One Shell Plaza, Houston, Texas (USA)

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2. One Shell Plaza, Houston, Texas (USA)

Owner: *Gerald D. Hines Interests, Houston, Texas*

Architects-Engineers: *Skidmore, Owings & Merrill, Chicago, Illinois*

Contractor: *W. S. Bellows Construction Co., Houston, Texas*

Completion date: *1971*

The 52-story One Shell Plaza (Fig. 1) is the first building designed on the basis of tube-in-tube concept. The building rises 714 ft. above street level and is the world's tallest lightweight concrete building. The exterior tube is formed by closely-spaced column-spandrel beam grid, while the inner tube is shearwall enclosure of the core. It measures 132 ft. by 192 ft. in plan (Fig. 2), offering a 40 ft. clear column-free office space between outer and inner tubes. The total framed area is 1.3 million square feet. The building, designed to resist hurricane wind pressure, involved minimal premium for its height.

Structural System

The project was originally thought of as a 35-story building due to practical foundation limitations, even though a taller building up to 50 stories was desirable from an investment point of view if it was economically feasible. A preliminary analysis showed that if high strength, lightweight concrete (115 lbs. per cu. ft.) could be used in combination with tube-in-tube system, then a 52-story building could be built for the original estimated unit cost of 35-story building.

The tube-in-tube concept used in One Shell Plaza is a further evolution of the frame-shearwall interaction concept used in the Brunswick Building. Here, the exterior frame characteristics were modulated to represent a punched wall, or a bearing wall with small penetrations, in order to reduce the shear frames component of the lateral deflection to a minimum at 15 to 20 per cent level. Close column spacing at 6 ft. and deep spandrel beams constitute this punched tube. The close spacing also reduced the window area and thus limited the air conditioning load. The space between exterior tube and the interior core is spanned by concrete joists and waffle slab systems, as shown in Fig. 2.

The structural joists were also spaced at 6 ft. on centers so that each joist was supported at the perimeter column. This simplified the spandrel beam design and detailing. The perimeter columns are 2 ft. wide and are spaced 6 ft. on centers. The column depth was increased near building corners to compensate for heavier loads from waffle slab column strips. This structural feature, expressed on outside face of the tower, created an undulation effect (Fig. 1). The spandrel beams are approximately 4 ft. 3 in. deep and their width varies in proportion to the column depth (Fig. 2). A 9.5 ft. deep transfer girder was used at second floor level to create larger openings at plaza level. The core shear wall thickness is 2 ft. at the base and reduces to 10 in. at roof level in 2 in. steps. A 6,000 psi lightweight concrete was used for columns, shearwalls, transfer girder and mat; and a 4,000 psi lightweight concrete was used for floor beams, joists and spandrels.

Mat Foundation and Soil-Structure Interaction

One Shell Plaza site in Houston has primarily overconsolidated clay extending down to more than 2,000 ft. below ground level, and therefore a floating type mat foundation is quite suitable. This means that the weight of the earth removed must approximately equal the weight of the building. This required a 60 ft. deep excavation, which was also the practical limit on excavation. The lightweight concrete was used for superstructure and mat in order to limit the superimposed loads. The mat measured 171 ft. x 232 ft. (52.46 m x 70.70 m) in plan and 8.25 ft. (2.52 m) in thickness. Soil-structure interaction between the clay and heavily reinforced concrete mat was considered. A significant differential settlement between the exterior columns and the shear core was anticipated and thus joists were designed to resist differential settlements.

