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Developing Material Specification and Application Criteria for Sealing Concrete Bridge Decks

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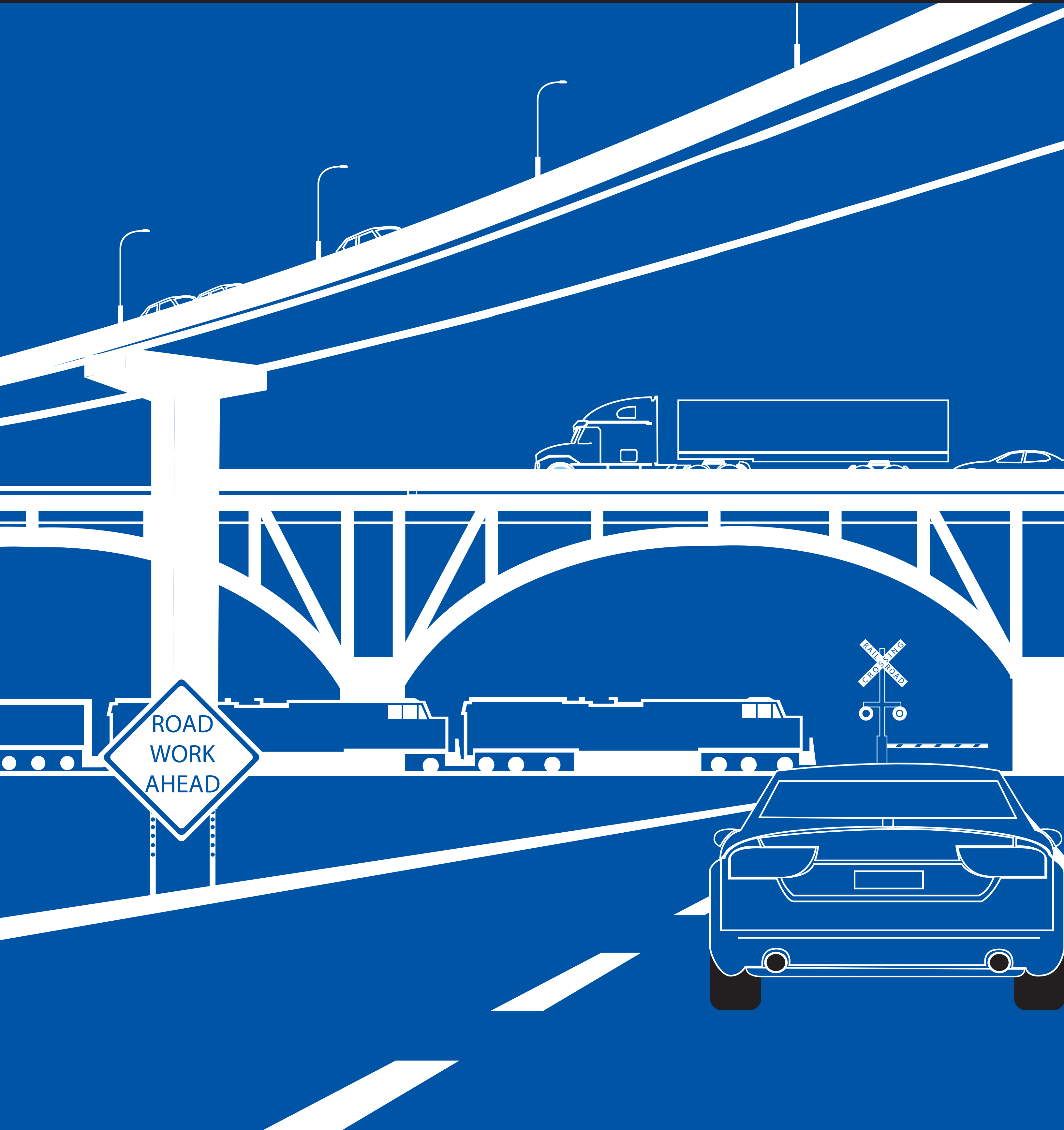

Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

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University of Kentucky

Research Report
KTC-19-09/SPR19-56-5-1F

Developing Material Specification and Application Criteria for Sealing Concrete Bridge Decks

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May 2019

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Introduction

The Kentucky Transportation Cabinet (KYTC) has more aggressively pursued preventive maintenance in recent years. Sealing concrete bridge decks is one preventive maintenance activity the Cabinet has actively pursued. KYTC's Divisions of Maintenance and Structural Design requested assistance from researchers at the Kentucky Transportation Center (KTC) in developing a material specification and application criteria for sealing concrete bridge decks at an appropriate time in their life cycle.

