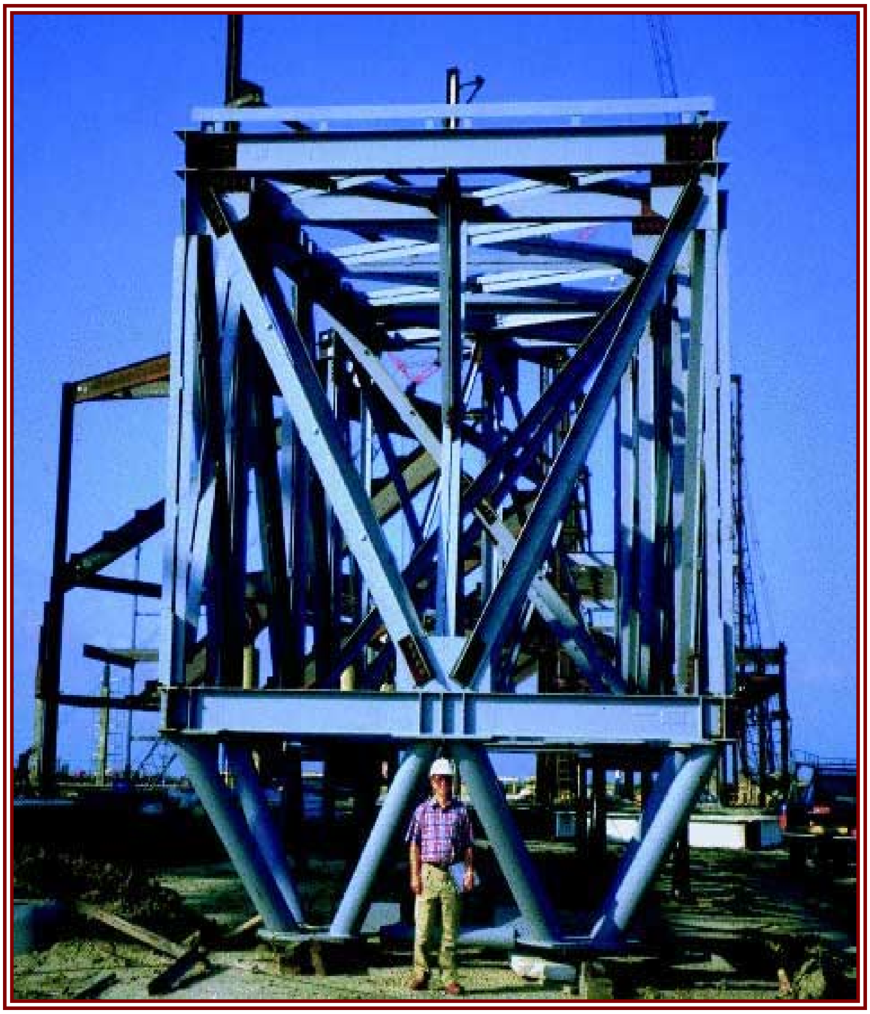
“TABLE TOP TRUSS” SUPPORTS ARENA ROOF

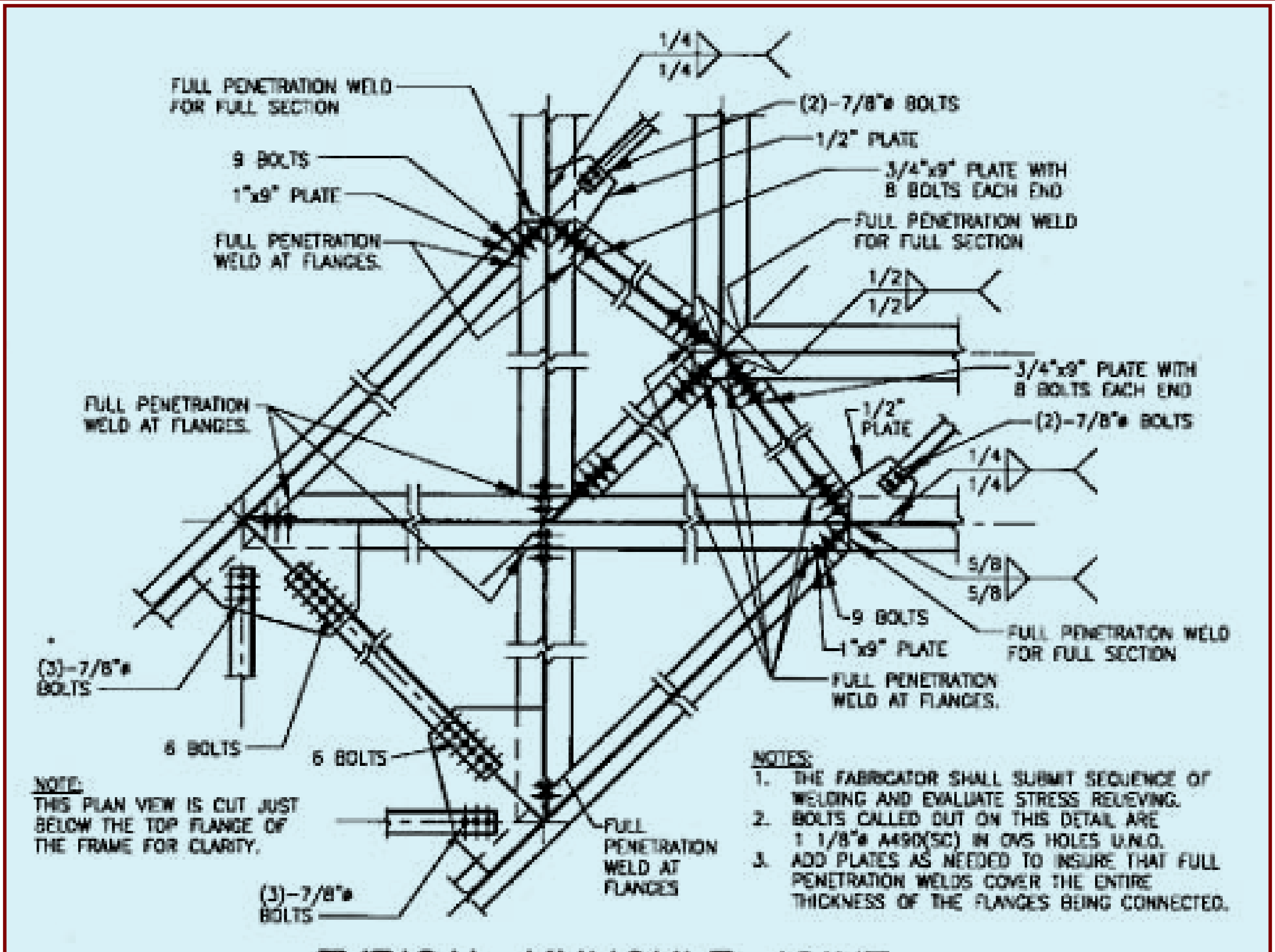
The roof system for the new Reed Arena at Texas A&M University takes a skeletal form that works in perfect synergy with the architectural design and diverse functions of a modern multipurpose arena



By Lawrence G. Griffis, P.E. and Douglas G. Ashcraft, P.E., S.E.

FOR THE PATRONS LOOKING UP AT THE ROOF SYSTEM FOR THE NEW MULTIPURPOSE arena on the campus of Texas A&M University, it won’t be difficult to figure out what is going on up there. Rather than seeing a structural system that follows a more traditional form but seems to fight the often complex catwalk, rigging, lighting, and sound support systems that are randomly hung from it, the skeleton of this arena works in perfect harmony with them. Why? Because the longspan roof system was purposefully conceived to economically span the great distances required of a modern arena and at the same time function in harmony with all the systems that drive the operation of such a building. It’s the kind of solution borne out of extensive experience with the building type.

The Reed Arena is a modern multipurpose arena used for graduation commencements, basketball and sporting events, concerts, circuses, ice shows, rodeos, banquets, and conferences. Designed by architect Lockwood Andrews Newnam, Inc. and structural engineer Walter P. Moore and Associates, Inc. (WPMA) both headquartered in Houston, it seats 12,500 for basketball (7,500 at the main



TYPICAL KNUCKLE JOINT

level and 5,000 balcony seats) and can accommodate 2,000 playing floor seats for banquet events. The facility contains a total of 230,000 square feet with a 6000 square foot meeting room on the third level and four 1,200 square foot meeting rooms on the second floor in adjoining space to the main seating bowl. At an economical cost of only $36.8 million, the building is located on the west campus across from Kyle Stadium where the Aggie football team plays.

