

Polymer Concrete Overlay Evaluation

Final Report
June 2016



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EXECUTIVE SUMMARY

The objectives of this work were to document the state-of-the-practice with respect to polymer concrete overlays, document the placement of two overlays in Iowa, monitor the field performance of the overlays over a two-year period, and relate their performance to material usage and/or workmanship.

Prior to placement of the overlays, the researchers reviewed national and international literature on the use of polymer concrete overlays with a particular focus on long-term performance, degradation mechanisms, and case studies. In addition, they conducted a brief survey of state departments of transportation (DOTs) to seek out specifications for the use of polymer concrete overlays, information on general performance, and results of any research completed.

The two bridges—a Johnson County, Iowa bridge over I-80 on 12th Avenue in Coralville, and the Keg Creek Bridge on Hwy 6 in western Iowa, 10 miles east of Council Bluffs—were overlaid during the summer/fall of 2013. The process by which each bridge was overlaid was similar in many ways, although a few slight differences existed.

The deck preparation was completed similarly by shot blasting the deck to an approved surface roughness and blowing the deck free of debris. The blowing process differed slightly, but it appeared that the same result was achieved.

The way by which the epoxy polymer was measured and mixed and how the cast aggregate was placed was likely the greatest difference observed. The polymer material used at each location differed, but met specifications at both.

The epoxy polymer for the Keg Creek Bridge deck was precisely measured using automated controls; whereas, the material used on the Johnson County bridge deck was closely approximated by dispensing each part into equally sized muck tubs.

At Keg Creek, the aggregate was cast via a vacuum and blower; whereas, at the Johnson County bridge, the aggregate was cast via a more labor-intensive hand broadcasting method.

Aside from these differences, the process by which the polymer was mixed and spread onto each deck was nearly identical (Jiffy paddles and notched squeegees). In the end, the final product was quite similar with neither one appearing to be better than the other.

Over time, each overlay has generally performed quite well with only a few areas of exception. It is believed that these localized areas likely underperformed due to poor deck preparation, improper polymer mixing, snowplow impact, or a combination thereof.

INTRODUCTION

Background

For nearly 15 years, the Kansas Department of Transportation (KDOT) has been using polymer-based overlays on primary highway bridge decks. Since the first trial application, more than 200 decks have been overlaid with primarily epoxy-based materials; recently, however, KDOT has started trials with overlays based on methacrylates and polyesters.

In general, anecdotal evidence suggests that the KDOT experience has been good. However, implementation has not been without problems and a commonly encountered learning curve.

Despite these problems, KDOT has started using polymer overlays on new structures in place of their more conventional silica fume overlays. While most problems that have been encountered were not attributed to material problems, there has been no concerted effort to track or document their performance with time or to relate performance to material usage and/or workmanship.

Project Objectives

The objectives of this work were to document the state-of-the-practice with respect to polymer concrete overlays, document the placement of two overlays in Iowa, monitor the field performance of the overlays over a two-year period, and relate their performance to material usage and/or workmanship.

The two bridges—a Johnson County bridge over I-80 on 12th Avenue in Coralville, and the Keg Creek Bridge on Hwy 6 in western Iowa, 10 miles east of Council Bluffs—were overlaid during the summer/fall of 2013.

Report Content

The remainder of this report is comprised of four primary chapters: Information Collection, Field Observations, Overlay Performance Evaluations, and Summary. It also includes two appendices: a four-part deck repair map for the Johnson County overlay and a compilation of the state DOT specifications received from 17 of the survey respondents.

INFORMATION COLLECTION

A national and international literature review related to the use of polymer concrete overlays, with a particular focus on long-term performance, degradation mechanisms, and case studies was performed. In addition, a brief survey of state departments of transportation (DOTs) was conducted, which aimed to seek out specifications for the use of polymer concrete overlays, information on general performance, and results of any research completed. Each is summarized in this chapter.

Literature Review

Research on polymer overlays has been conducted and published for several decades now. Field evaluations on polymer overlays can be found dating back to 1974. Since then, research has been continually produced, which has led to some substantial improvements from the first overlays. For this reason, recent literature is the focus of this review with special attention given to the causes of premature failure of an overlay and steps to be taken to ensure the longevity of an overlay. Within the studies highlighted, data have been gathered and analyzed from hundreds of bridges across several states to support findings.

Field Performance of Polymer Bridge Deck Overlays in Michigan was published by the Keweenaw Research Center at Michigan Technological University for the Michigan DOT (MDOT) in 2003 (Alger et al. 2003). The researchers collected and analyzed data on every bridge in Michigan utilizing an epoxy overlay at the time. They attempted to test and quantify the bond strength between an epoxy overlay and a concrete deck and found that, when an epoxy is allowed to properly bond to concrete, the bond formed is stronger than that of the tensile strength of concrete. During the tests, a thin layer of concrete was often pulled off with the epoxy overlay, indicating a very strong bond and a well-placed overlay. However, there were still overlays tested that delaminated from the original deck surface, which would indicate to the researchers that the overlay may not have been properly installed.

These findings provided the researchers with some valuable information that can be used when a state DOT is identifying good candidates for epoxy overlays. If an overlay is placed on a deteriorating deck, it is likely that the deck surface will still fail because the epoxy does not penetrate the surface of the deck, thereby adding overall strength; the overlay only bonds to the top of the deck, protecting it from future exposure.

The researchers were also able to identify that the failure to remove moisture or foreign material from the deck prior to installation was cause for some epoxy overlays to peel from the original deck. Moisture and foreign material removal are essential for creating a strong and long lasting bond. MDOT had hoped several more long-term conclusions would be made, but due to the relatively young age of many of the overlays, these conclusions could not be made at the time.

Performance of Concrete Bridge Deck Surface Treatments was a research study prepared by Brigham Young University for the Utah DOT (UDOT) in 2005 (Guthrie et al. 2005). The study

was conducted to gain perspective on different surface treatments and their value. The authors found that epoxy polymer overlays are the best choice when considering the type of polymer overlay to use. Epoxy polymer is capable of preventing a deck from cracking, reducing chloride contamination, and increasing skid resistance.

Silicone overlays are another choice in overlays that are able to protect the deck, but do not offer much for increasing skid resistance like epoxy polymer does. Methyl methacrylates also protect a deck, but fail to provide minimum levels of acceptable skid resistance on the deck.

Brigham Young also identified errors a contractor can make that can lead to a premature failure. Some failures result from human mixing errors, such as improper proportions of ingredients and improper mixing techniques. The authors recommend that contractors be required to use automated tools to proportion and mix the epoxy polymer because ensuring a proper mixture is crucial to the health of the overlay. Not only will using automation decrease risk of errors, it will also greatly expedite the process.

The authors surveyed 19 state DOTs and found that the most common failure mechanisms of polymer overlays were cracking and delamination. The authors found that when an epoxy polymer is immediately applied to a new bridge, it will develop large cracks from the settling of the structure. This creates a timing problem for overlay placement; the overlay should be placed after this initial settling has occurred but not too long after. If a DOT waits too long to apply an overlay, the deck will be contaminated with chlorides and be weakened. An ideal timing for the placement of an epoxy polymer overlay should be one to two years after the bridge is constructed. This minimizes the exposure to chlorides and still allows for initial settling to occur.

In 2007, the Missouri DOT (MoDOT) published *Investigations of Failures of Epoxy Polymer Overlays in Missouri* (Harper 2007). MoDOT gathered and analyzed information from 98 bridges across Missouri that utilized epoxy polymer overlays (EPOs). EPOs have an economic advantage over traditional deck sealants because they have a long life expectancy. Unfortunately, many of the EPO treatments were failing within the first two years of placement. To minimize this loss, Missouri sought out the cause for these premature failures. The researchers looked for correlations in the data between an EPO's performance and a bridge's characteristics to find the answers.

The largest and also the most unexpected problem Missouri encountered was pitting; in 62 of the 98 bridges, pitting had occurred. This problem arises when air enters the epoxy polymer during the mixing phase, forming bubbles that do not leave when the polymer is spread over the deck. This problem can be minimized by mixing the polymer with the correct paddle, such as a jiffy or Sika paddle. Along with this, proper mixing speeds and techniques should be strictly followed according to the manufacturer's instructions. When the outside temperature heats up, additional bubbles will enter the mixture and extra care should be given to limit introduction to the mix.

After pitting, Missouri found several correlations between characteristics and poor performance. High temperatures during placement, high number of freeze/thaw cycles, long girder lengths, and previous lower deck ratings were all related to a premature failure. To reduce the number of

failed overlays, they first recommend using EPOs on decks that are new or have recently been repaired. It is recommended that if a deck is in need of repair on more than 5% of its surface, an EPO should not be used. The EPO will not fix a deteriorating deck; it will only deteriorate with the deck. EPOs are only to be used as a preventive measure, not a fix. Before EPOs should be used, a pull-off test on the deck should be required to ensure the deck is strong enough to benefit from an overlay and is not overly contaminated with chlorides.

In bridges with longer spans between supports, more cracking was found to occur; it is recommended that a more flexible EPO be used on these types of bridges, allowing the polymer to bend with the deck. A test should be mandated before the polymer can be placed on the deck. ASTM D4263 checks for moisture on the concrete and is critical to ensuring a strong bond. While the polymer is curing, it becomes hydrophobic, so any areas of the deck with moisture on them will repel the polymer, creating a weak bond.

The Michigan DOT (MDOT) Region Bridge Support Unit, Bridge Field Services published an educational document, *Thin Epoxy Overlay/Healer Sealer Treatments on Bridge Decks*, in 2011 to provide information on when and how the treatments should be used (Rogers et al. 2011). First, the deck must be inspected for cracking and delamination. If the deck is in good condition Michigan will apply an epoxy overlay; if the deck is in poor condition, the deck must be replaced or repaired before an overlay may be used. The authors state that the overlay is only a preventive measure.

Before applying the overlay, the contractor must shot blast the deck. Shot blasting removes the top layer of cement mortar and exposes the large aggregate, which promotes a stronger bond between the overlay and deck. After shot blasting the deck, it should be meticulously cleaned of debris. It is imperative that there be no dust or small debris on the deck when the epoxy is being applied. Anything between the epoxy and the concrete will only weaken the bond formed. Another check for moisture is required. ASTM D4236 shows if there is moisture on the deck, it will prevent the EPO from bonding with the concrete deck.

A detailed mixing and spreading procedure was written to prevent the most common mistakes made by contractors during the installation procedure. The contractor should mix the epoxy with consideration of the air and epoxy temperatures, mixing speed, mixing technique, epoxy spreading rate, and thickness of the layers. Any premature failures of an EPO can almost certainly be attributed to improper following of these instructions. If a delamination occurs in a small area, it can be shot blasted and the epoxy may be re-applied, but if the entire deck is delaminating it must be completely re-overlaid. After 10 years, an additional coat is to be applied to seal any cracks and provide an additional 10 plus years of protection.

MDOT sometimes uses an epoxy healer sealer treatment instead of the traditional epoxy overlay. The healer sealer is a faster and less expensive version solution to sealing the cracks in a bridge's deck. The downside to this healer sealer is that it does not provide a wearing surface on the deck. This healer sealer treatment is quicker because it penetrates the deck's surface; this decreases the level of shot blasting required. The healer sealer epoxy treatment is a one-day operation.

The *Specification for Type EM (Epoxy Multi-Layer) Polymer Overlay for Bridge and Parking Garage Decks* published by the American Concrete Institute (ACI) in 2007 is divided into three primary sections: General, Products, and Execution (ACI Committee 548 2007). The General section includes the following: Scope; Reference standards; Reference organizations; Submittals; Project conditions; Labeling, storage, and handling of materials; and Safety. The Products section includes the following: Epoxy Binder; Aggregate; and Polymer Overlay. The Execution section includes the following: Procedure qualification; Surface preparation; Mixing epoxy binder; Overlay application; Curing; Excess aggregate removal; Joints; and Open to traffic.

Overall, this document gives good comprehensive instruction for the application of a polymer overlay on a concrete bridge deck. Project conditions, materials, equipment, and procedures are all covered.

Another resource, *Guide Specifications for Polymer Concrete Bridge Deck Overlays*, published by the American Association of State Highway and Transportation Officials (AASHTO) in 1995, is a good resource for those writing a specification for polymer overlays (AASHTO – Task Force 34 1995). Various overlay types are discussed including multiple-layer polymer concrete overlays, slurry polymer concrete overlays, and premixed polymer concrete overlays. An overview of polymers and their use in concrete is given along with guidelines on when to use polymer concrete overlays. A fairly detailed discussion of surface preparation, safety, and material handling is also provided. Typical expectations of tensile rupture strength, permeability to chloride ions, and bald tire skid number over the course of the life for several types of polymer overlays is shown through several charts.

Survey

An online survey aiming to identify the state of the practice around the US was sent to each state department of transportation via a web link. Respondents were asked anywhere from 12 to 15 questions, depending on their responses. The questions are shown in Table 1.

Table 1. Survey questions and response figure numbers

Question	Response Figure
1. For which state are you completing this survey?	Figure 1
2. Has your state ever used bridge deck polymer overlays?	Figure 2
3. Does your state currently used bridge deck polymer overlays?	Figure 3
4. If applicable, why did your state cease to use bridge deck polymer overlays?	*
5. How long has/did your state use(d) bridge deck polymer overlays?	Figure 4
6. On how many bridges in your state has a polymer overlay been applied?	Figure 5
7. On which bridges are polymer overlays applied: New Construction, Existing, or Both?	Figure 6
8. What constitutes a good candidate for bridge deck polymer overlay application?	*
9. Which types of polymer overlays were formerly used and/or are currently used: Epoxy, Epoxy Urethane, Polyester, Methacrylate, or other?	Figure 7, Figure 8, Figure 9, Figure 10
10. Does your state require a materials representative onsite during mixing and subsequent placement of the epoxy polymer?	Figure 11
11. What are the common causes of degradation of polymer overlays, if any, that have been seen in your state: Improper installation, High traffic volume, High temperatures, Low Temperatures, High relative humidity, Saturated concrete, Other?	Figure 12, Figure 13, Figure 14, Figure 15
12. Does your state have a written specification for polymer overlays? **	Figure 16

* See the text following the figures.

** Specifications are provided in Appendix B from those states that provided them.

The rightmost column of the table correlates the questions to the figures that follow. Overall, responses were collected from 39 different states. Figure 1 through Figure 16 show the responses received on US maps by state.

