**Zeitschrift:** IABSE structures = Constructions AIPC = IVBH Bauwerke

**Band:** 6 (1982)

**Heft:** C-23: Selected works of Fazlur R. Khan (1929-1982)

**Artikel:** John Hancock Center, Chicago, Illinois (USA)

**Autor:** [s.n.]

**DOI:** https://doi.org/10.5169/seals-17602

## 6. John Hancock Center, Chicago, Illinois (USA)

*Owner:* *John Hancock Mutual Life Insurance Company*
*Architects & Engineers:* *Skidmore, Owings & Merrill, Chicago, Illinois*
*Contractor:* *Tishman Realty & Construction Co., Inc.*
*Completion date:* *1970*

The 100-story John Hancock Center (Fig. 1) is a multiple-use building involving commercial, parking, office and apartment-type space in one building. The tower provides about 1,000,000 sq. ft. of office space, 1,000,000 sq. ft. of apartments and about 800,000 sq. ft. of parking and commercial areas. The ground floor plan of the building measures approximately 160 ft. x 260 ft. and the clear span from central core is approximately 60 ft. The building is tapered to the top to a dimension of 100 ft. x 160 ft. and the exterior clear span reduces to 30 ft., as shown in Fig. 2.

### Tapered Tube Concept

Initial schemes had envisioned a multiple building complex with one building for the office and another for the apartments. It was apparent from an environmental point of view that this would create a congested site with relatively no setbacks from streets and very little plaza space at the ground level. It was, therefore, decided during the preliminary planning stages that a single tower incorporating all three uses would be desirable, if an economical structure could be devised and if architectural requirements could be suitably integrated. In apartment planning, deep space from window wall to building core cannot be effectively used, since proximity to windows for viewing and natural light are key factors. Office spaces, however, could accept a much deeper space from the window wall. The natural consequence of placing apartments above office space would have been to create a wedding cake-type arrangement with a broad building for office at the bottom and a narrow one for apartments at the top. A logical solution was a tapered tube building form, which was generated by placing the largest feasible apartment on the 46th floor (first apartment floor) and the largest office floor at the bottom. The taper was extended upward until the programmed requirements were met. The tapered form allowed a continuous structure to be used on the exterior faces of the building as a tapered tube.

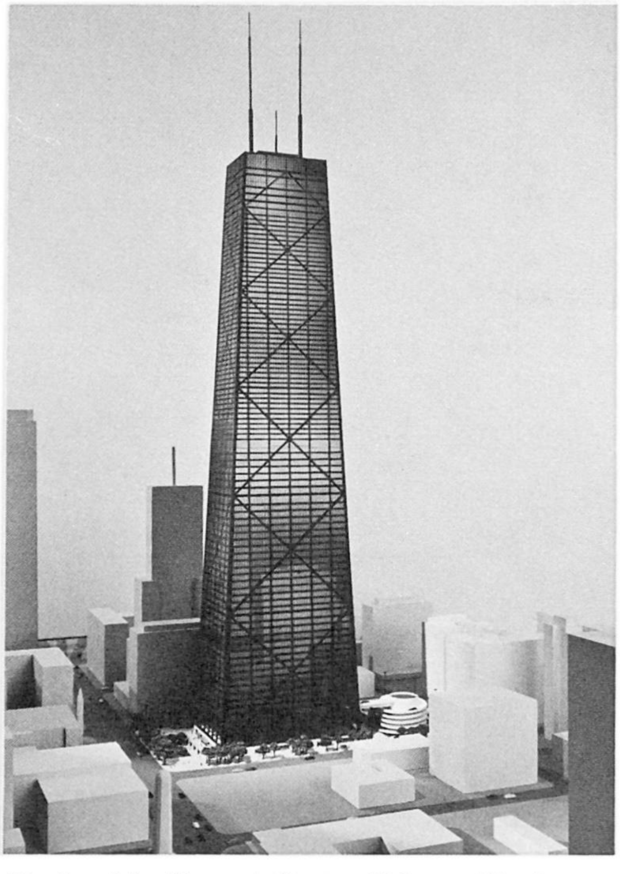

*Fig. 1 John Hancock Center, Chicago, Illinois*

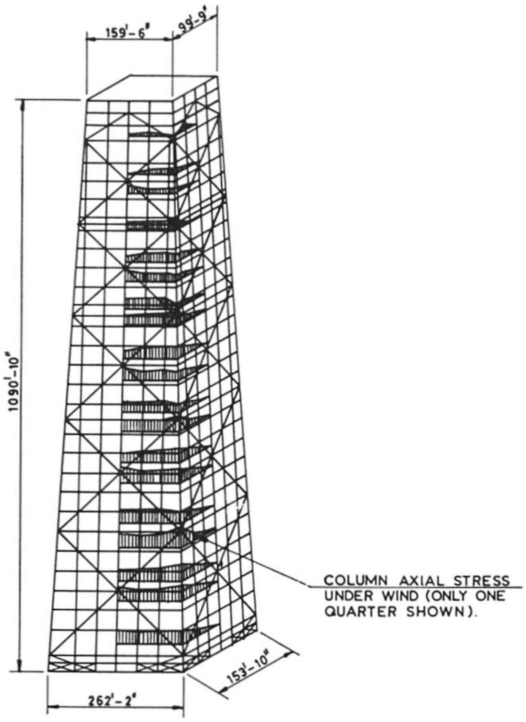

*Fig. 2 Column axial stress distribution in exterior diagonalized tube*

### Diagonalized Tube Structure

The structural system consists of diagonally braced exterior frames which act together as an equivalent tube (Fig. 2). The uniqueness of the system lies in

