Mac To Matt

Figure 1: Arena during construction. Courtesy of Hoffman Construction.

A State of the Art Arena for University of Oregon

By Ali A.K. Haris, Ph.D., P.E., S.E. and Guohui Guo, Ph.D., P.E., S.E., LEED AP

In January 2011, the standards for college basketball arenas were elevated. Specifically, University of Oregon's basketball program made the move from McArthur Court, their beloved 85-year old facility, to the new Matthew Knight Arena, a multi-purpose arena. The new facility has a seating capacity of 12,500 screaming fans, which will ensure its future as an NCAA Division I Arena. The funding was made possible through a donation from Nike's Phil Knight, in addition to expected ticket revenues, corporate sponsorships, and other donations. This state of the art venue will soon become known as a premier college basketball arena in the United States.

The project included three distinct components: the new multi-purpose arena with a practice court to the south, the five-story Ford Alumni Center and the two-story underground parking garage (*Figure 1*). Both the Alumni Center and parking garage were funded and constructed separately from the Arena.

Several criteria affected the arena design, such as the desire to keep a low profile, constraints of a tight site, and reflection of the letter "O" for Oregon within the plan geometry. TVA Architects, the design architects, and Ellerbe Becket, the sports specialty architects, arrived at the current design that satisfied such criteria. The elliptical sloping high roof tops off the facility's elegant design. Haris Engineering, Inc. was selected as the structural engineer, bringing their experience in sports facilities, including the previous successful completion of the Autzen Football Stadium expansion in Eugene, Oregon.

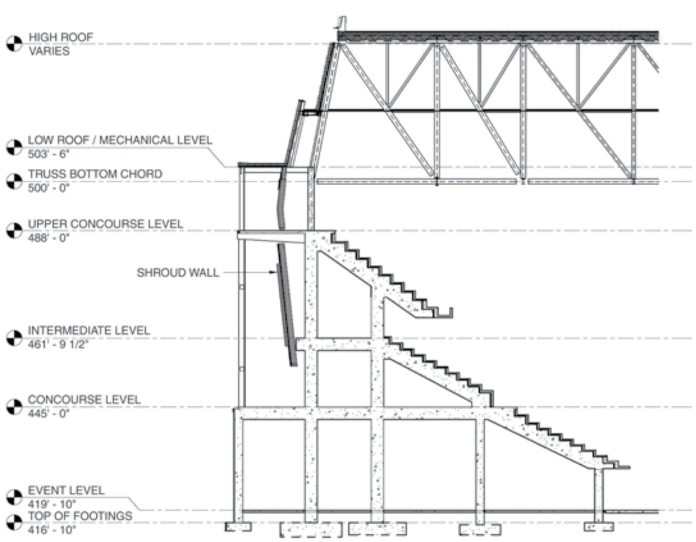

Figure 2: Arena typical elevation view.

Consistent collaborations enabled the completion of this structure on time and within budget. As the owner's representative, JMI Sports provided on-site construction management through all phases of development to construction closeout. Hoffman Construction, the general contractor, and their on-site staff played a major role resolving construction issues with continual communication with structural engineers and architects.

Foundation and Soil Retention System

To address the need for a low profile exterior, the court was lowered to 25 feet below the natural grade. The water table indicated in the geotechnical report is approximately 10 feet below the natural grade. Therefore, excavation needed to address the potential underground water issue. Two possible schemes were considered and designed by Haris engineers:

Scheme 1 designed the structure as a waterproof tub with hold-down piles at 15 feet on center to resist the hydrostatic pressure. The tub consisted of 24-inch event floor slab and 36-inch perimeter walls. This scheme was considered only if dewatering in Scheme 2 was prohibitive for the city storm water capacity.

Scheme 2 includes a complete drainage system to dewater underground soil and eliminate hydrostatic pressure on walls and floor slabs. This scheme was selected after it was determined that the amount of water to be pumped was manageable. For this scheme, the soil retention system consists of steel soldier piles with timber lagging and temporary tiebacks. The foundations included spread footings and cast-in-place concrete walls.

