United States Department of the Interior
National Park Service

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in National Register Bulletin, *How to Complete the National Register of Historic Places Registration Form*. If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions. **Place additional certification comments, entries, and narrative items on continuation sheets if needed (NPS Form 10-900a).**

1. Name of Property

historic name 500 N. Michigan

other names/site number

Name of Multiple Property Listing

(Enter "N/A" if property is not part of a multiple property listing)

2. Location

street & number 500 North Michigan Avenue ☐ not for publication

city or town Chicago ☐ vicinity

state Illinois county Cook zip code 60606

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended,

I hereby certify that this ___ nomination ___ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60.

In my opinion, the property ___ meets ___ does not meet the National Register Criteria. I recommend that this property be considered significant at the following level(s) of significance: ___ **national** ___ **statewide** ___ **local**

Applicable National Register Criteria: ___ **A** ___ **B** ___ **C** ___ **D**

Signature of certifying official/Title: Deputy State Historic Preservation Officer Date

Illinois Historic Preservation Agency
State or Federal agency/bureau or Tribal Government

In my opinion, the property ___ meets ___ does not meet the National Register criteria.

Signature of commenting official Date

Title State or Federal agency/bureau or Tribal Government

4. National Park Service Certification

I hereby certify that this property is:

___ entered in the National Register ___ determined eligible for the National Register

___ determined not eligible for the National Register ___ removed from the National Register

___ other (explain:)

Signature of the Keeper Date of Action

500 N. Michigan
Name of Property

Cook ,Illinois
County and State

5. Classification

Ownership of Property
(Check as many boxes as apply.)

- [X] private
- [ ] public - Local
- [ ] public - State
- [ ] public - Federal

Category of Property
(Check only **one** box.)

- [X] building(s)
- [ ] district
- [ ] site
- [ ] structure
- [ ] object

Number of Resources within Property
(Do not include previously listed resources in the count.)

Contributing	Noncontributing	
1		buildings
		site
		structure
		object
1		**Total**

Number of contributing resources previously listed in the National Register

6. Function or Use

Historic Functions
(Enter categories from instructions.)

COMMERCE/TRADE/business

Current Functions
(Enter categories from instructions.)

COMMERCE/TRADE/business

7. Description

Architectural Classification
(Enter categories from instructions.)

MODERN MOVEMENT

Materials
(Enter categories from instructions.)

foundation: CONCRETE

walls: STONE, GLASS, METAL

roof: SYNTHETICS

other:

Narrative Description

(Describe the historic and current physical appearance and condition of the property. Describe contributing and noncontributing resources if applicable. Begin with **a summary paragraph** that briefly describes the general characteristics of the property, such as its location, type, style, method of construction, setting, size, and significant features. Indicate whether the property has historic integrity).

Summary Paragraph

Constructed between 1965 and 1967, 500 N. Michigan is a 24-story (288'–3" tall) skyscraper with a flat roof in the International style. It is located in the Near North Side community area of Chicago, Illinois at the northwest corner of Michigan Avenue and Illinois Street. The area is characterized by tall glass-clad office and residential towers and by two- to five-story commercial buildings. The 500 N. Michigan office tower was designed by the firm of Skidmore, Owings & Merrill (SOM), with Bruce Graham as the architectural lead and Fazlur Khan as the lead structural engineer. The building features a lower level tenant parking, ground floor retail, and upper level flexible floorplates with leasable office space. Unlike earlier buildings with metal or concrete structural framing systems, 500 N. Michigan was designed using a “framed tube” structural system developed by SOM engineer Fazlur R. Kahn. The system efficiently resists lateral loads, without the use of massive shear walls or a structural core, through its rigid loadbearing exterior walls. The walls, which are five bays wide (east and west elevations) and eight bays deep, are framed with vertical columns and horizontal spandrels of reinforced concrete, which form strong planes with regular fenestration. The four framed elevations joined together create the building’s tube-like structural form. A limited number of interior concrete columns support floor loads. The framed tube system is clearly expressed by the grid-like form of the building’s four elevations. It is finished with a thin veneer of travertine marble. Original bronze-tinted windows characterize the building’s upper floors. The building retains very good interior and exterior integrity and continues to visually express its revolutionary structural system.

Narrative Description

500 N. Michigan is partially obscured by adjacent towers on its west and north elevations. Overall, the building occupies its full rectangular parcel, which is less than one half of a city block and is bounded by Michigan Avenue on the east, Illinois Street on the south, a public alley on the north, and a private building on the west. Michigan Avenue, on this block, is a bi-level viaduct that intersects Illinois Street on its lower level and bridges Illinois Street on the upper level. An original upper-level sidewalk extends from Upper Michigan Avenue west along the south side of the building along Illinois Street. The building’s primary entrance is on the east elevation at Upper Michigan Avenue, while vehicular entrances are located off Lower Michigan Avenue. A small original plaza extends the width of the rear west elevation at the first-floor level.

Exterior

The grid-like frames that form each of the building’s four elevations are clearly expressed by travertine limestone-cladding on all vertical columns and horizontal spandrels. A water table at the first-floor level remains visible on the north, south, and west elevations and is clad in honed pink granite panels. The travertine cladding contrasts with the building’s regular fenestration, which consists of fixed, bronze-tinted glazing with a lower bronze aluminum panel (window units typically measure a total of 6'–9½" wide by 8'–6" tall). The four “framed” elevations meet at rabbeted corners that emphasize the building’s tube-like structural form. Below the first-floor level is a lower level (LL1) that is visible on the south elevation along Illinois Street, the east elevation on Lower Michigan Avenue, and the north elevation along a public alley. At the first-floor level, on all elevations, the column spacing is doubled and is capped by a tall transfer beam, which is larger than typical upper spandrel beams. Lower level (LL1) elevations are clad in original buff tone brick with exposed concrete columns. All cladding at the first and second floor levels of the east and south elevations was replaced in 2020 with non-historic matte black metal panels. The top of the building (24th floor) is capped by a double-height mechanical space with louvered bays.

The primary elevation is 99'–6" wide and faces east on to Michigan Avenue. A transfer beam separates the building's upper floors (2-24) from its base. On upper floors, the east elevation is divided into ten equal window bays; this changes to five wider bays at the first floor and lower levels. The office building's main entrance is located within the center bay; it is accented by a non-historic canopy added circa 2020. Retail storefronts with modern signage and lighting flank the center bay. The elevation's first two floors are fully clad with non-historic matte black panels, while on the third floor the metal panels are only present on the northernmost and southernmost bays. Despite the non-historic paneling, the structure's character-defining transfer beam remains visible and is visually distinguishable from upper-level spandrel beams. The lower street level (LL1) is clad in buff-toned brick and features a loading dock with service doors.

The south-facing elevation is 164'–11" wide and faces on to Illinois Street. The elevation is divided into sixteen equal window bays on upper floors (2-24), while the first-floor level and the lower level are arranged into eight double width bays. Illinois Street has a main sidewalk that runs along the south side of the building at the LL1, as well as an upper sidewalk level that runs along the south side of the building's first floor level. The upper sidewalk is supported by painted exposed steel columns that line up with the vertical columns on the building. The edge of the sidewalk forms part of the building's first floor level water table and remains clad in original honed pink granite panels. The sidewalk also features an original wrought iron railing. The upper level was completed as part of the building's construction in 1968. The south elevation at LL1 is clad in original buff-toned brick and features original vehicular doorways for garage access, service doors, and mechanical louvers. The first and second floor columns and spandrels, as well as the easternmost bay of the third floor, are clad in black paneling. Similar to the primary east elevation, the wide transfer beam remains visible.

The west and north elevations are both considered to be secondary elevations and are largely obscured by adjacent skyscrapers. They are nearly identical to the primary east and south elevations and retain nearly all of their original travertine cladding and bronze aluminum windows. The first-floor levels retain original water table cladding of dark granite and lower levels are clad in buff toned brick. The first-floor level of the west elevation retains a portion of the original recessed pedestrian arcade, as well as the travertine-clad transfer beam; this area currently houses mechanical equipment. The north elevation extends down to LL1, where exterior walls are clad with brick and feature louvers and service doors. The travertine-clad transfer girder and granite-clad water table are visible west of the third bay. Both the west and north elevations incorporate limited areas of black paneling where they meet the Michigan Avenue (east) and Illinois Street (south) retail elevations.

Interior
The interior of 500 N. Michigan includes a variety of spaces that range from utilitarian service areas and parking to tenant retail and upper floor offices. All tenant levels are accessed by a central set of elevators and a main egress stair. Restrooms and utility chases are also stacked near the elevators and stairwell. Retail tenant spaces are located on the lower floors (portions of LL1 through Floor 2) and offices comprise the upper floors from Floor 3 to 23. At the top of the building on Floor 24 is an original double-height mechanical space.

The basement (LL2) continues to serve as vehicular parking for the building and largely retains its original configuration, including the locations of elevators, parking attendant booth, and mechanical room. Vehicular doorways on the south and east elevations access this level, which is characterized by painted and unpainted exposed concrete floors, walls, and ceilings. Exposed MEP is found throughout.

Lower Level 1 (LL1) is a largely utilitarian level with a main double-loaded corridor that is flanked by mechanical rooms, service rooms, and storage spaces. Finishes include vinyl tile and exposed concrete floors, painted gypsum board or CMU walls, and ceilings with exposed metal and concrete structure and MEP. Corridors and tenant amenity spaces typical feature dropped acoustic tile ceiling systems.

The first floor is accessed from the building's main east entrance off Michigan Avenue. Sets of glazed metal doors open into the entrance lobby, which is separated by a set of four steps into a vestibule area and an inner elevator lobby area. The vestibule and elevator lobby areas occupy the middle three of five east to west oriented column bays. The elevator lobby portion is arranged into two smaller elevator lobbies with banks of four elevators each. The east elevator lobby features elevators that access level 1 through 12, while the west elevator lobby has four elevators that access Lower Level 1 and levels 13 through level 23. A fifth elevator in the west bank exclusively runs between level 1 and the parking garage on Lower Level 2. Both east and west elevator lobbies are accessed on level 1 by a pair of north and south corridors that connect with the main lobby and primary Michigan Avenue entrance on the east.

There are three retail suites on the first floor. Two suites encompass the north and south column bays, which were originally open-air arcades. A third retail suite on the west end of the floor occupies part of an original retail space, as well as a portion of the footprint of the original open arcade. An open-air arcade originally was inset the width of one column bay and encircled the first-floor lobby and a set of narrow retail spaces. The north, east, and south pedestrian arcades were enclosed in 1989 by installing glass storefront windows in the arcade openings. An original west arcade remains intact along the west elevation. This remodeling provided additional street-level retail space and updated the elevator and entrance lobby with a Neo-Prairie style theme. The lobby was remodeled again in 2004 and 2020 when the non-original retail tenant spaces were expanded into the non-original lobby area that had been created in the former east arcade. The entrance lobby vestibule is finished with terrazzo floors and steps that date to the 1989 remodeling, and gypsum board walls and ceilings. The elevator lobby has terrazzo floors that date to the 1989 remodeling, as well as original travertine wall cladding. Dark granite wainscotting was applied over the lower 3-feet of the travertine-clad walls as part of the 1989 remodeling. South of the lobby there are two retail spaces that line the south elevation in the footprint of the former arcade. The west retail space has a non-original stair and elevator that access a continuation of the space on the second-floor level. Finishes include non-historic tile floors and gypsum board walls and ceilings.

Typical office floors (floors 3-23) were designed for flexibility and could accommodate either a single tenant or multiple tenants. Each floor has a central circulation core with an elevator lobby, stairs and restrooms, while corridors vary in length and width depending on the configuration of tenant suites. Elevator lobby finishes generally include carpeted floors, gypsum board walls (painted or with wall coverings), and a combination of dropped plaster and/or acoustic tile ceiling systems. Metal elevator surrounds appear to be historic; elevator indicators are also original (though some have been covered with translucent glass). Original mail chutes remain intact in the south corridor on each level, beside the main stair. Most restrooms retain some original wall tile, fixtures, and toilet partitions, though other restroom finishes have been remodeled. Typical of office buildings of the period, leasable tenant office suites have been renovated and repartitioned repeatedly over time to meet the requirements of changing tenants. Typical office finishes include non-historic carpet and/or tile, painted gypsum board walls, wood slab doors, and acoustic tile ceilings. A small number of tenant spaces retain what may be original floor tile, doors, and closets. Some floors (4, 10, and 12) are currently unfinished and have exposed concrete columns, concrete slab floors, and concrete ceilings.

The 24th mechanical floor houses both mechanical and back-of-house areas, which generally retain their original configuration and utilitarian appearance (i.e., exposed concrete floors, walls, and ceilings, as well as mechanical equipment and exposed building systems). Similarly, the roof retains an original access hatch, and an original cooling tower, that is inset to the 23rd level below, remains open and visible along the northern side.

Integrity Statement

500 N. Michigan retains sufficient integrity to express its innovative “framed tube” structural system. This system is visually expressed by the building’s rhythm of fenestration and by its exterior columns and spandrels, which together form a near monolithic grid from base to roof.

The original tube-like form comprising the building's four grid-like framed elevations remains visible and continues to express the building's early framed tube structural system. Structural members retain nearly all original travertine cladding, which contrasts with the building's extant original bronze-tinted windows. The original travertine cladding was replaced in 2020 with matte black panels on the first and second levels, and on single bays on the third floor of the south and east elevations. However, this change does not significantly alter the visual expression of the building's structural system because the total area of replacement affects less than 7% of the building's original cladding and all new cladding covers the same vertical and horizontal structural surfaces as the original cladding. Original travertine cladding and granite water table remain fully intact and visible on the north alley and west arcade elevations. All original travertine cladding remains fully intact on the south and east elevations above level three. All original buff brick and exposed concrete columns remain intact and visible on the lower-level elevations, including the south facing elevation along Illinois Street. The original granite water table also remains intact along the fascia of the upper level of the Illinois Street sidewalk, which was completed as part of 500 N. Michigan.

Similarly, although the building originally featured an open arcade at the first floor, this was also an aesthetic treatment independent of the building's structural parameters. This former open space was framed by the building's exterior wall structural system of columns and spandrels, which remain visible. One difference in this portion of the building is the wide column spacing, which accommodates wider openings in the bays at the first floor, and supports a deep transfer beam that encircles the building. The transfer beam, although partially reclad in non-historic finishes, retains its dimension and scale, which continues to visually set it apart from the overall grid-like structural form of the framed tube system.

On the interior, the building retains very good integrity of layout, circulation, and expression of its structural system. The first-floor elevator lobby occupies its original footprint and retains original travertine wall cladding. Alterations made to the first floor in 1989 expanded the area of the building's original first-floor retail space and widened the lobby corridors; however, remodeling in 2004 restored the lobby corridors to their original widths. On lower levels, the building retains its original tenant parking garage, including configuration, ramps, and elevators. The building's upper office floors also have very good integrity and retain original elevator lobbies, stairwell and restroom locations, mail chutes, and overall flexible floor configurations. Individual floors also express the building's structural system through deep exterior columns that continue to conceal original vertical utility systems for water and electrical distribution.

Overall, 500 N. Michigan remains the earliest example of Fazlur Khan's innovative development of the framed tube structural system as applied to meet the space and light requirements of an office building. Sufficient integrity remains to support listing of the building under National Register Criterion C for Engineering.

- *Location:* The building remains in its original location. It continues to occupy a prominent location along North Michigan Avenue.

- *Design:* The tower's rectangular form and rhythm of windows set against its grid of columns and spandrels remain intact and visible on the exterior of the building. The original fenestration pattern remains intact on all four elevations. Most importantly, the grid-like exterior walls that comprise the building's "framed tube" structural system remain prominent and legible despite cladding changes on two elevations at the base in 2020. Additionally, the building's International style continues to be articulated through the expression of the structural frame, flat roof without coping, upper floor louvered mechanical top, and the predominantly smooth and unadorned exterior.

- *Setting:* 500 N. Michigan was constructed during the post war period and is part of the Modern Movement. Many of the surrounding buildings predate this skyscraper and serve to retain integrity of setting.

- *Materials and Workmanship*: The building retains integrity of materials and workmanship in the upper floors (3-24) as well as at lower street levels (LL1 and LL2). Although some updates have changed the appearance of the retail storefronts on the first and second floors, the unadorned travertine cladding and contrasting bronze-tinted windows still dominate the building's exterior appearance. Louvers at the 24th floor also remain intact.

- *Feeling and Association*: The high-rise scale and rectangular massing, expression of the concrete structure, overall façade composition, original materials (e.g., travertine limestone, bronze-tinted windows, and louvers), and continued office/retail use collectively continue to convey integrity of feeling and association.

500 N. Michigan
Name of Property

Cook, Illinois
County and State

8. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing.)

- [ ] A Property is associated with events that have made a significant contribution to the broad patterns of our history.
- [ ] B Property is associated with the lives of persons significant in our past.
- [X] C Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.
- [ ] D Property has yielded, or is likely to yield, information important in prehistory or history.

Criteria Considerations
(Mark "x" in all the boxes that apply.)

Property is:

- [ ] A Owned by a religious institution or used for religious purposes.
- [ ] B removed from its original location.
- [ ] C a birthplace or grave.
- [ ] D a cemetery.
- [ ] E a reconstructed building, object, or structure.
- [ ] F a commemorative property.
- [ ] G less than 50 years old or achieving significance within the past 50 years.

Areas of Significance
(Enter categories from instructions.)

ENGINEERING

Period of Significance

1965-1967

Significant Dates

1967

Significant Person
(Complete only if Criterion B is marked above.)

Cultural Affiliation (if applicable)

Architect/Builder

Skidmore, Owings & Merrill

Statement of Significance Summary Paragraph (Provide a summary paragraph that includes level of significance, applicable criteria, justification for the period of significance, and any applicable criteria considerations).

Summary

The 24-story office building at its namesake address of 500 North Michigan Avenue (500 N. Michigan) was constructed between 1965 and 1967. It is locally significant under Criterion C, in the area of Engineering, as an important early example of the "framed tube" engineering system designed by engineer Fazlur Rahman Kahn (1929-1982). Kahn, who worked in the Chicago office of Skidmore, Owings and Merrill, became nationally recognized for his achievements in the design of tube-type structural systems for the development of efficient tall and super-tall buildings. The design for 500 N. Michigan is an excellent early example of Khan's experimentation and development of his revolutionary tube-like structural systems. Of these, one of his most successful is the "framed tube" system, which enabled a building to resist lateral wind loads without reliance on interior shear walls, which had become a common structural system for tall buildings at the time. This feat was accomplished by shifting significant lateral support from interior structures to the exterior, forming a rigid, tube-like wall system. It achieved this while retaining large windows to maximize light, views, and spatial openness. 500 N. Michigan was not simply a step in the evolution of the framed tube structural system, but it was the first successful application of the system to meet the requirements of a modern, speculative-built office tower.

The construction of 500 N. Michigan realized two important factors of office tower development using the framed tube system. First, the framed tube structural system proved to be cost effective compared with existing skeleton frame structural systems. Second, the structural design provided both a large ratio of window to wall area and it maximized leasable floor area by reducing the space occupied by vertical structural columns. These two factors were enhanced by the innovative use of lightweight concrete in the building's floor slabs, which made the building lighter and allowed for even smaller vertical structural members. The concrete framed tube system developed for 500 N. Michigan became an established design that Khan and Skidmore, Owings and Merrill continued to apply in many of the firm's high rise office tower designs during the 1960s and 1970s.

The period of significance under Criterion C begins in 1965, when construction began, and ends in 1967, the year that the 500 N. Michigan office building was completed.

Narrative Statement of Significance (Provide at least **one** paragraph for each area of significance.)

History and Development of 500 North Michigan Avenue

In 1964, the *Chicago Tribune* announced that a new 20-story office building designed by the Chicago architecture firm of Perkins and Will would be built at 500 N. Michigan. The developer was Lithos Properties, Inc. of New York, which acquired the site for $1.3 million. Development costs were anticipated to be over $8 million.[1] Complying with the rising demand for office and rental space, 500 N. Michigan would have at least 15,000 square feet of rentable area per floor. By May of 1965, Skidmore, Owings & Merrill (SOM) was brought on board, with Bruce Graham as lead architect and Fazlur Khan as lead engineer. Estimated development costs increased to $10 million, and the building height grew to a proposed 25 or 27 stories.[2]

Later that year, the property was sold to Washington, D.C.-based developers Stanley Reines and Sidney Teplin. Newspaper accounts from the time suggest that Jerry Wolman, who later developed the John Hancock Center and was a frequent business partner of Reines and Teplin, also had an ownership stake.[3] Groundbreaking followed in October 1965, still with an intended office use and a spring 1967 projected opening. A November 1965 rendering illustrates the

[1] James M. Garvin, "Skyscraper Planned for Michigan Av.," *Chicago Tribune*, July 7, 1964. Newspapers.com.
[2] "New High-Rise Building Set for N. Michigan," 114.
[3] "Demolition Due at Site for High Rise," *Chicago Tribune,* September 30, 1965, 93, Newspapers.com.

building's final design with an arcade at the base and a double height 24th floor. Reported development costs increased to approximately $15 million.[4]

In 1966, construction paused briefly to address defects found in two caissons, a problem that had also occurred at the John Hancock Center's building site.[5] Repairs were made quickly, and installation of the exterior travertine limestone continued. The tower's concrete structure was completed in October 1966, exactly one year after groundbreaking.[6]

In March 1967, Arthur Rubloff & Co. brokered the sale of 500 N. Michigan to a group of Chicago and New York investors for an undisclosed price.[7] Concurrently, Rubloff's firm also took over as the building's new management and leasing agent. Over the next year, several notable leases were signed. The largest was for the Standard Oil Company of Indiana, which relocated the headquarters of its subsidiary, American International Oil Co. from New York City to the upper eleven floors (approximately half the leasable floor area) of 500 N. Michigan. Standard Oil subsequently developed a headquarters building, originally the Standard Oil Building (200 East Randolph Street; now known as the Aon Center), which is similar in design to 500 N. Michigan and was completed in 1973. It is a steel framed-tube structure and was famously clad in travertine.[8] Additional early leases included Ogilvy and Mather Inc.; WGN Continental Broadcasting Co.; and the Chicago public relations department of General Motors.[9] Later in 1968, leases were signed for the Republic of South Korea and the headquarters of the "Nixon for President" campaign.[10] More esteemed tenants were attracted to the new high-rise office building in 1969, with Olympic Airways and Station WFMT signing leases.[11] Arthur Rubloff & Co. continued to be involved with 500 N. Michigan until around 1989.[12] Building management allowed Rubloff to retain a long-term stake in the successful use and tenancy of 500 N. Michigan.

