Thin Epoxy Overlay/Healer Sealer Treatments on Bridge Decks

November 2011
1. Introduction

Epoxy floodcoats have been used as a preventive maintenance treatment on bridge decks in Michigan for approximately twenty years. The early floodcoats were a mix of thin epoxy overlays and penetrating sealers, much like today, however, they were expensive, time consuming and many questions regarding effectiveness and longevity remained. Since then, improvements in material and application have been made through employee ingenuity and industrial innovations. By educating employees on the proper use and how to identify candidates for preventive treatments, fast, effective and long lasting floodcoats may be ensured to extend the life of Michigan’s structures.

Floodcoats

Floodcoat is a term used to describe the flooding of an entire bridge deck with a material to seal or bridge cracks to prevent moisture intrusion. While this term used to reference a thin epoxy overlay, it is in fact an application method and not an actual preventive treatment. Other methods of sealing cracks may be used, such as; crack chasing, spraying and rolling. The floodcoat method pours material on the deck and then squeegees or brooms the material over the entire surface, essentially flooding the deck. Floodcoating is typically used with thin epoxy overlays and penetrating sealers such as healer sealers, however, the term may be applied to other materials similar in nature.

Figure 1.1 Flooding a bridge deck with an epoxy penetrating sealer (healer sealer).
Choosing Method of Application

There are many factors to consider when choosing an application method for epoxy sealers. The primary factor is deck cracking. **A simple rule to follow is the 2 foot rule. If the cracks are more than 2 feet apart, then crack chase each individual crack, if the cracks are less than 2 feet apart, then floodcoat the entire deck.**

![Crack chasing operation](image)

Other factors to include are size of the deck, causes of cracking, profile of the deck, need for skid resistance, traffic control and cost. If the deck is fairly large with cracks just under 2 feet apart, it may be more economical to chase these cracks versus flooding the entire deck. Whereas, a small bridge with cracks every 3 feet apart may benefit further from a floodcoat.

When investigating the causes of cracking one must interpret whether the cracks are caused by seasonal weather changes, concrete shrinkage or stresses in the deck. If the cracks are due to shrinkage or weather fluctuations, there may be many micro cracks that are not visible to the naked eye and thus require a floodcoat. If the cracks are due to local stresses in the deck, they may be better suited to a crack chasing operation to ensure significant penetration of the material.

The profile of the deck may also determine the method of application. A deck with heavy tining will require significant preparation work and material to floodcoat, especially a thin epoxy overlay. A smooth deck is easy to floodcoat, requires minimal preparation and will see a benefit in skid resistance from a floodcoat.

Often a bridge deck requires a high friction surface as well as sealant to increase skid resistance and prevent icing of the structure. In these cases a thin epoxy overlay floodcoat will seal the cracks and provide a high friction wearing surface.
Mobility also needs to be considered as well as cost. Crack chasing operations are faster and cheaper, but will only seal those visible cracks. A floodcoat operation involves longer lane closures and more money in epoxy and aggregate, but successfully seals every crack.

**Thin Epoxy Overlay vs. Healer Sealer**

Thin epoxy overlays and healer sealers, though both epoxy systems, are uniquely different. They both seal the cracks in bridge decks but do so in different methods. A thin epoxy overlay “bridges” the cracks in a deck. The thin epoxy overlay acts as a sacrificial layer on the bridge that prevents moisture from entering the cracks. It is a two coat system, each coat consisting of a layer of epoxy and aggregate. The epoxy is applied approximately 1/8 inch thick and followed by a layer of small aggregate, typically chipped flint, quartz or bauxite. Because this type of system does not penetrate and only bridges the cracks, it is imperative that the preparation to the deck prior to application be done properly. The preparation involves a heavy shotblast to remove any contamination and properly profile the deck surface. The overlay must bond to the aggregate in the concrete deck. The cement mortar is not strong enough to provide a proper bond and will result in a failure of the thin epoxy overlay. By shotblasting the deck heavily the top layer of mortar is removed and the aggregate in the deck is exposed. This ensures all contamination has been removed and allows the epoxy to bind to the large aggregate, creating a strong bond and preventing delamination of the overlay.

