Affordable Bridge Girder End Repair Method Restores Concrete Beams to Original Strength

What Was the Need?
Reinforced concrete bridge beams bear heavy loads well for decades. If beams show distress, it’s often at beam ends located under bridge expansion joints, which are necessary for thermal expansion. Expansion joints consist of flexible neoprene seals that are prone to tears from roadway objects and material buildup. Water and salts leaking through these tears can corrode the reinforcing steel embedded in concrete elements under the joint, including the beams and supporting structure. Deterioration at the beam end can compromise the safe function of the entire bridge.

MnDOT Bridge 27568 is a prestressed, reinforced concrete girder bridge over Nine Mile Creek. It was built in 1975 by Hennepin County and acquired by MnDOT in 1988. In the years following the acquisition, the bridge expansion joints were replaced but corrosion damage was widespread from prior joint failure. District maintenance engineers and bridge inspectors were concerned with concrete degradation on the bridge and poor concrete in the bridge deck.

During a 2013 repair, crews encountered two locations of severe beam deterioration. To repair these areas, MnDOT used a novel method developed in Michigan that involved removing deteriorated concrete and cleaning the area, placing steel reinforcement cages around the damaged beam ends and then encasing the beam ends with concrete. The repair concrete was a specific form of concrete placement called “shotcrete”—a mix of sand, aggregate and cement that is applied with a hose that is wetted at the nozzle before the mixture is sprayed at high velocity onto the repair surface. When the desired thickness of the concrete placement is reached, the placement is troweled and shaped to finish to the desired cross section. The beam end repairs were made in October 2013 and allowed the bridge to continue its function to the public.

Several years later, the bridge was scheduled for replacement. The repaired girder ends appeared to be in good condition, but the repair technique had not been studied for strength. The bridge replacement presented MnDOT with an excellent opportunity to evaluate the repair method for use on other damaged girder ends.

What Was Our Goal?
Researchers examined and tested beams removed from the bridge over Nine Mile Creek to evaluate the effectiveness of the reinforced shotcrete repair method.

How Did We Do It?
The bridge consisted of 49 spans. Each span was 60 feet long and contained at least eight prestressed concrete beams. MnDOT identified two pairs of beams, each con-
taining one repaired beam and one good condition beam. The good condition beams were not located under expansion joints but were very similar in design to the repaired beams.

During removal, crews separated the existing bridge deck from the supporting beams. The beams had to be cut from 60 feet to less than 38 feet to fit in the structural engineering lab at the University of Minnesota. Once the specimens were in the laboratory, the research team cast a new, high-strength concrete deck for each of the four girders, recreating the beams’ field configuration for effective testing.

Each beam was then loaded by a hydraulic ram pushing down on the beam. Investigators applied a load in 25,000-pound increments to almost 500,000 pounds on each girder. They traced cracks with colored markers on the beam ends, recording details about the beam condition at each step of the way. Failure was photographed, data was recorded, and the next beam was tested.

What Did We Learn?

All repairs had been done in field conditions that have the potential to adversely affect the results. But when the beams broke in the lab, the shotcrete repair did not separate from the bonding surface. The repaired reinforced concrete beam ends were found to be at least as strong as similar beams that were in good condition and had not needed repair. The initial repair methods and subsequent testing of the prestressed beam ends are demonstrated in a video created by the research team.

Using this method, severely deteriorated beam ends can be repaired with reinforcement cages and shotcrete for $5,000 to $10,000. The alternative to this type of repair involves constructing a new beam, closing traffic, removing the bridge deck over the damaged beam as well as the beam itself, and recasting the bridge deck and barrier—an intrusive replacement that costs hundreds of thousands of dollars and more than a month of bridge lane closures.

What’s Next?

Results have been presented internally at MnDOT, at state and Midwest conferences in late 2017, and at the National Bridge Preservation Partnership Conference in April 2018. Presentations have impressed transportation engineers from around the country and have increased confidence in dealing with aging infrastructure. MnDOT will continue to refine repair methods with the shotcrete treatment based on best industry practices, and will continue to use the beam end repair method if similar conditions are encountered in the state.