Engineering Awards of Excellence

Merit Winner

# Jacobs Field

For 62 years, Cleveland Municipal Stadium was home to the Cleveland Indians. They played their first game at the stadium, originally built in a failed attempt to attract the 1932 Olympics, against the Philadelphia A's. The Indians lost. The enormous stadium located next to Lake Erie had over 74,000 seats, more than any other major league baseball stadium. However, that wasn't necessarily a positive, especially for those stuck in "the Dawg Pound," center field's bleacher seats – a place no batter had ever reached with a home run.

It was only a matter of time before the Indians would find themselves in a new home. Originally, the plan was to build a domed stadium in downtown Cleveland, but voters who didn't want the increase in their property tax rejected this proposal. Finally, in 1992, construction began downtown on Jacobs Field. Both public and private money helped finance the building of the stadium. Richard Jacobs, owner of the Indians, provided $91 million; the rest of the money ($84 million) came from a 15-year tax on cigarettes and alcohol in Cuyahoga County.

The Osborn Engineering Company, structural engineers for the project, was given several constraints for design of the ballpark. They included finding an alternative lateral bracing system, aesthetics, multiple levels of suites, unobstructed views, asymmetry and a fast track schedule.

When the design architects first approached them, they suggested modeling the cross section after the ballpark at Camden Yards, home of the Baltimore Orioles, a project the architects had just completed. However, one major variation was needed—elimination of the primary vertical cross bracing system. Though an efficient means for stabilizing the ballpark and economizing the structural design, primary vertical cross bracing interferes with circulation space behind the suites.

Another reliable method of lateral support would have to be found if this was to be done. Different methods were explored, and it was finally decided welded trusses were the best option. They were chosen in order to develop large couples within their top and bottom chords to resist lateral forces. Trusses at least 6' in depth were required based on spans. Wide flange beams 24" to 36" in depth were coupled with welded moment connections when floor to floor heights prevented the use of trusses.

After a short study of the advantages of concrete versus steel, it was decided steel would provide a quicker and more aesthetically pleasing ballpark. They wanted the stadium to fit in with the present structures along the Cuyahoga River. Also, steel could be erected easier in the winter. In order to meet the unobstructed view and the three levels of suites requirement, column location would have to optimized versus allowable spans for cantilever framing. There were 32 separate "events" around the ballpark and each had a different structural response. In the end, 41 separate cross-sections were analyzed and designed.

### Columns

Jacobs Field's layout involves 37 grid lines used with 74 column lines, one 4' each side of a primary grid, making it very asymmetrical. The layout features a twin column arrangement with 24"-diameter and ¾"-thick columns spaced 4' on each side of the 42'-6" gridline. For three-dimensional stability of the large unbraced length, round columns were necessary, along with all columns at one row being staggered one-half bay in plan. This created triangular framing in the floors, which made up for the absence of cross bracing.

By cantilevering three levels of suites, extremely large moments were formed creating the need for a row of W36x300 columns. The cross sectional spacing of columns across a bent line was optimized in order to balance loads about this row of columns and reduce the tendency for the structure to drift inward toward the playing field. The cross bracing in the exterior elevations does not resolve itself to the main concourse, but instead was used to reduce the unsupported length of columns rising to support the upper concourse level 60' above.

### Trusses

For aesthetic purposes, the exposed trusses were composed of wide flanges with W12x40 top chords, W8x40 bottom chords and W8x31 verticals and diagonals. Truss members were connected with 5/16" fillet welds. Welding came into play when the trusses were connected to the round columns in manner that would allow the chords develop the required moments and axial forces necessary to develop lateral force resisting couples. While the proportions of the trusses and round columns eliminated the need for bracing, large moments resulted at connections of trusses and girders to the columns.

## Project Team

*Structural Engineer:*
The Osborn Engineering Company, Cleveland

*Architect:*
HOK Sport, Kansas City

*Construction Manager:*
Huber, Hunt & Nichols, Indianapolis

*Owner:*
The Gateway Economic Development Corp., Cleveland

*Steel Fabricator and Detailer:*
Kilroy Structural Steel

Unfortunately, the columns used to carry the vertical loads were 24”-diameter, ¾”-thick HSS members, which created a problem. The design team modeled stability of the 24”-diameter column shell at primary connections for local buckling by finite element methods. Now it was necessary to reinforce the column at primary connections, so a 24” diameter, 1.75” wall insert of 46 KSI steel was used. Using semi-automatic SAW techniques, an 8’-long insert was full penetration welded to the ¾” wall standard pipe column and located at the proper elevation in relation to the 6’ deep trusses framing to the column. As many as five trusses were framed into one insert without having to add any internal stiffeners. As a result, thicker tubular steel was located in columns only where it was needed, with thinner tubular cross sections used elsewhere to reduce costs.