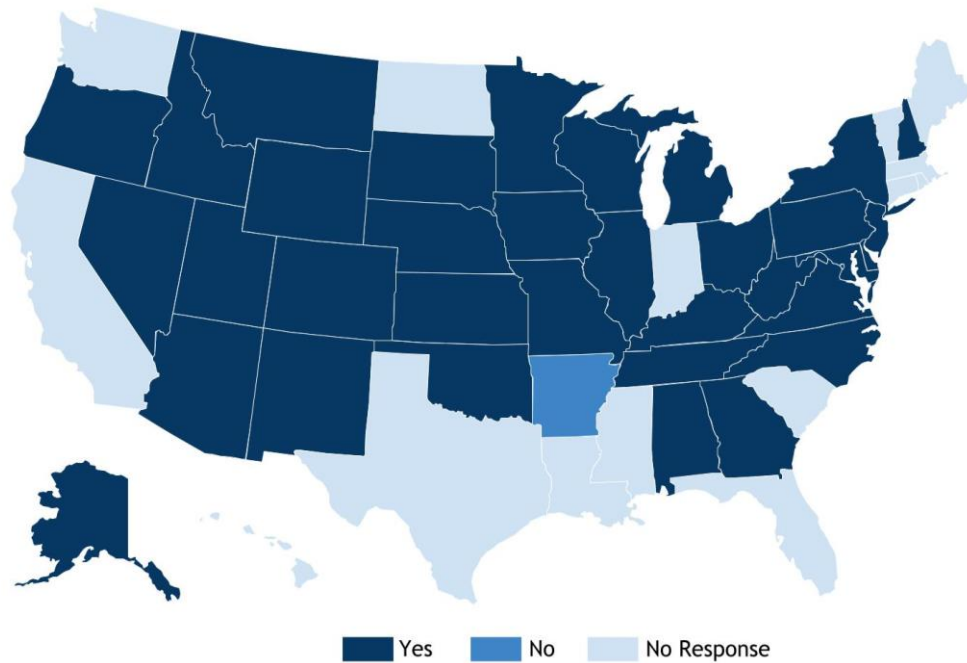


Figure 3. States that are currently using polymer overlays

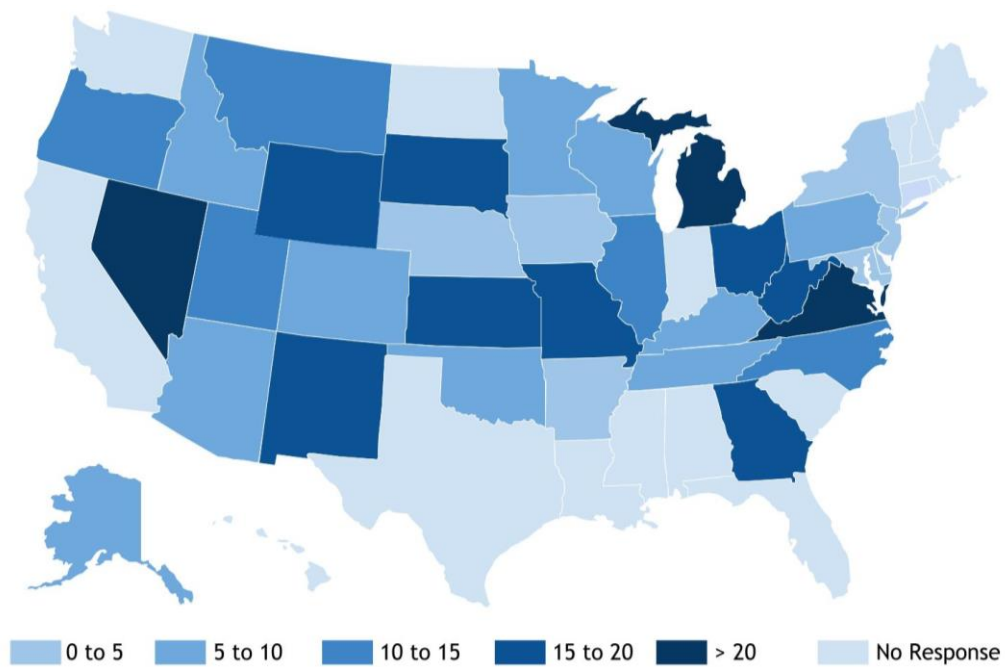


Figure 4. Total number of years that states have used polymer overlays

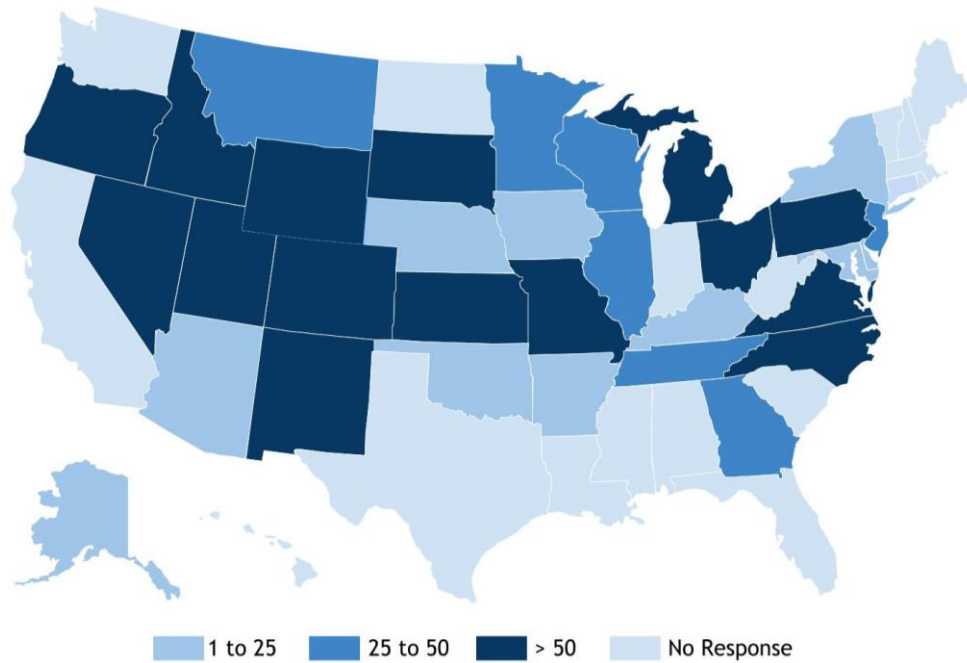


Figure 5. Total number of bridges on which polymer overlay has been used

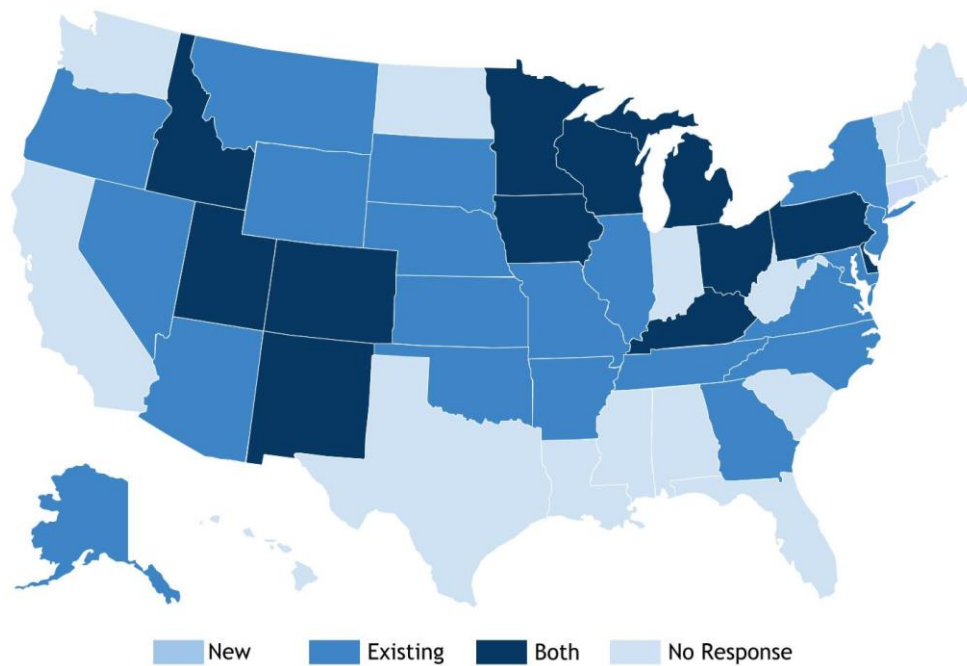


Figure 6. Bridge age at which polymer overlay is applied

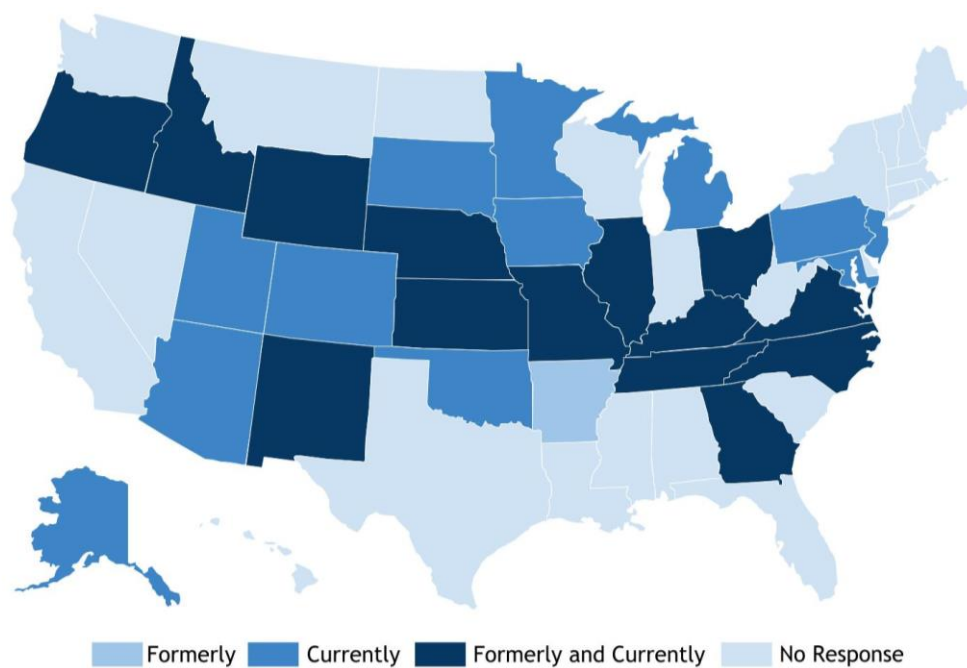


Figure 7. States that use epoxy polymer

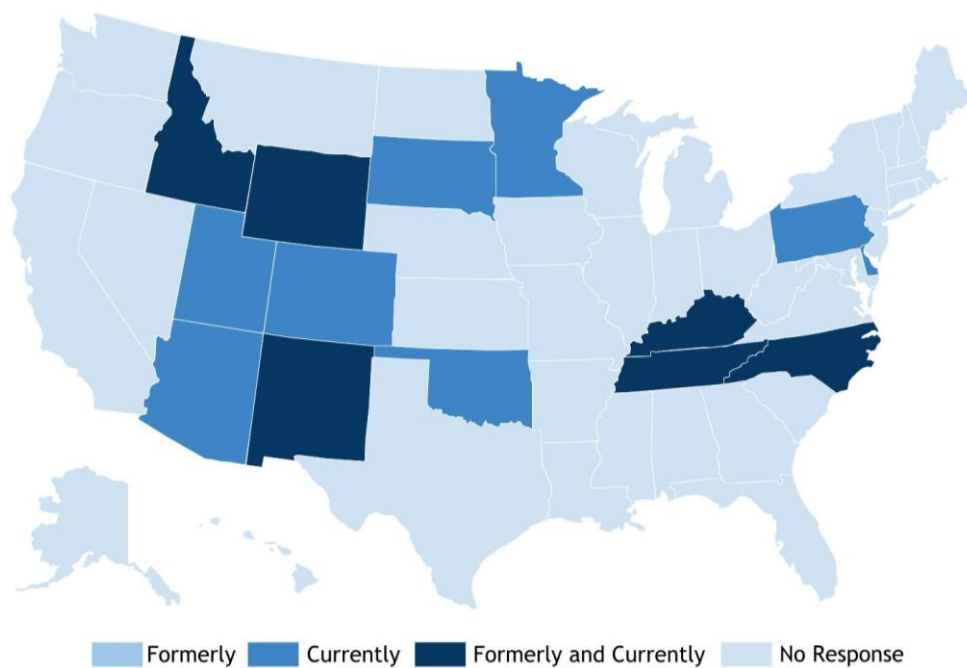


Figure 8. States that use epoxy urethane polymer

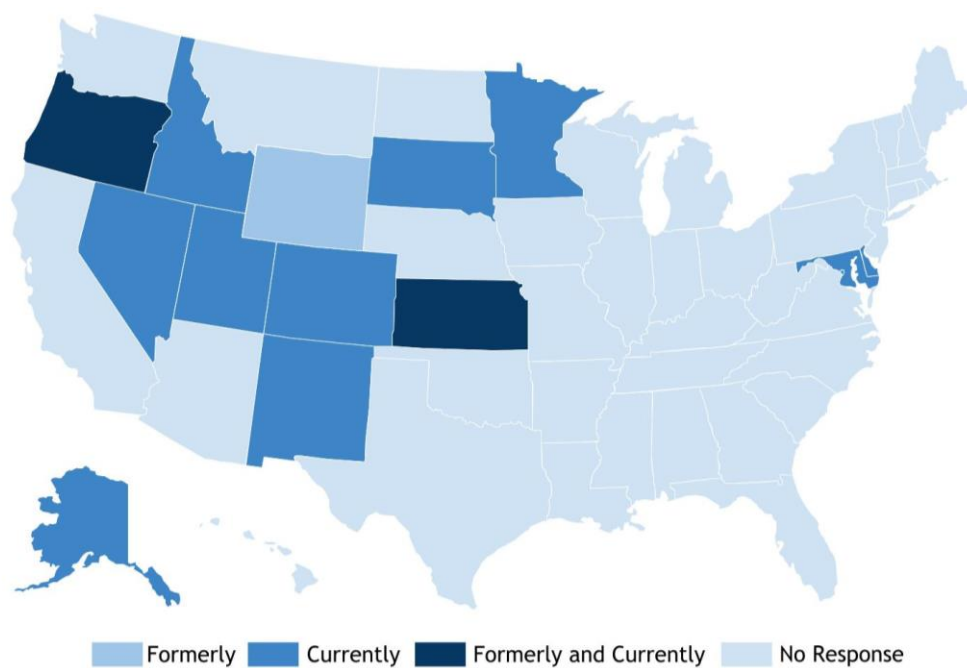


Figure 9. States that use polyester polymer

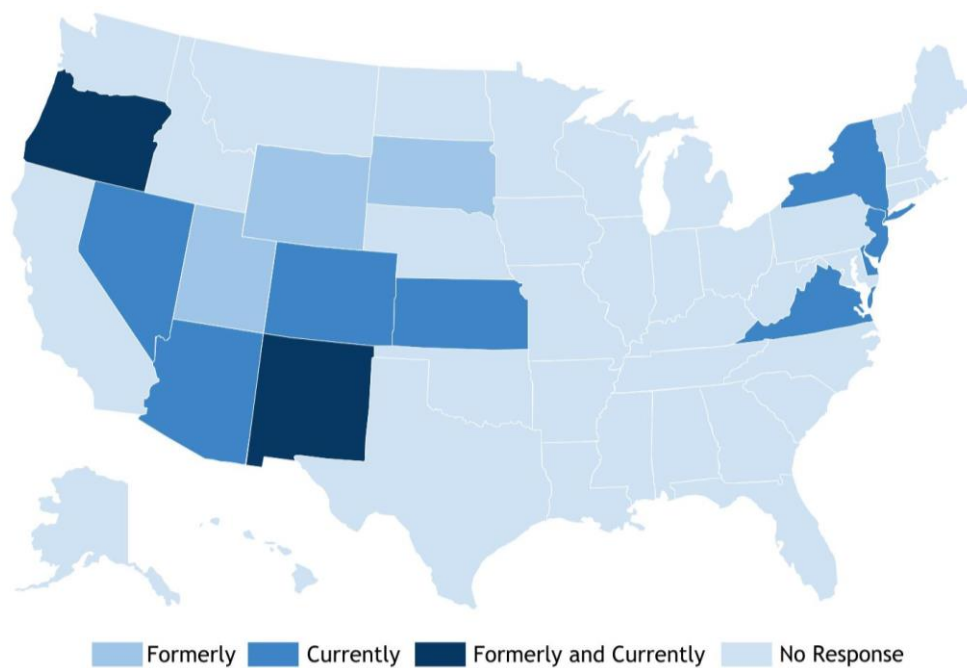


Figure 10. States that use methacrylate polymer

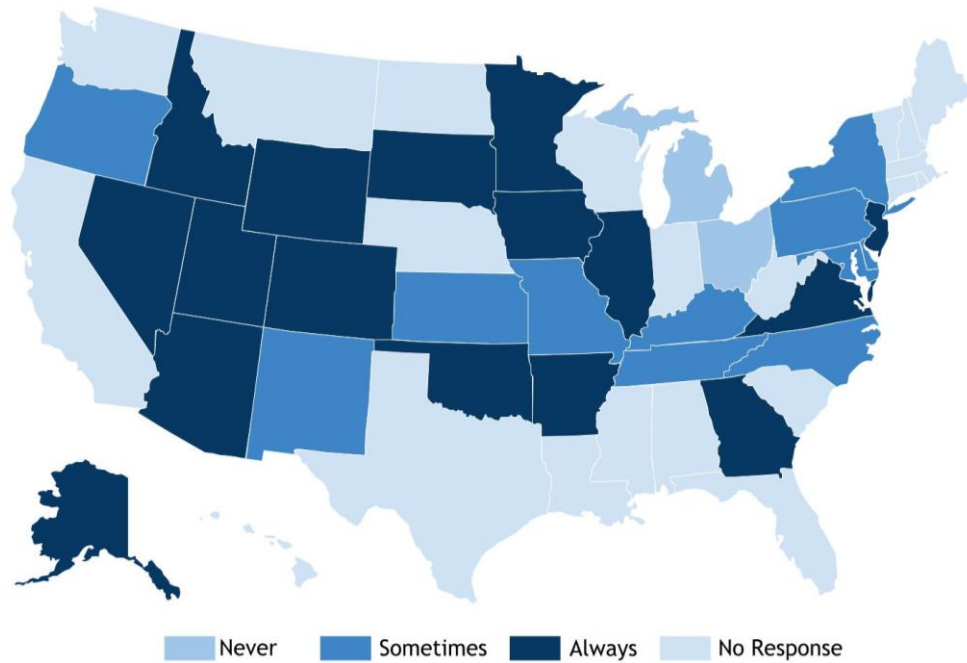


Figure 11. States that require a material representative on site during installation

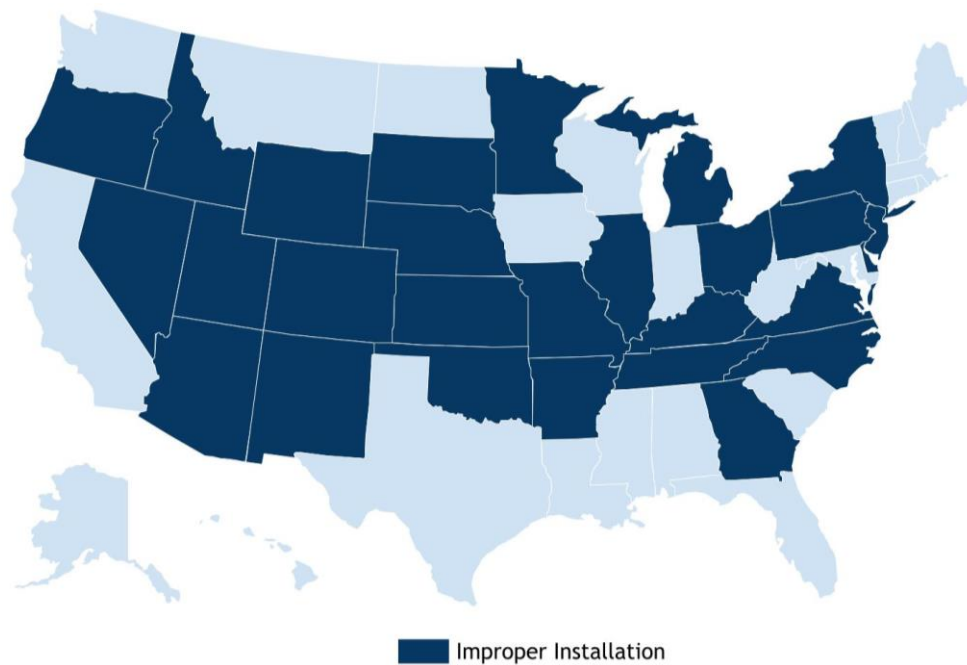


Figure 12. States that indicated improper installation as a common cause of overlay degradation

