Post-Tensioned Tendon Grouting on the St. Croix River Crossing

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The St. Croix River Crossing connects Minnesota State Highway 36 and Wisconsin State Highway 64 over the St. Croix River just east of Minneapolis–St. Paul, Minn. Constructed by Lunda/Ames Joint Venture (LAJV) from 2014 to 2017, the bridge is a 5080-ft-long post-tensioned concrete box girder structure. The approach spans are 10- to 14-ft-deep precast concrete box-girders, and the approach gore areas and ramps consist of 10- to 18-ft-deep cast-in-place box girders. Approach spans range from 190 to 290 ft in length. The main river spans are 600-ft-long precast concrete extradosed spans composed of side-by-side, 18-ft-deep concrete box girders, which are post-tensioned using high-strength steel, multi-strand tendons inside corrugated plastic or galvanized steel ducts.

Preparing to inspect grout at grout vents. Photo: Paul Kivisto, Minnesota Department of Transportation.

Grout being batched in a colloidal mixer. Photo: Paul Kivisto, Minnesota Department of Transportation.

Protection of a bridge's post-tensioned tendons is extremely important, and grouting, along with duct type, concrete quality, and sound joints, is a key component ensuring a bridge's durability. This article describes the grouting practices used for the post-tensioning tendons on the St. Croix River Crossing.

Grouting Specifications

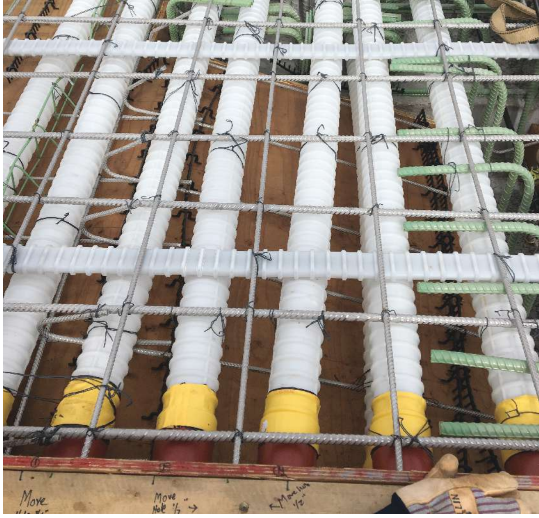
The project specifications required the use of thixotropic grouts, specific minimum and maximum temperatures for grouting, time limits on the amount of time tendons can be left ungrouted, and experienced personnel to perform the grouting.

Thixotropic grout materials are a recent advancement in grout technology. These materials are highly resistant to the formation of bleed water. They are flowable when injected under pressure into a closed duct system, but they quickly stiffen while at rest. Once at rest, thixotropic grouts are very stable and minimize the air voids that occurred when older cement-water grouts were used. Elimination of bleed water means no excess water is left in the ducts, which can lead to early deterioration of the tendons.

Grouting operations were limited to concrete substrate and ambient air temperatures between 40°F and 100°F. Given these temperature restrictions and Minnesota's climate, grouting typically could not be performed from November through March, and grouting during the summer often had to be performed during early morning or evening hours, when temperatures were cooler. On this project, the maximum allowable time between installation of post-tensioning steel and grouting was 15 calendar days.

Precast concrete segment fabrication and erection and cast-in-place concrete operations continued during the late fall and winter months when temperatures were much colder than 40°F. Specifications

Grout being pumped into the ducts at the crossbeam in the extradosed spans (the crossbeam connects two columns of a pier). The crew is grouting the post-tensioned bars that extend across the width of the crossbeam (about a 16-ft-long bar). Photo: Paul Kivisto, Minnesota Department of Transportation.



A cast-in-place pier table segment on an approach bridge. The round longitudinal post-tensioning ducts are 4 in. in diameter, and the flat transverse post-tensioning ducts are 1 in. by 3 in. Photo: Parsons Transportation Group.

allowed for grouting to be deferred during winter months; during that period, tendons were installed but not grouted and vapor-phase corrosion inhibitors (VPCIs) were used to minimize risk of strand corrosion. The VPCIs worked well but required a sealed duct system to provide protection through a charged atmosphere. During the project, it was noted that, in some instances, minor amounts of water got into ungrouted tendons. VPCIs do not protect tendons in such situations. Therefore, the Minnesota Department of Transportation (MnDOT) needed to be aware of cold weather segment erection practices in circumstances in which there was a risk of water intrusion prior to grouting. As a best future practice, MnDOT will consider grouting temperatures when determining whether cold weather segment erection operations will be allowed.

