



Splitting the Uprights

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Lucas Oil Stadium in Indianapolis takes the whole concept of retractable roofs and gives it a quarter-turn.

THE FIRST DECADE OF THE 21ST CENTURY

has marked a new era for National Football League stadiums: the Age of the Retractable Roof. Fans of the Houston Texans, Arizona Cardinals, Indianapolis Colts, and Dallas Cowboys (the latter, starting this fall) can enjoy live football without the threat of inclement weather. Too hot, too cold, or too wet and the roof slides shut.

The latest of these weather-beating venues is Lucas Oil Stadium, the new home of the Indianapolis Colts as of the 2008 season. While not the first of the retractable-roof NFL stadiums to be built, it is first in one way: Its retractable roof is the first to part lengthwise.

Another first for an NFL facility is its 214-ft-wide by 88-ft-high operable glass window wall—the largest in the nation—that gives a spectacular view of Monument Circle and downtown Indianapolis.

Lucas Oil Stadium—which seats 63,000 but is expandable to a capacity of 70,000—will serve not just its NFL team but also a wide array of concerts, special events, and conventions and will also secure the city's position as a frequent host of NCAA basketball Final Four events.

Function Follows Form

While retractable roofs for football stadiums typically open with the panels opening at mid-field and sliding towards the end zones, the architectural look of Lucas Oil Stadium necessitated a different approach. The stadium's design celebrates Indiana's traditional field house look, complete with a gabled roof—peaking lengthwise above the middle of the field—hence the need to

Courtesy Hunt Construction



To create the pitched roof that evokes a traditional Indiana field house, the panels were oriented to slide perpendicular to the field sidelines.



Arched transverse trusses span to two superframes that in turn span parallel to the field sidelines, supporting the entire roof without compromising sightlines.

Photos: © Blake Marvin/HKS Inc. (left) and Courtesy Walter P Moore (right)

reconfigure the opening point by 90° compared to other retractable roofs.

The movable roof provides a fully climate-controlled environment for trade and sports events year-round and an open-air football experience on pleasant autumn days. Two enormous panels quickly and quietly retract to create an 180,000-sq.-ft opening, the largest of any NFL venue to date. The panels separate along the roof's longitudinal ridge and roll away from each other, traveling down the straight 13.2° pitch, then land and rest along the sides of the building.

The 600-ft by 150-ft roof panels are supported atop 36-in.-diameter steel wheels aligned similarly to roller blades. The wheels roll down five sloping steel rails aligned at 144-ft centers. The rails are supported atop five peaked box trusses that span between two 752-ft-long steel "superframes" that run the length of the stadium along the field sidelines, 300 ft apart. The top of each sideline superframe is 241 ft above the stadium floor. The superframe columns are 217 ft tall and supported by 35-ft tall concrete shear walls at the street level.

Walter P Moore and mechanization expert Uni-Systems adapted a "four-bar linkage" mechanism to relieve the stresses that develop due to thermal strains between each rail. Though the rails had to be located precisely to provide low-maintenance wheel operation, Walter P Moore worked closely and creatively with the contractor and steel erector to develop adjustable field connections that would meet the strict tolerance requirements. This innovative application ensured that the panels could be installed and operated without the binding and premature wear.

The roof movement mechanism employs

a "winding spool" technology, which had been proven on University of Phoenix Stadium in Arizona. For Lucas Oil Stadium, the technology was further refined and adapted to accommodate the 13.2° incline, the steepest of any retractable roof. A 960-hp cable-drum drive system moves the retractable panels—each weighing 1,450 tons (also the largest of any NFL facility)—to silently close the roof in just 9 to 12 minutes, depending on weather conditions. To further save energy, the drive system reclaims much of that energy spent, as the roof opens under its own weight via the force of gravity.

The roof was designed with the capacity to hang up to 200,000 lb of show rigging for center-stage or end-stage events. The five transverse trusses were designed with five catwalk systems that interconnect the entire roof structure at multiple elevations and provide the structural capacity to support the largest show rigging load of any building in North America.

With 15,500 tons of steel in the air, the roof structure itself took 18 months of the total 36-month construction schedule.

Throughout the roof, 3,100 tons of ASTM A913 Grade 65 steel was used to reduce tonnage, contributing greatly to the economy of the project's structural system. High-strength steel was used extensively in the superframe and transverse trusses to reduce the member sizes; as with all compression members, truss members in Grade 65 steel rely on maintaining short unbraced lengths. In the superframe, each chord, diagonal, and post was made with four W14 shapes laced together with angles to create 3-ft by 6-ft box shapes. These shapes allowed for efficient compression members with lengths exceeding 70 ft.

A Clear View

Lucas Oil Stadium is oriented on an angle so that its north façade faces downtown Indianapolis. To maximize this stunning view and to connect downtown citizens visually and acoustically to the excitement of the games, the design features North America's largest independent operating glass window wall. Opening dimensions are 214 ft wide by 88 ft high, with six translating 36-ft × 88-ft panels. Each wall panel travels at 30 ft per minute for an opening time of four minutes. The bottom of each 50-ton panel rolls on two 24-in diameter steel wheels along a single rail, and the top of each panel is supported by a pair of top guide roller assemblies.

Point(s) After

From the outset, Lucas Oil Stadium was intended to be the most flexible and well-used community asset of its type in the world. Just as important, it serves as a crucial cornerstone element in a massive renewal of downtown Indianapolis, helping the city build on its standing as a pre-eminent destination for conventions and world-class entertainment events such as NCAA Final Fours and the upcoming Super Bowl XLVI in 2012—and creates a whole new ball game for stadiums worldwide.

MSC

Tarek Ayoubi served as project manager, Andy Stoebner served as project engineer, and Kenneth Byle served as design manager for Lucas Oil Stadium. All are with Walter P Moore and can be reached at 800.364.7300.



Five transverse trusses span 300 ft to create a distinctive exposed structural form. This first-of-its-kind structural layout eliminated the need for the retractable roof to overhang the edges of the stadium. At 752 ft long, the superframes comprise the longest roof span in the country.

Owner

Indiana Stadium and Convention Building Authority, Indianapolis

Architect

HKS, Inc. (Sports and Entertainment Group), Dallas

Prime Structural Engineer and Roof Design

Walter P Moore, Houston

Steel Fabricator

Hillsdale Fabricators, St. Louis (AISC Member)

Steel Erector (Joint Venture Partners)

Alberici Constructors, Inc., St. Louis (AISC Member)

Derr Steel Erection Co., Euless, Texas (AISC Member)

Steel Detailer

BDS Steel Detailers, Tempe, Ariz. (AISC Member)

Construction Manager

Hunt Construction, Indianapolis

Retractable Roof and Moving Wall/Door Consultant

Uni-Systems, Minneapolis

Software

SAP2000

Detailing Software

Tekla Structures

Sealed with a Twist

Though most operable roof stadiums experience some leakage during rainstorms, the operation requirements for Lucas Oil Stadium demanded a higher level of protection against water intrusion. An innovative and redundant seal system at the interfaces of the moving roof with fixed elements and at the roof peak keeps the venue dry.

The entire perimeter of the moving roof system is protected with a custom seal system, the first such application in North America. This mechanized joint seal system with ridge caps locks the panels tightly at the peak. Special hinging doors, which open during the roof movement, prevent blowing rain from sweeping beneath the lower edges of the moving panels. A back-up gutter system catches any water that might somehow penetrate the seal.