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The First Skyscraper Revisited

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Abstract Debates on what is the first skyscraper have been ongoing from time to time since the construction of the Home Insurance Building in Chicago in 1885, which is generally recognized as the first built skyscraper. This paper attempts to verify this assertion through a detailed investigation after identifying the criteria that characterize a skyscraper. By considering and examining several competing buildings for the title of "first skyscraper" in terms of their levels of satisfying these criteria, the paper reconfirms that the Home Insurance Building in Chicago indeed qualifies as the first skyscraper and is the harbinger of future skyscrapers. By introducing technological and associated architectural innovations in this pioneering building, its designer William Le Baron Jenney paved the way for the construction of future skyscrapers. In traditional construction, heavy masonry walls especially at lower levels did not allow large window openings in exterior walls that would permit ample daylight. For the Home Insurance Building, originally built with 10 stories, Jenney created a metal-framed skeletal structure that carried the building's loads, making the building lighter and allowed for large windows permitting ample natural light to the building's interior. The exterior iron columns were encased in relatively small masonry piers mainly for fireproofing, weather-protection and façade aesthetics. Relying on the structural framing on the building's perimeter, the exterior masonry thus turned into a rudimentary "curtain wall" system, heralding the use of curtain wall construction in future skyscrapers. This building's innovative structural system led to what is known as the "Chicago Skeleton," and eventually produced remarkable skyscrapers all over the world.

Keywords Tall Building, Skyscraper, Home Insurance Building, Masonry Building, Skeletal Structure, Curtain Wall, Passenger Elevator

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1. Introduction

A tall office building was characterized by Louis Sullivan in 1896 as a building that "must be tall …every inch a proud and soaring thing, rising in sheer exultation that from bottom to top it is a unit without a single dissenting line…" A tall building must be tall in the strict sense of the term. It has been variously called, including a high-rise for its quality of "rising high" or a skyscraper to emphasize its metaphoric connotation of looking up to the heavens and "scraping" the sky. Whereas a tall building is a generic expression for such a building, the term skyscraper offers us to conceive a visual integration of the tall building with the vast realm of the sky. Different skyscraper architects aware of past traditions have introduced their own morphologies and metaphors into their creation to the point where it becomes somewhat subjective and ambiguous to insist on a restricted definition of skyscraper.

Various definitions can be found in different dictionaries and in the literature. Although the Council on Tall Buildings and Urban Habitat (CTBUH), the most influential international organization on tall buildings, has defined tall, supertall, and megatall buildings (CTBUH, 2015), yet it has not formally defined a skyscraper. In a nutshell, it may be defined as a tall building with many stories and exceptional height in a particular era. But this is not adequate for fully defining a skyscraper. The absence of a rational and complete definition leads to the problem of identifying the first skyscraper entailing its striking attributes. Since the late 19th century, various claims have been made about the first skyscraper by many including

some notable architectural critics and historians, such as Schuyler (1899), Mujica (1930), Webster (1959), Weisman (1953 & 1970) and Condit (1952 & 2015), to name a few, whose different opinions will be introduced later in this paper. The most recent comprehensive and intense debates on the first skyscraper occurred in the CTBUH's International Symposium in Chicago titled "First Skyscrapers | Skyscraper Firsts" of 2019, though it did not result in any definitive conclusion.

Advances in different technological fields, i.e., structural systems, building facades, vertical transportation, materials, fire safety, constructability, lighting, HVAC, plumbing, electrification, window cleaning at great heights, etc. have all contributed to the continued development in the process of arriving at the modern-day skyscraper (Beedle, et al., 2007). Thus, the first skyscraper of the world can even be recognized under each of the above technological fields available in the late 19th century. However, some technologies are primary or more fundamental in the development process of modern tall buildings, while some other technologies are secondary to the primary technologies (Moon, 2013). Considering these factors in a comprehensive manner, this paper attempts to identify the first skyscraper encompassing most of the defining qualities that led to today's tall, supertall and megatall buildings.

Arguments on what is the first skyscraper have been ongoing from time to time since the construction of the Home Insurance Building in Chicago in 1885, which is generally recognized as the first built skyscraper of the world. Through a comparative evaluation of different buildings in terms of their levels of satisfying the essential criteria that characterize a skyscraper, the paper reconfirms that the Home Insurance Building in Chicago indeed can be considered as the first skyscraper and when built it was poised to be the forerunner of latter-day skyscrapers.

The first skyscraper was built based on the breakthrough application of new technologies as will be presented in this paper. Innovative ideas have been crucial for advancing building technologies to create higher quality and more sustainable built environments.

2. Basic Criteria of a Skyscraper

Since the emergence of tall buildings in the late 19th century, various definitions of a skyscraper have been proposed by many including architectural critics and historians. One of the early definitions was made by Mujica (1929). He defined a skyscraper as "a building of great height constructed on a steel skeleton and provided with high-speed electric elevator." Weisman (1953) defined it later merely as "a tall office building." Fleming et al. (1972) defined it as "a multistory building constructed on a steel skeleton, provided with high-speed electric elevators and combining extraordinary height with ordinary room spaces such as would be used in low buildings."

While these definitions describe some representative characteristics of a skyscraper concisely, these still miss some important factors and thus lack comprehensiveness. Webster (1959) was one of the rare historians who developed some comprehensive criteria for calling a building a skyscraper, and his criteria were also adopted later by Condit (1964). Webster proposed 11 "necessary factors in the developed skyscraper." These factors were divided into three categories. The first category, "essential characteristics (the end)," includes three factors, i.e., great height, interior arrangement in stories, and utmost space and light. The second category, "necessary means," includes also three factors, i.e., skeleton construction, appropriate structural materials such as steel incorporated with fireproofing, and passenger elevators. The third category, "favoring conditions," include five factors related to economic, social, technological, psychological and aesthetic issues.

While the concise definitions of a skyscraper introduced earlier omitted some important factors, the 11 criteria by Webster included some non-essential factors that can be considered secondary in nature justifying the construction of skyscrapers. Skyscrapers possess a few clearly definable qualities. Building on the previously proposed definitions and criteria, the authors have identified the essential criteria of a skyscraper as:

1. *Quality of tallness*: A qualitative feature emphasizing the verticality rather than horizontality of the building. When a building has a great height, but its width dominates, that is, when the height-to-width aspect ratio is very low, it is a high building and not a tall building. This explains why a mountain is usually called high and not tall.
2. *Many stories of enclosed occupiable and habitable space:* Interior space organization within tallness is an important factor that distinguishes skyscrapers from other types of tall structures. Medieval tall cathedrals are not skyscrapers even if some Gothic cathedrals can place early 10-story buildings of the late 19th century under their ceiling of the naves because the naves only provide single tall spaces.

