

JOINT TRANSPORTATION RESEARCH PROGRAM

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Development of a Cost-Effective Concrete Bridge Deck Preservation Program

Introduction

Concrete bridge decks across the state of Indiana have experienced ongoing degradation caused by applications of deicing salts during the winter. Salt water collects on the deck and permeates the concrete through the cracks and the deck surface, allowing chlorides to initiate corrosion of the reinforcing steel. Over time, corrosion of the reinforcement leads to the need for costly deck repairs or even deck replacement prior to the expected service life of the bridge. The use of localized crack sealers and deck surface sealers has the potential of providing a cost-effective method of deck preservation that could be implemented across the state to prolong the life of bridge decks.

The objective of this study is to investigate potentially effective and economic bridge deck preservation methods to significantly extend the service life of bridge decks, and as a result, extend the life of bridge structures in Indiana. A literature review and survey of state departments of transportation were completed to guide the development of the experimental program and construction of the test specimens. The experimental program included continual monitoring of the specimens exposed to a salt water ponding regimen for a period of 1600 days, autopsy of the specimens to correlate observed interior corrosion with measured corrosion activity, and application of a deck sealer to specimens with preexisting corrosion to evaluate the sealer's effectiveness in slowing the rate of corrosion. Deck sealer performance was investigated further by correlating the occurrence of corrosion with sealer penetration depth and chloride penetration profiles. A preliminary field test of sealer applications was also completed to inform the development of field application methods. The research is presented in two volumes. Volume 1 presents the development and implementation of the experimental program while Volume 2 presents the results of the experimental program.

Findings

Volume 1

Based on the literature review and survey, the following findings were developed:

- Both epoxy and methacrylate products have been identified as effective localized crack sealers. Epoxy crack sealers

generally are shown to have stronger bond strength and better durability in wider cracks, while methacrylate crack sealers provided better crack penetration particularly for narrower cracks.

- Silicone-based products, such as siloxanes and silanes, have been determined to be high-performing deck surface sealers. Silanes were found to be the most effective in most cases, especially solvent-based products with higher solids content.
- Water-based silane products also performed well as deck sealers and would be useful as a substitute in an environmentally sensitive situation. It is important to note, however, that reapplication of a water-based product may not be effective as water-based products repel themselves wherever traces of the sealer remain from previous applications.
- Linseed oil has been used as a deck sealer with varying success rates.
- Products within the same chemical family have been capable of very different performance; therefore, the specific product used is important.
- If a bridge deck is expected to be exposed to deicing salts, any cracks should be sealed, as well as the full deck surface. Sealing should be completed as soon as possible in the life of the bridge to prevent as much chloride intrusion as possible.
- A variety of methods and materials exist and are in use today for protecting bridge decks. Different states have varying thoughts on the effectiveness of different types of products and whether their use is economically beneficial.
- Both epoxy and methacrylate products are commonly used as crack fillers/sealers and currently are the only products in use by responding states. Silane and linseed oil are the most commonly used deck sealers by responding states. Other preservation approaches include barrier membranes and overlays.

Volume 2

Based on completion of the 1600-day experimental program and the field test, the following findings were developed:

- Sikadur 55 SLV and Dural 335, low-viscosity epoxies, were shown to be effective in reducing corrosion in cracked concrete by as much as 80 to 100%. The methacrylate crack sealer MasterSeal 630 exhibited contradictory

performance. It was found that it has the potential to effectively seal cracks; however, its performance in this experimental program may have been sensitive to installation procedures due to its lower viscosity as compared with the epoxies. Furthermore, methacrylate crack sealers have been shown to be more effective in narrower cracks (<0.016 in.) than those investigated in this experimental program.

- The deck sealers MasterProtect H 440 HZ, MasterProtect H 400, and linseed oil were not effective at preventing salt water intrusion in cracked concrete. The use of a deck sealer does not prevent salt water intrusion at cracks; moreover, the deck sealer may actually inhibit evaporation of moisture from the deck, causing even more corrosion than in an unsealed deck.
- The four crack and deck sealer combinations investigated were extremely successful in reducing chloride ingress and preventing corrosion activity for the duration of the experimental program. The only exception to this performance was the varied results of the sealer combination comprised of crack sealer MasterSeal 630 and deck sealer MasterProtect H 440 HZ, which again suggests that MasterSeal 630 may have been sensitive to installation methods.
- Simulation of traffic wear on uncracked concrete with applied deck sealer revealed that the likelihood of corrosion increases as the depth of sealer penetration is abraded over time. Therefore, reapplication of deck sealers over time is warranted.
- Application of a deck sealer to reinforced concrete with preexisting corrosion did not appear to slow the rate of corrosion. This finding was likely due to the presence of surface cracks, which are not effectively sealed by use of a deck sealer alone. However, given the observed effectiveness of applying both a crack and deck sealer to reduce salt water ingress, it is expected that the use of such a sealer combination would effectively slow the rate of preexisting corrosion.
- When installing a two-part epoxy crack sealer, the use of a two-component joint sealer pump such as the model used in the field test provides an effective and efficient means of crack sealer application.
- Deck sealer application can be accomplished effectively and efficiently by use of a truck-mounted sprayer bar, such as the one developed for the field test.

Implementation

It is recommended that both localized crack sealers and deck surface sealers are used to resist chloride ingress in the deck and to reduce corrosion of the reinforcing steel. First, it is

recommended that wide cracks be sealed using epoxy crack sealers (Sikadur 55 SLV or Dural 335) and narrow cracks be sealed using a methacrylate crack sealer (MasterSeal 630). Completion of crack sealing should be followed by application of a deck sealer to prevent/reduce ingress through the deck surface. Although all three deck sealers in this experimental program were shown to be effective, it should be noted that the use of MasterProtect H 440 HZ is no longer permitted in the state of Indiana. It should also be noted that MasterProtect H 400 is a water-based product. While this product can be effective for initial application, it is not recommended for reapplication as water-based products repel themselves wherever penetrating deck sealers remain from previous applications.

To prepare for installation, it is recommended that dust and debris be cleaned from the cracks and the deck surface prior to application of crack sealers and deck sealers. Surface preparation in the form of roughening or sandblasting, however, is not required prior to sealer applications because the preexisting roughness of the bridge deck from surface tining and traffic abrasion allow for sufficient sealer penetration.

To maintain effectiveness of the sealer over time, it is recommended that decks are resealed every 5 years. Traffic abrasion was found to significantly reduce the effectiveness of deck sealers as it removed the layer of protection provided by the sealer. Extended reapplication times may be appropriate for bridges with low traffic volumes. As discussed previously, reapplication of a water-based product (such as MasterProtect H 400) is only effective in locations where the sealer has been removed as water-based products repel themselves wherever traces of the sealer remain from previous applications. For this reason, reapplication using non-water-based sealers is recommended. If a water-based sealer is used, the remaining penetration depth of the previous sealer should be removed through preparation of the surface such as sandblasting to ensure that the full penetration depth of the sealer can be achieved.

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