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World's Biggest (Tall) Buildings



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Abstract

In both professional circles and in the public eye, the subject of the World's Tallest Building (WTB) has held the spotlight for more than a century. After the title of WTB left US shores at the end of the 20th century, competition and press attention went global. Key points of discussion have been how to measure height and what parts of the building to count. Yet there is another competitive category of high-rise size that has been ignored: Biggest. What were, and are now, the World's Largest Buildings (WLB) measured by floor area? Area, after all, is the dimension that owners value most. Measured by floor area, the American skyscrapers completed in the 1970s—the original World Trade Center and Chicago's Sears (now Willis) Tower—were the biggest ever constructed (and they may still hold that title when rigorous analysis is attempted). Twenty-first century supertalls, especially in the Middle East and in China, have far surpassed the former giants in height—but not in floor area. One part of the evolution of the skyscraper is the story of ascending height. Another is of increasing size—but only to a point. Notably, the apogee of that evolution came 50 years ago.

Keywords: Gross Floor Area, Height, World's Biggest Buildings, World's Largest Buildings

Introduction

What is the world's tallest building and why do we care? This perennially popular subject has held the spotlight for more than a century. Woolworth, Empire State, World Trade Center, and Sears Tower: these American giants capture the imagination and have inspired numerous books, TV shows, and podcasts. Some stories about the forces that drive the ambition for height have been told so often that it seems they must be true—for example the supposed "race into the skies" of the former partners, then rival architects of the Chrysler Building and 40 Wall Street, William van Alen and Craig Severance. But good stories can often create false narratives.

Clearly, the title of World's Tallest Building (WTB) carries bragging rights, and that celebrity does translate into value. Add the competition between countries or continents (as began in 1996) and you have forces at work bigger than egos. The subject is catnip to the media, especially as a new tower ascends and a record will be broken, attracting free worldwide attention. It also continues to pay off for years or decades in the many "Tallest" charts and documentaries that are evergreens on The History Channel and the like. These buildings get ratings!

Perhaps it's human nature to fixate on "tallest." But arguably, the primary focus on vertical height is a failing from a professional perspective—whether the profession of historian or of organizations such as CTBUH. Is this too pedantic? What does it hurt if TV shows repeat stories about the rivalry of architects William van Alen and Craig Severance who, supposedly, ratcheted up the height of their towers' tips to best a former partner who was now a competitor? Well, first, that story suggests to the general audience that it's architects who decide how tall a building will be. Or that you can just add tons of superstructure to an already-constructed tower without re-engineering the design below. CTBUH has expended considerable energy on the topic of "Tallest," including distinguishing heights based on the tip, architectural top, or highest occupiable floor. We need to find a way to move beyond the storyline of vertical height *in excelsis*.

