

Collaboration Breeds Success

High performance steel bridges help interchange exceed expectations.

By Robert Wills

The Marquette Interchange reconstruction project in Milwaukee, WI, is the largest and most complex highway project ever undertaken by the Wisconsin DOT (WisDOT)—and one of the most successful.

Completed in August 2008, the nearly \$800-million interchange was finished about three months early and \$10 million under budget thanks to a unique collaborative relationship between the DOT, its project design and engineering consultant, contractors, fabricators, and the steel industry.

David Nguyen, P.E., project manager with WisDOT on the Marquette Interchange project, says, “Our goal was

to construct an interchange with a functional service life of at least 75 years that required little maintenance and could be constructed within a fast four-year window of time. The entire project team needed to push the bridge building envelope.”

From an innovative steel procurement program, implemented in the critical early days of this project, to the selection of high performance steel (HPS), this project lived up to its preset goals from start to finish.

The Marquette Interchange, the cornerstone of the southeastern Wisconsin freeway system, includes three interstate highways (I-94, I-794, and I-43) with a five-level system interchange, five miles of interstate highway, 28 ramps, more than 60 bridges totaling 2.1 million sq ft of bridge deck, and five miles of retaining wall.

Reconstruction included the demolition of 88 bridge units from the old interchange to make room for the new design that included a combination of steel plate I-girders, steel box girders, and pre-stressed concrete beams.

The centerpiece of the project



All curved multi-span twin steel composite box-girder bridges up to 2,400 ft long, the eight high-level system ramps were the centerpiece of the project.



The new design combined steel plate I-girders, steel box girders, and prestressed concrete beams. Photo by Richard Publitz.

consists of eight high-level system ramps, all curved multi-span twin steel composite box-girder bridges up to 2,400 ft long. Individual bents range up to 1,600 ft long between movement joints.

Milwaukee Transportation Partners (MTP), a joint venture between HNTB (www.hntb.com) and CH2M HILL (www.ch2m.com), provided preliminary and final design services for the \$800-million reconstruction and reconfiguration of the Marquette Interchange and adjacent freeways.

The preliminary engineering phase identified two feasible bridge types for the system ramps—trapezoidal steel box girders and concrete segmental box girders. After 14 months of engineering and cost analysis, the WisDOT and MTP opted to move forward with a hybrid high performance steel (HPS).

Tony Shkurti, Ph.D., P.E., structural engineer with MTP leading the design of the trapezoidal steel box ramp, says,



Aerial view of the Marquette Interchange construction project upon completion.

“Since we were looking for safety and longevity, and because the twin steel box girders only include two main girders, one of the most important design considerations was the material’s resistance to cracking. High-performance steel offers superior resistance to crack propagation.”

However, at the time the guide specifications would not allow use of hybrid section designs. As a result, Shkurti and his team selected a hybrid segment design using HPS-70W for the tub girders segments at the piers and HPS-50W for the mid-span segments, providing both the function and cost-benefit needed for all flyover ramps. On all other steel bridges, they called for regular grade 50 steel that was readily available.

“Bottom line, the fracture critical bridge elements such as integral pier caps and trapezoidal steel box girder ramp bridges were fabricated from high-performance steel,” continues Shkurti. “These elements are defined as fracture critical, as their failure would possibly

mean a failure of the whole structure, which of course could not be tolerated.”

With a steel box girder design in mind, all eyes turned to the procurement, only to come up with a near project-ending challenge.

Steel Demand

A confluence of several unanticipated national and international factors emerged that the project team believed would delay the delivery of required steel for the interchange to the fabricator for a major part of the project.

Typically on a project such as this, the contractor assumes the risk for availability and delivery of the material, in this

case steel, selecting the drawing detailer and the steel fabricator. It’s a linear complex process that typically takes several weeks or even months from the time of award to placing a steel order with the mills—delays that the owner and project team simply could not afford.