*Figure 1.3 Shotblasting in preparation of a thin epoxy overlay.*
A healer sealer is a penetrating epoxy sealer. The viscosity of a healer sealer is approximately 50-80 centipoises (cps), whereas a thin overlay epoxy has a viscosity of approximately 2000 cps. To further understand, water has a viscosity of approximately 1 cps and honey 2000-3000 cps. A healer sealer is a one coat system that involves flooding the deck with the epoxy penetrating sealer and broadcasting a dry mason’s type sand over the epoxy to maintain skid resistance. Unlike the thin epoxy overlay, the healer sealer penetrates the cracks to seal them and therefore, is not as dependant on deck preparation. A quick shotblast is still necessary to remove contaminants and “open up” the cracks in the deck. Through shotblasting, the cracks’ edges are rounded off and any debris in the crack is removed, allowing the healer sealer to further penetrate the crack. Any epoxy on the deck surface that does not penetrate is meant to wear off in time. The epoxy that penetrated the cracks remains and continues to prevent moisture intrusion.

As a result of less preparation and only requiring one coat, a healer sealer is more economical than a thin epoxy overlay. A healer sealer requires half the material, a much less expensive aggregate and a third of the time to complete. However, they both have their advantages and disadvantages.

Table 1.1 Cost and application data for maintenance crew workers.

<table>
<thead>
<tr>
<th>2010 Flood Coat Epoxy Cost And Application Data</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Epoxy Type</th>
<th>2010 Epoxy Cost</th>
<th>Application Rate For Estimating Order</th>
<th>Approved Products</th>
<th>Manufacturer’s Application Rate</th>
<th>Mix Ratio</th>
<th>Shelf Life</th>
<th>Approved Fine Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healer Sealer</td>
<td>$27 / Gallon</td>
<td>75 St. / Gallon</td>
<td>UniTeex Bridge Seal</td>
<td>65 - 100 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>1 Year</td>
<td>Cheboygan Mason Sand</td>
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<tr>
<td></td>
<td>$0.36 / St.</td>
<td></td>
<td>Poly-Carb Mark-127</td>
<td>100 - 150 St. / Gallon</td>
<td>2:0 A : 1:0 B</td>
<td>2 Years</td>
<td>Technisond 11.5W</td>
</tr>
<tr>
<td></td>
<td>$0.36 / St.</td>
<td></td>
<td>Euclid Dural 305</td>
<td>100 - 200 St. / Gallon</td>
<td>4:0 A : 1:0 B</td>
<td>1 Year</td>
<td>Sand Products AFS 50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sika Sikadur 55 SLV</td>
<td>100 - 150 St. / Gallon</td>
<td>2:5 A : 1:0 B</td>
<td>2 Years</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Epoxy Overlay</th>
<th>2010 Epoxy Cost</th>
<th>Application Rate For Estimating Order</th>
<th>Approved Products</th>
<th>Manufacturer’s Application Rate</th>
<th>Mix Ratio</th>
<th>Shelf Life</th>
<th>Approved Fine Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$ 20 / Gallon</td>
<td>25 St. / Gallon</td>
<td>UniTeex Propoxy Type III</td>
<td>1st 40 St. / Gallon, 2nd 20 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>2 Years</td>
<td>Best Sand #121 Quartz</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Poly-Carb Flexogrid Mark-164</td>
<td>1st 35 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>1 Year</td>
<td>Unimin Corp. EP-5 Mod. Quartz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Poly-Carb Flexogrid Mark-163</td>
<td>1st 35 St. / Gallon</td>
<td>2nd 15 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>2 Years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Euclid Flexolite 216</td>
<td>1st 40 St. / Gallon</td>
<td>2nd 30 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>2 Years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E-Bond 526-Le-Mod</td>
<td>1st 40 St. / Gallon</td>
<td>2nd 20 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>1 Year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Axson Akabond 811</td>
<td>1st 35 St. / Gallon</td>
<td>2nd 15 St. / Gallon</td>
<td>1:0 A : 1:0 B</td>
<td>1 Year</td>
</tr>
</tbody>
</table>
**Pros and Cons**

The following are the pros and cons associated with healer sealer applications and thin epoxy overlay applications.