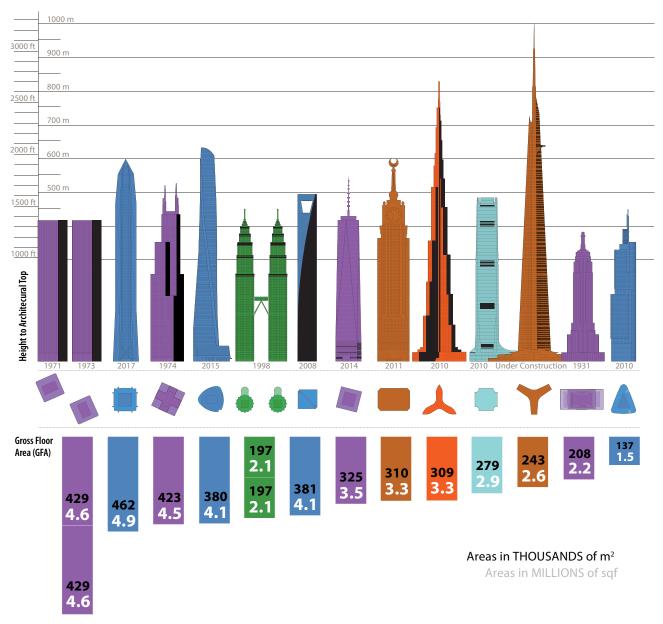


Figure 1. World's biggest buildings by heights and area. © The Skyscraper Museum

World's Biggest Buildings

So let's turn our attention to another superlative category: World's Biggest Buildings. What were, and are now, the World's Biggest (Tall) Buildings measured by floor area? There are no charts on the CTBUH website of this category. An inattention to floor area makes no sense—area is, after all, the dimension that owners of skyscrapers value most. Square meters or feet generate rent. Admittedly, tracking and comparing buildings by area is hard to do, especially if one wants to be accurate and consistent. Formulas for calculating Gross Floor Area (GFA) can vary widely across cities, countries, and decades indeed, up to 24 percent, as an excellent CTBUH research paper has calculated. When the Starrett Brothers and Eken built the Empire State Building, they said it was 2.1 million square feet: today the building management's fact sheet calls it "2.7 million square feet of office space," while the Skyscraper Center database lists the Tower GFA as 2,248,355 square feet. We should all be grateful that CTBUH has been adding the Tower GFA on the information page of new buildings. Alas, though, this information is simply posted as received from the developer, so it reflects whatever formula is used in that city or region.

The Skyscraper Museum used these GFA statistics to create some graphics to simultaneously visualize both the height and the area of some of the world's biggest buildings (see Figure 1). What can we learn from this chart? Certainly, we see that Tall and Big are very different things. Which skyscraper today has the greatest GFA? It's not a simple answer. It may be the complex of Abraj Al Bait in Mecca with its centerpiece, the 601-meter Makkah Clock Tower, which, conjoined with the

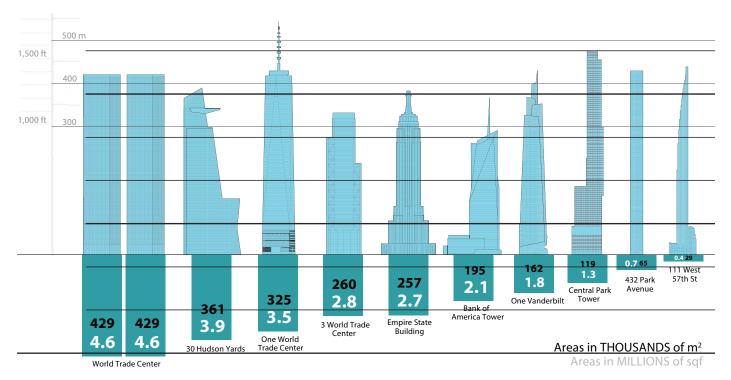


Figure 2. New York's tallest skyscrapers ordered by area, not height. © The Skyscraper Museum

six other hotel towers comprise nearly 17 million square feet (1,575,820 square meters). Just the Clock Tower section, though, contains just 3,343,680 square feet (310,638 square meters). A better candidate is Ping An in Shenzhen, which boasts a Tower GFA of 4,942,648 square feet (459,187 square meters) within its 599-meter height. Of all the 21st-century towers worldwide, there are only three that exceed 4.5 million square feet—a number that serves as a meaningful historical benchmark, as discussed below. These are Ping An, CITIC Tower in Beijing, and Shanghai Tower. It is also notable that about 3 million to 3.3 million square feet (278,000–306,000 square meters) is the most common range of GFA for the tallest of the supertall category (see Figure 1).

There's more food for thought in another chart that re-orders the list of the ten tallest buildings in New York City according to their GFA (see Figure 2). What is surprising here? First, the size of 30 Hudson Yards, a building that really does not look or feel that big on the skyline or on the ground, but is probably the eight largest building in the world. Most people will be astonished at the very tiny areas of the two structures at the far right, which are the residential towers 111 W. 57th Street (last in row) and 432 Park Avenue. These beanstalks of "Billionaire's Row" follow a "logic of luxury" that I have described in several previous CTBUH talks, a design strategy of slenderness that piles the limited floor area allowed under New York's zoning constraints as high in the sky as possible. The diagram clearly shows that while these towers are very tall, but they are not very big. The terms "tall" and "big" should not be used interchangeably. But they are often confused in public discourse, especially by those who would put height caps on towers. And they are also

frequently muddled in the media. We must work harder to clarify the distinction.