Since it was desired to have a vertical member approximately 10” from the face of the column, the exterior truss to column connections was complicated. A connection plate was welded continuously to the vertical and top and bottom chord extensions. In the connection of top and bottom wide flange chords of trusses to the insert, complete penetration welds were necessary. Slip critical, A-490 type F bolts were also used in these connections.

### Floor Framing

The floors were designed with composite floor deck spanning over non-composite beams. The need for studs in beams and tops of chord trusses was eliminated because of the triangular configuration of framing for a typical bay with offset columns at line H. The plan specified for a 3”, 20-gage composite deck with multiple spans. Normal weight concrete was used, which also added dead weight to counter balance the overturning moment of the Level Three suites. (The pedestrian ramps and bridge ramps were framed this way, too.)

### Suite Framing

There are 121 suites at Jacobs Field, most of which are stacked three levels high. The suites are all cantilevered approximately 30’. In order to insure vertical support, hangers were made using two 1¼” x 6” steel plates spaced 1” apart for loads up to 300 kips. At the lower club suite levels, TS4x4x5/16 hangers were used. Additional diagonal struts (two 1¼”x10” plates) had to be added at the lower and club level suites to redistribute loads back to the primary columns because a single line of hangers generated so much reaction.

A problem arose because on each side of the hangers located on the primary grid line, the structural framing was offset. The girders, which were carrying large reactions over 400 kips that had to be connected back to the columns, needed to be laterally braced. Stiff, triangular transfer frames were made from W27x102 and W27x89 shapes welded together, and were placed in the 8’ space between floor girders in front of the columns and centered on hangers. The two W27x102 floor girders at each level were tied. It also resolved the horizontal and vertical components of the diagonal struts, through welded gus-

set plates into the transfer frame.

### Cantilever Trusses

Three triangular welded cantilever truss styles were used in the project. The first was shallow with a long span and was used to support the club seating along the first base line and mezzanine seating in right field. The design, which was 9'-9" deep but only cantilevered 32'-6", was controlled by deflection. The second cantilever truss style is a simple design (common to ballparks) where the truss is used at each column line to cantilever the front third of the upper seating level. This design was slightly modified to accommodate seating for the disabled. A different style of truss was used for the large portions of the upper and club level concourses behind right field and to support the club lounge and its 30' high curtain wall. The last cantilever style was used for aesthetic purposes and to support the sunscreen over the back of the upper seating bowl. The top chord of these trusses have a 50' radius and the bottom chord is angled 10 degrees upward from the playing field. Attached to the bottom chord are purlins spaced 10' on center, which support the metal panels making up the roof. A brace (W12x40) was welded behind the sunscreen trusses to resolve the bending moments into 24" round columns supporting the roof load. This was repeated every third point in each bay around the ballpark to for a "crown," unifying the design and adding an aesthetic element.

### Stadium Club

The design of the stadium club involved the complicated task of trying to juxtaposition the terraced multi-level floor system at a 45 degree angle into the 42'-6" ballpark grid system. The use of suspended structural glass curtain walls (built to provide unobstructed view of the field from the terraced dining room) provided another problem. Welded trusses with heavy top and bottom chords were used, along with additional cross bracing within the depth of the truss system to laterally brace jack trusses at reaction points.

### Upper Seating

The upper seating bowl was designed using precast concrete, double tread and riser unites that were supported by brackets welded to W36x118 rakers. Both ends of the precast units spanning the 8' simple span were fixed between the twin belt lines, adding lateral support.

The diaphragm created by this, along with additional X-bracing in the plane of the rakers, provided necessary longitudinal stiffness. The beams and trusses that ring the back of the seating bowl provide additional lateral support. The upper structure is anchored by the stub extensions of the W36 columns at line E, which extend 8' above the upper concourse level. The W36 x 118 rakers are attached with full welded moment.

### Light Towers

A cantilever structural design is used to support 19 separate banks of field lighting that are arranged vertically. The height of the lights made a third 24" round column necessary in order to support the reactions and deflection. The column springs from a system of welded x-braces arranged in a triangle below the upper concourse.

### Scoreboard

The stadium is home to the world's largest freestanding scoreboard, with a combined surface area equal to the façade of a 5-story building (200' long). It was structures from five triads of 24" diameter by 1.75" wall pipe columns centered in an isosceles triangle with an 8' base and a 7' altitude. Twin shear walls that spring from the foundation of the center field bleachers buttress the columns. Large reactions developed through welded couplers transfer the reactions into No. 11 rebar developed in the buttresses, making connections of shear walls to 1½" thick embedded steel plates possible.

Over 10,000 tons of steel and 18 months later, the construction of Jacobs Field is complete. While the new stadium is smaller than Cleveland Stadium (almost 20,000 fewer seats), this hasn't hurt the ballpark. Ticket sales have actually increased for games, making the stadium a success.