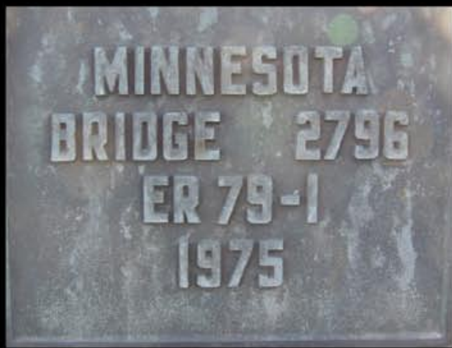

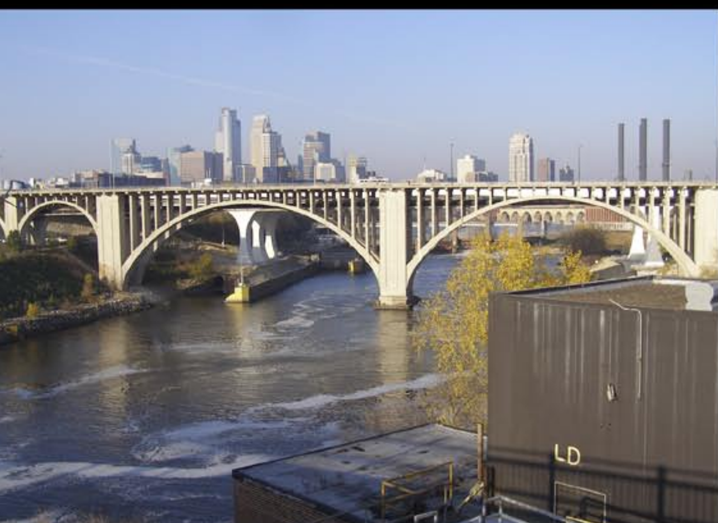

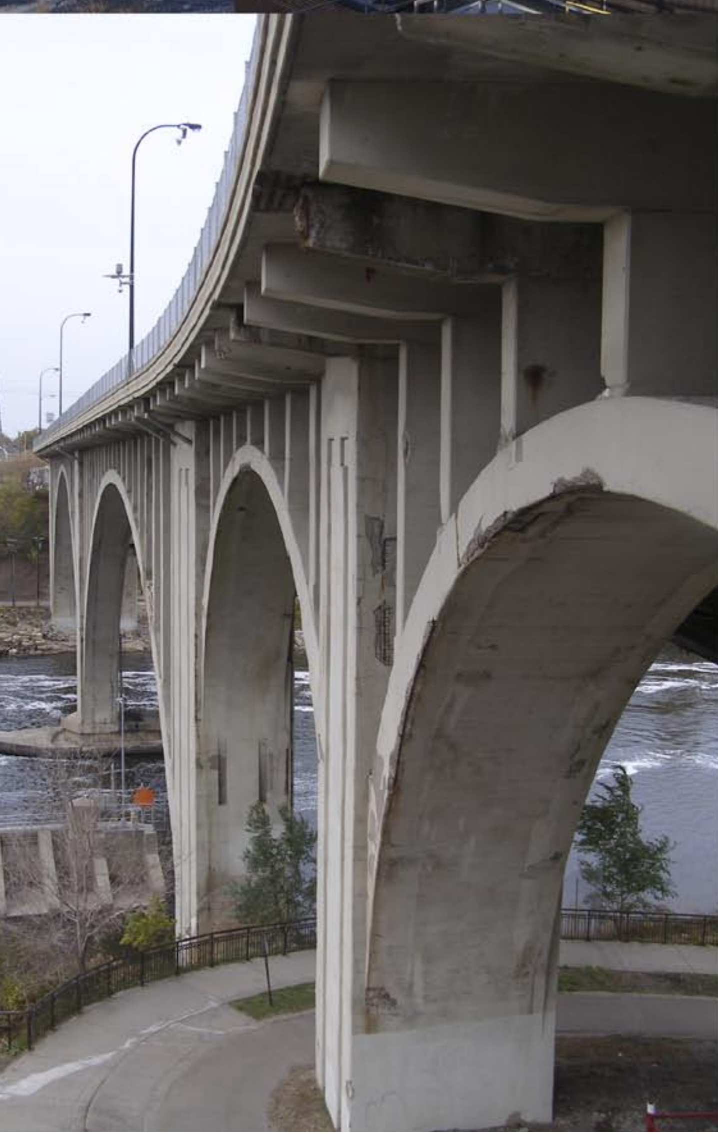

Structural Evaluation Report for the 10th Avenue Bridge over the Mississippi River

(Mn/DOT Bridge No. 2796)

Prepared for the

City of Minneapolis

September 2009

Prepared by

SRF Consulting Group, Inc.
Engineers | Planners | Designers

in association with

BRAUN[SM] INTERTEC

EXECUTIVE SUMMARY

BACKGROUND

The City of Minneapolis retained SRF Consulting Group, Inc. to perform a structural evaluation of the 10^{th} Avenue Bridge (Mn/DOT Bridge Number 2796). The main objective of this evaluation was to identify areas of deterioration and distress and to develop repair options to address these areas. The evaluation included a field investigation, material testing, a hazardous materials assessment, a bridge load rating, and a scour evaluation.

