$100M or greater

EAE

Merit Award

Seattle Seahawks Stadium

Seattle

Photo courtesy Timothy Hursley.

Photo courtesy Michael Dickter, Magnusson Klemencic.

Juror Comment

"The idea of isolating the mass of the roof structure to resist lateral transfer loads in seismic events reflects a real sense of ingenuity by the engineering team."

The Seattle Seahawks Stadium and Exhibition Center is a $430-million public-private development project. It incorporates a 67,000-seat football/soccer stadium, a 201,800-sq.-ft exhibition hall, and a parking structure on a small site just south of downtown Seattle

The new stadium is located within the space envelope of the old Kingdome, but offers a new experience for spectators: two signature 720′ tied structural steel arches support the stadium roof, and no columns block views of the field, downtown Seattle, the water, or the mountains.

The project was finished one month ahead of schedule and on budget. Even though the stadium has large roof sections and is located in a high seismic zone on liquifiable soils, it cost 7% less on a per-seat basis than the last 13 NFL stadiums constructed.

Steel Innovations

First-Ever Seismically Isolated Stadium Roof. The stadium sits on liquifiable soils in a high seismic zone. In the event of an earthquake, the site's north end could move a foot to the north while the south end moves a foot to the south, potentially stretching or compressing the roof up to 2′. Expansion/contraction due to temperature could be 8″ in the roof. Special bearings known as "friction pendulum dampers," allow the ground/seating bowl to move independently from the roof during an earthquake, isolating the roof from movement and potential damage. The ends of each 720′ roof arch rest on these dampers, located within the roof support pylons. Each damper supports 3 million lb of vertical load. By decoupling the mass of the roof from the rest of the building, it was possible to reduce the design forces on the pylons and foundations. This also saved more than $3 million in the construction cost.

Special Hinged Columns Take Up the Slack. With the potential for the roof to move up to 2′ atop the dampers in the pylons, "hinged columns" support the roof around the back of the bowl to accommodate this movement.

New "Slipped Nickel" Approach. A "slipped nickel," approach to the roof geometry was developed to simplify the roof framing and connections. A uniformly skewed stack of circular, parallel planes (the nickels) became the template for roof geometry, yielding a condition where all roof beams are parallel and equal length, and the roof deck is flat and parallel. This simplified construction, shortened the schedule, and cut costs.

Advanced Shaping Exercise Optimizes Arch Curvature. A sophisticated

Photo courtesy Michael Dickter, Magnusson Klemencic.

Photo courtesy Corky Trewin, Puget Sound Digital.

shaping exercise helped determine the optimum funicular shape of the roof arch. Funicular—or "rope-like"—refers to the concept that between any two points, a rope suspended will hang in a naturally perfect shape under a given set of loads. This translates into an optimized stadium roof arch representing the most economically efficient shape.

Extensive Integration of Steel Detailing into the Engineering Design Process. The structural steel detailer was incorporated as a part of the design team, which allowed all the structural details to be industrially "tested" (using 3-D CAD tools) and included on the structural drawings. This provided bidders more precise information than would normally be available.

New "Erection Structure as Final Structure" Technique. The dramatic tied-arch roof comprises two separately erected elements that work compositely as one. The lower tri-chord truss was built on the ground in seven pieces and lifted on three erection towers. It was then used as a staging platform for the remainder of the roof erection, eliminating the need for additional erection platforms. Next, the dramatic steel arch was erected with 16 A-frame components.

Precision Post-Tensioning Controls Roof Arch Deflection. Each tri-chord truss is post-tensioned with 4.5 million lb in 130 strands. This post-tensioned approach allowed the arches to lift off the erection towers, and final vertical deflections to be precisely controlled.

Dramatic Seating Cantilever. To bring fans as close as possible to the field, the upper deck was cantilevered over the lower deck seating. This creates the longest interior cantilever seating overlap (56′) and the most intimate sightlines in the NFL.

Advanced Vibration Analysis. Specialized wind and vibration analyses were performed on specific elements of the stadium to meet performance objectives. The structural steel tower for the scoreboard—the first portrait-oriented board in an NFL stadium—was subjected to a special vibration analysis for wind. Vibration analyses also were performed for the cantilevered seating deck to avoid the need for any costly supplemental vibration-reduction technology.★

Owner
Washington State Public Stadium Authority, Seattle
Paul Allen, Seahawks owner, Seattle

Architect
Ellerbe Becket Architects & Engineer, Kansas City, MO
LMN Architects, Seattle

Engineer
Magnusson Klemencic Associates, Seattle

General Contractor
Turner Construction, Seattle

Engineering Software
SAP Non-Linear

Detailing Software
Tekla Xsteel