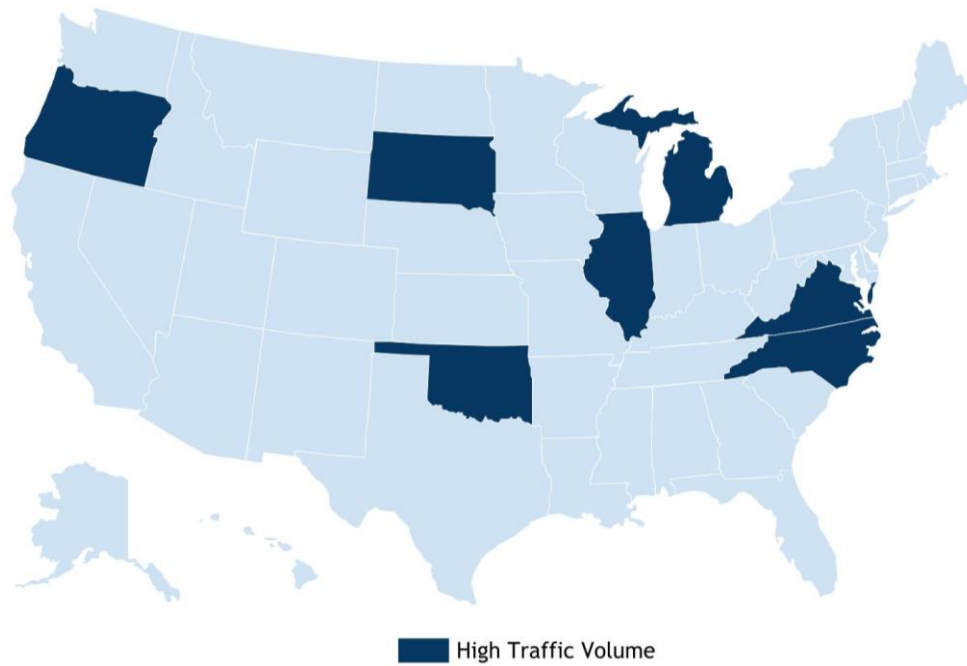


Figure 13. States that indicated high traffic volume as a common cause of overlay degradation

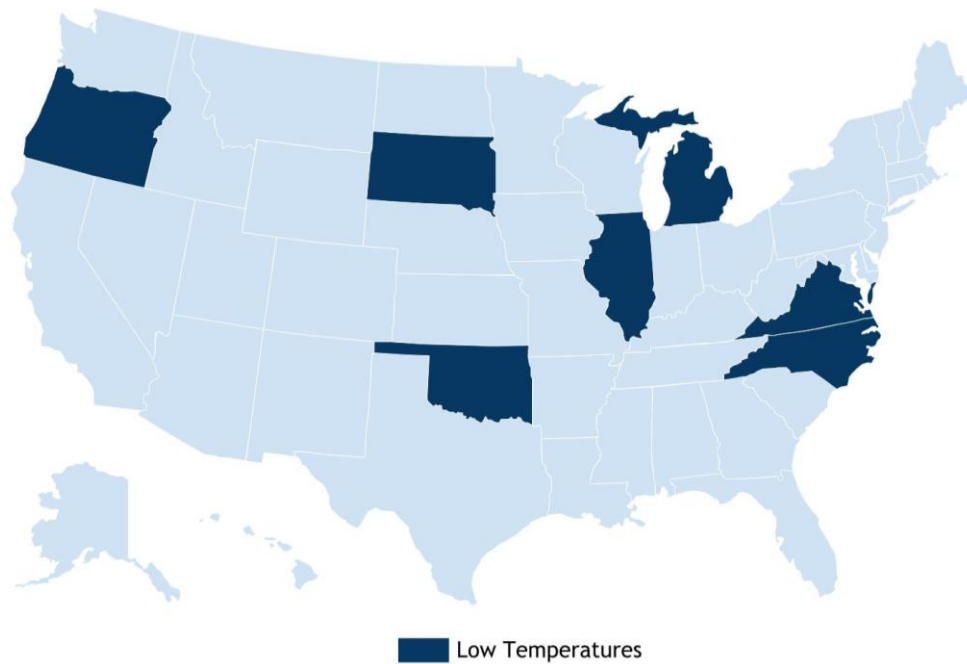


Figure 14. States that indicated low temperatures as a common cause of overlay degradation

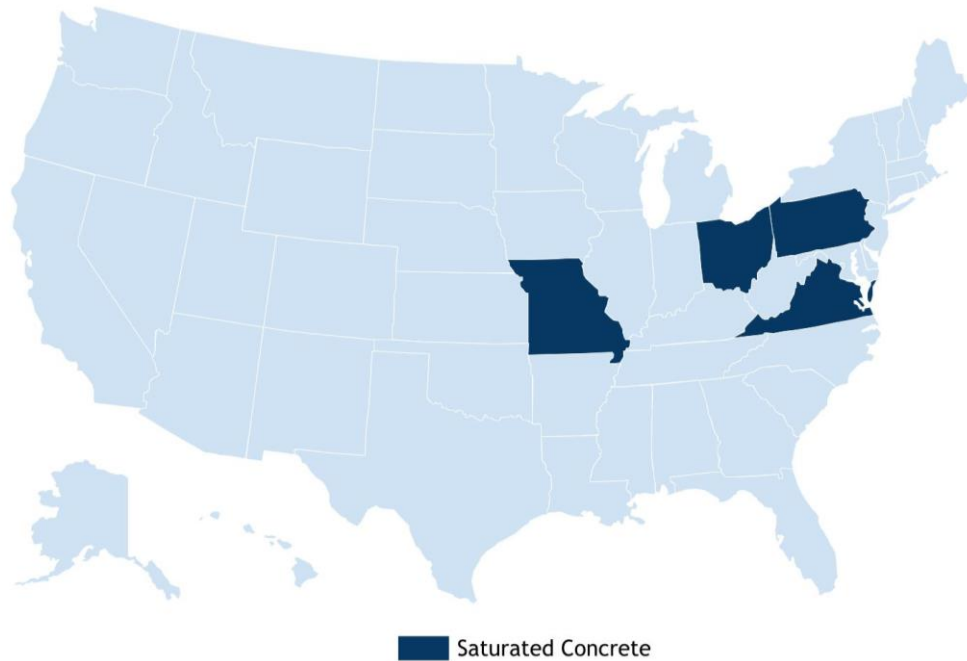


Figure 15. States that indicated saturated concrete as a common cause of overlay degradation

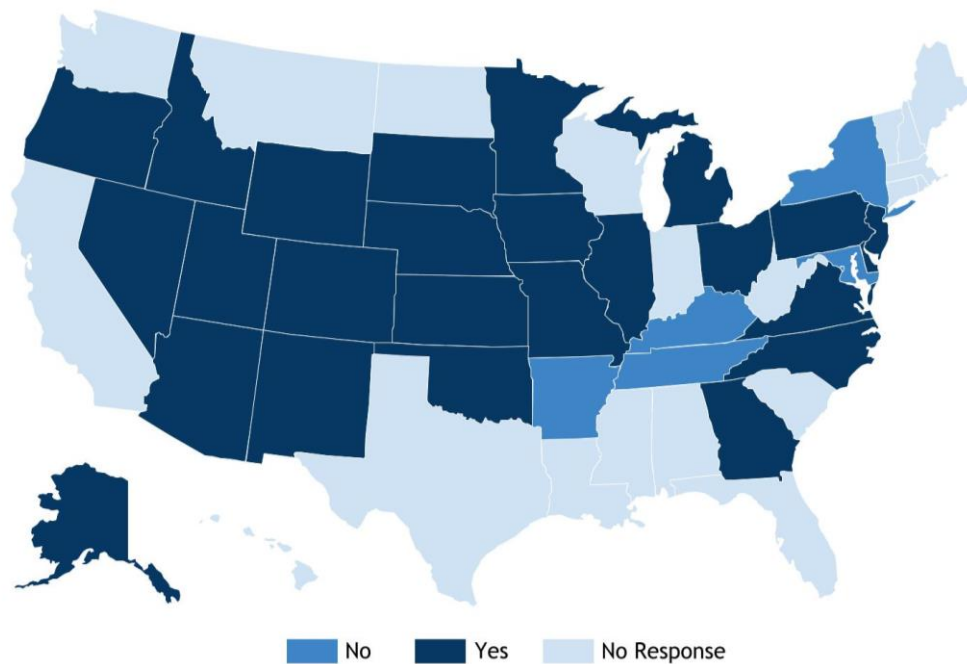


Figure 16. States that have a written specification for polymer overlays

Responses to Question 4

Question 4: If applicable, why did your state cease to use bridge deck polymer overlays?

“We have only done a few demonstration projects in the past out of Maintenance Division. Worked well where the deck was good. Nobody really pushed it so it never got used in any design jobs. Actually plan to start using in the near future.” – Arkansas

Responses to Question 8

Question 8: What constitutes a good candidate for bridge deck polymer overlay application?

“Large complex structures.”

“On new construction - A polymer overlay has been used to address a construction defect, such as insufficient clear cover to the reinforcing steel or questionable concrete to improve the durability. On existing bridge decks - polymer overlays have been applied to worn surfaces to improve friction. Also they have been used a couple of times on bridge deck in fair condition but are cracked to increase service life.”

“An older deck which you are trying to preserve which is in fair or better condition Polymer overlay is an option for extending the deck life.”

“Bridges with sound concrete but having cracks in the deck with limited spalls. Also, bridges with decks integral to the structure, such as post-tensioned box girders, etc.”

“Bridge deck rated 5 or 6, minimal patching. Maintenance of traffic constraints limit use of latex modified concrete.”

“Typically, it would be a concrete bridge deck that was given an NBI deck rating of a '6' or higher, it has very minor cracking, and very little rutting.”

“Moderate cracking, but sound condition, with or without rutting and minor spalling.”

“The deck must be in good condition. There can be cracking, but no delaminations or potential delaminations.”

“Bridge deck in need of minor rehabilitation and/or in area of state that can benefit from attributes of the overlay in climates exposed to de-icing and plowing.”

“New bridge decks.”

“Existing bridges that have previously required crack sealing, and or other deck maintenance, as well as structures exhibiting extensive deck cracking and deterioration.”

“We have used polymer overlays to rehabilitate a bridge constructed in the 1960s that couldn't support the weight of a traditional overlay without posting where the deck was in reasonably good condition. We have also polymer overlaid a new bridge deck that had leaking joints.”

“Typically a concrete bridge deck with a deck General Condition Rating of 6 or greater would be considered a candidate for a polymer overlay. In Virginia, we use epoxy concrete overlays placed in two courses. This is considered to be a preservation activity.”

“Decks that show signs of cracking and require minimal to moderate repair. However an inspection assessment and cost estimates are performed and developed to determine good candidate bridge decks.”

“Needs to have a good deck. Plan to use it as a preservation method.”

“We've chosen a polymer overlay as part of deck rehabilitation. The existing deck must have sound concrete to which the polymer can be bonded.”

“Decks in relative good condition i.e. only minor patching required and small quantities at that. Also on bridges with weight restrictions limiting the thickness of overlay allowed.”

“Bridges built within the last 10 years.”

“Condition 6 or better on the deck. Few patches. Good aggregate.”

“Deck generally in good condition w/ <5% delaminations/spalls. Deck average Chloride content <1.5 #/cf at the top mat.”

“We used it on a cable stay bridge where we were looking for 100 year service life. Typically we use it to extend the life of existing bridge decks after a rehab.”

“Less than 15 to 20% of deck area in need of patching. Cracks that are greater than or equal to 2 mm wide. Protection of an existing subdeck or previously applied concrete overlay to prevent the need for a new concrete overlay. The intent of polymer overlays is to place them on structures that are not seriously deteriorated and require minimal deck repair, thus preserving structures that are still very serviceable.”

“1. New bridges after initial cracking has occurred. Prefer to overlay after 1 year. 2. Older bridges which have been rehabilitated and which have had all deck delamination repaired.”

“A bridge deck in good condition with all deck delaminations or potholes appropriately corrected with repairs. Deck must also be thoroughly cleaned. We require shot blasting the surface.”

“A new deck with little to no delamination. Probably decks with an age of 12 years or less. We would not put a deck polymer overlay on a deck with black rebar.”

“Decks in condition states 1 or 2. Little or no delaminations.”

“Older bridges with lower structural capacity bridges needing overlay replacement, high traffic bridges with some accident history, newer bridges with high amount of deck cracking, historic bridges to prevent future other element deterioration, accelerated bridge construction, precast full depth deck panels, concrete box girders, sidewalks on bridges with lots of concrete cracking.”

“Good deck. Used to extend service life by providing a wearing surface and sealing the deck.”

“Bridge decks with Higher ADT where traffic lanes cannot be closed for extensive time.”

“Unsealed/bare existing bridge decks. New concrete bridge decks where the deck is required structurally under dead load.”

“Deck with good condition.”

“Bridge decks in fairly good condition (rating of a 5-7) with some indications of deck cracking without a lot of delaminations.”

“Deck concrete is in good condition with primary reason to protect deck from chlorides also improve skid resistance.”

“Bridge decks with concrete without pozzolans (pre-2002) that have a General Condition Rating of 6.”

FIELD OBSERVATIONS

Johnson County Overlay Installation

The bridge located over I-80 on 12th Avenue in Coralville, Iowa was scheduled for an epoxy polymer concrete deck overlay during the summer of 2013. Prior to the overlay, deck repairs were required and completed where portions of the deck were moderately deteriorated. Areas identified by Iowa DOT crews were saw-cut and milled approximately 1 inch below the surface. Hand-held pneumatic chippers were then used to remove concrete to and around the top reinforcing steel bar mat beginning at approximately 1-1/2 in. below the top surface (see Figure 17).



Figure 17. Top reinforcing steel bar mat on Johnson County bridge

Some reinforcing steel bar was damaged from the miller (completely severed) and chippers (dented), although considered to be a negligible amount. Any exposed reinforcing bar looked in good condition; little, if any, corrosion was observed (see Figure 18).



Figure 18. Exposed reinforcing steel bar condition on Johnson County bridge

No class B fixes (areas having more than 9 ft² and more than 50% of the deck thickness) were required. Smaller patches, as seen in Figure 19, were completed using rapid-set bag mix, which is mixed at the site and troweled in place.



Figure 19. Completed deck repairs on Johnson County bridge

Two larger patches required ready-mix High Performance Concrete – Overlay (HPC-O) for workability and longer setup time. A surface map was created that locates the areas of repair and is included in Appendix A.

Upon completion of deck repairs and an adequate amount of cure time, the polymer overlay activities commenced. The procedure was completed by Vector Construction, a subcontractor to the general contractor, Iowa Bridge & Culvert. To achieve the specified surface relief (International Concrete Repair Institute (ICRI) preparation level 6 or 7) the deck was shot blasted twice, using the machine shown in Figure 20, since the first pass did not provide the necessary relief.



Figure 20. Shot blasting Johnson County bridge deck

The final surface results are shown in Figure 21.



Figure 21. Johnson County deck surface relief prior to overlay

Upon completion of the shot blasting, magnets were used to pick up any remaining shot on the deck and a wheeled walk-behind blower and leaf blowers (see Figure 22) were used to blow off any remaining loose materials from the deck; deck drains were covered using duct tape.



Figure 22. Johnson County deck cleaning

As shown in Figure 23, a moisture test was completed per the guidelines of ASTM D4263 at three separate locations. In each case, no appreciable moisture was observed in the deck.



Figure 23. Johnson County deck moisture test

The polymer overlay was started at the north end of the bridge at 10:45 p.m. and moved south until completion. The air temperature remained in the upper 60s throughout the procedure. The polymer was a one-to-one two-part mix, Sikadur 22 Lo-Mod, from the Sika Corporation. Each part was dispensed from 50 gallon drums into five gallon pails (see Figure 24) and, then, combined in a muck tub and mixed with a drill-mounted paddle mixer for three minutes (see Figure 25).



Figure 24. Johnson County epoxy polymer mixing



Figure 25. Johnson County paddle mixer

Note that the first batch or two was not mixed for the entire three minutes due to some confusion on instructions.

Any long-term effects, if any, would be revealed at the far north end of the bridge. Although the muck tub method of measurement could be considered reasonably accurate, actual dispensing of each part was not metered.

Once mixed, the epoxy polymer was spread on the deck, as shown in Figure 26, using 3/16 in. notched rubber squeegees (see Figure 27) over a predetermined area given the volume of polymer (10 gallons per 410 ft²).

