Post-Tensioned Composite Truss Reduces Costs

A new proprietary truss system consists of wide flange sections for the tension chords and web members and concrete-filled tubular members for the compression chord

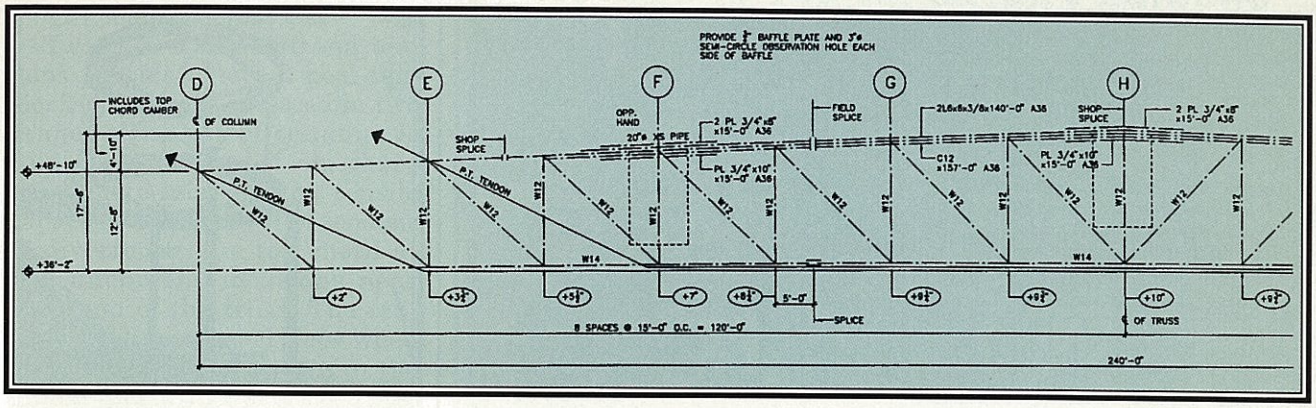
By Jon M. Jorgensen, P.E.

As the convention and trade show business continues to grow, many cities are expanding their existing facilities to handle these bigger shows. But as competition intensifies, design requirements become more stringent. When the Convention Center at Myrtle Beach, SC, recently tripled the size of its existing 80,000-sq.-ft. facility, the owner required a 420'x 240' column-free space with a minimum 35' ceiling height and that the space could be easily subdivided into three separate exhibit halls. In addition, the expansion needed to be able to accommodate arena or stage functions with 10,000 movable seats.

The expansion includes a spacious new pre-function area, featuring a glass roof and wall next to the main entry drive, which offers an accessible and attractive design. A new loading dock with other service areas is conveniently located at the rear parking area. A new lobby, which permanently houses the South Carolina Hall of Fame, is located in the space between the new construction and the old facility, which was converted into a grand ballroom, meeting rooms and support areas.

The project was bid under a design/build contract, led by Centex Rooney Construction Company of Fort Lauderdale, FL. Other key members included architect Cannon of New York City, structural engineer Bliss & Nyitray, Inc., of Miami, and steel fabricator Owen Steel, an AISC active member.

The expansion's success hinged on whether the 100,800-sq.-ft. main hall could be built to the required specifications and within budget. Factors considered in choosing a structural system included a variety of loading conditions—live, snow, wind, seismic, uniform hanging and



movable hanging load. Effects of temperature and temporary load conditions during erection also were considered.

A variety of systems were considered and the building team ultimately chose a combination of steel roof deck, open web steel joists spaced 15' o.c., and a series of boxed double joist girders spaced 60' o.c. The joist girders spanned between the end wall frames and two primary 240'-long trusses, located 120' apart and centered over the main exhibit hall.

Diaphragm stresses and wind uplift resulting from ASCE 7 wind loads at the perimeter zones controlled the selection of the 3" steel roof deck. The typical 36"-deep long-span joists worked comfortably under normal uniform loads, and their capacity was easily increased to adapt to special loading requirements. The 12'-deep, 120' x 150' long double joist girders were assembled into box sections by spacing the girders 7'-6" apart and connecting their top and bottom chords on the ground before hoisting. This construction permitted the use of moderately sized components, repetitious usage and easy transportation from the plant to the site. The box trusses did not require additional lateral bracing during or after erection and allowed the future installation of catwalks as required. These same boxed truss girders served as lateral supports for the end wall frames and the two primary interior trusses.