Originally constructed in 1929, the 10^{th} Avenue Bridge is a twenty-one span, 2,135-foot long, open-spandrel arch bridge that spans a gap between West River Parkway and 2nd Street SE, connecting 10th Avenue SE in the Marcy-Holmes neighborhood of Minneapolis to 19th Avenue South on the West Bank of the University of Minnesota. The bridge is located 300 feet east of Interstate 35W (I-35W), and approximately one-half mile northwest of the Washington Avenue Bridge. The 68.1-foot-wide bridge deck contains a 55.5-foot roadway and a barrier-protected eight-foot-wide pedestrian facility.

The concrete arch portion of the 10^{th} Avenue Bridge consists of two main spans, each 290'-6" in length, spanning the Mississippi River. Flanking the main arch spans are five smaller arch spans (three to the south and two to the north) ranging from 108'-0" to 113'-0" in length. The northern approach to the concrete arches consists of six steel beam spans ranging from 31'-0" to 78'-1 11/16". The southern approach to the concrete arches consists of eight precast concrete beam spans ranging from 37'-3 3/8" to 92'-6 1/4". The bridge connects 10^{th} Avenue SE to 19^{th} Avenue S in The City of Minneapolis, Minnesota. The bridge is located west of the University of Minnesota, east of downtown Minneapolis, and is parallel to the newly constructed I-35W Bridge over the Mississippi.

From 1972 to 1976, major bridge rehabilitation was undertaken. The original approach spans were reconstructed and realigned and the original arch span deck and floor beams were replaced. In 2001, the top half-inch of the existing deck surface was milled and a two inch, low-slump, concrete wearing course was installed.

In 1989, the 10^{th} Avenue Bridge was listed on the *National Register of Historic Places* under its historic name (The Cedar Avenue Bridge). It is historically significant as the longest, pre-1945, reinforced concrete, continuous arch bridges to span the Mississippi River in the Twin Cities. The Minnesota Historical Society states that the true beauty of the bridge lies not in ornamental features, but in the clean lines of the form that reveal the bridge's engineering elegance. The purpose of this report is to identify methods to preserve the bridge as a functional monument to the historic structure's renowned architect, Kristoffer Olsen Oustad. As one of four innovative Norwegian-American engineers involved in the design of the great early 20th-century bridges of the Twin Cities, Oustad remains a significant asset to Minnesota's transportation and engineering history.

FIELD INVESTIGATION AND LABORATORY ANALYSIS

Concrete Quality – Overall, the quality and strength of the concrete tested was good. Compression strength tests indicate that the concrete strength ranged from 5,060 to 8,880 psi. Petrographic tests showed that the concrete is undergoing very little age related deterioration. However, chloride ion contents of concrete were very high in many locations. Areas beneath expansion joints were shown to be especially contaminated with chlorides. This contamination may be accelerating the corrosion of the reinforcing steel within the piers, floor beams, spandrel columns, and arch ribs.

Bridge Deck – The top of the bridge deck is in fair condition. Nearly the entire deck surface contains map cracking and transverse cracks. Cores through the deck show that some of these cracks are penetrating to the reinforcing steel. The bottom of the concrete deck is primarily in good condition except near expansion joints where it is in poor to serious condition. Areas approximately 18-inches to 24-inches on either side of the floor beams under all joints were found to be severely delaminated or completely spalled do to water and salt intrusion.

Bridge Barriers and Railing – The bridge railing and barriers were in good condition with only minor areas of deterioration. However, both the sidewalk railing and roadway barriers do not meet current standards for safety. The sidewalk railing is 5-inches lower than that recommended for bicycle traffic. The roadway barriers have substandard terminations which may cause spearing, snagging, or launching of a vehicle.

Floor Beams – The fifty-one floor beams on the arch spans support the deck in areas without expansion joints and are in good condition. The twenty-two floor beams that lie beneath expansion joints are in poor to serious condition. The amount of delamination at these floor beams indicates a high level of chloride contamination and corrosion of reinforcement in floor beams under joints.

