EVALUATION OF BOND-CONTROLLED, EPOXY-COATED PRESTRESSING STRAND on HUBBARD CREEK BRIDGE

Experimental Features Project OR 84-06

Interim Report

by

Allison Petrak
Research Specialist

in collaboration with

Richard L. Groff, P.E.
Structural Design Engineer IV

Keith Martin, P.E.
Research Coordinator

OREGON STATE HIGHWAY DIVISION
Research Section
Salem, Oregon 97310

prepared for

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DISCLAIMER

INTRODUCTION

Oregon's many coastal bridges are subject to a severely corrosive environment, being exposed to frequent rain and fog and a nearly constant misting of salt spray. Heavy rains flush ocean salts off the sides and decks of bridges, but leave the undersides covered with salty ocean spray. Because of this spray, coastal bridges are more subject to corrosive attack on the underside than from chlorides applied to the deck. A significant number of coastal bridges are succumbing to the effects of this harsh environment and will be in need of replacement over the next several years.

Prestressed concrete bridges will most likely be chosen to replace these deteriorating structures. Corrosive agents can attack the steel reinforcement contained in prestressed concrete structures, causing tensile stresses which fracture the concrete. Coating the reinforcing steel with epoxy encases and protects the steel from these corrosive agents.

While epoxy coated reinforcing steel has been used successfully to combat corrosion for several years, epoxy coating for prestressing strand is a relatively new development. An NCHRP study "Corrosion Protection of Prestressing Systems in Concrete Bridges" (Project 4-15, FY '82) is currently underway to test the mechanical behavior and corrosion resistance of epoxy coated 7-wire strand used in pretensioning applications. However, an evaluation of actual girders in service in the appropriate environment, as opposed to laboratory tests and simulations, was considered essential.

THE BRIDGE

The relatively short 138 foot replacement structure for the forty-year-old Hubbard Creek Bridge, located on the Oregon Coast Highway (US101) one mile south of Port Orford, was chosen as the experimental project bridge. Due to its proximity to the surf and its past record of environmental corrosivity, this bridge site was ideal for testing the effectiveness of the epoxy coated prestressing strand.

Seven prestressed bulb tee beams, six feet high and 139 feet long, were used for this single span bridge. Each web contained 26 harped strands, with 26 more strands in the bulb. The low relaxation, 1/2" diameter, 7-wire strand was specified to have a minimum epoxy coating of 30 mils, with proprietary grit impregnation to increase bonding capacity.

Incorporated into the design of the replacement structure were several features intended to directly combat the corrosivity of the salt spray environment. These features included:

1. The use of 3" minimum concrete cover over the reinforcement wherever practical (everywhere except the precast, prestressed bulb-T girders);

2. The use of a waterproof coating on all exposed concrete surfaces except the travelled roadway;

3. The use of epoxy coated reinforcing bars throughout; and

4. The use of low relaxation, bond-controlled, epoxy coated prestressing strand in the bulb-T girders.

EVALUATION PROCEDURE

The experimental project was to specifically investigate the condition of the epoxy coated prestressing strand in the yard, and its performance after stressing but before casting of the girders, during construction, and periodically for the first five years of service. At each post-construction inspection, the web and bottom flange surfaces of the girders will be observed for cracking, and the midspan deflection will be recorded relative to a fixed frame of reference. Additionally, the creep and the deflection of the girders will be monitored. These last two characteristics are considered as proof of proper bonding of the strands to the concrete.

Inspection vaults were constructed at Bent 1 and Bent 2 to allow monitoring for slippage of eight prestressing strands (four at each end) in beam number seven. The strands were left extended, and will be measured relative to a fixed reference point. The vaults, while strictly for research, added an additional $3,498.00 to the contract.

The specified five year period is probably insufficient to evaluate the coating's effectiveness in preventing corrosion, but it is long enough to determine any structural performance problems with girders containing epoxy-coated strands.

A Final Report will be submitted upon completion of these inspections.