These first two are the most fundamental and primary attributes of skyscrapers. Without these, no building can be called a skyscraper.

3. *Ample daylighting:* This is essential for worker productivity and a lively indoor environment. This can be achieved with larger windows and more glazing in the exterior wall. Daylighting of a building significantly impacted the architectural layout of early tall buildings.

As will be discussed in more detail in this paper, ample daylighting was the most important spatial and environmental quality sought for early tall office buildings due to the absence of efficient artificial lighting at that time. Today, however, with the availability of LED, fluorescent light, etc., daylighting, although desirable, is not as critical

as it was in old days.

4. *Structural efficiency, lightness, and economy of materials:* An efficient structural system is desirable to allow taller buildings with ample daylighting and also resulting in more efficient spaces as well as the reduction of construction cost. This is generally possible by devising a skeleton frame that supports the building by its composition of beams, girders and columns carrying the imposed loads. This is a criterion of utmost importance without which skyscraper construction is inconceivable.
5. *Curtain wall construction:* In this criterion the outer wall of a building is supported on the structural frame. This is an important consequence of using skeletal frames instead of traditional loadbearing masonry. Lighter materials can be used for the curtain walls thereby reducing the building's weight and consequently construction cost. It carries only its own weight and lateral wind forces and no floor loads from the building. The lightness allows the building to be more efficiently taller.
6. *Vertical transportation*: An essential requirement to move people vertically to great heights defines this criterion. Without elevators the skyscraper would not be possible. Technically speaking, buildings could have been built taller, but the fatigue to climb stairs and the time needed to do so rendered the commercial value and merits of the higher floors impractical. On the other hand, despite the availability of passenger elevators, if skyscrapers could not be built taller with efficient structural systems, the elevators would have found only limited application in multistory buildings.

These last three criteria are the most critical technological provisions to build modern skyscrapers. Without these, today's skyscrapers are practically impossible. This paper tries to identify the first building designed and constructed with all these three criteria as the first skyscraper that led to latter-day tall buildings when other criteria are also reasonably met.

The following criteria are also desired for any building, but especially for skyscrapers.

7. *Fire safety at great heights:* Fire hazard is one of the most dreaded dangers for the occupants of tall buildings. While fire safety is of concern for any building with human occupancy or use, it poses special problem for tall buildings. Without adequate fire safety, development of skyscrapers would be unthinkable.
8. *Fast construction at great heights:* This is needed for the development and growth of the skyscraper phenomenon. The invention of skeletal framing and curtain walls enabled the speedy construction of skyscrapers thereby significantly reducing floor erection cycle time.

Once skeletal frame construction was invented, masonry construction for subsequent high-rise buildings lost its popularity other than for cladding, fireproofing of structural steel members, partitions, and other non-structural applications. Steel frame construction followed by concrete frame construction with the Ingalls Building in Cincinnati, Ohio as the first 15-story concrete skyscraper built in 1903 and subsequently mixed steel-concrete skyscrapers have become popular at present (Ali, 2001).

One of the most fundamental criteria which makes tall buildings of ever-growing heights practically viable, is through efficient structures, i.e., the ubiquitus application of skeletal frames. Curtain wall facade is in fact a natural outgrowth of the skeletal structure. It is noted that elevators are employed as part of tall building construction, but they are not necessarily used only in tall buildings and have other applications. They are, however, instrumental in facilitating vertical transportation in tall buildings. On the other hand, skeletal construction was developed by Jenney *exclusively* for tall buildings without which tall building construction reaching today's great heights would be inconceivable.

Beyond these eight criteria, there are many other factors influencing skyscraper developments, such as population increase, urbanization, land cost increase, etc. However, while these factors point to the justification of why tall buildings are needed or built, they do not directly define a skyscraper per se. For instance, Frank Lloyd Wright's driving force behind his mile-high ILLINOIS tower proposal in the 1950s was not the consideration of dense urbanization (Wright, 1957). More recently, the 462 m tall Lakhta Center was constructed in 2019 as the Europe's tallest and the world's 13th tallest building in St. Petersburg, Russia, a city not known for any other notable tall buildings. Furthermore, the 828 m tall Burj Khalifa in Dubai, the world's tallest building at present, and the Jeddah Tower over 1 km tall in Jeddah now under construction were not conceived due to the problem of density or land price but because of ambition or ego of developers/owners, competition, etc. (Ali, 2005).

This paper is focused on the essential factors that made the physical existence of skyscrapers possible. The following section investigates technical developments toward the inception of the modern-day skyscrapers, beginning with the Home Insurance Building.

3. Technological Developments

Early multistory buildings were built using mainly masonry that has a low compressive strength. Thus, the walls carrying the weight from upper floors needed to be very thick and heavy, so the building did not collapse under its own weight. The need for having thick and wide bands of masonry load-bearing walls in exterior walls to carry interior floor beams or girders supported on these walls to carry the loads from above did not allow large window openings. This was very problematic in terms of



Figure 1. Home Insurance Building of 1885 (10 stories, left) and 1891 (12 stories, right). [Images in Public Domain]

introducing maximum daylight into early multistory buildings. Before the invention of fluorescent lamps for office buildings, daylight was the main source of lighting. Incandescent lamps were invented earlier than fluorescent lamps and available beginning from the late 19th century. However, they were expensive at that time. In addition, in order to achieve appropriate indoor lighting environments, the heat gains through incandescent lamps were too intense to be resolved by natural ventilation, and modern mechanical HVAC systems were not invented yet. Therefore, daylighting was critical. But very thick and wide masonry piers in multistory masonry buildings, especially in the lower floors kept daylight from entering the interior spaces of these buildings, resulting in undesirable indoor light environment and consequent lower rental income.

To make buildings tall beyond certain height, innovations in which use of a strong material like iron became necessary that could carry the weight of the structure without making the building bulky and consequently maximize usable area and daylighting. An opportunity to build a lighter structure came when the Home Insurance Co. of New York retained William Le Baron Jenney to design a building in Chicago that would be good for an office building with ample floor space with maximum number of small offices above the second floor. The booming economy of the 1880s created the need for more floor space, but the business district's compact land area meant that the building had to go only upward. This demanded an innovative solution to the challenge. Technological advances derived from bridge construction, the development of early elevators, developments in material technology particularly in iron followed by steel, made the innovative design of the Home Insurance Building possible (Figure 1).

