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Additional Methods for Testing Sealer Penetration

Nebraska Department of Roads

Research Project: Additional Methods for Testing Sealer Penetration

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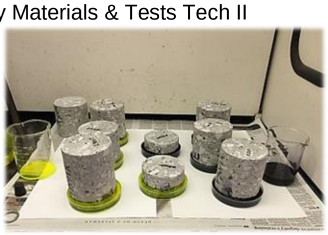

Cores Submerged in dye solution

Cores drying post submersion

Paraffin wax applied to a core

BACKGROUND

A previous investigation by the Department (Heyen & Halsey, 2016) found that the penetration of sealers could be visually evaluated by applying water to the surface of split cores. Some of the sealers were not easily observed; this prompted the need for an additional method for observing sealer penetration.

The Department acquired three possible methods for this investigation. The first method (Oklahoma D.O.T., 2003) evaluated the use of a sulfonozo III sodium salt solution as a blue dye to see the sealer penetration. The second method (Chamberlain, 2004) evaluated a sodium fluorescein solution as a yellow dye to see the sealer penetration. The third method (Oklahoma D.O.T., 2003) involved measuring the mass gain of a paraffin wax sealed core with only the sealer treated surface exposed when submerged in water.

OBJECTIVE OF THE INVESTIGATION

The purpose of this investigation is to evaluate the three additional test methods in order to visually observe sealer penetration.

FIELD APPLICATION

Sealers were applied to selected panels at the intersection of US-34 and NW 40 Street near Lincoln, NE. The intersection was built in the summer of 2007 with a concrete mix design containing supplemental cementitious materials (SCM) with a low permeability. Panels were treated with sealers per the manufactures recommendations.

The three penetrating sealers applied are listed below:

- Product 1 100% Silane Water Repellant
- Product 2 100% Silane Water Repellant
- Product 3 Water Absorbent & Water Repellant

Twenty four hours after application of the sealers, three 4 inch cores were collected from the field for each sealer applied. The cores were collected in accordance with ASTM C 42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. The cores were tested in the laboratory by each individual method and evaluated as to how well each method worked for observing sealer penetration. Three cores were collected for Product 1 in June of 2015 and four cores were collected for Product 3 in November of 2015. Due to scheduling, three cores were collected only two days after application of Product 2 in July of 2015. This was a not a concern due to the fact that the sealer had sufficient drying time.

LABORATORY TEST METHODS

BLUE DYE (SULFONOZO III SODIUM SALT DYE SOLUTION)

Based on Oklahoma's test method (Oklahoma D.O.T., 2003); each core was placed with the sealed surface down in a petri dish. The petri dishes were then filled with sulfonozo III sodium salt dye solution, shown in Figure 1 and 2. Cores were submerged for 30 minutes and then removed to air dry for 24 hours. The cores were split lengthwise in accordance with ASTM C 496 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens for visual observation. Sealer penetration was observed as the area near the sealed surface that was not blue from the dye.

Figure 1 shows the blue dye. *Figure 2 shows submersed cores in blue dye solution.*

YELLOW DYE (SODIUM FLUORESCEIN)

Following the City University in London method (Chamberlain, 2004), *a* core of each sealer was evaluated. Each core was placed with the sealed surface down in a petri dish. The petri dishes were then filled with the yellow dye, shown in Figure 3. The core were submerged for 4 days, shown in Figure 4, and then air-dried for 2 days. After drying, the cores were split lengthwise for visual observation. The sealer penetration was observed as the area near the core sealed surface that did not show fluoresces yellow-green under a short wave UV light source.

Figure 3 shows the yellow dye. *Figure 4 shows submerged cores in yellow dye solution.*

WAX CORE METHOD

Based on an Oklahoma method (Oklahoma D.O.T., 2003), a concrete core of each treatment was air-dried and weighed. Cores were then sealed with paraffin wax, exposing only the sealer treated surface shown in Figure 5. The cores were fully submerged in water for 24 hours, as shown in Figure 6, surface dried and weighed. Sealer protection of the cores corresponded with a low or no percent mass gain of water.

Figure 5 show cores sealed in wax.

Figure 6 shows cores submerged in water.

LABORATORY VISUAL SEALER PENETRATION OBSERVATION

BLUE DYE

After the cores were split they were visually evaluated for blue dye penetration. It was observed that the dye had slightly penetrated the surface of the control core (unsealed surface), shown in Figure 7. The dye of the control core verifies that if the core has no protection the dye would penetrate. In contrast, review of the sealed cores found no dye penetration at the surface concluding that the sealers performed in preventing water penetration. Dye penetration was observed on the sides of the cores where the concrete was not protected by a sealer, as shown in Figures 8, 9, and 10. Dye penetration could also be seen on the concrete surface if there was chipped. This method was easy to perform, but a major shortcoming was that the contrast between the dye and concrete was poor. This made evaluation of the dye penetration difficult.