Structural Systems

Many structural systems were investigated and the two major systems with extensive studies were as follows: (a) reinforced concrete framing to concourse level and steel framing above; or (b) concrete framing to upper concourse level including concrete rakers and steel framing for low roof/mechanical floor and high roof. The latter framing system

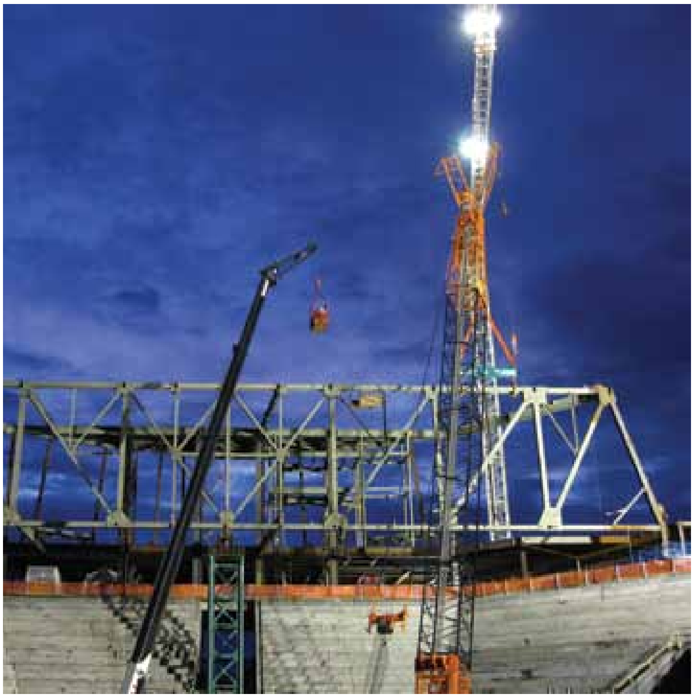

Figure 3: Roof truss erection. Courtesy of Hoffman Construction.

was chosen for efficiency in material, fast schedule and budget. *Figure 2 (page 23)* shows a typical building section of the arena.

The floor framing system consists of one-way reinforced concrete slab and beam system at concourse and upper concourse levels. The steel framing at the mechanical level consists of 3-inch concrete on 2-inch metal deck.

On the arena north and south sides, 18- and 14-inch round HSS members were used to provide supports for the building façade. Those members are architecturally exposed structural steel and filled with reinforced concrete.

Above the loading dock located on the west of the arena, 10-foot deep post-tensioned girders span more than 100 feet between arena and parking garage. Those girders were designed to support double tees, topping slab, heavy planters, and AASHTO HS20 truck loads.

Based on Seismic Design Category D assigned to the arena, a combination of lateral systems provided seismic force resistance: special reinforced concrete shear walls below the concourse level, special reinforced concrete moment frames for the concrete portion above the concourse level, and special steel moment frames (SMF) to support the mechanical level and high roof. For steel framing, either SMF (response modification coefficient R = 8) or special steel concentrically braced frames (SCBF, R = 6) could have been used. However, the R value used for design at any story below shall not exceed the lowest value of R that is used in the same direction at any story above that story. Thus, if the SCBF system was used, the special reinforced concrete moment frame would require an R value of 6 instead of 8 designated for this system. This would significantly increase the seismic load for the structure below.

Structural Design

Two separate SAP2000 models were developed for concrete frame analysis, the lateral model and the gravity model. In the lateral model, only concrete moment frames are able to resist lateral loads and moment frames were designed and detailed using this model. The remaining concrete members were pinned at their ends in this model. In the

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gravity model, all members were modeled with moment connections and designed accordingly.

The seismic lateral analysis was performed using the two-stage equivalent lateral force procedure outlined in ASCE 7. Two separate models were created, one for the upper structure using the special concrete and steel moment frames, and the other for the lower portion using special reinforced concrete shear walls.

The vibration performance of the arena is crucial during sporting events, especially with some raker beams cantilevering out 17 feet and some seating units spanning 40 feet. According to the 1990 *National Building Code of Canada* (NBCC) and AISC *Steel Design Guide No. 11*, a dynamic forcing function coupled with a live load of 30 psf was used for the vibration analysis in the SAP2000 model. The vertical acceleration at the cantilever end of raker beams and mid-span of precast seating units were kept below 5 percent of the acceleration of gravity, the maximum value recommended by NBCC.