The Structural History and Economic Feasibility of Tall Office Buildings

SOM and Fazlur Kahn contributed many advances in the structural engineering of tall buildings during the 1960s. Their advances, which are embodied in the design of 500 N. Michigan, were built on a deep foundation of engineering accomplishments that made the construction of tall office buildings possible. Throughout the history of building tall, challenges, such as overcoming limitations of materials, reducing construction costs, and maintaining structural integrity at new heights, were consistently addressed with new and innovative structural systems and materials. Within this history, increasing demand for and evolution of an environment, purpose-built exclusively for office use, helped drive demand for ever taller buildings. During the post-World War II period, Kahn's pioneering framed tube structural systems provided a new and innovative engineering method for tall and super tall buildings, which significantly influenced the development of tall buildings during the late-twentieth century.

The development of tall office buildings during the late-nineteenth and twentieth centuries was shaped by several related social shifts and technological changes. Growing urban populations and increasing numbers of workers in non-manufacturing jobs helped both give rise to the need for the first office "skyscrapers" and provided momentum for

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[4] "25-Story Building Starts on Michigan," *Chicago Daily News*, November 18, 1965, 103, Newspapers.com.
[5] "2 Caisson Defects Slow Construction," *Chicago Tribune*, September 13, 1966, 28, Newspapers.com; "Caisson Crack Causes Pause," *Chicago Sun-Times*, September 13, 1966, 5, Genealogy Bank; "Plan Parley on Hancock Work," *Chicago Tribune*, September 20, 1966, 60, Newspapers.com.
[6] "Office Building is Topped Out in One Year," *Chicago Tribune*, October 27, 1966, 107, Newspapers.com.
[7] Alvin Nagelberg, "Act to Acquire 25-Story Bldg. On N. Michigan," *Chicago Tribune*, March 30, 1967, Newspapers.com; Albert Jedlicka, "Delayed Skyscraper Here Sold," *Chicago Daily News*, May 8, 1967, Genealogy Bank.
[8] Standard Oil's 1973 building was designed by Edward Durell Stone and Perkins and Will. Engineer and architect Al Picardi left SOM in 1967 around the time of the completion of 500 N. Michigan and joined Perkins & Will Corp. He was the structural engineer and associate architect for the Standard Oil Building. "Standard Oil Unit Moving," *Chicago Tribune*, July 6, 1967, 108, Newspapers.com
[9] "500 N Michigan Ogilvy & Mather lease," *Chicago Tribune*, September 7, 1967, 97, Newspapers.com; "500 N. Michigan WGN lease," *Chicago Tribune*, December 6, 1967, 96, Newspapers.com.
[10] "500 N Michigan Republic of South Korea opens consulate general offices in building," *Chicago Tribune*, August 1, 1968, 117, Newspapers.com; "Donates Lincoln Document," *Chicago Tribune*, October 29, 1968, 26, Newspapers.com.
[11] "Station WFMT Moves to New Quarters, Soon," *Chicago Tribune*, April 17, 1969, 77, Newspapers.com; "Olympic Airways," *The Greek Star*, April 26, 1969, 2, Newspapers.com.
[12] Rubloff, Inc. appears as "owner/agent" on the building's 1989 renovation plans.

implementing new technologies that facilitated the construction of tall office buildings. Advancing technologies and a continued push for the "tallest," combined with the financial metrics of leasable office space versus cost of construction, drove office buildings ever higher. Yet, in the wake of World War II, changing architectural fashions emphasizing structural expressionism promoted the use of new, lighter weight cladding systems. The use of lighter cladding and interior finishes in tall buildings reduced the number of stiffening materials and required the introduction of additional structural systems to resist flexing caused by lateral wind loads. However, in the pursuit of ever taller buildings, greater heights experience increasingly stronger lateral wind loads, which requires exponentially more structure to remain rigid. Engineer Fazlur Khan identified this as a "premium for height" and addressed the challenge by developing a series of new structural systems that could feasibly permit the construction of tall buildings.[13] 500 N. Michigan represents this critical juncture in the structural evolution of the modern office building. It exemplifies the modern features demanded of office buildings during the mid-twentieth century, while successfully realizing the economic feasibility of Khan's new structural system: the "framed tube."

The Office and a Space for Business: 1860s–1880s

The concept of the "modern" office, a space devoted solely to administrative, service, and other non-manufacturing functions of a company, emerged during the mid-nineteenth century with the rise of geographically dispersed companies and corporations. Railroad companies, with regionally distributed managing offices, contributed to the development of complex interoffice communication and management systems. The organization and hierarchies developed by railroads illustrated a means for increasing productivity and profit. These processes were adopted and improved by new service-oriented communications (telegraph), banking, and insurance companies.[14]

Manufacturing firms later emulated these new business models as well. Increasing industrialization required increasingly complex systems of distribution, marketing, and handling of finances among other administrative duties within companies. Until this time, administrative functions were largely accommodated by offices within a company's main building, such as a manufacturing plant, or in other existing building types. Business transactions prior to the Civil War were largely conducted in-person; however, new office technologies made it possible to complete more transactions from a single location without time spent in transit. Administrative workers, including brokers, lawyers, and agents, increased during the late-nineteenth century, eventually developing new specialized firms to handle the growing demand for more complex services from large companies and new corporations. These factors contributed to a growing need for office space.

During the late-nineteenth century, an increasing number of firms concentrated in downtown areas and occupied offices in business blocks. Emerging technologies, including the telephone and the typewriter, increased the amount of information that could be processed at an office and contributed to the need for storage space for paper records and document filing. Access to client records and to means of communication helped define the cellular form of the typical late-nineteenth century office. Speculative builders erected new offices buildings that offered a range of individual partitioned office units that could be arranged in clusters and rows.[15] This allowed for regular repeating floor layouts. Small, individual offices became common because they were more easily rented and therefore more profitable than larger, undivided spaces.[16] The typical office size in a building also helped determine the dimensions of structural bays, which were defined by the distance between loadbearing columns. Office placement in a building was limited by access to natural sources of light and ventilation. Therefore, in early purpose-built office buildings, offices were typically organized in regular rows along

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[13] Fazlur R. Khan, "Column-Free Box-Type Framing With and Without Core," *IABSE [International Association for Bridge and Structural Engineering] Congress Report*, August 1968, 262, www.e-periodica.ch.

[14] "Carbons to Computers. A Short History of the Birth and Growth of the American Office," Smithsonian Education, Smithsonian Institution, 1998, site: www.smithsonianeducation.org/scitech/carbons/text/birth.html

[15] Linda Stewart Gatter, *The Office: An Analysis of the Evolution of a Workplace*. 1982. Massachusetts Institute of Technology, master's thesis, 16-18.

[16] William H. Birkmire, *The Planning and Construction of High Office-Buildings* (New York: John Wiley & Sons, 1900) 68.

exterior walls and were limited to a maximum depth of 20-feet; the deepest that natural daylight could penetrate.[17] Common corridors, typically double-loaded, accessed the offices.

Chicago's downtown, similar to other large cities prior to the 1880s, was primarily comprised of buildings of six stories or less. These structures relied on traditional loadbearing structural systems, which employed heavy masonry walls to support floor loads. For additional stories, lower walls required additional wythes of brick to carry greater loads. The demand for centrally located office space placed a premium on downtown real estate, which, with the aid of elevators, made it expedient and profitable to build tall office buildings. However, loadbearing systems for tall buildings required thick walls, which significantly reduced leasable floor area.[18] Burnham and Root's Monadnock and Kearsarge Building (currently the north half of the Monadnock Building, 53 West Jackson Boulevard), completed in 1891, reached sixteen stories, which was considered a significant achievement in height at the time.[19] However, the building's outer walls taper inward with each additional story above its six-foot-thick base, which reduced the potential leasable floor area throughout the building.

Structural Frame Construction and the Rise of Tall Office Buildings: 1880s–1931

The development of framed structural systems during the last decades of the nineteenth century provided a new means to build even taller buildings that could better meet office demand. Instead of relying on thick exterior masonry walls, framed structural systems benefited from advancements in the production of cast iron and steel. These materials were made into columns and beams that, when joined together, formed a rigid frame or skeleton. The regular arrangement of vertical columns also created the open structural bays that defined common corridors and offices. An exterior curtain of non-structural masonry was hung from the frame to enclose the building. Unlike loadbearing masonry, exterior curtain walls were supported by framing at each level and were only as thick as required by local building code.

In Chicago, framed construction permitted the walls of a tall building, like the Monadnock, to be reduced in thickness from six feet to just two feet at the base.[20] This reclaimed significant square footage from building mass and made it available as leasable floor area. William Le Baron Jenney's 10-story Home Insurance Building of 1885 (not extant) is widely considered to be the first fully framed building.

Framed systems provided a departure from traditional linear—from foundation to roof—construction and created new opportunities for efficiency and—ultimately—savings in construction costs. Iron and steel shop-made components were quickly assembled on-site to create a frame on which all finishes and ornamented cladding were applied. This significantly reduced construction time and allowed laborers to complete exterior cladding and interior partitions at independent levels. On Jenney's Manhattan Building (1891, 431 South Dearborn Street, extant) the terra cotta cornice was installed above the sixteenth story before walls were erected below it.[21] Generally, it was estimated a typical ten-story loadbearing building took a full year to complete, whereas a 25-story frame building could be erected in the same period.[22]

During the 1890s, builders capitalized on the efficiencies of framed construction and erected dozens of "high office-buildings" in Chicago. Burnham and Root completed the twenty-one-story Masonic Temple Building in 1892 at 151 North State Street (not extant). The same firm in 1893 completed the framed Katahdin and Wachussetts Building, which forms the south half of the Monadnock Block (extant). Charles Atwood's 15-story Reliance Building at 1 West

[17] Gatter, *The Office: An Analysis of the Evolution of a Workplace*, 14.
[18] Birkmire, *The Planning and Construction of High Office-Buildings,* 8.
[19] Birkmire, *The Planning and Construction of High Office-Buildings*, 2. Today, the Monadnock Building's north half (the original Monadnock and Kearsarge portions) is regarded as the tallest loadbearing masonry building in the United States.
[20] J. Stanley Rabun, *Structural Analysis of Historic Buildings. Restoration, Preservation, and Adaptive Reuse Applications for Architects and Engineers* (New York: John Wiley & Sons, Inc., 2000) 29-30.
[21] Joseph Kendall Freitag, *Architectural Engineering. With Special Reference to High Building Construction, Including Many Examples of Chicago Office Buildings* (New York: John Wiley & Sons, 1895) 46-47.
[22] Birkmire, *The Planning and Construction of High Office-Buildings*, 39.

Washington Street opened in 1894. Its entire steel frame was erected in just three weeks.[23] Burnham and Company designed the eighteen-story south portion of the Fisher Building at 343 South Dearborn Street (extant). It was completed in 1896 in just ten months from the contract signing to the day the first tenant moved in.[24] The Fisher was erected in a non-linear method, similar to the Manhattan Building, with its terra cotta cladding begun at an upper level.

Tall office buildings and so-named "skyscrapers" became an important economic symbol of the American urban landscape. Large cities, such as Chicago and New York, experienced phenomenal development with the vertical growth of their central business districts during the 1880s and 1890s. Occasional financial "panics" set back some development, but the construction of tall buildings remained a component of urban growth into the twentieth century. Despite efficiencies in construction using frame systems, tall structures were still an exceedingly costly venture. Developers and investors expected a building to return a profit by attracting tenants. Decorative exteriors in any combination of revival styles presented a visual representation of the wealth and power of a building's owners. The first corporate towers, largely built by insurance companies, leveraged the public's fascination with engineering feats by displaying their expensive and often palatial tall office buildings in advertising. For speculative buildings, well-planned interior layouts combined with attractive exteriors were seen as key to attracting tenants.[25]

As buildings grew taller engineers and architects began encountering the effects of lateral wind forces and the movement and structural stresses they created. Engineers generally agreed that tall buildings could rely on their sheer weight to resist lateral forces. The heavier the building, "…the greater the static conditions which must be overcome to allow failure."[26] However, lighter weight steel frame buildings with masonry curtainwalls did not have enough mass to resist wind loads. Instead, some engineers during the 1890s concluded that wider buildings could rely on masonry partitions and cladding to brace their frame and resist wind loads without the addition of steel bracing. In 1895, engineer Joseph K. Freitag expressed that, "a building with a well-constructed iron frame should be safe if provided with brick partitions, and if the base is a large proportion of, or equal to the height."[27] This was echoed by engineer and steel frame system promoter William H. Birkmire, who wrote in 1900, "a building whose height does not exceed three times its base and which has a well-constructed frame scarcely needs a special system of wind-bracing to make it secure."[28]

While added width improved the feasibility of additional stories, tall and relatively slender buildings required additional bracing to resist lateral movement. Freitag cautioned that such tall buildings should achieve their rigidity from the strength of their frame only, without reliance on masonry partitions. He was one of only a few engineers at the turn of the twentieth century to advocate for greater analysis of wind loads and lateral stability in tall frame buildings. Freitag recommended the use of additional structural bracing, such as struts, turnbuckle rods, and sway rods to resist lateral forces. [29] Ernest Flagg's 41-story narrow Singer Building in New York (1908, not extant) and Cass Gilbert's 60-story Woolworth Building in New York (1913, extant) presented new structural challenges, which were addressed by advances in wind bracing through improved column-beam connections. Engineers continued to improve connections to resist shear and bending caused by lateral forces.[30]

Framed structural systems during the late nineteenth and early twentieth centuries helped develop tall buildings that could economically satisfy increasing demand for office space. These systems, clad in masonry and internally partitioned into corridors and offices, remained the design of choice and showed little change from the earliest tall office buildings of the late nineteenth century. This trend continued unabated through a post-World War I business boom, which helped spur

[23] Birkmire, *The Planning and Construction of High Office-Buildings*, 51.
[24] Birkmire, *The Planning and Construction of High Office-Buildings*, 49.
[25] Birkmire, *The Planning and Construction of High Office-Buildings*, 19.
[26] Joseph Kendall Freitag, *Architectural Engineering. With Especial Reference to High Building Construction, Including Many Examples of Prominent Office Buildings* (New York: John Wiley & Sons, 1901) 254.
[27] Freitag, *Architectural Engineering. With Special Reference to High Building Construction, Including Many Examples of Chicago Office Buildings*, 137.
[28] William H. Birkmire, *The Planning and Construction of High Office-Buildings,* 205.
[29] Freitag, *Architectural Engineering. With Special Reference to High Building Construction, Including Many Examples of Chicago Office Buildings*, 137.
[30] A. C. Wilson, "Wind Bracing with Knee Braces or Gusset Plates," *The Engineering Record*, September 5, 1908, 272-274; S. F. Holtzman, "Design of the Woolworth Building. Features of Substructure and Calculations for Wind Bracing of Tower," *Engineering Record*, July 5, 1913, 22-24.

extensive office development during the 1920s, until the Great Depression. New office buildings were constructed taller and were designed to fit as much office space onto a given parcel as was economically feasible. The design of offices was refined during the 1920s to maximize profits by improving the efficiency of office tasks through the scientific layout of equipment and employees. Improvements in efficiency contributed to the reduction in the total area of individual office layouts and allowed for greater efficiency in the design of new buildings.[31]

The tallest steel framed building was realized in 1931 with the completion of Shreve, Lamb & Harmon's 102-story Empire State Building in New York. Despite its height, the Empire State continued to reflect the established width-to-height ratio described by both Freitag and Birkmire decades earlier. Its height is approximately four times the width of its base, which occupies nearly two acres on a full city block. Two other tall office buildings completed in New York include William Van Allen's 77-story Chrysler Building of 1930 and Raymond Hood's 66-story RCA (Radio Corporation of America) Building (30 Rockefeller Plaza) of 1933. All three tall buildings are representative of the types of office buildings that continued to be built until the Great Depression, when the need for office space sharply declined.

New Technologies, Economies, and Modern Ideals: 1931—1960

Around the same time that the tall Empire State, Chrysler, and RCA buildings were reshaping New York City's skyline, a new tall office building was completed in Philadelphia in a refined architectural style that anticipated the future. Howe and Lescaze's PSFS (Philadelphia Savings Fund Society) Building opened in 1932 (extant) and presented the public with great bands of aluminum-frame windows set against an outlined steel frame. The PSFS Building was one of the last tall office buildings to be built before the lull of the Great Depression set in. *Fortune Magazine* at the time noted how the building surprised and startled Philadelphians with its relatively unadorned facades.[32] The frame building's austerity exemplified prevailing modern or "Contemporary" design ideals in Europe at the time. It also reflected economic efficiencies through the use of materials to maximize natural light and to provide desirable leasable space.[33] Although modern styles were popular in Europe, in the US architects continued to follow historicist revival styles. Additionally, the nascent products that would make glassy modern buildings possible, such as insulated glass, fluorescent lighting, and air conditioning systems were not yet efficient or commercially viable. Architects such as Walter Gropius, Le Corbusier, and Ludwig Mies van der Rohe approached architecture from a uniquely functional place that balanced architectural and construction-related aspects in an efficient and rational form. Structure and the divisions between interior space and exterior space were resolved by bold expanses of sheer, lightweight curtainwalls. The PSFS Building represents a key step in the United States toward the functional, climate-controlled glass office buildings that became popular after World War II. This new "pure" form of architectural expression, as conceived in the US, was carefully defined and explored by Henry-Russell Hitchcock and Philip Johnson in their 1932 book *The International Style*, a name that became associated with this modern form.[34]

Almost no new office buildings were erected during the Great Depression and World War II; however, a strong post-war economy contributed to a boom in office building development beginning in the late 1940s. Remarkably, the new buildings reflected more strongly the modern ideals of functional expressionism. While unpopular before the war, the refined futuristic styles of the Modern Movement gained popularity in

the post-war era due to new technologies. The minimal designs represented an optimistic vision for the future, which was embraced by both architects and the public following the Great Depression and WWII. Leading modernist architects, several of whom emigrated to the US and to Chicago, guided the development of modern styles. One significant contribution to the advancement of the so-called "ultra modern" style was a series of forward-looking articles published in the May 1943 issue of *Architectural Forum*. Several notable architects prepared designs and ideas that explored the possibilities in architecture in the postwar period. The series, titled "New Buildings for 194X," anticipated designs for a

[31] Gatter, *The Office: An Analysis of the Evolution of a Workplace*, 28-32.
[32] "Philadelphia's Fancy… Turns to Thoughts of Architecture. How the City's Oldest Bank Put on the City's Newest Front," *Fortune Magazine*, December 1932, 65.
[33] "Building Façade Emphasizes Steel Frame," *Engineering News-Record*, November 10, 1932, 549.
[34] Henry-Russell Hitchcock and Philip Johnson, *The International Style: Architecture Since 1922* (New York: W. W. Norton, 1932).

variety of building types that could be built in the post-war era using new technologies and materials.[35] The article series marked an important shift in the architectural expectations of the public and illustrated the optimism of the postwar future.

The modern glass office building developed almost as predicted and continued to evolve with new technologies and engineering systems during the 1950s and 1960s. Technical innovations in materials and systems made before the war became commercially viable post-war because of wartime refinements and a strong economy. Specifically, air-conditioning, fluorescent lighting, and a variety of types of glazing, including double glazing and heat-absorbent glass, became available in reliable forms in the post-war era.[36] In addition, the advancement of commercially viable mining and refining methods for aluminum introduced a revolutionary material that was strong and could be precision machined for close-fitting cladding and efficient window frame systems.[37] These seemingly simple technologies revolutionized the office environment and the design of office buildings by nearly eliminating a long-established reliance on windows for light and air.

Fluorescent lighting and air conditioning enabled workspaces to extend deeper into a building than the typical 20-foot depth established during the nineteenth century. Windows no longer existed out of necessity but were freed to become part of a building's outward architectural expression. The use of glass in place of heavier cladding allowed for the external emphasis of structural systems, which had become a characteristic of the growing modern movement and especially of the "ultra modern" and International styles. Early examples of buildings with extensive glazing were often criticized for their inefficiency and poor climate regulation. Expensive, hand-made plate glass provided no insulation, created glare, and contributed to heat gain. New types of glazing, including Solex and Thermopane brands, emerged as cost-effective glazing types that reflected heat and/or provided a degree of thermal insulation. Their development, combined with new machined and extruded aluminum components, enabled the practical application of exterior glazing systems.[38] New office buildings gradually reduced the standard high ratio of perimeter windows to floor area and created deeper, open office floor plates.

The traditional cellular layout of the typical partitioned office gradually began to shift towards more open floor plans. So-called "bullpens," or open desk areas for clerical workers, had existed in conjunction with partitioned management offices as early as the 1900s. These spaces were designed around efficiency and mirrored the "scientific" management strategies that had been applied to factory work.[39] The modern open office, with grids of workstations, emerged in the post-war era as the country's economy surged and consumer culture expanded. Concurrently, the US labor force shifted from predominantly manufacturing to service jobs, with the number of white-collar workers increasing at nearly twice the rate of the total workforce between 1946 and 1960.[40] In 1952, according to the Bureau of Labor Statistics, the service-producing sector comprised 53.3 percent of all employment, up from 48.6 percent in 1940. By 1962, nearly 60 percent of workers were employed in the service sector.[41] The strong post-war economy, lifting with it a rapidly expanding population of new office workers, created new demand for office space. However, unlike the partitioned spaces assigned to clerical and managerial workers, the modern office required an even distribution of workspaces for a large, mid-level workforce. The most efficient layout was a variation of the former "bullpen" where large clusters of workstations could be arranged. The open office layout that developed to accommodate the burgeoning white-collar class of workers was facilitated by deep floor plates, which were made feasible by artificial lighting and climate systems.

