Using Chemical Adhesives to Post-Install Epoxy-Coated Rebar in Concrete

What Was the Need?
As bridges age, local and state agencies are called on to repair and upgrade elements. Local agencies may install new light posts and replace chain-link rails, while state agencies may replace slabs on wing walls, deck and crash barriers, and other non-hanging bridge components. Work like this requires replacing concrete elements and installing new reinforcement bars. Until recently, MnDOT and local agencies used epoxy-coated steel rebar for these post-installed concrete panels and barriers.

Epoxy-coated rebar resists corrosion from salt and water that penetrate concrete members, especially at seams and cracks. Post-installed rebar requires chemical adhesives to secure the bar in place to effectively transfer loads from one concrete slab to another. Manufacturers test these adhesives with standard uncoated steel rebar to provide users with application guidance and to give engineers data on the tensile pullout strength of the rebar in concrete, a key property in the design of concrete bridge components.

As with many bridge materials, specifications for adhesives are conservative; the tensile strength of chemically adhered rebar can be assumed to be much higher than specified. Despite the almost certain safety of the practice, the MnDOT Bridge Office suspended the use of epoxy-coated rebar in post-installation applications because manufacturer specifications are based only on results from testing with uncoated rebar.

What Was Our Goal?
The goal of this project was to determine the effect of the epoxy coating on the tensile strength of rebar that is post-installed with a chemical adhesive. To achieve this goal, researchers surveyed other state transportation agencies to determine how these agencies use epoxy-coated steel rebar in certain post-installation practices. In addition, the research team conducted laboratory evaluations of common adhesives and epoxy-coated rebar installed in hardened concrete.

What Did We Do?
Two post-installation applications were studied: crash barriers between bridge support piers and crash barriers on the edges of bridge decks. Investigators distributed a survey to all 50 state transportation agencies to learn the state of the practice related to post-installing epoxy-coated rebar with chemical adhesives in hardened concrete bridge elements. The research team also studied MnDOT procedures for using adhesives with epoxy-coated and uncoated rebar during post-installation of rebar in crash barriers.

Investigators then conducted a laboratory study of the four most common adhesives used in Minnesota. They installed six uncoated lengths of rebar for each adhesive in one concrete slab and six epoxy-coated lengths of rebar for each adhesive in another slab. Rebar was pulled from the concrete to determine the tensile strength.
What Did We Learn?

Thirty states responded to the survey. Twelve of these state agencies do not use epoxy-coated rebar post-installed with chemical adhesives in concrete. Eleven of the 18 agencies that do use epoxy-coated rebar in these applications employ manufacturers’ data on bond strength; another six use a standard, national calculation method.

Tensile pullout strength of the bars varied by adhesive type. In all cases, the manufacturer specifications for strength were very conservative and safe, identifying strength values 200 to 300 times lower than shown in laboratory tests. MnDOT’s approach to adhering epoxy-coated and uncoated reinforcement steel in hardened concrete barriers results in safe, reliable bonding and load transfer.

The difference in strength between chemically adhered epoxy-coated steel and uncoated steel bars was on the order of 10 percent; in some cases, coated rebar was slightly stronger with the tested adhesive. Below are the pullout strength ratios of epoxy-coated bars to uncoated bars (reduced by three standard deviations) for the four adhesives:

- Powers AC100+ Gold: 0.89.
- Red Head A7+: 1.02.
- ATC Ultrabond 365CC: 0.98.
- Hilti HIT-RE 500 V3: 1.11. (In this case, however, bars ruptured, and pullout strength was not definitively established.)

Researchers recommended a modification factor for calculating bond strength to reflect the findings. Investigators also recommended changing a MnDOT bond stress specification or adopting manufacturer values, which would better meet national specifications for bridge design.

What’s Next?

Although MnDOT is not currently considering the use of epoxy-coated rebar in post-installed concrete, this study suggests what steps may be necessary to reauthorize its use in these applications. One solution would be to specify longer epoxy-coated rebar to mitigate the minor potential loss in pullout strength, allowing bridge managers to leverage the corrosion-resistance benefit of epoxy-coated rebar in these applications. For local agencies that already employ such conservative measures, the study suggests the practice is effective.