The Prequalified Reduced Beam Sections (RBS) per AISC 358-05 was selected for SMF. To satisfy the code specified story drift requirements, heavy members, W14x550 columns and W36x256 beams, were required due to the inherent low lateral stiffness of SMF system.

Arena Roof

The roof consists of six Pratt trusses with spans ranging from 218 to 265 feet, and span-depth ratios between 6 and 8. The truss chords are wide flange members ranging from W14x74 to W14x370.

Geometric complexities of the roof – a sloping surface and elliptical shape in the horizontal plane – posed great challenges to the design of truss connections. In addition, connections for members that are part of the seismic load resisting system are required to be configured such that a ductile limit state controls the design. Thus it was critical that connections be designed and detailed in conjunction with the design of the members and seismic requirements. As a result, Haris engineers elected to design all truss connections for such a complex structural framing system.

The majority of the truss connections were field-bolted; field-welded connections were kept to an absolute minimum to speed truss erection. Having truss connections fully detailed on the drawings expedited the shop drawing approval process tremendously.

Roof trusses were pre-assembled at the steel fabrication plant, W&W Steel of Oklahoma City, to identify any potential detailing, fabrication, fit-up, and tolerance issues. Erection of each truss took approximately one week, including truss assembly in the field, shoring tower relocation, truss erection, and installation of fill beams and braces (*Figure 3, page 24*).

After all roof members were erected, it was discovered that the scoreboard load was much greater than had been anticipated in the original design. The scoreboard assembly weighs about 62,000 lbs, in addition to the hoist weight of about 24,000 lbs. As a result, the whole roof structure was reanalyzed, and several members and their connections were required to be strengthened accordingly (*Figure 4*).

REVIT Model

During design, 3-D REVIT models (*Figure 5*) were developed by the team to enable a more interactive design between architects and consultants. Responsibilities

Figure 6: The completed Matthew Night Arena. Courtesy of ericMaxwell Photography.

Figure 4: Opening game night. Courtesy of ericMaxwell Photography.

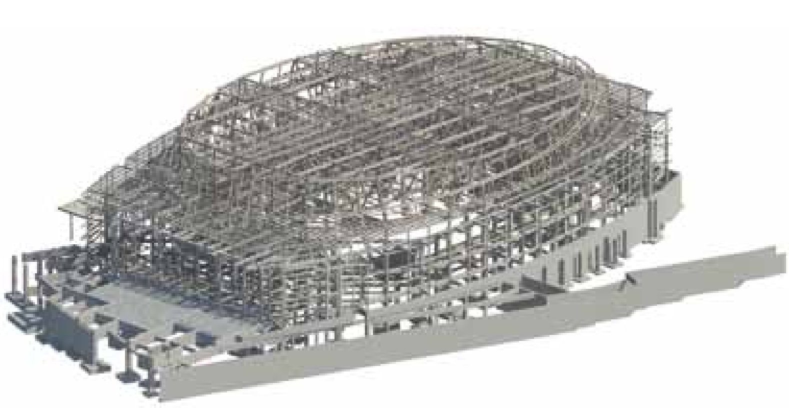

Figure 5: REVIT structural model.

for portions of the model were divided between the architects and structural engineers. For example, the precast elements were shown in the architectural REVIT model, while the raker beams were in the structural REVIT model. During design, REVIT models were exchanged between consultants and all parties collaborated effectively to identify conflicts and highlight areas that needed changing in the design. Also REVIT models were shared with the general contractor to conduct material quantity take off, facilitate construction by speeding erection, and identify conflicts at an early stage.

REVIT models were particularly useful when dealing with the complicated roof framing and shroud wall framing. The mid-roof slopes down from east to west, while the high roof slopes in the opposite direction. In addition, the mid-roof and high roof drum wall framings lean towards the inside of the arena. With REVIT models, Haris engineers were able to collaborate with TVA architects to coordinate numerous framing details successfully.

Conclusions

The journey of the Matthew Knight Arena began with schematic design in January 2006, continued with the ground-breaking in February 2009, and began an entirely new chapter with the grand opening in January 2011 (*Figure 6*).

The arena design and construction team provided University of Oregon with one of the most advanced college basketball facility in the country. University alumni, students, and enthusiastic fans can be proud to host their basketball rivals at the arena for many seasons to come. Go Ducks!▪

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