The metal and glass clad tall buildings of the post-WWII era realized the aspirations of early modernists. One of the first tall office buildings to be erected in the "ultra modern" style of the postwar era was architect Petro Belluschi's 14-story design for the Equitable Savings and Loan Association in Portland, Oregon. Belluschi had prepared a design for a modern office building as part of the *Architectural Forum's* 1942 series on postwar architecture. His entry anticipated all the

[35] "New Buildings for 194X," *The Architectural Forum*, May 1943, 69-152, 189.
[36] Thomas Leslie et all, "Deep Space, Thin Walls: Environmental and Material Precursors to the Postwar Skyscraper," *Journal of the Society of Architectural Historians*, March 2018, 79.
[37] Leslie et all, "Deep Space, Thin Walls: Environmental and Material Precursors to the Postwar Skyscraper," 88.
[38] Leslie et all, "Deep Space, Thin Walls: Environmental and Material Precursors to the Postwar Skyscraper," 84-88.
[39] Gatter, *The Office: An Analysis of the Evolution of a Workplace*. 19.
[40] Gatter, *The Office: An Analysis of the Evolution of a Workplace*. 79.
[41] Michael Urquhart, "The Employment Shift to Services: Where Did it Come From?" *Monthly Labor Review*, April 1984, 16.

aspects of a typical modern office building. He proposed a fireproof structure of reinforced concrete with lightweight cladding of aluminum and glass and demountable interior partitions for flexibility. Luminous ceilings consisting of fluorescent lights set in a repeating grid of removable acoustic panels reflected his design's inherent modular character.[42] The design Belluschi envisioned was widely celebrated for its efficient design, which could be mass-produced, as well as for its potential low cost of construction.[43] The design became the basis for his 1948 Equitable Building (renamed the Commonwealth Building) and continued to influence postwar office development in cities across the country.

Numerous examples of framed office buildings were completed shortly after the Equitable Building. The 39-story United Nations Secretariat Building in New York was completed in 1951 and designed by a board of architects representing ten nations, led by the firm Harrison & Abramovitz. Harrison & Abramovitz also designed the 31-story Alcoa Building in Pittsburg, Pennsylvania, completed in 1953. Skidmore, Owing and Merrill's 24-story Lever House was completed in New York in 1952. In Chicago, the city's dearth of new office buildings was finally addressed by Naess & Murphy's 41-story Prudential Building (130 East Randolph Street, extant) in 1955. In 1957, Skidmore, Owing and Merrill's completed Inland Steel Building (30 West Monroe Street, extant) became the first new office building completed in Chicago's Loop and clearly expressed postwar ideals of both architecture and the workplace. Its floor-to-ceiling windows, made possible by changes in fire codes, achieved a transparency long-pursued by earlier modernist architects.[44] Also, the building's floor plates, opened free of obstructions by 56-foot-wide beams, created a uniform environment that was conducive to an increasingly "white collar" workforce. As new office buildings were completed through the 1950s, the modern office environment, made possible by perfected technologies and shifts in the economy, became a standard for business.

Postwar Structural Challenges and Innovations: 1948—1960

The modern office building, characterized by glass cladding and deep, artificially illuminated, and air-conditioned spaces, presented a new engineering problem. In Chicago, the most efficient use of a downtown parcel required building upwards. The limited availability of downtown land restricted a building's potential footprint, which directly influenced the area of leasable office space. Maximizing leasable space and thereby minimizing floor area allocated to mechanical or structural systems was imperative in developing a profitable office building. As with pre-WWII tall buildings, the point of feasibility, as determined by the leasable area, remained contingent on the number of floors that could be built. Framed structural systems proved the ability to reach great heights and to resist lateral wind forces. However, SOM engineer Fazlur Khan noted that the lateral rigidity of tall, framed buildings, "…was considerably augmented by the use of the traditional block partition walls as well as masonry or stone exterior facings." The replacement of these rigid materials with lightweight glass and metal cladding, as well as the shift to more open office spaces with lightweight demountable interior partitions, placed a greater reliance on the lateral stiffness of a building's frame. Khan concluded that to establish lateral rigidity in such lightweight framed buildings, exponentially more structural material was needed with each additional floor. Additional material corresponded to significant additional cost, which Khan referred to as a "premium for height."[45]

The emergence of the "modern" office building during the post-WWII period advanced with new engineering solutions to the problem of lateral rigidity. Steel framed buildings continued to evolve with ever stronger column-beam connections. However, builders needed to find a financial balance between providing enough leasable floor area to make a project feasible and the premium cost of additional floors that could render a project infeasible. Reinforced concrete became a cost-effective alternative structural material to steel during the early twentieth century. Early on, it was recognized for its ability to serve both as structure and cladding. However, concrete did not become a popular construction material for tall office buildings until the post-WWII period.

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[42] Pietro Belluschi, "Office Building," in "New Buildings for 194X," *The Architectural Forum*, May 1943, 108-112.
[43] Meredith L. Clausen, "Belluschi and the Equitable Building in History," *Journal of the Society of Architectural Historians*, June 1991, 115.
[44] Thomas Leslie, et all, "Reconstruction as Research: Digital Modeling of Key Postwar Skyscrapers," *Council on Tall Buildings and Urban Environment (CTBUH) Journal*, 2018, 24.
[45] Khan, "Report on Column-Free Multi-story Buildings With and Without Rigid Cores," 262.

An early experiment in the US with reinforcing concrete for a tall office building was completed in 1903. Architects Elzner and Anderson designed the extant fifteen-story, terra cotta-clad Engalls Building in Cincinnati, Ohio as a monolithic reinforced concrete frame with solid three- to five-inch-thick floor slabs and integrated columns and beams. It proved the possibilities of casting tall buildings from concrete and revealed potential cost savings over steel, which, in addition to material cost, required expensive handling and hoisting machinery.[46] Architect Alfred Elzner anticipated that refinements in formwork and concrete design would make concrete highly competitive with steel for tall building construction. Furthermore, he believed concrete was the fireproof solution to the architectural problem of honesty in architecture. It could be cast as an exposed frame and could therefore rationally express a building's structure without obscuring it beneath an "architectural dress."[47] The potential for honesty in architecture, as well as cost savings over steel, raised the appeal of reinforced concrete as a structural material.

Wind resistance and lateral rigidity remained a concern for reinforced concrete buildings. Similar to steel frame, connection points between columns and beams or floor plates required additional structure to increase rigidity. This was often achieved through the use of wide plates or capitals on columns and through careful arrangement of reinforcing bars at joints. Taller buildings require additional lateral stability, which was achieved in two ways. One method involved building structural walls to form a rigid core around a building's stairs and/or elevators. The concept of a structural "core" became a key component of steel frame buildings, as well as concrete buildings. Khan described the core as a type of cantilever out of the ground, where lateral wind forces push against the core in a manner similar to gravity acting on a horizontal cantilever. A core was designed to resist the entire lateral load that a building might experience.[48]

Wind load-resisting cores and "shear walls" were employed in similar ways in early postwar office buildings. Shear walls could either be scattered in through a building or concentrated to form a central core around elevators and stairwells. The reinforced concrete slab and column structure of the Equitable Building (1948) in Portland, Oregon was supported by a reinforced concrete stair and elevator core set on its rear elevation. This approach was repeated with Chicago's Prudential Building (1955) and Inland Steel building (1957), which relied on rear reinforced concrete cores to support their steel framed systems.[49] Individual shear walls became common, especially in residential architecture as solid, windowless, end walls or solid walls between units. In office buildings, this approach was used for the United Nations Secretariat Building in New York (1951), which is bookended by shear walls without fenestration.

Reinforced concrete cores and shear walls were important in the development of modern office buildings after World War II; however, as with any technology, they had limitations, which the framed structural system had met. In the pursuit of height, as required by the demand for new and open office space, Khan calculated that shear walls and cores lost efficiency above a certain height; wind loads became too strong for the structural system. Khan carefully assessed various structural systems and calculated the maximum heights that could be optimally achieved without requiring additional costly structure or "premium for height." For office buildings, which require greater ceilings heights than residential buildings to accommodate utility and office systems, he calculated the maximum height was roughly 20-stories.[50] Above this point, additional stories cost a premium, which resulted from the exponential expense of additional material required for larger columns, walls, and slabs.[51] Khan projected that, "the premium in structural material for increase in height of

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[46] Elzner, "The First Concrete Skyscraper," *The Architectural Record*, June 1904, 541; Carl W. Condit, "The First Reinforced-Concrete Skyscraper: The Ingalls Building in Cincinnati and Its Place in Structural History," *Technology and Culture*, January 1968, 19-22.

[47] Elzner, "The First Concrete Skyscraper," June 1904, 541, 544.
Also in 1903, French architect Auguste Perret completed his 10-story Rue Franklin apartment block (extant) in Paris. For this building he left exposed the ferroconcrete (reinforced) frame as an architectural element and an expression of the building's structure. Rue Franklin represents one of the earliest examples of a reinforced concrete frame tall building with exposed structure, a form that Elzner saw the future of concrete buildings. See: Sigfried Gideon, *Space, Time and Architecture. The Growth of a New Tradition*, fifth edition (Cambridge, MA: Harvard University Press, 1976) 328-332.

[48] Fazlur R. Khan, "Current Trends in Concrete High-Rise Buildings," presented at *Symposium on Tall Buildings, University of Southampton, England, April 1966*, 3-4, Ryerson and Burnham Library, Art Institute of Chicago; Yasmin Khan, *Engineering Architecture: The Vision of Fazlur R. Khan* (New York: Norton, 2004), 60.

[49] Leslie, et all, "Reconstruction as Research: Digital Modeling of Key Postwar Skyscrapers," *21-22,* 24.

[50] Khan noted that typical office floors are 12 feet in height including interstitial space for mechanical systems, whereas residential floors typically have little to no interstitial space and are on average 8- to 9-feet in height.

[51] Khan, "Current Trends in Concrete High-Rise Buildings," 5; Fazlur R. Khan, "The Nature of High Rise Buildings," *Inland Architect*, July 1967, 9.

building is indeed substantial enough to influence the entire economic feasibility of any building."[52] This meant that for a conventionally framed structure with a core or shear walls, the cost of resisting wind loads from additional stories could outweigh the potential profit from increased leasable area.

Khan anticipated that demand for office space would continue and that taller buildings would be required to supply the market. However, Khan estimated that existing steel frame systems and reinforced concrete slab and column systems were inadequate for the efficient or economical construction of taller buildings. This situation presented Khan with the opportunity to develop a new type of structural system, a system that could remain rigid against lateral wind loads at greater heights.[53]

Building Even Taller: Fazlur Khan and the Development of "Tube" Structural Systems

Fazlur Khan wrote in 1967, "It is apparent that what makes a building high-rise is not the height itself as much as its distinct difference in structural, mechanical and planning requirements compared to other buildings."[54] While 500 N. Michigan is not especially tall at 25-stories, it accomplished an engineering feat that would have been economically infeasible without Khan's innovative "framed tube" structural system.

500 North Michigan Avenue was built at a critical point in the history and development of tall office buildings. As a speculative office building, its open interior spaces and glass expanses express the ideals and demands of an expanding postwar economy. Large and flexible office floor plates, designed for a growing class of "white collar" workers, exemplify the characteristics that the building's developers felt would attract tenants. As a speculative building, its developers needed an efficient structure that could maximize leasable office space on the site's relatively small parcel. Although initially conceived as a 20-story framed structure, additional floors were needed to financially satisfy the building's programing/occupancy requirements. However, the addition of more floors would have exceeded the structure's optimal efficiency and cost a "premium for height" (*see figure 23*). To provide additional floors of office space without incurring additional expense for more structural material to resist lateral loads, a new and more efficient and economically feasible structural system was needed. The solution was to develop a rigid exterior structural system using modern materials and methods. The development team commissioned Skidmore, Owings and Merrill to prepare a new design. The 24-story 500 N. Michigan building became the first office building in Chicago to employ a revolutionary new structural system: the "framed-tube."

In the early 1960s, several years before 500 N. Michigan became an SOM project, Fazlur R. Khan determined that framed buildings greater than 20 stories were structurally inefficient. He felt that… "the main objective of any search for a newer structural system for high-rise buildings should be aimed at creating 'optimum' structures that need be designed for gravity loads only while the stresses due to lateral loads will automatically remain within the normally allowable overstresses…"[55] Optimum buildings needed to function as a single, rigid structure with minimal bending due to wind or other lateral forces.

Khan theorized that a taller building would be more efficient if it was designed like a column or pole in the ground. Structural columns could be placed on the exterior perimeter and joined together by rigid spandrels to act like a single, rigid tube. In an effort to describe novel exterior structural systems some architectural journals and writers emphasized the system's exterior nature by calling it an "exoskeleton." This was perhaps in contrast to the familiar steel "skeleton" structural system. Others called it a "shear-shell," which focused on the system's function similar to a common shear wall.[56] Khan compared the tube-like structural system with the familiar traditional masonry bearing wall system, which supports gravity loads but lacks the lateral stability achieved in the rigid tube system. He explained in a 1967 issue of *Inland Architect* that, "this arrangement would simulate solid exterior bearing walls perforated with windows. The

[52] Khan, "Report on Column-Free Multi-story Buildings With and Without Rigid Cores," 262.
[53] Khan, "Current Trends in Concrete High-Rise Buildings," 3.
[54] Fazlur Khan, "The Nature of High Rise Buildings," *Inland Architect*, July 1967, 6.
[55] Khan, "Current Trends in Concrete High-Rise Buildings," 3.
[56] "Sheer Tower in Chicago: a design develops from engineering studies by computer," *Architectural Record*, January 1966, 160.

resulting total system… behaves somewhat like an upright cantilever."[57] Similar to a load-bearing building, the exterior walls of a tube structure carry gravity loads. However, brick loadbearing buildings are not very rigid and require substantial heavy material to resist lateral loads. This becomes impractical above a certain height. The *Architectural Forum* echoed this consideration and endeavored to describe the novel exterior structural system while eliminating misconceptions. In 1967, it wrote:

> Although the structure of these buildings is referred to as "bearing wall" (and therefore would indicate a return to times past) the limitations of the old bearing wall are now gone and the new buildings can rise to almost any height. The change from a punctured bearing wall to a wall of light columns brings with it new esthetic and planning considerations as well as the more obvious structural ones.[58]

The tube structural system achieves greater lateral stability because of deep spandrel beams that link columns to form exterior frames that are almost monolithic. Four such frames together form a rigid box and brace each other to resist lateral forces. The tube system was adaptable to different scales depending on the arrangement and construction of tube forms, ranging from the "framed tube," for buildings up to 40-stories, up to the "truss tube," which Khan theorized could achieve heights of up to 140-stories (*see figure 22*).

Khan evaluated the possibilities of a tube-like structural system and concluded that each pair of rigid exterior frames placed parallel to the wind direction provided almost as much lateral resistance as shear walls.[59] Khan was keenly interested in the *interaction* between these frames and interior shear walls, and after further analysis published his findings in the journal of the *American Society of Civil Engineers*.[60] Khan developed a tube-like exterior structural frame system with an interior rigid core composed of shear walls for the Brunswick Building completed in 1965. He referred to it as the "shear wall-frame interaction" system. It is considered an immediate precursor to the "framed-tube," a system with a rigid exterior tube and interior columns for gravity loads.[61] Khan's framed-tube was first applied to the residential DeWitt Chestnut apartment building of 1964 and was adapted for office layouts for 500 N. Michigan completed in 1967.

The Tube Structural System and its Influences

Adapting modern steel and reinforced concrete materials to form rigid exterior walls was a novel approach that was explored by architects during the postwar period. In 1953, architect Myron Goldsmith (1918-1996), who later joined Skidmore, Owings and Merrill and collaborated with Khan, completed his master's thesis with his advisor Ludwig Mies van der Rohe entitled *The Tall Building: The Effects of Scale*. In it, he explored the limitations of structural systems and suggested that individual systems had an optimal range of scale for efficient and optimal use.[62] This was a key argument that Khan later developed in his concept of an optimal tall building with no structural premium for height. Myron's work also considered structural systems composed of modern materials that functioned as rigid exterior walls. This included a design for an 80-story building of reinforced concrete.[63]

Innovations in rigid exterior wall structural systems revealed significant economies over typical framed systems and reinforced concrete slab and column structures. In 1958, the firm of I. M. Pei and Associates with engineer August Komendant developed a reinforced concrete wall system for the Kips Bay Plaza apartment development in New York

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[57] Fazlur R. Khan, "The Nature of High Rise Buildings," July 1967, 9.
[58] "A Tale of Two Towers," *Architectural Forum*, April 1966, 28.
[59] Yasmin Khan, *Engineering Architecture*, 65.
[60] Yasmin Khan, *Engineering Architecture*, 69. See also: Fazlur R. Khan and John A. Sbarounis, "Interaction of Shear Walls and Frames," *Journal of the Structural Division, ASCE* 90, no. 3 (1964): 285-338.
[61] Yasmin Khan, *Engineering Architecture*, 69. While the Brunswick Building has all of the characteristics of a tube-in-tube concrete structure, Khan did not initially conceive of the building that way. As Yasmin Khan notes, the four frames were not *required* to be placed at the perimeter walls to create a tube form, and furthermore, Khan at first thought that tubular structures would require a tighter column spacing. See also, "Construction's Man of the Year," *Engineering News-Record*, February 10, 1972, 25.
[62] Myron Goldsmith, *The Tall Building: The Effects of Scale*, Unpublished Master's Architecture thesis, Illinois Institute of Technology, 1953.
[63] Yasmin Khan, *Engineering Architecture*, 100; Alfred Swenson and Pao-Chi Chang, *Architectural Education at IIT 1938-1978* (Chicago: Illinois Institute of Technology, 1980) 170-173.

City (1960, extant).[64] The team rejected established brick-clad concrete slab and column systems that had come to define urban renewal projects in favor of a more efficient and architecturally attractive system involving cast reinforced concrete exterior walls. In 1960, architect Edward L. Freidman, of I. M. Pei and Associates, explained in the journal *Progressive Architecture* that:

> Because the apartment distribution did not allow a regular design rhythm in the façade, it was decided to split the normal exterior column into equally spaces, loadbearing segments. This was economically justified by the production of a repetitive forming system, and the creation of a structural frame at the façade, which could receive and transmit most of the wind load to the ground.[65]

The 21-story Kips Bay Plaza's innovative exterior frame proved the potential for exterior rigid wall systems for tall buildings (*see figures 11 and 12*). The design allowed for a uniform window spacing of 5'-10" on center and facilitated the Federal Housing Authority's desired unit count and room arrangement. The framing method also showed the potential for savings in both time and construction costs. The use of monolithic reinforced concrete eliminated the material and labor costs of exterior brick facing, and reduced construction time by several weeks.[66] The efficiencies of the system prompted Pei to employ a similar structural system for the firm's twin nine-story University Apartments in Chicago, which were completed between 1959 and 1961 at 1400 to 1451 East 55th Street (extant), and later for the trio of 31-story residential Society Hill Towers in Philadelphia (completed in 1964, extant).[67] The success of Pei's reinforced and precast concrete walls in residential projects influenced SOM and likely contributed to Khan and Goldsmith's studies of structural systems for tall buildings.

The Brunswick Building: 1961-1965

The Brunswick Building, at 69 West Washington Street, led SOM to advance and improve the structural design of rigid exterior walls. It contributed to the firm's development of tube structural systems, which both satisfied the requirements of the modern postwar office and achieved sufficient height to meet programing requirements. The Brunswick represents the first step towards SOM's development of the framed-tube structural system, which the firm first applied to office building design in the development of 500 N. Michigan.

The Brunswick Building was constructed between 1961 and 1965 for developer and owner Arthur Rubloff and leased to the Brunswick Corporation.[68] Planning for the project began during the late 1950s as part of a larger plan to reinvigorate Chicago's Loop businesses district and its east-west Washington Street corridor. Development stalled as the owner solicited anchor tenants but began in earnest once the Brunswick Corporation became an anchor tenant. Early design iterations called for a steel framed building clad in Cor-ten, but this was revised once SOM began collaborating on the design for the neighboring Civic Center (Richard J. Daley Center, 1965, extant), which called for Cor-ten cladding. Instead, according to architect Bruce Graham, SOM partner Bill Hartmann suggested considering a tube-like structural system after Pei's Kips Bay project.[69]

With input from the architectural team, led by Bruce Graham and Myron Goldsmith, Khan devised a concrete structural system with closely spaced columns on each façade that were joined by rigid and deep spandrel beams (*see figure 21*). The beam and column configuration transformed the outer walls into stiff structural frames that, when joined together by rigid concrete floor plates to a central shear wall core, provided optimal lateral resistance. Khan was not yet satisfied that an exterior frame alone could resist lateral movement. Through analysis, he determined that deflection in a structural frame could be countered through interaction of the frame walls with an interior core shear wall.[70] The resulting system

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[64] Ieoh Ming Pei founded his architectural firm I. M. Pei and Associates in 1958.
[65] Edward L. Friedman, "Cast-in-Place Technique Restudied," *Progressive Architecture*, October 1960, 160.
[66] Friedman, "Cast-in-Place Technique Restudied," October 1960, 165.
[67] Friedman, "Cast-in-Place Technique Restudied," October 1960, 163, 170-172.
[68] *Oral History of Bruce John Graham*, interviewed by Betty J. Blum, 1998, Chicago Architects Oral History Project, The Art Institute of Chicago, 90.
[69] *Oral History of Bruce John Graham*, interviewed by Betty J. Blum, 1998, 89.
[70] Lynn S. Beedle and Hal Lyengar, "IABSE Structures C-23/82. Selected Works of Fazlur R. Khan (1929-1982)," *IABSE [International Association for*

was the first combination of two previously separate structural systems, which Khan labeled the "frame-shear wall interaction." SOM engineer Joseph P. Colaco, who worked alongside Khan on the project, reflected on the Brunswick Building in a 2006 interview:

> It was an all-concrete building. And what that developed was a style that combined structure and architecture into one expression. When you can develop a combined architectural/structural system, not only is it aesthetically pleasing and makes sense, but you get the benefit of having the architectural elements, like the skin of the building, provided in the structural frame. You develop a lot of economies.[71]

Similar to Kips Bay, the Brunswick Building's innovative reinforced concrete frame saved material and labor costs in cladding by serving as both an exterior wall and building structure. The close spacing of window openings, by way of relatively narrow 1'-9" wide columns, maximized fenestration on all sides of the building. Glass panes were set directly, without use of a secondary frame, into the building's 9'-4" column spacing. *Architectural Forum* remarked that the building's ample windows and 37-foot-deep, core to exterior floor spans created a sense of spaciousness and openness.[72] The 9' wide windows were almost too wide for the efficient modular division into private offices, but were ideal for the increasingly popular open office plan.[73] Architecturally, as *Architectural Forum* described, "Brunswick… is everything a purist might want; its light, concrete columns are clearly expressed, and plainly exposed."[74]

In contrast, another approach to rigid exterior walls wall was designed by Eero Saarinen for the Columbia Broadcasting System (CBS) Building in New York, which was also completed in 1965. Saarinen conceived of a tall tube-like structure but employed five-foot-wide exterior columns that reduced windows and emphasized verticality (*see figure 21)*.[75] The vertical prominence of the CBS Building is also unchallenged by any ground level arcades or reduction in columns. Below ground, a transfer beam was employed to transfer loads around subway lines. This same concept was applied to the Brunswick above ground, which created the building's distinctive 24-foot-tall and 8-foot-deep transfer beam. The beams consolidated vertical loads to a small number of points, which resulted in fewer expensive-to-drill foundation caissons.[76] The decision to carry the beam above ground was done to relate the Brunswick to the new Civic Center opposite it.[77] The open floorplates and ample glass that Khan and SOM specified for the Brunswick Building gave Rubloff the type of desirable and distinguished office space he believed was most in demand. On completion, the building was over 80 percent leased.[78]

The Brunswick Building succeeded in combining three important characteristics that were highly valued in office buildings during the postwar period. It achieved a balance of lightness and openness by providing both extensive fenestration on all sides and unobstructed floorplates within. While this engineering feat had been achieved in shorter buildings, the premium for height using a conventional framed system made taller structures unfeasible. Use of the tube-like "frame-shear wall interaction" system facilitated the construction of an economically viable rigid and tall building with leasable floors that met market demand. While the engineering achievement of the Brunswick Building is significant, the building relied structurally on an inner core for rigidity. Khan later referred to the resulting system as a "tube-in-tube."[79] While the tube-like set of rigid exterior walls contain the building, the inner shear wall core is bulky and occupies about one-sixth of each floor. The Brunswick Building has a relatively large footprint, but for projects with smaller parcels, a different structural system was needed to achieve the same structural integrity in lightness, openness, and height

Bridge and Structural Engineering] Periodica, November 1982, 64-65, www.e-periodica.ch.
[71] William F. Stern and Christof Spieler, "35 Years of One Shell Plaza," *Cite Magazine*, Summer 2006, 25.
[72] "A Tale of Two Towers, "April 1966, 32-33; Beedle and Hal Lyengar, "IABSE Structures C-23/82. Selected Works of Fazlur R. Khan (1929-1982)," 64.
[73] Gatter, *The Office: An Analysis of the Evolution of a Workplace*, 78.
[74] "A Tale of Two Towers," April 1966, 36-37.
[75] "A Tale of Two Towers," April 1966, 32.
[76] Khan, "Current Trends in Concrete High-Rise Buildings," 8-9.
[77] Beedle and Hal Lyengar, "IABSE Structures C-23/82. Selected Works of Fazlur R. Khan (1929-1982)," 64; "A Tale of Two Towers," April 1966, 29.
[78] "Beauty, Success Blended in Tower," *Chicago Tribune*, December 5, 1965, 73.
[79] Khan, "Current Trends in Concrete High-Rise Buildings," 7. As aforementioned, Khan did not initially plan the Brunswick as a "tube in tube" type structural system.

but without reliance on a substantial core. Khan and SOM realized this goal in a concurrent residential apartment tower, the Dewitt Chestnut.