**Thin Epoxy Overlay**

*Pros*

- Seals cracks in bridge deck
- Provides aesthetic wearing surface
- Increases skid resistance
- Prevents icing of the bridge
- Improves ride quality

*Cons*

- Time consuming (3 day operation minimum)
- Very reliant on deck preparation
- Susceptible to snow plow damage
- Expensive aggregate
- Not suited for adjacent box beam structures or those with stay-in-place forms

**Healer Sealer**

*Pros*

- Seals cracks in bridge deck
- Quick operation (1 day typical operation)
- Very inexpensive aggregate (mason sand)
- Allows deck to “breathe”, can be used on box beams and stay-in-place forms
- Not reliant on preparation
- Same material as used for crack chasing

*Cons*

- Does not provide a wearing surface
- Can be aesthetically displeasing
- Shorter life expectancy
2. Technical Data

Skid Resistance

Skid resistance is measured by determining the Skid Number (SN). The SN is a measure of the frictional resistance to motion (F) divided by the load perpendicular to the interface (L) multiplied by 100.

\[ \text{SN} = \frac{F}{L} \times 100 \]

A SN greater than 35 is acceptable for heavily traveled roads. Typical bridge decks throughout the state have a SN between 35 and 45.

A thin epoxy overlay will increase the SN of a bridge deck to approximately 65. This is a significant increase in skid resistance. A healser sealer will increase or maintain a SN of 45. It will temporarily increase the SN of a smooth deck and maintain the SN of other decks. After the healer sealer has worn off, the deck will return to the original SN.

*Figure 2.1 Angular aggregate used for thin epoxy overlays increase skid resistance.*
Viscosity

Viscosity is a measure of a fluid’s resistance to flow. Unlike density or specific weight, which are defined as a fluid’s mass or weight per unit volume, viscosity is an additional characteristic that is helpful to determine how a fluid will act under a shear stress such as a squeegee.

Knowing the viscosity of a material is helpful in understanding its characteristics during epoxy application. A higher value will require more effort to spread across the concrete surface and dictate whether or not it penetrates cracks. For example, if a similar amount of pressure is exerted on two separate squeegees spreading Unitex Bridge Seal (40 cps) and Euclid Dural 335 (80-100 cps), the Bridge Seal epoxy will spread further covering additional surface area. The variation of viscosity values emphasize the importance of documenting square feet coated and volume of epoxy for each application.

Table 2.1 Viscosities of approved thin epoxy overlay materials.

<table>
<thead>
<tr>
<th>Thin Epoxy Overlay Dynamic Viscosity (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euclid, Flexolith 216</td>
</tr>
<tr>
<td>1700 @ 75 °F</td>
</tr>
</tbody>
</table>

Comparing the viscosity values in Table 2.1 and Table 2.2 help display how one method “bridges” cracks and the other penetrates them. The smaller values for healer sealer indicate the mixed material can flow easily into tight cracks. The larger numbers for thin epoxy overlay indicate the material remains on the deck surface. Typical application rates for healer sealer are 100 square feet per gallon. However, variations in viscosity may increase/decrease rates by as much as 50 square feet per gallon.

Table 2.2 Viscosities of approved healer sealer materials.