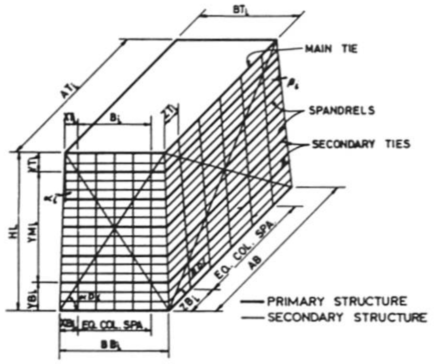

*Fig. 3 Base tier module*

the fact that a few diagonals added in the plane of exterior columns created a rigid box effect. This diagonal framing system had to follow a rigorous geometric discipline. The diagonals from each face had to intersect at a common corner point so that wind shear, carried axially in web side diagonals, could be effectively transferred to flange side diagonals of the tube. The diagonal path is a continuous line from face to face, creating an 'X' brace for each face and for each tier (Fig. 2). The diagonals are connected with exterior columns so that load could be transferred from the diagonals to the columns. Tie beams were provided at levels where the diagonals intersect corner columns so that the diagonals could effectively distribute the gravity load among the columns. Consequently, diagonals remained in compression under wind pressure which simplified member connections. Because of this distribution, all exterior columns on each face were made equal in size.

Fig. 3 shows a typical tier, with the "primary" system consisting of columns, diagonals and primary floor spandrels, and the "secondary" system consisting of floor beams between the primary levels. Only the primary framework was required to develop continuity and ability to transmit axial forces. The secondary system of spandrel beams was designed for gravity loads only and was supported by the primary system. The tower's lateral stiffness is primarily derived from a cantilever mode, with 80% of the lateral sway due to column shortening and only 20% due to shear frame effect. Fig. 2 shows distribution of column axial forces when tower is subjected to wind on a broad face. The almost uniform stress distribution on flange face and the approximate linear decrease of stress across the web indicates a predominant cantilever mode and very little shear lag effect in the tower behaviour. Adoption of the diagonally-braced rigid tube concept resulted in a total steel quantity of 29.7 lbs. per sq. ft. (145 kg/m²) which represents an efficient, low premium structural system.

The floor system consists of a 5″ (12.7 cm) semi-lightweight concrete slab placed directly on steel beams having shear studs to develop composite action. On apartment levels, the beams were arranged in such a way that they would fall in line with partition and walls. The bottom surface of the concrete slab was plastered and used a finished ceiling. The geometric discipline of the exterior or diagonal system was maintained with three typical office floor heights (approx. 12′–6 each) used for four apartment stories (approx. 9′–4 each).

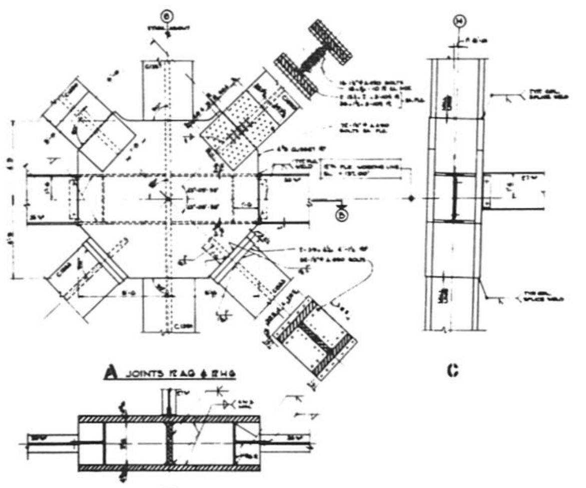

*Fig. 4 Joint detail at 12th floor level*

**Steel Fabrication**

The columns, diagonals and ties were fabricated to an I-section composed of three independent plates welded together. This shape was used as it greatly simplified the joint details. The maximum plate thickness was 6″ (15 cm) and the maximum overall dimension of a column 36″ x 36″ (91.5 cm x 91.5 cm). All floor framing was designed for gravity load only, and rolled beams with simple connections were used. The interior columns were designed for gravity loads using rolled and built-up sections. The majority of the structure was fabricated from A-36 steel. The only exception were gusset plates at diagonals to column joints which utilized A-441 steel ($F_y = 42$ ksi).

Field welding was used only with spandrels, main ties and column splices. Fig. 4 shows details of a central diagonal-column joint. The joint consists of double gusset plates to which diagonal members are connected by high-strength A490 bolts. Connections with columns at top and bottom of the gusset plates were similar to typical column splices with web bolting and minimum partial flange welds. All gusset plate assemblies were shop welded. The welding of corner gusset plate assemblies introduced residual stresses and therefore needed stress relieving. The simplified detailing resulted in a speed in excess of 3 floors per week.

**Conclusion**

The diagonally-braced tube system used in the John Hancock Center represents the simplest and the most efficient steel structure that have been conceived so far. The system offers considerable potential to be used in a variety of ways. The exterior framing of structure offers unique opportunities for different architectural expressions.