

The Art of Engineering

By Guy Decker, P.E., Joseph Dowd, P.E. and David Platten, P.E.

Walter P Moore was an Outstanding Award winner for the Cowboys Stadium project in the 2010 NCSEA Annual Excellence in Structural Engineering awards program (Category – New Buildings over \$100 million).

In 1971, Texas Stadium was a brand new 65,000-seat facility featuring an iconic domed roof with a hole in the middle that became synonymous with the Dallas Cowboys Football brand. By the 2000s, however, the symbolic structure was feeling its age. With fan demand far exceeding seating capacity and no ability to ward off the Texas heat, the Cowboys were in need of an upgrade. The design team (led by Dallas-based architect HKS) worked extensively with the Jones' family to create an environment that would not only be state-of-the-art, but would be a facility that would meet the needs of the Cowboys and the community for many years to come. The new Dallas Cowboys Stadium far exceeds this mark.

If its hole-in-the-roof design defined the old Texas Stadium, the twin monumental steel arches have emerged as the signature element of the new Cowboys Stadium. The arches soar through the interior space of the stadium, reaching an apex almost 300 feet above the field and spanning nearly a quarter of a mile – longer than any other roof span in the world. Walter P Moore designed each 17-foot wide and 35-foot deep box truss with a Quadrangular Warren configured web comprised of grade 50 steel. The designers exploited the benefits of high strength grade 65 steel, produced in Luxembourg, to reduce the weight and cost of the four chords of each arch by 25%. These two trusses are truly the backbone of the stadium. In addition to supporting over 660,000 square feet of roof structure, they support two 256-foot by 410-foot retractable roof panels, a video board weighing over 1,200,000 pounds, and up to 200,000 pounds of show rigging. Each end of each arch is secured with a true pin into an abutment foundation that experiences a thrust force of up to 19 million pounds. The



The stadium proudly shows off its retractable roof in action. (Copyright Aerial Photography Inc. 2009)

thrust then transfers into the ground through an 18-foot wide by 71-foot deep by 170-foot long series of concrete slurry walls.

The new stadium pays homage to the history of the original Texas Stadium by maintaining its iconic hole in the roof. A mechanized retractable roof allows for the roof opening to be displayed on game days when the weather cooperates. And when it does not, a closed roof provides a climate controlled experience that fans and players appreciate. The retractable roof panels, weighing in at 3,500,000 pounds each, are supported on mechanized rails mounted to the top of the arch trusses. The roof mechanization system, designed by Uni-Systems, overcomes a 23 degree slope with the use of sixty-four 7.5 hp motors per panel that allow for the panels to be opened or closed in as little as 12 minutes utilizing a rack and pinion system. The stadium's end zone operable doors complete the open-air experience. The glass-clad operable doors are 180 feet wide and 120 feet tall, and can be opened or closed in 6 minutes. Minimal steel structure was chosen in the end zone areas to connect the outdoor environment with the rest of the stadium and provide the potential for an outdoor stadium atmosphere on game days.

Simply closing the roof and doors, however, can transform the stadium into an arena on steroids as the focal point of the world's largest center-hung video board dominates. The video display is comprised of two 160-foot wide by 72-foot tall side boards and 51-foot by 29-foot end boards. The Mitsubishi designed and manufactured boards are supported by a steel structure ten stories tall, which is robust enough to support another 90,000 pounds of rigging load below. The video board structure is hung off of the two box trusses spanning the opening between the arch trusses, with a block and tackle mechanized pulley system that allows for the video board to be raised and lowered for a wide spectrum of different event types.

This versatility, along with Cowboys Stadium's many other state-of-the-art attributes, allow the facility to host not only Cowboys' games, but the Super Bowl, NBA All Star Game, world-class concerts, boxing matches, and even bowling tournaments. At each of these events, the structure is on impressive display, showcasing the art of structural engineering. With the largest center hung video board in the world, the steepest retractable roof, the largest operable doors, the longest roof span, and the ability to host events with more than 100,000 spectators, Cowboys Stadium is in it for the long haul. ■

Project Team

Owner:	City of Arlington, Texas
Developer:	Blue Star Development/ Dallas Cowboys
Architect:	HKS Inc., Dallas, TX
Lead Structural Engineer:	Walter P Moore, Dallas, TX and Austin, TX
Associate Structural Engineer:	Campbell & Associates, Inc., Dallas
Mechanization Consultant:	Uni-Systems, LLC, Minneapolis, MN
General Contractor:	Manhattan Construction Company, Dallas

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