The death of Root, the end of the Adler and Sullivan's Partnership, and Jenney's losing power because of his old age, changed the common tradition of the period after 1900. Architects in the city increasingly focused on residential and public works rather than commercial architecture as a strong transition of the Chicago School. Also, Daniel Burnham was interested in city planning. He published "Plan of Chicago" in 1909. Prairie School, which is usually associated with architects influenced by Louis H. Sullivan and Frank L. Wright, emerged in this environment in Chicago.

As well as effects of the Fire of 1971 on Chicago, World War I (1914-1918), The Great Depression (1929-1939), and World War II (1939-1945) influenced the city and

American Architecture in this long period. Second Chicago School emerged and played an essential role in twentieth-century architecture. Because of economic shrinkage during the Great Depression, the number of big-scale private building construction decreased. Many architects immigrated to the US by bringing their experience of Bauhaus and International Style like Mies van der Rohe as a catalyst of the Second Chicago School. He and his followers continued to form the city. In addition, Fazlur Kahn, Myron Goldsmith, Bruce Graham and Walter Netsch, Bertland Goldberg, and Harry Mohr Weese are important names of the Second Chicago School (http 3).

Important innovations and inventions in the construction sector affected the structure, materials, geometry, and indoor conditions of buildings in Chicago. Not only these changes but also the challenges that triggered the structural solutions were explained via literature review and diagrams to display the progress in building technology of the era under the following four categories:

- Development of skeleton construction and the invention of elevators
- Development of foundations for Chicago's soil conditions
- Development of fire construction
- Chicago windows and façade characteristics

2.1. Development of Skeleton Construction and the Invention of Elevators

Before the invention of steel skeleton frames in buildings, the load-bearing masonry buildings' walls were getting thicker from the top to the bottom (Figure2). Although this old construction method restricted natural light due to masonry buildings' thick exterior walls, it was the common system during the earliest age of office building construction in the country. Unlike brick and stone, the usage of fireproofed iron enabled more open floors and smaller columns inside of the buildings as well as bringing new aesthetic opportunities (Leslie, 2013).

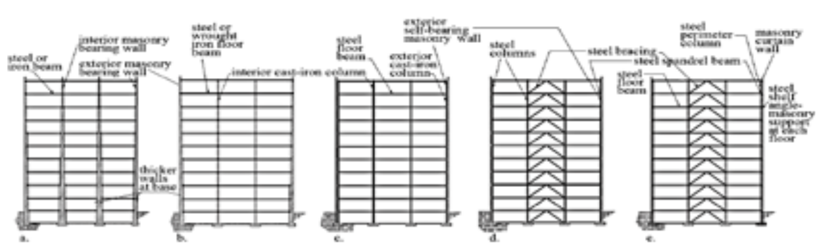


Figure 2: *Schematic cross-sections a). Pure bearing-wall building b). Mixed bearing-wall building, c). Wall-braced cage building, d). Frame-braced cage building, e). Skeleton frame building (Modified from source: Friedman, D. 2012).*

Technological improvements refined the concept of skeletal construction and curtainwalls. For instance, the Home Insurance Building by Jenney used skeletal framing and masonry walls which partially carry the gravitational loads. However, only six years later, in the Wainwright Building built by Sullivan, the steel frame structure carried the entire loads supporting the curtainwalls around the columns. These opportunities enabled more efficient lighting and ventilation conditions and layout flexibility in buildings. Since the steel frame was supported by rigid joint connections, the tall building envelope could be opened up to get adequate natural light and air (Roche & Lasher, 2010). Thus, not only indoor conditions of buildings were improved but also dense high-rise building areas reached better conditions. These prepared the city for economic, social, and cultural growth. Also, this trend of tall building construction created different needs such as elevators for faster and easier travel between floors.

As Randall and Randall (1999) mention, the development of elevators in which Chicago played a critical role was crucial for tall buildings. Until the mid-1950s, steamed-powered grain elevators were in use. The passenger elevator was installed first in New York and then in Chicago in 1856 and 1864, respectively. This was also steamed-powered. In 1870, the first hydraulic elevator was developed. It was installed in a store building in Chicago and was considered the first practical elevator. The first electric elevator started to be used universally in 1887 (Randall & Randall, 1999). With this essential development, accessing upper stories became easy and fast in tall buildings. Also, it provided more commercial places and economic profit for developers.