<table>
<thead>
<tr>
<th>Healer Sealer Dynamic Viscosity (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unitex, Bridge Seal</td>
</tr>
<tr>
<td>40 @ 77 °F</td>
</tr>
</tbody>
</table>

Scoping

Thin epoxy overlays and healer sealers are preventive maintenance treatments, not a repair for a deck with a poor condition rating. Scoping for work to be conducted under a Capital Scheduled Maintenance contract or with direct maintenance forces should occur when the deck has a condition rating of 6 or 7. Proper planning and utilization of these treatments will help to achieve the most effective use of capital and resources, and extend the life of Michigan bridges.
Thin epoxy overlays should never be applied to a deck with a condition rating less than 5 (most manufacturers recommend a rating of 7), but considerable judgment and understanding of the surface preparation is required if the material is to be applied to a deck rated 5 or 6. However, an exception to this standard applies if the epoxy overlay will act as a sacrificial layer at a snowmobile crossing. Since the epoxy adheres to aggregate exposed from shotblasting all of the concrete must be sound and the aggregate well bonded. If unsound areas are not patched, the overlay will fail as the concrete fails. All patches must be allowed to cure for 28 days prior to overlaying otherwise the epoxy will crack/debond, reducing effectiveness.

Healer sealers are more forgiving since the epoxy sand surface is intended to wear off. They may be applied to a deck with any condition rating; however, flooding decks with a poor rating will not substantially extend their current condition nor validate the cost of the application. At a minimum, the deck should have a 5 rating, but use of the material on decks rated at 7 or 8 with repeated applications every 5 to 10 years will substantially increase their life expectancy.
Cost

Epoxy and delivery costs fluctuate sharply as the price of oil rises and falls. Maximizing orders and storing excess products from full truckloads offset lump sum shipping fees. For example, shipping charges are typically $850 for 11 jumbo sacks of sand. Since 11 sacks can be purchased for approximately $2500 it is important to maximize all orders and store any excess, because a significant portion of the charges are freight. Table 2.3 has the average 2011 material costs for both thin epoxy overlays and healer sealers.

Table 2.3 2011 epoxy and aggregate material costs.

<table>
<thead>
<tr>
<th></th>
<th>Thin Overlay</th>
<th>Healer Sealer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Epoxy per Gallon</td>
<td>$22.30</td>
<td>$34.00</td>
</tr>
<tr>
<td>Cost of Epoxy per Square Foot</td>
<td>$0.89</td>
<td>$0.45</td>
</tr>
<tr>
<td>Cost of Aggregate per Pound</td>
<td>$0.08</td>
<td>$0.11</td>
</tr>
<tr>
<td>Cost of Aggregate per Square Foot</td>
<td>$0.26</td>
<td>$0.16</td>
</tr>
<tr>
<td>Combined Cost per Square Foot</td>
<td><strong>$1.15</strong></td>
<td><strong>$0.61</strong></td>
</tr>
</tbody>
</table>
**Thin Overlay Surface Preparation**

Surface preparation is the most important step for any thin epoxy overlay application. Shotblasting the deck surface is essential to remove oils, dirt, curing compounds, weak surface mortar and other contaminants. The velocity of the shotblaster and number of passes across a surface determine the Concrete Surface Profile (CSP). Usually three or more slow passes are required to achieve a concrete surface profile of seven. Because steel shotblasting may create surface profiles ranging from three to eight it is important to understand the surface roughness required for proper bonding of the epoxy. The International Concrete Repair Institute Guidline (ICRI) No. 03732 defines the surface profiles and classifies them on a scale of 1 to 9.

Description of surface profiles:
- CSP 1 – Acid Etched
- CSP 2 – Grinding
- CSP 3 – Light Shotblast (Healer Sealer)
- CSP 4 – Light Scarification
- CSP 5 – Medium Shotblast
- CSP 6 – Medium Scarification
- CSP 7 – Heavy Abrasive Blast (Thin Epoxy Overlay)
- CSP 8 – Scabbed
- CSP 9 – Heavy Scarification

When placing a thin epoxy overlay the deck tining needs to be removed to achieve a profile of CSP 7. However, if hard natural aggregate is present there may still be portions of the tining visible. In either case, a layer of aggregate in the deck should be exposed without mortar covering it. Figure 2.4 is an example of improper surface preparation; the deck tining of the concrete has not been removed resulting in a CSP 3 and there is an area of unsound concrete.

