HIGHLIGHTER

EXPECTED LIFE OF SILANE WATER REPELLENT TREATMENTS ON BRIDGE DECKS

May 2017

OVERVIEW Concrete structures face a multitude of problems that threaten the serviceability of the structure, one of the largest being chloride ingress. Chlorides permeate through the concrete matrix causing corrosion of the steel reinforcement. According to a study conducted by the Federal Highway Administration, the total direct cost of corrosion from 26 analyzed sectors was determined to be $279 billion per year in the United States. Of this total, it was estimated that $8.3 billion in damages occurred specifically to highway bridges. One cost effective method to prevent chloride ingress is the use of protective coatings. These coatings reduce chloride ingress by either clogging the pores of the matrix thus reducing the material that permeates into the concrete, or by lining the concrete pores with a water repellent coating. An example of the latter is organosilane or silane. Silane is used by the State of Oklahoma and other agencies to prolong the service life of bridge decks. Although silanes have been proven to be effective at reducing the ingress of brine solutions, little work has been done to show the effective lifespan of these sealers and their long-term performance.

RESULTS This project investigated the service life of silane sealers on Oklahoma bridge decks and evaluated silane sealer and a two part sealer (i.e. silane and epoxy) for resistance to chloride penetration in the laboratory. Two non-destructive methods, micro X-ray fluorescence and X-ray radiography, were used to test penetration and performance.

The performance of silanes on bridge decks was assessed on 60 bridges that were in service between 5 to 20 years. Samples were taken from the travel lane and the shoulder. Figure 1 shows the average and standard deviation of the silane depth from the three cores in the travel lane for each bridge. A horizontal line at 1/8" is shown in the graph, as this is the minimum value required by specification and verified at construction.

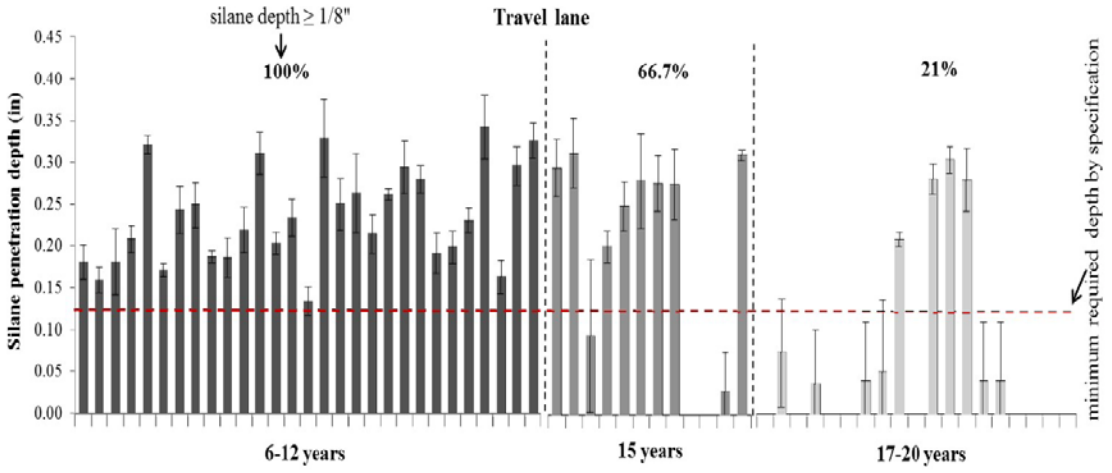

Figure 1 Average Silane Visual Detection Depth of Samples from Travel Lanes in Bridge Decks

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Results showed that the average depth of silane decreases with time. For bridges with 17 to 20 years of service, the average layer thickness reduced by 75% compared to the bridges that were less than 12 years of age. The study found that the sealant deterioration is likely caused from the alkaline pore solution, not from traffic, ultra violet light or external moisture.

The study used micro X-ray fluorescence (μXRF) technique to compare penetration resistance for samples. μXRF is a non-destructive chemical imaging technique which rapidly measures chloride ion profile with less human effort and provides important insights not possible with the typical profile grinding analysis. Figure 2 shows the comparison of a control sample to the two-part silane-epoxy system and a widely used type of silane in Oklahoma. The two-part silane-epoxy sealer system had 20% less penetration when compared to the typical silane; both silane treatments outperformed the control.

