Joint Transportation Research Program

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Synthesis Study: Review of Durability and Performance of the Latest Epoxy-Coated Rebar

Introduction

The use of deicing salts on the roads in the winter months has proven to be harmful because of the corrosion damage to the reinforcement that increases maintenance costs. Of the wide variety of corrosion protection systems implemented by the United States' Departments of Transportation, by far the most widely used are quality concrete, adequate cover, and fusion bonded epoxy-coated reinforcing bars. Their ease of implementation, effectiveness of corrosion protection, and economic advantages exceed that of any other method. Epoxy-coated bars were first introduced in Pennsylvania in 1973 and first implemented in Indiana bridges in 1976. This report contains a summary of the state of the art in the fabrication and use of fusion epoxy-coated and Allium (stainless steel coated) reinforcing steel in concrete bridge decks and one-way solid slab and T-beam bridges.

The study findings indicated that although the original epoxy materials were still used, the significant improvements that took place in the fabrication and handling of the epoxy coated bars resulted in improved corrosion protection of the reinforcement. Notably, there is a lack of motivation in the producers of epoxy coatings to produce improved epoxy material. It could be concluded that this lack of motivation may be due to improved performance against corrosion of this reinforcement. The findings from a literature review and the responses to a survey questionnaire of State DOTs indicate that although DOTs view epoxy-coated reinforcement as effective in protecting the steel against corrosion, they continue to look for alternatives to improve corrosion protection.

The higher initial cost of alternate methods of corrosion protection that are deemed more effective, such as stainless steel, is seen as a significant barrier for its full-throated implementation. This calls into question whether life-cycle improvements in concrete bridge deck performance are a result of using corrosion protection methods with higher initial cost that also have the potential to be more effective than epoxy-coated bars. Unfortunately, such alternate methods of corrosion protection often lack the time and prevalence in the field of epoxy-coated bars to make a proper comparative assessment. Considering that other contributing factors impact the long-term performance of concrete bridge decks, it is important to properly assess the benefit of a more costly method, such as stainless steel. In some instances, interventions are carried out due to some other contributing issue(s) not related to corrosion of the reinforcement. Increasing the overall costs of the project could possibly diminish the positive impact from the more expensive initial cost of stainless steel.

Findings

The most reliable and widely used epoxy-coated reinforcement was Fusion Bonded Epoxy (FBE) coating. It meets the ASTM A775/A775M (green coating) standard and is manu-factured in plants that participate in the CRSI voluntary epoxy coating plant certification program.

- In general, epoxy-coated reinforcement continues to perform well. Departments of Transportation in the U.S. are still using epoxy-coated reinforcement as their go-to method of corrosion protection in the construction and rehabilitation of concrete bridge decks. Out of the surveyed DOTs, only the New Jersey DOT had a negative experience with epoxy-coated reinforcement.
- Construction practices have been identified as one of the main factors contributing to the deficient performance of epoxy-coated reinforcement. Practices such as handling, storage, placing, pouring of concrete, low concrete cover, and patching of damaged areas are keys to the adequate performance of epoxy-coated reinforcement.
- Laboratory and field evidence has identified epoxy-coated reinforcement as an effective method for protecting the steel against corrosion, provided that it meets standards, that fabrication and handling guidelines are followed, and that high quality concrete is used in conjunction with adequate concrete cover.

- State Departments of Transportation continue to explore new corrosion protection methods or combinations of existing corrosion protection methods and construction practices to enhance the performance of concrete bridge decks. Identified methods include improved concrete quality and steel reinforcement. Examples include the use of high-performance concrete in combination with epoxy-coated reinforcement. Other alternatives, such as stainless steel reinforcement, galvanized steel, ChromX ASTM 1035 steel, and fiber reinforced concrete, require more data on their cost effectiveness over the life of the structure.

Implementation

It is recommended that, under the following conditions, INDOT continues to use FBE 413 (green coating) in combination with high quality concrete and specified cover as an effective method of corrosion protection.

1. *Epoxy-Coated Reinforcement:* Epoxy-coated reinforcement should be obtained from coating plants that are participating in the voluntary CRSI program. Epoxy-coated reinforcement should meet standard ASTM A775/A775M. INDOT should continue to implement the method from Samples and Ramirez (1999), which uses a larger coating thickness to mitigate potential damage during handling and casting operations.
2. *Construction Practices:* Adequate concrete cover as determined by relevant standards, should be provided. The use of high-quality concrete with low permeability should be maintained, as well as the practice presented in Section 2.6 regarding the following guidelines.
    - Maintain adequate handling and storage of epoxy-coated reinforcement before and during construction and minimize sun exposure.
    - Monitor and patch any damage to the coating during construction using the patching material specified by the manufacturer.
    - Placement of the reinforcement should adhere to the guidelines in Section 2.6.
    - Minimize foot traffic over the reinforcement and concrete hoses movement during placement of the reinforcement and continue the use of extension on hose during casting operation to mitigate potential damage to the coating.
    - Vibrators should be equipped with non-metallic heads.
3. *Lifecycle Cost Assessment:* To properly assess the impact on the lifecycle of concrete bridge decks, more detailed inspections, such as those conducted in the Samples and Ramirez (1999) study, should be scheduled to collect data on the bridge condition and on interventions, including economic costs, since 1976. These detailed inspections should take place in addition to regular inspections. This data should be recorded and analyzed to monitor the long-term field performance under Indiana environments and traffic. This information will complement the findings in this study and will provide a better understanding of the actual performance of bridge decks in Indiana; thus, a more informed decision can be made regarding the use of epoxy-coated reinforcement versus other alternatives.
4. *Interventions:* The survey indicated that INDOT is implementing a silane deck sealer at about year 3 and year 7 of a bridge deck's life, and then a polymer overlay is programmed. This practice may serve as an additional protective layer to help prevent the ingress of chloride into the concrete. However, the effects of implementing this method alongside epoxy-coated reinforcement remain unclear. Therefore, it is recommended to evaluate the effectiveness of the silane sealer and polymer overlay by collecting data on the bridges where this intervention was implemented. Furthermore, the survey of DOTs supports the implementation of a bridge cleaning program following the winter season. State DOTs found the cleaning program beneficial for the bridge deck performance at a low cost compared to other alternatives.

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