To develop a material specification and application criteria for sealing concrete bridge decks, KTC researchers conducted the following work:

1. Perform a national survey of departments of transportation (DOTs) for guidelines.
2. Perform a literature search to determine current practices and guidance.
3. Contact bridge deck sealer manufacturers for recommendations and review test methods.
4. Identify factors related to bridge decks that influence sealing.
5. Develop deck inspection criteria.
6. Prepare a final report that includes criteria for applying sealer to a bridge deck at the appropriate time and a material specification.

National Survey Summary

To determine practices currently used at other state transportation agencies, KTC prepared an online survey and requested the participation of all adjacent states and several northern states. A literature search was also performed. Sealer manufacturers were contacted for guidance and recommendations. Manufacturer-published test methods were also reviewed. The survey results and literature review summaries are presented below.

Survey Results

A survey focused on application criteria and material specification for bridge deck sealing was prepared and sent to all agencies in states adjacent to Kentucky plus eight other states located in the Midwest and north. The survey questions are listed in Appendix A. State transportation agencies in the following states responded: Missouri, Tennessee, Oklahoma, Iowa, North Dakota, Minnesota, and Michigan. Three agencies indicated that they did not have a deck sealing program.

Missouri, Minnesota, and North Dakota use independent laboratory testing results for material acceptance. Performance testing for penetrating sealers include:

- AASHTO T259 (*Standard Method of Test for Resistance of Concrete to Chloride Ion Penetration*),
- AASHTO T260 (*Standard Method of Test for Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials*),
- ASTM C642 (*Standard Test Method for Density, Absorption and Voids in Hardened Concrete*),
- ASTM C672 (*Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals*),
- OHD L-35 (*Method of Test for Moisture Vapor Permeability of Treated Concrete*),
- OHD L-40 (*Method of Core Test for Determining Depth of Penetration of Penetrating Water Repellent Treatment Solution into Portland Cement Concrete*),
- Alberta Technical Standard BT001 (*Measuring Waterproofing Performance After Abrasion*), and
- ASTM E274 (*Standard Test Method for Skid Resistance of Paved Surfaces Using a Full- Scale Tire*).

Table 1 lists all qualification tests and minimum acceptable results. The Michigan DOT reported using manufacturer-published test results to determine qualification. In this case, field observations are utilized to track performance in order to maintain qualification of a product. The products are installed with a manufacturer's representative onsite — when possible — to assure proper installation. All parameters are documented for repeatability. Follow-up visual inspections are performed to evaluate performance.

Little information was gleaned on application criteria. The North Dakota DOT stated that sealer is only applied to a deck with an NBI condition rating of 6 or greater. Others reported the application depends on deck condition but did not elaborate. The interval between sealer re-application varied from 5 to 10 years, averaging 7.2 years. The North Dakota DOT uses both contractor and agency forces to apply sealers. The Missouri DOT reported that all new construction is sealed by the contractor, with agency crews responsible for all future applications.

The Minnesota DOT indicated that it performs a hazardous evaluation/environmental review of each product submitted for approval. A few of the responding agencies shared links to online guidance documents. The next section discusses these materials.

Literature Search Summary

The Minnesota DOT requires the sealer manufacturer to submit the following: 1) independent laboratory testing, 2) product/technical data sheet, and 3) a one-quart sample of the sealer to the materials lab for quality assurance testing and IR scanning 30 days prior to the start of the work for approval and use (1). Immediately before a sealer is applied, workers must direct a 125 psi blast of clean, dry air from a compressor unit with a minimum volume of 365 ft^3/minute over the entire surface to remove all dust and debris, paying special attention to carefully clean all deck cracks. A manufacturer's technical representative is to be present for a 50 ft^2 test section five days prior to application.

