Design-Construction Feature

The Carrier Dome Syracuse, New York

Describes the principal design features and erection aspects of the Carrier Dome—one of the largest and most innovative indoor stadiums built in the United States.

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On September 20, 1980, the Carrier Dome officially opened with the first football game of the season at Syracuse University, New York.

The Carrier Dome, a new 50,000-spectator stadium, provides space for collegiate team sports such as basketball and football, as well as entertainment such as rock concerts and circus performances.

The ground was broken just 17 months earlier. This tight schedule could be met only through the use of precast elements for the major part of the structure and an air-inflated roof design. Thus just only 8 months after the first precast component was erected, roof cables were strung, fabric panels that form the roof skin were installed, and the roof was inflated on July 15, 1980.

The price tag for this stadium was $26,000,000 or $520.00 a seat. The major reason for the low cost of the building is the highly integrated mechanical and structural designs.

In structures with air-inflated roofs, the mechanical systems become part of the structure and thus are much more complex than those in conventional buildings. Since hot air supply is used at the roof

Panoramic view of the Carrier Dome, Syracuse, New York.

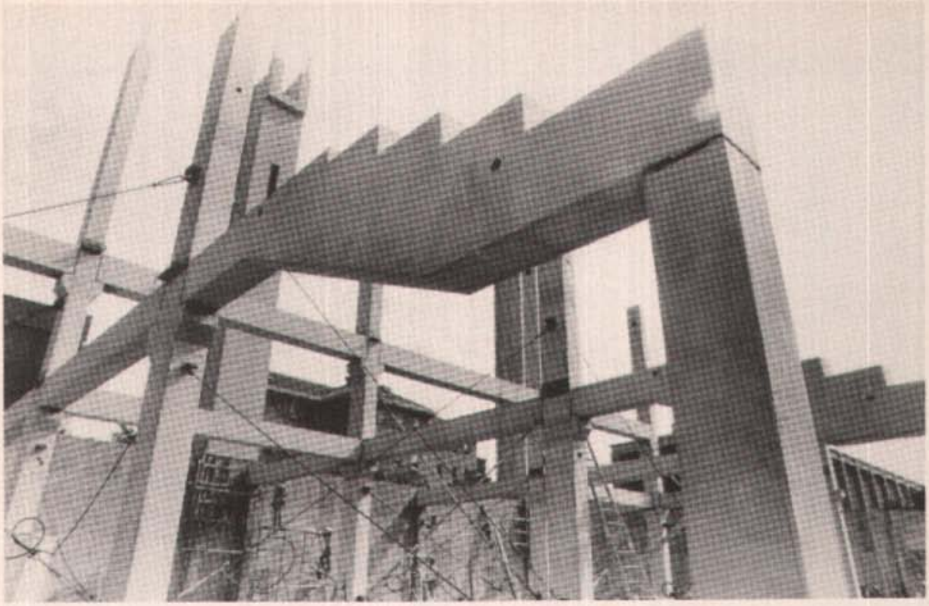
level for melting accumulated snow on the roof fabric, the columns supporting the ring beam are box columns and used as hot air ducts.

Similarly, the ring beam, "U" shaped in cross section, acts as a big gutter for the roof and is used as a retention tank because the existing storm system cannot instantaneously accommodate all the rainwater from the 6.5-acre (2.6 ha) roof.

Structural Design

The behavior of the air-inflated roof substantially influenced the structural design of the building. The fabric roof, reinforced by fourteen 2⅞-in. (73 mm) diameter cables, is bordered by a 13 ft 2 in. (4 m) wide ring beam which encompasses the roof membrane not unlike a picture frame around a painting. This beam resolves the horizontal components of the cable forces and distributes horizontal wind loads. For the ring beam to be effective in this manner, it must be allowed to move radially but must be restrained vertically and tangentially for stability. This was accomplished by rigidly connecting the ring beam to the 60-ft (18.3 m) high columns and hinging the columns radially at their base.