4. The Skeletal Frame and Jenney's Role

The motivating force behind the invention of the metal skeletal frame for early tall buildings was to overcome the limitation of traditional masonry construction to introduce maximum daylight to provide better working environments (Hoffmann, 1973 & 1998). This can be well observed from Jenney's own writing in 1885:

"As it was important in the Home Insurance Building to obtain a large number of small offices with abundance of light, the piers between the windows were reduced to the minimum, and the following system of construction

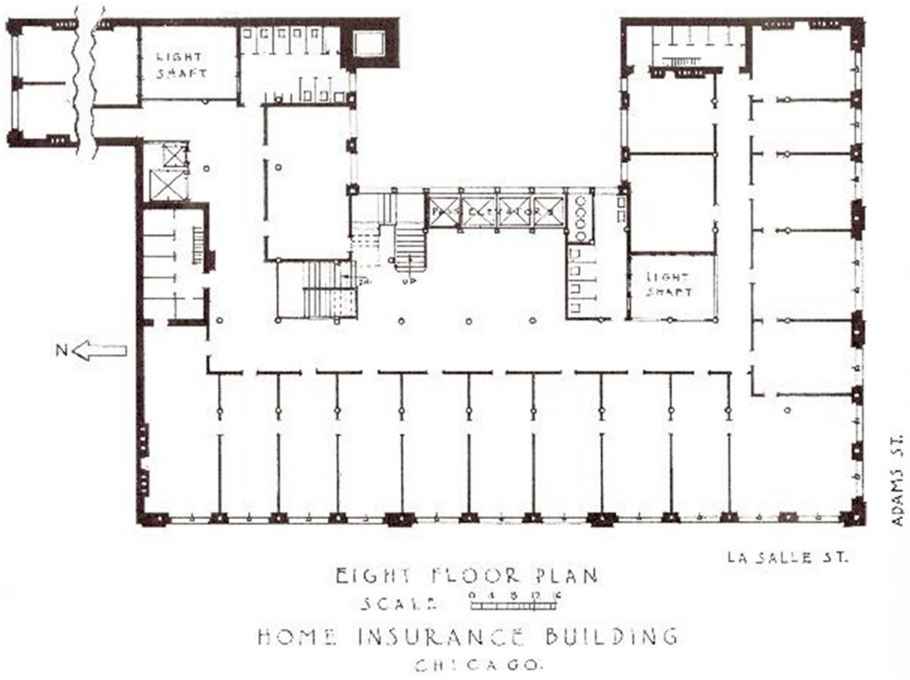


Figure 2. Typical floor plan of the Home Insurance Building. [Tallmadge, 1939]

was adopted. Iron was used as the skeleton of the entire building except the party walls, and every piece of iron was protected from fire by masonry, excepting only some columns so situated as not to be dangerous if left exposed." (Jenney, 1885)

Note above the use of the word 'skeleton' in the sentence "…the skeleton of the entire building…" by Jenney who also wrote later on "Chicago Construction or Steel Skeleton Construction" (Jenney 1889), while he described that the Home Insurance Building was the very first example. Jenney wrote further in 1891:

"This construction carries all the loads on metal columns which are placed in the piers and in the walls. They not only carry the floor girders, but also the entire walls, story by story, by means of beams or lintels from column to column…… The masonry is reduced on the exterior to what is necessary to hold the window frames and to fireproof the metal……" (Jenney, 1891)

The Home Insurance Building's plan was mainly a rectangle of 138 ft (42 m) on LaSalle Street and 98 ft (30 m) on Adams Street with an ell of 50 ft × 26 ft (15 m × 8 m) at the northeast corner. A light court of 49 ft × 33 ft (15 m × 10 m) was placed on the east side, making the rectangular plan indented (Figure 2). The original construction in 1885 had 10 stories rising 138ft (42 m). The first two stories on the streetfront were of solid rock faced granite backed with tiles. Cast iron columns were erected from the third story to the roof on the streetfront perimeter, while the iron columns were used throughout the height of the building for the light court walls and interior spaces. Interior girders and beams at every floor as well as perimeter beams placed only at selected floors, which generated the skeletal frame of the building along with the columns, were typically of wrought iron members. On the streetfront walls with windows, cast iron lintels and structural mullions at their midspan performed both structurally like sub-frames as part of the skeletal frame and architecturally as the building's façade elements. Street façades above the two lower stories of granite masonry were mostly of red pressed brick in combination with stone and terra cotta. (Tallmadge, 1939)

Indeed, Jenney and other architects had used iron columns in combination with masonry piers before as will be discussed later in this paper. However, uses of these iron columns were typically limited to interior columns. Jenney was the first to recognize the great structural potential of iron as the material for the skeleton of the entire building including its perimeter. For the Home Insurance Building, he created a metal framework that held the floors and the interior and most exterior walls up. He was rumored to have been inspired by observing a birdcage in his home carrying a heavy book on its top (Sawyer, 1986). He then envisioned a skeletal frame for tall buildings. The framed structure carrying the building's loads made the building lighter, introduced ample daylight into the interior of the building, and also

[1]Jenney also explained his skeletal system from a viewpoint of foundation in a statement read before the American Institute of Architects in 1891 (Mujica, 1930): "the condition of a very compressible soil carrying only a light weight per square foot necessitated a different method of construction from those in general use. The piers must be narrow in order that proper space might be left for windows, the walls must not be as heavy as in the old construction, or there would not be sufficient space on the ground for foundations."