2.2 Development of Foundations for Chicago's Soil Conditions

Chicago originally had swampy and low-lying ground. The emergence of new structures in Chicago required new techniques to adapt to the city's soil condition shown in Figure 3. Because of the instability of the wet and silty soil, foundation, drainage, and sewage disposal were the serious problems of this growing city (Peck, 1948). To solve this problem, different methods were tried during the history of Chicago. One of the most interesting techniques was raising the structures to build new foundations underneath and to add several meters of the earth under existing buildings.

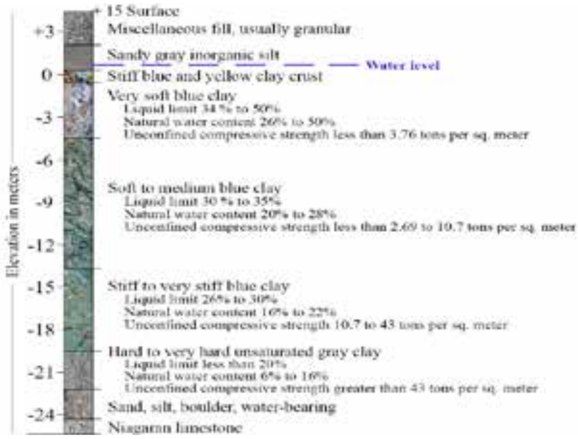
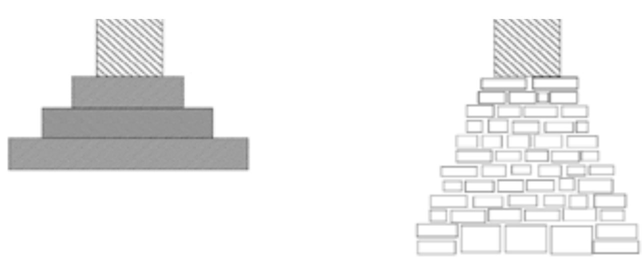


Figure 3: *Typical soil conditions in Chicago (Modified from source: Peck, 1948).*

Many buildings in Chicago not only lifted but also moved by using jacks simultaneously to other locations to accommodate the sewers and build stone walls around the blocks until 1864 (Peck, 1948). This allowed people to retain the filling of the street. An important turn in the material used for foundations reduced the volume of footings and gave them more strength. Until 1874, hard limestone was used as the most common material in construction. When this even-bedded and 8-12 inches thick stone was cut into rectangular slabs, it was called dimension stone (Figure 4a). Rubble stone piers were made of small pieces (Figure 4b). Both dimension stone and rubble stone were common materials for foundations. On the other hand, concrete was not considered a reliable element since it was not reinforced. These footings were built up in layers. Between the joints of roofing gravel and fresh cement, a mortar was used. From top to bottom, the layer of footing area increased. Also, the offsets of layers were generally smaller than the thickness of the stone. When the footing rested on the sand, first a thin layer of broken stone or gravel was used. Then the footing was rammed into the surface and grouted with the use of cement mortar (Peck, 1948).



a. Dimension stone b. Rubble stone pier

Figure 4: *a) Dimension stone, b) Rubble stone (Modified from source: Peck, 1948).*

Another method was "the floating method" to provide resistance to Chicago's fragile soil. Since deep excavations and piling were not necessary, a thick mat of concrete was used under the structures until this continuous mat broke apart under the buildings such as the City Hall (by van Osdel, 1872) and Board of Trade (by Boyington, 1885), and caused the demolition (Leslie, 2013). On the other hand, the system of isolated footings allowed quantifying individual column loads.

In 1873, Frederick Baumann published about this system that provides pads to spread the loads over. He proposed pyramidal footings of stone, brick, and concrete that matched the dimensions of the columns' base plate above. This helped to estimate the required area of soil below however pyramidal footings required a large area. In the mid-1880s, iron rails started to be used instead of pyramidal footings. Because the bending capacity of iron provided that foundation pads could work as cantilevers in reverse, it could spread the loads. This approach did not require volume, unlike pyramidal footings (Leslie, 2013). Wood piles and caissons were other construction elements that became popular during that time.