The Michigan DOT requires abrasive blasting of decks to remove curing compounds before sealing new concrete (2). Abrasive blasting of concrete can introduce exposure problems to silicates, among other hazards. Precautions must be taken to minimize exposure to hazards such as air contaminants, poor ventilation, vision impairment, and noise.

The Michigan DOT has three Bridge Preservation Matrices to aid in bridge deck maintenance decision making: one each for black, epoxy-coated (Table 2), and stainless rebar (3).

NCHRP Report 244 (4) states that a factor which appears to be misleading about some concrete treatment materials is that the phrase "penetrating sealer" is a misnomer for almost all the materials tested. However, silane exhibits a measurable penetration and produces a non-wettable concrete surface to a depth of about 0.10 inch. Other products tested were boiled linseed oil, epoxy, polyurethane, methyl methacrylate, and polyisobutyl methacrylate. Of these products linseed oil exhibited the worst performance. Silane was the only product tested that **did not** perform well when applied to surfaces previously treated with boiled linseed oil. Selection of a concrete sealer should not be based on a single performance test such as salt ponding. Skid resistance was not considered in this series of tests, however, the report mentioned that numerous products had a "slippery" appearance.

An article published in 2000, "A Clear View of Sealers," (5) states there are many products marketed as penetrating sealers despite few penetrating concrete to a measurable depth. Only silanes, siloxanes, silicates, and siliconates can accurately be described as penetrating sealers. And only silanes and siloxanes achieve significant penetration. The molecular structure of silane is smaller than that of siloxane, thus it should have better penetration characteristics. Unfortunately, manufacturers often use different test methods to measure a certain property, making it difficult to evaluate and compare products.

The *Guide for Maintenance of Concrete Bridge Members* (ACI 345.1R-06) (6) summarizes that for concrete penetrating sealers to be effective, they must have the following performance characteristics: damp-proofing ability; breathability (gas exchange between the concrete and the surrounding environment); resistance to chemicals, ultraviolet ray penetration, and deterioration; low toxicity; low volatility; resistance to freezing and thawing; and resistance to deicing salt scaling. Penetrating sealers include linseed oil, siloxanes, silanes, and siloxane-silane combinations in various concentrations and carriers. Silicates that have good penetration are not considered sealers. To perform adequately, penetrating sealers should penetrate, and their ability to penetrate is influenced by factors such as concrete permeability, moisture content near the concrete surface, and the surface preparation required to remove contaminants such as form oils, curing compounds, previously applied surface sealers, or roadway oils. The deepest penetration occurs when the concrete surface is clean, dry, and porous. Sealers may not significantly improve the protection provided by high-performance, low-permeability concrete. The depth of penetration can be determined by extracting and examining cores. Field tests, such as ASTM D 6489 (*Standard Test Method for Determining the Water Absorption of Hardened Concrete Treated with a Water Repellent Coating*) should be performed 1) after application at construction to measure acceptance of damp-proofing performance and 2) as a follow-up to determine the service life of the sealer. Sealer product selection should never be based on generic type alone because there is substantial variation among similar products within any generic group. The manufacturer should be consulted to verify product performance claims in the given conditions, and independent approval testing is recommended.

Visual inspection is usually the first and often the most important method for evaluating the surface condition of bridge decks. Valuable information can be obtained by an experienced inspector during the initial visual inspection. Such information may indicate the need for non-destructive testing (e.g., chain drag, impact echo). The goal is to determine the proportion of deck distress and to gather information on the quality of the deck surface, cracking patterns, general concrete distress, and guide additional testing. Most cracks penetrate the deck to the top layer of reinforcing steel or further. Usually, transverse deck cracks penetrate the entire deck thickness, exposing the top and bottom mats of steel as well as any supporting girders or beams to deicer-laden water. There has not been sufficient research to determine the effectiveness of penetrating sealer on concrete cracks. For concrete with cracking more pronounced than hairline cracks, a healer/sealer type repair should be considered. Another consideration should be chloride content. Applying a sealer makes sense if chloride levels at the bar depth are less than or not greatly in excess of the threshold for corrosion (for black steel this level is about 0.03% by weight of concrete) and the concrete has high to moderate permeability, such that the sealer will substantially improve the resistance of the concrete to chloride ingress. It may not be cost-effective to apply a surface sealer to concrete with very low permeability, since its effect will be minimal (7).

