



Steeling Home

BY JOSEPH M. ALES, JR., PH.D., S.E., AND JUSTIN BARTON, P.E.

Mortenson Construction and Blue Sky Aerial Photography

The bold and creative use of structural steel offers fans and players an outstanding game day experience.

THE 40,000-SEAT OPEN-AIR TARGET FIELD is the new home of the Minnesota Twins baseball club. This architecturally pleasing and structurally complex ballpark has taken full advantage of the versatility and strength of structural steel. Designed and built to fit seamlessly into a small and highly constrained site, the baseball stadium is located on the west edge of downtown Minneapolis, just across Interstate 394 from Target Center, home of the Minnesota Timberwolves basketball team.

One of the reasons for choosing this site was the large amount of support infrastructure already in place. This includes three large parking structures, an extended light rail running through downtown and a new heavy-rail line going to Northern Minnesota that terminates at the ballpark. However, those and other existing site features—active rail lines on the west edge; elevated city streets along the north and south edges; and an interstate highway and on-ramp along the east edge—contributed to the project challenges. In addition, an existing 33-ft-wide box culvert running along the third base line had to be avoided.

The lower ballpark structure consists of a four-level cast-in-place concrete moment frame along the infield from foul pole to foul pole supported on driven steel piles filled with concrete. Above that, the view deck (upper deck), canopy, scoreboard, and all outfield framing are structural steel, as is the cantilevered seating at the club and terrace levels.

The design team consisting of architect-of-record Populous,

structural EOR Walter P Moore, and MEP engineer M-E Engineers, Inc. collaborated closely with M.A. Mortenson, the ballpark construction manager, to work through the numerous complexities of designing and building a stadium on this “postage stamp” site.

Cantilevered Seating

As is typical in most new ballparks, portions of the seating bowl are cantilevered out, bringing fans as close to the game as possible. The club rakers cantilever 30 ft beyond the columns and are supported with HSS and boxed wide-flange members. The architect desired a “clean” look of the raker, so the typical wide-flange, double-angle web of the raker was modified to box shapes with only one web member. To continue with this look, the web member was welded directly to the top and bottom chord eliminating the gusset plates. The rakers were fully assembled in the shop and erected on site as large single pieces.

The top and bottom chords of the raker are attached to a composite column with an embedded W33 wide-flange column. The steel column is used to transfer the large loads—some as great as 1,200 kips, although the average is around 800 kips—from the raker into the concrete system. The architect required that the connection of the raker to the column be concealed, which caused the vertical column reinforcement to be interrupted. The flanges of the W33 served as the tension reinforcement in the column until the reinforcement could be developed.

Opposite page: The new Target Field, which opened in April, was constructed on a highly constrained site in downtown Minneapolis.

The wide-flange column uses ¾-in.-diameter studs to transfer load into the concrete column. To minimize the amount of column bending, an HSS kicker extends from the bottom chord-column connection to the mid-span of the post-tensioned concrete girder above. The large tension force in the top chord of the raker is taken into the girder with high strength anchor rods extending to mid-span of the girder.

The terrace level (upper concourse) rakers cantilever approximately 16 ft beyond the column line. The seating is supported by an HSS-framed raker. The shorter cantilever produced a smaller compressive load in the bottom chord, so the column was designed to resist the bending from the bottom chord load, and no kicker was required.

Due to the small site, the left field club level seating extends all the way to the outfield wall. This means that the concourse and raker framing have to cantilever 45 ft off the nearest column line with only 10 ft of depth. A steel truss supports these loads. Full depth stiffeners at the column-chord connection transmit the large chord forces (1,450 kips) to the kicker behind, which extends to the adjacent column-beam intersection.

Framing Over the On-ramp

The right-center-field portion of the stadium is built almost entirely over an active interstate on-ramp and abuts to an existing parking garage, severely limiting the options for column placement. An initial study proved it would be uneconomical to cantilever the structure over the road. Instead, columns were placed on the opposite side of the ramp, adjacent to the parking garage, which still proved extremely challenging.

