Laboratory Investigation of Concrete Beam-End Treatments

tech transfer summary

Concrete coatings (silanes, epoxies, etc.) for protecting prestressed concrete beam ends may help prevent premature deterioration due to moisture and chloride penetration.

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RESEARCH PROJECT TITLE
Laboratory Investigation of Concrete Beam-End Treatments

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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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Background

The ends of prestressed concrete beams located under bridge expansion joints are often exposed to extended periods of moisture and chlorides. This exposure can cause the beam ends to deteriorate prematurely, corrode the prestressing strands, degrade the surrounding concrete, and eventually reduce the capacity of the beam.

Problem Statement

Previous research has investigated the use of concrete coatings (silanes, epoxies, etc.) for protecting prestressed concrete beam ends, but insufficient laboratory research has evaluated the performance of these coatings for this application.

The Iowa Department of Transportation (DOT) currently specifies coating the ends of exposed prestressed concrete beams with Sikagard 62 (a high-build, protective, solvent-free, epoxy coating) at the precast plant prior to installation on the bridge. However, no physical testing of Sikagard 62 for this application has been completed.

Meanwhile, the Iowa DOT continues to see deterioration even in beam ends treated with Sikagard 62. The Iowa DOT therefore wanted to evaluate several available prestressed beam-end treatment alternatives in the laboratory and in the field.

Research Objectives

The objectives of this research were to evaluate the performance of several concrete coating alternatives based on the American Association of State Highway and Transportation Officials (AASHTO) T259-80 chloride ion penetration test and to evaluate them based on their performance on in-service bridges. In addition, alternative beam-end forming details were developed and evaluated for their potential to mitigate the deterioration caused by corrosion of the prestressing strands on prestressed concrete beam ends.

Research Description and Methodology

This research involved the following tasks:

- A literature review of the use of concrete coatings for protecting prestressed concrete beam ends
- Selection of several beam-end treatment products, including the one currently specified by the Iowa DOT (i.e., Sikagard 62)

- Evaluation of the selected beam coating alternatives in the laboratory using the AASHTO T259-80 chloride ion penetration test (Standard Method of Test for Resistance of Concrete to Chloride Ion Penetration)
- Application of the beam coating alternatives on two prestressed concrete girder bridges, with monitoring for the duration of the project (18 months)
- Laboratory tests to evaluate alternative beam-end fabrication details

The selected beam-end treatment products included the product currently specified by the Iowa DOT, Sikagard 62, and seven other products chosen based on the literature review and input from the project technical advisory committee (TAC). The following products were selected:

- Sikagard 62 (epoxy)
- TEX•COTE XL 70 BRIDGE COTE with Silane
- TEX•COTE RAINSTOPPER 140 (40% silane sealer)
- Viking Aqua Guard Concrete Sealer (two-part water-based epoxy)
- PAULCO TE-3008-1 (two-part solvent-based epoxy)
- BASF Sonoguard (two-part polyurethane waterproofer)
- BASF Hydrozo 100 (100% silane penetrating sealer)
- Evercrete Deep Penetrating Sealer (DPS)

The selected products were tested in the laboratory according to AASHTO T259-80. Each product was applied to a designated square on each of three concrete ponding slabs, with each slab from a different precast facility in or near Iowa. In addition, two coats of Sikagard 62 were applied to one square, and two were left uncoated as controls.

The three slabs were submerged in a 3% chloride solution for 90 days, and samples were taken to be tested at the Iowa State University materials testing facilities. This procedure was repeated two more times.

The selected products were tested in the field on 19 beam ends on two bridges around Des Moines, Iowa: the Interstate 35 (I-35) Bridge over E.P. True Parkway and the US 65 Overflow Bridge.

The precaster prepared all girders for coating as defined in the Iowa DOT specification. Immediately before the coatings were applied, the research team removed any visible surface rust from the prestressing strand ends using an angle grinder and removed any dust and visible surface debris. The coatings were then applied, and the beam ends were inspected after about 18 months in the field.