The DeWitt Chestnut: 1961-1964

Khan, Graham, and the SOM team improved on the Brunswick Building's structural system and engineered a new system for a residential building: the DeWitt Chestnut, at 260 East Chestnut Street in the Streeterville neighborhood of Chicago (*see figure 20*). The 45-story apartment tower was begun in 1961 and opened in 1965.[80] Due to site constraints and programmatic requirements, a tower of more than 40-stories was needed that could resist lateral loads. Unlike the Brunswick Building, the smaller footprint and residential limitations ultimately led the team to design a structural system that focused all lateral rigidity in the exterior walls without the support of a central core and shear wall. The resulting "framed-tube" structural system combined a rigid exterior "tube" with internal columns to carry gravity loads. This refined system enabled the construction of 500 N. Michigan, which presented many of Brunswick's desirable features but on a compact footprint.

SOM received the commission for the DeWitt Chestnut Apartments in 1961 from developer Metropolitan Structures. Metropolitan requested a pair of residential towers to complement their adjacent previously completed 860-880 North Lake Shore Drive apartments, designed by Ludwig Mies van der Rohe. In the interest of not crowding or obstructing views of 860-880, Graham and the SOM team proposed combining Metropolitan's apartment program into a single tower with ample surrounding space.[81] The building needed to be over 40 stories to hold all the units needed. Conventional reinforced concrete was not well suited to the residential program, because required shear walls would have either occupied too much central floor area or, as an exterior wall, would have eliminated windows and views. Conventional steel framing was considered but was not an optimal solution for such a tall building because of the premium for height.[82]

In order to make the DeWitt Chestnut project economically viable, Khan sought a new approach. If the team was to eliminate a structural service core in favor of additional floor area, the exterior walls would need to carry all lateral loads and function as a true cantilever. A closed box-like structure was determined the best form for the building, because pairs of perpendicular walls brace each other at their corners and provide greater resistance to bending and torsion than would an open box-like shape composed of framed members. Early calculations were limited to individual joints and could not easily determine the effect of loads on an entire structure and its assembly of jointed components. Instead, each of the four exterior walls were designed as individual structural elements that could more easily be calculated. Initial calculations proposed small window openings to preserve the structural integrity of the solid wall, but later calculations, aided by advancing computer programs, indicated that larger windows could be achieved without a significant reduction in rigidity.[83] The walls were designed with perimeter columns that were tightly spaced at 5'-6" on center and firmly secured together with 2-foot-deep spandrel beams. Increasing the depth of horizontal spandrel beams between columns created larger and stronger joints than were designed for the Brunswick Building, which relies on core shear walls for support. Together, the columns and beams functioned as individually framed shear walls and, when connected with other walls, formed a box-like tube with punched openings for windows.[84]

Analysis indicated that the design for the DeWitt Chestnut building had no discernable "premium for height," which was one of Khan's objectives for the project. In terms of cost, it was equivalent to the cost of a 28-story conventionally framed tower.[85] The design, despite being revolutionary and untested, also met the requirements for the building's $7,983,900 loan from the Federal Housing Administration.[86] The FHA had requested only one change to the project, which

[80] Some publications indicate that the building was completed in 1965, however Yasmin Kahn dates the completion to 1964; Yasmin Khan, *Engineering Architecture,* 69.
[81] *Oral History of Bruce John Graham*, interviewed by Betty J. Blum, 1998, 146.
[82] Yasmin Khan, *Engineering Architecture,* 88.
[83] "Sheer Tower in Chicago," January 1966, 161; Yasmin Khan, *Engineering Architecture,* 90-92.
[84] Khan, "Current Trends in Concrete High-Rise Buildings," 12.
[85] Yasmin Khan, *Engineering Architecture.*
[86] "43 Stories," *Chicago Tribune*, August 15, 1963, 101.

incidentally reduced construction costs. It required that the proposed building have a cladding material in place of exposed concrete, which despite increasing popularity had received criticism for its failings under structural movement and cracking. The SOM team opted for a durable cladding of Travertine with an insulative foam backing. The material was similar in tone and consistency to concrete, and the added insulation reduced the need for specially designed joints for accommodating temperature-induced movement.[87] The team had similarly planned to clad the Brunswick Building in travertine, but financing did not allow this, and instead complex hinged joints were installed to connect floor plates with exterior shear walls.[88]

The framed tube emerged as a powerful structural system because of both its efficiency, and its flexible open floor plan (interior columns, needed only to carry their share of gravity loads, were typically clustered around the core).[89] The popularity of the framed tube spread, and soon, "its configuration of closely spaced columns and deep spandrel beams became a familiar basis for high-rise planning."[90] The DeWitt Chestnut apartment building is widely recognized as the first building to employ a "framed tube" structural system. The project's success proved the system's ability to realize a tall building at the cost of a shorter structure. Not only was the "frame tube" efficient in resisting lateral loads with minimal structural materials, but it also facilitated the construction of a core-less building. Without a core occupying floor area, more space could be devoted to the footprints of rental apartments. Thus, DeWitt Chestnut maximized floor area while minimizing construction costs.

500 North Michigan: The First Framed Tube Office Building

Growing demand for leasable office space in the 1960s prompted the speculative development of 500 N. Michigan, a 24-story office building in Chicago's Near North Community Area. Similar to the DeWitt Chestnut project, the team was limited to a relatively small project site on which the client required a certain amount of office space. As the building was being planned, between 1964 and 1965, its proposed height increased from 20 to 25 stories to capture an even larger share of a burgeoning office market. While 25-stories was not especially tall, the site's depth limited the amount of floor area that could be occupied by a service core and structural systems.

An efficient structural system, such as the demonstrated "framed tube," was needed to meet programmatic demands and site limitations. The final design for 500 N. Michigan built off the system used to build the DeWitt Chestnut but incorporated additional methods to increase structural efficiency and reduce construction costs. Although office buildings require more elevators and service chases than residential buildings, the central elevators and stairs at 500 N. Michigan were installed without encircling them in heavy shear walls, as was done at the Brunswick Building. Instead, the building's lateral load resisting structure is focused on the exterior framed box-like tube, which is similar in concept to the system used at the DeWitt Chestnut (*see figures 17, 18, and 20*). The elimination of interior shear walls helped conserve floor area. Earlier buildings, such as the Prudential and Inland Steel buildings, reduced the presence of core structure and systems by locating them on the side of the building. While this was a practical solution, 500 N. Michigan limited site area prohibited this approach.

Due to the importance of larger windows in office design, 500 N. Michigan was designed with greater spacing between columns than the residential DeWitt Chestnut. Smaller windows were ideal for the intimacy of a residential apartment program at the DeWitt Chestnut, but the postwar shift in office design had effectively standardized greater ratios of windows to exterior wall surface. While the DeWitt Chestnut accomplished a rigid frame using columns spaced every 5'-6", the spacing for 500 N. Michigan was nearly twice as wide at 9'-2 ½" on center along the east and west elevations and 9'-4 ½" on center along the north and south elevations. Greater width was made possible through the use of taller spandrel beams between columns, which benefited from the building's use for office. Unlike residential buildings, which have floor heights of 8' between slabs, office buildings include obscured interstitial space for mechanical systems. At 500 N.

[87] Yasmin Khan, *Engineering Architecture,* 95-96.
[88] *Oral History of Bruce John Graham*, interviewed by Betty J. Blum, 1998, 93.
[89] Mir M. Ali and Paul J. Armstrong, *Architecture of Tall Buildings* (New York: McGraw-Hill, 1995), 103.
[90] Yasmin Khan, *Engineering Architecture,* 103.

Michigan, the true ceiling heights, including interstitial space are 11', which allowed for otherwise obtrusive spandrel beams to protrude into the building while remaining hidden above drop ceilings.

The "framed tube" system was successfully adapted for the requirements of an office building at 500. N Michigan. The system provided a rigid structure and eliminated space typically lost to interior shear walls. The team also reduced the area occupied by other typical structures and building systems. Building systems, which typically occupy central pipe chases and other large voids, were redistributed to novel smaller chases on the inner-facing side of the exterior columns. A similar approach was used at the Brunswick Building, but this was adopted on a larger scale for 500 N. Michigan.

Interior columns also occupy a significant floor area in most buildings. While the "framed tube" system reduces the number of interior columns, some are still needed to support gravity loads of floors. Floorplates at the DeWitt Chestnut were divided into apartments and interior columns were cleverly distributed to support gravity loads. While these critical interior columns were easily hidden within the partitioned apartment layouts, this approach was not feasible for an open office floor plan. At 500 N. Michigan, interior columns are aligned to create roughly 18-foot-wide structural bays. This was a long-established standard width for office buildings. While office design during the late 1950s and early 1960s focused on the creation of unobstructed office space, by the mid-1960s there was a growing recognition that fewer and smaller columns were better than many.[91] For 500 N. Michigan, the approach was to create smaller and therefore less obtrusive columns. Because the columns exclusively support gravity load of the floors above, their strength and size are relative to the weight they must carry. The SOM team and Khan chose to reduce the weight of the building's 6 ½-inch-thick concrete floor slabs by casting them from lightweight concrete. Around the same time, Khan and the SOM team were beginning to design One Shell Plaza in Houston, Texas (completed 1971), which benefited significantly from its use of lightweight concrete.[92] Lighter-weight floor slabs resulted in a reduction of columns, which enabled the construction of a much taller building for the same cost.[93] While at One Shell Plaza lightweight concrete enabled the construction of a taller building, at the earlier 500 N. Michigan this meant that interior columns could be significantly reduced in size.

Architecturally, the framed elevations of 500 N. Michigan accurately express the building's structure and visually reveal the transfer of loads down the building to the ground. The design is similar to DeWitt Chestnut, except for its wider and taller windows, which help differentiate it as an office building. Again, insulated panels of travertine clad the building's columns and spandrel beams. The building is anchored by a relatively diminutive five-foot-tall transfer beam that encircles the top of the first floor. The concept was effectively used at the Brunswick Building where it was completed as a monumental 22-foot-tall beam. This reduction in beam size reflects the SOM team's refinement of the tube concept and the advancement of the "framed tube." For both DeWitt Chestnut and 500 N. Michigan, the transfer beam is less of a bold structural statement and more of a subdued expression of load transfer. Along the east elevation on Michigan Avenue, the building's eleven vertical columns are reduced to only six columns that reach the sidewalk. The other five columns all visually terminate at the transfer beam and allow for both large ground floor spaces and, more importantly, reduce the number of expensive foundation caissons.

500 N. Michigan is significant as an office building because it was able to efficiently deliver open office space on a small site, while also providing ample windows. The building's "framed tube" structural system helped maximize use of the small site by reducing the footprints of typical structural and systems features. This provided more ample and deeper office floor plates that exemplified the characteristics of in-demand office space. In addition, the building confirmed the possibilities of cost saving through the use of lightweight concrete, which the SOM team immediately employed in other tall office building projects, such as One Shell Plaza. The successful application of the "framed tube" to the requirements of an office building led both SOM and other architects to adopt the structural system. In a 1968 article, Khan observed, "a number of tall buildings using this concept are now in the planning stage, the most significant of which is the 110-story twin towers for the World Trade Center in New York."[94] In Chicago, a project influenced by Khan's tube structural systems is the 83-story Standard Oil Building (now known as the Aon Center) at 200 East Randolph Street, which was designed by architect Edward Durrell Stone. Completed between 1970 and 1973, it features a steel "framed tube" type

[91] Gatter, *The Office: An Analysis of the Evolution of a Workplace*, 78.
[92] Beth Jacob, *One Shell Plaza*, listed October 18, 2018.
[93] Beedle and Hal Lyengar, "IABSE Structures C-23/82. Selected Works of Fazlur R. Khan (1929-1982)," 66.
[94] Khan, "Report on Column-Free Multi-story Buildings With and Without Rigid Cores," 5.

structural system. Architect and engineer Al Picardi, who left SOM in 1967 served as the structural engineer and associate architect for the Standard Oil building.[95] Khan and SOM continued to improve the concept of the structural tube and developed several variations of the system for different types of buildings. However, of all the systems, the "framed tube" became a standard structural system for office buildings by the 1970s.

Khan and SOM: Later Works and the Influence of the Framed Tube System

In 1964, SOM began planning for the John Hancock Center (now known by its address as 875 North Michigan Avenue). The "super tall" building anticipated approximately 1 million square feet of office space, 1 million square feet of residential apartments, and 800,000 square feet of parking on one site. Initial studies showed a preference for dividing the program into two buildings, but ultimately Graham, Khan, and the SOM design team determined that a single tower scheme, separated by function, might be more effective. Khan had been investigating a variation of the framed tube, using diagonal bracing, which he thought would be appropriate for the proposed tower. The concept derived from Khan's work with thesis students at the Illinois Institute of Technology (IIT), where he and SOM colleague Myron Goldsmith taught in the school of architecture. "By associating himself with IIT from 1962 onward, Khan had the distinct advantage of collaborating with architectural students and faculty there, and through his supervision of many student research projects he could conceive new structural systems or validate his intuitive concepts about a potential new system. He used many of these systems for actual building projects at SOM."[96]

Khan developed and presented what he termed a "trussed tube" concept for the John Hancock tower. Conceived in steel, the system involved widely-spaced exterior columns tied together with large diagonal members; together, these components created a stiff perimeter tube form. Exterior walls tapered slightly inward, resulting in smaller floor plates towards the top of the building. Analysis found the trussed tube to be an efficient and economical approach for the 100-story tower. Working drawings were developed with the aid of a new in-house computer system, capable of rapidly performing detailed calculations and analyses of the building structure. The building, completed in 1969, was praised for its structural clarity and expression, following in the tradition of the First Chicago School when engineering had been a "stimulus to tall building design."[97] For Khan, the building represented a significant achievement in which he was able to realize the "still-nascent tubular concept in an altogether new way."[98]

Meanwhile, Khan also tested other ideas to further refine the framed tube. One line of inquiry that interested him involved the interaction between tubes and other means of resisting lateral loads (i.e., shear walls). He applied this thinking to the shear-wall frame interaction system he had previously developed for the Brunswick Building. "By joining the four exterior frames into a perimeter tube and the independent shear walls around the core into an interior tube, he could take advantage of tubular action to create a new, more efficient, structural type."[99] Khan soon developed and tested this "tube-in-tube" concept with the development of One Shell Plaza in Houston, Texas.

Developer Gerald Hines began working with Bruce Graham on an earlier iteration of the project, but a new anchor tenant secured in 1965 resulted in a new and expanded program. The Shell Oil Company planned to occupy a portion of the 1 million square foot building, and the remainder was to be leased as speculative office space. The developer's original intention was to construct a conventional building with reinforced concrete and shear walls. When Khan became involved with the project, he proposed the tube-in-tube system, suggesting that an even taller building could be constructed for a similar cost. Khan also suggested further reducing material costs by using lightweight concrete, which he had employed partly in the construction of 500 North Michigan. However, for One Shell Plaza, he intended to use it for the structural frame. This was considered by some to be risky given the difficulty in obtaining high quality lightweight aggregate concrete.[100] Exterior perimeter columns were placed 6-feet on center, and connected with deep spandrel beams. The

[95] Yasmin Khan, *Engineering Architecture,* 385 (endnote 28).
[96] Ali, *Art of the Skyscraper*, 53-54.
[97] David P. Billington, *The Tower and the Bridge: The New Art of Structural Engineering* (New York: Basic Books, 1985), 242.
[98] Yasmin Khan, *Engineering Architecture,* 105.
[99] Ibid., 142-143.
[100] Ibid., 146.

façade was particularly interesting from a visual standpoint. Because of the way the floors were designed (which combined joist- and waffle-slab framing), the beams connecting each corner of the core to the perimeter walls resulted in eight points where loads were increased. To account for this, columns were thickened in these areas, resulting in an undulating façade. As Khan described it "the visual effect obviously breaks the monotony of the disciplined grid and creates an unusual and yet honest structural façade."[101] The 50-story building was completed in 1971. Khan's experience with One Shell Plaza influenced his approach to One Shell Square in New Orleans, one of the first composite (i.e., steel and concrete) examples of a framed tube.

The Sears Tower (now Willis Tower, 233 South Wacker Drive) presented the opportunity for the next iteration of the tubular concept. Design commenced in 1969. Sears had acquired a 3-acre site west of Chicago's downtown western edge, and projected a need for approximately 4 million square feet of office space; roughly half was needed to house the company's headquarters, and the remainder would be leased. Working collaboratively with Bruce Graham, Khan designed a "bundled tube" structural system composed of nine interconnected steel tubes, each 75-feet square, arranged in a grid pattern. Two tubes stop at 50th floor, two at the 66th floor, and three more at the 90th floor, while the remaining two tubes continue to the top (110th) floor. The design allows each tube to retain its integrity and rigidity even as the floor area is reduced. The building, completed in 1974, was the tallest in the world until 1998, when its 1,450-foot height was exceeded by the Petronas Towers.