Standard testing was required for all grout applications to ensure that the grout as prepackaged, mixed, and as placed in the ducts met requirements for temperature, fluidity, strength, wet density, control of bleed, and chloride ion content. Standard field production test methods included modified flow cone, mud balance, and Schupack[1] pressure bleed testing. Field test frequencies were as follows:

- Mud balance at outlet for every tendon with five or more strands and every fourth tendon with four strands or less
- Modified flow cone for every 2 yd^3 of grout or every 2 hours
- Pressure bleed test and grout cube samples per each grouting operation

Project grouting operations are technically critical, and it is important for grouting personnel to be trained and experienced. Specifications required that the post-tensioning grouting supervisor must have experience on at least four previous projects and American Segmental Bridge Institute grout technician certification. Grouting crew members were trained and under the direct supervision of personnel with at least three years of experience.

Prior to production grouting, the contractor was required to construct a grout mock-up that would be dissected to demonstrate that grouting operations could be successfully performed.

Contractor's Operations

The bridge's precast concrete segments and cast-in-place concrete box girders are post-tensioned with tendons ranging from 19 to 31 strands in 4- to 5-in.-diameter ducts. The river pier crossbeams were post-tensioned with 52 strand tendons in 6-in.-diameter ducts. Transverse deck tendons consist of four strands in 1-in. by 3-in. rectangular plastic ducts. For grouting, LAJV used grout plants consisting of double-tank colloidal mixers, which ensured proper mixing. Some grouting was done on transverse deck tendons in the casting yard; however, most grouting was done on the erected structure. Crews typically had an approved grouting supervisor, plus two workers at the mixing plant, as well as one worker at the inlet and one at the outlet. A quality control (QC) representative for LAJV and the MnDOT/construction engineering inspection (CEI) quality assurance (QA) staff monitored the grouting operations to ensure compliance with project specifications.

A critical step prior to grouting is to check that ducts can hold air pressure. If leaks are found, the source must be identified and repaired. Leaks are most common at anchorage end caps, vent tubes, and segment joints. In this project, leaks at segment joints were repaired by drilling holes between ducts directly in the joint between segments and filling the space with epoxy. This method sealed one duct from another and avoided grout crossover. In some cases, where the tendons in adjacent ducts were already tensioned, the ducts could be grouted at the same time with use of a manifold.

Grouting Challenges

LAJV found that thixotropic grout tended to set up quickly on warmer days, which can complicate grouting, but grouting typically proceeded very well. With more than 2000 miles of post-tensioning strand on the project, the scheduling of grouting operations was challenging. The contractor used two crews at peak times and was able to provide an adequate number of trained and experienced supervisors. At times, the 15-day maximum grouting time requirement between post-tensioning steel installation and grouting became an issue, and the project team needed to come to agreement on how to best get back within specifications.

Air leaks occurred on several occasions and were repaired as previously explained. Only one duct had grout crossover into an untensioned tendon. LAJV double-end tensioned that tendon to the design

A modified flow cone test was required to be performed for every 2 yd^3 of grout or every 2 hours Photo: Paul Kivisto, Minnesota Department of Transportation.

force. Post-grouting inspection of tendon anchorage caps and inlet/outlet vents was performed for each tendon to confirm complete and successful grout filling of the tendons, and there were only a few isolated instances of incomplete grouting or voiding. Once identified, these minor areas were repaired using either gravity-fed or vacuum grouting procedures.

Dry grout material was tracked, and any product older than six months or stored onsite for more than one month was discarded.

Environmental Considerations

Because the St. Croix River Crossing spans a National Scenic Waterway, the project needed to follow environmental best management practices; therefore,the grouting operations needed to be contained such that any spills, grout residue, or other hazardous materials would be contained, properly disposed of, and not enter the river or wetlands.

QA Inspection Process

Parsons Transportation Group assisted MnDOT with QA inspections. CEI staff were required to have at least five years of experience with post-tensioned bridge construction, including grouting experience. QA inspections included verifying air-pressure testing, witnessing field production tests at the inlets and outlets, reviewing all repairs, verifying post-grouting inspection adequacy of the grouted duct, and documentation of all grouted tendons.

The project specifications for grouting the post-tensioned tendons, the grouting process by the contractor, and the QC/QA verification process implemented on the St. Croix River Crossing will lead to a durable bridge for years to come.

Reference

1. Post-Tensioning Institute (PTI). 2012. *Specification for Grouting of Post-Tensioned Structures (PTI M55.1-12).* Farmington Hills, MI: PTI.

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EDITOR'S NOTE

For more details on this project, see the project article on the St. Croix River Crossing in this issue.