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Author: Abbas Aminmansour, University of Illinois at Urbana-Champaign

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High-rise with Cable Net Facade for the 21st Century!

Abbas Aminmansour
University of Illinois at Urbana-Champaign, USA

ABSTRACT

One North Wacker Drive, the largest office building under construction in the United States, utilizes a number of innovations and the most advanced technologies in its design. They include state-of-the-art in indoor air quality and telecommunication technologies. The building design also utilizes an innovative net wall glass system as well as interesting structural features. This article offers a synopsis of some of the unique features of the building and offers an insight into the collaboration between team members involved in the design and construction of the building.

THE PROJECT

A new tall building is being added to the Chicago skyline. One North Wacker Drive is a 51-story multi-use building under construction at a prime location within the Chicago Loop. The building rises over 653 ft. above the street level (Fig. 1).

One North Wacker provides over 1.68 million sq. ft. of leasable space in the busy downtown Chicago, making it the largest office building under construction in the United States. In addition to office space, the building will house a conference center, restaurant, and about 230 parking spaces.

The building is owned by The John Buck Company and developed by Lend Lease Real Estate Investments, Inc. Morse Diesel International is the general contractor. Construction is expected to conclude by June 2001 with an estimated cost of $250 million.

THE ARCHITECTURE

The architect, Lohan Associates, utilized a postmodern stainless steel curtainwall and the latest telecommunications and other technologies to design a building ready for the challenges of the twenty-first century. Lohan Associate's Design Principal Jim Goettsch led the design.

The building's many innovative features provide tenants increased productivity and lower operating costs. Constant temperature control, air quality monitoring, and high-speed elevators with curved glass cabs are among features that make this building stand out.

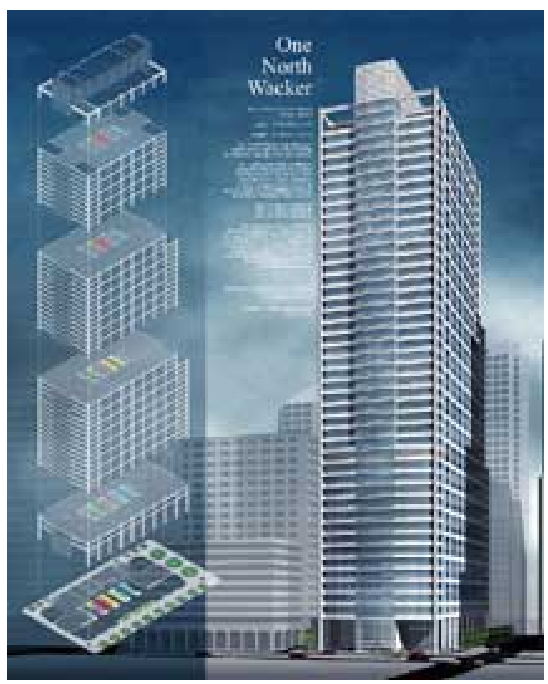

Fig. 1 Rendering of One North Wacker (courtesy of Lohan Associates)

One North Wacker is divided into four zones. The lobby consists of retail and restaurant space. Extensive use of glass in the east, west, and south walls create a very transparent lobby (Fig. 2). Originally, the developer opted for stone cladding at the base. Associate Principal Steve Nilles of Lohan Associates, felt, however, that the modern stainless steel curtainwall and stone cladding are not a good match. The solution: transparent walls that draw the passerby's attention to the granite and marble interior core wall, without the use of stone at the building exterior base.

The developer wanted the building to have floor sizes flexible enough to accommodate the varying needs of the tenants. Therefore, the tower consists of three zones above the lobby level with 38,000, 33,000, and 29,000 sq. ft. floor areas. This led to a stepped ower design.

Fig. 2 Rendering of the lobby area and the south wall (courtesy of Lohan Associates)

INNOVATION AND COLLABORATION

A very innovative [net] wall system used on the east, west, and south walls of the building lobby, utilizes an extensive amount of glass (Rothrock, 2000). But don't expect to see any mullions in this lobby! One North Wacker is the first building in the United States to incorporate this innovative two-way cable net enclosure concept.

The net wall was designed by Steve Nilles, and engineered, fabricated and installed by Advanced Structures, Inc. (ASI) of Marina del Rey, CA. Trainor Glass Company was the glazing contractor.