PRECONSTRUCTION EVALUATION

On April 10, 1985, inspections were made of the epoxy coated strand as it emerged from the guide ring of its original shipping coil in the plant of the precaster. Most of the strand appeared to be coated uniformly, with fairly consistent grit impregnation and a surprising range of blue and blue-green colors.

In some areas on one coil, the coating had loose flakes underlaid by apparently tight coating, with less grit density and less apparent coating thickness between individual wires of the strand. With the removal of the loose material and verification of the underlying coating thickness and integrity, the strands were accepted for use in the middle of the section's bulb. The flaky appearance of the coating was perhaps due to the coil being rolled before the coating had cooled and hardened sufficiently, causing areas to adhere to the coating of adjacent strands on the coil.

Due to the abrasive surface of the coated strand, installing the strand after stirrups were in place would damage the epoxy coating on the stirrups. To prevent this, the strands were raised off the stirrups with temporary wooden blocks, which were removed after the strands were in place.

After casting, the epoxy strand could not be released until the concrete surface temperature cooled to approximately 120 degrees F. This caused no delay or additional expense, as the contractor was able to schedule stripping and form work during this time.

A girder cast the previous day was inspected for apparent cracking, spalling, and evidence of strand slippage, which would indicate bond failure. The initial camber was approximately 4", as compared to the prediction of 2-7/8". This excessive camber may have been due to excellent bonding or, because of the relatively early release time, the concrete may not have reached the anticipated elastic modulus. In either case, the large camber is indicative of adequate initial strand bonding.

A small number of very thin vertical cracks were observed near the "dead" end of the beam, possibly the result of horizontal friction in the supports resisting shrinkage, or stress differential during detensioning in the region where the strands had not been embedded and developed enough to introduce significant compression into the ends of the member. These cracks were considered insignificant by the State Inspectors.

Camber was measured upon release of the completed girders, and varied from 3-7/16" to 3-15/16". These values were compared to a predicted value of 2-7/8". Again, this large camber is indicative of excellent bond. After erection of the girders and before pouring the deck, camber measurements were repeated. The increase in values ranged from 3/4" to 1-11/16", and were reasonably consistent with the anticipated long term camber projections.

POST-CONSTRUCTION EVALUATION

Construction of the Hubbard Creek Replacement Bridge was completed September, 1985, as scheduled. As set out in the Work Plan, the finished deck grades have been regularly monitored. The maximum midspan deflection since January has been 0.01 feet. This indicates no loss of bond or slippage. No cracking was observed on the web or bottom flange surfaces of any girder.

From the inspection vaults, no measureable movements were detected of the strands left extended.

The inspections and monitoring of the deck and the girders will be continued through the fifth year of service. The data from these inspections will be recorded, analyzed, and included in the Final Report.

COST COMPARISON

The epoxy coated strand, "Flo Bond", is only available from Florida Wire and Cable Company. It is approximately $0.45/lin.ft., compared to $0.195/lin.ft. for the same strand uncoated. Using the epoxy coated prestressing strand on the Hubbard Creek Replacement Bridge added $14,030 to the $134,760 cost of the beams, amounting to 10.4% of the total cost of the beams, and 4.3% of the $326,555 price of the bridge.

Additionally, special chucks and jaws were required to handle the epoxy coated strands at the yard. These tools, while expensive, can be used again on any project utilizing epoxy coated strand. The one-time cost for these tools was $3,043.

No other costs which could be attributed to the use of epoxy coated strands were reported in casting the beams or during the field installation.

CONCLUSIONS

The use of epoxy coated strands caused no significant construction or casting problems. All evidence received supports the conclusion that epoxy coating of the prestressed strand does not cause any short term bonding difficulties. Monitoring will continue for the remainder of the five-year period; however, it is believed the greatest risk of bonding difficulties would occur immediately after casting and construction.

The use of epoxy coating on prestressing strand placed in coastal zone structures will be considered on all future installations. As more data is collected from this installation and NCHRP Project 4-15, we would expect to see the frequency of use increase.