

The Best Show at the Super Bowl

Admiring the 'Underwiring' at Reliant Stadium

By: Lee W. Slade, P.E.

I admit it. I missed it. When Janet Jackson's infamous wardrobe malfunction turned the Super Bowl stage at Reliant Stadium into the world's largest peep show, I missed it entirely. Oh, I was there all right, less than 100 yards from Janet and Justin, enjoying with clients the modern spectacle that Super Bowls have become. But I must confess: as a structural engineer, whose firm had created the structure hosting the event, I was staring at the underwiring of the stadium, not at Ms. Jackson's bustier.



Photo credit to Russ Andorka

What makes Reliant Stadium different than all other stadiums is its *incredible adaptability*.

From August through December, the stadium hosts 69,500 fans in the NFL's largest and most comfortable venue. A movable roof keeps the portable grass field growing between games, and gives the team the option of putting on their show outdoors or in air conditioned, rain-free comfort.

For three weeks each winter, Reliant Stadium is transformed to host the world's largest rodeo, with cowboys and livestock tangling on a sanitized dirt floor. Our "little rodeo" generates about \$200 million for the local economy *each year*, about the same as a Super Bowl. Without the rodeo's annual tenancy, there would be no need for a roof on Reliant Stadium.

"...demanded structural engineering and construction at its most innovative."



Photo credit to Russ Andorka

The structural design of Reliant Stadium - and especially its landmark roof - has been well chronicled. To some, the roof may seem like a giant translucent patio door on roller skates. Its design, however, demanded structural engineering and construction at its most innovative. Houston-based Walter P. Moore served as structural engineer, working in close collaboration with the mechanization consultant, Uni-Systems, Inc., of Minneapolis and the architects, Houston Stadium Consultants (a joint venture of Houston firms Hermes Architects and LAN Architects) with HOK Sport, Kansas City.

Four massive hollow concrete supercolumns at the corners of a 385-foot by 675-foot grid support the entire roof system. Each 13-foot wide column tapers from 68 feet to 34 feet long at its top, 150 feet above the field. From the top of each column protrude 78 carefully located 2.5-inch diameter, 20-foot long A354 anchor rods. These rods lock down huge trapezoidal steel supertrusses, creating two giant portal frames. The supertrusses are 72 feet deep across the top of the columns, gracefully reducing to just 50 feet deep at midspan. Each supertruss cantilevers 164 feet beyond the column, stretching its total length to over 950 feet. To reduce deflections and steel tonnage, Walter P. Moore designed the concrete top deck integral with the top chords of the supertrusses, thereby creating some of the world's largest composite building trusses.

Atop these runway-like decks, magic occurs. A single ribbon of steel (6-inches tall, 175 plf) running down the center of each supertruss deck creates the wheel rail. Ten steel transporter assemblies rest atop each rail. Each transporter moves on a pair of 36-inch diameter steel wheels driven by two 5-horsepower, 460-volt, three-phase computer-controlled electric motors. Simple but effective linkages between the two-wheel transporters ensure



Photo credit to Michael Goodman

that the wheels ride smoothly along the rail, while accommodating inevitable variations in the rail elevations due to structural deflections and foundation settlements. An innovative 'four bar linkage' helps the system accommodate up to 21 inches of differential horizontal movements perpendicular to the rail due to erection tolerances, temperature movements, and other secondary forces. Economically solving this single crucial design challenge sets Reliant Stadium apart from many of its predecessors.

"...the linkage accommodates up to 21 inches of differential horizontal movements..."

Each transporter supports the end of one tri-chord truss (18 feet wide by 30 feet deep) spanning 354 feet between the rails. Stretched tightly between the tri-chords is a translucent fiberglass fabric that creates two huge abutted panels, each 385 feet by 250 feet.



Photo credit to Russ Andorka

At the push of a button laptop key, five pairs of transporters head north and five pairs head south at about 35 feet per second. The roof smoothly parts at mid-field to create a giant opening over the entire field. Ten minutes after starting, the lightweight panels dock over the cantilevered ends of the supertrusses. Inside of each carrier beam, one-of-a-kind hydraulic scissor clamps tighten around the rail as soon as the roof panels stop moving, to keep the steel and fabric panels from “flying away” due to uplift winds.

When the roof is closed, the mid-field gap between the panels is sealed with an inflatable bladder, creating a watertight environment. Once fabric sound-baffles and a complete 170,000-pound capacity rigging grid is hung from the trusses, the stadium is transformed into the finest stadium concert venue in the world.

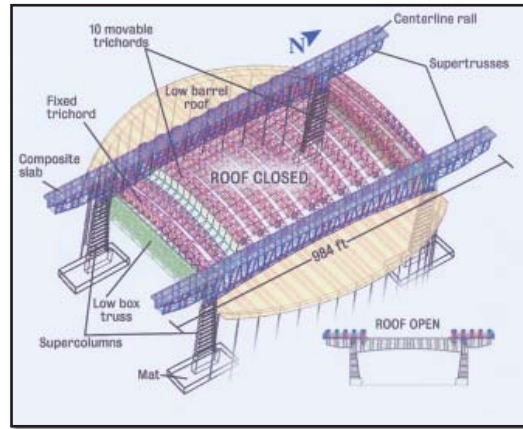
“...the stadium would be more machine than building...”

One key to the project success was that Walter P. Moore and Uni-Systems worked as a single team throughout the design. The team paid excruciating attention to detail, especially in ensuring compatibility of movement strains in every component of the structure and mechanism so that the moving structure could be powered with extremely modest horsepower. The team took the approach that the stadium would be more machine than building, and invested in thoughtful and careful problem solving that drew heavily on their past experience with other moving structures. As innovations were developed in various subcomponents, including the clamping system, the four bar linkage, and the lightning protection system, production prototypes were tested to confirm that the new ideas worked.

To achieve an aggressive 30-month delivery schedule, the engineering team collaborated with the builder, Manhattan Construction, Houston, to utilize innovations in every aspect of the fast-paced construction. The supertrusses were prefabricated and erected quickly in giant panels. A “plug ‘n play” electrical system allowed the tri-chord roof trusses to be quickly erected on a single set of shoring towers at the north end of the stadium, and immediately moved south along the rail with a minimum

of field electrical connections. As a result, the construction was actually completed a little ahead of schedule, a rarity in the stadium construction industry.

Reliant Stadium opened in 2002 to rave reviews from fans, media, and its two tenants. Its worldwide coming-out party this past January impressed a global audience, as it seamlessly hosted the biggest single annual U.S. sporting event. Come to think of it, perhaps I didn’t miss the most important show at the Super Bowl. Even as Justin Timberlake created the world’s first operable bustier on worldwide television, I was too busy admiring the real story at the Super Bowl -the ‘underwiring’ of Reliant Stadium.■



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