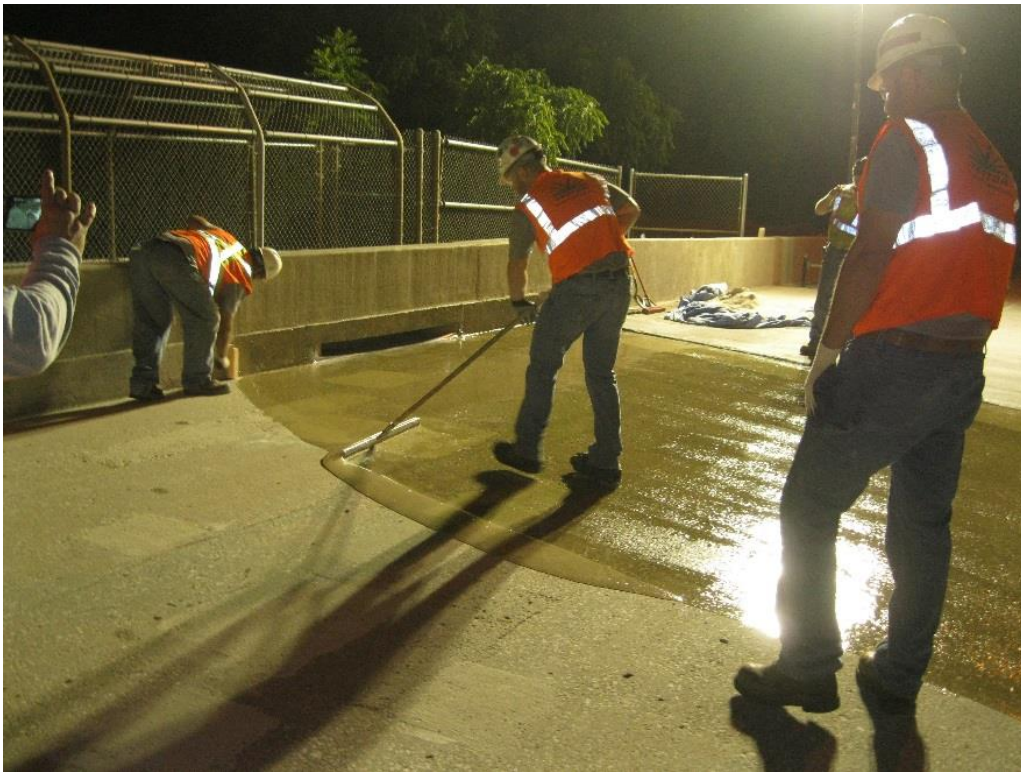


Figure 26. Spreading polymer on Johnson County bridge deck



Figure 27. Johnson County rubber squeegee

Using paint rollers, the lower 12 in. +/- of the barrier rail was also coated with polymer. Flint chips were cast into the polymer by hand within minutes of the polymer being spread as shown in Figure 28.



Figure 28. Casting flint chips on Johnson County bridge deck

The chips, shown in Figure 29, were small and angular per the specification.



Figure 29. Johnson County flint chips

The procedure continued in the same order (mixing, spreading, and casting) from north to south using a crew of nearly a dozen workers. Progress was made quickly (see Figure 30) until completion at 12:30 a.m.



Figure 30. First layer progress on Johnson County bridge deck

The final first-layer overlay is shown in Figure 31.



Figure 31. First layer complete on Johnson County bridge

The procedure to complete the second layer was very similar to that of the first layer. Prior to being able to spread the polymer, all loose flint chips were removed using blowers and compressed air (see Figure 32).



Figure 32. Johnson County deck preparation prior to second layer application

The total length of deck to be covered by one batch corresponding to the prescribed rate was marked along the barrier rail (see Figure 33).



Figure 33. Marking Johnson County barrier rail

The polymer was mixed and spread (see Figure 34) over the first layer at a rate slightly lower than during the first layer in consideration of the increased void areas between the flint chips.



Figure 34. Second layer of polymer application on Johnson County deck

Once both layers were completed and allowed to fully cure, tensile tests, shown in Figure 35, were conducted at three locations to ensure adequate bond to the prepared deck surface.



Figure 35. Tensile tests on Johnson County deck surface

The minimum required strength specified was 250 psi or failure of the concrete and, in each of the three tests, the specification was met. The first test reached a tensile stress of 399 psi prior to the failure of the glue holding the test probe in place. The second test reached a tensile stress of 502 psi before failing in the same way. In the last test, a tensile stress of 360 psi was reached before a portion of concrete pulled off the deck.

Keg Creek Overlay Installation

This bridge over Keg Creek (Figure 36), located on Hwy 6 in western Iowa, 10 miles east of Council Bluffs, was constructed using accelerated bridge construction (ABC) methods and completed during the fall of 2012.



Figure 36. Keg Creek bridge

The ABC method involved using modular superstructure elements, which were joined by ultra-high-performance concrete (UHPC) closure pours once in place, which can be seen in Figure 37.



Figure 37. Keg Creek UHPC deck closure pours

Consequently, the number of longitudinal deck joints was greater than that of a bridge constructed using typical methods. This doesn't necessarily impose additional care or maintenance, but the potential exists for water intrusion through the deck joints. For this reason and that the Iowa DOT intended to evaluate the performance of epoxy polymer overlays in Iowa, Keg Creek was scheduled for a polymer concrete deck overlay during the summer of 2013. Given that the construction of the bridge was completed a little less than a year prior to the overlay placement, deck repairs were not required.

Wildcat Concrete Services, a contractor from Kansas with extensive polymer overlay experience, was the awarded low bidder for the work. The process took place September 3 and 4, 2013. The bridge was divided into halves for completion of the polymer overlay; thus, a detour was not required.

To prepare the deck and achieve the specified surface relief (ICRI preparation level 6 or 7), the deck was shot blasted (see Figure 38).



Figure 38. Keg Creek bridge deck shot blasting

Only one pass of the Blastrac shot blaster using Amasteel S-550 cast steel shot and grit was required, although the inherent roughness present in the longitudinal tining aided the process. In addition to the Blastrac's onboard vacuum, a large sweeper truck, a trailer-mounted compressor (Figure 39), and walk-behind magnets were used to remove the steel shot from the deck surface.



Figure 39. Keg Creek surface preparation

The final deck surface relief is shown in Figure 40.



Figure 40. Keg Creek surface roughness

Once the deck was prepared, a semi-truck and trailer carrying a hopper full of flint chips, vats of parts A and B of the epoxy polymer, and a blower was positioned at the east end of the bridge. As shown in Figure 41, large rollers holding a protective mat was mounted on the front of the semi and a receiving roller was mounted at the end of the trailer behind the vehicle.



Figure 41. Keg Creek deck protection

This mat was used to protect the bridge deck from any oils or other contaminants the truck may disperse while traversing the bridge.

The polymer used at Keg Creek was Pro Poxxy Type III from Unitex, a two-component flexible epoxy binder meeting ASTM C881 Type III Grade 1 Classes B and C. The components, parts A and B, were to be mixed at a 1 to 1 ratio by volume.

At 5:45 p.m., the polymer placement process began; the air temperature was 82° F. Mixing of parts A and B of the epoxy polymer was observed by a representative from Unitex and was completed using Jiffy mixers in a 35 gallon trash can for three minutes (see Figure 42).



Figure 42. Keg Creek polymer mixing

The proportions of each (10 gallons) were metered as they were dispensed from the holding vats to ensure a proper mix.

Once mixed, the polymer was dumped onto the bridge deck and spread using 3/8 in. notched squeegees over the deck and bottom 12 in. of parapet wall as shown in Figure 43.



Figure 43. Spreading the polymer on the Keg Creek deck

Flint chips were then blown onto the polymer until full coverage was achieved (see Figure 44).



Figure 44. Blowing flint chips into polymer on the Keg Creek deck

The process of mixing, spreading, and blowing continued (see Figure 45) until the vehicle reached the west end of the bridge and the south side of the bridge was covered at 6:30 p.m. (see Figure 46).



Figure 45. Flint chips spread on the Keg Creek deck



Figure 46. Finished flint chip application on the Keg Creek deck

In the end, 6,072 ft² (276 by 22 ft bridge deck and approaches) were covered using 360 gallons of polymer (180 gallons each parts A and B).

The overlay was allowed to cure overnight before preparation for the second layer commenced. Loose flint chips were blown off using compressed air and removed with the sweeper truck. One small location, roughly 4 by 4 ft, of the first layer was removed and reapplied as it was found to have not properly bonded to the deck. An hour was allowed to pass before placement of the second layer began. At 9:15 a.m., with an air temperature of 72 ° F, the placement began and proceeded in the same manner as the first layer. At 10:15 a.m., the entire south side of the bridge had been covered again using 430 gallons of polymer (215 gallons of each part, A and B).

Pull-off tests were completed after the second layer was allowed to cure; in the eastbound lane, three total tests were completed (480 psi, 860 psi, and 920 psi); all surpassed the pull-off test requirements.

OVERLAY PERFORMANCE EVALUATIONS

Johnson County Bridge

Visit 1 – March 14, 2014

A visit to the Johnson County bridge was completed on March 14, 2014, shortly after 3 to 4 winter months of significant cold and snowfall. Overall, the overlay appeared in very good condition (see Figure 47).



Figure 47. Johnson County revisit March 14, 2014

No apparent delamination was observed, other than at two minor areas located immediately adjacent to the end joints, as shown in Figure 48 through Figure 51.



Figure 48. Johnson County delamination at north end of bridge (1 of 2)



Figure 49. Johnson County delamination at north end of bridge (2 of 2)



Figure 50. Johnson County delamination at south end of bridge (1 of 2)



Figure 51. Johnson County delamination at south end of bridge (2 of 2)

It was assumed that the delaminations are the result of snowplows entering the bridge and/or possible poor deck preparation at these locations.

Minor smoothing of the cast aggregate was observed in the wheel lines, but a good overall friction surface was still maintained. No observable leaking or efflorescence was present on the underside of the deck.

Visit 2 – October 16, 2014

Figure 52 is one of the photographs taken during the second visit to the Johnson County bridge, October 16, 2014, after one year of overlay service.



Figure 52. Johnson County revisit October 16, 2014

Both of the locations (at the ends of the bridge) identified during the first visit to have delamination from poor surface preparation or snow plow impact had been repaired; an epoxy polymer and aggregate were placed by the District 6 bridge crew. The south and north locations are shown in Figure 53 and Figure 54, respectively.



Figure 53. Johnson County epoxy polymer repair at south end of bridge



Figure 54. Johnson County epoxy polymer repair at north end of bridge

During this visit, a smaller area in the southbound lane just north of the center pier, approximately 3 by 2 ft, was noticeably different in appearance than the surrounding deck areas (see Figure 55).



Figure 55. Johnson County area of discoloration

Although the appearance was different, there was nothing that indicated imminent delamination. The location was noted and would be reevaluated during future visits.

The remaining areas of the bridge deck appeared in very good condition with no apparent delamination or damage. Similar to the first visit, minor smoothing, primarily in the wheel lines, was observed (see Figure 56). This smoothing was not unexpected and is simply a result of the traffic to which the deck is subjected.



Figure 56. Johnson County smoothing in the wheel lines

Visit 3 – April 29, 2015

The third visit to the Johnson County bridge was completed on April 29, 2015. By this date, the polymer overlay had been in place for 1.5 years and had been subjected to two Iowa winters, which not only introduces extreme cold but the effects of snowplows.

The majority of the polymer overlay appeared in good condition (see Figure 57), although two areas noted during previous visits were notably changed from the last visit during the fall of 2014.



Figure 57. Johnson County revisit April 29, 2015

The joint at the north end of the bridge where repairs had been completed during the summer of 2014 was again showing signs of delamination. The condition is shown in Figure 58 and Figure 59.



Figure 58. Johnson County epoxy polymer repair at north end of bridge (1 of 2)



Figure 59. Johnson County epoxy polymer repair at north end of bridge (2 of 2)

The delaminated area was smaller in size than the original area of repair, although additional delamination appeared imminent.

The second area near the center pier also showed signs of additional degradation. Shown in Figure 60 and Figure 61, an area approximately 6 by 6 ft had delaminated and peeled from the bridge, which resulted in the exposure of the concrete deck under it.



Figure 60. Johnson County delamination in southbound lane



Figure 61. Johnson County close-up of exposed concrete deck in southbound lane

Visit 4 – September 10, 2015

The fourth and final visit to the Johnson County bridge took place September 10, 2015. The overall condition of the polymer overlay largely remained unchanged from previous inspections; that is, good adhesion with few delaminations over almost the entire deck with minor aggregate smoothing in the wheel lines was observed.



Figure 62. Johnson County revisit September 10, 2015

Three areas where poor conditions were noted were at the expansion joints at both the north and south ends of the deck and just north of the center pier in the southbound lane.

At the south expansion joint, a moderately sized piece of the bridge deck had been removed, taking with it the polymer overlay, which was adhered to the top (See Figure 63).



Figure 63. Johnson County expansion joint at south end of bridge

This condition is not a reflection of the overlay performance; rather, it appears to be the result of impact at the deck edge. The overlay at this location appears to be otherwise in satisfactory condition.

At the north expansion joint (shown in Figure 64) where previous overlay repairs took place during the summer of 2014, areas of delamination were observed.



Figure 64. Johnson County expansion joint at north end of bridge

Where the polymer was missing altogether, the remaining polymer edges were pliable and unattached to the deck. This condition seemingly would lead to additional delamination in the not too distant future.

Lastly, delamination was observed in the area immediately north of the center pier in the southbound lane as shown in Figure 65.



Figure 65. Johnson County delaminated area north of the center pier in the southbound lane

Figure 66 provides a close-up of the same area.



Figure 66. Close-up of delaminated area on Johnson County bridge deck

The delamination appears to have advanced since the last inspection during the spring of 2015. More areas of the overlay have been removed completely. The exposed edges were pliable and unattached to the bridge deck, which will likely lead to additional delamination in the near future.

Keg Creek Bridge

Visit 1 – March 17, 2014

The first visit to Keg Creek was completed on March 17, 2014, shortly after 3 to 4 winter months of significant cold and snowfall. The bridge appeared in very good condition and no apparent delamination was observed (see Figure 67).



Figure 67. Keg Creek revisit March 17, 2014

Some smoothing of the cast aggregate occurred, especially in the wheel lines and, as shown in Figure 68 and Figure 69, the curb lines had accumulated a fair amount of the cast aggregate that had become loose and presumably pushed to the curbs by plow trucks.



Figure 68. Keg Creek collection of cast aggregate at curb line (1 of 2)



Figure 69. Keg Creek collection of cast aggregate at curb line (2 of 2)

The performance appeared to be equally as good at the UHPC joints and precast deck locations. As shown in Figure 70, some reflective cracking was seen on the approach slabs where cracks were observed prior to the polymer overlay application.



Figure 70. Keg Creek reflective cracking in approach slabs

Also, some scuffing from snow plows was observed at the bridge entrances as shown in Figure 71.



Figure 71. Keg Creek scuffing from plow at bridge entrance

Visit 2 – October 24, 2014

The second visit to the Keg Creek Bridge after the polymer overlay was completed occurred on October 24, 2014. This date marked just over one year of service for the overlay. The overlay condition was quite good in nearly all areas (see Figure 72), although a few areas were noted for their less than good condition.



Figure 72. Keg Creek revisit October 24, 2014

First, as seen in Figure 73, the joint filler between the bridge deck and the approach slab was missing in some areas.



Figure 73. Keg Creek aggregate in expansion joint

As a result, these areas had filled with loose aggregate from the overlay that had not originally adhered to the deck or had subsequently been removed by plows or other traffic.

Secondly, as expected, it was observed that the polymer overlay does not resist cracking in the substrate to which it is adhered. Reflective cracking like that shown in Figure 74 was seen throughout the overlay in each of the approach slab locations.



Figure 74. Keg Creek reflective cracking in approach slab

From this, it can be surmised that any cracking of significance has not occurred on the bridge deck itself due to the lack of overlay cracking there.

Finally, as previously noted, scuffing of the overlay along the approach slab entrance was quite noticeable after the first winter in service. It was observed that the scuffing did not lead to further degradation or delamination (see Figure 75).



Figure 75. Keg Creek scuffing at approach slab entrance

Shown in Figure 76, only one small area at the deck entrance along the shoulder was found to be delaminated.



Figure 76. Keg Creek small delamination at end of deck

The surrounding area did not appear to be affected or at risk for further delamination.

Visit 3 – April 13, 2015

The third visit to Keg Creek after the polymer overlay installation occurred on April 13, 2015. The overall condition was, for the most part, unchanged since the previous inspection (see Figure 77).



Figure 77. Keg Creek revisit April 13, 2015

Generally, the condition remained very good with total adhesion and no delamination over the whole deck surface.

Figure 78 shows an area of scuffing at the bridge entrance caused by snow plows.



Figure 78. Keg Creek scuffing at bridge entrance

This area has not deteriorated disproportionately on account of the mechanical wearing. Only the aggregate has been smoothed to a greater degree than what was otherwise seen; no delamination has occurred at these locations.

The most noteworthy observation on the bridge deck is the wheel line smoothing as seen in Figure 79.



Figure 79. Keg Creek wheel line smoothing

As expected, the aggregate has worn more quickly in the wheel lines than other areas of the bridge. Although a difference is clear, the smoothed aggregate still provides a moderately coarse surface. Close-ups of the deck in the wheel lines and outside of the wheel lines are provided in Figure 80 and Figure 81, respectively.



Figure 80. Keg Creek surface roughness where wheel line smoothing



Figure 81. Keg Creek surface roughness outside of wheel line smoothing

Visit 4 – September 17, 2015

The last follow-up visit after polymer overlay completion occurred on September 17, 2015, after just under two years of service. Similar to previous inspections, the deck surface generally appeared to be free of delamination or other signs of degradation (see Figure 82).



Figure 82. Keg Creek revisit September 17, 2015

The scuffing at the bridge entrance, shown in Figure 83, was not observed to be in any worse condition than what was seen during the previous inspections.



Figure 83. Keg Creek bridge entrance scuffing

No delamination was present, only mechanical smoothing of the aggregate.

As shown in Figure 84, joint filler at the east end of the bridge continues to be removed from the joint between the deck and approach slab.