Typical ponding slab with coating alternatives applied

To test alternative beam-end fabrication details that could reduce exposure of the strand ends to the elements, four methods were developed based on input from precasters and the TAC:

- Single beam-end blockout around the entire cluster of strands in the beam's bottom flange
- Double beam-end blockout around the two clusters of strands in the beam's bottom flange
- Individual blockout around each strand in the beam's bottom flange
- Drilling out the strands

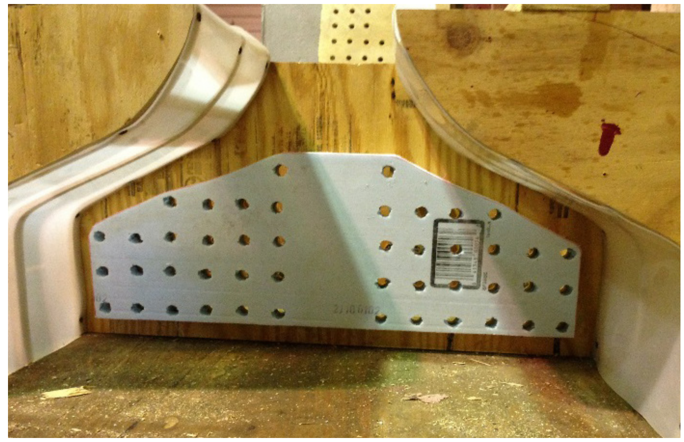
All blockouts were filled with grout or similar material.

In addition to developing the fabrication details, three alternative grout products were evaluated for their ability to encase the strand ends:

- Sikacrete 211 SCC Plus
- Garon TIGERCRETE SP
- UNIQUE Overhead and Vertical Repair

Key Findings

- In laboratory testing, the coatings performed similarly on all three concrete slabs, indicating that concrete mix design did not significantly affect coating performance.
- For the most part, the coated slab sections resisted chloride penetration of the concrete much better than the uncoated control sections. The only exception was the section coated with TEX•COTE XL 70 BRIDGE COTE with Silane.
- Based on the results of the AASHTO T259-80 chloride penetration test, the coatings showing the best to worst performance were as follows: (1) three-way tie between BASF Sonoguard, BASF Hydrozo 100, and Sikagard 62 – two coats, (2) Viking Aqua Guard Concrete Sealer, (3) Sikagard 62 – one coat, (4) TEX•COTE RAINSTOPPER 140, (5) PAULCO TE-3008-1, (6) Evercrete DPS, (7) TEX•COTE XL 70 BRIDGE COTE with Silane.
- In field testing, the inspection results of the coated beam ends varied from product to product and, at times, from one beam to another coated with the same product.
- In general, the performance of all of the products was excellent. No signs of peeling or deterioration of the coating were found on the concrete surfaces. All noticeable problems appeared to be at the prestressing strand locations.
- In the rare case when all prestressing strand ends were covered after the Iowa DOT preparation process, the beam end showed no signs of deterioration. However, in most cases several of the strand ends were visible and appeared rusted immediately before the coating was applied. All visible rust was removed before applying the coatings, but this is believed to be more a superficial fix than a long-term maintenance plan.
- At the precast plant, the strands protruding from the ends of the untrimmed and untreated beam ends were found to be heavily rusted. Before treatment, moisture and rust likely migrated into the beam end via the strands.
- The pre-existing moisture and rust on the strands within the beam ends before application of the coating likely caused most of the failures found on the coated bridge beams. Some coated beam ends only had visible signs of rust on the strand ends, others had visible rust piercing the coating, and a few others had the coating peeling off and missing completely from the strand ends.
- All three grout products provided an adequate bond to the existing concrete and were easy to mix and apply to the vertical voids. However, all three products exhibited shrinkage cracks within a few days of application.



Single blockout formed with 2 in. foam

Implementation Benefits and Readiness

With the exception of TEX•COTE XL 70 BRIDGE COTE with Silane, the selected coating products resisted chloride penetration of the concrete much better than the uncoated concrete. Adding a second coat of Sikagard 62 slightly improved chloride ion penetration performance, but likely not enough to warrant the extra time and cost involved in the process.

Single, double, or individual bar blockout are excellent options for separating the face of the beam end and the end of the prestressing strand. Viable alternative beam-end fabrication details include any of the blockout options: single, double, or individual strand.

Foam was found to be the best material for creating the voids. Further investigation is warranted into potential grout products, epoxy products, or both that can adequately fill voided areas without cracking.

Drilling out the strands after each is flush cut to the beam face was found to be nearly impossible and is not considered a viable option.