Khan was not interested in innovation simply for the sake of building increasingly tall buildings. He was quoted as saying, "it seems meaningless to develop structural systems for high rise buildings if the results do not have a positive effect toward creating better cities and better environment."[102] As *Engineering News-Record* observed when awarding Khan its "Man of the Year" honor in 1972, "Khan designs for the owner by cutting costs. Khan designs for people by giving close attention to what happens at ground level where people and city's facilities come together. By going high with his structures he leaves maximum space for a surrounding plaza. It's because of this belief that Khan has no qualms about going as high as possible with buildings."[103]

In all, Khan engaged in over 40 major projects involving both concrete and steel structural systems during his tenure at SOM. Through the 1970s, he continued to test innovative structural approaches in projects including Two Shell Plaza (1972; Houston, Texas), notable for its arched transfer of loads; First Wisconsin Center (1973; Milwaukee, Wisconsin); One Magnificent Mile (1983; 940-980 North Michigan Avenue); and Onterie Center (1985; 441 East Erie Stret). The latter two examples were completed posthumously, as Khan died of a heart attack while on a business trip to the Middle East in 1982. As David Billington, author of *The Tower and the Bridge: The New Art of Structural Engineering*, put it, the buildings that Khan designed at SOM between 1960 and 1982 constituted "a new approach to tall building design. As with the other great structural artists, Khan was technically a master of engineering. No one practicing structural engineering since World War II has better understood building structures."[104]

Over the course of his career, Khan published more than 100 articles, 35 of which were in professional journals, and his projects were frequently featured in publications such as *Engineering News-Record* and *Progressive Architecture*. He was in high demand as a speaker and presented his work at numerous international conferences. Khan received several professional awards and was recognized by *Engineering News-Record* among the "Men Who Served the Best Interests of the Construction Industry" in 1966, 1968, and 1971. In 1972, he was named *Engineering News-Record's* Man of the Year, and his photograph was featured on the cover. The publication's editorial read:

> In singling out Khan as Man of the Year…ENR's editors were impressed, of course by his innovation upon innovation in the field of structural engineering high-rise buildings. But beyond the height records and the weight savings and cost savings of his designs, beyond the technical genius of this man, a sensitive student of the urban environment stands forth…Fazlur Khan is a leader among the world's

[101] Billington, 238.
[102] "The Future of High Rise in America," *Progressive Architecture*, October 1972, 79.
[103] "Construction's Man of the Year," *Engineering News-Record*, February 10, 1972, 23.
[104] Billington, 235.

designers of great buildings. In this new era of the skyscraper, in this time of concern for human safety, comfort, and convenience in high-rise homes and offices, he is a philosophical leader of thought.[105]

Engineer Fazlur Rahman Khan (1929—1982)

Fazlur Khan was born in 1929 in Dacca (now Dhaka) in British-ruled India (the region later became East Bengal in 1947, East Pakistan in 1955, and Bangladesh in 1971). Urged by his father, a mathematics teacher, to study either physics or engineering, Khan chose engineering. He enrolled in Calcutta's highly regarded Bengal Engineering College in 1946. Because political turmoil forced Khan to return home shortly before his final exams, his Bachelor of Engineering degree was technically conferred by the University of Dacca. In 1952, Khan received both a Fulbright scholarship and a scholarship from Pakistan's Ministry of Commerce and Education, enabling him to pursue graduate studies in the United States. That fall, he enrolled at the University of Illinois in Urbana-Champaign with the intention of studying pre-stressed concrete. He excelled in the demanding academic environment, taking an above-average course load. Within three years, Khan earned three degrees: a master's degree in civil engineering, a master's degree in theoretical and applied mechanics, and a doctorate in structural engineering.[106]

At the urging of a friend, he applied in 1955 for a position in the Chicago office of Skidmore, Owings & Merrill (SOM). It was his first time working with architects in a multi-disciplinary environment, and he enjoyed the challenge of applying his technical knowledge to real-world design problems. Khan's projects included the structural design of the dining hall at the Great Lakes Naval Training Center north of Chicago, which had a long-span pre-stressed concrete roof, and the design of several concrete highway and railroad bridges at the U.S. Air Force Academy.[107]

When his visa expired in 1957, Khan returned home with the intention of taking a job with the Pakistani government in fulfillment of his scholarship commitment. Accepting an offer to work with the Karachi Development Authority, Khan found that the work was too administrative and did not offer the intellectual and technical challenge that he desired. During this time, in 1959, Khan married Liselotte Turba, an Austrian woman whom he met while in the United States.[108]

Khan decided to return to Chicago, and in 1960 resumed his position as a structural engineer at SOM. He was assigned to several projects including the United Airlines Executive Offices near O'Hare airport, and the diligence and skill which he brought to his work began to catch the attention of managing partner William Hartman and design partner Bruce Graham. In 1961, SOM was awarded the commission for the Brunswick Building, a 37-story office tower in Chicago's central business district. Khan was asked to serve as the structural designer. It was Khan's first large-scale high-rise project, and, the first in a long series of technically innovative structural designs that would define the course of his career.[109]

Comparable Buildings with "Tube" Structural Systems

Alternatives to the established steel and concrete frame systems were developed during the postwar period, primarily during the 1960s. Fazlur Khan and the SOM team were the most prolific in their development of "tube" structural systems, where a building's lateral rigidity is derived from a stiff exterior wall system. These systems were largely aimed at reducing the cost of constructing taller buildings that could efficiently resist lateral loads. Other architects also experimented with alternative structural systems that relied on rigid exterior walls. Several buildings in this category were completed during the late 1950s and the late-1970s.

500 N. Michigan is significant as the first example of a framed-tube office building. It is the only example by Kahn of a frame-tube office building in Chicago. This specific tube structural system was designed to meet functional requirements

[105] Editorial, *Engineering News-Record*, February 10, 1972, 68.
[106] Jacob, *One Shell Square*, NRHP #100003027, listed October 18, 2018.
[107] Ibid.
[108] Ibid.
[109] Ibid.

for office use and relies on an exterior rigid wall system without a central core shear wall, as is found in the more common tube-in-tube buildings designed by Kahn and others. 500 N. Michigan is unique in its full reliance on its exterior walls system for lateral load resistance. Although the framed-tube system was successful for residential programing with the DeWitt Chestnut building, the larger floor and window proportions required for office programming show significant progress in the development of the system and its successful application to an office building. 500 N. Michigan served as a critical step in the evolution of the "office building," and it exemplifies the innovations in structural systems that were achieved in response to postwar economic growth and demand for office space. Below are several extant examples of residential and office buildings with "tube" structural systems. These are organized in chronological order by completion date.

500 N. Michigan

- *Structural system:* Framed-tube
- 1965-1967

The subject of this proposed nomination was designed by SOM with Fazlur Khan as engineer. The 24-story building was completed between 1965 and 1967 as a speculative office building. It features a reinforced concrete "framed tube" structural system, which became a worldwide construction standard. The building's small site and the need to maximize office floor area prevented the use of a central core with shear walls and consequently the building relies entirely on its rigid exterior walls for lateral support. The building is also an innovative example of the use of lightweight concrete to reduce overall structural weight.

Comparable buildings begun before 1970

- **Kips Bay Plaza – New York City**
  - *Structural system:* Frame tube and shear wall
  - 1958-1960

  The 21-story Kips Bay Plaza was completed in 1960 and designed by the firm of I. M. Pei and Associates with August Komendant as the structural engineer. The building was designed as an apartment building and features an exterior rigid wall system of reinforced concrete with cast in place window openings. The design was one of the first to employ reinforced concrete to construct a new type of rigid fenestrated wall. It provided a greater ratio of windows to wall surface than the established brick clad, concrete slab and column structural system that became popular for the construction of affordable apartment buildings in New York during the 1950s. The system provided both ample light and structural support.

- **University Apartments – 1400 to 1451 East 55th Street**
  - *Structural system:* Frame tube and shear wall
  - 1959-1961

  The twin nine-story University Apartment buildings were completed in 1961 and designed by the firm of I. M. Pei and Associates with August Komendant as the structural engineer. Lowenberg and Lowenberg served as associate architects. The buildings were designed for apartments and feature exterior rigid wall systems of reinforced concrete with cast in place window openings.

- **IBM Building – Pittsburg, Pennsylvania**
  - *Structural system:* Diagonal Truss Tube
  - 1961-1964

  The 13-story IBM building was completed in 1964 and designed by the firm of Curtis and Davis with Worthington, Skilling, Helle & Jackson as structural engineers. The building was designed as an office building and features a unique steel exterior diagrid frame comprised of closely spaced stainless steel diagonal members.
  - Contributing building in the Pittsburg Renaissance Historic District (NR#13000252).

- **Brunswick Building - 69 West Washington Street**
  - *Structural system:* Frame-shear wall interaction/ Tube-in-tube
  - 1961-1965

  The 38-story Brunswick Building was designed by SOM with Fazlur Khan as engineer. It was completed in 1965 as an office building and features a reinforced concrete "frame-shear wall interaction" structural system, which Khan later acknowledged was similar to his later named "tube-in-tube" system. This building achieves lateral stability from its central core shear walls and its rigid exterior walls.

- **CBS Building – New York City**
  - *Structural system:* Frame-shear wall interaction/ Tube-in-tube
  - 1961-1965

  The 35-story CBS building was completed in 1965 and designed by Eero Saarinen. It was designed as an office building and features a reinforced concrete structural system that is similar to Khan's "frame-shear wall interaction system," which relies on both a core shear wall system and a dense perimeter of exterior columns for lateral rigidity.[110]

- **Society Hill Towers – Philadelphia, Pennsylvania**
  - *Structural system:* Frame tube and shear wall
  - 1962-1964

  The trio of 31-story Society Hill Towers were completed in 1964 and designed by the firm of I. M. Pei and Associates with August Komendant as the structural engineer. The buildings were designed for apartments and have rigid exterior wall systems of reinforced concrete with cast in place window openings.

- **DeWitt Chestnut– 260 East Chestnut Street**
  - *Structural system:* Framed-tube
  - 1963-1965

  The DeWitt Chestnut was designed by SOM with Fazlur Khan as engineer. The 42-story building was completed between 1963 and 1965 as an apartment building. It features a reinforced concrete "framed tube" structural system with exterior columns that are space 5'-6" on center. The building's residential programing prevented the development of a core with shear walls and consequently the building relies entirely on its rigid exterior walls for lateral support.

- **The John Hancock Building – 260 East Chestnut Street**
  - *Structural system:* Column-Diagonal Truss Tube
  - 1965-1969

  The John Hancock Building was designed by SOM with Fazlur Khan as engineer. The 100-story building was completed between 1965 and 1969 as a mixed-use building. It features a steel "Column-Diagonal Truss Tube" structural system that combines the basic "tube" system with a larger system of diagonal bracing that forms a monumental tube superstructure.[111]

- **National Life and Accident Insurance Building – Nashville, Tennessee**
  - *Structural system:* Framed Tube
  - 1965-1970

  The 31-story National Life and Accident Insurance Building was designed by SOM with Fazlur Khan as engineer. It was completed in 1970 as an office building and features a reinforced concrete "framed tube" structural system. The building is clad in travertine and has similar dimensions to the DeWitt Chestnut and 500 N. Michigan.

[110] "A Tale of Two Towers," April 1966, 28-31.
[111] Khan, "Report on Column-Free Multi-story Buildings With and Without Rigid Cores," 266-271.

- **One Shell Plaza – Houston, Texas**
  - *Structural system:* Tube-in-tube
  - 1965-1971

  The 52-story One Shell Plaza was designed by SOM with Fazlur Khan as engineer. It was completed in 1971 as an office building and features a reinforced concrete "tube-in-tube" structural system. This building achieves lateral stability from both its central core shear walls and its rigid exterior walls. Additional stories were able to be built on this project using lightweight concrete. The building was originally designed as a 35-story structure due to foundation limitations, but the use of lightweight concrete allowed for a taller structure to be built for nearly the same cost.[112] The use of lightweight concrete was selected for this project shortly after its successful use at 500 N. Michigan.

- **Bank of New Orleans Building – New Orleans, Louisiana**
  - *Structural system:* Tube-in-tube
  - 1967-1971

  The 31-story Bank of New Orleans was designed by SOM with Fazlur Khan as engineer. It was completed in 1971 as an office building and features a reinforced concrete "tube-in-tube" structural system. This building achieves lateral stability from both its central core shear walls and its rigid exterior walls.[113]
  - National Register #16000712

- **One Shell Square – New Orleans, Louisiana**
  - *Structural system:* Framed tube (composite steel and concrete)
  - 1969-1972

  The 51-story One Shell Plaza was designed by SOM with Fazlur Khan as engineer. It was completed in 1972 as an office building and features a composite framed tube structural system with reinforced concrete outer framed walls and interior steel columns with lightweight concrete topped steel deck floors. Additional stories were able to be built on this project using lightweight concrete.
  - National Register #100003027

Conclusion

The office building 500 North Michigan Avenue is an important early precursor in the development of the modern tall building. Its influential "framed tube" structural system combined lessons learned by master engineer Fazlur Khan in his pursuit of economically viable and structurally efficient tall buildings. During his tenure at the firm of Skidmore, Owings & Merrill, Khan developed and continued to evolve structural designs for tall buildings, solving the problem of height and economy that had prompted similar ingenuity in the earlier development of framed buildings and concrete shear wall structures. Khan's innovation in the design of tall office buildings began with development of new structural systems for the Brunswick Building, which pioneered the rigid exterior wall system in Chicago and led Khan to develop his "framed tube" system. In devising 500 N. Michigan's structural system, Khan altered his "framed tube" design to accommodate the requirements of the modern office, providing both the necessary wide window openings and largely unobstructed open floor plates that were most in demand by office tenants. The 500 N. Michigan building was Khan's first successful application of his revolutionary "framed tube" structural system to the design of a tall office building and remains a significant early example of a tall office building in Chicago with a rigid exterior wall system.

500 N. Michigan is locally significant under Criterion C in the area of Engineering as a pioneering early example of Fazlur Khan's framed tube structural system, and represents a significant step in the structural history of the tall office building. The success of the framed tube structural system employed at 500 N. Michigan served as a basis for Kahn's later iterations of tube-like structural systems for tall office buildings both in Chicago and beyond. The design also influenced

[112] Fazlur R. Khan, "Lightweight Concrete for Total Design of One Shell Plaza," Paper SP 29-1, Fazlur Khan Collection, Burnham and Ryerson Library, The Art Institute of Chicago.
[113] Beth Jacob, *One Shell Square*, National Register #100003027, listed October 18, 2018.

other architects, who further progressed the frame tube concept and contributed to the development of the tall office building during the latter half of the twentieth century.

500 N. Michigan has very good integrity and continues to exemplify Kahn's structural framed tube engineering system. Each of the building's four elevations clearly express their individual grid-like "frames." The horizontal and vertical components that form the exterior frames remain expressed and largely retain their original travertine cladding. While replacement cladding on the first two floors changed the *material* quality of part of the building, the new cladding does not obscure but follows the same vertical and horizontal columns and spandrels as the original cladding. The building therefore continues to express Kahn's innovative engineering and exemplifies his framed tube structural system.

On the interior, 500 N. Michigan's expansive floor plates, which were made possible by Kahn's structural system, remain open despite changes in finishes and office partitions for tenants over time. All exterior walls of office floors continue to express the original visual pattern of large, fixed, bronze-tinted windows separated by repeating vertical columns with integrated pipe chases. Original curbs at each window also continue to conceal office climate systems, which were a fundamental support feature of the modern, post-WWII, office environment.

500 N. Michigan remains the earliest example of Khan's application of the framed-tube system to the design of the modern tall office building.

500 N. Michigan
Name of Property

Cook, Illinois
County and State

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Previous documentation on file (NPS):

____preliminary determination of individual listing (36 CFR 67 has been requested)
____previously listed in the National Register
____previously determined eligible by the National Register
____designated a National Historic Landmark
____recorded by Historic American Buildings Survey #__________
____recorded by Historic American Engineering Record # __________
____recorded by Historic American Landscape Survey # __________

Primary location of additional data:

____State Historic Preservation Office
____Other State agency
____Federal agency
____Local government
____University
____Other
Name of repository: __________________________________

Historic Resources Survey Number (if assigned):

10. Geographical Data

Acreage of Property Less than one
(Do not include previously listed resource acreage; enter "Less than one" if the acreage is .99 or less)

Latitude/Longitude Coordinates
Datum if other than WGS84: ______
(enter coordinates to 6 decimal places)

	Latitude	Longitude
1	41.8911563	-87.6246496
2		
3		
4		

Verbal Boundary Description (Describe the boundaries of the property.)

The east 40.00 feet of Lot 8, all of Lots 9 and 10 and the west half of Lot 11 in Block 17 in Kinzie's Addition to Chicago in the North Fractional Section 10, Township 39 North, Range 14, East of the Third Principal Meridian, in Cook County, Illinois.

Boundary Justification (Explain why the boundaries were selected.)

The boundary follows the extent of the original parcel.

11. Form Prepared By

name/title Matt Wicklund, Senior Consultant; Beth Jacob, Director date March 2026
organization Ryan LLC telephone 312.980.1122
street & number 227 West Monroe Street email matt.wicklund@ryan.com
city or town Chicago state Illinois zip code 60606

Additional Documentation

Submit the following items with the completed form:

- **GIS Location Map (Google Earth or BING)**
- **Local Location Map**
- **Site Plan**
- **Floor Plans (As Applicable)**
- **Photo Location Map** (Include for historic districts and properties having large acreage or numerous resources. Key all photographs to this map and insert immediately after the photo log and before the list of figures).

Photographs:

Submit clear and descriptive photographs. The size of each image must be 3000x2000 pixels, at 300 ppi (pixels per inch) or larger. Key all photographs to the sketch map. Each photograph must be numbered and that number must correspond to the photograph number on the photo log. For simplicity, the name of the photographer, photo date, etc. may be listed once on the photograph log and doesn't need to be labeled on every photograph.

Photo Log

Name of Property: **500 N. Michigan**

City or Vicinity: **Chicago**

County: **Cook** **State:** **Illinois**

Photographer: **Beth Jacob**

Date Photographed: **April 2024**

Description of Photograph(s) and number, include description of view indicating direction of camera:

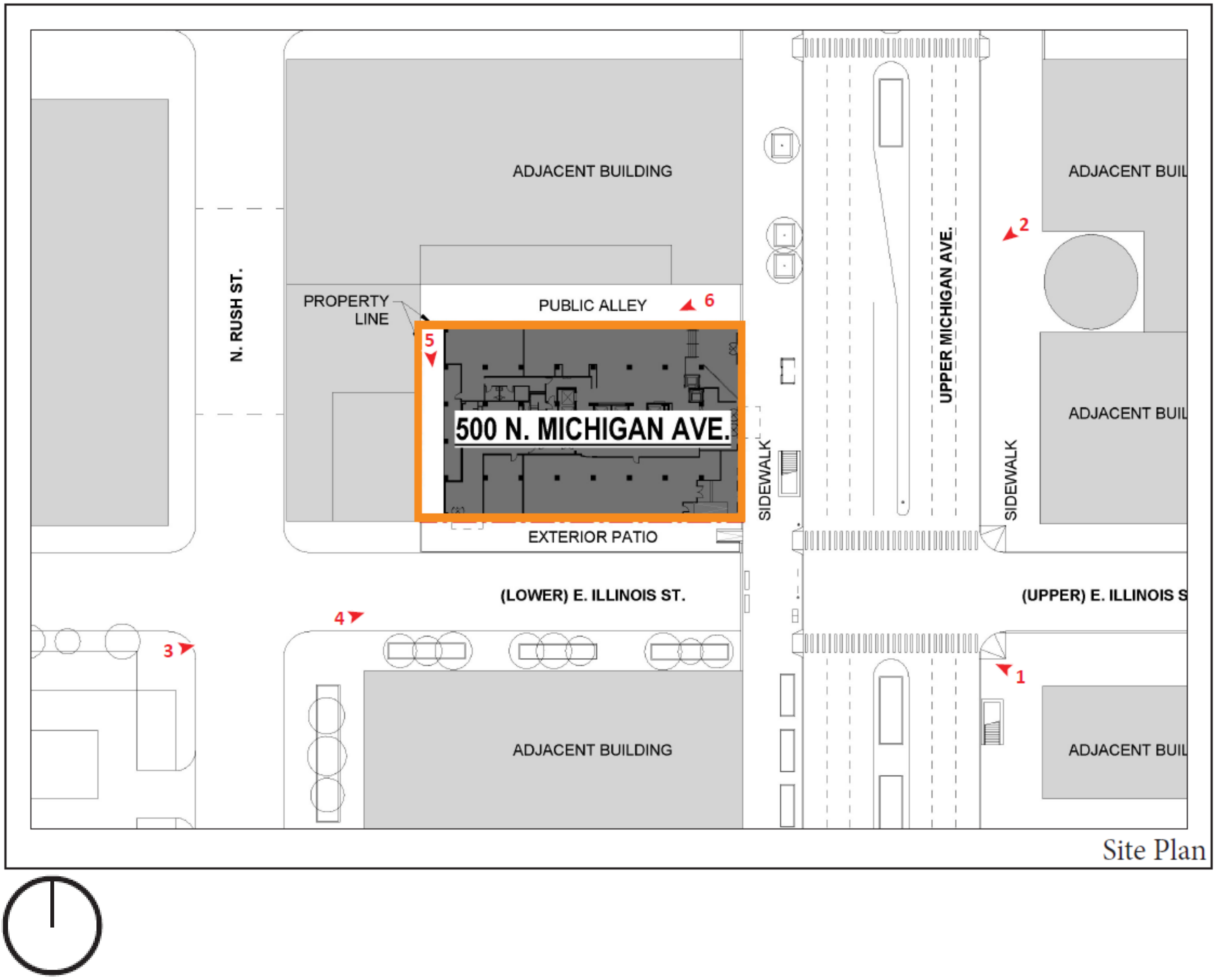
Photo 1 of 18: South and east elevations, looking northwest across Michigan Avenue
Photo 2 of 18: East elevation and partial view of north elevation, looking southwest across Michigan Avenue
Photo 3 of 18: South elevation and partial view of west elevation, looking northeast along Illinois Street
Photo 4 of 18: South elevation and upper Illinois Street sidewalk, looking northeast
Photo 5 of 18: West elevation arcade, looking southeast
Photo 6 of 18: North elevation, looking west along public alley
Photo 7 of 18: Roof and inset cooling tower, looking north
Photo 8 of 18: Lower Level 2 parking garage, looking southwest
Photo 9 of 18: First floor, main entrance vestibule and lobby, looking west
Photo 10 of 18: First floor, lobby corridor, looking west
Photo 11 of 18: First floor, east elevator lobby, looking south
Photo 12 of 18: Typical upper floor elevator lobby, floor 8, looking north
Photo 13 of 18: Typical upper floor corridor, floor 12, looking east
Photo 14 of 18: Typical upper floor corridor and mail chute, floor 8, looking southeast
Photo 15 of 18: Typical upper floor restroom, floor 13, looking southeast
Photo 16 of 18: Typical upper floor raw office space, floor 22, looking east
Photo 17 of 18: Typical upper floor office space, floor 23, looking north
Photo 18 of 18: Typical upper floor office space, floor 23, looking southeast

List of Figures
(Resize, compact, and paste images of maps and historic documents in this section. Place captions, with figure numbers above each image. Orient maps so that north is at the top of the page, all documents should be inserted with the top toward the top of the page.