2.3 Development of Fireproof Construction

After the destruction of the Great Fire in Chicago, one of the most needed innovations was preventing possible fires and creating regulations. The fire showed that brick or stone walls were not enough to protect buildings. So, a new method was developed to protect structural materials from fire by John Van Osdel. This prominent architect used this method of fireproofing with clay tile. He applied this method in the Kendall Building. So, the building was considered the first fireproof building in the city. In addition, according to the 1886 law amendment of the Chicago Building Ordinance, new buildings taller than 90 feet (27.4 meters) must be of incombustible material (Randall & Randall, 1999).

Available common materials in Chicago's market were timber, stone, and cast iron for commercial structures but their fire performance was limited. After insurance companies and city governments started to require more fire-resistant construction, buildings were constructed with new fireproof clay floors and brick (Leslie, 2013). First, limestone and granite were common materials to cover load-bearing brick on the external façade. When steel-skeletal construction began to build, they were covered with brick, terra-cotta, or sandstone. These buildings had an outer masonry envelope to cover the structure (Harwood et al., 2008). Terra-cotta was first used in interior work such as flooring systems, and column and beam protection (Freitag, 1895).

Terra-cotta contains more water than brick. Since it is made of finer clays, more detailed and complex shapes can be formed with terra-cotta. As well as its ornamental possibilities on building facades, terra-cotta was used as a fireproofing material. To prevent different weights and separate shapes of ornaments, terra-cotta tiles were created via an effective system. The architectural expression created by terra-cotta can be seen on the facades of various buildings such as the Reliance Building in Chicago, the Wainwright Building in St. Louis, and the Guaranty Building in Buffalo.

2.4 Chicago Windows and Façade Characteristics

There are innovations on the facades as well. The "Chicago window" originated in this innovative period. As shown in Figure 5, it is a three-part window with a central large glass panel with two smaller double-hung sash windows on two sides. This configuration improved indoor spaces in terms of a better view, light, and ventilation. When the middle single large pane was fixed, two surrounding panes were operable. Rectangular grid pattern facades and large windows were popular in early skyscrapers in Chicago. There are bay, oriel, or rectangular windows with vertical piers on exterior walls. Especially large plate windows were used for stores on lower stories and street levels. By taking advantage of technology, windows were prefabricated and produced as standard sizes and large pieces. Also, opalescent glass was used in some buildings to emphasize the entrance.

Figure 5: *Horizontal Chicago-style windows and terra-cotta (Personal collection of Egemen Deniz Bahar).*

The colors of the buildings usually came from the material used on the facade. Common façade characteristics such as verticality, order, and simplicity were emphasized with windows and piers. While street-level windows were planned large and wide to display products, smaller windows in upper stories were arranged in grid patterns. Entries were usually large and dominant by using an arch. Rooflines with heavy cornices are generally designed as a flat slab or a decorated projecting form (Harwood et al., 2008). In addition, the usage of base, shaft, and top/capital like a classical column was a common feature (Figure 6). Especially, the period's notable architect Louis Henry Sullivan used this façade composition in his office buildings, such as the Wainwright Building, Guaranty Building, and Carson, Pirie, Scott, and Company Building for visual cohesion.

Figure 6: *Façade composition of Sullivan's buildings: Wainwright Building, Guaranty Building, and Carson, Pirie, Scott, and Company Building.*

In the following section, the reflection of the Chicago School on the architecture and technical advances will be explained using five case studies. The use of these new construction techniques and the progress will be exemplified through notable buildings of Sullivan. Each case study will be explained in terms of materiality, structural system, foundation, and exterior features. Also, through site visits, additional details and interior elements will be presented for the buildings located in Chicago.

3. NOTABLE BUILDINGS BY LOUIS HENRY SULLIVAN

Between the Great Fire and the Great Depression, 330 structures were built by well-known architecture firms such as Burnham and Root Architectural Company, Holabird and Roche, and Adler and Sullivan. Through the partnership with Dankmar Adler who had a large knowledge and experience in the mechanics of buildings as an engineer, Sullivan designed stores, office buildings, warehouses, hotels, and theatres. Between 1881-1884, they developed an extensive design of private houses, four or five per year. This number of designs allowed Sullivan to develop a special interest in ornaments (Connely, 1960). The Borden, Rothschild, Jewelers, Revell, Troescher, and Ryerson Buildings, as the early works of Sullivan and Adler between 1880 and 1884, were examples of skeletal masonry structures. Except Jewelers Building, all these buildings in Chicago were demolished (Leslie, 2013).

