

The deal with seal

Illinois DOT studies effectiveness of preservation tactic

Preventive maintenance of infrastructure elements such as reinforced concrete bridges in Illinois is increasingly vital as resources to repair and replace these elements become less available.

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One of the key factors affecting bridge-deck performance is the penetration of chloride ions into bridge-deck concrete. Chloride ions play a significant role in the corrosion of reinforcing steel. The corrosion of the reinforcing steel leads to a loss of strength and, ultimately, the deterioration of the bridge deck.

The causes of chloride penetration relate mainly to roadway safety and maintenance procedures and are difficult, if not impossible, to avoid. Starting in the 1960s, the Illinois Department of Transportation (IDOT) implemented a “bare-road policy” for its winter-maintenance programs. Rock salt and salt brine (sodium chloride and calcium chloride) are the primary chemicals used for winter maintenance.

Frost development on highway bridges is very difficult to predict. Traffic and highway operation demands have shown that anti-icing methods are very effective in reducing accidents caused by frost that forms on bridges. The process of anti-icing involves routinely applying a salt brine solution (23% sodium chloride) from September through April. The brine solution is applied twice a week, during normal work hours, on bridges and culverts known to frost. This practice prevents early morning frost from forming on decks and saves significant time and money on additional maintenance work after ice has formed, and where road crews spread salt on frosted bridges, often during hazardous conditions. The use of salt brine, in addition to Illinois’ traditional rock-salt usage, has improved the safety and reliability of state roadways. But it also has increased the presence of chlorides that tend to deteriorate reinforcing steel in the bridge decks.

During the past 20 years, high-performance concrete and epoxy-coated steel reinforcement bars have been used to reduce steel corrosion. However, at cracks in the deck, salt can attack the steel through any defect in epoxy-coated steel. Previously, concern had only been about corrosion of steel reinforcement in the bridge deck. Now, the usage of anti-icing brine has raised additional questions about the durability of the concrete itself.

As a response to the durability concerns, IDOT initiated a seven-year

research project. The project, titled “Effectiveness of Concrete Deck Sealers and Laminates for Chloride Protection of New and In Situ Reinforced Bridge Decks in Illinois,” evaluated the effectiveness of various sealers and laminates under specific conditions (weather, construction practices and maintenance practices) found in Illinois. The project ran from 2002 to 2009 (www.dot.il.gov/materials/research/pdf/prr155.pdf).

The research evaluated more than 20 different concrete sealer and laminate products applied to more than 60 different structures throughout Illinois. The concrete-sealer products were selected from manufacturers prequali-

fied for use by IDOT in accordance with the “Approved List of Concrete Sealers” found at www.dot.state.il.us/materials/concretesealers.pdf. The research considered both penetrating and film-forming sealers.

Penetrating sealers are chemicals that are spray applied to the surface to penetrate into the concrete and provide a protective barrier on the bridge deck. Typically, penetrating sealers are water-repelling agents such as protective coat (boiled linseed oil and mineral spirits) as specified at www.dot.il.gov/desenv/spec2012/Div1000.pdf Section 1023, silanes, siloxanes or combination products.

An eye on the ions

Film-building sealers are chemicals that are spread onto the concrete surface using a squeegee. These sealers get into larger concrete pores and cracks and block the penetration of water and chlorides. Film formers, typically epoxies, require small-gauge gravel to be spread onto the film for traffic-bearing surfaces.

The laminates evaluated in the study were selected from products that comply with IDOT “Guide Bridge Special Provisions” for “Bridge Deck Thin Polymer Overlay,” “Bridge Deck Latex Concrete

Overlay” and “Bridge Deck Microsilica Concrete Overlay” (www.dot.il.gov/bridges/gbsp.html). Laminate products create a new deck-wearing surface. The techniques and equipment used for laminates are more specialized and typically cost more than those utilized for the sealers.

The research evaluated both new and existing concrete bridge decks. The new decks included traditional and high-performance concrete mix designs. The existing concrete decks had varying years of service and overall condition. All structures were monitored for chloride ion penetration as well as the physical condition of the decks.

The results of the IDOT study demonstrated that sealers and laminates significantly slow the ingress of chloride ions into bridge-deck concrete when compared with unprotected control structures.