Conclusions

The two main categories of concrete sealers are topical and penetrating. Topical sealers, including low viscosity epoxies (monomer and polymer), polyurethanes, and high molecular weight methacrylates (HMWM), can reduce skid resistance, so aggregate must be broadcast on a driving surface. This type of sealer can be very effective for sealing small cracks. Penetrating sealers include silanes, silicates, siliconates, and siloxanes. Silicates and siliconates are classified as densifiers and hardeners. Silanes and siloxanes are considered water repellants. Silanes have a smaller molecular structure and should offer better penetration characteristics. Different types of silanes will also have slightly varied molecular structures. The isobutyl silane has the smallest molecular size and also dries the quickest. The isooctyl silane has the largest molecular size with a slower dry time.

Silane: Silane has the smallest molecular size of penetrating sealers and the deepest penetration. Silane penetrates porous concrete surfaces and forms a molecular bond with the concrete that greatly reduces capillary absorption into the concrete pores while maintaining vapor transmission capabilities. Typically, silane will not affect the appearance or impact the skid resistance of the concrete surface. Silane is hydrophobic and oleophobic. The performance service life of silane depends on the depth of penetration; as the protected surface wears away its effectiveness declines. Solvent-based silane tends to penetrate more deeply than water-based formulations. Due to the small molecular size, silane must be flooded, and the application rate should be closely monitored to assure adequate coverage.

Silicates: Silicates also have a small molecular structure, with options ranging from premium lithium silicates to economical sodium silicates. Silicates form calcium-silicate hydrate crystals, which can densify concrete surfaces and be burnished to yield a polished appearance. Silicates are also hydrophobic and oleophobic. They are no longer effective when the concrete surface wears away. Silicates are noted for crystallization and are frequently used for polishing concrete floors, which is popular in large-format retail outlets. Silicates can raise the pH level in concrete and have been linked to Alkali Silica Reaction (ASR).

Siliconates: Siliconates are moderate-size molecular compounds that react with alkalis and calcium hydroxide to form crystalline structures within the capillaries of porous concrete surfaces. Siliconates are also hydrophobic and oleophobic and will wear away when the concrete surface itself wears away. Siliconates are frequently used for sealing exterior concrete, such as roads, driveways, walls, porous brick, and porous stone. Unlike other penetrating sealers, siliconates can be applied to fresh concrete as a curing agent.

Siloxane: Siloxane has the largest molecular structure and is the least reactive of commonly available penetrating sealers. Siloxane forms a bond within porous masonry that blocks the surface pores; it is hydrophobic. The larger molecular structure does not allow adequate penetration, and it is subject to quicker wearing and weathering than other penetrating sealers. To compensate for this siloxanes is sometimes blended with silane. Siloxane is frequently used for sealing porous concrete, concrete block, and brick.

Recommended Material Acceptance Criteria

Most manufacturers perform chloride ion penetration testing (salt ponding). This test is typically performed using AASHTO T259/260 or NCHRP 244 Series II and/or IV. While resistance to chloride ion penetration is an important property it should never be the only performance characteristic considered. Table 3 contains a list of recommended tests and minimum acceptable results. Alternate test methods for a specific characteristic are provided in Table 3 as product manufacturers have been known to evaluate their products using either of these tests. Selected material should also include a manufacturer-added fugitive dye to assist with proper application and inspection. See Appendix B for recommended material qualification requirements. NCHRP 244 test method and Alberta Technical Standard BT001 are the only test methods that specify a mix design. Other standards state that a mix design appropriate for the respective test may be used. Therefore, KTC recommends that manufacturers submit concrete mix designs for each of the standard tests their products have been evaluated on. KTC also recommends that mix design be considered as part of qualification process for list of approved materials.

The AASHTO National Transportation Product Evaluation Program (NTPEP) is another option, as the 2018 work plan (8) lists several of the recommended tests (Table 5). NTPEP requires one specific mix design for all physical testing.