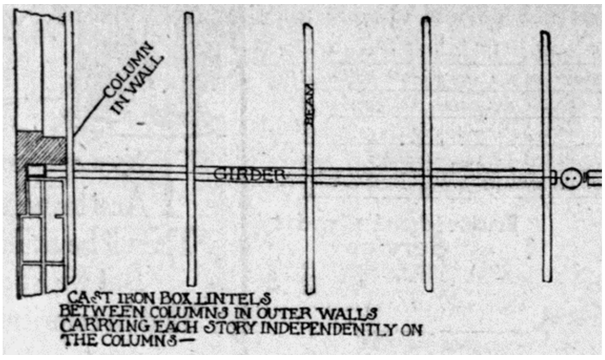


Figure 3. Jenney's own drawing to illustrate the floor framing system employed in the Home Insurance Building of 1885. [Fullerton, 1907]

resulted in the economy of materials and reduced the cost of foundation.[1]

In his original design regarding the building's perimeter, cast iron box lintels above the wide window openings were supported by the exterior cast iron columns encased in relatively small masonry piers for mainly fireproofing and protection against the climate (Figure 3). These lintels were designed to carry each story independently and transfer the loads to the columns. According to the field reports, the lintels were constructed to be also supported at their mid-span by cast iron structural mullions that were typically extended to the lintels of the floor below (Tallmadge, 1934 & 1939; Sanderson et al., 1932; Blaser, 1992). The lintels used were heavy cast iron pans containing concrete akin to what is now known as composite construction. The 24-in (610-mm) wide and 4 ¾-in (121-mm) deep lintels having trough-like sections spanned from column to column and acted as structural beam elements as part of the overall skeletal framework (Figure 4). The vertical structural mullions had also acted in a dual role as window mullions. The lintels were "jointed" with bolted connections over the mullions to ensure the continuity of the lintels from column to column (Tallmadge, 1939).

The structural mullions were set vertically between the horizontal lintels. Spandrel beams consisting of a pair of wrought iron I-beams just 3/4in (19 mm) above the lintels were installed at the third, fifth, eighth and tenth floors spanning column to column. (Tallmadge, 1939) Therefore, the lintels, structural mullions and spandrel beams together formed subframes between the perimeter columns (Figure 5). The double spandrel beams at the four levels were engaged to strengthen the overall structural frame by virtue of their role of bracing and tying together the columns and supporting the structural mullions. Interestingly, placement of these beams at the selected levels made the structure resemble somewhat like an elementary form of today's superframes.

Relying on the metal frames composed of the perimeter columns and subframes between them, the exterior masonry walls turned into an evolving "curtain wall" system that heralded the use of modern curtain wall construction for future skyscrapers. In the Home Insurance Building, however, the outermost masonry façade layer in front of the cast iron perimeter columns and notched-back end portions of the lintels (exterior masonry layer inside the dotted rectangle in Figures 4) was not supported by the metal frames, resulting in a not-fully-developed version of masonry curtain wall. Yet the development of overall skeletal structure leading to this basic curtain wall

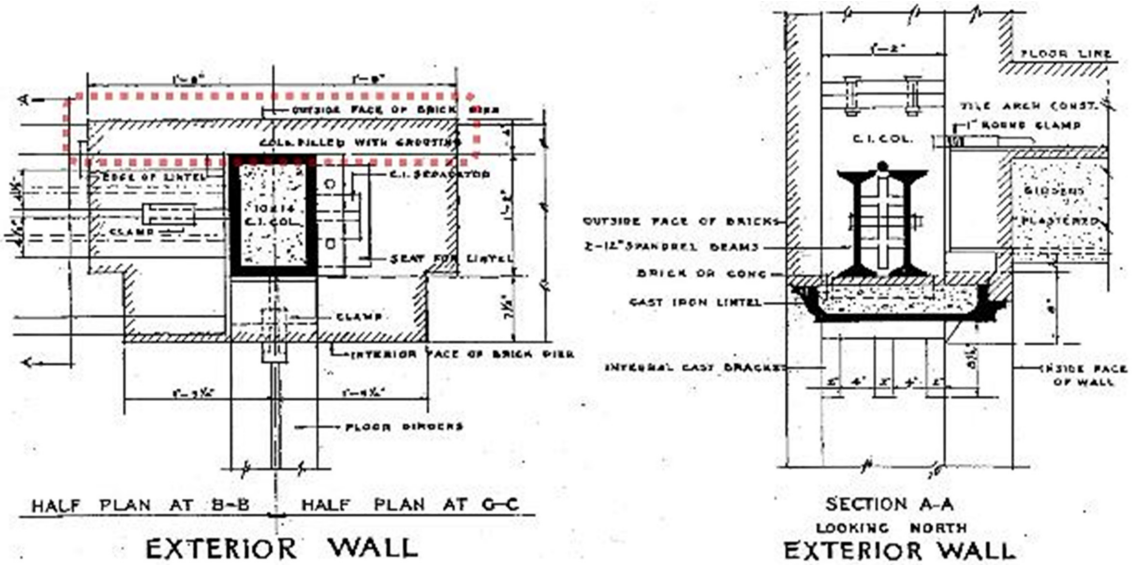


Figure 4. Fifth floor exterior wall plan and section of the Home Insurance Building around the junction of an exterior column, spandrel beams, lintels and interior girders from *field-measured drawings*; exterior masonry layer inside the dotted rectangle was not particularly *constructed* to be supported by the skeleton of the building. [Tallmadge, 1934 & 1939]