Historical Examples

Now let's look at some historical examples. We all understand the evolution of the skyscraper as the story of ascending height. Increasing size would seem to be as inexorable—but that progress was true only up to a point. The "apogee of area" was fifty years ago, in the mid-1960s and 1970s. The original Twin Towers of the World Trade Center and Chicago's Sears/ Willis Tower were the biggest tall buildings constructed in the twentieth century. Each had 110 floors and a GFA that topped 4 to 4.5 million square feet (371,000 to 418,000 square meters) (see Figures 3 and 4).

What forces drove these buildings to be so big? We well understand the architectural innovations and engineering genius that enabled the towers to rise to unprecedented heights and to be strong, economical, and create large, open floor plans. The subject here, though, is not to focus on the roles of architects Minoru Yamasaki and Bruce Graham or engineers Leslie Robertson, Fazlur Khan, and their colleagues as important as these figures were to these stories. Instead, let's consider why these buildings contain so much floor space.

Key technological advances radically changed the interiors of office buildings in the postwar era. Fluorescent lights and air conditioning allowed offices to have floor plates of 60 feet (18 meters) deep, or even more. No longer were Class A



Figure 3. World Trade Center in 1978. Courtesy of Library of Congress. © Camilo J. Vergara



Figure 4. Chicago skyline with the Sears/Willis Tour in 1990. Courtesy of Library of Congress. © Carol M. Highsmith



Figure 5. Lower Manhattan in 2001. Courtesy of Library of Congress. © Carol M. Highsmith

office buildings hampered by the real-estate rule of "no space deeper than 28 feet (8.5 meters) from an outside window to the interior corridor," to quote from the 1929 brief for the design of the Empire State Building. Through the 1930s, workspaces had been lit principally by daylight through large, operable windows, supplemented by light from hot, incandescent bulbs. Because fluorescent lighting produced far less heat, deep space could be converted into well-lit interiors. Light levels rose from a 1930s standard of 25 footcandles to 100, and in many postwar buildings, the entire ceiling became a continuous plane of light. In addition, new technologies of HVAC mechanical systems could climatize full floors. Air conditioning also meant that windows did not have to open to ventilate the space. Glass curtain walls became standard.

Buildings got bigger in the 1960s, especially as the demand for new office space boomed in the postwar economy. Many large, successful corporations invested in new headquarters that broadcast their success and modernity. In Chicago, of course, there was Sears, Roebuck & Co., the world's largest retailer, as well as the Standard Oil Building (now the Aon Center), an 83-story tower with a GFA of 3.6 million square feet (334,450 square meters). In New York, SOM designed both the capacious glass-box headquarters of One Chase Manhattan Plaza downtown and of Union Carbide on Park Avenue (being demolished in 2019). Floor plates for these bespoke skyscrapers ranged from 20,000 to 50,000 square feet (1,858 to 4,645 square meters). Because most modernist towers rose as simple, straight shafts (except Sears), office floors had identical dimensions. These large floor plates afforded big companies space to pack whole departments on a single floor.

Speculative buildings, which are always the majority of all highrises in every cycle of new construction, also increased in size. Some examples in New York are 1 New York Plaza (1969) and 55 Water Street (1972), which with 3,680,000 square feet (341,883 square meters) became the world's largest privately-developed office building, two years before Sears Tower was completed (see Figure 5). These roomy rectangular boxes were erected principally as "back office" space for financial service companies. Located along lower Manhattan's East River waterfront, these buildings could reach behemoth proportions because they were able to assemble large sites by replacing mostly low-rise, nineteenth century structures that were ripe for development. Some developers were even permitted to de-map streets and organize multiple lots in superblocks.