Figure 84. Keg Creek expansion joint

This removal has resulted in the joint being filled with loose aggregate and the growth of plant life.

The reflective cracking seen in the approach slabs (Figure 85) appeared to be worsening.

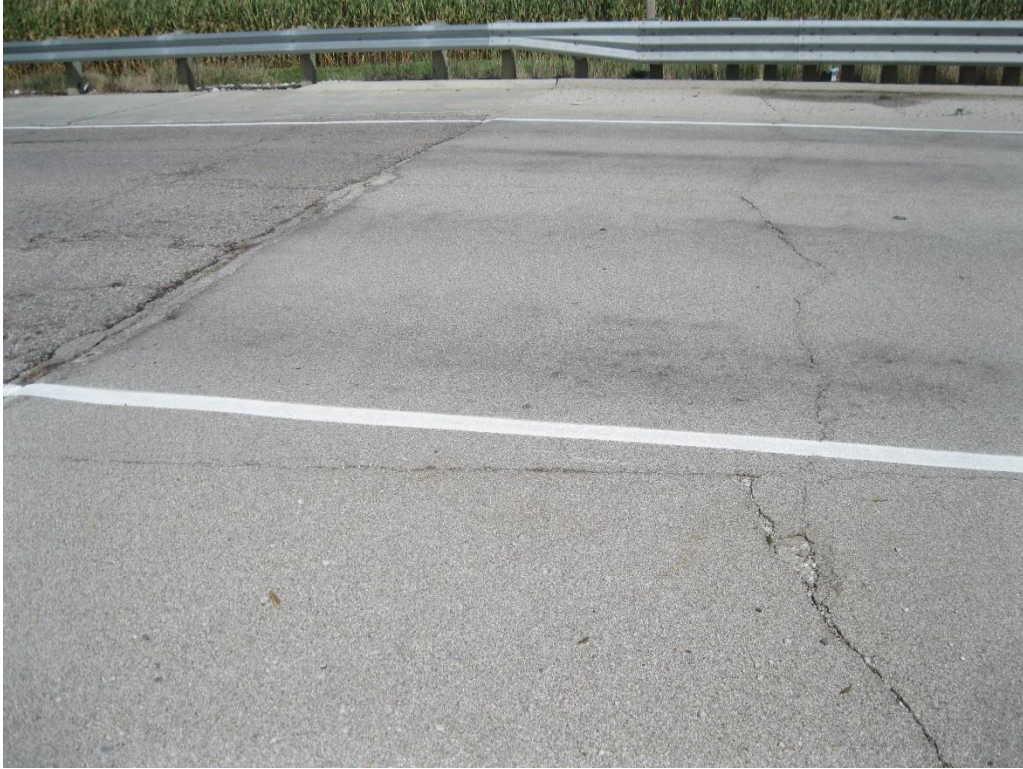


Figure 85. Keg Creek reflective cracking

The edges of the polymer overlay along the cracks were chipping. In this case, the function of the overlay at the cracks was lost long ago, although it gives a good indication of what could happen at other cracks, potentially in the bridge deck, should they ever occur.

Figure 86 shows the lane condition.



Figure 86. Keg Creek lane condition

SUMMARY

An effort to track the performance of epoxy polymer overlays over time and relate the performance to material usage and/or workmanship was performed for two bridges in Iowa. To complete this effort, several tasks were performed: document the state-of-the-practice with respect to polymer overlays around the nation, document the installation of the two overlays in Iowa, and monitor the performance of the overlays over a two-year period.

Prior to placement of the overlays, several sources were sought to identify the current state-of-the-practice with respect to epoxy polymer overlays, and primarily published literature and DOT personnel from across the US. From these sources, the researchers found that the success or failure of any overlay project can often be attributed to three things: existing condition of the deck, preparation of the deck surface, and proper mixing of the epoxy polymer.

Prior to the determination of epoxy polymer overlay use, the deck condition must be assessed and found to be in a satisfactory state. That is to say, the epoxy polymer is not intended to fix existing deficiencies in the deck, but, rather, to prevent the elements from acting on the deck and expediting deterioration.

The preparation of the deck surface prior to the application of the overlay is paramount to the success of the project. A certain level of surface roughness must be attained and the deck must be free of foreign material and moisture. If these requirements are not met, the bond between the overlay and the deck surface will be greatly compromised and likely apt to fail in short order.

Any epoxy polymer used will have a specified method of measurement and mixing. These methods are backed by the manufacturers' own research and should be strictly followed to ensure the polymer is properly prepared for deck application. Without proper mixing, the polymer effectiveness could be compromised, resulting in a premature failure of the overlay.

In Iowa, two bridges (Johnson County and Keg Creek) were overlaid during the summer/fall of 2013. In each case, the overlay process was observed and documented. The process by which each bridge was overlaid was similar in many ways, although a few slight differences existed.

The deck preparation was completed similarly by shot blasting the deck to an approved surface roughness and blowing the deck free of debris. The blowing process differed slightly (leaf blowers versus trailer-mounted air compressor), although, in the end, it appeared that the same result was achieved.

The way by which the epoxy polymer was measured and mixed and how the cast aggregate was placed was likely the greatest difference observed. The polymer material used (different but meeting specifications at each location) at Keg Creek was precisely measured using automated controls; whereas, the material used at the Johnson County bridge was closely approximated by dispensing each part into equally sized muck tubs. At Keg Creek, the aggregate was cast via a

vacuum and blower; whereas, at the Johnson County bridge, the aggregate was cast via a more labor-intensive hand broadcasting method.

Aside from these differences, the process by which the polymer was mixed and spread onto each deck was nearly identical in nature (Jiffy paddles and notched squeegees). In the end, the final product was quite similar with neither one appearing to be better than the other.

Over time, each overlay has generally performed quite well with only a few areas of exception. It is believed that these localized areas likely underperformed due to poor deck preparation, improper polymer mixing, snowplow impact, or a combination thereof.

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APPENDIX A – JOHNSON COUNTY DECK REPAIR MAP

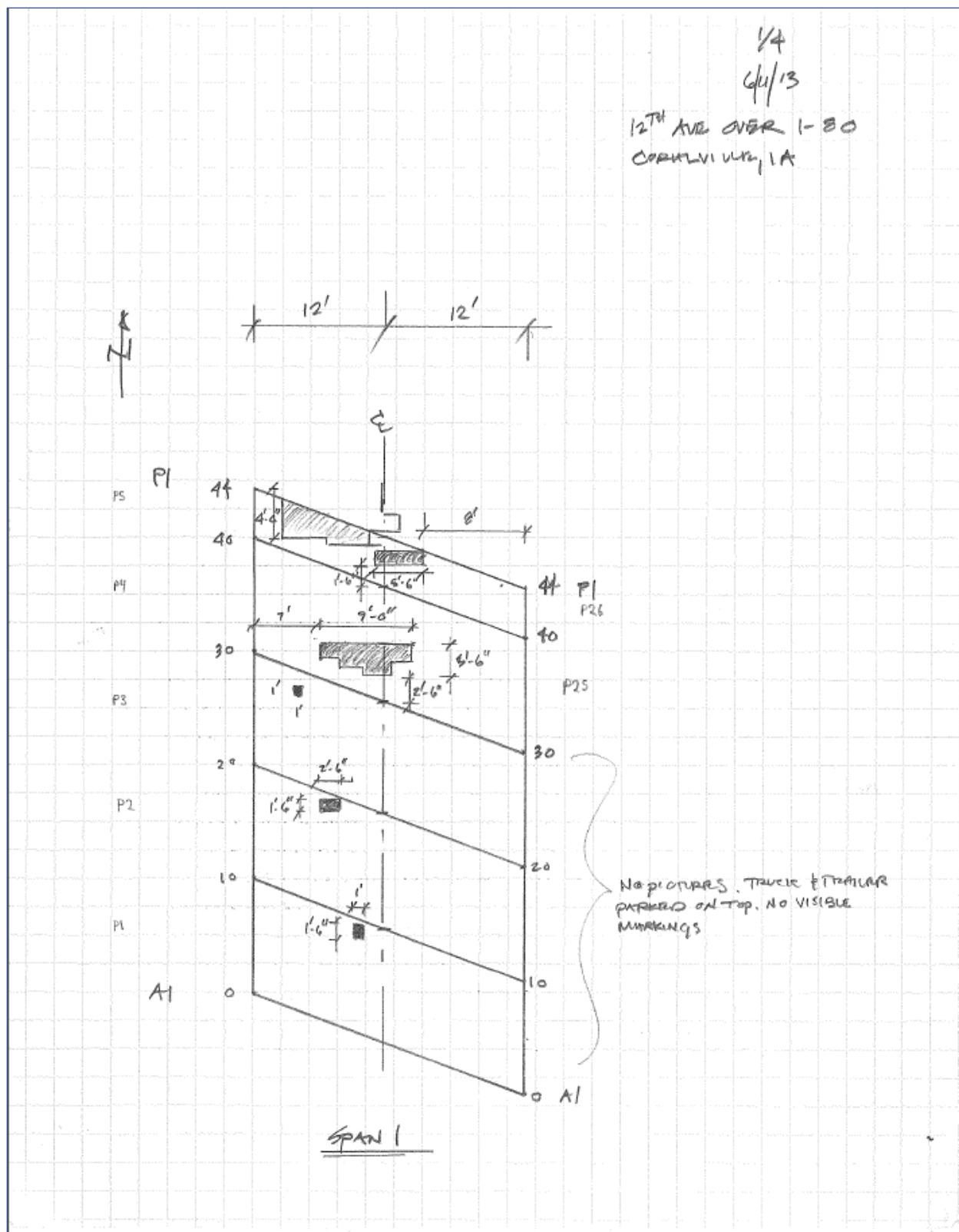


Figure 87. Johnson County Span 1 repair map

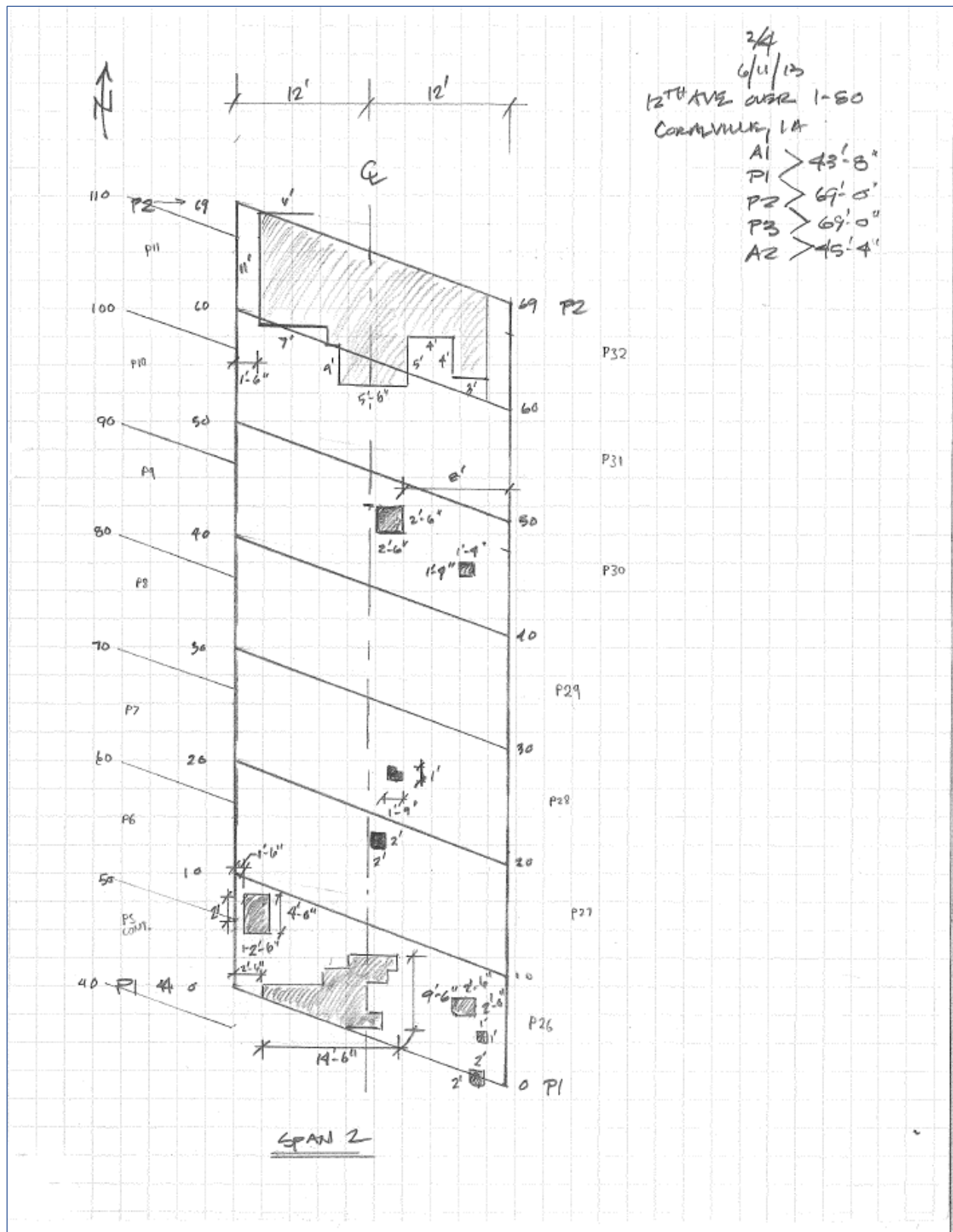


Figure 88. Johnson County Span 2 repair map

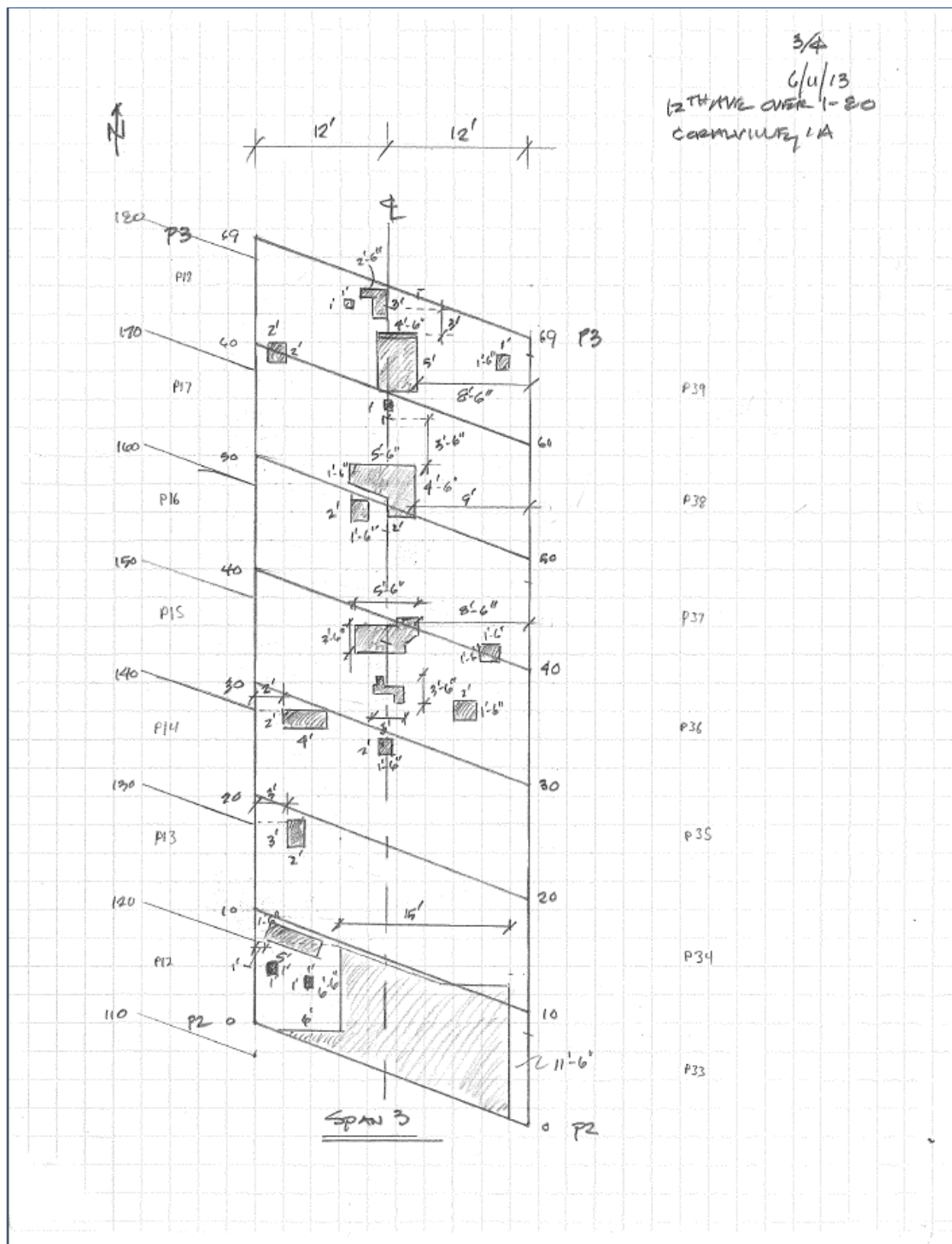


Figure 89. Johnson County Span 3 repair map

[illegible]

89

APPENDIX B – STATE DOT SPECIFICATIONS FROM SURVEY RESPONDENTS

Delaware Specifications

602733 - THIN POLYMER OVERLAY

Description:

This work shall consist of furnishing and placing a thin polyester polymer overlay where indicated in the Contract Documents. The work shall include the preparation of receiving surfaces.