Wall elements between the columns consist of 2-ft (0.6 m) deep double tees floating between the bottom of the ring beam and the top of the foundation wall. Only at the cut-off corners of the building, two 40-ft (12.2 m) wide bays of double tee walls are reinforced and rigidly attached to the columns, ring beams, and foundation walls to form a lateral shear wall. Even



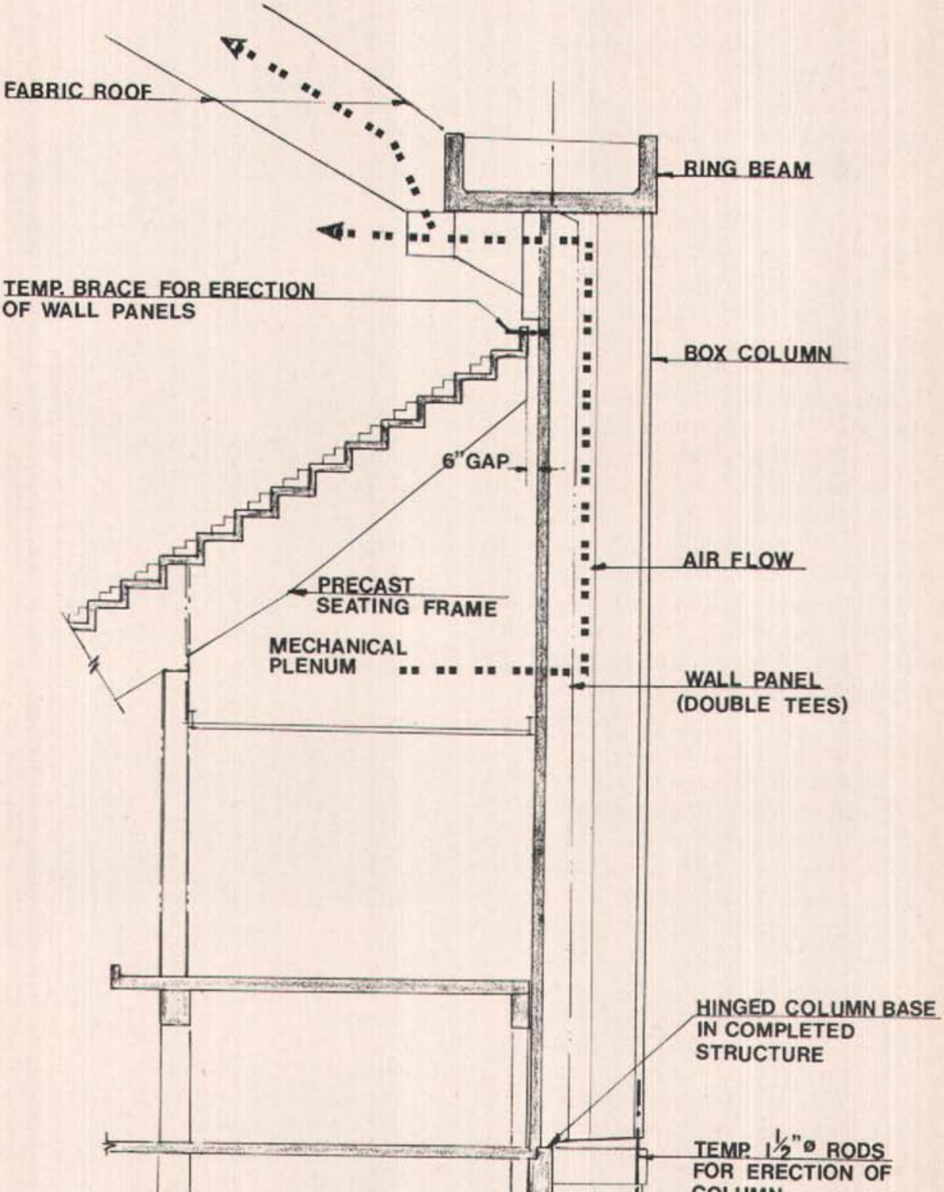
Precast prestressed concrete frame in place.

