Design/Build of I-35W Bridge Replacement

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ABSTRACT: The collapse of the I35 W bridge in Minneapolis on August 1, 2007 was a tragedy with national implications. Whereas many agencies and media outlets were focused on the collapse and possible causes, the Minnesota Department of Transportation (Mn/DOT) had to solve serious infrastructure challenges. While most of Minnesota was still in shock, the Mn/DOT had to decide how best to replace a vital traffic artery that carried 141,000 vehicles per day. This Case Study will review the Mn/DOT response to the challenges and then provide an overview of the design, addressing the many technical and innovative enhancements utilized to resolve the site challenges.

Mn/DOT RESPONSE

The collapse of the I35 W bridge in Minneapolis on August 1, 2007 was a tragedy with national implications. Whereas many agencies and media outlets were focused on the collapse and possible causes, the Minnesota Department of Transportation (Mn/DOT) had to solve serious infrastructure challenges. With most of Minnesota still in shock the Mn/DOT had to decide how best to replace a vital traffic artery that carried 141,000 vehicles per day.

Certain sections in Mn/DOT focused on reconfiguring the traffic flow on the existing roads and bridges while another was charged with deciding on the best course of action to get a permanent, high quality bridge replacement in a compressed time frame. Mn/DOT decided that the best course to follow was to proceed with a Design/Build process for the Replacement Bridge. Mn/DOT had contracted for six other major Design/Build projects and had extensive experience in managing the design and construction aspects of such projects.

Mn/DOT publicly solicited Design/Build Teams to submit a qualification letter expressing interest on August 4, 2007. Mn/DOT short listed five DB teams to proceed in the process. Based on Mn/DOT's experience and the unique aspects of the I35W Replacement; Mn/DOT and the FHWA decided to pursue a Design/Build with the following facets:

- Utilize Best Value Approach
- Emphasize Geometric Improvements
- Leverage the Technology of the D/B teams through the Alternative Technical Concept process

Best Value Approach- On six previous Design/Build Projects, Mn/DOT had utilized the Best Value Approach where the DB Team submits qualifications and a technical approach to a project along with a cost proposal. A select committee reviews each of the Technical proposals and scores them according to a criteria that was make public in advance. Mn/DOT followed State and Federal statutes and policies when reviewing and scoring the proposals. Once the scores are compiled, Mn/DOT opens the cost proposals in open forum and the Best Value is the D/B Proposal whose Cost is divided by its Technical score is lowest. On some national D/B projects an additional element of time is added to the determination. For the I35W Replacement Project the Best Value included a cost of $200,000 per day for each contract day. Thus the equation was D/B SCORE=[COST+(Days*$200,000)]/Technical Score. For this important project 27 individuals from six agencies participated in reviewing and scoring the Design Build Proposals.

Emphasize Geometric Enhancements – The old I35W bridge had severe geometric constraints that had lead to traffic accidents; congestion and decreased public safety. Mn/DOT and the FHWA determined that the Replacement Bridge needed to eliminate as many of the six design exceptions that decreased public safety and utilization.

Alternative Technical Concept- The ATC process can allow a D/B Team to confidentially get approval from the Owner during development of the response to the RFP. For example, if the D/B Team has a concept that results in an improvement and cost savings that is not specifically allowed by the RFP; the D/B Team could present the ATC concept to Mn/DOT for approval. If approved then the D/B Team could base their RFP response and Cost Proposal on this ATC. ATC are kept strictly confidential and not shared with the other D/B Teams. The benefit of the ATC process is it allows for the expertise and innovations from the D/B Teams to be utilized. It encourages technological advances and innovations based on the best practices from national experts in design and construction.

On August 8, 2007, Mn/DOT short listed five DB Teams. Mn/DOT conducted weekly face to face meetings with each D/B Team until the Technical Proposals were submitted. The Final RFP was issued on August 23, 2007 with the Technical Proposals due September 14, 2007. Within 45 days of the collapse, Mn/DOT had developed a plan; short listed five D/B Teams; developed an extensive RFP; and received Technical proposals from four of the D/B Teams. Technical scoring started on September 14 and the sealed Cost Proposals were received on September 18, 2007. In open forum on September 19, 2007, Mn/DOT announced the technical scores and then proceeded to open the Cost Proposals that included a Construction Cost and number of days to build the project.