Figure:

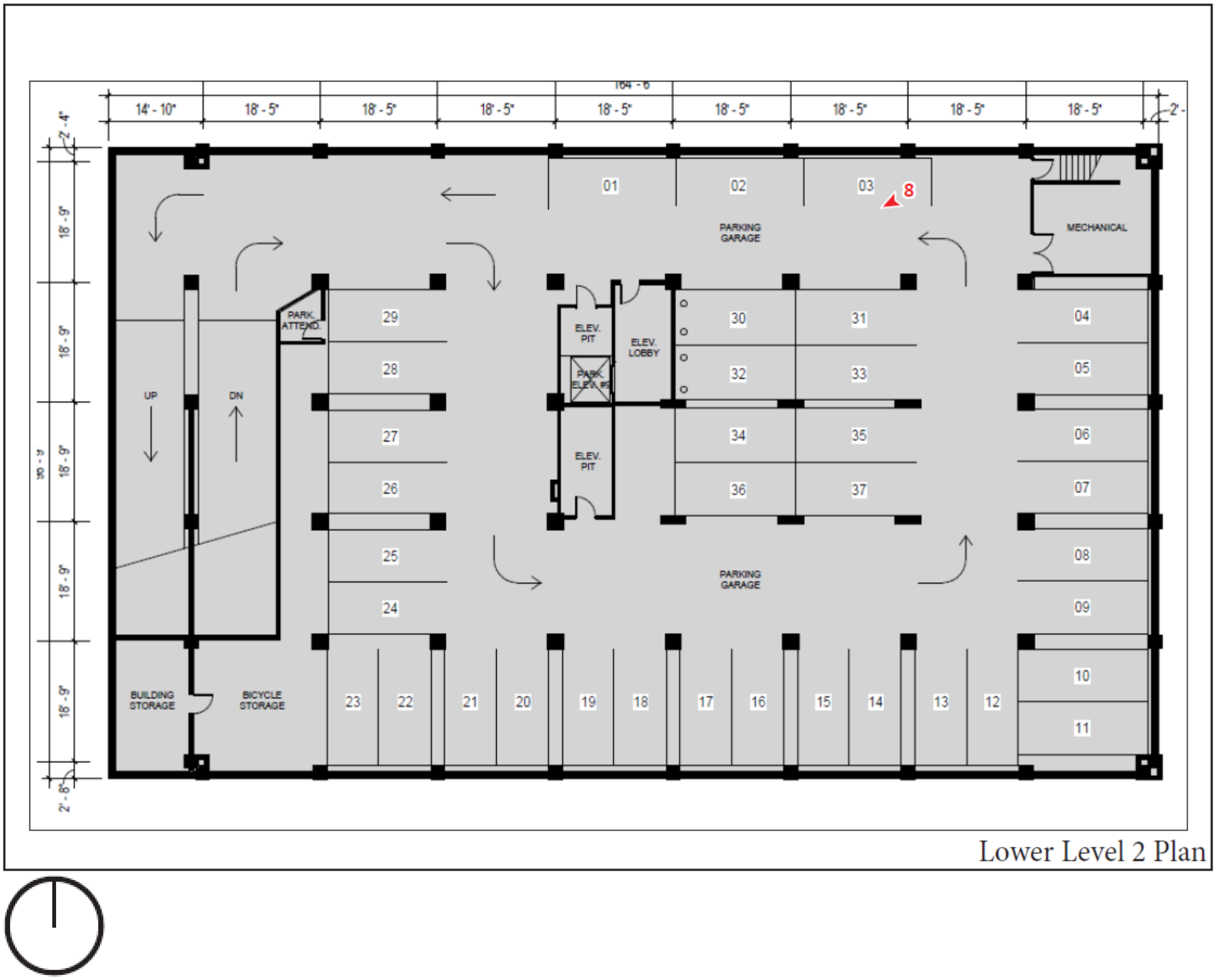
Property name: 500 N. Michigan
Illinois, County: Cook

1 of 24: Site context plan and photo key



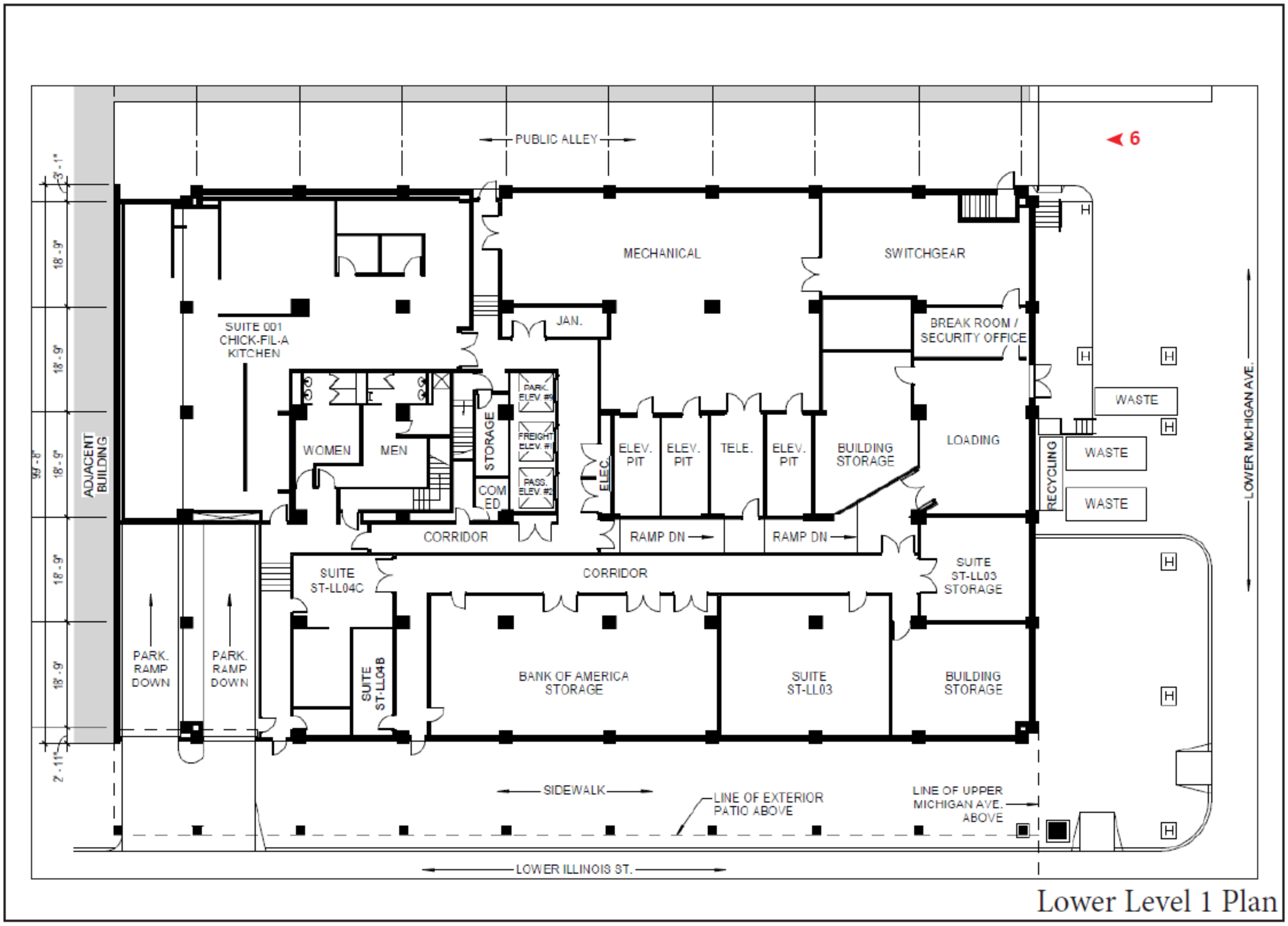
Property name: 500 N. Michigan
Illinois, County: Cook

2 of 24: Lower Level 2 plan and photo key



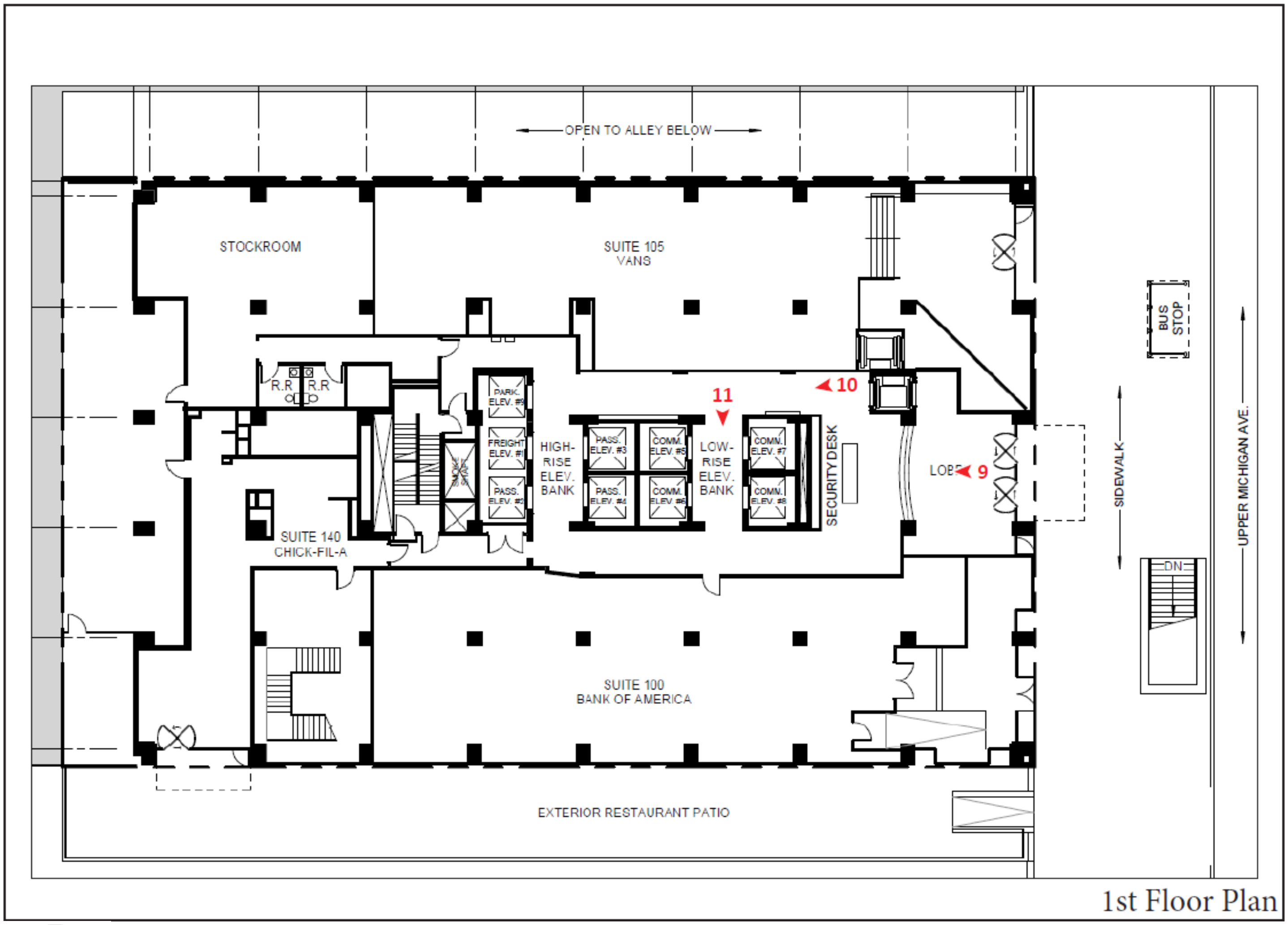
Property name: 500 N. Michigan
Illinois, County: Cook

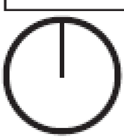
3 of 24: Lower Level 1 plan and photo key



Property name: 500 N. Michigan
Illinois, County: Cook

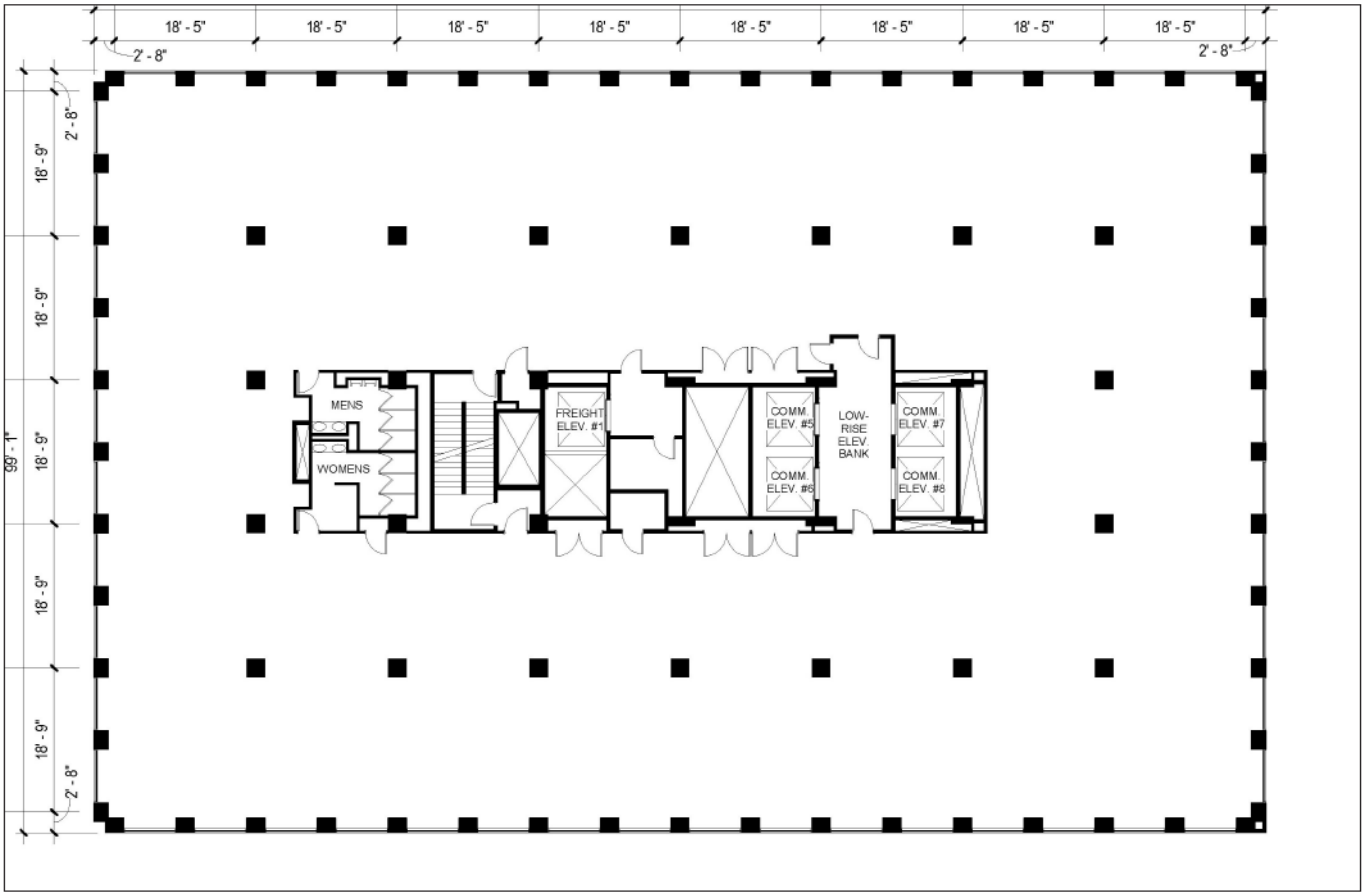
4 of 24: First floor plan and photo key



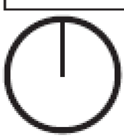


Property name: 500 N. Michigan
Illinois, County: Cook

5 of 24: Typical floor plan (Floors 3 through 6)

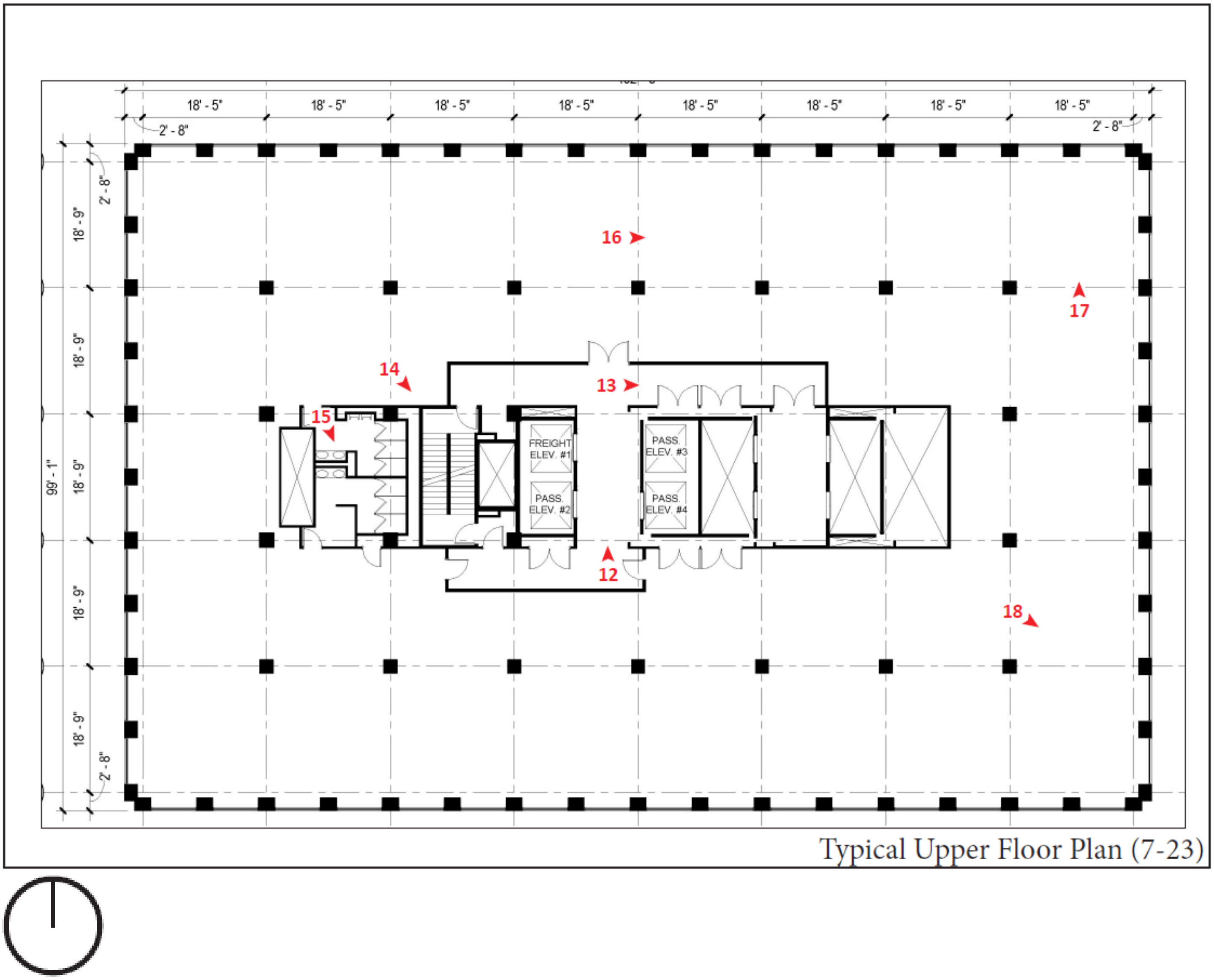


Typical Floor Plan (Floors 3–6)



Property name: 500 N. Michigan
Illinois, County: Cook

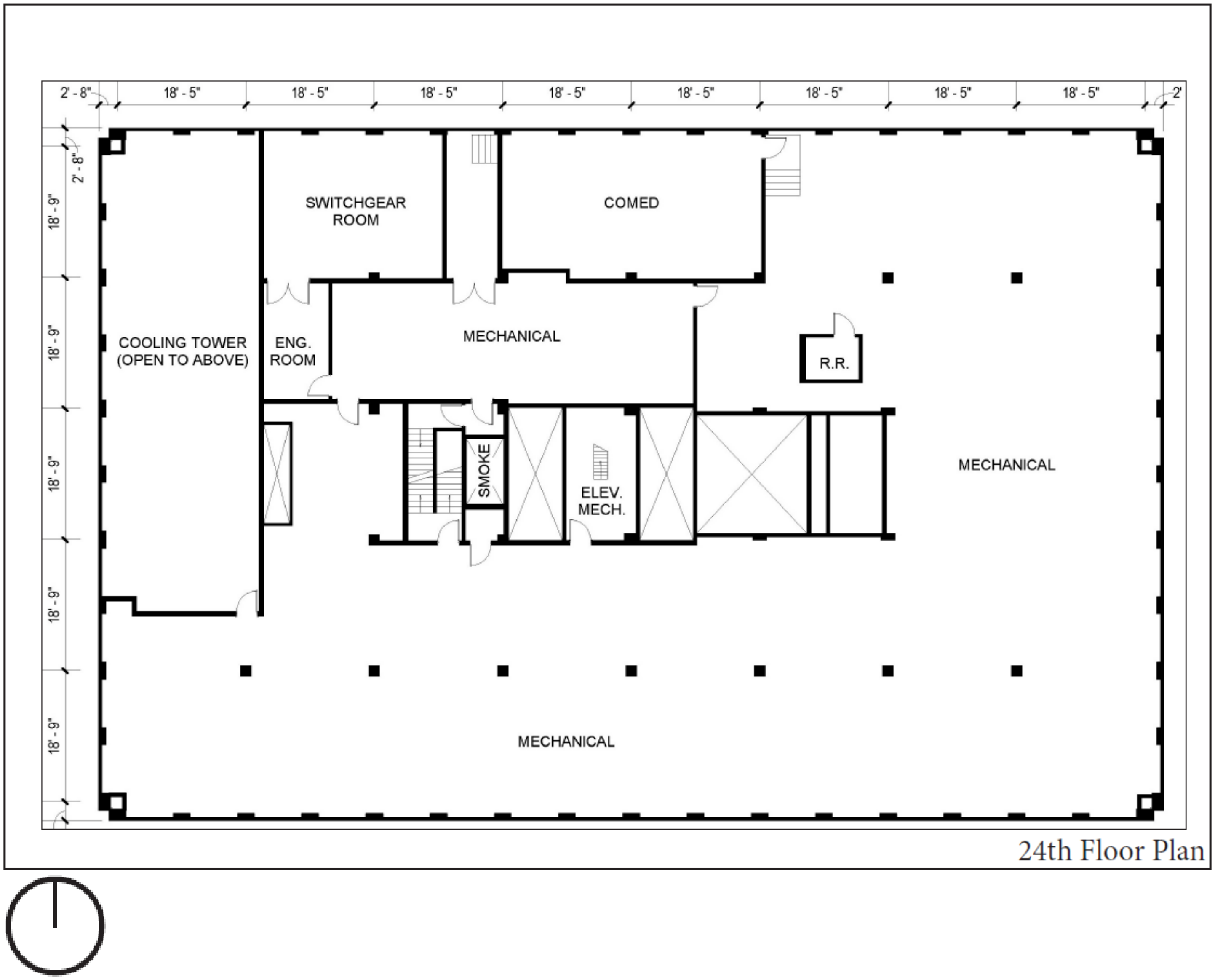
6 of 24: Typical floor plan (Floors 7 through 23) and photo key



Typical Upper Floor Plan (7-23)