Sullivan's existing buildings, Jewelers Building, Auditorium Building, and Carson, Pirie, Scott, and Company Building in Chicago, Wainwright Building in St. Louis, Missouri, and Guaranty Building in Buffalo were selected to exemplify the technical systems such as foundational and structural systems, cladding and distinctive features on the façade that are mentioned in the previous section. Following the historical order, five buildings of Sullivan were analyzed through photographs and drawings to display the characteristics of the era and progress in building technology (Table 1).

Table 1. *Characteristics of the selected buildings (Randall and Randall, 1999, http 4)*

Building	Location	Date	Façade Type	Foundation Type	Height
Jewelers	Chicago	1882	Masonry Piers	NA	5 stories
Auditorium	Chicago	1889	Bearing Masonry	Grillage (modified)	17 stories /73m
Wainwright	St. Louis	1891	Steel Frame	Raft footings	10 stories/45m
Guaranty	Buffalo	1896	Steel Frame	NA	13 stories /51m
Carson, Pirie, Scott	Chicago	1899	Steel frame	Pile	12 stories /63m

These historical buildings investigated in this study have varying levels of information available in literature. Some of them have very limited data whereas, one of the most widely studied structures is Sullivan's iconic Auditorium Building. It will be described thoroughly thanks to diverse sources, archival materials, and especially collected data and photographic evidence from numerous on-site evaluations in Chicago. Therefore, a comprehensive analysis of both interior and exterior attributes of the Auditorium Building will be presented including structural information, foundational elements, lighting arrangements, and ornamental features.

3.1. Jewelers Building

The Jewelers Building was built as a store in 1882 by Adler and Sullivan (Randall & Randall, 1999). It is located at 15-17 South Wabash in Chicago (Figure7). This building is the only surviving example of Sullivan's early works in the Loop (Chicago's business center). The façade type of the five-story building is masonry piers. Since cast-iron mullions were used in the central bay rather than masonry piers, the building could have an open exterior façade with large windows. In addition to this distinctive feature of the facade, floral ornaments provided a unique character to this building. Continuous piers as structural elements express the verticality when other elements in façade, brink, iron and glass created the visual hierarchy. Iron was used for mullions and nonstructural spandrels. Brick and stone as solid façade elements give the color of this building.

Figure 7: *Jewelers Building (Author's personal collection)*

3.2. Auditorium Building

The Auditorium Building, which is located at 430 S. Michigan Avenue, has been a National Historic Landmark and Chicago Landmark since 1975 and 1976, respectively. As one of the best-known projects of Sullivan and Adler, the building is a part of Roosevelt University today. This one of the first mixed-used buildings was originally designed as Chicago's opera house, with a hotel on the Michigan Avenue side and offices facing Wabash Avenue and Congress Street (Figure8).

Figure 8: *Auditorium Building (Personal collection of Egemen Deniz Bahar).*

Ferdinand Peck, who was a businessman and one of the earliest residents of Chicago, wanted an opera house that included a hotel and office space. The architectural office of Adler and Sullivan was selected for the project. The project of the Auditorium Building was the most costly, tallest, and heaviest building at its time. It was also one of the first buildings with electric lighting, an air conditioning system, and fireproofing throughout the entire structure. The theater would seat 4,200 people. Also, there would be a 400-room hotel, 136 offices, and retail stores (Perlman, 1976).

In 1887, eighteen-year-old Frank Lloyd Wright began to work as Sullivan's direct assistant in the preparation of the building's ornamentation. Wright worked with Adler and Sullivan for six years until 1893 when he began independent practice. The construction of the Auditorium building began in 1887 and took three years. The Auditorium Building's exterior walls and two main partition walls between the theatre and other parts were built with masonry (Figure 9). Because "the continuous abutment foundations" of the building had to carry more than two tons per square foot, they were made of "concrete reinforced by huge timber and iron grillage" (Morrison, 1935).