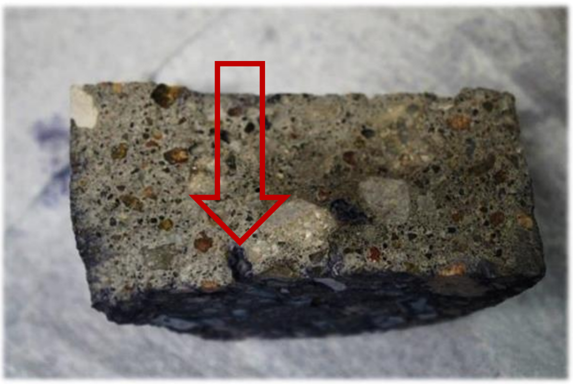

Figure 7 shows the control core. Slight blue dye can be seen penetrating at the surface.

Figure 8 shows the Product 1 core. Slight blue dye can be seen on the sides of the core.

Figure 9 shows the Product 2 core. Blue shading can be seen across the middle.

Figure 10 shows the Product 3 core. Slight blue shading can be seen in the left corner, caused by a chip in the surface.

SUMMARY OF OBSERVATION

- All sealer treatments prevented dye penetration by sealing the core surface.
- The blue dye provided a very low contrast and was hard to distinguish if the core had been dyed.
- The blue dye method was fast and easy to perform.

YELLOW DYE

The cores were visually evaluated for yellow dye penetration. It was found that the control core showed dye penetration as a yellow-green layer at the surface, shown in Figure 11. In contrast, review of the sealed cores showed little to no sealer penetration concluding that the sealers performed, preventing water penetration. Dye penetration was observed on the sides of the cores were the concrete was not protected by a sealer. Dye could also be seen to have penetrated into chips of the core surface, particularly the left corners shown in Figures 12 and 14. This method provided a high contrast between the core and the dye, allowing for easy identification of where the dye had penetrated. However, the method was time consuming, required safety considerations, and required a UV lamp.

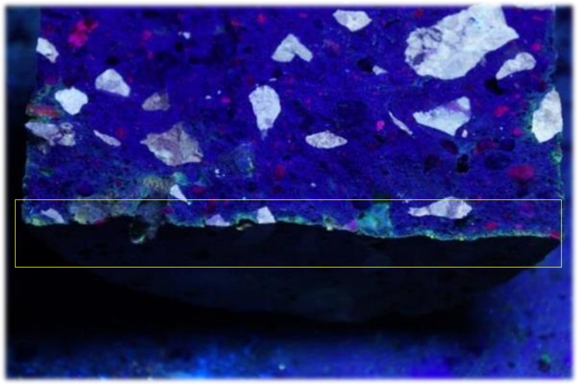

Figure 11 shows the control core with a very narrow band of coloring at the surface indicating no protection.

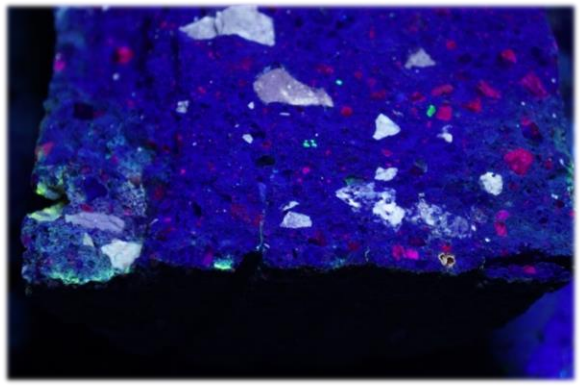

Figure 12 shows the Product 1 core with little to no dye observed at the surface. The left corner shows some fluorescence.

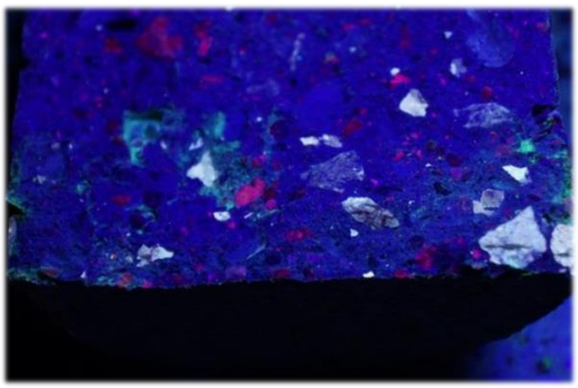

Figure 13 shows the Product 2 core with no coloring at the surface.