Shkurti says, “The Marquette



The trapezoidal steel box ramps are highly resistant to cracking.

Interchange is comprised of 50 percent steel bridge structure. Delays in steel delivery, and especially of the HPS steel for the bridges, would have spelled disaster.”

The design team looked to the steel industry for an answer. Alex Wilson of ArcelorMittal USA and chairman of the Steel Market Development Institute (SMDI) Bridge Task Force, explains, “The transportation industry relies on organizations like SMDI to draw all parties together. We can effectively bring everyone from the owners and designers to the contractors and fabricators together to find collaborative solutions.” He added that the American Iron and Steel Institute’s knowledge of the unique requirements of HPS production and its history of arriving at cost-effective bridge solutions were also extremely valuable in the process.

Under advice from the steel industry, WisDOT contracted to an outside engineering firm to prepare preliminary shop drawings in sufficient detail to place a mill order immediately upon award to the successful contractor on structures critical to the schedule.

“This advance order ensured delivery of the HPS steel to the fabricator in a timely manner for all structures on the schedule’s critical path and drastically reduced the risk of project delays,” says Shkurti.

For the remaining structures, the winning contractor would take responsibility for all aspects of the steel procurement, as usual.

WisDOT procured preliminary shop drawings from Tensor Engineering (www.tensorengr.com) for the critical structures that required steel erection in the first 12 months of the project.

The engineering design team worked closely with Tensor, providing draft drawings and answering requests for information (RFI) about details such as plate sizes with a 24-hour return period. The NSBA/AASHTO-compliant drawings included calculation plans, web camber diagrams, flange cutting diagrams, and diaphragm layouts to the stage permitting material orders from the steel mills.

WisDOT let the project on September 1, 2005 to the prime con-

tractor, Marquette Constructors, LLC.

PDM Bridge, the fabricator, placed the initial steel order with ArcelorMittal USA eight days later. PDM began fabrication of the critical steel members on November 8, 2005 and began delivery of the fabricated steel to the project in April of 2006.

WisDOT’s Nguyen says, “The availability of these preliminary shop drawings at bidding cut about eight weeks from the steel delivery schedule—and ultimately helped put the entire Marquette Interchange project ahead of schedule.”

Additional benefits included early resolution of design issues, significant reduction of steel scrap, and ensured reservation on the steel mill’s rolling schedule.

Began in April 2004, the Marquette Interchange reconstruction—which included 60 bridges—was officially opened on August 19, 2008. The interchange’s ramps and bridges, supported by predominantly high performance steel, are considered one of the nation’s safest highway structures. These are the first twin-steel-box-type structures the Federal Highway Administration (FHWA) has ever approved as structurally redundant bridges.

Finn K. Hubbard, P.E., former Wisconsin state bridge engineer, says, “Rated as ‘non-fracture critical’ by the FHWA, the Marquette Interchange’s eight double-box girders are so strong that they won’t collapse even if one of the two boxes has cracked all the way through. Added to this, the combination of 50,000-psi to 70,000-psi strength provides about ten times as much resistance to cracking as normal steel.”

MTP’s Shkurti says, “High-performance steel is a superior product with



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higher optional strength, improved weldability, and greater levels of toughness than comparable regular steels or even other material options. It also has improved weathering resistance, all of which can lead to more economical bridges than conventional 50W designs.”

The entire project is representative of what can happen when everyone works together to find the best possible solution to a project.

Currently, WisDOT has several more bridge and highway projects proposed, including the reconstruction and expansion of the Mitchell Interchange in southeast Wisconsin linking I-43, I-94, and I-894 near General Mitchell International Airport in Milwaukee. Additionally, the Zoo Interchange, the busiest interchange in the state that connects I-94, I-894, and US 45 in western Milwaukee County, is undergoing early environmental and engineering analysis as it nears its useful life.

Shkurti says, “We expect to once again call on the benefits of high performance steel in both of these complex reconstruction projects because of inherent toughness and long lifecycle advantages.”



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