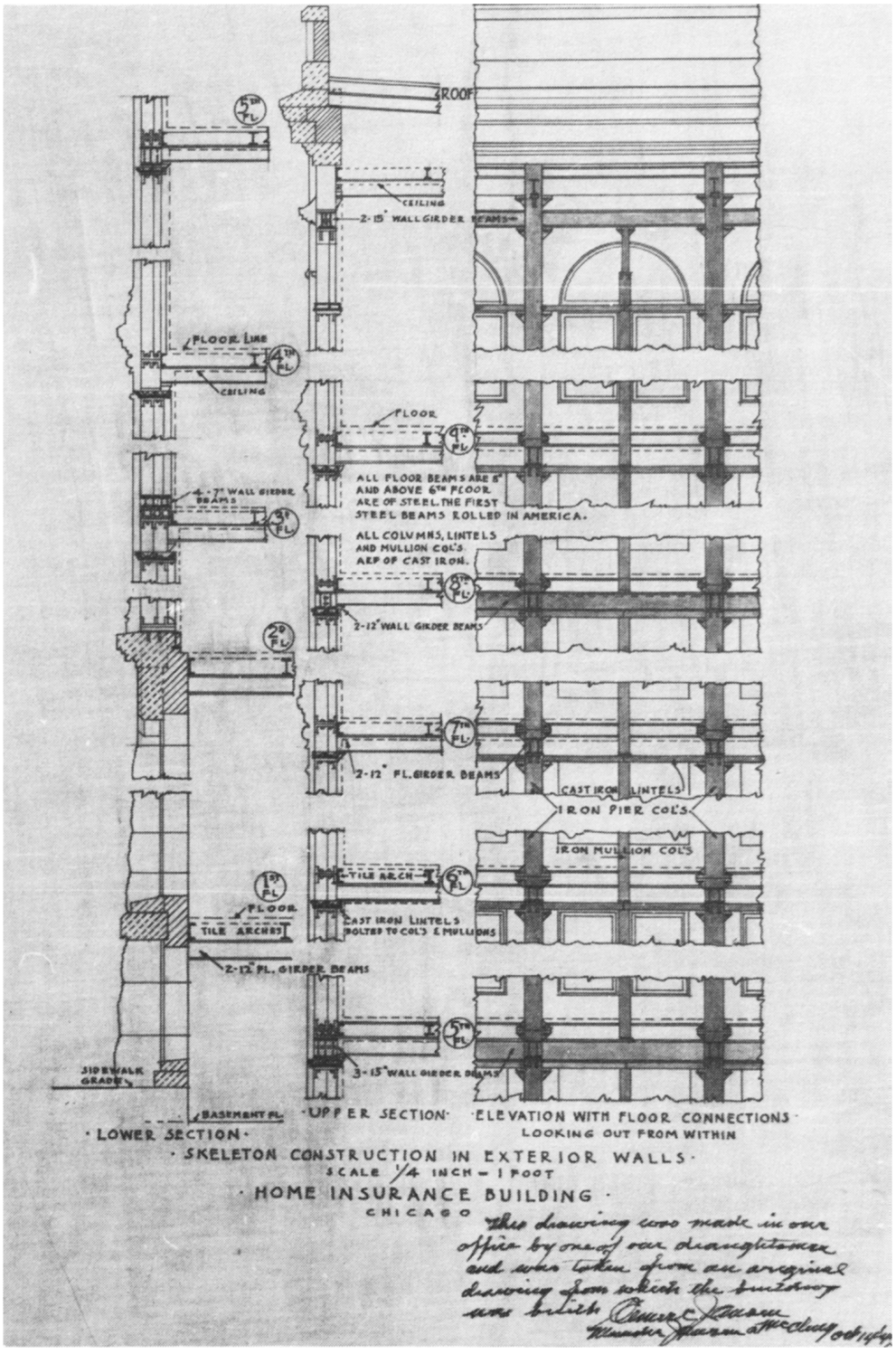


Figure 5. Streetfront exterior wall's skeletal metal frame configuration of the Home Insurance Building showing connections and the continuity of the composite lintels over the structural mullions. [Jensen & Halstead, Ltd., Chicago]

concept as a consequence of it was a very important breakthrough toward its future developments, which occurred very rapidly after the Home Insurance Building. The result is a lighter building that can soar to many stories into the sky, and allow more daylight into the building. Rigid beam-to-column connections were not yet known and practically not conceivable due to the brittleness of cast iron. However, masonry party walls and other masonry elements in the building still resisted wind loads for a building of this height.

The skeletal frame of the Home Insurance Building began to be built with only cast and wrought iron elements. However, steel was also introduced for some horizontal frame members from the seventh floor to the top, which made the Home Insurance Building the first multistory office building to use structural steel which was expensive at that time (Jenney, 1889; Tallmadge, 1934 & 1939). With the construction of this building the transition rapidly began from the historical load-bearing masonry wall to an innovative skeletal frame designed to carry initially all gravity loads and subsequently wind loads as well. Beginning from around the turn of the century, all steel skeletal frames began to be used widely because of their superior material property compared to iron, including their high strength-to-weight ratio in both tension and compression, ductility, ease of assembly and field erection, and economy in transport to the construction site.[2]

The Home Insurance Building originally had 10 stories including a raised basement. During the construction, the city officials became worried that the light building with a novel structural system could topple and halted the construction for some time so they could ensure its safety. Two floors were added later in 1890 at the top, making the building 180ft (55 m) tall. The building was demolished in 1931 to construct the new 45-story Field Building (now called LaSalle‘ National Bank) on the site.

5. The First Skyscraper

The Home Insurance Building, despite some of its imperfections that some critics can ascribe to it, was still the unprecedented building that satisfies more or less all the criteria of a skyscraper listed earlier in this paper.

Though there were even taller masonry buildings constructed much earlier than the Home Insurance Building, its 10 stories including the raised basement was still significantly tall at the time of its construction (Criteria 1 and 2). And the building's height was not shorter than any of its two primary plan dimensions, meaning that it was a tall building, not a high building.[3]

The Home Insurance Building was the building that had the most critical three provisions to produce modern skyscrapers for the first time for a building of that height. Its large window openings allowed plenty of natural light (Criterion 3) that eventually led to the development of the "Chicago Window." The building's interior and most of its perimeter employed skeletal structures that rendered the building structurally efficient and lighter than conventional masonry tall buildings while its exterior walls acted as rudimentary curtain walls for the first time for a 10-story office building (Criteria 4 and 5). The Home Insurance Building also had four passenger elevators already employed for multistory office buildings since 1870 (Criterion 6).

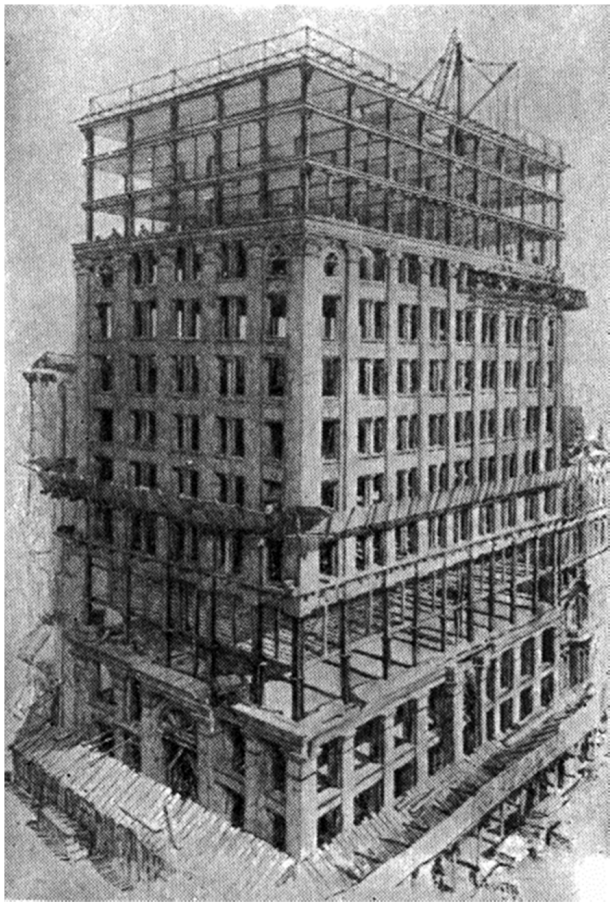


Figure 6. Jenney's New York Life Building in Chicago during construction in which a "top-down" method of masonry construction allowing speedy erection was employed. [Image in Public Domain]