*Figure 2.4 Thin overlay failure due to improper surface preparation.*
Paint striping acts as a bond breaker and must be removed. A shotblaster may achieve the proper profile where striping is not present, but extra attention with the shotblaster or a line grinder is often needed to remove paint. If any unsound areas are discovered during shotblasting they should be repaired and the overlay application delayed. All patches, regardless if fast setting, have to cure for a minimum of 28 days.

After shotblasting is complete vehicles are not allowed on the prepared surface prior to completing both courses of the overlay. In the event the lane has to be opened, the surface must again be prepared with a light shotblast. Proper planning will reduce the amount of repetitive shotblasting occurrences.

**Healer Sealer Surface Preparation**

Shotblasting must also be performed prior to applying healer sealer; however, the level of preparation is far less than that of a thin epoxy overlay application. The purpose of shotblasting for a healer sealer has less to do with preparing a bonding surface and more to do with rounding crack edges and facilitating penetration of the epoxy. A concrete surface profile of CSP 3 from ICRI Guideline No. 03732 is easily achieved by a light shotblast. Usually tining is not removed nor is aggregate exposed, but the surface should be visibly lighter in color.
Traffic may be placed on the prepared surface of a healer sealer for approximately one week after achieving the required surface profile. The ability to reopen lanes is helpful when contracting shotblasting because the same traffic control devices may be used at multiple structures. With proper planning, multiple structures in the same corridor may be shotblasted in a single day and later treated, decreasing affects to mobility.

**Final Cleaning**

Expansion joints should be taped off prior to spreading epoxy. Removing cured epoxy from strip seal joints often damages the gland and may lead to deterioration of the beams, bearings, and substructure as a result. If deck drains are present they should be taped well or covered to prevent the release of epoxy to a roadway or surface water below.

*Figure 2.6 MDOT staff shotblasting with a department owned unit.*

*Figure 2.7 Dry compressed air is used to remove loose surface particles.*
A rolling magnetic sweeper is helpful to retrieve steel shot for reuse and reduce the amount of particles on the deck. Clean the deck with dry compressed air after shotblasting to remove any dust or loose particles from the cleaning operation. A vacuum truck may not be used in lieu of compressed air.

**Moisture Testing**

Moisture testing must be completed on all contracted projects, and also when the presence of moisture is suspected during an application by direct forces. An 18 inch x 18 inch 4 mil polyethylene sheet must be taped to the deck for at least two hours to determine if moisture is present. Moisture will be identified by condensation on the sheet. The procedures of the test method are specified in ASTM D 4236.

**Application Temperature and Weather**

The minimum recommended air and surface temperature for proper curing of epoxy is 50°F and rising. If moisture is present or precipitation expected within eight hours do not place epoxy. Removing a floodcoat is an expensive endeavor using specialized equipment that is not readily available.

**Mixing**

When daytime high temperatures will not reach 70°F epoxy and aggregate should be stored in a warm location for several hours prior to placing at the site. If it is either impractical or impossible to keep both materials warm, drum heaters set at 100°F should be used to ensure the epoxy is not too viscous for proper mixing.

![Figure 2.8 Contained mixing station with clock ensures the material is mixed thoroughly.](image-url)
Mixing the epoxy must be done in a controlled fashion to eliminate any variances during the process. Ratios range from 1:1 to 4:1 depending on the brand. The epoxy should be measured in containers that are clearly labeled “A” and “B”. After measuring the correct portions, place them in an oversized mixing container of 150 percent larger volume to prevent spills. Placing a tarp underneath the mixing containers and having an absorption kit nearby is helpful to capture any spilled material.