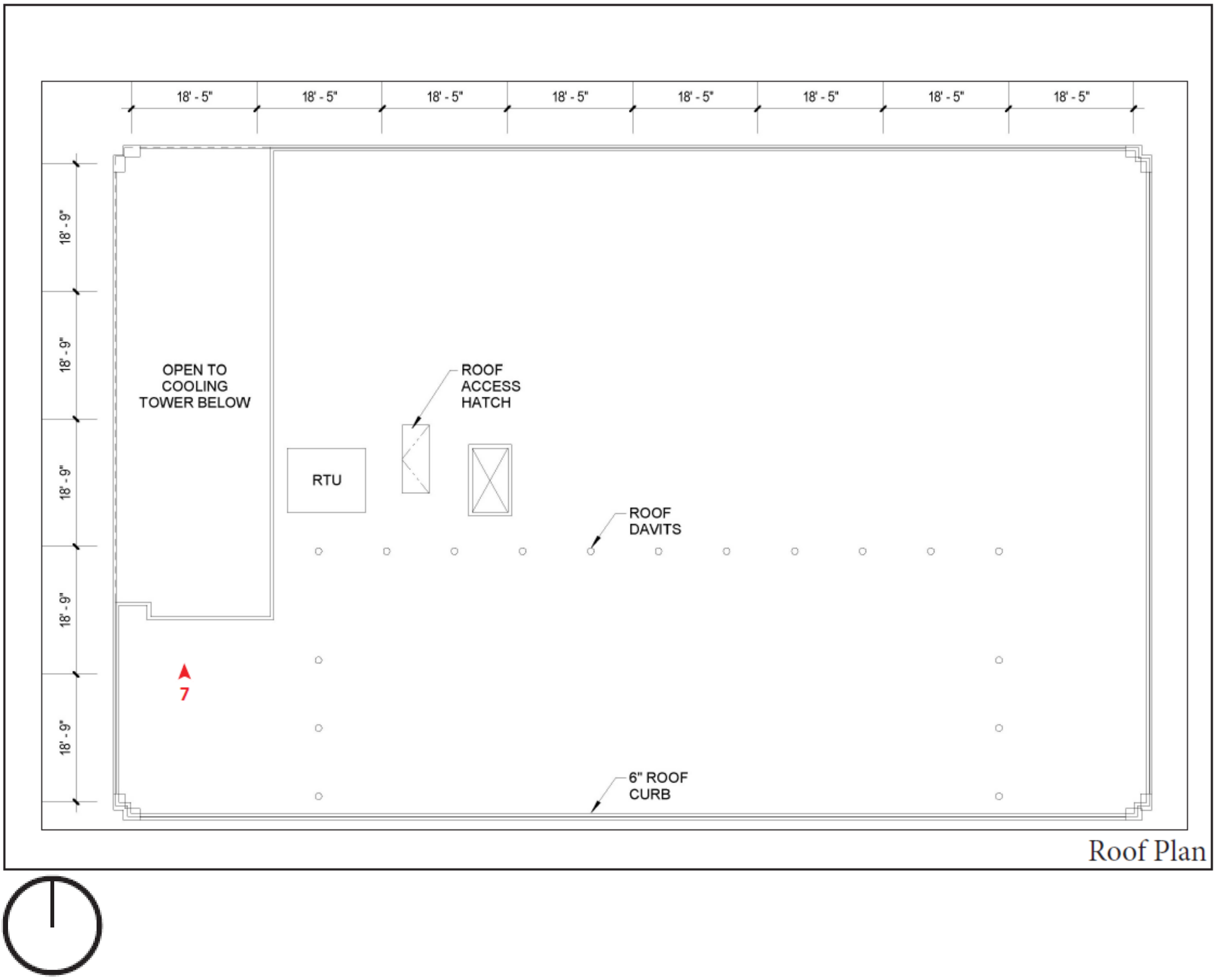
Property name: 500 N. Michigan
Illinois, County: Cook

7 of 24: 24th floor mechanical level plan



Property name: 500 N. Michigan
Illinois, County: Cook

8 of 24: Roof level plan and photo key



Property name: 500 N. Michigan
Illinois, County: Cook

9 of 24: 1965 view looking north along Michigan Avenue toward the McGraw-Hill Building (center) and the future site of 500 N. Michigan (left).

Chicago History Museum

Property name: 500 N. Michigan
Illinois, County: Cook

10 of 24: View looking north along Michigan Avenue in June 1966, showing 500 N. Michigan under construction on left.

Sigmund J. Osty, Chicago History Museum

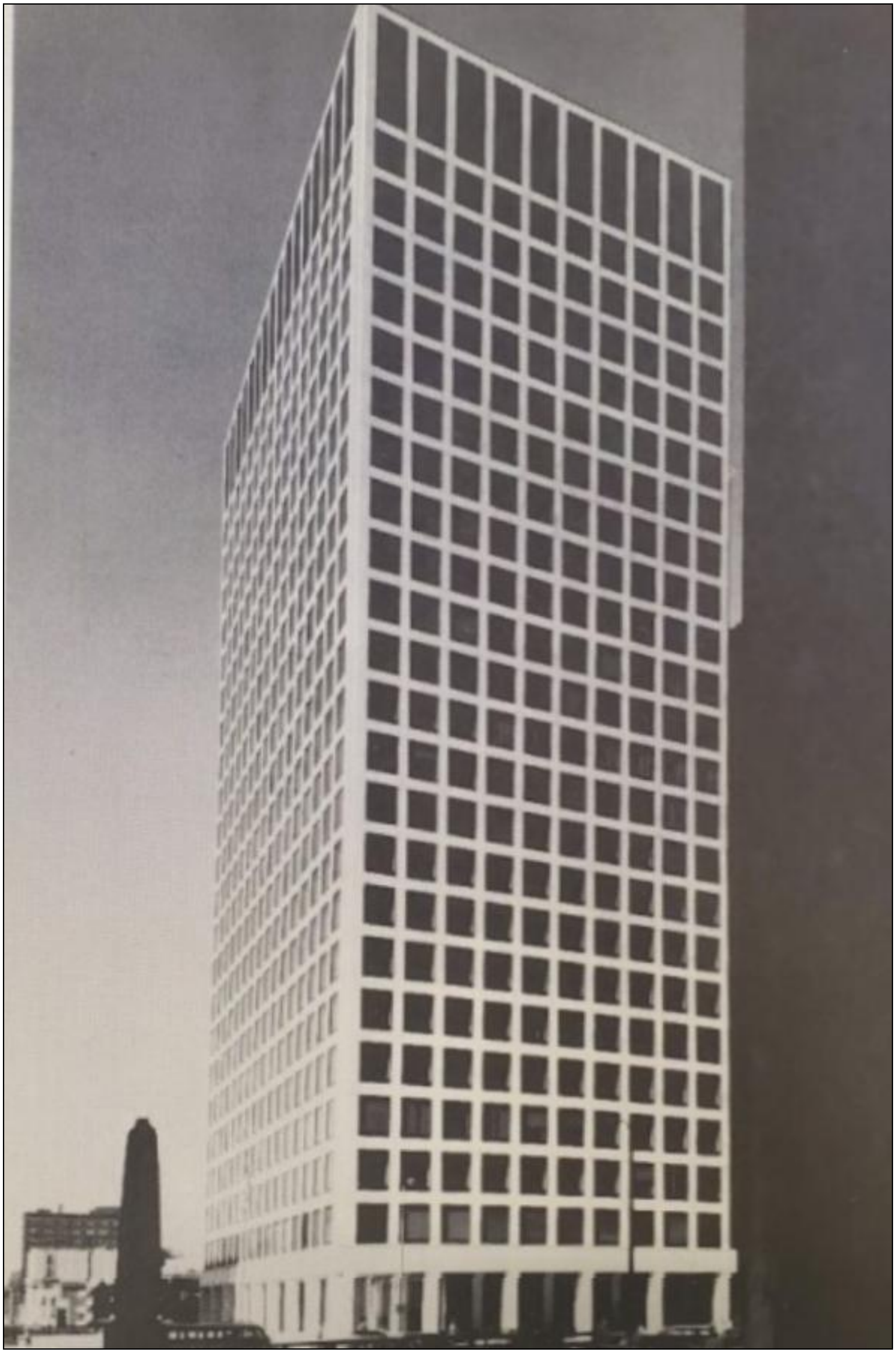
Property name: 500 N. Michigan
Illinois, County: Cook

11 of 24: 500 N. Michigan under construction in October 1966 – looking northwest toward the south and east elevations. The reinforced concrete "frames" of the east and south elevations are visible in this image. Scaffold is set up on the 21st floor for the installation of travertine marble cladding.

HistoricImages.com

12 of 24: 500 N. Michigan circa 1970 – looking northwest toward the south and east elevations.

Analysis and Design of High-Rise Concrete Buildings (Detroit: American Concrete Institute, 1985) 77.



Property name: 500 N. Michigan
Illinois, County: Cook

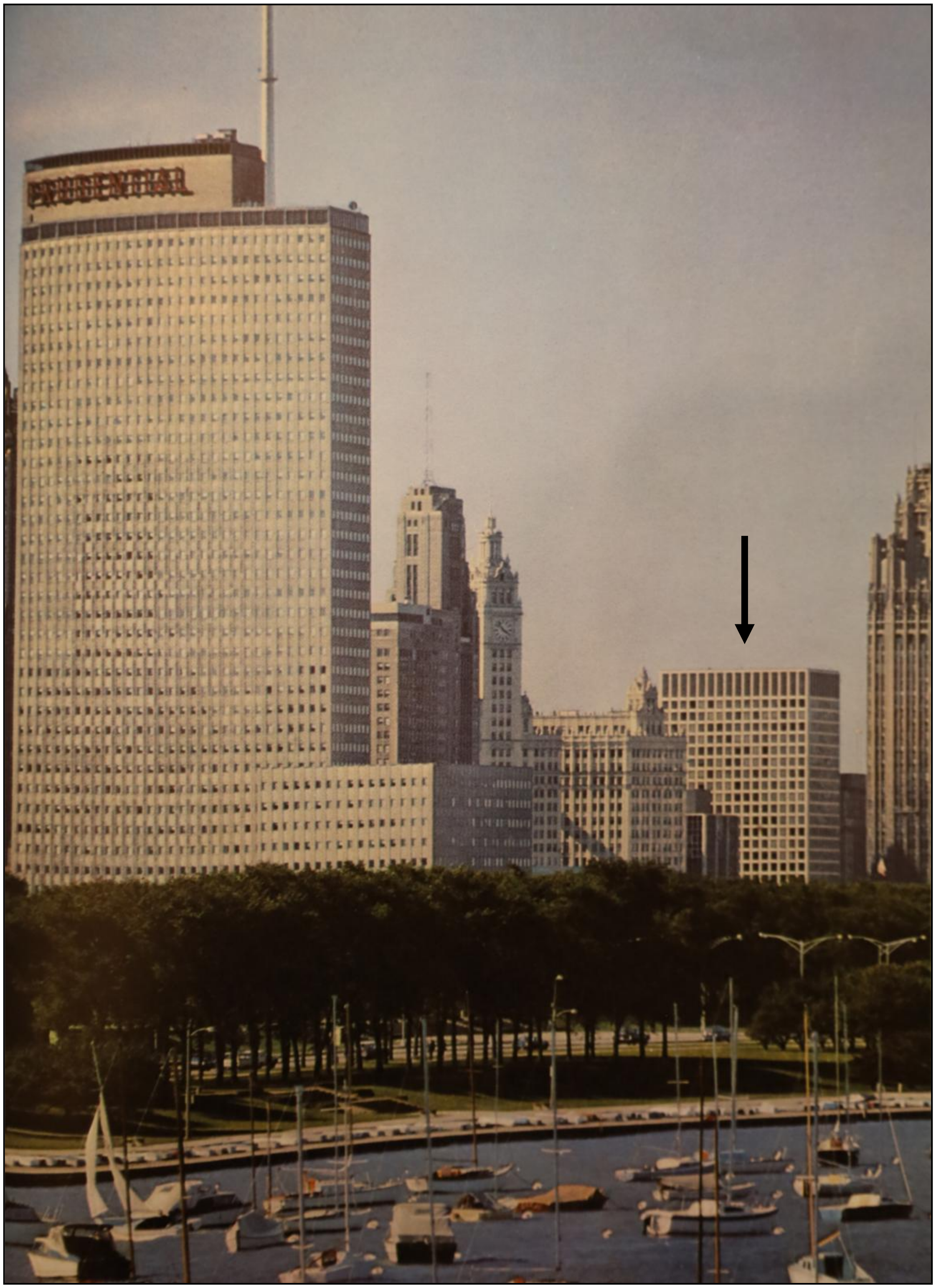
13 of 24: 500 N. Michigan entrance circa 1980 showing the original Michigan Avenue entrance and open arcade – looking west.

500 N. Michigan building files

Property name: 500 N. Michigan
Illinois, County: Cook

14 of 24: The Chicago skyline with 500 N. Michigan circa 1970.
Looking northwest across Grant Park toward One Prudential Plaza (left), with (from left to right) 333 N. Michigan, the Wrigley Building, the Apollo Savings and Loan building, 500 N. Michigan (identified with an arrow), and Tribune Tower.

Archie Lieberman and Robert Cromie, *Chicago in Color. Profiles of America* (New York: Hastings House Publishers, 1969 [1976]), dustjacket and p. 85.



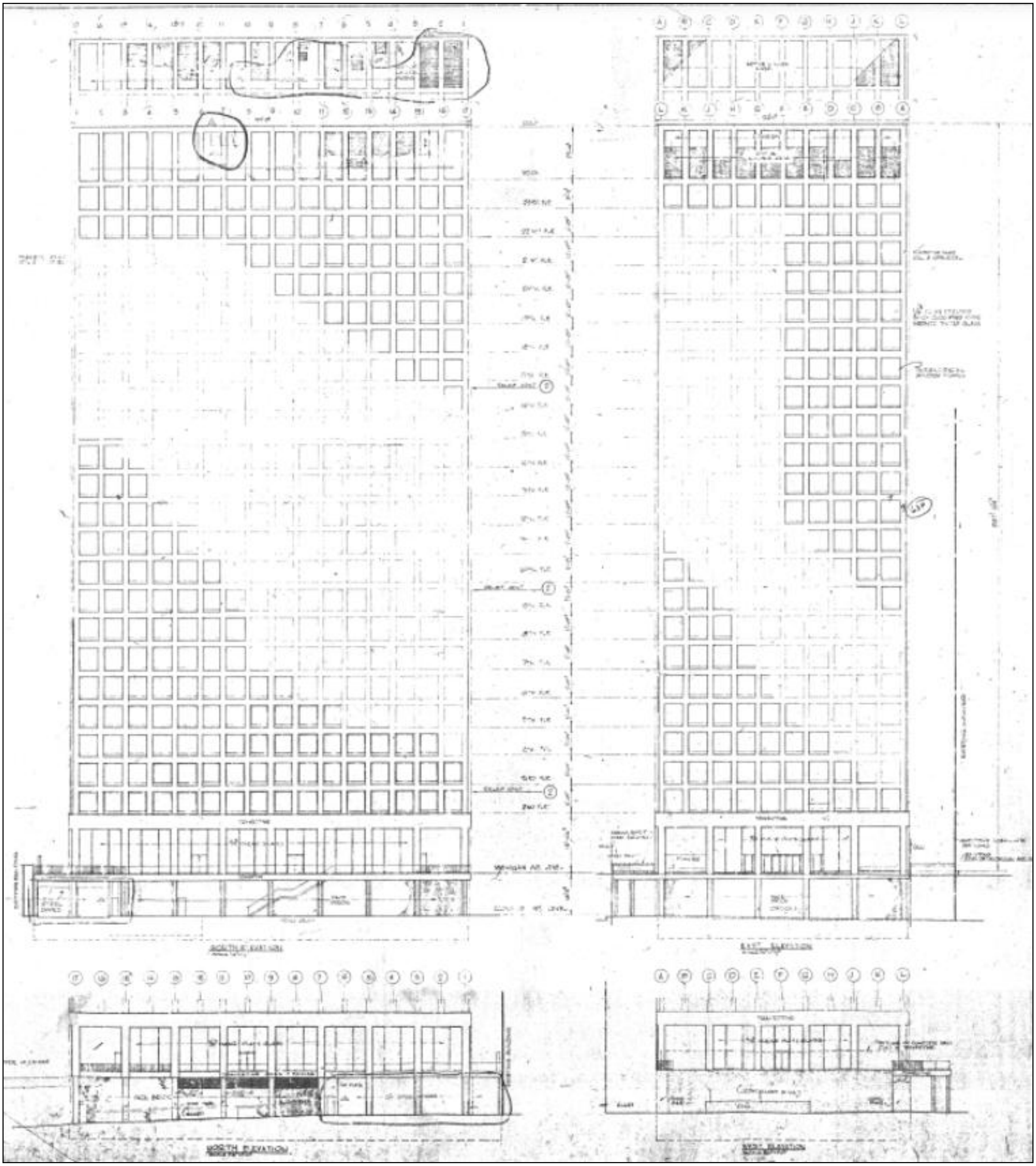
15 of 24: 500 N. Michigan circa 1989 following remodeling of the Michigan Avenue entrance – looking northwest toward the south and east elevations.

500 N. Michigan building files

Property name: 500 N. Michigan
Illinois, County: Cook

16 of 24: Original SOM elevation drawing sheet, dated 1966.

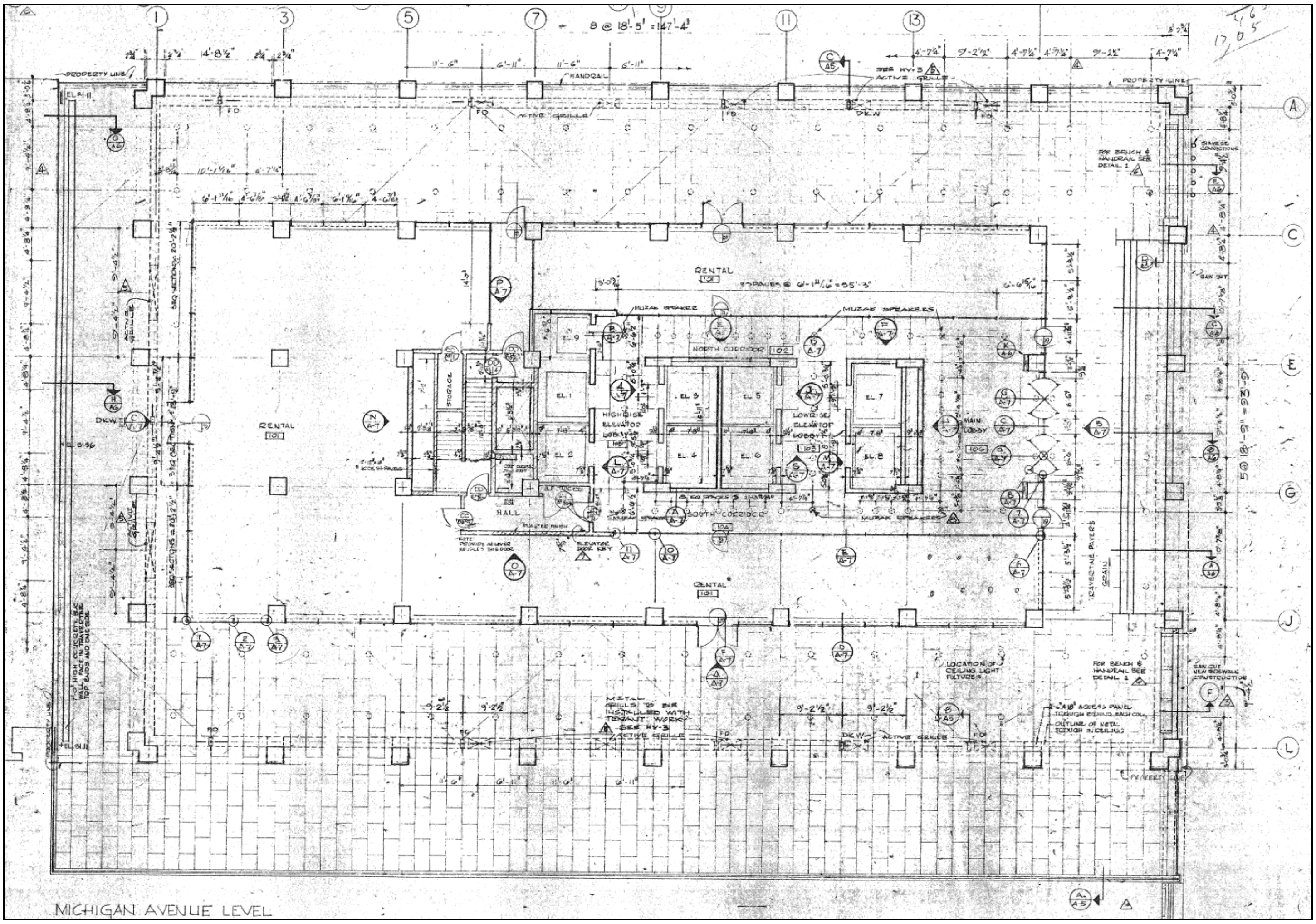
500 N. Michigan building files

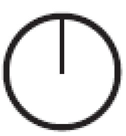


Property name: 500 N. Michigan
Illinois, County: Cook

17 of 23: Original SOM drawing sheet showing first floor, dated 1966.