Erected box shaped precast column in the foreground is assembled in place from two heavy double tee precast sections. In the background a column half weighing 35 tons (32 t) is lifted in place.

this shear wall is detailed to tilt radially so that the ring beam retains its effectiveness.

The box columns are made of two heavy 8-ft (2.4 m) wide and 3-ft (0.9 m) deep double-tee sections with their stems attached to each other. The ring beam, flush with the exterior face of the columns, is cantilevered 6 ft (1.8 m) toward the center of the building. It is constructed of two 4 ft 6 in. (1.4 m) deep precast beams that form the upstanding legs of the "U" section. A 3 in. (76 mm) filigree slab spanning between the bottom of 4 ft 6 in. (1.4 m) deep precast beams form the horizontal tie of the "U".

Cast-in-place topping [8 in. (203 mm)] covers the filigree slab and is doweled to the upstanding beams achieving a com-



Exterior wall framing system.

posite structural section. The precast beams are spliced over the columns through a 6-ft (1.8 m) wide concrete rib cast in place. This rib also receives the anchor of the roof cables and transfers the large horizontal forces from the cables to the ring beam.

The geometry of the exterior wall system and ring beam supports were dictated by the most economical fabric span which results in a roof cable spacing of 40 ft (12.2 m). Thus, the exterior column spacing varies between 40 and 60 ft (12.2 and 18.3 m) for geometric reasons. The interior structure supporting the seating and concourse level is fully independent from the exterior wall framing.

As a result, the most economical structure for the seating bents and precast seats could be obtained. Average spacing of the seating bents is 26 ft (7.9 m). All bents, including all framed seating units, vomitory components, and tie beams are precast. Concourse framing consists of an 8-in. (203 mm) deep hollow-core slab with 2 in. (51 mm) topping. Only the foundation work, grade beams, slab on grade, and the exterior stairs are cast in place.

Erection

The erection of the structure was expedited through the use of precast concrete elements allowing uninterrupted work through the winter. All connections were either bolted or field-welded and grouted during the warmer spring months. For the erection of the exterior wall system, the column halves, each weighing 35 tons (31.8 t), were lifted vertically in place and bolted through 1½-in. (38 mm) diameter treated rods to the prepared foundation piers. The column halves were then connected through field-welding of lacing plates at 2 ft (0.6 m) center to center to form the box column. Foundation and box columns were designed to accommodate the erection stage of a freestanding 60-ft (18.3 m) high cantilevered column.

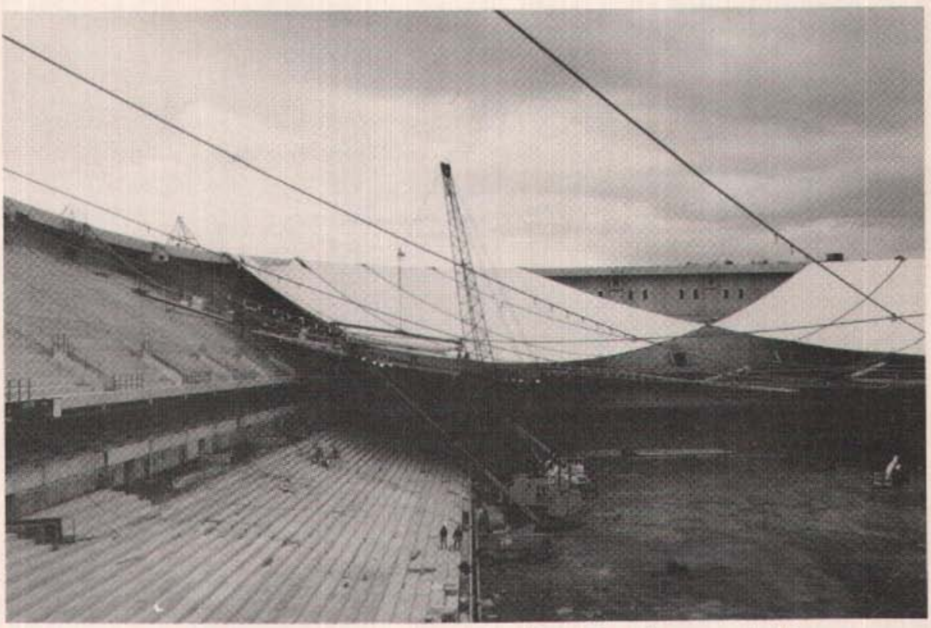
The ring beam, supported by the box columns, braces the double-tee walls. However, since the ring beam was erected after the placement of the double-tee walls, the tees were braced temporarily by the interior seating framing until the ring beam was complete. The flanges of the double tee were bolted together with lacing plates forcing uniform deformation of the wall components. Differential movement of the tees could cause air leakage which must be kept to a minimum, since the final structure is pressurized to keep the roof inflated.