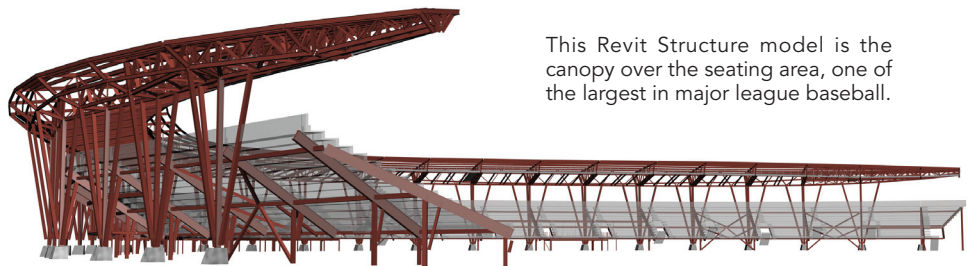
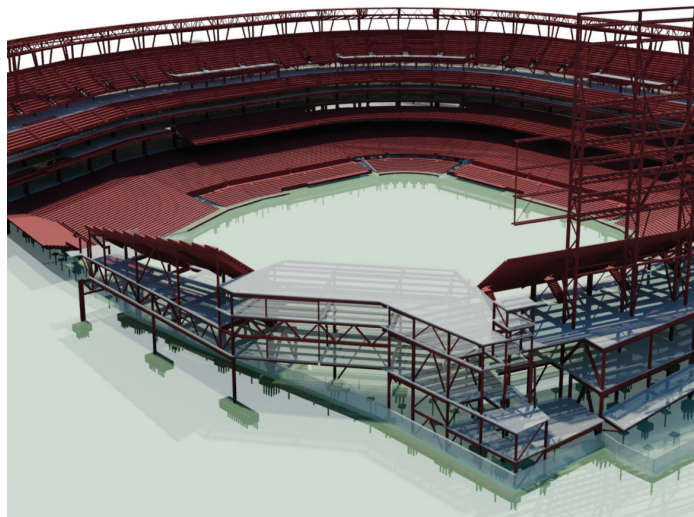
Due to the limited space, only three columns could be placed adjacent to the garage. As a result, three transfer trusses were used to support the concourse and stadia framing. To avoid the existing garage foundations, one of the trusses was required to frame into a second transfer truss. The foundations had to be designed eccentrically, allowing the columns to be located as close to the parking garage as possible. Due to vertical clearance requirements over the road below, an 11-ft-deep transfer truss over the road is located at the club level and hangers support the main concourse framing below. The main concourse beam and girder depths were limited to 14 in. With some girders spanning up to 40 ft, that resulted in using some very heavy members, with a maximum size of W14x283.



photos this page by Walter P. Moore

Above: The club level seating at Target Field is cantilevered out 30 ft from the columns using HSS and boxed wide-flange members.

Right: All the major framing in the ballpark was modeled using Revit Structure, including several sub-models created for components such as the canopy, the scoreboard support, and the existing buildings adjacent to the ballpark.

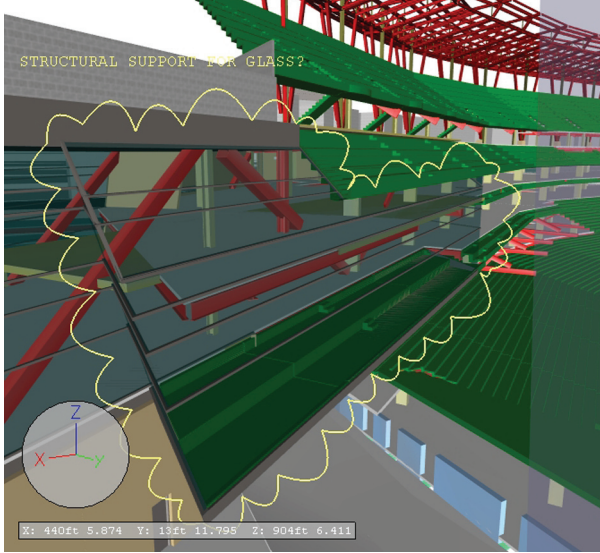


This Revit Structure model is the canopy over the seating area, one of the largest in major league baseball.

Joseph M. Ales Jr., Ph.D., S.E., is a principal and managing director of Walter P Moore's Los Angeles office. He served as the project manager on Target Field and can be reached at jales@walterpmoore.com.

Justin Barton, P.E., is an associate with Walter P Moore and was the project engineer on Target Field. He can be reached at jbarton@walterpmoore.com.