Figure 9: *Auditorium Building walls (Author's personal collection).*

As shown in Figure 10a, cast-iron columns were used between the structural walls of the Auditorium Building as interior supports. These were carried by isolated spread footings: "small pyramids of concrete reinforced by steel rails (Figure 10a and 10b), placed just below the level of the cellar floor" (Morrison, 1935). A 30 cm by 30 cm pine timbers were used under the foundations. Randall and Randall (1999) expressed this system in the following:

> "Foundations rest on a timber mat of two thicknesses of 12-inch by 12-inch pine timbers at right angles to each other: they consist of a bed of concrete, and layers of iron beams and rails, on top of which are heavy alternate courses of dimension and rubble stone, with a capstone carrying the cast-iron bases of the cast-iron columns."

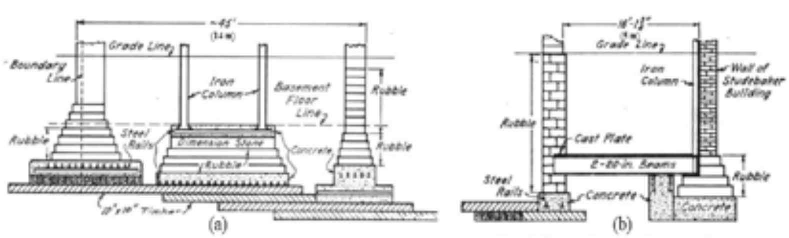


Figure 10: *Auditorium Building, section through combined footings* (*a*) *and cantilever footing* (*b*) *(Peck, 1948).*

The difficulty of supporting a seventeen-story tower created the need for a special foundation and construction method. Although the tower was 266 square meters, its foundation was 622 square meters which enabled the load to spread. According to Morrison (1935), the foundation was a combined platform that consisted of 1.5m thick concrete reinforced by multiple layers: two layers of heavy timbers, three layers of crisscrossed steel rails, and three layers of iron I-beams. They used artificial loading as a solution by using pig iron and brick in the basement and lower stories of the tower on Congress Street. As shown in Figure 11a, above the tenth story, the tower walls were built on the adjacent wall. Morrison (1935) mentioned about challenges of this loading system:

> "…The problem was merely to translate artificial load into real load, and this was done by gradually removing the pig-iron and bricks as the tower grew to its full height and weight. When the tower reached the top, ninety-five feet higher than the adjacent walls, all the artificial load was gone, but the total weight was just the same as it had been at the tenth-story level."

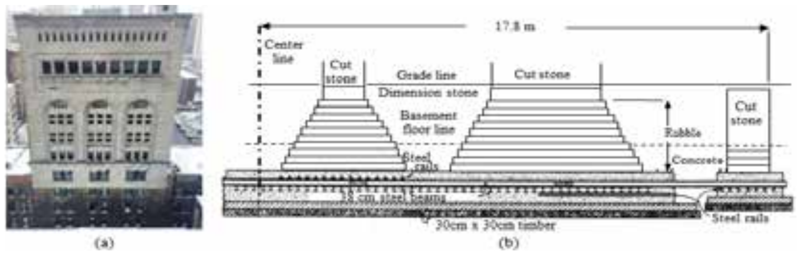


Figure 11: *(a) Auditorium Building Tower (Author) and (b) Tower Foundation (http 7-Library of Congress, HABS).*

Another problem was about the basement level below the stage in the theatre. Because of several mechanical equipments such as "pumps" and "ventilating machinery", the basement floor needed to be 5.5 meters below the stage and this level was 2 meters below the water level of Lake Michigan. So, waterproofing was provided by using a "laminated floor" to solve the problem. The floor was built up of concrete, Trinidad asphalt, and asphalt-saturated felt. Also, it was counterweighted by concrete and steel rails. Thus, the upward pressure of groundwater beneath the floor was offset (Morrison, 1935).

Figure 12: *Details of Auditorium Building (a) mosaics, (b) leaded windows, (c) lighting bulbs (d) iron ornaments (Author's personal collection).*

The walls were of solid masonry with cut stone above three granite stories. Sullivan combined plant forms with geometric shapes (Figure12). These can be seen as square, oval, and rectangles in the mosaics of the walls and floor surfaces, windows, lighting fixtures, and iron ornaments of stairs in the building (Harwood et al., 2008). The Auditorium Building was purchased by Roosevelt University in 1946, and hotel rooms and offices started to be used as classrooms and faculty offices. The hotel dining room became the library reading room. Over the years, many rooms, such as the Sullivan Room on the second floor (originally the ladies' parlor), the lobby on Michigan Avenue, and the tower have been restored between 1953 and 1975.