Even when new high-rises were more centrally located on smaller, pricier lots in the Financial District or in Midtown, the postwar buildings took the new boxy shape that the industry called "block-type" buildings, meaning structures with floor plates that could accommodate tenants requiring 25,000 square feet (2,323 square meters) or more. These modern buildings were efficient and productive, serving well both tenants and owners. The president of the Real Estate Board of New York, Lee Thompson Smith, summarized their virtues, contrasting them with towers of the 1920s and '30s: "One salient characteristic of the new buildings that cannot be adapted to old buildings at any price is their basic planning. They provide large blocks of space on one floor, with great glass areas, better lighting, fewer courts, less waste space, and new automatic elevator arrangements, with fewer cars and faster service. Deeper floor areas, among the other developments in design, result in as much as eighty percent of the space on each floor being rentable space, as compared with sixty-five percent in the buildings that were conventional twenty years ago."

In 1961 another major factor changed the rules of the game for real estate development in New York City and contributed to the near ubiquity of big rectangular slab buildings. A new zoning law replaced the formulas established in 1916 that regulated bulk and required a series of setbacks at upper levels. Under the old law, the "wedding cake" form of stacked boxes could be topped with a tower of unlimited height that occupied no more than a quarter of the site: think Chrysler Building. The new 1961 zoning created an entirely different formula based on a maximum floor area, called "FAR" for floor area ratio. Developers could now build only as many square feet as the zoning allowed for that lot (unless one purchased air rights or built a zoning-bonus plaza). That finite number was considerably less than under the old law. The percentage of the site a tower could cover was now expanded to 40 percent and developers could configure the FAR in whatever shape they wished. It's ironic that office buildings became standardized as big rectangular boxes at the very time that regulations on form got looser. Put another way, the designs of the 1960s show how much clients wanted big buildings with large, regular floor plates.

World's Biggest Buildings

Let's turn from generic big buildings to the extreme of world's biggest and consider Sears Tower. Sears is especially interesting because it was designed with an extraordinary amount of client input. In 1969, the company hired the firm SLS Environetics as their "space planning and design consultants" for the interiors of the new headquarters—all 50 floors, 2.2 million square feet (204,600 square meters), accommodating some 7,000 employees. According to the writer John Pile, author of several industry volumes on office interiors, "SLS devoted years to the preliminary study of space requirements, work relationships, and existing equipment that might be reused. (In the end nothing was reused)." SLS analyzed the current and future needs of 93 departments. Their recommended layout for a typical floor can be seen in the remarkable floor plan drawing in Figure 6. The super-square of nine "megamodules" of column-free space created by SOM's bundled-tube structural system were divided into guadrantsfour zones, distinguished as built by different color schemes. Within the humongous floor plates of more than 50,000 square feet (4,645 square meters) were "private offices, semiprivate offices, departmental spaces enclosed by partitions, and open work areas."

You only have to glance at the SLS floor plan in Figure 6 to understand that the team thought a lot about office planning. You might even consider this perfect square plan a sort of corporate and architectural mandala. As an architectural historian, I have always approached Sears Tower as the work of the architects and engineers at SOM, but it's apparent that the preliminary work with the client in planning the workspace had a significant impact on the architectural design. Whether it was SOM or SLS Environetics, or a combination, the story about the design process recounted in the *Chicago Tribune* in 1970 makes clear that the client had strong preferences for very large floor plates and that the designers need to talk them down. Here is the story told to Alvin Nagelberg, the Real Estate Editor of the *Tribune*:

"Graham explained that Sears Roebuck officials were accustomed to big floor areas of 100,000 to 150,000 square feet and wanted large spaces in the new building. They also wanted to build about four million square feet of space, some of which would be offered on the open market.

The architects first had to convince Sears officials that 50,000 square foot floors would be better than 100,000 square feet. Employees would be tied closer together by elevator.

The first concept was for one tower with large floors the full height. It would have suited Sears, but not many other tenants who prefer smaller spaces and windows.