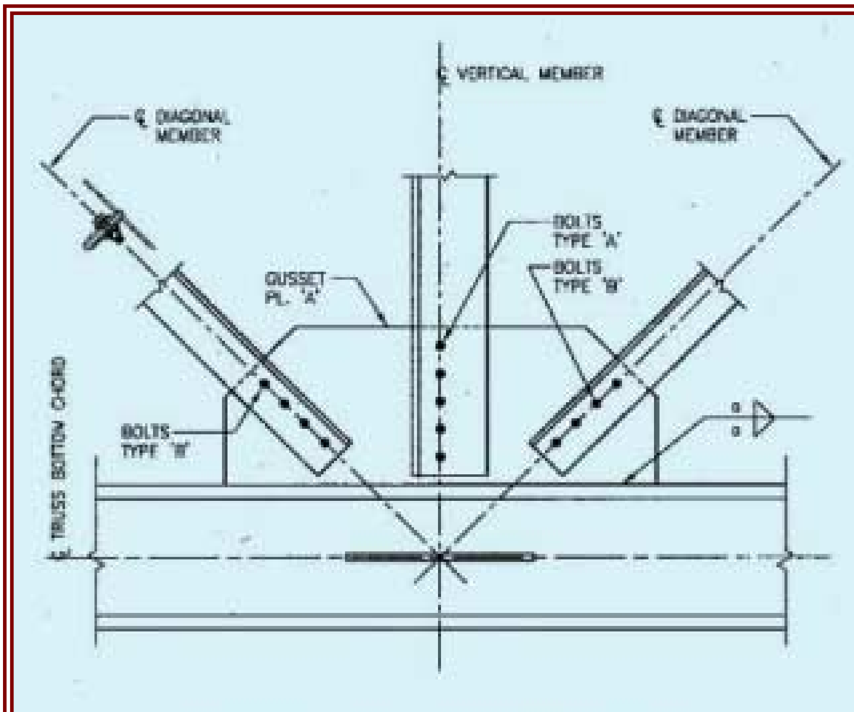
Roof Framing System

The logic that went into the structural roof form, dubbed the "table top truss system" because in plan it looks like a flat table with four projecting corner legs, can best be understood by exam-

ining the catwalk/rigging plan located at the bottom chord truss level. Good building design should have the architecture and structure complimenting each other. The idea was espoused by 19th century architect, Louis H. Sullivan, who stated that "form follows function." All modern arenas require a catwalk system that circles the playing floor to support sound and lighting systems as well as provide access to them and to the scoreboards. Within the footprint of the catwalk area above the playing floor located at the same level is a crisscrossed pattern of rigging beams that support both center stage and end stage concert events. Modern concert and road shows demand hanging loads as much as 120,000 pounds, with point loads of 8,000 pounds. The WPMA engineering team worked closely with the operator to establish capacity and spacing of the rigging beams, placed in a 16'x22' grid, which were designed as two parallel built up W14 sections 1' apart and laced together as a box beam. This configuration accommodates the vertical and lateral load patterns for rigging concert events with maximum flexibility. The beauty of the roof system lies in the fact that the "table top truss system" takes the form of a box truss in cross-section with the bottom chord of the box truss providing access for the catwalks surrounding the playing floors. The skeletal plan of the box truss defines the area of the rigging gridiron, which is hung from the roof joists at the center and frames into the box truss at the periphery.