3.3. Wainwright Building

This 10-story office building was built in St. Louis, Missouri between 1890 and 1891 (Figure13) (http 8). Like in many early tall buildings, different types of foundations were used in the Wainwright Building such as isolated supports for piers and continuous bearing walls on the back through the first story. Adler and Sullivan used iron and steel framing on the exterior. The first two stories are brown sandstone while the rest of the façade is red brink which provides a different texture (Figure14). "Raft footings of reinforced concrete, the braced and riveted steel frame, the walls bays carried on spandrel shelf angles, the fireproof-tile covering all structural members, movable interior partitions" were used in the building (Connely, 1960). Above the ground floor, which was intended for there are offices with a U-shaped plan (Figure13).

Figure 13: *Wainwright Building plan, St. Louis, Missouri (public domain).*

Similar to typical contemporary steel framed structures with curtainwalls, the entire loads of the Wainwright Building were carried by the steel frames. In this building, Phoenix columns were used. This column type which is a hollow cylinder was invented in 1862 by the Phoenix Iron Company in Pennsylvania. Although many buildings had secondary thin columns between the main columns, the Wainwright Building did not have thin steel columns at midspans (Siry, 1996).

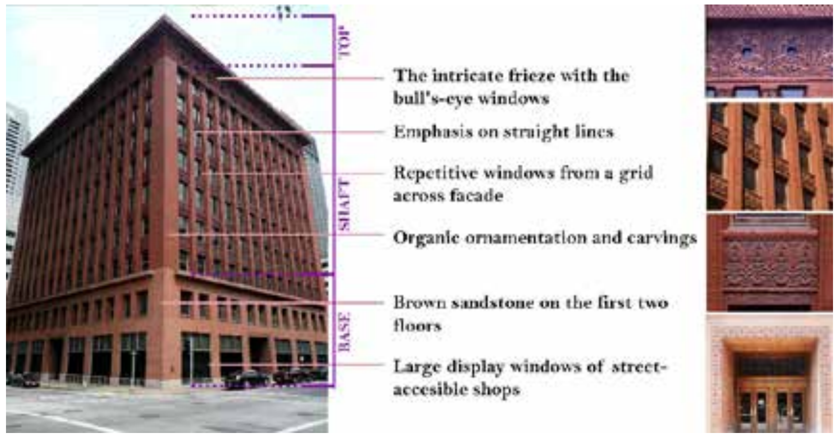


Figure 14: *Wainwright Building, St. Louis, Missouri (http 9, Photographer: Tom Bastin).*

Sullivan's tripartite design concept was applied on this building. The first two stories as the base are used as street-accessible shops. Offices continued to the ninth floor as the shaft. Mechanical systems are located in the attic of the building under the decorative cornice (Lupkin, 2018). Compared to the large show windows of the base, office floors have a repetitive window system expressing verticality. While on the ground level, there is no nonstructural element between columns to have large entrances, there are vertical bands on the masonry curtainwalls between the third and ninth levels. In the Wainwright Building, thicker corner columns are expressive.

Sullivan showed the significance of the Wainwright Building for his career in the letter to Claude Bragdon:

> "As to my buildings: Those that interest me date from the Wainwright Bldg. in St. Louis marks the beginning of a logical and poetic expression of the metallic frame construction. The Prudential [Guaranty] Bldg. is the 'sister' of the Wainwright. All my commercial buildings since the Wainwright are conceived in the same general spirit."

When Sullivan described the close relationship between Wainwright and Guaranty Building, he also aimed to give each structure he designed an individuality and special character.

3.4. Guaranty Building

The Guaranty Building, now called the Prudential Building, was originally designed to contain 275 offices, a bank, and a restaurant by Adler and Sullivan as the last collaborative effort (http 10). The U-shaped steel skeleton building was completed in 1896 at the center of Buffalo's civic center (Figure 15). Red terra-cotta ornament, which covers the piers, spandrels, columns, and arches of the Guaranty Building, was used on the exterior of the building (Kowsky, 1991). Adler and Sullivan's design ideas to get adequate daylight and air in office spaces such as the maximum distance for the light source and maximum depth of an office building were later published in Adler's essays (Adler, 1892; Siry, 1996).