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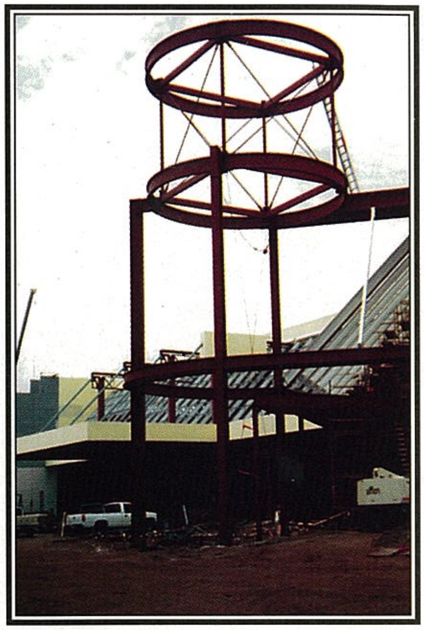


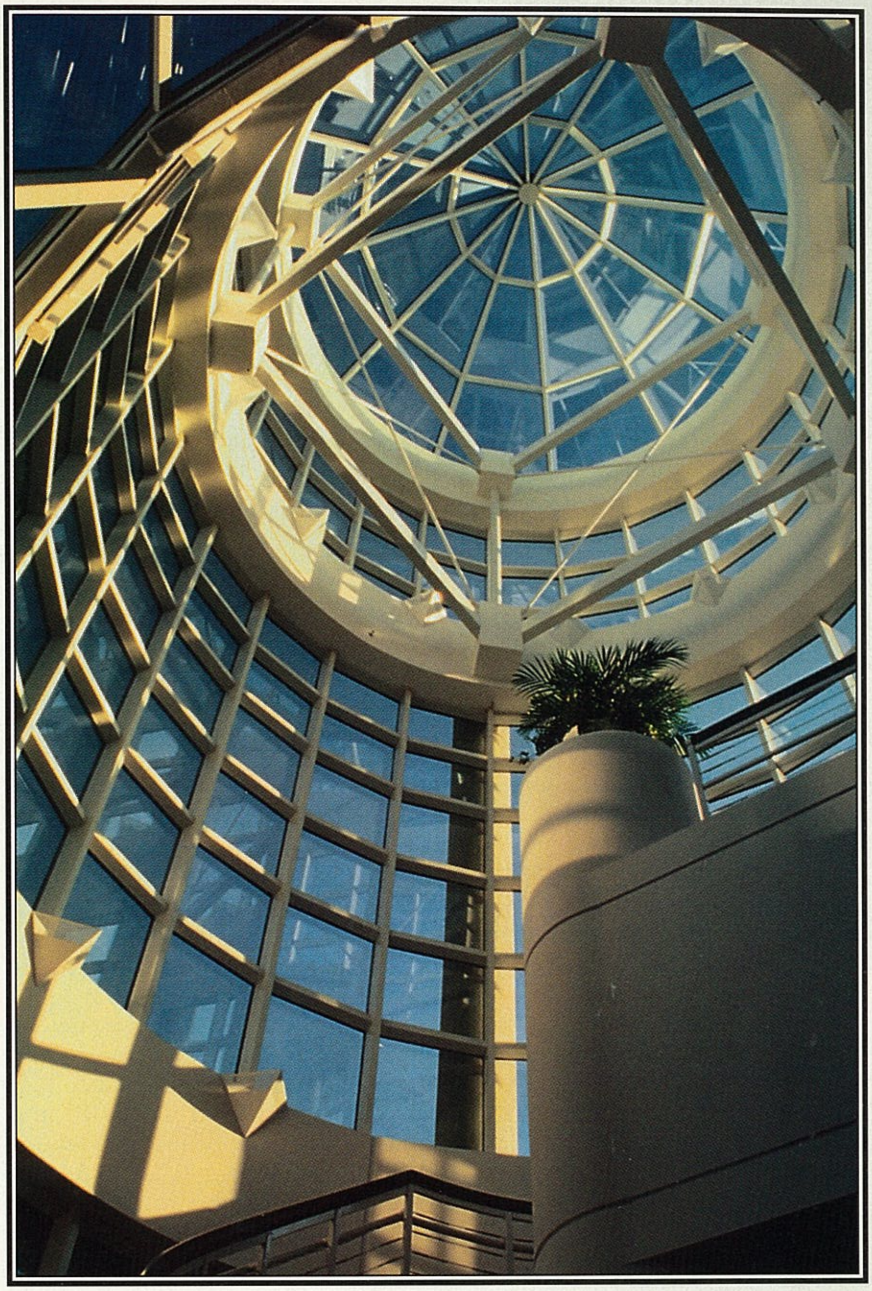
Innovative Truss System

The design/build team made a cost comparison between primary truss systems: a conventional wide flange truss and a proprietary post-tensioned composite truss called the SuperTruss. The SuperTruss system was developed by Bliss & Nyitray, Inc., for longspan roof structures such as stadiums, arenas, hangars and, of course, convention centers. The Myrtle Beach Convention Center was the first project selected to use the system and it met all expectations.