The Home Insurance Building complied with the last two criteria as well necessary for skyscrapers. Fire safety was one of the most important reasons for using masonry in combination with the metal-framed structures for the Home Insurance Building and other early tall buildings (Criteria 7). The skeletal structure and resulting fundamental curtain wall concept of the building eventually led to more fully developed curtain walls allowing fast construction (Criterion 8). Different from traditional masonry structures, as the building skeleton could be completed first rapidly in the new system, masonry curtain walls typical at that time did not need to be placed from the bottom to the top any longer.

[2]Following the Home Insurance Building that partially used structural steel in upper floors, the first all-steel skeletal structure was employed in the Rand McNally Building of 1889 in Chicago (Mujica, 1930).

[3]In the case of the 10-story Home Insurance Building originally completed in 1885, its height-to-width aspect ratio was about 1.4. In the case of the expanded 12-story Home Insurance Building of 1890, its aspect ratio was increased to about 1.9.

[4]According to Mujica (1930), Tacoma Building of 1889 in Chicago was the first building in which exterior masonry work was begun simultaneously at different levels.

It may be noted that in Jenney's another metal-framed building, New York Life Building of 1894 in Chicago, the speed of construction was increased by installing curtain wall masonry on multiple floors simultaneously including "top down" masonry construction (Figure 6; Fullerton, 1907)[4]. This process attracted visitors to see it during construction as it was built during the Chicago World Fair of 1893, and this construction method was adopted in future skeletal tall buildings. In the case of the Home Insurance Building, however, with its underdeveloped masonry curtain walls, building them completely by the top down construction method was not possible. This is because, as alluded to before, the outermost masonry layer in front of the cast iron perimeter columns (exterior masonry layer inside the dotted rectangle in Figure 4) still warranted the traditional "bottom up" construction. Nonetheless, without the overall breakthroughs toward the skeletal structure and curtain wall concept in the Home Insurance Building, no further developments would have been possible. A fully developed form cannot be anticipated in any breakthrough technology. Its importance lies in its potential for forging ahead the state-of-the-art.

Indeed, the Home Insurance Building was the first building that complied with all the criteria listed in this paper which would justify this tall building to be called a skyscraper albeit in an early form. Thus, the Home Insurance Building with its skeletal framing clearly represented the pivotal step forward that paved the way for the design and construction of other tall buildings that later was known as the "Chicago Skeleton." The pioneering metal-framed structure of the Home Insurance Building has thus set the trend of taller skyscrapers that would forever dominate the skyline of American cities and other cities of the world and can be aptly designated as the "first skyscraper".

6. Historical Paradigms of the First Skyscraper

Identifying the first skyscraper has been a topic of debates for many decades. The most well-known competitor of the Home Insurance Building for the title is the Equitable Building of 1870 in New York, as this title was bestowed upon this building by some renowned historians like Winston Weisman (1970) and Carl Condit (1961, 1996). The reason why the Equitable Building was alternatively considered as the first skyscraper is that at its 7-1/2 stories including the half-story attic height this was the first multistory office building with passenger elevators. In fact, this building also used skeletal structures with cast iron columns and wrought iron beams for its interior framing. However, its exterior walls were entirely masonry. The point is that with masonry exterior walls, it was practically impossible for any building to evolve to a skyscraper of great height culminating in today's extreme height.

There is a common misconception that if the Equitable Building cannot be considered as the first skyscraper due to its masonry exterior walls, it results in an awkward consequence that some renowned early tall buildings such as New York's Western Union Building (230 ft: 70 m) and Tribune Building (260 ft: 79 m), which were in fact much taller than the Home Insurance Building (138 ft: 42 m), cannot be called skyscrapers either. Both these buildings completed in 1875 were also alternatively considered as the first skyscrapers by Montgomery Schuyler (1899) and Winston Weisman (1953)[5], and "proto-skyscrapers" by Carson Webster (1959)[6]. However, tall buildings of masonry and skeletal structures are different *breeds*. Tall buildings with masonry structures flourished once and evolved to some of the renowned tall buildings at the time of their construction. In this trajectory, admittedly, the Equitable Building, being the first multistory office building with passenger elevators, paved the way for taller masonry buildings to come, such as the Western Union Building and the Tribune Building. However, as the breed had serious inborn limitations to grow taller with masonry construction, it naturally died out in the tall building industry before the turn of the century. These masonry tall buildings were also called "sky-scrapers" from around the early 1880s (Landau & Condit, 1996). While this old breed was still widespread in the 1880s, a new breed of tall buildings with skeletal structures emerged, competed with the old breed, and eventually won the competition and have evolved to today's tall and supertall skyscrapers.

Architecture, including tall buildings, is time-dependent and cannot be considered without the context of its era. When the first skyscraper is considered, it should be the first one of the breed to which latter-day tall buildings also belong. The skeletal structure in conjunction with curtain wall concept originally developed for the Home Insurance Building has truly propelled the tall building industry to build taller since its completion in 1885. The transition period from the old masonry to the new skeletal frame technology took only a few years. Based on the new technology, tall buildings of about 10 stories in their early years evolved very rapidly, reaching the height of over 100 stories – an impossible height with traditional masonry and made possible only by the use of skeletal frame – in less than 50 years. Therefore, as has been considered by many, notably by Mujica (1930) and Tallmadge (1931), the Home Insurance Building is "the true father" of modern tall buildings that clearly deserves the title of the first skyscraper.

[5]This was Weisman's original position presented in his article "New York and the Problem of the First Skyscraper" of 1953. However, he changed this position in his later article "A New View of Skyscraper History" of 1970. His revised vote was given to the Equitable Building (Kaufmann, 1970; Jencks, 1980).

[6]Webster considered the Masonic Temple of 1892 in Chicago as the first skyscraper.