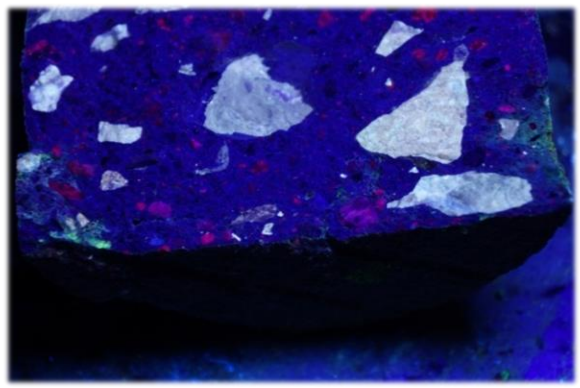

Figure 14 shows the Product 3 core with little to no coloring at the surface.

SUMMARY OF OBSERVATION

- All sealer treatments performed better than the control core.
- The yellow dye provided a high contrast and was easily to visualize.
- This method was time consuming and required safety considerations for the dye.

WAX CORE

Based on Oklahoma's test method, (Oklahoma D.O.T., 2003) a concrete core of each treatment was air-dried and weighed. Cores were then sealed with paraffin wax, shown in Figure 15. Only the sealer treated surface was left exposed, shown in Figures 16 and 17. Cores were then fully submerged in water for 24 hours, shown in Figure 18. After 24 hours, the cores were surface dried, shown in Figure 19, and weighed. The increase in mass would be the mass of water absorbed by the core through the treated sealer surface. The results are shown below in Table 1.

Table 1. Wax Core Method Results

Sealer	PRODUCT 1	PRODUCT 2	PRODUCT 3
Percent Mass Gain	0.21%	0.19%	0.56%

Table 1 shows that each core did gain mass from being submerged in water. Product 1 and Product 2 cores gained a similar percent mass in water. The mass gain of 0.21% and 0.19%, respectively, shows that the protection of Product 1 and 2 was similar. Product 3 had a higher percent mass gain than Products 1 and 2, but this was expected due to the difference in the technology. Product 3 is an absorbent and repellent. It absorbs water to expand and fill gaps within the concrete, and then repels water to protect the concrete. This means that even with the formation of new cracks, Product 3 would adjust to further protect the concrete. This also means that the core would gain water mass. Therefore, in comparing these three products, Product 1 and Product 2 deviate in characteristics to Product 3 in evaluating protection.

For this method, perfect protection would be for the wax sealed core to have a mass gain of 0% may be an impractical expectation even with a concrete with a low permeability due to SCM's.

The amount of water gained by each core was 3.8g, 3.5g, and 9.6g, respectively. Considering the small values in mass gained for each core, it seems fair to assess that the products did protect.

While this method did provide quantifiable values for protection, it unfortunately doesn't provide a visual assessment of the depth of sealer penetration. It does not meet the objective of this investigation.

SUMMARY OF OBSERVATION

- This method provides a quantifiable value for sealer protection.
- The method does not provide information as to the depth of sealer penetration.

Figure 15 show the application of paraffin wax to the cores.

Figure 16 shows the cores with paraffin wax applied to the sides and bottom.

Figure 17 shows the sealer treated surface of the paraffin wax sealed cores.

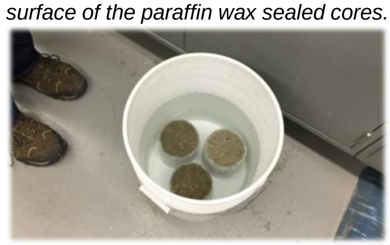

Figure 18 shows the cores submerged in water for 24 hours.

Figure 19 shows the surface drying of a previously submerged core before the measuring the final mass.

CONCLUSION

In a past investigation (Heyen & Halsey, 2016), the Department found that the penetration of solvent-based sealers could be visually evaluated by applying water to the surface of split cores. The penetration of some of the solvent-based sealers was not easily observed using this method. This prompted the evaluation of additional test methods in order observe sealer penetration.

The Yellow Dye method was the best at observing the sealer penetration as it was highly effective in identifying the sealer penetration on split core surfaces. Under a short wave UV lamp, there was good contrast between the sealed areas and the unsealed areas, meeting the objective of the investigation. The Blue Dye method did not meet the objective as the sealed areas and the unsealed areas were very similar in color and difficult to distinguish. This was unfortunate as it was the easiest method out of the three methods investigated. The wax core method did provide quantifiable values for protection of each sealer, but it did not meet the objective of the investigation of providing a visual sealer penetration.

IMPLEMENTATION

As per the findings, the best method to use to visually observe sealer penetration was the Yellow Dye method. This method was added to the Department's internal policy, *Internal Procedures for Concrete Core Test-APL-Sealer Approval,* for solvent based sealers that could not be visually observed by the application of water to a split core. This Yellow Dye method will be used for approval and evaluation of sealers, if the application of water to a split core fails to clearly define the depth of sealer penetration.

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