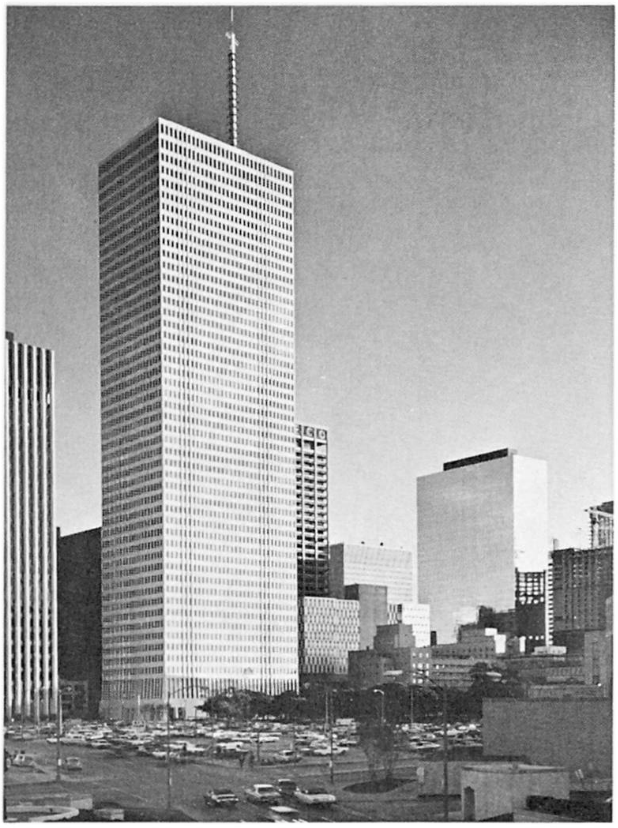

Fig. 1 One Shell Plaza building, Houston, Texas

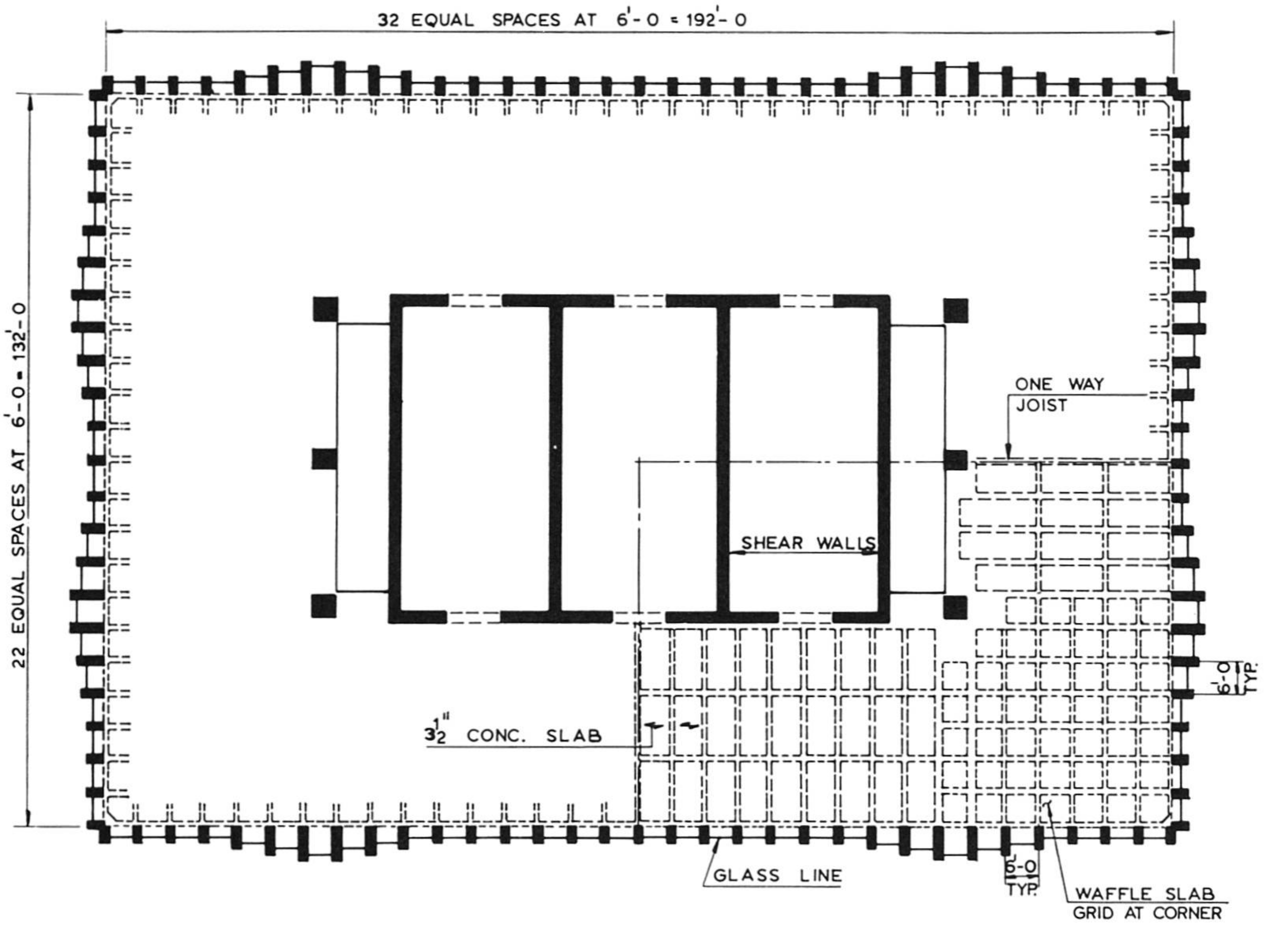

Fig. 2 One Shell Plaza – Typical floor plan

Creep, Shrinkage, and Temperature Details

Temperature analysis was made for all columns, and glass line was so located that the maximum relative movement at the top of the building under the most severe winter conditions should not exceed 3/4 in. (1.905 cm). The resulting glass line interestingly follows the column profile instead of arbitrarily being a straight line. This is shown in Fig. 2. Nominal modification of typical partition details was needed to avoid stresses in the partitions for such movements. The detailing of connection between cladding and the structure took into account the relative movements between cladding and the rest of the structure and provided mechanism to relieve such stresses.

To account for creep movements, shear wall and the interior columns were connected by a deep beam, as shown in Fig. 3. This arrangement made the adjacent columns act as part of the shearwall system. Since the shearwall with lower percentages of vertical reinforcement creeps more than the adjacent column, the connecting beam basically transfers loads from the shearwall into the adjacent columns. The result is that the adjacent column has to accept more load than would be considered by elastic design and the shearwall will be shedding load over a period of time. The connecting beam was thus designed for the necessary shear transfer from the shearwall into the adjacent column.

Summary

Tube-in-tube system introduced in One Shell Plaza represents a logical integration of inner and exterior tubes for structures which demand added stiffness and strength to resist extreme wind loadings and, in its various forms, offers potential for use in ultra-tall buildings.

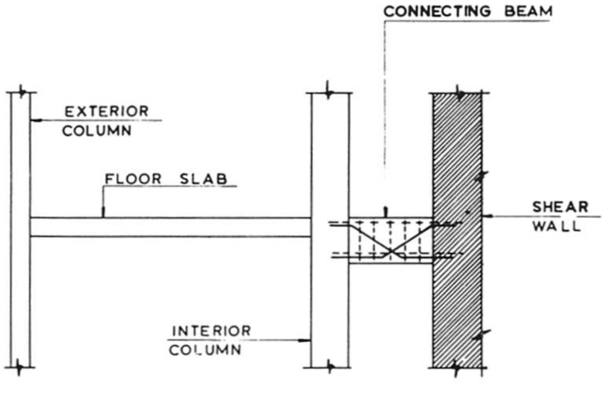

Fig. 3 Connecting beam between shearwall and column