The next idea was two buildings. One with 50,000 square foot floors and the other 30,000 square feet. But they didn't fit well on the site. Only a narrow alley separated the structures.

So Graham and his colleagues decided to stack three buildings each of smaller floor size and varying floor configuration on top of a 50-story base section with 52,000 square foot floor areas to accommodate Sears."

Those upper sections of the building with their smaller floor plates were designed for the rental market. Like most headquarter high-rises through history—whether the 1874 Tribune Building or 1909 Metropolitan Life Tower, or One Chase Manhattan Plaza (1961), all in New York—Sears Tower built extra floors to generate revenue. They occupied 2.2 million square feet (204,386 square meters) of the four million square feet (this four million number, based on Skyscraper Museum research, measures from street to roof; if including lower levels, the number is 4.4 million square feet). That amount, however, was all too soon proven to be too big. By 1988, the company had put the tower up for sale and planned to move a major portion of their workers to a suburban campus. They did move out in 1992 and ultimately sold the tower in 2009 to a group of investors who gave the building a new name, Willis Tower, to attract the anchor tenant Willis Group Holdings, a multinational risk advisor.

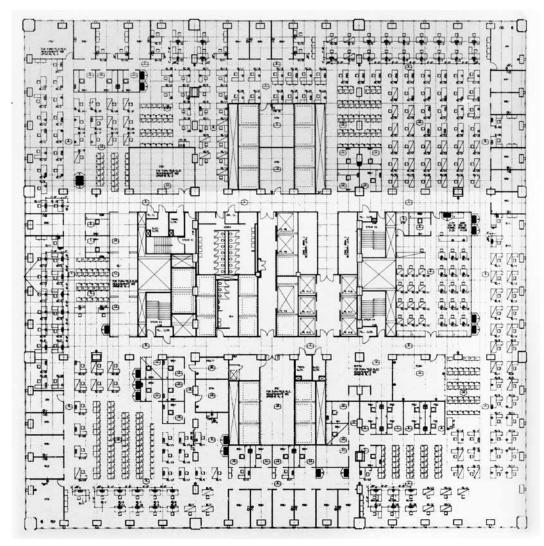


Figure 6. A typical floor plan below the 50th story in Sears/Willis Tower. Presumably drawn by Sears's office planning consultants SLS Environetics. Source: John Pile, Interiors 3rd Book of Offices, 1976.

Sears had stretched to surpass New York's World Trade Center, finished just the year before, and captured the title of "World's Tallest." But the Chicago tower could not legitimately also claim the record as "World's Largest." With 4,624, 000 square feet (429,583 square meters) each, the Twin Towers remained the two biggest buildings by floor area. Their square plans, 209 feet on a side, encompassed floors of more than 43,000 square feet (3,995 square meters): 210 floors, each with an acre of space. Rental-floor plans for two floors, one for a single tenant and the other subdivided, are shown in Figure 7. One sees both the advantages and disadvantages of occupying the vast columnfree spaces.

The titanic scale of the entire World Trade Center project is not our focus here. Begun in the boom of the mid-1960s, constructed during the economic stagnation of the early 1970s, and completed as New York City slid into the fiscal crisis and barely avoided bankruptcy, the Twin Towers proved to be far too big for the existing office market. It did not fill up with the Port Authority's original target tenants, businesses related to the Port of New York, and instead the State of New York and the PANYNJ itself spread out into a significant portion of the space.

The gigantic World Trade Center and Sears Tower were anomalies in their time, and they were also apparently, too big—whether measuring floor plates or total GFA—for any time, because they were not repeated. The standard size of skyscrapers in the later 1970s and subsequent boom cycles did not grow steadily larger. As the technology of desktop computers and wired "smart buildings" spread, many large companies preferred an office floor plan of 35 to 45-foot depth from the core to the facade. "The ideal building, from the functional point of view," noted architect William Pedersen of KPF, "calls for a square plan with each of its sides... approximately 145 to 175 feet." Such structures were often stubby, rather than soaring and ranged from around 34 to 60 stories. Examples include the World Financial Center at Battery Park City and Worldwide Plaza in New York, and the AT&T Corporate Center and Leo Burnett Building in Chicago.