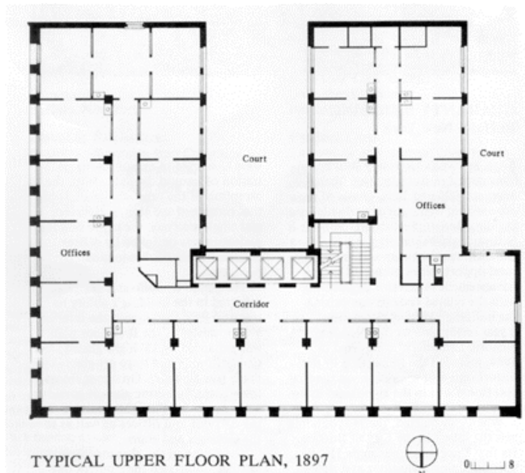


Figure 15: *Guaranty Building plan, Buffalo, New York (public domain).*

Like the Wainwright Building, Guaranty Building is a steel frame, however, Guaranty's outer walls are lighter than the Wainwright's. The techniques they used such as slender piers, and the combination of masonry and iron were to receive maximum daylight. On the other hand, Guaranty's steel frame is more rigid than Wainwright's due to the use of Gray columns which were developed with greater stiffness against wind loads (Siry, 1996). These columns were used as two-story length. For instance, one column continued between the first floor to third floor while another one in the next bay stood between the second and fourth floors. The building has secondary thin steel columns at midspans.

Figure 16: *Guaranty Building, Buffalo, New York (http 11, Photographer: Tom Bastin).*

Automated passenger elevators used in the building were the first in the city. In the building, the first two floors, which are public spaces, constitute the base. The doors of the building are framed in nonstructural arches. When the office areas created the shaft, the projecting cornice and round windows on the street sides made up the capital/top. Influenced by Art-Nouveau, terra-cotta sheathing with natural ornament patterns covers the building's metal skeleton. Piers emphasizes the structure's verticality (Figure 16). The main motif of the reddish-brown terra-cotta façade is seed shape.

3.5. Carson, Pirie, Scott, and Company Building

Carson Pirie Scott and Company Building, formerly known as The Schlesinger and Mayer Building, and called now, The Sullivan Center is located in Chicago's busy and crowded center (Figure 17). Sullivan's last work in the Loop was built in three phases between 1899 and 1906 (Randall and Randall, 1999). The 12-story, steel-framed building has been a Chicago Landmark since 1975 (http 12).

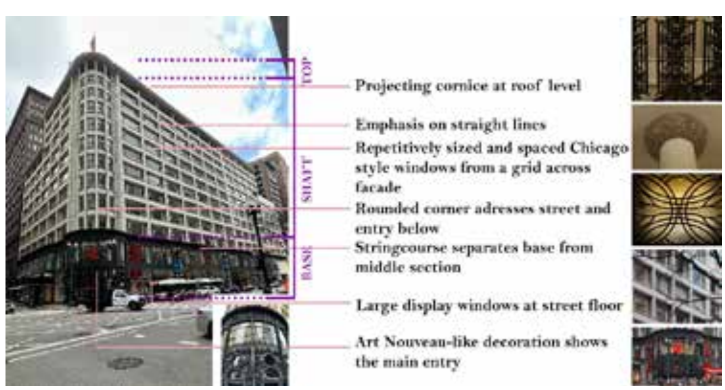


Figure 17: *Carson, Pirie, Scott and Company Building, Chicago, Illinois (Author's personal collection).*

The project began as a 9-story building. A tripartite window which includes a wide center window and double-hung sash windows is part of the grid on the facade. The large "Chicago windows" give a horizontal effect to the building. The first two floors were covered by durable cast-iron ornamentation. The distinctive main entry rounds at the southeast corner of State and Madison Streets. In 1902, the second phase, including digging new caisson foundations while the existing corner store remained in operation started. Chicago-style windows continued on three new upper stories (Leslie, 2013).