Precast twin tee column in place, adjacent column being erected.

Construction of the stadium bowl. The interior arena space lends itself readily for storing the precast columns and bents.

Erection of the exterior wall system. Openings in the wall panels are for air intake dampers. Note the cantilevered steel dunnage to receive the inside precast flange for the "U" shaped ring beam.

The erected stadium bowl 8 months after ground was broken. The precast double tees and columns create a clean and maintenance free exterior.



Erection of the roof fabric over the strung roof cables. The gig supported by an overhead cable spools out the fabric roof panels which are clamped to the roof cables.

Aerial view of roof material being installed.

The Carrier Dome—A new sports facility for Syracuse University.

Night view of the completed Carrier Dome in Syracuse, New York.

The completed stadium in use. 50,000 fans can be accommodated for football, track and field, and basketball.

PRESTRESSED CONCRETE COMPONENTS

A total of 307,203 ft^3 (8700 m^3) of precast concrete was used consisting of:
Ring columns: 72 units 60 ft (18.3 m) high
Compression ring members: 36 units 40 to 60 ft (12.2 to 18.3 m) long
Double tee wall panels: 346 units 60 ft (18.3 m) high
Columns for seating structure: 238 units
Beams and bents: 346 units
8-ft (2.4 m) hollow-core slabs: 150,700 ft^2 (1400 m^2)
Lower level bleachers: 218 units
Parapet walls: 20 pieces
Upper-level bleachers: 566 units
Vomitory and stairs: 112 units
Filigree slabs: 288 units

After the installation of the wall components, the ring beam was erected. A steel dunnage, cantilevering 6 ft (1.8 m) toward the interior of the building from the erected box columns, supported the interior precast ring beam sections as well as the roof cable anchors. Continuity of the ring beam was achieved by catwelding extended reinforcing bars of the precast ring beam section together. Reinforcing bars from the exterior face of the box columns were extended into a 6-ft (1.8 m) wide rib, which ties the exterior and interior leg of the "U" shaped ring section together.

Filigree slabs were placed between the vertical precast elements of the "U" section to form the bottom of the "U" and receive the extended vertical dowels of the double-tee wall sections. An 8-in. (203 mm) topping was then placed over the filigree to achieve a composite section and to provide full lateral hold of the double-tee wall elements. After completion of the ring beam, the double tees were released from the interior structure, and the 1½-in. (38 mm) diameter threaded rods of the outside flange of the column at the base were removed to achieve the hinged condition. Joints between the wall double-tee flanges were closed by backer-rods and sealants to achieve an airtight building envelope.

The roof cables were strung and the roof fabric was attached once the interior framing was complete. Since the roof fabric was installed from the roof cables, the interior space remained unobstructed for the completion of the interior framing.

All in all, the erection of the 50,000-spectator arena was accomplished in a record 17 months. The cost of the precast concrete and its erection was 6 million dollars, 23 percent of the total construction cost.

Credits

Architects: Finch Heery, Huber, Haves, Glavin, Syracuse, New York.

Engineers: Geiger Berger Associates, P.C., New York, New York.

General Contractor: Huber, Hunt & Nichols, Indianapolis, Indiana.

Precast Prestressed Manufacturer: Wincrete Pre-Cast Corporation, Syracuse, New York.

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