Photos this page by Walter P Moore

The Use of BIM

BIM and 3D modeling were used extensively on the project to work with the complexities presented by existing site conditions and determine solutions for various complex structural challenges.

Walter P Moore developed a complete BIM of the structure using Autodesk Revit Structure. From that several sub-models were created for components such as the scoreboard and the existing adjacent buildings. The complex sunscreen structure was also fully modeled in Revit, and was then overlain with the 3D cladding model prepared by the architect for the metal panel soffit cladding to ensure that the structure and cladding were coordinated. The BIM also was used to maintain a running total of steel tonnage, which was a crucial concern throughout the fast-track project.

The model was used as a basis to create additional models, primarily using Google Sketchup, to explore various structural solutions. The architect modeled both the stadia and exterior building skin in 3D, and this was combined with the structural frame in Autodesk Navisworks to perform valuable in-depth coordination. Redmarks and coordination markups typically were communicated via .pdf and .dwt format using Autodesk Design Review.

The BIM was made available to the contractor and subcontractors, though the steel fabricator elected to create a separate Tekla model for the structural steel. A .dwg file of the structural model was exported to Mortenson for use in preparing a Navisworks clash detection analysis. This model was used by Mortenson as a reference in building its 3D model as construction progressed. Mortenson employed three full-time BIM modelers to support construction scheduling and help identify conflicts prior to construction commencing in a given area.

MSC

Owner

Minnesota Twins, Minneapolis

Architect

Populous, Kansas City, Mo.

Structural Engineer

Walter P Moore, Atlanta (AISC Member)

Steel Fabricator

LeJeune Steel Company, Minneapolis (AISC Member)

Steel Detailer

LTC, Inc., West Salem, Wis. (AISC Member)

Steel Erector

Danny's Construction Company, Inc. (DCCI), Shakopee, Minn. (AISC Member)

Software

Revit Structure, Navisworks, Sketchup, Redmarks, Design Review



Four 8-ft-deep truss-columns support the 101-ft-long video screen as well as two additional 33-ft-wide panels for ads.

3D coordination was accomplished using Navisworks, allowing electronic markup of the most current structural model.

Canopy and Tree Columns

To protect fans from the occasional cold spring rain and hot summer sun, the owner and architect desired a large canopy, one of the largest in Major League Baseball. Architecturally, the desire was for a floating appearance, finished top and bottom, with no “erector set” framing visible from below. The canopy was also to house all but one of Target Field’s light banks, which were integrated into the canopy to provide for a very streamlined look.

Because of the desire for an open concourse, any canopy solution had to provide lateral support to the view deck as well. After many design charrettes and late night sessions, an elegant solution incorporating “tree columns” at each major gridline, and 50-ft-long cantilevered trusses was selected. Not only are the tree columns an architectural feature, they also provide the needed lateral support for both the canopy and view deck framing. It is extremely efficient as it seamlessly addresses both the architectural form and structural function.

At each end of the view deck, the canopy cantilevers nearly 90 ft from the last set of tree columns, formed with a pair of steel box trusses that reduce in depth from 10 ft to 4 ft. Unlike most ballparks, the canopy framing is fully enclosed by a metal panel soffit. The bottom soffit has a varying profile that typically changes at each gridline, causing the cantilevered trusses at each gridline to vary slightly in their geometry. Curved cold-formed metal framing studs supported by steel purlins support the curving soffit shape.

Scoreboard

The main scoreboard features a 50-ft by 101-ft 1080P high-definition video board supported by four vertical truss-columns. On each side of the video board, large advertising panels (33-ft-wide by 57-ft-high) cantilever off the last set of columns. Above the video board is a large light standard (12-ft-high by 110-ft-long). Each vertical truss is only 8 ft deep with large W14 shapes as chord elements. The truss is laced with HSS6x6 members in a chevron configuration so as not to interfere with access to the six levels of catwalk. Support for the ad panels on each side of the scoreboard is provided by W24 and W30 members oriented horizontally, which resist the wind load, and a tension rod that carries the gravity load.

The top level of the lighting standard is 158 ft above the club level and 210 ft above the foundation level. To help brace the scoreboard framing, the scoreboard column trusses were tied into the rakers supporting the seating below. Due to the framing constraints, half of the scoreboard columns were transferred out at the club level.