7. Discourse on the First Skyscraper

One of the arguments about the qualifications of the Home Insurance Building as the first skyscraper is whether the building indeed used metal skeletal structure and hence curtain wall concept. This debate primarily stems from the ambiguity of the design and the nature and extent of performance of the masonry elements surrounding the perimeter iron columns. To verify the performance of the iron columns without the surrounding masonry even during the use of the building, an exterior column of the fifth story was uncovered and structural lintels connected to it were exposed in January 1924 (Mujica, 1930). It was concluded that "the entire weight of the walls and piers, together with the floors, is carried by the iron columns in the piers." (Randall, 1949). Nonetheless, the controversy continued. This debate was never fully resolved despite the in-depth investigations by multiple groups of experts during the demolition process of this building years later (Tallmadge, 1931; Sanderson et al., 1932; Randall, 1949; Shepherd, 2003; Leslie, 2013). Some people still argued and some continue to argue that the gravity load was shared by the iron columns and surrounding masonry and therefore this building was not strictly the first skeletal structure. A small portion of the load might have been shared by the masonry because of the development of bond between the columns and masonry as well as the related underdeveloped masonry curtainwall construction. However, the major portion of the load was undoubtedly carried by the metal with its much higher value of the modulus of elasticity compared to masonry.

An important fact is that considering the height of the building Jenney intended to design this building to carry loads from each floor including the weight of the masonry by the cast iron columns so that the problem of anticipated differential thermal expansion and contraction due to the significant building height could be resolved. As this was the first attempt in multistory buildings of this scale employing exterior metal frame, it is, of course, unjust to expect the complete implementation of the design intent in terms of actual design and construction as is typical in a newly developed technology. However, the photograph of the partially destroyed masonry around a

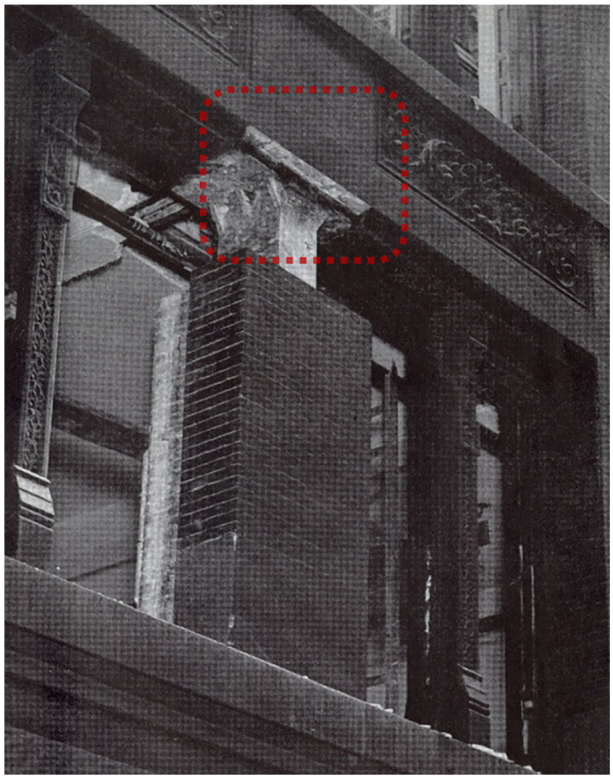


Figure 7. Partially destroyed masonry around a third floor exterior column and lintels of the Home Insurance Building showing notched-back ends of lintels at the column and the bottom of masonry between them (white horizontal strip inside the dotted rectangle) not supported by any frame member. [Tallmadge, 1939 & 1941].



Figure 8. Joint of the exposed cast iron column, wrought iron interior girder and cast iron lintels examined by Earl H. Reed of the Committee for the Examination of the Construction of the Home Insurance Building before its demolition in 1931; this is the same column shown in Figure 7, but photographed from inside. [Tallmadge, 1939].

third-floor column and lintels (Figures 7 and 8; Tallmadge, 1939) shows that the fourth-floor perimeter masonry could indeed be supported by the cast iron columns even with the discontinued masonry around the third-floor column. This validates the fact that the Home Insurance Building was able to perform as Jenney intended in terms of skeletal structure and curtain wall concept. Although not specifically about the Home Insurance Building, Jenney, however, articulated his design approach for skeletal construction with the following words: "All the loads and the floors and all the walls, both interior and exterior are carried independently story by story on the columns, so that it is possible to build the wall or remove the walls of any story without regard to what there may be above or below it." (Jenney,1889)

However, what Jenney explained above about the "skeletal construction" had not been fully realized in the Home Insurance Building yet. In particular, the curtain wall concept did not entirely materialize as some deviation from a fully developed form of curtain walls was present. As shown in Figure 7, a small portion of the exterior masonry layer was not supported by the structural frame. Nonetheless, the Home Insurance Building's overall technological breakthrough of skeletal structure and introductory curtain wall concept certainly acted as the precursor of latter-day skyscrapers.

It is also noted that the thickness of the outermost masonry façade layer in front of the cast iron perimeter columns and notched-back end portions of the lintels (exterior masonry layer inside the dotted rectangle in Figures 4 and 7) was constant throughout its height at each column line, while the encased cast iron column sizes were increased toward the bottom to carry accumulated loads from above while the sizes were reduced toward the top. This configuration implies that whereas the iron columns were designed as primary structural elements, the outermost masonry layers were not.

Figure 8, which shows the same third floor column from inside, clearly reveals the junction of the various key members of the skeletal frame, i.e., the cast iron exterior column, wrought iron interior girder and cast-iron lintels. It is reiterated here that the cast iron lintels also participated as part of the skeleton frame in the Home Insurance Building.

Another criticism about the Home Insurance Building about its qualification as the first skyscraper employing skeletal structure is that no wind-load resisting system was provided in the metal frames (Condit, 1963). However, such a system was not much necessary in the metal frame of this building. The Chicago building code at that time required heavy masonry party walls, and the Home Insurance Building had to be accordingly designed with masonry party walls in two primary directions of the building (Figure 2). It is reasonable to assume that Jenney as an architect and structural engineer logically envisioned that the metal frame for a building of 10-story height did not require substantial additional wind bracings due to the already provided masonry walls in the building. Based on this configuration, the building performed like shear-wall-supported hinged metal frames, which are occasionally used even today. In fact, use of the masonry party walls is another criticism about this building's qualification as the first skeletal structure because this means the Home Insurance Building only partially used the metal frame. Again, provision of exterior masonry party walls in the perimeter was a code requirement to be strictly followed at that time to prevent spread of fire to adjacent buildings. It is worth noting that various wind load-resisting mechanisms were rapidly developed after the construction of the Home Insurance Building using the skeletal structure, and Jenney's Manhattan Building of 1891 was one of the earliest tall buildings employing metal frames with diagonal wind bracings (Leslie, 2013).