Proposer	Tech. Proposal SCORE	PRICE Proposal	TIME (Days)	ADJUSTED SCORE (A+B)/TECHNICAL PROPOSAL SCORE
Ames /Lunda	55.98	178,489,561	392	4,588,952.50
McCrossan	65.91	176,938,000	367	3,798,179.34
WALSH	67.88	219,000,000	437	4,513,847.97
Flatiron	91.47	233,763,000	437	3,511,129.37

Several major decisions by Mn/DOT and the FHWA positively affected the Costs for this project. Due to the importance of this project, Mn/DOT's DB process selected a team of highly experienced individuals in design and construction management to be dedicated on this project. Another important decision was the commitment to reviewing Design Submittals within seven calendar days.

When a D/B Team puts together a Cost Proposal, it has to evaluate Risk Factors of many varieties like material availability; anticipated labor efficiency; etc. One of the Risk Factors is delays caused by waiting for decisions from the Owner. These are delays that are beyond the D/B Team's control and are a major risk. For the I35W Replacement, it was clear that Mn/DOT and the FHWA were utilizing an experienced team with the authority to make decisions. In the D/B Team's opinion, the Mn/DOT and FHWA Review Team for this project had significant design and construction experience. As this project progressed the D/B Team favorable opinion of the Review team has been borne out. The Mn/DOT D/B Review Team consistently reviewed the many design submittals and resubmittals within seven days. The project has a highly detailed Quality Review process for all of the Design Elements with multiple levels of QA and QC checks by the DB Team and also by Mn/DOT. Even with the highly structured and detailed design review process, the majority of the main structural design elements were approved within four months.

Another example of the exemplary work of the Mn/DOT and FHWA Review D/B Team was their willingness to solicit input from national experts if needed. This design anticipated utilizing large diameter drilled shafts (between 7' and 9') into the underlying bedrock. The bedrock consists of sandstone that varies from weakly cemented and weathered to moderately cemented at depth. The Flatiron/Mason D/B Team brought in subcontractors with extensive drilled shaft experience. The Mn/DOT Review Team also brought in nationally recognized experts in this field. Before the Test Shaft Program commenced there were many meetings and teleconferences in which the in opinions of all of the parties were frankly discussed and used to select the parameters of the Test Shaft Program. The actual Test Shaft testing actually occurred on Thanksgiving Day 2007 and senior staff from Mn/DOT and the FHWA were present for the test. They also had the national experts on call on this holiday if they were needed. This dedication and commitment by Mn/DOT and the FHWA helped ensure that the foundations for this structure were designed and constructed for maximum quality and durability.

PROJECT DESCRIPTION

The new bridge is composed of separate crossings for both north and southbound traffic. Each structure consists of four spans at 341', 498', 236' and 147' for northbound and 315', 504', 248' and 147' for southbound (see Figure 1). Each crossing consists of dual concrete box girders joined at the center creating a 90'-4" road deck. The superstructure is 25' deep at the piers and 11' deep at the middle and ends, except at the middle of Span 4 where the depth is 6'. The bridges are separated by an 8'-8" gap.

Construction began on the new St. Anthony Falls (I-35W) Bridge on October 8th, 2007 and is scheduled to be complete by December 24th, 2008 (15 months total construction time). The Design/Build Team includes the Minnesota Department of Transportation (Owner), Flatiron-Manson (a joint venture of Flatiron Constructors, Inc. of Longmont Colorado, with Seattle-based Manson Construction Company), and FIGG, the designer of the bridge. The FHWA has also been an important member of the team and is involved in on-site review of design decisions and providing support.

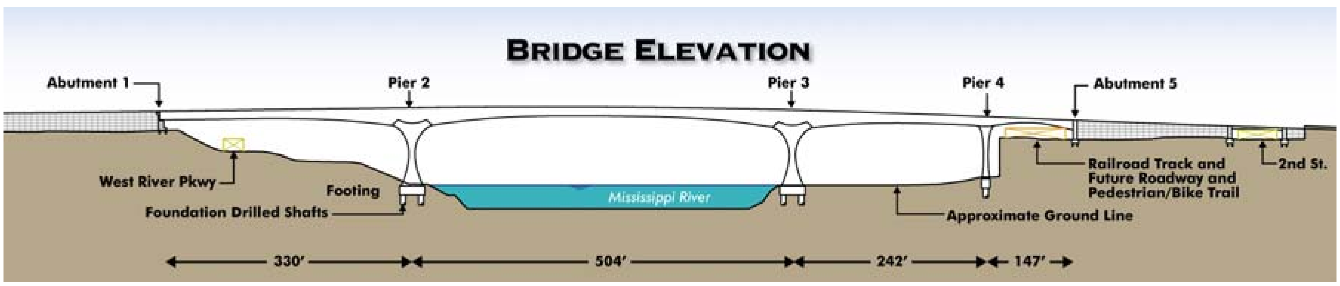

Figure 1 – I-35W Bridge Schematic

Four massive 70' tall columns at each pier (twelve total) support the superstructure. The piers for each structure (northbound and southbound) are founded on a common footing supported by large-diameter drilled shafts.

