PUTTING RESEARCH TO WORK

BRIEF

Lab Tests Rate Sealants Under Freeze-Thaw Conditions

Maintenance crews frequently spread deicing salt over concrete bridge decks during Wisconsin winters. As ice melts and mixes with the salt, chloride ions can penetrate the concrete and induce corrosion of the reinforcing bars, or seep through cracks and cause deterioration of the steel or concrete substructure. Deck and crack sealants are used in Wisconsin and other states to prevent chloride ion intrusion and the costly damage it causes.

What's the Problem?

Although crack sealants are commonly used, limited research has been conducted on these products. No studies have measured crack sealants' bond strength or durability, or their effectiveness when exposed to freeze-thaw cycles typical of Wisconsin. Similarly, the performance of deck sealants exposed to these conditions is largely unknown. A systematic study of sealants was needed to evaluate and compare their characteristics, performance and cost.

Research Objectives and Methodology

The primary objective of this study was to assess the effectiveness and performance of concrete bridge deck and crack sealants. Investigators selected 13 deck sealants and 10 crack sealants for laboratory evaluation under conditions simulating exposure to deicing salts and freeze-thaw cycles. Products were selected based on a survey of district bridge maintenance engineers, a literature review of sealants, and the list of deck sealants currently approved by Wisconsin DOT.

Deck Sealant Study. To evaluate the deck sealants' ability to improve concrete's resistance to chloride ion intrusion, researchers simulated salt water ponding (when deicing salt and melting ice form a salt water solution that ponds on the surface of a bridge deck). Concrete specimens were sealed, sandblasted and ponded with a sodium chloride solution for 90 days according to AASHTO T 259 procedures. Some specimens were subjected to freeze-thaw cycles while being ponded to simulate a typical Wisconsin winter. After ponding, samples were removed from the specimens and tested for chloride ion content according to AASHTO T 260 procedures. In addition, investigators attempted to identify a relationship between sealant penetration depth and resistance to chloride ion intrusion using a dye method with specimens that were cast and sealed but not sandblasted.

Crack Sealant Study. Researchers assessed crack sealants' performance by measuring their ability to penetrate and fill cracks. Concrete specimens with prescribed crack widths were prepared and sealed according to manufacturer specifications, then saw-cut to reveal the depth of sealant penetration. Next, investigators assessed the sealants' bond strength and durability. Bond strength was measured by loading the specimens and inducing tensile stresses along the cracks. Durability was measured using additional specimens subjected to freeze-thaw cycles prior to measuring bond strength.

Based on the results of these studies, the deck and crack sealants were assigned to one of three performance categories. Sealants offering the best performance and protection were assigned to Category I. Those that offered a moderate level of protection were assigned to Category II, while Category III sealants provided the least amount of protection.

Results

Researchers' main findings from the deck sealant tests included:

- Two sealants, Hydrozo Silane 40 VOC and Sonneborn Penetrating Sealer 40 VOC, exhibited the best performance and were assigned to Category I. These sealants had the largest depths of penetration and offered the best protection against chloride ion intrusion.

Investigator

"We tested nearly all of the sealant products on the market that WisDOT would consider using on bridge decks."

–José Pincheira
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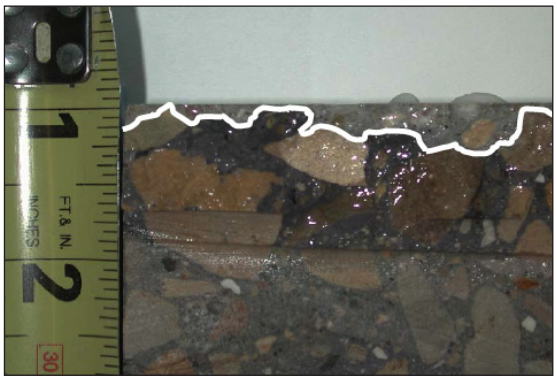

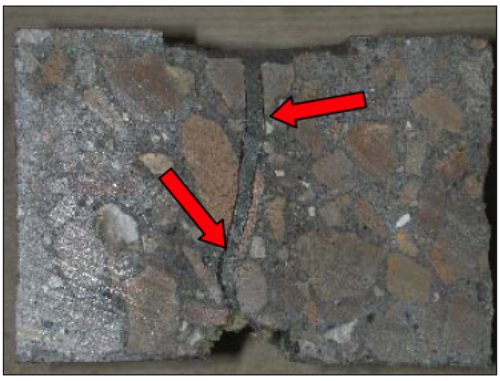

Researchers tested the penetration depth of deck sealants, as indicated by the white line on the image at left (Figure 6.2.9 of the final report). Crack sealant tests included bond strength and durability, and revealed several failure modes, including cracking between the sealant and the concrete, as indicated by the red arrows on the image at right (Figure 7.2.5 of the final report).

- On average, solvent-based silane products had larger depths of penetration than water-based or siloxane products.
- When not exposed to freeze-thaw cycles, solvent-based products were generally able to reduce the ingress of chloride ions better than water-based products.
- Exposure to freeze-thaw cycles decreased the ability of most sealants to reduce chloride ion ingress.

Researchers' main findings from the crack sealant tests included:

- Sikadur 55 SLV showed excellent performance in hairline, narrow and medium cracks and was assigned to Category I. Dural 335 also performed very well in the crack size recommended by the manufacturer—hairline cracks—and was assigned to Category I.
- For most sealants, bond strength decreased with increasing crack width and exposure to freeze-thaw cycles.
- Sealants tested on different crack widths tended to exhibit similar performance in each crack width—crack width did not appear to significantly influence sealant performance.

Implementation

WisDOT will consider incorporating freeze-thaw and other methodologies developed in this project into its sealant testing program. The department will continue to monitor the field performance of sealant products currently approved for use, some of which were included in the lab studies, and look for opportunities to field test some of the other Category I products for possible future approval.

Benefits

Once they are validated in the field, expanded use of Category I sealants identified in this project could extend the service life of concrete bridge decks in Wisconsin. Methodologies developed by this research will be very useful in comparing critical characteristics of the tested sealants, including cost, surface preparation requirements, cure time and expected durability.

Project Manager

"Bridge maintenance engineers can compare the evaluations of the sealants tested and make better informed decisions when selecting these products."

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