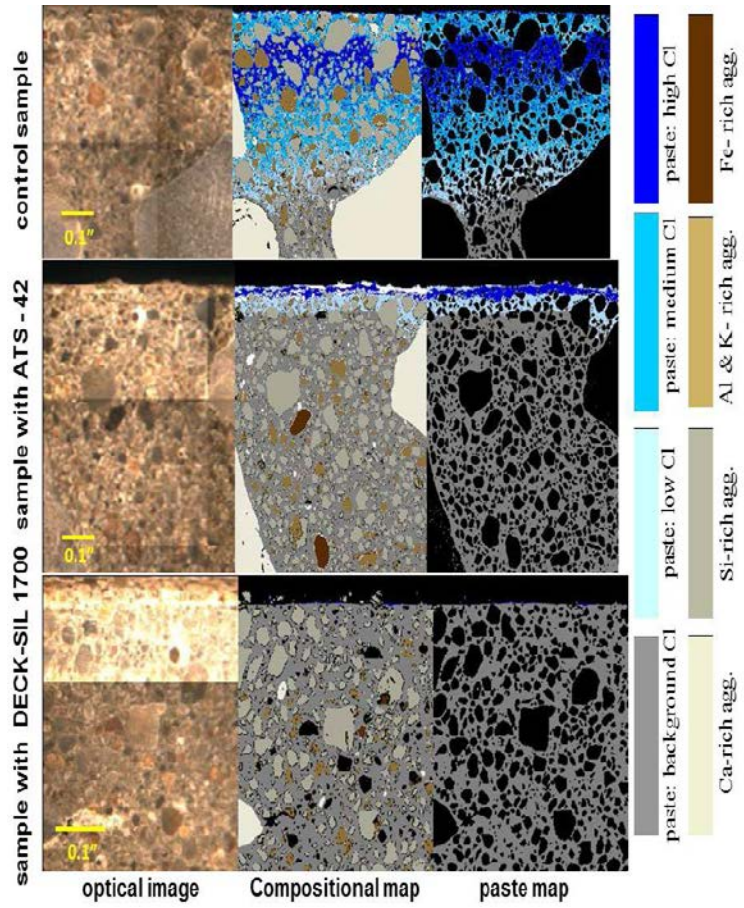

Figure 2 Micro X-Ray Fluorescence Images for Evaluation of CI Penetration Resistance

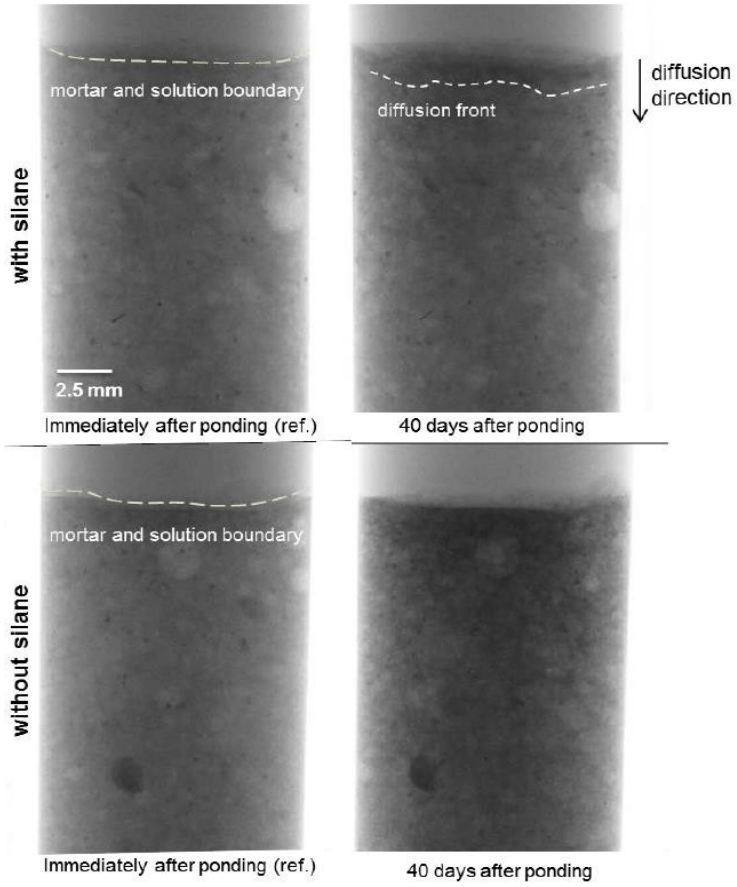

Figure 3 X-Ray Radiography Images for Evaluation of Ion Diffusion

The study also used X-ray radiography to detect diffusivity of ions in concrete (Figure 3). This non-destructive technique allows the determination of where and at what rates fluids move within cement systems. Specifically, it provides insight about the permeability of cement paste and the performance of different surface coatings. The results showed correlation between the μXRF and X-ray radiography techniques. Therefore, X-ray radiography was found to be a reliable method to evaluate performance of different cement systems against ion intrusion. The method does not provide a direct chemistry measurement, but by using standards, one can take rapid measurements to determine the penetration of salt solution. Another advantage of the method is that the experiment can be conducted in-situ.

POTENTIAL BENEFITS This work demonstrated that silane sealers are a useful tool to help Oklahoma Department of Transportation engineers extend the service life of structural concrete. It also introduced rapid, non-destructive testing methods for determining chloride ingress for structural concrete.