The Home Insurance Building did not use the skeletal frame for the entire building as discussed. It used metal frames for the two streetfront facades and interior space including the light court area. For the streetfront facades, the first two stories used traditional stone masonry and the third to tenth stories used the skeletal frames.[7] Masonry party walls and interior iron columns were already being used at that time. Thus, the most significant innovation of this building was the partial but prominent use of the skeletal structure for the two major streetfront exterior facades. Despite this fact, this was one of the most critical breakthroughs in the history of not only architectural technology and tall buildings but also architecture in general because this breakthrough did lead to the development of modern-day tall buildings and eventually modern architecture of lightness and transparency (Moon, 2013).

A related argument by some is that if the first partial use of skeletal structures for exterior walls qualifies the Home Insurance Building as the first skyscraper, the title should also be considered for the 10-story Opera House Block also of 1885 in Chicago as this building used the skeletal structure partially as well for exterior walls. However, the Opera House Block used the iron columns and curtain wall concept only for the first two stories (Condit, 1952). Its third through tenth floors were traditional masonry structures. Therefore, the Opera House Block performed overall as a traditional masonry structure with some deviation in the first two stories, while the Home Insurance Building substantially performed as a frame structure laterally supported by the masonry shear walls as discussed earlier.

One other argument by some is that Rookery Building of Chicago built in 1888 is the first tall building with exterior structural metal framing because the central

[7]The Home Insurance Building was originally designed using traditional masonry structures. During the very early stage of construction, however, the design was changed to metal skeletal structure (Sawyer 1986).

Table 1. Candidates for the first skyscraper and their evaluations (∨: Criterion met, Δ: Criterion marginally met, O: Criterion not met. All images are in public domain.)

Building	City	Year	Story	Skyscraper Defining Criteria							
				Quality of tallness	Many stories of occupiable space	Ample daylighting through facades	Skeletal structure in streetfront walls	Curtainwall in streetfront walls	Passenger elevators	Fire safety at great heights	Fast construction at great heights
Equitable 	NYC	1870	7 1/2	Δ	∨	O	O	O	∨	∨	O
Western Union 	NYC	1875	10	∨	∨	O	O	O	∨	∨	O
Tribune 	NYC	1875	10	∨	∨	O	O	O	∨	∨	O
Opera House 	Chicago	1885	10	∨	∨	O	O	O	∨	∨	O
Home Insurance 	Chicago	1885	10	∨	∨	∨	∨	Δ	∨	∨	Δ
Rookery 	Chicago	1888	12	∨	∨	O	O	O	∨	∨	O
Tacoma 	Chicago	1889	13	∨	∨	∨	∨	∨	∨	∨	∨
Masonic Temple 	Chicago	1892	21	∨	∨	∨	∨	∨	∨	∨	∨

atrium walls exposed to the exterior employed metal framing with spandrel beams at every floor unlike the Home Insurance Building that had spandrel beams only at selected floors. Despite the Home Insurance Building's uncommon spandrel beam and subframe configurations, however, its qualification as the first tall building employing skeletal framing on the streetfront exterior walls was already explained in this paper in detail. Further, the Rookery Building has loadbearing masonry walls on all street and alley sides except at two lower levels on the alley sides (Condit, 1961). Therefore, this building does not qualify as a tall building that has structural framing on the streetfront exterior walls and is primarily a masonry building.

Table 1 summarizes all buildings introduced in this paper as a potential candidate for the first skyscraper and if they meet the skyscraper-defining criteria suggested in this paper. Different critics and historians selected different buildings as the first skyscraper often based on much subjective considerations. In Weisman's case, he even changed his selection of the first skyscraper from the Western Union Building and Tribune Building of 1875 in 1953 to the Equitable Building of 1870 in 1970 "after much contemplation (Weisman, 1970)." Webster (1959) wrote "…… I find that those which impress me as being very tall are more than two hundred feet high ……" and based on his personal impression laying emphasis on the height he selected the 302ft (92 m) tall Masonic Temple of 1892 in Chicago as the first skyscraper. Clearly, this is a subjective choice.

While it is tempting to engage in subjective decision-making processes, the first building that met all eight criteria presented in this paper is the Home Insurance Building of 1885 in Chicago as can be seen in Table 1. The Equitable Building, Western Union Building and Tribune Building were built before the Home Insurance Building, but they did not meet all criteria. These buildings' exterior walls were built with heavy masonry structures, not skeletal frames and curtain walls. Therefore, introducing ample daylighting into the interior space was difficult and fast construction was not possible. Both Tacoma Building and Masonic Temple located in Chicago completed in 1889 and 1893, respectively, met all the criteria proposed in this paper; they were, however, built after the Home Insurance Building and advanced the technology pioneered by Jenney.

8. Concluding Remarks

There have occasionally been doubts and debates on the qualifications of the Home Insurance Building as the first skyscraper due to the incomplete nature and extent of the skyscraper criteria met by this building and other misconceptions. However, as is typical in the development of any new technology, the importance of being the first is to provide the potential for future developments.

The overarching criterion for the first skyscraper is that it must be the forerunner of latter-day skyscrapers by virtue of paving the way for future skyscrapers to emerge. Even though taller buildings with masonry loadbearing exterior walls existed during the era when this building was constructed, the progressive development of such buildings naturally ended as these were no longer economically or functionally defensible. The modern skyscraper construction racing for height would be impossible without the wide-ranging metal frame construction first employed in the Home Insurance Building. Undoubtedly, such construction, which allowed for the provision of the curtain wall in the exterior walls and hence ample daylighting and fast construction, has resulted in continued growth and progression of taller cost-effective skyscrapers. Therefore, today the Home Insurance Building that basically encompasses all the important criteria of a skyscraper listed in this paper well deserves the title of *the "*first skyscraper."

Indeed, the Home Insurance Building, especially with its structural technology leading to other important provisions, as discussed in this paper, for the first time for a multistory office building of that scale, led not only to the advent of modern skyscrapers but also modern architecture. This was so critical epoch-making moment in the history of tall buildings as well as architecture in general. Since the advent of Gothic architecture many centuries ago, such a technology-based new building type emerged for the first time, ultimately leading to new architectural style and expressions. The Home Insurance Building stood at the very starting point of this.

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