Materials:

1. Primer. The prepared surface shall receive a wax-free low odor, high molecular weight methacrylate prime coat. The prime coat shall be a resin, and prior to adding initiator the resin shall have a maximum volatile content of 30 percent, when tested in accordance with ASTM designation D 2369, and conforming to the following:

High Molecular Weight Methacrylate (HMWM) Resin		
Property	Requirement	Test Method
Viscosity* (Brookfield RVT with UL adapter, 50 RPM at 77°F)	0.025 Pa•s, maximum	ASTM D 2196
Specific Gravity* (at 77°F)	0.90, minimum	ASTM D 1475
Flash Point* (Degrees C)	10	ASTM D 3278
Vapor Pressure* (mm Hg at 77°F)	1.0	ASTM D 323
Tack Free Time (minutes at 77°F)	400 min. maximum	ASTM C 679
PCC Saturated Surface-Dry Bond Strength (MPa at 24 hrs at 70±1°F)	0.5 psi minimum	

*Tested prior to adding initiator

The prime coat promoter/initiator shall consist of a metal drier and peroxide. If supplied separately from the resin, **at no time shall the metal drier be mixed directly with the peroxide.** The containers shall be stored in a manner that will not allow leakage or spillage from one material to contact the containers or material of the other.

NOTE: Mixing the metal drier directly with the peroxide will result in a violent exothermic reaction.

2. Aggregate. Aggregate for polyester concrete *and finishing sand* shall conform to the requirements of Section 804, except the gradation shall meet the following:

Combined Aggregate		
Sieve Size	3/8" Max. Percent Passing	#4 Sieve Max. Percent Passing
1/2 "	100	100
3/8"	83-100	100
#4	65-82	62-85
#8	45-64	45-67
#16	27-48	29-50
#30	12-30	16-36
#50	6-17	5-20
#100	0-7	0-7
#200	0-3	0-3

Aggregate retained on the #8 sieve shall have a maximum of 45 percent crushed particles when tested in accordance with AASHTO Test Method T27. Fine aggregate shall consist of natural sand only.

Aggregate absorption shall not exceed one percent as determined by AASHTO Test Methods T84 and T85.

At the time of mixing with the resin, the moisture content of the aggregate, as determined by AASHTO Test Method T 255, shall not exceed one half of the aggregate absorption.

Finish sand shall be a dry No. 8/20 commercial quality blast sand.

3. Polyester Binder. The polyester concrete shall consist of polyester resin binder and dry aggregate. The resin shall be an unsaturated isophthalic polyester-styrene co-polymer conforming to the following:

Polyester Resin Binder		
Property	Requirement ^a	Test Method
Viscosity* (RVT No. 1 Spindle, 20 RPM at 77°F)	0.075 to 0.20 Pa•s	ASTM D 2196
Specific Gravity*	1.05 to 1.10 at 77°F	ASTM 1475
Elongation	35 percent minimum Type I at 0.45"/min. Thickness = 1/4" ± 0.04"	ASTM D 638
	Sample conditioning: 18/25/50 + 5/70	ASTM D 618
Tensile Strength	17.5 MPa minimum Type I at 0.45"/min. Thickness = 1/4" ± 0.04"	ASTM 638
	Sample conditioning: 18/25/50 + 5/70	ASTM 618
Styrene Content *	40 percent to 50 percent (by weight)	ASTM D 2369
Silane Coupler	1.0 percent, minimum (by weight of polyester styrene resin)	
PCC Saturated Surface Dry Bond	3.5 MPa, minimum at 24 hours and	

Strength	70±1°C	
----------	--------	--

*Tested prior to adding initiator

^a Values are based on specimens or samples cured or aged at 77°F unless otherwise indicated.

The silane coupler shall be an organosilane ester, gammamethacryloxypropyltrimethoxysilane. The promoter shall be compatible with methyl ethyl ketone peroxide (MEKP) and cumene hydroperoxide (CHP) initiators.

4. Samples. Samples of materials for all components of the overlay system shall be submitted by the manufacturer to the Materials and Research Section a minimum of sixty (60) days prior to the overlay application. Samples shall be representative of the materials to be used in the overlay application and shall consist of one four-liter sample for each liquid component and a 5 pound sample for each dry component.

5. Packaging and Shipment. A Material Safety Data Sheet shall be furnished prior to use for each shipment of polyester resin binder and high molecular weight methacrylate resin. All components shall be shipped in strong, substantial containers, bearing the manufacturer's label specifying date of manufacture, batch number, brand name, quantity, and date of expiration or shelf life. In addition, the mixing ratio shall be printed on the label of at least one of the system components. If bulk resin is to be used, the Contractor shall notify the Engineer in writing 10 days prior to the delivery of the bulk resin to the job site. Bulk resin is any resin that is stored in containers in excess of 55 gallons.

6. Basis of Acceptance. Project acceptance of the polyester overlay materials will be based on the following:

1. Delivery of the overlay materials to the project site in acceptable containers bearing all the label information as required in 5. Packaging and Shipment.
2. Receipt of a manufacturer's certification stating the primer, aggregate and polyester binder meet the material requirements found under MATERIALS, 1-3.
3. Approval by the Materials and Research Section based on conformance with the material requirements above.

Construction Methods:

A. General. At least ten (10) days before start of work, the Contractor shall provide the Engineer with two (2) copies of the manufacturer's written instructions for the installation of the overlay system.

The manufacturer's technical representative shall be made available for up to three (3) working days to make recommendations to facilitate the overlay installation. This shall include, but not be limited to, surface preparation, overlay application and overlay cure.

During surface preparation and overlay application, precaution shall be taken to assure that traffic is protected from rebound, dust and construction activities. Appropriate shielding shall be provided as required and directed by the Engineer.

During overlay application, the Contractor shall provide suitable coverings (e.g. heavy duty drop cloths) to protect all exposed areas not to be overlaid, such as curbs, sidewalks, parapets, etc. All damage or defacement resulting from this application shall be cleaned and, or repaired to the Engineer's satisfaction, at no additional cost.

B. Storage of Materials. All materials shall be stored in accordance with the manufacturer's

recommendation to ensure their preservation until used in the work. Applicable fire codes may require special storage facilities for some components of the overlay system.

C. Equipment.

1. **Surface Preparation.** All equipment to be used for surface preparation shall be as specified by the overlay manufacturer and approved by the Engineer. Unless otherwise specified, the Contractor shall use automatic shot blasting units to clean pavement surfaces. In those areas not accessible to this machinery, the surface may, with the Engineer's approval, be cleaned with blast cleaning equipment.

Automatic shot blasting units shall be self propelled and include a vacuum to recover spent abrasives. The abrasive shall be steel shot. Magnetic rollers shall be used to remove any spent shot remaining on the deck after vacuuming.

2. **Application.** Polyester concrete shall be mixed in mechanically operated mixers. Mixer size shall be limited to 9 cubic feet capacity. A continuous mixer employing an auger screw/chute device may be approved by the Engineer if a demonstration shows its ability to produce a satisfactory product. The continuous mixer shall 1) be equipped with a metering device that automatically measures and records the aggregate volumes and the corresponding resin volumes and 2) have a readout gage, visible to the Engineer at all times, that displays the volumes being recorded. The volumes shall be recorded at no greater than five (5) minute intervals along with the time and date of each recording. A printout of the recordings shall be furnished to the Engineer at the end of each work shift.
3. **Finishing and Texturing.** Finishing shall be performed using a mechanical screed riding on preset rails. Screeds shall be approved by the Engineer prior to the application of the overlay. No vibratory screeds will be allowed.

Texturing shall be performed using spring steel tines in accordance with Subsection 602.20.c-2, Manual Texturing.

D. Surface Preparation. All structural slab surfaces that will be in contact with the overlay shall be prepared as follows:

1. The Contractor shall determine the size of shot, flow of shot, forward speed of shot blast machine and number of passes necessary to provide a surface capable of a tensile bond strength greater than or equal to 250 psi or a failure area, at a depth of 1/8" or more into the base concrete, no greater than 50% of the test area. The testing shall be as per ACI 503R-93, Appendix A. The Engineer will designate the location of the test patches.

Before application of the primer, the entire deck surface shall be cleaned by shot blasting and other means using the approved cleaning practice to remove asphaltic material, oils, dirt, rubber, curing compounds, paint, carbonation, laitance, weak surface mortar and other potentially detrimental materials, which may interfere with the bonding or curing of the overlay. Acceptable cleaning is usually achieved by significantly changing the color of the concrete and mortar and beginning to expose coarse aggregate particles. Mortar which is sound and firmly bonded to the coarse aggregate must have open pores due to cleaning to be considered adequate for bond. Areas of asphalt larger than 1 inch in diameter, or smaller areas spaced 6 inches apart, shall be removed. Traffic paint lines shall be considered clean when the concrete has exposed aggregate showing through the

paint stripe. A vacuum cleaner shall be used to remove all dust and other loose material.

If the Engineer determines that an approved cleaning practice has changed prior to the completion of the overlay application, the Contractor must return to the approved cleaning methods and re-clean the suspect areas or verify through tests at no additional cost to the Department that the practice is acceptable.

All patching and cleaning operations shall be inspected and approved prior to placing the overlay. Any contamination of the deck after initial cleaning shall be removed. The entire overlay system shall be applied following the cleaning and prior to opening the area to traffic.

Cleaned pavement surfaces shall not be exposed to vehicular or pedestrian traffic other than that required by the overlay operation. If the pavement is contaminated before being overlaid it shall be re-cleaned by abrasive blasting to the satisfaction of the Engineer. No additional payment will be made for re-cleaning work.

The concrete shall be dry at the time of application of the overlay.

2. All steel surfaces that will be in contact with the overlay shall be cleaned in accordance with SSPC-SP No. 10, Near-White Blast Cleaning, except that wet blasting methods shall not be allowed.

After the cleaning operation is completed there shall be no visible evidence of oil, grease, dirt, rust, loose particles, spent abrasives or other foreign material on any of the surfaces to be overlaid.

E. Application.

1. Prime Coat

Prior to applying the prime coat, the area shall be dry and shall be blown clean with oil-free compressed air. The surface temperature shall be at least 10°C.

The prime coat shall be uniformly applied to completely cover the surface to receive the polyester concrete. The rate of spread shall be approximately 2.3 ounces per square foot of deck surface or as recommended by the manufacturer. The prime coat shall be allowed to cure a minimum of 15 minutes before placing polyester concrete.

When magnesium phosphate concrete is placed prior to the deck overlay, the magnesium phosphate concrete shall be placed at least 72 hours prior to placing the prime coat.

When modified high alumina based concrete is placed prior to the deck overlay, the prime coat shall not be placed on said concrete until at least 30 minutes after final set.

2. Polyester Concrete

Test Patches

Prior to constructing the overlay, one or more trial overlays shall be placed on a previously constructed concrete base to determine initial set time and to demonstrate the effectiveness of the mixing, placing, and finishing equipment proposed as well as curing period. Each trial overlay

shall be 12' wide, at least 6' long, and the same thickness as the overlay to be constructed. Conditions during the construction of the overlay and equipment used shall be similar to those expected and to be used for the construction of the polyester concrete overlay. If the cleaning practice, materials and installation procedure are not acceptable, the Contractor must remove the failed test patches and make the necessary adjustments and test all test areas at no additional cost to the Department until satisfactory test results are obtained.

The test patch shall have a minimum bond strength of 250 psi as determined by ACI 503R-93, Appendix A to assure that the overlay adheres to the prepared surface.

All material used in the trial overlay, including the concrete test patch shall become the property of the Contractor and shall be removed (if required) and disposed of at the Contractor's expense.

The polyester concrete shall be placed within 120 minutes after the prime coat has been applied. The prime coat shall be allowed to cure a minimum of 30 minutes before placing polyester concrete.

The polyester concrete shall contain approximately 12 percent polyester resin by weight of dry aggregate; the exact percentage will be determined by the Engineer during placement to enable proper finishing and texturing of the overlay surface.

The polyester overlay shall be placed at a minimum thickness of $\frac{3}{4}$ ".

Termination edges of the overlay may require application and finishing by hand trowel due to obstructions such as a curb. All hand troweling shall be followed by broadcasting aggregate or surface texturing while the resin is still wet to provide acceptable surface friction characteristics.

Expansion joints shall be adequately isolated prior to overlaying or may be sawed within four hours after overlay placement, as approved by the Engineer. The exact time of sawing will be determined by the Engineer.

The amount of initiator used in polyester concrete shall be sufficient to produce an initial set time between 30-120 minutes during placement. The initial set time will be determined by using an initial-setting time Gillmore needle in accordance with the requirements of ASTM Designation: C 266. Accelerators or inhibitors may be required to achieve proper set times and shall be used as recommended by the resin supplier.

The resin binder shall be initiated and thoroughly blended just prior to mixing with aggregate. The polyester concrete shall be mixed a minimum of 2 minutes prior to placing.

Polyester concrete shall be placed prior to gelling and within 15 minutes following addition of initiator, whichever occurs first. Polyester concrete that is not placed within this time shall be discarded.

The surface temperature of the area to receive polyester concrete shall be the same as specified above for the prime coat, a minimum of 50°F.

The finishing and texturing equipment used shall strike off the polyester concrete to the established grade and cross section. Finishing and texturing equipment shall be fitted with vibrators and tines or other means of consolidating and texturing the polyester concrete to the required compaction.

The finish sand shall be applied by either mechanical means or hand broadcasting immediately after strike-off, before gelling occurs, at a minimum rate of 2.75 ounces per square foot.

F. Surface and Thickness Requirements. The overlay surface shall be checked at random by the Engineer immediately after it has hardened to assure that no depressions exist that will pond water. The smoothness of the polyester concrete surface will be tested with a straightedge.

The surface shall not vary more than 1/4" from the lower edge of a 12' ±0.2' long straight edge placed in any direction. Any surfaces which fail to conform the above tolerance shall be removed by grinding with an approved grinding tool.

To ensure adequate pavement friction, the completed overlay surface shall be free of any smooth or "glassy" areas such as those resulting from insufficient quantities of surface aggregate. Any such surface defects shall be repaired in the manner recommended by the manufacturer and approved by the Engineer.

Thickness of the overlay shall be checked prior to its initial set using a ruler. If the Engineer determines that the minimum thickness has not been attained, an additional layer shall be applied after the overlay hardens. This layer shall be a minimum of 1/4" and shall be applied at no additional cost to the Department.

G. Curing. Traffic and equipment shall not be permitted on the overlay for a minimum of four (4) hours following final finishing. Overlays shall be protected from moisture for not less than four (4) hours after finishing. The polyester overlay shall be allowed to reach final cure before subjecting it to traffic loads. Cure time is dependent upon the ambient and deck temperatures. Actual degree of cure and suitability of the overlay for traffic shall be as determined by the Engineer.

Method of Measurement:

The payment of the item "Thin Polymer Overlay" will be measured by square yard-inch of the placed mixture. The actual area finished and accepted will be measured, exclusive of the areas of metal expansion dams exposed.

Basis of Payment:

The payment of the item "Thin Polymer Overlay" shall be made at the contract price bid per square yard-inch for placing the polyester concrete overlay, which price and payment shall constitute full compensation for furnishing all labor, materials, tools, equipment, and necessary incidentals to complete the work involved in constructing the polyester concrete overlay, complete in place, including application of prime coat and furnishing, constructing and disposing of test patch overlays and base. The contract price bid shall also include the cost of having the polymer manufacturer's representative present as required.

8/23/10

Georgia Specifications

**DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA
SPECIAL PROVISION
P.I. NO.: MXXXXXXX
XXXX County
Section 519 – Concrete Bridge Deck Overlay**

Add the following:

Section 519—TWO-PART POLYMER BRIDGE DECK OVERLAY

519.1 General Description

This work includes preparation of the bridge deck and furnishing and placing of a two-part polymer bridge deck overlay at the location and thickness as indicated on the plans. This bridge deck overlay system consists of a minimum 3/8 inch (9.5mm) thick application to provide complete waterproofing as well as providing a non-skid surface that withstands continuous heavy traffic and extreme changes in weather conditions.

519.1.01 Definitions

A. Standard Specifications

General Provision 101 through 150.