Spandrel Columns – The condition of the 146 spandrel columns varied from good to poor. The columns with the most deterioration are located beneath deck expansion joints. The estimated area of delaminated or spalled concrete on the faces of columns under joints ranged from 10 percent to almost 100 percent of the total area of column face. Another area of deterioration occurred on the shorter spandrel columns towards the center of the arch spans. These columns are very stiff and are not very tolerant of thermal movements. The bridge deck expands and contracts as the outside temperature rises and falls causing the spandrel columns to rotate at the arch ribs. Since the stiffness is high and the capacity is low, large cracks have formed at the base of the shorter columns.

Arch Ribs – In general, the arch ribs are in satisfactory to fair condition. Concrete in non-deteriorated areas is sound and, according to compression strength tests, has strength in excess of that required by design. The areas of most severe deterioration on the shorter span arch ribs (Spans 1-3, 6, and 7) are at the top face areas just below the expansion joints. Water pools in these areas and is causing a large amount of reinforcement corrosion and concrete delamination. The areas of most severe deterioration on the longer span arch ribs (Spans 4 and 5) occurs over the tops of the internal steel trusses. Large cracks have formed over the internal steel members allowing water and salts to accelerate corrosion in these members. This corrosion has caused large areas of concrete to spall or delaminate.

Arch Piers – In general, the upstream and downstream faces of the arch piers are in satisfactory condition and the north and south faces of the arch piers are in poor condition. The north and south faces of each pier lie below expansion joints. Water and salts are infiltrating the joints and running down the faces of the piers causing reinforcement corrosion and concrete delamination. Similar to the floor beams, concrete beams running along the north and south faces of the piers are undergoing severe delamination and spalling. In most cases this deterioration is more severe than at a typical floor beam.

Utility Hangers – The majority of areas where the utility hangers frame into the spandrel columns are undergoing moderate to severe deterioration. In most locations the hangers are placed directly below the location where the 1970's rehabilitation meets the original 1929 construction. Placing fresh, chloride-free concrete adjacent to existing, chloride contaminated concrete may have induced corrosion in the reinforcing steel. This corrosion may have been accelerated when moisture penetrated the holes drilled for the hanger anchorages.

South Approach Spans – The beams and piers on the south approach spans are in good condition with only minor, isolated areas of deterioration at the ends of beams and on pier caps. This deterioration was most likely caused by expansion joints that had failed. These expansion joints were replaced in 2001 and the deterioration has likely slowed.

North Approach Spans – the beams and piers of the north approach are in good condition with only minor, isolated corrosion. Similar to the south approach, this deterioration is occurring near the expansion joints which were replaced in 2001 and has likely slowed.

Asbestos and Hazardous Material Survey – The results of the asbestos sampling activities did not identify any asbestos-containing materials on the 10th Avenue Bridge. The field analysis indicates that the green paint on the steel beams of the north approach contains lead and is considered lead-based by the EPA, MPCA, and the MDH. Observations made of this paint during the overall visual survey indicate that the paint is in good condition with only localized areas of peeling. Several miscellaneous materials were indentified that may require special handling or disposal if removed. The items identified include:

- Eight (8) high-intensity discharge (HID) light fixtures on the underside of the bridge at the north and south abutments.
- Twenty (20) HID streetlight fixtures.
- Eighty-eight (88) 8-lb lead plates on bearing assemblies.
- Seven hundred twelve (712) 4-lb lead shims on the road way railing between the top of the concrete railing and the supports for the 4-inch diameter steel pipe.

SCOUR EVALUATION OF RIVER PIERS

Data from previous surveys, reports, analyses, and studies was reviewed to determine the adequacy of scour and scour protection for Piers 4-6. A review of the available data provides the following observations:

- Pier 4, Pier 5 and Pier 6 are located within or immediately adjacent to the Mississippi River channel and are exposed to flow conditions that have the potential to produce significant scour.
- Inspection of Pier 4 and Pier 6 revealed no evidence of scour affecting the bridge foundation, with countermeasures in good condition.
- The underwater inspection of Pier 5 found minor defects to be present with the sheet pile encasement and concrete fill within the encasement, but the report still rated the pier condition satisfactory.
- The underwater inspection report noted that the Pier 5 foundation had not incurred any significant change since the previous underwater inspection in 2002.
- Both the 100- and 500-year floods will create velocities high enough to scour through the alluvium to the underlying bedrock at Pier 5.
- Pier 5 is supported by a combination of bedrock and erodible alluvium soils that are contained within the sheet pile cofferdam.
- There is some concern identified in the reports that the bedrock in this area is somewhat erodible. For the purposed of this review, scour depths were assumed to be limited to the surrounding bedrock elevations.