The completed crossing will have five traffic lanes in each direction and is designed to accommodate light rail transit (LRT) in the future (see Figure 2). If LRT is incorporated on the bridge, the number of traffic lanes will be reduced from ten to eight and the inside shoulders will be converted to LRT tracks.

Figure 2 – I-35W Bridge Cross-Section

FOUNDATIONS AND FOOTINGS

The abutments at each end of the bridge are common to both structures. The north abutment rests on 40 4' diameter, 30' long drilled shafts socketed into bedrock (see Figure 3). The south abutment is founded on a total of 120 HP14x117 steel piles driven approximately 50' to bedrock (see Figure 4).

Figure 3 – Footings on North side of River

Figure 4 – Footings on South side of River

The main foundations are 7' and 8' diameter drilled shafts approximately 100' long and socketed into bedrock. The shafts were installed using slurry construction methods with self-consolidating concrete. The footings were designed to straddle over some of the original foundations and extensive storm drains on each side of the river (see Figure 5). Each footing varies in longitudinal length from 34' to 43' and in width from 81' to 112'. Depths also vary from 13' to 16' depending on footing location.

Figure 5 – Footing Straddling Storm Drain

No piers were located in the water (see Figure 6). This project constraint was stipulated to reduce potential scour damage and to preserve the navigation channel. This constraint actually had several advantages during design and construction that streamlined the schedule. During design, loadings due to ice, barge, and stream flow forces were small thus simplifying the design effort. For construction, crews and equipment (drilling rigs, cranes, and concrete pump trucks) had direct access to critical areas along the shore.

Figure 6 – Drilling Shafts from Land

PIERS AND BEARINGS

The Design/Build Team allowed the community a choice of pier concepts and chose a solid strong curved pier shape (see Figure 7). The unique 70' tall main pier profile, when viewed from the longitudinal side, curves inward from a 26' wide base, to an 8' width at mid-height, and outward again at the superstructure. The superstructure rests on large disc bearings. The largest are the 3 bearings under each box girder at the main piers (see Figure 8). Each of these bearings have a service capacity of 5,900 kips. Sliding bearings tend to be more maintenance intensive. Extensive modeling and analysis showed that design frictional forces in bearings were similar to shears applied by a pinned bearing system for both piers. Therefore, the bearings for all main piers, are pinned against translation in all directions. Pier extensions on each side to protect and conceal the bearings.

Figure 7 – Piers

Figure 8 – Large Bearings

SUPERSTRUCTURE

Spans 1 through 3 are continuous, while Span 4 is single span, cast integral with the north abutment. Expansion joints are located at the south abutment, and at the pier common to both Spans 3 and 4.

The fast-paced schedule required casting as much of the 220,000 square feet of deck as possible at the same time as segments were being made in the casting yard. The back spans are cast-in-place on falsework, while the main span portions are simultaneously precast at the casting yard (see Figures 9 and 10). Eight longline casting beds were utilized for precasting. These beds were constructed on top of the existing southern highway approach for the previous bridge. All longline beds were operational at the same time and were used only once. Rolling heated structures, following the segment casting, provided a suitable work and curing environment during the winter months. The precasting started in late January and was complete by early June