[Section 107 – Legal Regulations and Responsibility to the Public](#)

[Section 504—Twenty-Four Hour Accelerated Strength Concrete](#)

[Section 886—Epoxy Resin Adhesives](#)

[Section 934—Rapid Setting Patching Materials for Portland Cement Concrete](#)

519.2 Materials

- A. Submittals:** Submit the bridge deck overlay materials to the Office of Materials and Research for approval. The Office of Materials and Research will grant approval based on laboratory test results and on the system's performance during a 2 year field evaluation.
- B. Pre-treatment:** Use pre-treatment only when recommended by the overlay manufacturer. Use pre-treatment consisting of a two-part hybrid polymer that is free of any fillers or volatile solvents and formulated to provide simple volumetric ratio of two components such as one to one or two to one by volume. Formulate the two-part hybrid polymer to provide a unique combination of extremely low viscosity and low surface tension coupled with an affinity for concrete and steel. Use two-part hybrid polymer pre-treatment having the following physical requirements when cured:

PHYSICAL PROPERTIES FOR CURED PRE-TREATMENT SYSTEM		
TEST	REQUIREMENTS	TEST METHOD
Compressive Strength	5,500 PSI (38MPa) min.	ASTM C 109

Tensile Strength	3,100 PSI (21MPa) min.	ASTM D 638
Tensile Elongation	30% min.	ASTM D 638
Water Adsorption	0.10% max.	ASTM D 570
Shore "D" Hardness	65 min.	ASTM D 2240
Pot Life	40-70 minutes	GDT-58
Adhesion to Concrete	100% failure in concrete	ACI-503-R (Pull Out Test)

- C. Bridge Deck Overlay:** Use a bridge deck overlay consisting of a two-part polymer that is free of any fillers or volatile solvents and formulated to provide simple volumetric mixing ratio of two components such as one to one or two to one by volume. Use a two-part polymer system formulated to provide flexibility in the system without any sacrifice of the hardness, chemical resistance or strength of the system. Do not use external or conventional plasticizers. Introduce flexibility by interaction of elastomers to chemically link in the process of curing so that the flexibility of the molecule is minimally affected during the low temperature conditions that are confronted in actual use. Use a two-part polymer overlay system having the following physical properties when cured:

PHYSICAL PROPERTIES FOR CURED TWO PART POLYMER OVERLAY SYSTEM		
TEST	REQUIREMENTS	TEST METHOD
Compressive Strength	7,000 PSI (48MPa) min.	ASTM C 109
Tensile Strength	2,500 PSI (17MPa) min.	ASTM D 638
Tensile Elongation	30% min.	ASTM D 638
Water Adsorption	0.20% max.	ASTM D 570
Shore "D" Hardness	60 min.	ASTM D 2240
Pot Life	15-40 minutes	GDT-58
Flexural Creep	0.0065" (0.17mm) in 7 days	California Method 419
Adhesion to Concrete	100% failure in concrete	ACI-503-R (Pull Out Test)

- D. Aggregate:** Use bauxite, crushed porphyry, aluminum oxide or other similarly hard durable aggregates as recommended by the manufacturer and approved by the Engineer. Use embedded exposed aggregate conforming to the following gradation.

FINE AGGREGATE GRADATION	
SIEVE SIZE	% PASSING BY WEIGHT
No. 4	100
No. 20	0 – 5
No. 200	0 – 1.0

Broadcast coarse aggregate conforming to the following gradation over the first layer of polymer, immediately prior to broadcasting fine aggregate.

COARSE AGGREGATE GRADATION	
SIZE	% PASSING BY WEIGHT
5/8"	98 - 100
1/2"	55 – 60
3/8"	12 – 14
1/4"	0 - 1

519.2.01 Delivery, Storage and Handling

Deliver all materials in their original containers, bearing the manufacturer's label, specifying date of manufacture, batch number, trade name brand, quantity and mixing ratio.

Store all materials to prevent damage from the elements and to insure the preservation of its quality and fitness for the work. Avoid contact with flame.

Inspect all stored materials, although accepted before storage, prior to their use in the work. Ensure that all stored materials meet the requirements of the Contract at the time of use.

Remove from the site of the work immediately, any material rejected because of failure to meet the required tests or rejected because of damage. Replace all removed material at no additional cost to the Department.

519.3 Construction Requirements

519.3.01 Preparation

A. Removal and Preparation of Repair Area

Sound all visual bridge deck defects of greater than 1" X 6" (25mm X 150mm) to determine the limits of the damaged areas. Strike the deck surface around the defect with a hammer, chain drag, or other similar tool to detect unsound concrete having a "flat" or "hollow" sound. Mark the limits of the defective areas on the deck by making a rectangular area 2 inches (50mm) beyond the outer limits of the unsound concrete area to serve as a guide for sawing. Mark spalled areas within less than 6 inches (150mm) of each other as one spall area.

Saw the rectangular marked areas with near vertical faces not less than one inch (25mm) in depth. Exercise extreme care not to saw or damage the reinforcing steel. Remove all unsound material within the sawed areas. Remove concrete to a minimum depth of $\frac{1}{2}$ inch (13mm) below the top mat of reinforcing steel by power chipping or hand tools. Do not use pneumatic hammers heavier than a 15 lb. class (nominal). Do not operate pneumatic hammers and chipping tools at an angle exceeding 60 degrees relative to the surface of the deck slab. Such tools may be started in the vertical position but must be immediately tilted to a 60 degree operation angle. Clean all exposed reinforcing steel of all rust, corrosion products, oil, dirt, concrete fragments, loose scale and any other coating of any character that would destroy or inhibit the bond with the patching material. Exercise utmost care not to damage or fracture the sound concrete substrate left on the bottom of the spall repair area. Do not use sharp pointed bits.

Hold "over-cutting" of the bridge deck beyond marked areas to the minimum amount possible. Thoroughly clean all "over-cutting" of "saw slurry" and other contaminants. Then repair by filling full-depth with an approved Type II epoxy adhesive as specified in Section 886. Make such repairs as soon as possible.

Just prior to placing the patching material, thoroughly clean the surfaces within the repair areas by abrasive blasting and air blasting to remove any oil, dust, dirt, slurry from saw operation, and other contaminants. Remove abrasives from the blasting operation from the bridge deck. During blasting, protect traffic in adjacent lanes.

B. Placement of Patching Material

The Contractor shall use Repair Method No. 1 or Method No. 2 as described below. For both repair methods, ensure the surface within the repair areas is dry and thoroughly cleaned of all contaminants immediately before placement. Use air compressors equipped with suitable traps capable of removing all surplus water and oil in the compressed air for cleaning repair areas. Do not use contaminated air. Use air compressors capable of delivering compressed air at a continuous pressure of 90 psi (620kPa).

Ensure the finished surface meets a surface tolerance of $\frac{1}{16}$ inch (1.6mm). Utilize such approved measures as necessary to keep the deck surface adjacent to the patching operation reasonably clean of excess grout and other materials at all times. Unless otherwise specified, complete all patching operations and open all lanes to traffic before sunset each day.

1. Repair Method No. 1 (24 Hour Accelerated Strength Concrete)

After the repair area preparation is complete, completely coat all concrete surfaces within the repair area with a film of Type II epoxy at a thickness of 10 to 20 mils (0.25 to 0.50mm).

Use concrete meeting the requirements of Section 504. Mix the concrete on site. Use a mix design and mixing method approved by the Laboratory. Deposit concrete in the repair area while the epoxy is still tacky and vibrate sufficiently to form a dense, homogeneous mass of concrete, completely filling the area of the patch. Screed the concrete to the proper grade and allow to remain undisturbed until the water sheen disappears from the surface. Then cover the concrete with wet burlap or membrane curing compound. Continue curing for a minimum of 3 hours. The Engineer may require a longer curing time to ensure sufficient strength development of the concrete prior to opening to traffic.

2. Repair Method No. 2 (Rapid Setting Patching Material)

Follow the above requirements for Repair Method No. 1. Additionally, prepare the surfaces in the repair areas in accordance with the manufacturer's written recommendations. Handle, mix, place, consolidate, screed, and cure the

patching material in accordance with the manufacturer's written instructions as approved by the Laboratory. Continue curing for at least one hour and until the section is opened to traffic.

519.3.02 Construction

- A. Surface Preparation:** Clean the bridge deck by shotblasting to remove any oil, dirt, rubber or any other potentially detrimental material such as curing compound and laitance which may prevent proper bonding and curing of the material.

The Contractor is directed to Section 107 of the Standard Specifications giving the Contractor responsibility for the work site, and requiring conformance to all federal, state, and local laws relating to pollution control and worker protection. In particular, ensure that the Contractor is familiar with and in full compliance with the provisions of the laws concerning the management of waste and worker protection.

Do not allow construction traffic on any portion of the deck that has been shotblasted or on the overlay without specific approval of the Engineer. Overlay the deck surface within 24 hours of the surface preparation operation.

Ensure all surfaces to be overlaid are dry at the time of application. Immediately before applying the overlay system, clean all prepared surfaces with compressed air (or vacuum) to remove dust and debris. Use air compressors equipped with a filter to prevent oil in the air supply. Do not apply the overlay system when rain is forecast to occur within 24 hours of application. Do not apply the overlay system unless the minimum ambient temperature is 50° and rising.

If, in the opinion of the Engineer, the surface has become soiled or contaminated prior to the application of the overlay, re-clean the surface to the satisfaction of the Engineer at no additional cost to the Department.

- B. Field Test:** Prior to commencing the overlay operation, place a test area of overlay on the bridge deck. Prepare the area for the test overlay as described above. Ensure the test is large enough so the cleaning equipment and methods to be employed in the full-scale operation can be used for the field test. Ensure the degree of cleaning used on the test area is the minimum used on the remainder of the structure. Use the application of the overlay system to the test area to establish proper procedures and techniques for applying the overlay to the full structure.

After the test area has cured for 72 hours, check adhesion in accordance with ACI 503R-1980. Test a minimum of three sample areas. Ensure no adhesion test has an adhesive strength less than 250 psi (1725kPa) and the minimum average value for the 3 tests is greater than 300 psi (2070kPa).

If the test of a sample area fails to meet the above requirements due to a cohesive failure of the concrete substrate, the adhesive strength of the sample area will be considered acceptable. Successful completion of the adhesive strength tests will be required before the full-scale overlay operation is to begin.

- C. Application:** Provide suitable coverings, such as heavy duty drop cloths, to protect all exposed areas not to be overlaid, such as curbs, railings, parapets, deck drains, locations of expansion joints that are to receive expansion joint membranes, etc. Clean or repair any damage or defacement resulting from the application, at the Contractor's expense, to the satisfaction of the Engineer.

Ensure the application of the overlay system is done by the supplier, or by a factory trained or licensed applicator, with written approval from the manufacturer of the overlay system.

Ensure each component of the two-part polymer is metered, mixed together, and distributed onto the deck by machine. Use a dispensing machine capable of ratio check verification at the pump outlets as well as cycle counting to monitor output. Ensure the in line mixing is motionless so as not to overly shear the material. Ensure the machine makes maximum use of the working time of the polymer by mixing it immediately prior to dispensing onto the deck.

Provide the number of layers and the application rates of the materials in the various layers as recommended by the manufacturer in order to achieve a minimum $\frac{3}{8}$ inch (9.5mm) and maximum $\frac{1}{2}$ inch (13mm) overlay thickness when measured from the top of the concrete substrate to the top of the polymer (not the peaks of the aggregate). Ensure the application of the overlay system is as follows:

1. **APPLICATION OF POLYMER:** After mixing of the components, evenly distribute the polymer on the clean, dry deck surface at the rate recommended by the manufacturer.

2. **APPLICATION OF AGGREGATE:** After application of each layer of polymer, allow a minimum lapse period as required by the manufacturer's instructions before broadcasting the aggregate. Ensure the method and rate of aggregate application is in accordance with the manufacturer's recommendations.
3. **CONSOLIDATION:** If required by the manufacturer, use a hand operated roller as approved by the Engineer and the manufacturer within 10 minutes of the aggregate application to evenly consolidate the aggregate into the polymer.
4. **REMOVAL OF EXCESS AGGREGATE:** After initial cure, remove excess aggregate by a power vacuum or other Engineer approved method prior to the application of subsequent layers of polymer.
5. **APPLICATION OF ADDITIONAL LAYERS:** Additional layers may be applied immediately after the initial set of the preceding layer (as determined by the Manufacturer and Engineer) and removal of all excess aggregate. The maximum time allowed between each layer shall be at the discretion of the Engineer and the Manufacturer and may vary depending on the temperature and circumstances of the project. Ensure joints are staggered and overlapped between successive layers so that no ridges will appear.
6. **TRAFFIC CONSIDERATIONS:** Traffic may be allowed on the final layer after the polymer has reached its final cure (as determined by the Manufacturer) and after removal of all excess, loose aggregate.
7. **OVERLAY SURFACE:** Ensure the finished surface consists of a uniform coat of imbedded exposed aggregate.

519.3.03 Quality Acceptance

A. Thickness Verification

Ensure the overlay is at least $\frac{3}{8}$ " (9.5mm) thick as measured from the concrete substrate to the top of the polymer at three random locations for every 1000 yd² (830 m²) of surface area. Recoat thin areas as described above and re-verify thickness at no additional cost to the Department. This verification may consist of cores, holes, etc., but in all cases repair any areas tested to destruction before final acceptance.

In thin areas that have been recoated to obtain the required minimum thickness, the Engineer may require additional adhesion strength tests in accordance with ACI 503R-29 to verify the Contractor's procedure for recoating existing overlay.

519.3.04 Contractor Warranty and Maintenance

The polymer manufacturer and the Contractor, by acceptance of the work described in this Specification, shall jointly agree to guarantee the wearing surface against all defects incurred during normal traffic use for a period of ten years. Submit this agreement in writing to the Engineer signed by both the polymer manufacturer and the Contractor. Commence the ten year period on the date of acceptance of the work. The guarantee shall cover all labor and materials required by the Department to satisfactorily repair and replace the wearing surface.

519.4 Measurement

519.4.01 Surface Preparation:

Measure the area of the deck acceptably repaired and blast cleaned prior to installation of the overlay in square yards (meters) computed from surface measurements taken to the nearest 0.1 foot (30mm). Do not measure the blast cleaning of any longitudinal or transverse construction joints or vertical surfaces for payment.

519.4.02 Polymer Overlay:

Measure the area of the deck acceptably overlaid with polymer and broadcast spread crushed aggregate in square yards (meters) computed from surface measurements taken to the nearest 0.1 foot (30mm).

519.5 Payment

519.5.01 Surface Preparation:

Surface preparation is paid for by the square yard (meter) of the deck acceptably repaired and blast cleaned prior to installation of the overlay. Payment includes all expenses associated with removal of existing concrete, repair and blast cleaning operations.

519.5.02 Polymer Overlay:

Polymer overlay is paid for by the square yard (meter) of the deck overlaid, complete in place and accepted, provided, however, that the specified minimum overlay thickness requirement is met. The individual layers necessary to attain the specified thickness will not be paid for individually. Payment includes all labor and material cost, procurement, handling, hauling and processing, coring for thickness verification, guarantee, and includes all equipment, tools, labor, and incidentals necessary to complete the work.

Payment will be made under:

Item No. 519	Surface Preparation	Per square yard (meter)
Item No. 519	Polymer Overlay	Per square yard (meter)

Item No. 519-0515 Surface Preparation per Square Yard (Meter)

Item No. 519-0530 Polymer Overlay per Square Yard (Meter)

Idaho Specifications

S501-51A EPOXY OVERLAY

Description. Prepare and apply an epoxy and aggregate overlay on the concrete bridge deck surface area between the curb faces and from the begin bridge to end bridge as shown on the plans.

Materials. Provide an epoxy resin base and hardener that is a modified Type III, two-component system that meets the requirements of ASTM C881, Grade 1, Classes B & C. Store the epoxy in accordance with the manufacturer's specifications. Ensure epoxy properties are as follows:

TABLE S501.51-1
EPOXY REQUIREMENTS

Property	Requirement	Test Method
Pot Life	≥ 15 to ≤ 45	ASTM C881, Paragraph 11.2 modified
Tensile Strength (neat)	$\geq 2,000$ psi to $\leq 5,000$ psi at 7 days	ASTM D638
Tensile Elongation (neat)	$\geq 40\%$ to $\leq 80\%$ at 7 days	ASTM D638
Viscosity	> 7 to < 25 poises	ASTM D2393, Brookfield RVT Spindle No. 3 at 20 rpm
Minimum Compressive Strength at 3 hours	1,000 psi at 75 °F	ASTM C579 modified (with plastic inserts), mixed with aggregate
Minimum Compressive Strength at 24 hours	5,000 psi at 75 °F	ASTM C579 modified (with plastic inserts)), mixed with aggregate
Minimum Adhesion Strength at 24 hours	250 psi at 75 °F	ACI 503R, Appendix A, VTM 92
Permeability to chloride ion at 28 days	100 coulombs Max	AASHTO T277

Pack materials in puncture, rupture and leak proof containers. Label each container as Part A or Part B and clearly mark the name and address of the manufacturer, name of the product, mixing proportions and instructions, lot and batch numbers, date of manufacture and quantity.

Provide aggregate that meets the properties of Tables 501.51-2 and 501.51-3. Use aggregate that is non-friable, non-polishing, and clean without surface moisture. It should have a proven record of durability in this type of application. Provide aggregate with at least one mechanically fractured face for 100% of the materials retained on the #10 sieve, thoroughly washed, and kiln dried to maximum moisture content of 0.2% by weight in accordance with ASTM C566

TABLE 501.51-2
AGGREGATE REQUIREMENTS

Soundness Loss	AASHTO T104 5 cycles in Magnesium Sulfate	8% Max
Micro-Deval	AASHTO TP58	10% Max
Mohs Scale Hardness		7 Minimum
Evaporative Moisture Content	ASTM C566	<0.2%

TABLE 501.51-3
AGGREGATE GRADATION

Sieve Size	Percent Passing
0.187 in; No. 4	100
0.078 in; No. 10	10 – 35
0.033 in; No. 20	0 – 10

Construction Requirements. Submit the name of the manufacturer of the intended epoxy overlay materials including the name and phone number of the Manufacturer's technical representative at the pre-construction meeting. At least 10 days before the overlay placement submit a certificate of compliance from an independent nationally recognized laboratory stating that the epoxy materials meet the requirements listed in Tables 501.51-1, -2, -3 and other requirements specified herein.

Ensure the epoxy overlay manufacturer's representative is on the job site at all times and who, upon consultation with the Engineer, may suspend work items that are suspect of not meeting specification requirements. Work may resume only after taking appropriate remedial action to satisfy the manufacturer's representative and the Engineer.

Plan and prosecute the work to allocate the specified minimum curing periods, or other longer curing periods prescribed by the manufacturer, before opening to public or construction traffic.