The following guidelines and procedures were followed for drilling and sample locations and collection. These procedures were used each sampling time, from one bridge to another, in order to provide clarity and consistency for each bridge structure. Samples were collected prior to sealing. The bridge structures were drilled and sampled immediately prior to the application of the bridge-deck sealer or laminate. This set of samples provided a baseline to quantify the amount of chloride ion diffusion into the deck at future sampling points in years one, two, three, four and five. The individual structures were evaluated at the following locations annually throughout the period of study (including presealing).

The sample locations were chosen to isolate areas of the deck that would be most likely to show chloride ion penetration and places where bridge-deck wear is increased due to tire traffic. The sample locations were typically isolated to the first 15 ft of the structure to simplify traffic-control requirements. At each location, pulverized material was collected using a rotary impact drill.

The dust collected at each depth was then analyzed for acid-soluble chloride ion content in accordance with AASHTO

T260. The parts per million (ppm) of chloride ion for each depth was recorded, and an effectiveness measure was established for each sealer and laminate on each individual structure. The effectiveness measure was based upon the ability of the materials to deter the penetration of chloride ions in relation to control structures on which no sealer or laminate was applied.

The results demonstrated that sealers and laminates significantly slow the ingress of chloride ions into bridge-deck concrete when compared with unprotected control structures. Unprotected control structures, used for comparison, were located in similar geographical locations. This was done in order to ensure that the structures were subjected to similar weather conditions, deicing and anti-icing activities as well as similar average daily traffic (ADT). Bridge decks protected with a sealer or laminate had significantly less chloride ion ingress at the second and third depth. Chloride ions located deeper in the concrete provide more potential contact with reinforcement steel.

Preventing the electrolyte, or chloride ion, from accessing the reinforcement steel will significantly diminish the potential for a corrosion cell to form. Elimination of the corrosion cell leads to greater strength and durability of the concrete structure. In addition, limiting the chloride ion in the concrete will alleviate the potential for deleterious

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effects of freeze thaw such as scaling and delamination.

The prevention of chloride ion ingress was observed for both new and existing decks. Existing bridge decks with chloride ions found in the initial testing maintained similar levels of chloride ions at each depth after sealers and laminates were applied. Conversely, the control structures, in the same initial condition, rapidly increased chloride penetration at all depths but specifically in the furthest depth tested. Decks under this condition are more susceptible to deterioration.

The effectiveness of the sealers and laminates was determined over a seven-year period in order to capture the durability of the products over time. The durability factor and installation costs of the various products evaluated were utilized to determine the types of sealers to be recommended and used in current IDOT policy.

6 or better

In 2010, IDOT improved statewide policy for bridge-deck sealing as a result of the research findings. The study determined that routine application of bridge-deck sealers was a cost-effective way to extend the life of concrete bridge decks. With more than 4,500 bare concrete decks and 61 million sq ft of bridge-deck area, including those with concrete overlays, guidelines were established to aid in the selection of structures to have concrete sealers applied. All existing concrete bridge decks with National Bridge Inspection Standards (NBIS) condition ratings of 6 (satisfactory condition) or better were to be sealed. For new bridges and rehabilitated existing bridges, the decks and parapets would be sealed as part of the initial construction process.

To aid in prioritizing the initial application of bridge-deck sealers to existing bridge decks, the following characteristics were considered:



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- Bridges with bare decks with no concrete overlay;
- Decks on prestressed beams due to anticipated future difficulty with deck replacements;
- Locations receiving heavy and frequent applications of deicing chemicals;
- High-ADT locations; and
- Selected bridges within a corridor that would qualify for economical bid prices.

Based on the findings of the research, one of the recommendations was to establish a reapplication protocol.

IDOT guidelines recommend reapplication of concrete sealer every four years. Consideration is also given to the service life of the bridge deck and if a bridge deck will be removed or overlaid within the reapplication period of four years.

IDOT has established an annual dedicated line item to fund the deck-sealing program and has had success with letting contracts for deck sealing only within each of its nine districts. Typical contracts are advertised and let in the spring with application of the deck sealer in the summer. Application during the summer months allows the spring rains to clean the deicing chemicals off the decks. Summer also is the most appropriate time of the year to apply most concrete sealers, which require an ambient temperature of 40°F and above. **R&B**

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