Conclusions from the observations include the following items:

- The riprap armament downstream of the Pier 6 slope paving was found to be in disarray and should be repaired.
- As indicated by the elevation history, the scour potential is greater on the south side of Pier 5 due to the presence of the lock and dam guide wall which constricts flow through the south arch span. This survey should be continued and further riprap added if changes are observed, particularly on the south side location.
- The integrity of the sheet pile embedded into the underlying bedrock is of crucial importance for the structural stability of Pier 5 and the bridge.
- Scour countermeasures are crucial for the integrity of the bridge foundation and, therefore, should be inspected at the normal maximum recommended (NBIS) interval of five years or more frequently.

STRUCTURE LOAD RATING

A structural analysis was conducted for the 10th Avenue Bridge to evaluate Inventory and Operating Load Ratings. The analysis was carried out in accordance with the AASHTO *Standard Specifications for Highway Bridges* and the Load Rating was carried out in accordance with the Alternate Load Rating Method (Load Factor Design) in the AASHTO *Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges*.

The governing (lowest) rating factors for the 10th Avenue Bridge occur on the second span of the south approach. Beam #8 (the first interior beam on the west east side of the bridge) has an inventory rating factor of 0.61 and an operating factor of 1.02. These rating factors equate to the following load ratings:

Inventory Rating: HS12.2

Operating Rating: HS20.6

Additionally, the 10th Avenue Bridge was evaluated for load posting. Per Mn/DOT requirements, the bridge is required to be posted at 36T, 40T, and 40T with Mn/DOT sign R12-5. However, if the City of Minneapolis declares that the 10th Avenue Bridge does not receive any traffic of multi-axle single unit trucks, the 10th Avenue Bridge would not require load posting.

REPAIR CRITERIA

Repair recommendations were based on the following criteria:

***Live Load Capacity* –**All repairs considered will not reduce the live load capacity of any existing component.

Sufficiency Rating –The sufficiency rating of the 10th Avenue Bridge is 77.3 percent and is considered Adequate. All repair options were considered on the basis that they will not reduce the sufficiency rating.

Impact on Historical Resources – Repairs will preserve historic elements. The concrete piers, arches, spandrel columns, and floor beams would be considered historically significant. No repair method evaluated in this report would change the appearance or character of theses items. The deck, joints, and railing are assumed to not be historically significant.

Construction and Life-Cycle Costs – Recommended repairs will minimize initial and life-cycle costs.

REPAIR ALTERNATIVES

Although there are several repair options available for each bridge element, it is useful to combine the choices into alternatives for the basis of cost comparison. For the purpose of this report, three recommended alternatives have been chosen based on different levels of initial and life-cycle costs. These alternatives are for comparison purposes only and are not explicitly required to be combined in the manner presented.

All repair alternatives presented below involve the removal and reconstruction of either floor beam elements, spandrel column elements, or both. The undertaking of the Improvement repair actions for the floor beam and spandrel column elements requires the removal and reconstruction of the expansion joints. Costs for the expansion joint removal are included within the expansion joint elements. Any repair alternative that plans on replacement of the floor beams or spandrel columns must include the costs associated with expansion joint removal and replacement.

Repair Alternate I – The focus of Repair Alternative I is to repair all areas of distress as well as prevent future deterioration. The amount of initial work is extensive, but future repairs are minimized. This alternative calls for the expansion joints on the arch spans to be made waterproof with the installation of a neoprene gland type expansion joint device. All floor and pier beams beneath these repaired joints would be replaced. The deck would be sealed to reduce further deterioration of reinforcing steel. All delaminations and areas of spalling on the piers, spandrel columns, and arch ribs would be repaired and sacrificial anodes would be installed into patches to reduce future deterioration. The cracks at the bases of the spandrel columns and the anchor penetrations at utility hanger locations are sealed with a flexible caulk. Pier drains pipes are sealed and rerouted away from concrete faces. The damaged portion of the Pier 1 backwall would also be reconstructed. Large diameter (4-feet to 5-feet) riprap would be installed downstream of Pier 6. Additionally, safety would be addressed by adding a 5-inch extension to the sidewalk ornamental metal railing and by reconstructing the ends of the concrete traffic barriers.

Repair Alternate II – The focus of Repair Alternative II is similar to Alternative I, but initial work is reduced and future repairs are increased. The only difference involves eliminating the repair of spalls and delaminations on the arch piers. The amount of deteriorated area on the piers is very large and, therefore, initial costs are high. Although the deterioration on the piers is not structural in nature, the severity and quantity of spalls and delaminations will increase and will eventually need corrective action.

Repair Alternate III – In Alternative III, the amount of initial work is at the lowest recommended level, but future repair costs would increase. When compared with Alternative II, Alternative III further eliminates the repair of spalls and delaminations on the spandrel columns and arch ribs. The deterioration found on the Spandrel Columns and Arch Ribs is reducing the capacity of these elements, but not to a level that would reduce the overall Load carrying capacity of the bridge. Eventually, this deterioration will reach a level that will affect the bridge capacity and need to be addressed.