Figure 9 – Casting Yard

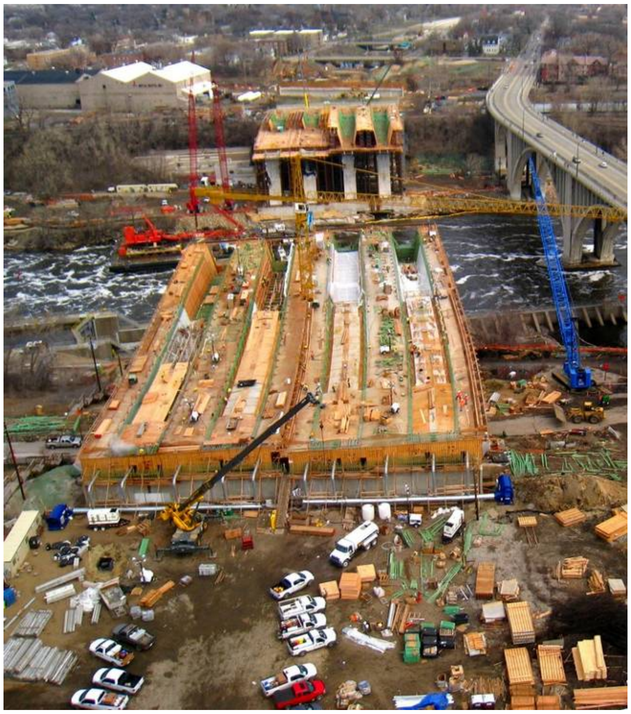

Figure 10 – Back Spans on Falsework

Each cantilever is approximately 250' long and contains 15 precast segments. Segments vary in length from 13.5' to 16.5', and depths from 25' to 11' (see Figure 11). Weight varies from 380 kips to 216 kips each. Once a completed cantilever was finished, the segments were split apart then hauled to the river shore to await erection by barge-mounted crane.

Figure 11 – Segments

The riding surface consists of a 2.5" integral overlay cast with the section. The 2.5" includes an additional 0.5" to facilitate deck grooving, geometry control and for optimum rideability. This type of overlay has the benefit of being precompressed in both directions with the typical segment post-tensioning and utilizes the same high strength, high performance concrete of the superstructure.

The north side of the bridge must clear an active railway located on the edge of a bluff (see Figure 12). In addition, the roadway alignment had to be low enough to clear under an existing overpass north of the project. Distribution of bending forces was optimized in Span 4 (which crosses the railroad) by designing the superstructure integral with the north abutment. This allowed for a slender span that satisfied both above and below deck clearance challenges.

Figure 12 – Railway on Bluff at North Side of Bridge

MAINSPAN ERECTION

The FMJV D/B Team began the erection of the precast mainspan segments on May 25, 2008. (see Figure 13) The 60th of 120 precast segments was erected on June 24, 2008. The final precast segment was erected on July 11, 2008. In 46 days FMJV successfully erected the 120 precast segments that weighed as much as 200 tons. FMJV was able to achieve a rate of four segments per day once the work force achieved experience with this new erection method. (see Figure 14).

Figure 13 – First Precast Erection May 25, 2008

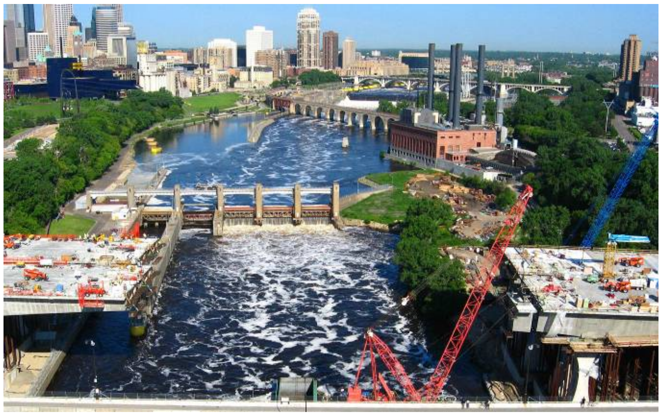

Figure 14 – Precast Erection June 2008

ADDITIONAL FEATURES

Numerous redundant load paths have been designed into the new structure. Multiple foundation elements, footings, columns, box girders and post-tensioning have been incorporated, creating no fracture critical elements (see Figure 15). Also, the north and southbound structures are separated, significantly reducing any potential interaction between the two during an extreme event.

Figure 15 – Each box girder is supported on its own column and own set of drilled shafts

Sensors are being placed throughout the bridge to monitor the structure during construction and service. Monitoring items include concrete maturity, displacements, and stresses, along with thermal sensing. An anti-icing system will also monitor the humidity, bridge deck and ambient air temperatures, automatically engaging when certain conditions are reached. The anti-icing fluid is distributed through recessed deck sprayers.

Another unique aspect of this fast-tracked project is the extensive public involvement that has been going on throughout the compressed schedule. On October 24th, 2007, 88 community representatives, from residents, business owners, cultural/arts groups, the University of Minnesota, and public officials gathered in a day-long community workshop, called a "FIGG Bridge Design Charette™", to select the aesthetic features of their new bridge (see Figure 16). Participants reviewed numerous renderings and animations of aesthetic elements. Through consensus voting, the community selected pier shapes, open barriers, abutments faced with native stone, and a white bridge color along with aesthetic lighting. Even with the fast pace of the project, the Design/Build team understood that it was important to involve the community and give them a voice and choices, since the bridge will have lasting significance in the visual landscape of the city.