Once a product is approved for use in Kentucky the manufacturer should be required to submit an annual statement certifying the material's formulation has not been changed during the previous twelve months. Otherwise, the product must be resubmitted for recertification.

Recommended Application Criteria

Factors like route, ADT and Snow Removal Priority Routes, age of the bridge deck, presence of overlays, crack size and density, deck concrete mix design, chloride content, type of rebar, NBI ratings for both top and bottom of the deck, and condition states shall aid in establishing standards.

Bulk concrete sealers are not typically effective for large crack openings. Where there are large cracks on decks, crack sealers should be considered. For shrinkage cracks, monomer epoxies, among other low viscosity healer/sealers, have been used with good success.

KTC recommends that a penetrating sealer be applied to all new concrete decks after a minimum cure time of 28 days. Deck inspection should be used to determine when to seal older concrete (Table 2). This inspection should also identify whether an overlay is present, and if so what type of overlay. Decks with a condition rating of 6 or better should be sealed on a five-year cyclical basis. Existing chloride content at rebar depth and type of rebar should also be a consideration. There is minimal benefit in sealing a deck with a high concentration of chloride. A chloride concentration of 0.03% by weight of concrete is typically considered the threshold for initiation of corrosion of uncoated black steel reinforcement. Although more research may be necessary, the threshold for epoxy-coated rebar is said to be 0.15%; for stainless rebar, it is 0.64%. The justification for increasing the threshold has primarily been due to satisfactory field performance (7).

When considering usage rates, manufacturers typically recommend a very broad range. This has a lot to do with factors such as concrete porosity, weather conditions, and application methods. However, there are times it may have to do with creating a competitive advantage. If given a choice the contractor will choose the lower rate of application to save on material. It has been suggested through conversations with various manufacturers that in order for a silane to pass qualification testing it requires a mass of approximately 11 grams of silane per square foot. To achieve this when using 40% silane requires an application rate of approximately 125 ft^2/gallon. The same mass using 100% silane would require approximately 300 ft^2/gallon (Table 4). The cost of 100% silane is typically 50% higher than 40% silane, but it should be more cost-effective with the extended coverage rate. Considering the previously mentioned factors affecting performance, KTC recommends silane at the application rate shown in Table 4 to maintain 11 to 12 grams of silane per square foot. To assist with the inspection process and while monitoring usage, KTC also recommends adding a manufacturer-approved fugitive dye to the sealer. This will also aid the workers in visual determination of proper coverage.

References

(1) Minnesota "Bridge Office Special Provisions" – SP2018-2433.4-S100 Bridge Penetrating Sealer
(2) Michigan "Bridge Capital Scheduled Maintenance Manual"
(3) Michigan "Bridge Preservation Matrix for ECR"
(4) NCHRP Report 244 "Concrete Sealers for Protection of Bridge Structures"
(5) McGovern; "A Clear View of Sealers", 2000, Publication #C00A053
(6) ACI 345.1R-06, "Guide for Maintenance of concrete Bridge Members"
(7) NCHRP Project 20-07, Task 234"Guidelines for Selection of Bridge Deck Overlays, Sealers and Treatments"
(8) "NTPEP Committee Work Plan for Evaluation of Concrete Coatings and Sealers" 2018

Table 1 Qualification tests and requirements from state agencies responding to survey

