Structural Engineering &DESIGN

Play Ball!!!

UNBONDED POST-TENSIONING USED IN TARGET FIELD

By Neel R. Khosa, MBA

It's not every year that Major League Baseball kicks off the season with a new ballpark. Target Field recently opened as the new home of the Minnesota Twins baseball team. On April 12, 2010, the $425 million open-air ballpark was the stage for the Twins' first regular-season home game. Almost 40,000 loyal fans celebrated the Minnesota Twins' 5-2 victory against the Boston Red Sox in the historic 50th anniversary home opener.

The Minnesota Twins had shared their previous home, the enclosed Metrodome, with the Minnesota Vikings professional football team. For the first time since 1961, the Twins had their own home. Outdoor baseball successfully returned to Minnesota as stadium seating was sold-out throughout the playoff-bound season. Easily accessible to downtown Minneapolis by public transit, Target Field endeavors to be an integral part of Minneapolis sports.

Construction team

The construction of Target Field started in August 2007 with a momentous groundbreaking ceremony that was attended by the Minnesota Ballpark Authority, construction representatives, and Minnesota politicians. Built on an 8-acre site, the natural-grass ballpark has more than 1 million square feet of space spread across several levels. The ballpark was skillfully built over portions of I-394 highway, as well as a BNSF main railroad track. More than 3,500 workers helped construct a marquee, LEED-certified structure that has 55,000 cubic yards of concrete.

During the design phase, unbonded post-tensioning was chosen as the preferred method to reinforce the concrete beams and girders because it permitted longer clear spans under heavy loading. The open floor plan allowed for more flexibility for architectural elements and concession arrangements. "Post-tensioned construction was selected for several areas of the structure," said Joe Ales Jr., Ph.D., S.E., managing director at Walter P Moore. For the main sections of the seating bowl, several structural systems were evaluated at the beginning of the project. A system consisting of post-tensioned girders and conventional reinforcement pan-formed beams was selected because of the long-span capabilities, reduced depth, and more cost-effective construction of the post-tensioned girders. Along the third base line, a major freight line runs directly beneath the promenade, necessitating the transfer of the main perimeter line of structural columns. Staged, post-tensioned transfer girders were selected due to the superior load-carrying abilities of post-tensioned construction. Finally, several areas of the mezzanine were designed with post-tensioned flat plates due to the long-span requirements and limited available headroom. Post-tensioning not only provided superior structural solutions, but contributed to the highly sustainable LEED Silver stadium by reducing concrete volume."

M.A. Mortenson Company hired Illinois-based AMSYSCO Inc. as the project's post-tensioning manufacturer. Furthermore, AMSYSCO's Post-Tensioning Institute (PTI)-certified plant provided LEED points on steel raw materials. Target Field successfully achieved LEED Silver certification and the highest rating for any ballpark in America at the time.

Post-tensioned concrete

Unbonded post-tensioning is a method of concrete reinforcement that has its roots from the precast/prestressed concrete industry. It consists of high-strength steel tendons encased in an extruded plastic sheathing that is filled with a corrosion inhibitor. Post-tensioning tendons act as tensile reinforcement since concrete is weak in tension. As opposed to conventional reinforcement, post-tensioning is considered to be an “active” reinforcement since it carries the force before the concrete has deflected enough to crack, according to the PTI. "Post-tensioning saved material costs and contributed to a column-free layout that helped with traffic-control and security camera's line of sight," stated Rattan Khosa, president of AMSYSCO Inc.

The compressive force in an unbonded post-tensioning tendon is transferred to the concrete by its end anchorages. The anchorage is composed of an iron casting where the steel strand is gripped inside by a conical, two-piece wedge. After the post-tensioning tendons are installed and the concrete has reached the required strength, a hydraulic jack tensions (or stresses) the tendon to 33 kips of force. Due to the tensioning process, the tendon actually stretches approximately 8 inches per 100 feet. After short-term and long-term losses are accounted for, one half-inch-diameter tendon will provide roughly 27 kips of final effective force in the concrete member.

In total, AMSYSCO Inc. supplied 142 miles of half-inch, encapsulated unbonded post-tensioning tendons that reinforced the concrete girders in the upper levels and the main promenade. This figure translates into 230 tons of post-tensioning installed by ironworkers. Additionally, the mezzanine entrance walkway had a two-way post-tensioned system that used banded and uniform tendons. “Post-tension construction is frequently utilized in the upper Midwest, and as such, Mortenson Construction is very familiar with managing the design, submittal, procurement, and installation process,” said Troy Blizzard, senior project manager at Mortenson Construction.

Target Field was unique in the multiple applications of post-tension construction on the same project. Typically, a single project applies the cables in the same manner, and the construction team is able to gain efficiencies from the repetition. Target Field required much closer coordination between the design and construction teams to ensure a high level of quality control for each different application. In fact, because of the complexity of the design caused by the site constraints, Mortenson utilized building information modeling (BIM) technology to model the post-tension cables and standard reinforcing; a level of detail that is not often required.

One of the greatest benefits of post-tension construction at Target Field was along the third base line over the railroad corridor. The post-tension design reduced the amount of concrete volume, eliminated the need for re-shoring through the rail corridor, and enabled Mortenson to coordinate a complicated sequence of construction. In one specific 100-foot by 100-foot area in the northwest quadrant of the project, the design necessitated standard pan-and-joist, cantilevered PT girders, precast double Ts, precast plank, and conventional PT girders; almost inconstructable without the flexibility of post-tension construction.”