500 N. Michigan building files

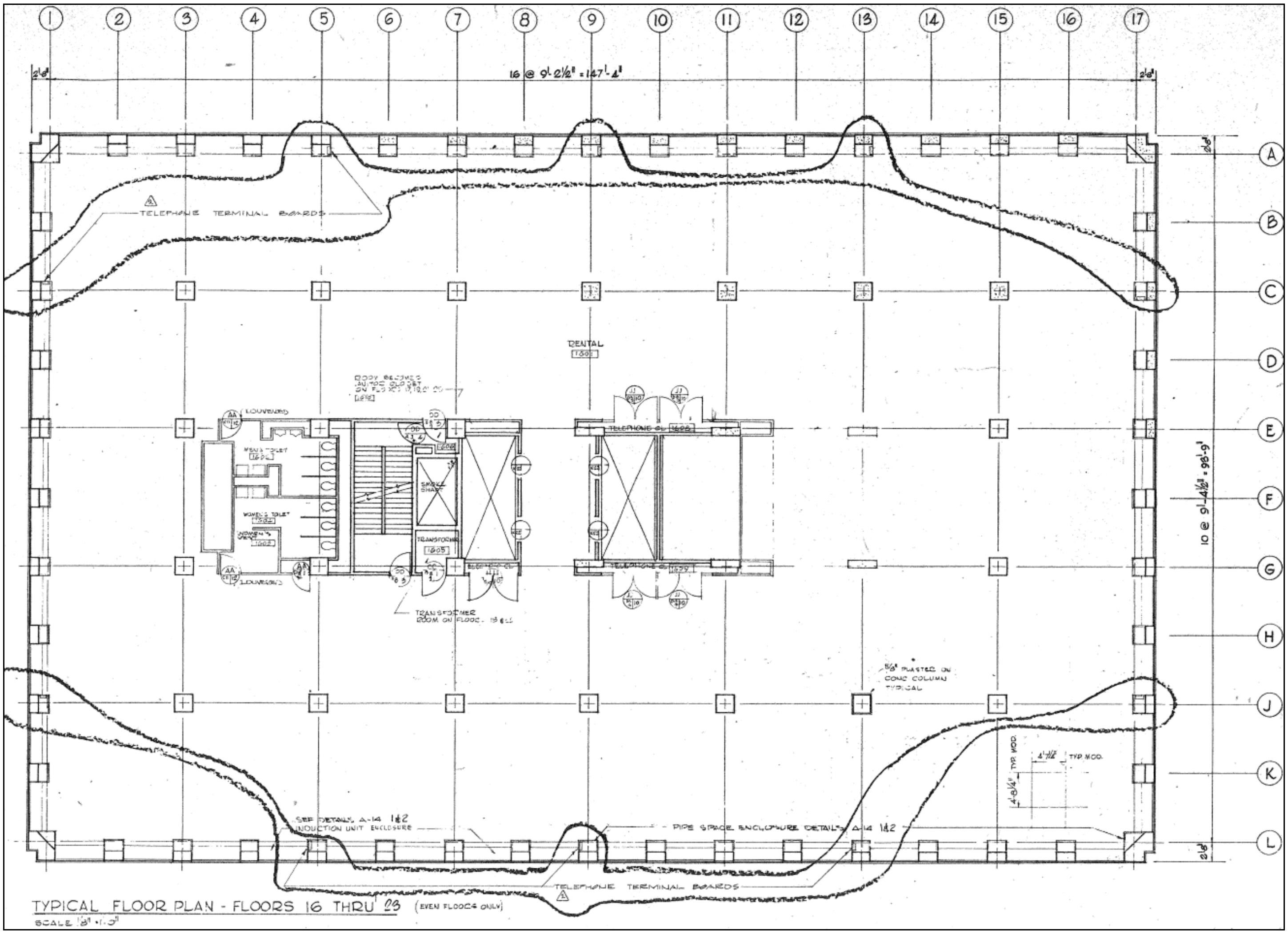


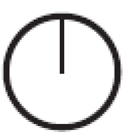


Property name: 500 N. Michigan
Illinois, County: Cook

18 of 23: Original SOM drawing sheet showing plan for a typical upper floor from 16 through 23, dated 1966.

500 N. Michigan building files





19 of 24: Article announcing construction of 500 N. Michigan in 1965

"Michigan Av. Building," *The Chicago Tribune*, November 18, 1965.

Michigan Av. Building

Drawing shows 25-story office building being erected at 500 N. Michigan av. The 15-million-dollar development is scheduled for completion in spring, 1967.

Work has begun on 60 caissons for a reinforced concrete office building at 500 N. Michigan av. at Illinois street.

Developers are Stanley Reines and Sidney Teplin of Washington. The building will be surrounded by a landscaped plaza and will have a 20-foot arcade on the Michigan avenue side where the entrance will be.

Financing is being provided by Mutual of New York Insurance company. Architect is Skidmore, Ownings & Merrill.

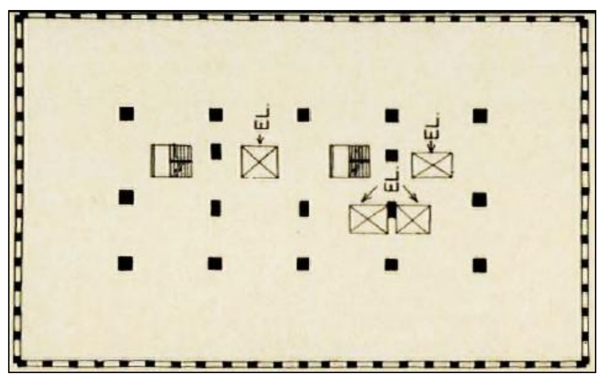
20 of 24: The DeWitt Chestnut west and south elevation and typical structural plan

Left: Khan and SOM designed the DeWitt Chestnut apartment building, which was completed in 1964. The exterior cladding forms four rigid walls of connected columns and spandrels, which together form a rectilinear tube. A decorative sheath of marble and insulation protects the cast concrete structure.

Richard Nickel Archive, Ryerson and Burnham Archives, Art Institute of Chicago.

Below: The DeWitt Chestnut has no rigid elevator core shear walls due to space limitations and instead relies on structural system Khan called a "framed tube." The building combines a rigid, load-resisting exterior "tube" of structural walls with scattered interior columns that support the floor slabs.

"Sheer Tower in Chicago," *Architectural Record*, January 1966, 160.

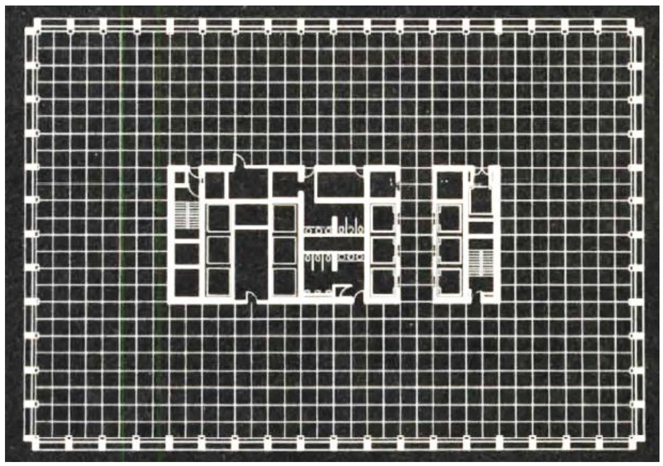


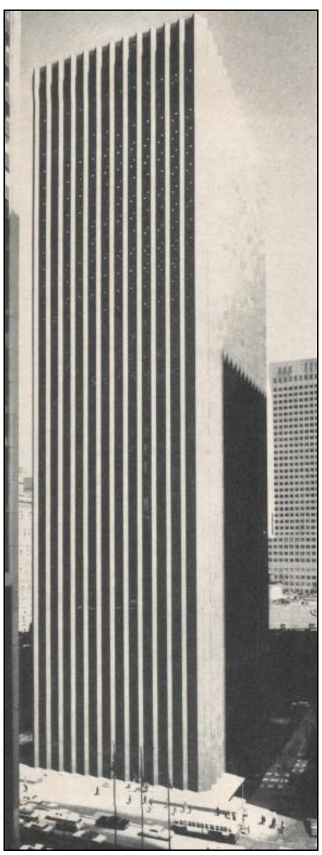
21 of 24: Comparative views and structural plans of SOM's Brunswick Building and Saarinen's CBS Building

Brunswick Building:

Khan and SOM's Brunswick Building completed in 1965 was designed with a rigid shear wall core and structural cast concrete cladding called a "frame shear-wall interaction system."

"A Tale of Two Towers," *Architectural Forum*, April 1966, 29, 33.

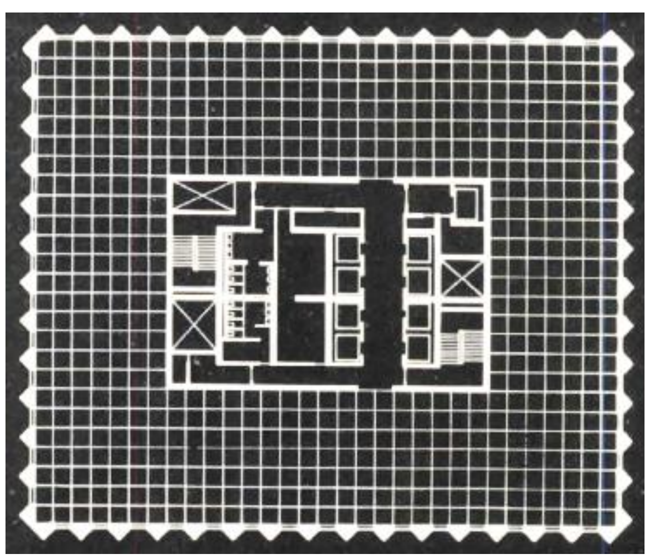




Saarinen's CBS Building:

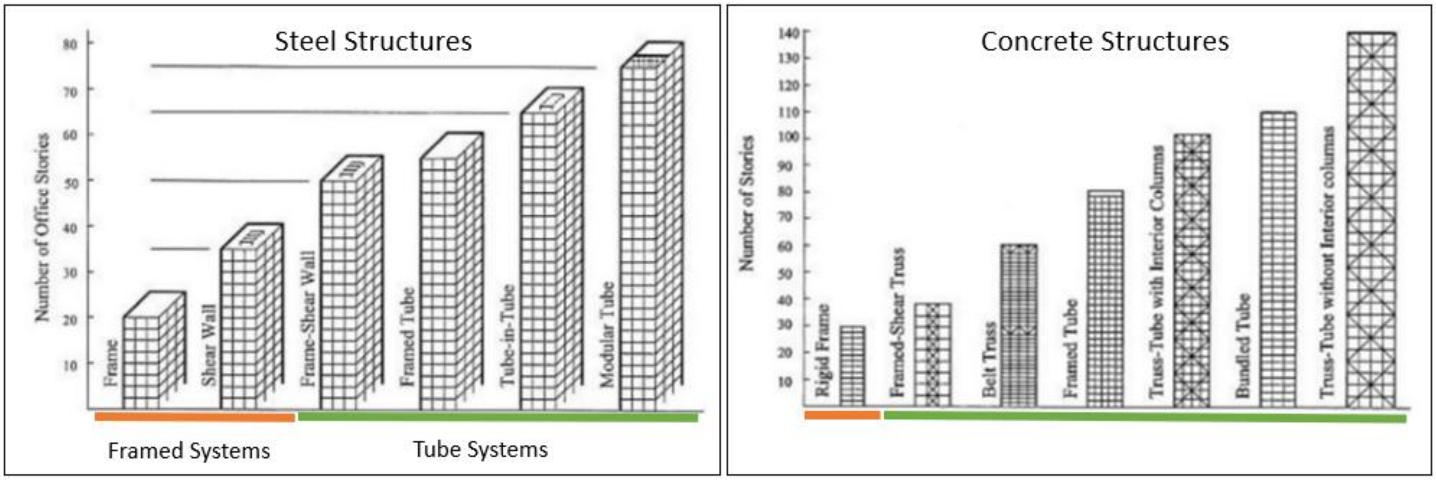
Eero Saarinen's CBS Building in New York was also completed in 1965. It has a rigid shear wall core with a structural steel exterior columns.

"A Tale of Two Towers," *Architectural Forum*, April 1966, 28, 32.



Property name: 500 N. Michigan
Illinois, County: Cook

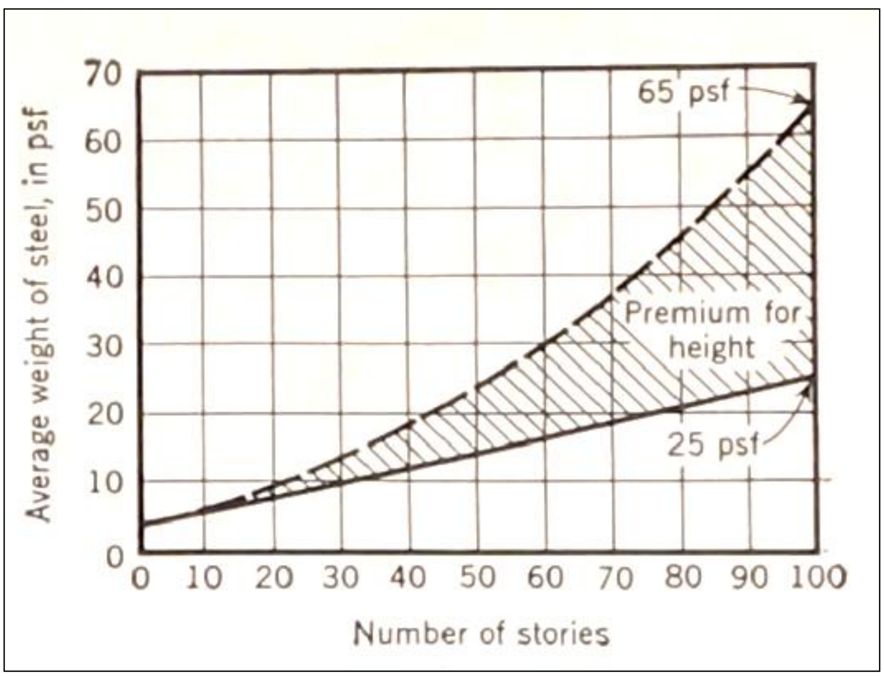
22 of 24: Classification of tall building structural systems by Fazlur Khan



The shorter systems framed systems (underlined in orange) were existing structural designs. Khan helped advance tube-like systems (underlined in green) that allowed for the construction of substantially taller buildings.

(Ali and Moon, "Structural Developments in Tall Buildings: Current Trends and Future Prospects," *Architectural Science Review*, September 2007, 208.)

23 of 24: Graph depicting the "premium for height" concept by Fazlur Khan

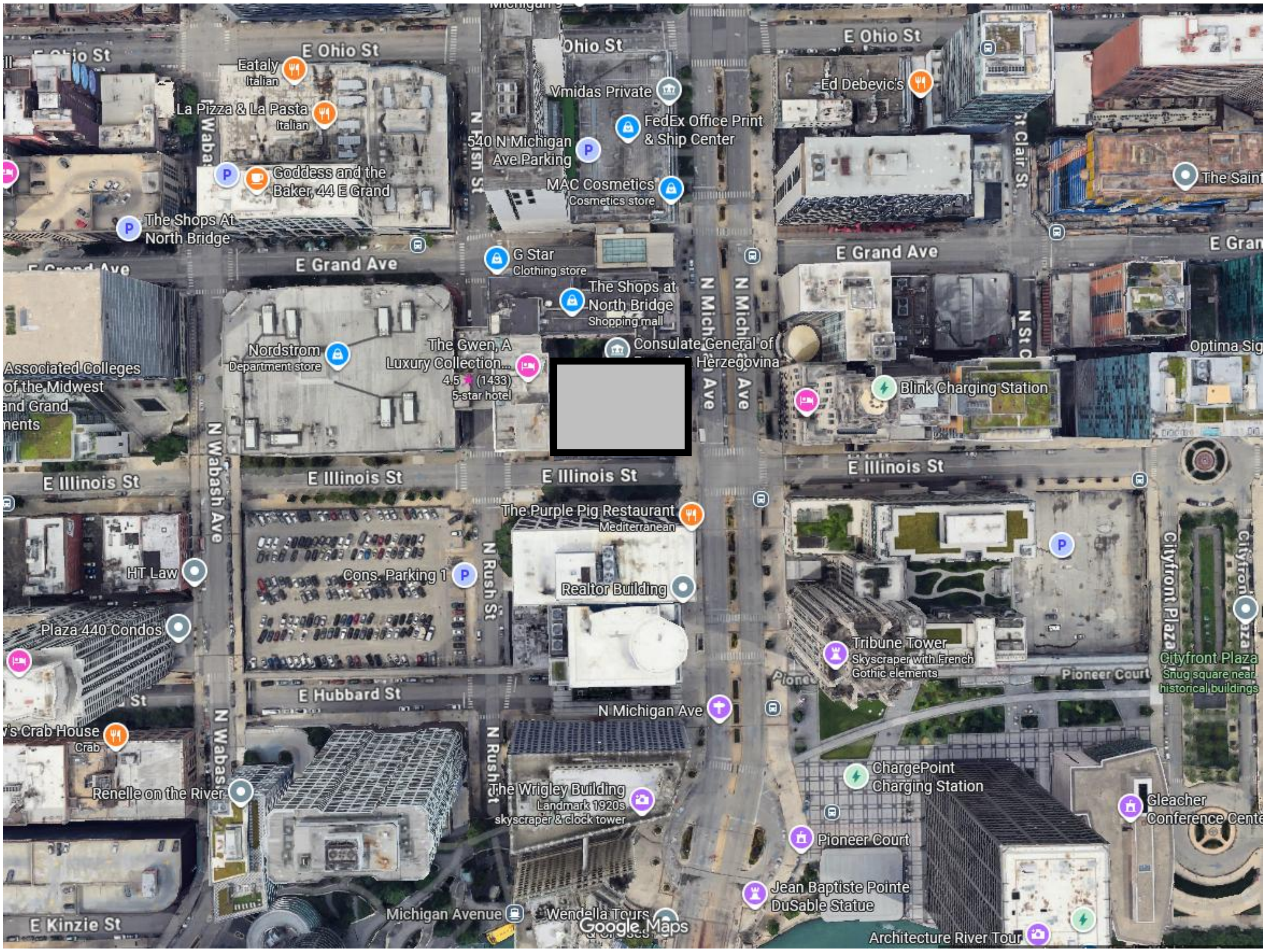


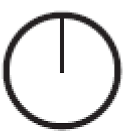
Engineer Fazlur Khan calculated that traditional framed structural systems had height limitations based on the cost of materials needed to not only support vertical loads, but to also resist lateral loads such as wind. Additional height in framed systems (top line in graph) required an exponential amount of material to resist lateral loads. He called this a "premium for height." The lower line represents total structural material for vertical support only. While this graph represents structures built of steel, the same concept was applied to buildings composed of other materials. Khan intended to design a system that efficiently resisted lateral loads while requiring little additional costly structural material.

Khan, "The John Hancock Center," *Civil Engineering*, October 1967, 39.

Property name: 500 N. Michigan
Illinois, County: Cook

24 of 24: Aerial map showing the location of 500 N. Michigan





500 N. Michigan
500 North Michigan Avenue
Chicago, Cook County, Illinois

Latitude: 41.8911563°
Longitude: -87.6246496°

500 N. Michigan
500 North Michigan Avenue
Chicago, Cook County, Illinois

National Park Service
National Register

1. South and east elevations – looking northwest

2. East and north elevations – looking southwest

3. West and south elevations – looking northeast along Illinois Street

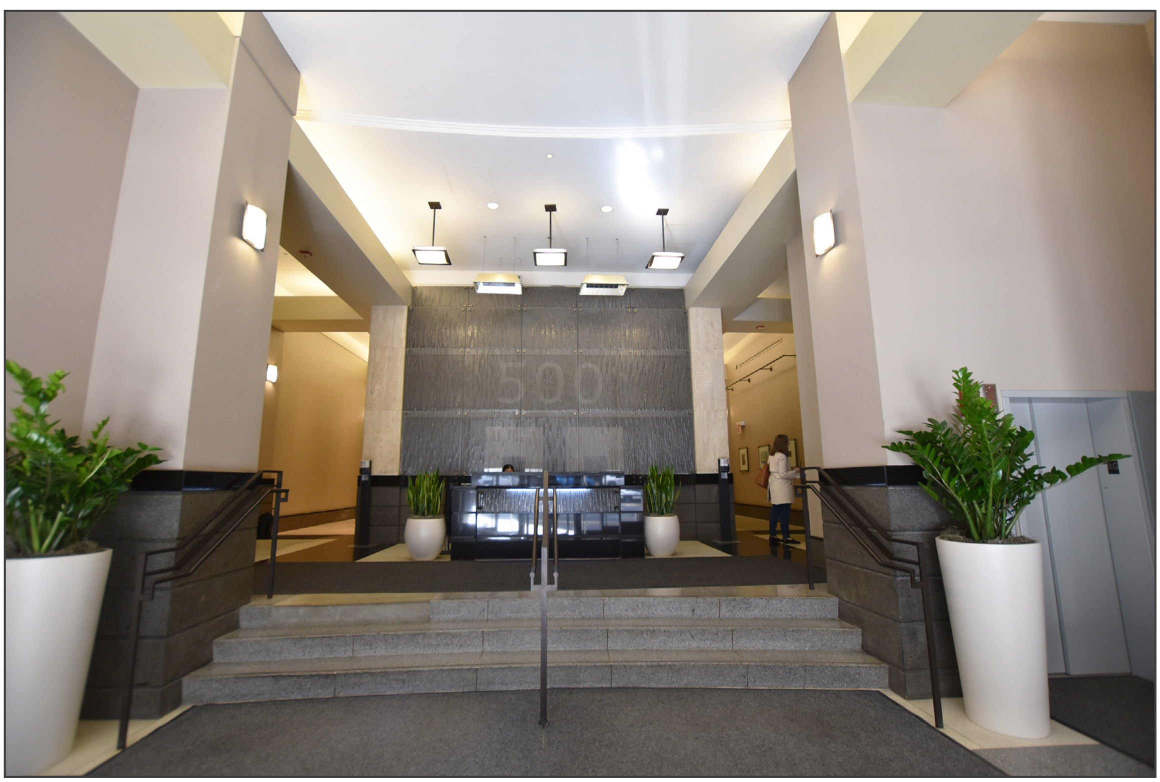
4. South elevation, showing original upper level sidewalk on Illinois Street completed with building in 1968 – looking northeast.

5. West elevation, on rear plaza and arcade – looking southeast.

6. North elevation, on the lower public alley showing the Lower Level (LL1) of the north elevation (left) – looking west along alley from lower Michigan Avenue.

7. Roof – looking north from the southwest corner

8. Lower Level 2, parking garage – looking southwest



9. First floor, entrance vestibule and lobby – looking west

10. First floor, north corridor to elevator lobbies showing original travertine wall finish – looking west

11. First floor, east elevator lobby – looking north

12. Typical elevator lobby – looking south.

13. Typical corridor – looking west.

14. Typical corridor, showing detail of original mail chute – looking northwest.

15. Typical restroom, showing original tile – looking northwest.

16. Typical unfinished office space showing exposed concrete structure – looking east

17. Typical finished office – looking north

18. Typical finished office – looking southeast.