Qualification Testing			
	Minimum Accepted Results		
Performance Test	NDDOT	MnDOT	MoDOT
AASHTO T259/260 Cl Ion Penetration	0.75 lb/cy at 0.5" to 1.0" depth	Less than .55 Cl content ratio of sealed/unsealed at 1/2" depth	80% reduction in Cl & 0.50lbs/cu yd @ 1/2 - 1" depth
ASTM C 642 Absorption	48 hrs 1% by wt; 50 days 2% by wt	80% reduction minimum NCHRP Series II	0.5% @ 48 hrs. & 1.5% @ 50 days
ASTM C 672 Scaling Resistance	0 @ 25 cycles; max 3 @ 50 cycles		
Alberta DOT BT001 Moisture Vapor Transmission		70%	
OHD-L40 Depth of Penetration		0.15"	
Alberta DOT BT001 Waterproofing after abrasion		86% reduction	
ASTM E274 Skid Resistance			Less than 10% reduction
NCHRP 244 Series II Absorbed Cl		85% reduction	
NCHRP 244 Series IV (Southern Exposure)		95% reduction	
Results accepted from	Independent laboratory testing	Independent laboratory testing	Independent laboratory testing
Additional Comments	100% alkyl-alkoxysilane and 2 hour dry time required. Sealer applied by agency crews.	Also performs hazardous evaluation & environmental review of each product submitted for the APL. Sealer applied by agency and contractor crews.	Sealer shall not discolor concrete, alter surface texture, form a coating, leave residue on glass or painted metal, reduce the bond of pavement markings, or reduce skid resistance. Contractor seals all new construction with application by state crews thereafter.
	MDOT relies on manufacture's data to select products and performs field trials to track performance.		

Table 2 Bridge Deck Preservation Matrix - Decks with Epoxy Coated Rebar

Deck Condition State				Repair Options	Potential Result to Deck Condition State		Anticipated Fix Life
Top Surface		Bottom Surface					
BSIR #58a	% Deficiencies (a)	BSIR #58a	% Deficiencies (b)		BSIR #58a (top surface)	BSIR #58b (bottom surface)	
≥ 6	N/A	N/A	N/A	Hold (c) / Seal Cracks	No Change	No Change	N/A
				Apply Silane			5 years
				Apply Healer/Sealer (d)			8 - 10 years
	≤ 10%	≥ 6	≤ 2%	Epoxy Overlay (f)	8, 9	No Change	15 - 20 years
	≤ 10%	≥ 4(k)	≤ 25%(k)	Deck Patching (e, j)	6, 7, 8	No Change	5 - 10 years
4 to 6	10% to 25%(k)	4(k)	10% to 25%(k)	Shallow Concrete Overlay (h, I, j)	8, 9	No Change	20 - 25 years
				HMA Overlay w/waterproofing membrane (f, i)	8, 9	No Change	8 - 10 years
		2 or 3(k)	> 25%(k)	HMA Cap	8, 9	No Change	2 - 4 years
≤ 3	> 25%(k)	4(k) or 5	2% to 25%(k)	Shallow Concrete Overlay (h, I, j)	8, 9	No Change	10 years
				HMA Overlay w/waterproofing membrane (f, i)	8, 9	No Change	5 - 7 years
		2 or 3(k)	> 25%(k)	HMA Cap (g, i)	8, 9	No Change	1 - 3 years
				Full Deck Replacement w/EPC or stainless bar	9	9	60+ years

(a)	Percent of deck surface area that is spalled, delaminated, or patched with temporary patch material. Top surface decision making based on concrete surface, not the condition of thin epoxy overlays or other wearing surfaces.
(b)	Percent of deck underside area that is spalled, delaminated, or map cracked.
(c)	The "Hold" option implies that there is ongoing maintenance to sustain current ratings.
(d)	Seal cracks when cracks are easily visible and there is minimal map cracking. Apply healer/sealer when crack density is too great to seal individually by hand. Sustains the current condition longer.
(e)	Crack sealing must also be used to seal the perimeter of deck patches and joint replacements.
(f)	Deck patching required prior to placement of epoxy overlay or waterproofing membrane.
(g)	Hot mix asphalt cap without waterproofing membrane for ride quality improvement. Deck should be scheduled for replacement in the 5 year plan.
(h)	If bridge crosses over traveled lanes and the deck contains slag aggregate, replace the deck.
(i)	When deck bottom surface is rated poor (or worse) and may have loose or delaminated concrete over traveled lanes, sidewalks, or non-motorized paths, an in-depth inspection should be scheduled. Any loose or delaminated concrete should be scaled off and false decking should be placed over traveled lanes where there is potential for additional concrete to become loose.
(j)	Some full-depth repairs should be expected where top surface deficiencies align with bottom surface deficiencies.
(k)	Contact the Bridge Engineer if a deck with epoxy coated rebar in poor condition is identified.