Solution for high design loads

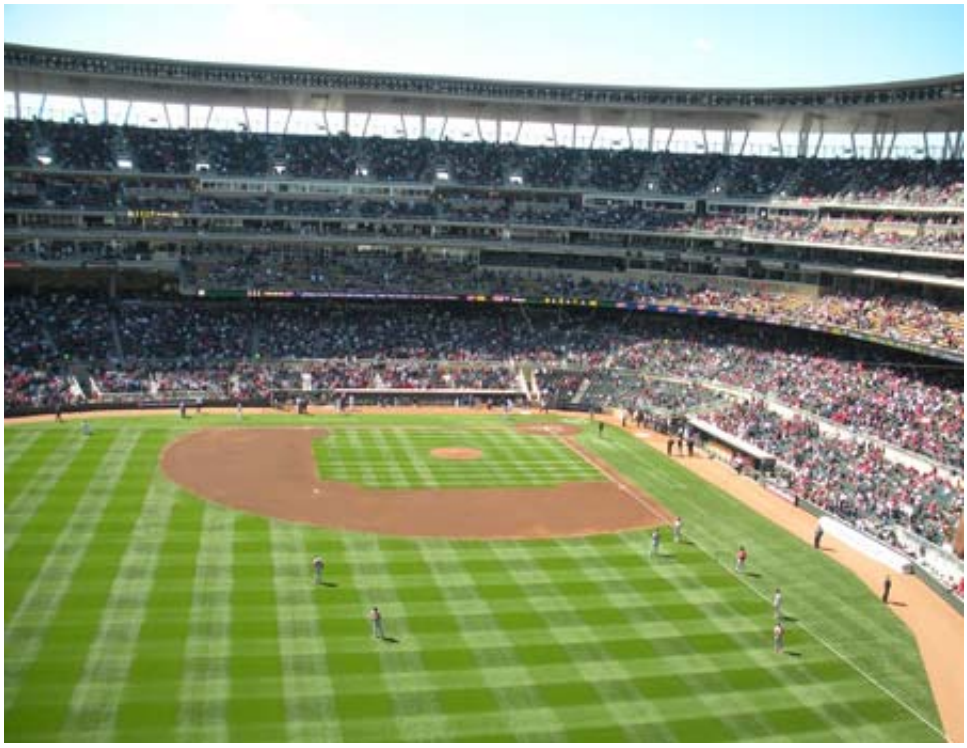
Due to the heavy loading in Target Field, the largest concrete girders required 5,805 kips of prestressing force to support the main concourse. More than 200, half-inch-diameter tendons were used for these post-tensioned girders. To avoid cracking caused by reverse tensile stresses, some girders required stage-stressing of tendons as the concrete gained strength and the upper levels added more dead load to the structure.

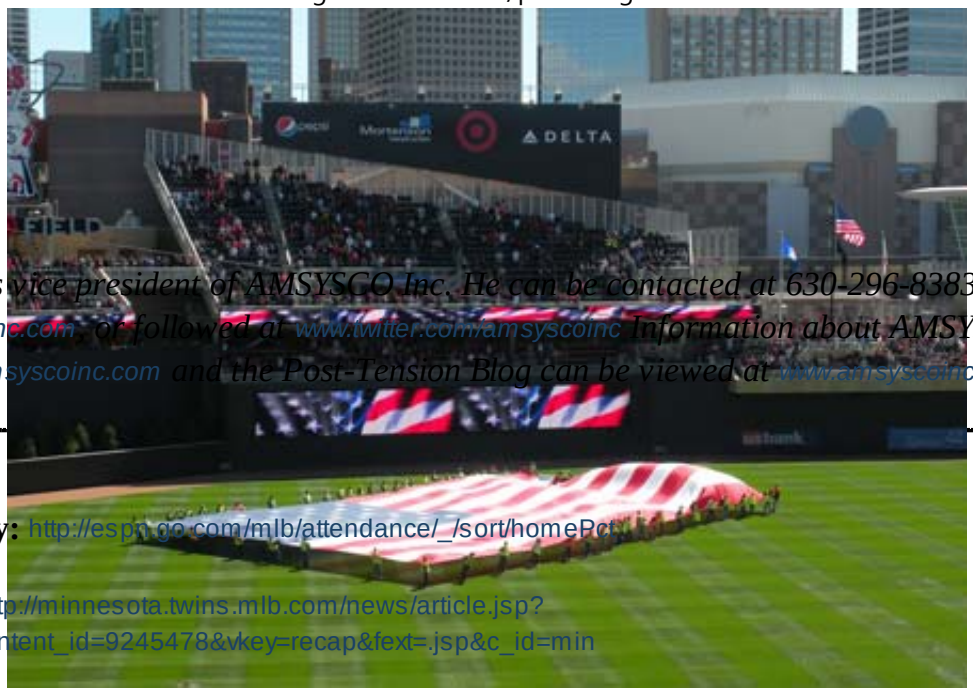
Since some girders had 15 times more post-tensioning than a typical beam in a parking structure, the construction team was concerned about potential conflicts between post-tensioning anchors and materials from other trades. Furthermore, the post-tensioned girders were built before the perpendicular joists in order to

speed up the construction schedule. Accordingly, concrete blockouts/sleeves were embedded into the girder to allow the transverse beam post-tensioning and MEP piping to run through the girders.

Before construction started, Mortenson Construction used BIM to coordinate structural design drawings by Walter P Moore with post-tensioning shop drawings by AMSYSCO. The detailed 3D environment illuminated several problem areas that subsequently were solved by revising the installation drawings. The strong collaboration of the construction team was one reason the project was completed three months ahead of schedule.

A live webcam of Target Field can be viewed by visiting:
http://mlb.mlb.com/min/ballpark/new_ballpark_webcam.jsp





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