In 1906, the architect and urban designer, Daniel Burnham designed the last addition, the five south bays on State Street. "The completed building –six bays on Madison and twelve bays on State- emerged in steps. It remained unchanged until 1948 when the original cornice or roof projection was replaced by a parapet" (Condit, 1964). In this landmark, the nonstructural vertical elements on the facades were completely omitted. Compared to earlier works of Sullivan, the structural frames of Carson, Pirie, Scott, and Company Building were truly expressed through straight lines. While large Chicago windows make this massive building lighter, they are surrounded by vertical and horizontal terracotta. The rounded corner of the building with dark color Art Nouveau-like ornaments express the entrance.

Following the chronologic order, five buildings of Sullivan exemplified the characteristics of the era and progress in building technology. As the only surviving example among Sullivan's early works in the city's business center, the five-story Jewelers Building is a relatively smaller structure compared to other buildings. Except Auditorium Building, all selected structures were designed as office buildings. As a mixed-used building with theatre, office, and hotel functions, the Auditorium Building is distinctive via its combined and cantilever footings, massive columns, and weight. Using raft footings, the Wainwright Building has iron and steel framing while the Guaranty Building uses steel skeleton framing. There is a strong connection between these two structures. Terra-cotta used on the facades gave them their distinctive red color. Having caisson foundations, the Carson, Pirie, Scott, and Company Building has a lighter and open façade via Chicago-style window. A common façade feature of these five structures is a separate base through different materials or larger openings.

CONCLUSION

Cities and societies are always prone to change according to the conditions of the present day. Because the city as a living manmade structure changes consistently, in this process, the change should be examined in the sense of its relation between spatial organization and also social structure. Chicago was incorporated as a city in 1837 (http 13) and “this most populous city in Illinois and the Midwestern United States” (http 14), has been formed by various economic, social, and political dynamics as well as natural factors. High-rise office buildings started to appear as an architectural form in Chicago that couldn’t have been imagined by Chicagoans in the 1830s. Elevators, complex plumbing and electric services, and open plans with large openings on exteriors became available for steel frame structures. In this process, strong movements became effective when many significant figures were influential.

Louis H. Sullivan who was one of the most important architects of the Chicago School made an incredible contribution to American Commercial Architecture. His architecture was original. Sullivan, with his partner Adler, designed several buildings that include stores, office buildings, warehouses, hotels, and theatres. They solved difficult problems when designing buildings in Chicago. Searching for better solutions to architectural and engineering problems, they offered many innovations and developments in the period. It was a turning point since nature started to be mastered. So, important advances in construction technology shaped the structure and form. He usually expressed height as a visually predominant element of his design of facades. Today, more than a hundred years later, supertall, mega-tall buildings were built on different topographic patterns all over the world.

As Jenney, Burnham, Root, Holabird, and Roche did, Louis Sullivan devoted his time to shaping the American style of architecture by solving many architectural and structural problems. His architecture, which was a mixture of simple geometry and explicit ornamentation in stone, wood, and terra cotta, influenced the course of American architecture. Sullivan’s contribution to the Chicago School of Architecture can be summarized with two main integrated features, function and aesthetics. The facades of his buildings were as essential as their practicality. The issue of considering the synthesis of them which connects with structure and form helped to create a new style and shape the own character of American architecture. While Sullivan was called “the father of skyscrapers”, “Form follows function” (more accurately, “form ever follows function”) was attributed to him and became a common doctrine of modern architects. His organic philosophy was adopted by other architects and triggered the creation of new movements.

This study discussed the greatest architectural works of the nineteenth century as a turning point. Selected five structures express the idea of modern high-rise buildings having all architectural elements such as solids and voids, proportion and rhythm, light and shadow, texture, materials, and color. These buildings are examples of technical and aesthetic solutions of the period. Their appearance reflects the activities within.

Distinctive features of the period are steel-frame buildings, three-part large plate glass windows, terra-cotta as fireproofing, and three parts of façade configuration (bottom, shaft, and top/capital).

Since contemporary tall buildings are still designed and built with the original concept of skeletal frames and curtainwalls, it is essential to look back, to understand the challenges of this period and the dynamic interactions of these systems. Looking at the progress from the early examples of skeletal structure to today's advanced double-skin façade systems, the continuous evolution of high-rise buildings would be impossible without the advances of the Chicago School of Architecture.

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