The box truss plan configuration has several other advantages as well. WPMA engineers were able to convince the architect to "pull in" the columns in plan at the corners of the bowl and to sculpt the balcony seating around the double concrete column truss supports. This substantially reduced the effective roof span over a conventional two-way truss system and helped to save steel weight. The box trusses were typically 6'-6" wide by 24'-0" deep at the periphery of the playing floor and 17'-0" wide by a varying depth of 15'-9" at the column support and 24'-0" deep at the center connection point. The box shape cross-section provides a very stable shape for erection, is self-bracing and also houses the catwalks. The box trusses substantially reduce member sizes for ease of fabrication and field erection. A572 Grade 50 chords were nominal W14 shapes (the largest is only a W14x193) with double angle posts and diagonal braces. All truss members were high strength bolted together using either 7/8" diameter or 11/8" diameter A490 slip critical bolts in oversize holes to reduce gusset plate size and tonnage, but still allow erection tolerance for fit up. Four corner "knuckle joints" at the top and bottom chords were shop welded together with a carefully prescribed welding sequence to minimize shrinkage and distortion. Ultrasonic examination was provided in the shop to ensure proper welding and conformance to dimensional tolerances. The Welding Procedure Specifications (WPS) were developed in conjunction with the fabricator and J.W. Post and Associates, Inc.

In-fill steel within and around the "table-top-truss-system" is provided by conventional deep longspan joists. 44DLH joists were used around the perimeter. 60 DLH and 28 LH joists were used within the perimeter of the playing floor area. Note that the joists were turned 90° at the ends of the center section to provide a balanced loading of the box truss and to minimize cross-sectional torsion. A specially designed 12'-deep joist girder picked up the longspan joists that were turned 90° and framed their load into the box truss. The design of the roof system proved not only to be very functional but economical as well. The architectural design required an exposed structural steel tapered capital or haunch detail over the double concrete column corner supports. 10" diameter standard pipes were used to transition from the bottom chord of the box truss to the concrete support columns, which were formed at the top with tapered capitals themselves. The tapered pipe truss support detail terminated to a 4'-0" diameter steel plate supported by four guided highway type pot bearings resting on top of the concrete column. The pot bearings provided shear resistance transverse to the corner box truss axis but permitted translation and rotation parallel to the truss axis.



TYPICAL TRUSS CONNECTION DETAIL

Roof System Erection

Project specifications required the general contractor to submit a detailed erection procedure that specified the precise step-by-step process used by the fabricator/erector team to erect the roof system. Experience has shown that a detailed written erection procedure, complete with details of shoring tower connections to the trusses, guying of showing towers, jacking procedures, schedule of bolting sequences, metal deck erection sequence and similar items is an excellent way to ensure a carefully planned and successful roof erection. It also ensures that the roof is stable at all stages of the erection process.

WPMA engineers offered two erection procedures for consideration by the erector. Both methods were analyzed for stability and erection stresses in the box trusses. The first method was conceived to be a natural outgrowth of the skeletal box truss plan. It involved assembly of the box trusses at or near playing floor level and jacking the complete "table top truss system" with all joists and metal deck in place in the center section over the playing floor defined by the area inside the box truss periphery. The double concrete columns at each corner would serve as jacking columns to raise the box truss assembly in one lift. The second method defined a more conventional approach using four shoring towers, one at each "knuckle joint" of the box truss assembly. The four corner box truss "leg" sections would be erected and placed on the shoring towers and corresponding corner columns followed by erection of the box trusses forming the sides of the rectangular center area over the playing floor. The fabricator/erector team chose the more conventional approach utilizing two crawler cranes lifting each truss section.

Column Support

Early value engineering studies showed that structural steel raker beams supporting precast seating were the most economical way to frame both the upper balcony and lower bowl. However, the architect required exposed concrete columns at the public concourse areas. WPMA engineers, therefore, utilized composite columns to carry the raker beams at the building perimeter. Interior concrete columns provided the other support for the raker beams. The composite column allowed normal AISC simple beam connections to the embedded W14 steel sections. Use of composite columns omitted the problem of embedded steel connection plates with headed studs that are difficult to design for carrying heavy loads and prone to congestion problems within the composite columns. Also, utilization of composite columns allowed the steel erection to proceed ahead of, and independent of, the concrete operations.

The owner's program required large open floor areas for meeting and conference rooms adjacent to the arena bowl. With an 83' clear span the floors for these areas were ideally suited for the use of the relatively new composite open web joist floor system. The floor system consisted of 2" deep 19 gage composite deck (2" + 41/4" slab) supported by 33" deep composite joists furnished by Vulcraft (33 VC). Joists were equally spaced between columns resulting in a variable spacing not exceeding 9'-0" on center. The General Contractor for the project was Huber, Hunt and Nichols. Steel fabrication was done by AISC-member Hirschfeld Steel.

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