Figure 16 – Bridge Design Charette

In addition, there will be extensive landscaping throughout the project site, and public observation decks at river level surrounding the main piers, adjacent to the river. The southbound structure has also been designed to accommodate a future pedestrian bridge to gracefully hang under and between the box girder sections (see Figure 17).

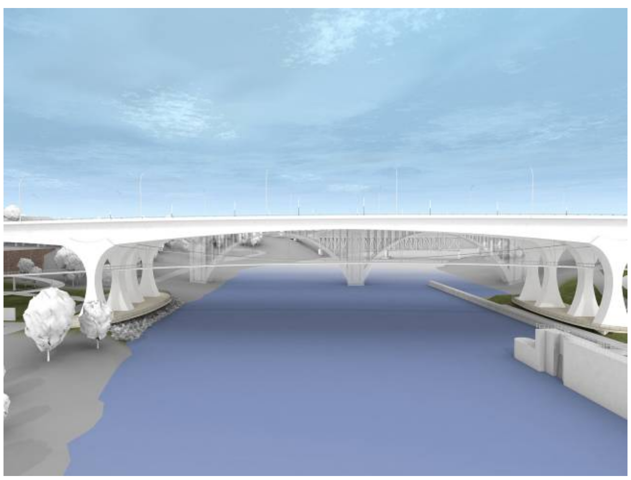

Figure 17 – Rendering of Hanging Pedestrian Bridge

INFORMATIVE AND INTERACTIVE PROJECT UPDATES

Formal outdoor talks are given every Saturday morning at 11:00 a.m. to keep the community up to date on current construction activities. Labeled "Sidewalk Superintendent Talks", up to 250 people have attended at one time and quite a few individuals come back regularly each week (see Figure 18). Talks begin at a parking lot near the site. A walking tour over the adjacent 10th Avenue Bridge takes place with personnel from the Project Team providing an update to progress and answering questions along the way. It is worth mentioning that even in the winter, in -10° F weather, we always had a dozen or so hardy folks show up for these talks. In more temperate weather, more than 100 people have participated.

Figure 18 – Sidewalk Superintendent Talks

At two locations in the Twin Cities (Minneapolis-St. Paul Airport and the Mill City Museum), kiosks that provide information on the project, were placed to help travelers and visitors understand the project. A project website is also maintained and receives approximately 400 visitors a day (see Figure 19). A large percentage of viewers monitor the up-to-the-minute web cameras, review construction progress and the latest project images. Interested individuals may also sign up to receive a weekly construction update email, including attached images. The project website may be reached through www.mndot.gov.

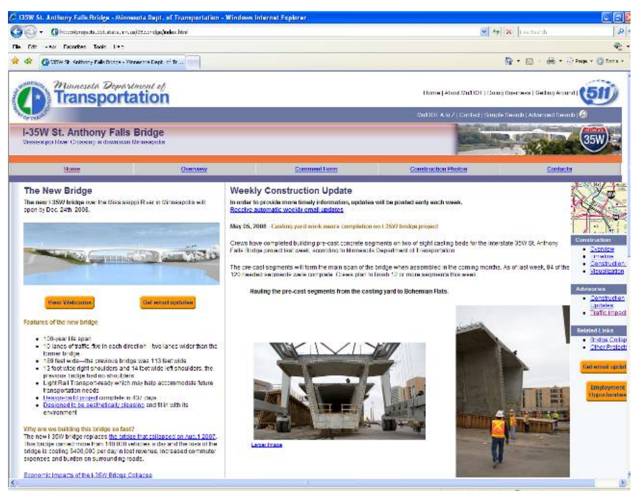

Figure 19 – Website

The many unique features of the new I-35W bridge will provide a structure of which the citizens of the region can be proud. The structure contains no fracture critical elements, utilizes extensive health monitoring capabilities during service, and is designed for 100-year life. At the time of this paper the project has been under construction for 8.5 months and the bridge project is progressing so well that the entire project is anticipated to be completed in the middle of September 2008. (see Figure 20) Thirteen and one half months after the collapse the State of Minnesota will have a completed I35W Replacement Bridge that will improve the traffic and safety of this very busy corridor.

Figure 20 – Construction on 6-22-08