Table 3 Recommended Qualification Tests

TEST	Standard/Method	Minimum Accepted Results / Comments
Resistance to Chloride	AASHTO T259/260 Resistance of Concrete to Chloride Ion Penetration	≤ 0.50lb/yd^3 @ 1/2" to 1" depth
	NCHRP 244 Series IV Accelerated Weathering – Southern Climate	95% reduction in chloride
	NCHRP 244 Series II Chloride Ion Penetration	85% reduction in chloride
Scaling Resistance	ASTM C672 Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals	0 @ 25 cycles (maximum of 3 @ 50 cycles)
Skid Resistance	ASTM E274 Standard Test Method for Skid Resistance of Paved Surfaces Using a Full Scale Tire	Coefficient of friction ≥90% of untreated specimen
Depth of Penetration	OHD-L-40 Depth of Penetration	0.25 inches
Absorption	OHD-L39 Water Immersion Test for Determining Percent Absorption	1.0% @ 48 hours / 2.0% @ 50 days
	ASTM C642 Standard Test Method for Density, Absorption, and Voids in Hardened Concrete	0.5% @ 48 hours / 1.5% @ 50 days
	ASTM D6489 Standard Test Method for Absorption in Hardened Concrete	85% reduction
	NCHRP 244 Series II Water Absorption	
Moisture Vapor Transmission	OHD-L-35 Moisture Vapor Transmission (Inactive)	≥80%
	NCHRP 244 Series II Moisture Vapor Transmission	
Abrasion Resistance	Alberta Technical Standard BT001 Test Procedure for Measuring Vapor Transmission, Waterproofing, and Hiding Power of Concrete Sealers – (6.3 Waterproofing After Abrasion)	≥85%
Maximum Dry Time		4 hours

Table 4 Mass of Silane per Square Foot (grams)

Silane%	Coverage rate (ft^2/gallon)						
	60	100	125	250	300	400	500
100	58.04	34.84	27.86	13.93	11.61	8.71	6.97
40	23.22	13.93	11.14	5.57	4.64	3.48	2.79
20	11.61	6.97	5.57	2.79	2.32	1.74	1.39

Table 5 Physical Tests from NTPEP 2018 work plan

Test	Reported Value
Moisture Vapor Transmission	Drying Rate Coefficient (DRC)
Waterproofing Performance	Moisture Content of Cubes, 7-Day Weight Gain, Saltwater Absorption Rate (SAR)
Chloride Penetration	Report the Relative Chloride Ratio (RCR) and Total Chloride
Depth of Penetration	Record Min., Max. and Ave. Depth of Penetration to Nearest 1 mm (0.04 in.)
Coating Thickness	Record Min., Max. and Ave. Thickness to Nearest 0.025 mm (0.001in.)
Coating Bond Strength	Record a minimum of 3 tests in MPa (psi)
Skid Resistance	Report British Pendulum Number (BPN) on Non-Weathered Samples
Time to Cure (Coating)	Gel Time, Tack-Free Time, and Final Set Time at Application Temperatures
Drying Time (Penetrating)	Initial Drying Time and Final Drying Time at Application Temperatures
Freeze Thaw Resistance	Record Concrete Deterioration Rating Scale and Freeze-Thaw Weight Loss Ratio (FTR)

Appendix A DOT Survey Questions

1. Does your agency apply penetrating sealers to concrete bridge decks?
2. When selecting a penetrating sealer, what performance test data does your agency rely on for acceptance of a product?
3. For a sealer to be approved for use by your agency, what are the accepted test results for the following tests?
4. How does your agency collect performance test data for penetrating sealers?
5. What criteria is used to select bridge decks for sealing?
6. Does your agency has guidance available online?
7. If deck have minor cracking and spalling, are they repaired prior to sealing?
8. How are cracked and spalled areas repaired?
9. Who performs the repairs and/or sealer application?
10. How often do you reapply a penetrating sealer?
11. What is the average cost per square foot for applying a penetrating sealer to bridge decks, including surface preparation?