The SuperTruss system consists of a basic steel truss built with readily available rolled shapes for the tension chord and web members, and tubular shapes for the compression chord. After erection, the truss is "supercharged" by adding high-strength concrete in the tubular top chord and external post-tensioning tendons to the bottom chord and selected web members. These modifications vastly increase the basic truss' capacity without significantly increasing the size of the connections. As an added benefit, post-tensioned tendons, using the principles of load balancing, provide very reliable control of truss deflections, which was important since the trusses directly supported fulllength, folding partitions.

Two sets of multi-strand tendons provide external post-tensioning and were stressed in two stages. One set of tendons is routed along the bottom chord member to increase the tensile capacity; the other set of tendons is diverted to the top chord at two anchoring locations near each end of the truss. The tendons acted as tension webs when diverted from the bottom to the top chord locations and further served to increase the truss' shear capacity.

The top chord was filled with 10,000-psi regular weight concrete modified with a high-range water reducer. This concrete, acting composite with the steel pipe, provides 75% of the total required capacity of the top chord. Concrete was pumped through ports fitted with valves; ports and valves downstream of the advancing concrete released the trapped air. The valves were closed when the concrete flowed from the relief valves. As the concrete left the last valve, that valve was closed and pump pressure was maintained, assuring complete filling of the chord. When the concrete had cured for 14 days and the post-tensioning tendons were fully tensioned, the shoretower was removed. Truss deflection was then checked to confirm previous calculations. The results showed that the post-tensioning relieved the shore load by approximately 50%, making shore removal easier.



Erection

Each SuperTruss was erected using three cranes and one temporary shoretower. Two cranes, one at each end, lifted and placed each truss. A third crane at midspan held and braced each truss while the other two cranes were repositioned to erect the joist girders. Once the three box trusses were connected to the SuperTruss, providing bracing for both the top and bottom chords, the center crane transferred the load to the midspan shoretower.

To obtain an efficient lateral bracing system for the approximately 60'-high building, the perimeter wall frames included carefully selected, infilled, reinforced masonry shear walls. The walls were built to allow two primary expansion joints located near the third points of each long side. These joints extend through the masonry walls along the lower, front pre-function structure and the rear loading/service structures. To preserve the roof deck's horizontal diaphragm, the joints do not extend through the exhibit hall roof structure.

Wide flange columns ranging from W10s to W18s surrounded by reinforced masonry piers support the roof at 30' o.c. At the middle section of the long walls, the W14 columns supporting the SuperTrusses and those between them were made composite with the piers by infilling with concrete. Other columns on the long sides were not encased in concrete and are thus free to move within the masonry piers. The flexible, non-encased column

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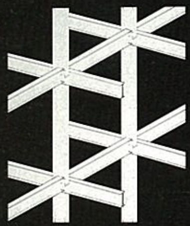

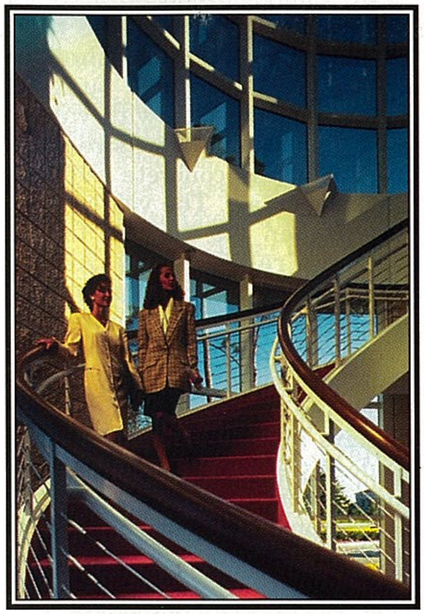

design accommodates the different thermal movements of the 420'-long roof structure without expansion joints, and the three separate wall portions the vertical expansion joints created. Columns on the end walls are of the same construction as those supporting the main trusses. These columns are designed to support lateral loads perpendicular to the plane of the walls.

The roof structure for the remainder of the facility uses conventional steel construction with open-web joists and joist girders. The limited second floor areas, designed for 100 psf superimposed loads, were designed using 2" composite metal deck and composite floor beams supported by composite joist girders.

The preliminary geotechnical report identified subsoil conditions having a potential for soil liquefaction in case of seismic activity. Vibro-compression was used to prepare the granular soils under the primary supports to increase bearing capacity and eliminate the liquefaction potential. This modification of the subsurface soils allowed the use of conventional spread and wall footings throughout the project, thus reducing construction time and cost.

The ground floor generally consists of floating slabs on grade; those installed in the bathroom facilities are suspended slabs designed to prevent plumbing damage from soil settlement caused by liquefaction. To control cracking, the exhibit hall floor is a 6"-thick slab with control joints at 15' o.c.

The new exhibit hall was constructed in 11 months, on time and on budget. The project received a Grand Award in the 1996 Engineering Excellence competition sponsored by the Florida Institute of Consulting Engineers.

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