The system utilizes 3/4-inch pretensioned stainless steel cables to hold up 5 by 5ft. panels of glass (Fig. 3). According to Nilles, "To enhance the net wall transparency, Lohan specified water white low iron non-reflective coated glass manufactured by Schott Corp." Stainless steel glazing nodes are used to install the glass panels permanently (Fig. 4).

Fig. 3 Pretensioned cable grid in the south wall (courtesy of Joshua DeYoung)

Patrick Loughran of Lohan Associates, the Project Architect for the curtainwall, says, "In the past, cable net wall facades have been the focal point of the buildings which incorporate them such as the Kempinski Hotel in Munich." He adds, "One North Wacker uses this enclosure technology to elegantly connect the street with the main lobby."

Fig. 4 Installation of a mock-up node in the net wall (courtesy of Lohan Associates

Fig. 5 Mock-up testing a net wall (courtesy of Lohan Associates)

The south wall of the lobby consists of seven bays, each 30 ft. wide and 40 ft. high. The east and west walls each measure 45 ft. wide and 40 ft. high. Loughran points out, "Multiple bays of cable net wall enhance the interior space without dominating it."

Clearly, this type of innovation requires collaboration between everyone involved in the design and construction of the system. Architect Nilles highlights the challenges involved in the design of this innovative wall system by pointing out that the architect, structural engineer, wall system designer, and the glazing contractor had to work very closely to ensure proper design and construction.

Franz Safford, a principal of ASI emphasizes the "critical collaboration" that his team had to have with the structural engineer to ensure that the boundary structure supporting the cable net structure was adequately designed to support the significant loads at the cable anchors.

Thomas Poulos, Project Manager of Thornton-Tomasetti Engineers states, "Columns were designed to support the 5 ft. grid of high-strength cables which support the elegant transparent net-wall glass system at the lobby." Poulos adds, "the composite column design allowed an unbraced length of 45 ft. without increasing the section of the original steel column design."

As with any tall building, the design of the wall system had to take into account the building's movement without causing any damage. According to Safford, a hinged U-shaped steel portal was used at the entrances to accommodate wall displacements without impacting the performance of the entrance doors. In addition to all the precautions taken, a full-scale prototype of the net wall system was made and tested (Fig. 5).

THE STRUCTURE

Thornton-Tomasetti Engineers opted for a hybrid steel frame and concrete core structure for the building. This system took 10,000 tons of steel and 13,600 cu. yds of concrete to construct.

The centrally located concrete core wall was designed to provide lateral stability for the structure. Project Manager Poulos explains, "the core displaces approximately 8 lbs per sq. ft. of steel, cumbersome moment and/or bracing connections, inherently provides sound-proofed elevator core and most importantly 46 ft. of unobstructed office space." The core also eliminated the need for fireproofing its contents.

The concrete core thickness ranges from 39 in. at the base to 15 in. at the 27th floor and above. Concrete strength of 12,000 psi was used below the 27th floor and 8,000 psi for the remainder of the core. The concrete core walls are supported on straight shaft caissons, which are drilled into bedrock at 95 ft. below the surface. The perimeter steel columns bear on belled caissons, which extend down to hardpan approximately a distance of 60 ft.

The design of the steel framing and columns was done using the Load and Resistance Factor Design (LRFD) method. According to Poulos, using LRFD contributed to an overall steel tonnage saving of 12%.

An Osterberg Cell Load Test was conducted on the in-situ bedrock to obtain higher load bearing values than ordinarily allowed by the Chicago Building Code (Fig. 6).

Detailed dynamic analysis of the building was done. The building periods in the x, y, and the z-directions were computed. Further, wind tunnel tests were carried out using dynamic properties obtained from ETABS as well as other information such as hand mass calculations and floor heights dictated by the architect. Highest occupied floor accelerations were limited to 9-12 mg, 20-25 mg, and 25 mg for 1-year, 10-year, and 100-year peak winds. Torsional velocity at the highest level was limited to 1.5 and 3.0 milli-rads/sec for 1-year and 10-year peak winds.

Fig. 6 Osterberg cell load bearing test (courtesy of Thornton-Tomasetti Engineers)

Lastly, the structure was analyzed for differential shortening between the concrete core wall and the steel perimeter columns. Elastic shortening, shrinkage and long-term creep during the life expectancy of the building were computed. The results required the concrete core to be super-elevated at time of construction.

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