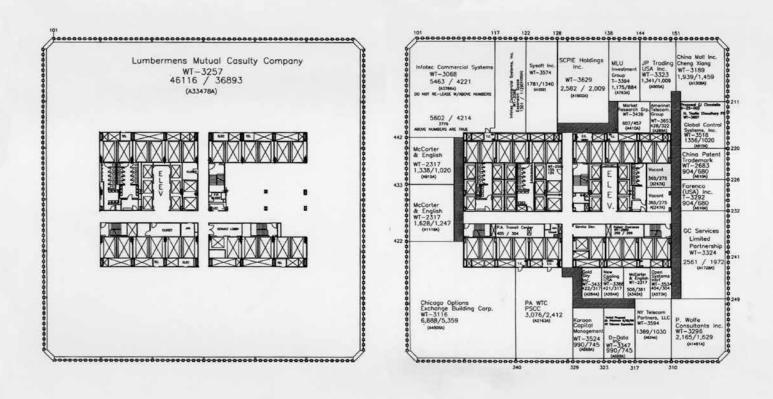


Figure 7. Floor plans of the 36th and 22nd stories in one of the towers of the original World Trade Center. Courtesy of The Skyscraper Museum. © Port Authority of New York and New Jersey

The Twin Towers (until their destruction on 11 September 2001) and Sears did reign as the three tallest and biggest buildings in the world until 1996 and the completion of the Petronas Towers, which surpassed only their architectural height. Sears/ Willis Tower continued to be the world's biggest tall building until 2017 and 2018 with the completion of Ping An in Shenzhen and CITIC Tower in Beijing. Skyscrapers worldwide did get taller in the 21st century, but did not grow comparably in GFA, as the chart of Table 1 shows.

Why is that? The answer has to be because so many of the tallest skyscrapers of the past two decades have been mixeduse buildings with a significant portion of the tower devoted to residential or hotel floors which require less space than offices. Many of the tower designs taper at the top to accommodate the smaller floor plates or contain actual voids at the center of the hotel section, as at Jin Mao, Guangzhou IFC, and KK100. Other good explanations may emerge if CTBUH asks its members, who design these buildings, to analyze this question.

If we ignore the measure of area as part of size, we miss a great deal of importance about both the history and fascinating stories of these great buildings.

	Tower GFA	Height	Year of completion
Ping An Finance Center, Shenzhen	459,187 m² / 4,942,648 ft²	599 m / 1,965 ft	2017
CITIC Tower, Beijing	437,000 m ² / 4,703,829 ft ²	528 m / 1,732 ft	2018
Willis Tower, Chicago	423,638 m ² / 4,560,000 ft ²	442 m / 1,451 ft	1974
Shanghai Tower, Shanghai	420,000 m² / 4,520,842 ft²	632 m / 2,073 ft	2015
Guangzhou CTF Finance Center, Guangzhou	398,000 m ² / 4,284,036 ft ²	530 m / 1,739 ft	2016
Shanghai World Financial Center, Shanghai	381,000 m² / 4,107,508 ft²	492 m / 1,614 ft	2008
Goldin Finance 117, Tianjin	370,000 m ² / 3,982,647 ft ²	597 m / 1,957 ft	2020
30 Hudson Yards, New York	361,993 m² / 3,896,460 ft²	387 m / 1,268 ft	2019
Wuhan Center, Wuhan	343,900 m ² / 3,701,709 ft ²	438 m / 1,437 ft	2019
One World Trade Center, New York	325,279 m² / 3,501,274 ft²	541 m / 1,776 ft	2014
Makkah Royal Tower, Mecca	310,638 m² / 3,343,680 ft²	601 m / 1,972 ft	2012
Burj Khalifa, Dubai	309,473 m ² / 3,331,140 ft ²	828 m / 2,717 ft	2010

Table 1. Ten tallest skyscrapers in the world ordered by area. © The Skyscraper Museum