![Figure 2.9](image)

*Figure 2.9* An electric drill with jiffy mixing paddle combines the resin and hardener.

Use a half inch electric or gas powered drill with a jiffy mixing paddle. Keep the entire paddle beneath the surface of the epoxy to prevent entraining air. All brands need to be mixed for exactly three minutes. A watch or other timing device must be used for accuracy. Less mixing will lead to improper curing and jeopardize adhesion of the product. Over mixing may result in premature setting of epoxy in the mixing containers.

**Applying Epoxy**

After mixing is complete, it is important to spread epoxy in a timely manner. Epoxy should be spread within five to ten minutes at surface, air, and material temperatures above 70°F. During cooler temperatures the product may be purposely held in the container for no longer than ten minutes to speed cure time. The container should be emptied completely after each batch to prevent cured material from being placed that will eventually scale from the deck.
Thin epoxy overlays are two course systems. The application rate for the first course must be a minimum of 40 square feet per gallon. After pouring the mixed material onto the deck, notched squeegees shall be used to distribute the epoxy evenly. Traffic is not permitted to be placed on the first course at any time. After the first course has cured, broom all excess aggregate from the deck prior to placing the second course. The same process is used for the second course; however, the application rate shall be a minimum of 20 square feet per gallon.

A healer sealer is a one coat system that is applied at approximately 100 square feet per gallon. Once the material is mixed it is spread using squeegees or brooms. Brooms are
especially helpful to spread epoxy on tined surfaces. Removing excess epoxy from tined areas of the deck maintains the existing profile and SN.

**Aggregate Placement**

There are multiple techniques to spread aggregate. Broadcasting by hand (“chicken feeding”) or using a gravity fed spinning distributor such as a fertilizer spreader is effective, but may be labor intensive and result in excessive waste. The most popular method utilizes a 375 cfm or 750 cfm air compressor connected to a venturi system. A vacuum is created by the venturi that draws aggregate from a 3,000 pound jumbo sack and distributes it onto the freshly placed epoxy through a 4 inch hose. An applicator directs it so no wet spots are visible. If epoxy bleeds through it the area should be covered with additional aggregate. One hose can be used to spread aggregate, but for large structures or experienced crews, two hoses will expedite the process. For two operations, a 750 cfm air compressor shall be used.

![Figure 2.12](image-url)  
*Figure 2.12 Two venturi units spreading aggregate substantially increase production.*

Multiple suppliers of aggregate are approved for thin epoxy overlays that exhibit the required Moh’s hardness of seven or greater. The high degree of hardness allows the approved materials such as quartz, river rock, and chipped flint to provide exceptional skid resistance for multiple seasons. The aggregate must remain dry prior to and during placement. Aggregate is spread at approximately 3.33 pounds per square foot and the material is often packaged in 3,000 pound waterproof sacks.
Fine aggregate (sand) is used for a healer sealer application. The sand must be applied to excess and provide a dry appearance to the deck after placement. If the surface appears wet additional sand will need to be placed immediately. The sand should be spread at a rate of at least 1.5 pounds per square foot. Sand is often shipped in 2,300 pound waterproof sacks. Traffic may be reestablished after the epoxy has cured and excess sand has been removed.
Life Expectancy

A thin epoxy overlay application is expected to last approximately ten years. Thin epoxy overlays older than 10 years that indicate cracking may be treated by crack chasing with healer sealer epoxy. Premature failures are almost certainly a result of improper surface preparation or improper mixing of material. Delaminations may be repaired by sandblasting the surface and reapplying the epoxy.

Figure 2.15 A delamination in an approximately 12 year old thin overlay is repaired.

Healer sealer treatments typically last 5 to 10 years prior to additional applications. Repetitive treatments will significantly delay deck deterioration by preventing corrosion and/or freeze-thaw damage. A log of floodcoated structures should be kept on file in each region so additional applications may be completed in a timely and proper fashion.