Appendix B Penetrating Concrete Sealers Material Acceptance Criteria

1. **General:** This section lists the required method of acceptance for a penetrating concrete sealer. The department will provide specifications on which sealer types are allowed for specific classes of concrete in a contract.
2. **Sealing Materials:** Silane or siloxane sealers will be acceptable for use provided they are from an approved manufacturer and certified as compliant in accordance with this section. An optional fugitive dye should be added by the manufacture to aid inspection and to determine uniform coverage.
3. **Submission Procedure:** Submit manufacturer product/technical data sheet, safety data sheet, and copies of test results reports from independent laboratories. The Kentucky Division of Materials will review this information. Upon approval of submitted data, product samples will be requested for testing.
4. **Acceptance Procedures:** Submitted sealers will be tested by Kentucky Division of Materials or designated independent labs. Sealers will be accepted upon successfully meeting the required test results listed in Table B1.

Table B1 Test Standards and acceptable results

TEST STANDARD/METHOD	Minimum Accepted Results
AASHTO T259/260 Resistance of Concrete to Chloride Ion Penetration	85% reduction in chloride
NCHRP 244 Series II Absorbed Chloride	85% reduction in chloride
NCHRP 244 Series IV Southern Exposure	90% reduction in chloride
Alberta Technical Standard BT001 Test Procedure for Measuring Vapor Transmission, Waterproofing, and Hiding Power of Concrete Sealers – 6.3 Waterproofing After Abrasion	85% reduction after abrasion
ASTM C642 Absorption	0.5% @ 48hrs & 1.5% @ 50days
OHD-L39 Absorption	1.0% @ 48hrs & 2.0% @ 50days
NCHRP 244 Series II Absorption	85% reduction in chloride
OHD-L-34 Method of Test for Depth of Penetration by Penetrating Water Repellant Treatment Solutions	0.20 inches
ASTM E274 Skid Resistance	90% of untreated specimen
ASTM C672 Scaling Resistance	0 @ 25 cycles (maximum of 3 @ 50 cycles)
OHD-L-35 Moisture Vapor Transmission of Treated Concrete	80%
NCHRP 244 Series II Moisture Vapor Transmission	
Maximum Dry Time	4 hours

Appendix C Application Criteria for Penetrating Concrete Sealers

1. **General:** This section lists requirements for applying a penetrating concrete sealer to bridge decks as part of new construction and/or maintenance. The department will provide specifications on the use of particular types of sealers allowed for specific classes of concrete within a contract.

2. **Equipment for Sealer Application:** Hand tools necessary for removing debris from deck, cleaning solvent for removing hydrocarbons, pressure washer capable of 3,000 psi (with fan tips as required), low pressure spray equipment capable of approximately 0.1 GPM at < 25 psi, brooms or notched squeegees for even sealer distribution. The preferred method of application is with a spray bar and multiple nozzles.

3. **Surface Preparation:** Clean all loose debris from the surface. Remove all visible hydrocarbons from the surface using a detergent approved by the deck sealant manufacturer. Pressure wash all surfaces that will be sealed at 2,000 to 3,000 psi. Hold pressure washing wand a minimum of 45° to the deck with a stand-off distance of ≤ 12 inches.

4. **Weather Limitations:** Surface and air temperature must be between 40°F and 95°F. Do not apply if ice or frost is present. Do not apply if precipitation is forecast within 4 hours of finishing.

5. **Application of Sealer:** Apply a test patch (25 ft^2) five days prior to sealer application to determine adequate application rate and depth of penetration. Use a low-pressure sprayer with overlapping passes to thoroughly wet the surface. Adjust pressure and/or nozzles to prevent an atomized spray. Maintain a standoff distance of less than 6 inches. Use a fugitive dye recommended by the sealer manufacturer to aid in the inspection process. Material usage shall be sufficient to apply 11 to 12 grams of silane per square foot (see Table C1) unless otherwise directed by the Engineer. Do not proceed until the application to the test patch has been approved.

Table C1 Coverage Rate for Proper Mass of Silane

Silane%	Coverage rate (ft^2/gallon)						
	60	100	125	250	300	400	500
100	58.04	34.84	27.86	13.93	11.61	8.71	6.97
40	23.22	13.93	11.14	5.57	4.64	3.48	2.79
20	11.61	6.97	5.57	2.79	2.32	1.74	1.39