A. Equipment. For mechanical applications, provide equipment equipped with a minimum of an epoxy distribution system, aggregate spreader, application squeegee, moisture-and-oil-free compressed air and a source of lighting if work will be performed at night. Ensure the epoxy distribution system accurately blends the epoxy materials in accordance with the manufacturer's specifications and distributes epoxy at the specified application rates to cover 100% of the work area. Propel aggregate spreader to uniformly and accurately apply the aggregate.

For manual applications, provide equipment with calibrated containers for measuring epoxy volumes, a paddle- type mixer, squeegees, shovels and brooms that are suitable for mixing the epoxy and applying the epoxy and aggregate at the specified application rates.

B. Preparation of Concrete Surfaces. Repair minor potholes and delamination in the deck surface by removing the damaged concrete and patching with an Engineer approved cementitious patching material before installation of the overlay. Epoxy overlay material is an acceptable patching material. Strike off patches so they are level with the existing deck and finish with wooden floats. Portland cement concrete patches require a minimum cure period of 28 days before application of the overlay.

Before placing the overlay, thoroughly clean the entire concrete deck by steel shot blasting to ensure proper bonding between the epoxy and the concrete substrate. Achieve a final surface texture meeting the International Concrete Repair Institute's (ICRI) concrete surface profile numbers 5 through 7 as defined in ICRI Guideline No. 03732 and as shown by Surface Profile Samples available from ICRI, or ASTM E965 *Pavement Macrotexture Depth* of 0.04 inches to 0.08 inches. Shot blasting is meant to expose the coarse aggregate and ensure the surface is cleaned of asphalt material, oil, dirt, rubber, curing compounds, paint carbonation, laitance, weak surface mortar and other potentially detrimental materials, which may interfere with the bonding or curing of the overlay. Remove and repair loosely bonded patches and remove traffic marking lines. Use moisture-and-oil-free compressed air or high volume leaf blowers to remove dust that adheres to the prepared surface. Blow the surface again with moisture-and-oil-free compressed air or high volume leaf blowers.

In order to determine the adequacy of the surface preparation, perform at least one bond test per lane of each bridge. For each test, apply palm-sized patties of binder aggregate, $\frac{1}{4}$ in to $\frac{3}{8}$ in thick at three locations. After the samples have cured, remove the patties with a hammer and chisel to examine the fracture and delamination plane. Verify that concrete with fractured aggregate has attached to the entire underside of the patty. If only lattice or small particles of concrete are attached, further deck preparation is required.

- C. Overlay Application.** Handle and mix the epoxy resin and hardening agent in a safe manner to achieve the desired results in accordance with the specifications, and the manufacturer's recommendations as Engineer approved or directed. Apply epoxy overlay materials only when weather or surface conditions are such that the material can be properly handled, placed and cured within the specified requirements for project sequencing, traffic control, or when rain is imminent within the manufacturers' recommended cure times. Completely dry, with no visible moisture, the prepared surface when applying epoxy. The Engineer may allow moisture-and oil-free heat sources or torches to dry the surface. Ensure the temperature of the deck surface and epoxy and aggregate components are at least 55°F and rising at the time of application. Do not apply epoxy if the gel time is less than five minutes or if pavement temperatures exceed 115°F. In situations where road closures are not under strict time constraints, obtain Engineer's approval to apply epoxy at lower temperatures.

Apply the epoxy overlay and aggregate using a double pass method. The double pass method applies the epoxy and aggregate in two separate layers at the corresponding application rates shown in Table 501.51-4.

TABLE 501.51-4

DOUBLE PASS METHOD- EPOXY & AGGREGATE APPLICATION RATES

Double Pass Method	Epoxy Rate - gal/yd ²	Aggregate - lbs/yd ² ^a
1st course	Not less than 0.22	10
2nd course	Not less than 0.45	14.5
^a Application of aggregate shall be of sufficient quantity to completely cover the epoxy.		

Mix the epoxy at a volume ratio of 1 Part A to 1 Part B and mechanically stir with a paddle type mixer for three minutes or according to the epoxy manufacturer's recommendations. After the epoxy has been properly mixed, immediately and uniformly apply to the pavement surface with a $\frac{3}{16}$ inch to $\frac{1}{4}$ inch V-notched squeegee. Apply the aggregate to cover the epoxy material while the epoxy is still fluid. Remove and replace first course applications that do not receive enough aggregate before gelling.

Ensure each course of epoxy overlay cures before removing the excess unbonded aggregate to prevent tearing or damaging of the surface. Use moisture-and-oil-free compressed air or high volume leaf blowers, vacuum or mechanical broom to remove excess aggregate. After loose aggregate is removed, remove remaining dust using Moisture-and-oil-free compressed air or high volume leaf blowers, vacuum or mechanical broom. Obtain the Engineer's approval before opening the first course to traffic. Begin application of the second course only after removing dust. The Department prohibits traffic on the overlay until it has cured sufficiently to prevent damage from wheel loads as specified in Table 501.51-5.

TABLE 501.51-5

TYPICAL CURING TIMES

Average Temperature of Deck, Epoxy, and Aggregate Components in °F

Course	60-64	65-69	70-74	75-79	80-84	above 85 ^a
1	4 hr	3 hr	2.5 hr	2 hr	1.5 hr	1 hr
2	6.5 hr	5 hr	4 hr	3 hr	3 hr	less than 3 hrs

^a Refer to manufacturer's recommendation

Apply the second course at the rates specified in Table 501.51-4. Apply epoxy using flat-bladed squeegee. Apply the aggregate to cover the epoxy mixture before polymerization. Take special care to ensure that the wet epoxy does not coat the wear surface (top) of the aggregate. Once the epoxy is cured, remove loose aggregate from the surface by moisture-and-oil-free compressed air or high volume leaf blowers, vacuum or mechanical broom. After removing loose aggregate, if there are any areas where epoxy has coated the top surface stone, remove the excess epoxy using a light shot or sand blast.

Protect the bridge deck expansion joints with a bond breaker (e.g., duct tape) that can adequately seal the joints from the epoxy. The Contractor may also use duct tape to delineate application areas. The Department recommends taped areas or bond breakers be removed before epoxy starts to harden. The Contractor may also remove epoxy by scoring the overlay before gelling or by saw cutting after cure. Feather the overlay out at the end of bridge or approach slab and at expansion joints (edge of armor angle) per the manufacturer's recommendation.

If the Contractor's operations or actions damage or mar the overlay, remove the damaged areas and reapply the overlay to the Engineer's satisfaction. In the event that part of the epoxy mixture does not cure, completely remove the overlay from the affected area and discard. Completely remove residual epoxy remaining on the pavement by mechanical means such as steel shot or abrasive blasting or scarifying before reapplying the overlay.

Maintain and provide records for each batch provided that includes the following:

1. Number of batches mixed and volume per batch
2. Location of batches as placed on deck, referenced by stations
3. Batch time
4. Gel Time (50 ml sample)
5. Temperature of the air, deck surface, epoxy components
6. Loose aggregate removal time
7. Time open to traffic

Method of Measurement. The Engineer will measure acceptably completed work by the square foot of deck surface.

Basis of Payment. The Department will pay for accepted quantities at the contract unit price as follows:

Pay Item	Pay Unit
Epoxy Overlay	SF

Illinois Specifications

BRIDGE DECK THIN POLYMER OVERLAY

Effective: May 7, 1997

Revised: February 6, 2013

Description. This work shall consist of furnishing and applying a thin, multiple-layer polymer overlay to the bridge deck as shown on the plans. The total thickness of the overlay system shall not exceed 3/8 inch (10 mm).

This work shall also include the final surface preparation of the existing concrete deck by shotblasting after all repairs have been completed and cured as specified.

The supplier of the material shall furnish a technical representative at the job site at all times during overlay placement.

Materials. The manufacturer of the materials shall supply Material Safety Data Sheets (MSDS) detailing the appropriate safety and handling considerations. These MSDS shall be prominently displayed at the storage site and all workers shall be thoroughly familiar with safety precautions prior to handling the material.

(a) Epoxy Binder. The epoxy resin base and hardener shall be composed of a two-component, 100% solids, 100% reactive, thermosetting compound with the following properties:

Property	Requirements ^A	Test Method
Viscosity (Poises)	7 – 35	ASTM D 2393, Brookfield RVT, Spindle No. 3, 20 rpm
Gel Time (Minutes)	15 – 45	ASTM C 881, Paragraph 11.2, Modified ^B
7-day Tensile Strength In psi (kPa)	1,100 – 5,000 (7,600 – 34,500)	ASTM D 638
7-day Elongation (%)	20 – 80	ASTM D 638
7-day Max. Absorption (%)	1.5	ASTM D 570
Shore D Hardness	58 – 75	ASTM D 2240-86
28-day Max. Chloride Permeability (Coulombs)	100	AASHTO T 277
Infrared Spectrum	^C	AASHTO T 237, Paragraphs 4 and 5

^ABased on specimens or samples cured or aged and tested at 75°F

^BUse a 70 ml sample instead of a 60 gram sample.

^CTo be established for each component by each manufacturer.

- (b) Aggregate. The aggregate shall contain less than 0.2 percent moisture and be clean and free of dust. The aggregate shall have a Mohs scale hardness greater than 6 and shall consist of bauxite, crushed porphyry, aluminum oxide, or other similarly hard, durable, angular shaped aggregate, as recommended by the manufacturer and approved by the Engineer. Wet bottom boiler coal slag shall not be used.

The aggregate shall conform to the following gradation:

Sieve Size	% Passing by Weight
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	30 – 75
No. 16 (1.18 mm)	0 – 5
No. 30 (0.60 mm)	0 – 1

- (c) Polymer Overlay System. The polymer overlay system shall have the following properties:

Property	Requirements ^A	Test Method
Minimum Compressive Strength at 8 Hrs. psi (kPa)	1,000 (6,900)	ASTM C 579 Method B, Modified ^B
Minimum Compressive Strength at 48 Hrs. psi (kPa)	5,000 (34,500)	Same as Above
Thermal Compatibility	No Delaminations	ASTM C 884
Minimum Pull-off Strength at 24 Hours psi (kPa)	250 (1,700)	ACI 503R, Appendix A

^ABased on specimens or samples cured or aged and tested at 75°F

^BPlastic inserts that will provide 2 inch by 2 inch (51 mm by 51 mm) cubes shall be placed in the oversized brass molds.

At the pre-construction conference, the Contractor shall provide the Engineer with the source of the material that will be used. The manufacturer shall furnish samples of resin material and aggregate as required by the Engineer.

The Department will maintain an Approved List of Bridge Deck Thin Polymer Overlay Systems, and independent laboratory test results showing the product meets the Department specifications will be required.

Equipment. The equipment used shall be subject to the approval of the Engineer and shall meet the following requirements:

(a) Surface Preparation Equipment. Surface preparation equipment shall be according to the applicable portions of Section 1100 and the following:

- (1) Mechanical Scarifying Equipment. Scarifying equipment shall be a power-operated, mechanical scarifier capable of uniformly scarifying or removing the existing concrete surface and new patches to the depths required in a satisfactory manner. Other types of removal devices may be used if their operation is suitable and they can be demonstrated to the satisfaction of the Engineer.
- (2) Shotblasting Equipment. The blasting medium shall be steel shot. The size and hardness of the shot, the flow of the shot, the forward speed, and the number of passes shall be as recommended by the manufacturer. The shotblasting equipment shall be capable of removing weak concrete at the surface, including the microfractured concrete surface layer remaining as a result of mechanical scarification, and shall have oil traps. The cleaning residue shall be contained and removed by the shotblasting equipment.
- (3) Hand-Held Blast Cleaning Equipment. Blast cleaning using hand-held equipment shall be performed by abrasive blasting. Hand-held blast cleaning equipment shall have oil traps.
- (4) Power-Driven Hand Tools. Power driven hand tools will be permitted. Jackhammers shall be lighter than the nominal 45 pound (20 kg) class. Jackhammers or chipping hammers shall not be operated at angles in excess of 45 degrees, measured from the surface of the slab.

(b) Pull-off Test Equipment. Equipment used to perform pull-off testing shall be either approved by the Engineer, or obtained from one of the following approved sources:

James Equipment
007 Bond Tester
800-426-6500

Germann Instruments, Inc.
BOND-TEST Pull-off System
847-329-9999

SDS Company
DYNA Pull-off Tester
805-238-3229

Pull-off test equipment shall include all miscellaneous equipment and materials to perform the test and clean the equipment, as indicated in the Illinois Pull-off Test (Surface or Overlay Method). Prior to the start of testing, the Contractor shall submit to the Engineer a technical

data sheet and material safety data sheet for the epoxy used to perform the testing. For solvents used to clean the equipment, a material safety data sheet shall be submitted.

- (c) **Overlay Application Equipment.** For mechanical applications, the equipment shall consist of an epoxy distribution system, aggregate dispersing equipment, sweeper broom or vacuum truck, and a source of lighting if work is to be performed at night. The epoxy distribution system shall thoroughly blend the epoxy components so that the resulting product has the same material properties as certified in the Materials section. The Engineer reserves the right to sample from the epoxy distribution system at any time during placement operations. The aggregate spreader shall be propelled in such a manner as to uniformly apply the aggregate so that 100 percent of the epoxy material is covered to excess. The sweeper broom or vacuum truck shall be self-propelled. Equipment shall provide compressed air that is free from oil and water.

For hand applications, the equipment shall consist of calibrated containers, a paddle-type mixer, squeegees or rollers, and a broom. All equipment shall be suitable for mixing and placement according to the epoxy manufacturer's recommendations.

Construction. All hot-mix asphalt removal and deck repairs shall be performed and cured according to the Special Provision for "Deck Slab Repair" prior to any surface preparation operations. The thin polymer overlay shall not be placed on any concrete surface that is less than 28 days old.

(a) **Surface Preparation.**

- (1) **Bridge Deck Scarification.** When specified, concrete bridge deck scarification shall be performed to the depth noted on the plans. Sidewalks, curbs, drains, reinforcement, and/or existing transverse and longitudinal joints that are to remain in place shall be protected from damage during scarification and cleaning operations. All damage caused by the Contractor shall be corrected at the Contractor's expense, to the satisfaction of the Engineer.

The scarification work shall consist of removing the designated concrete deck surface using mechanical scarifying equipment. In areas of the deck that are not accessible to the scarifying equipment, power-driven hand tools will be permitted.

A trial section located on the existing deck surface will be designated by the Engineer. The Contractor shall demonstrate that the equipment, personnel, and methods of operation are capable of producing results that are satisfactory to the Engineer. The trial section will consist of an area of approximately 30 sq. ft. (3 sq m).

Once the settings are established, they shall not be changed without the permission of the Engineer. The removal shall be verified, as necessary, at least every 16 ft. (5 m) along the cutting path. If concrete is being removed below the desired depth, the equipment shall be reset or recalibrated.

All areas designated to be scarified shall be scarified uniformly to the depth as specified on the plans, but shall not exceed 1 in. (25 mm). Concrete removal below the specified depth shall be replaced at the Contractor's expense, to the satisfaction of the Engineer.

- (2) Deck Patching. After bridge deck scarification, the deck shall be thoroughly cleaned of broken concrete and other debris. The Engineer will sound the scarified deck and all unsound areas will be marked for removal and repairs. All designated patching shall be completed according to the Special Provision for "Deck Slab Repair."

Patching shall be completed prior to final surface preparation. Patches shall be struck off and then roughened with a suitable stiff bristled broom or wire brush to provide a rough texture design to promote bonding to the overlay. Hand finishing of the patch surface shall be kept to a minimum to prevent overworking of the surface.

- (3) Final Surface Preparation. Final surface preparation shall consist of the operation of shotblasting equipment to remove any weak concrete at the surface, including the microfractured concrete surface layer remaining as a result of mechanical scarification. Any areas determined by the Engineer to be inaccessible to the shotblasting equipment shall be thoroughly blast cleaned with hand-held equipment.

Final surface preparation shall also include the cleaning of all dust, debris, and concrete fines from the deck surface including vertical faces of curbs and barrier walls up to a height of 1 in. (25 mm) above the overlay. Compressed air shall be used for this operation. When using compressed air, the air stream must be free of oil. Any grease, oil, or other foreign matter that rests on or has absorbed into the concrete shall be removed completely.

After the final surface preparation has been completed and before placement of the overlay, the prepared deck surface will be tested by the Engineer according to the Illinois Pull-off Test (Surface Method). The Contractor shall provide the test equipment.

- a. Start-up Testing. Prior to the first overlay placement, the Engineer will evaluate the shotblasting method. The start-up area shall be a minimum of 600 sq. ft. (56 sq. m). After the area has been prepared, six random test locations will be determined by the Engineer, and tested according to the Illinois Pull-off Test (Surface Method).

The average of the six tests shall be a minimum of 175 psi (1,200 kPa) and each individual test shall have a minimum strength of 160 psi (1,100 kPa). If the criteria are not met, the Contractor shall adjust the shotblasting method. Start-up testing will be repeated until satisfactory results are attained.

Once an acceptable shotblasting procedure (speed, size of shot, etc.) is established, it shall be continued for the balance of the work. The Contractor may, with permission of the Engineer, change the shotblasting procedure or equipment, in which case additional start-up testing will be required.

- b. Lot Testing. After start-up testing has been completed, the following testing frequency will be used. For each structure, each stage will be divided into lots of not more than 4500 sq. ft. (420 sq m). Three random test locations will be determined by the Engineer, and tested according to the Illinois Pull-off Test (Surface Method).

The average of the three tests shall be a minimum of 175 psi (1,200 kPa) and each individual test shall have a minimum strength of 160 psi (1,100 kPa). In the case of a failing individual test or a failing average of three tests, the Engineer will determine the area that requires additional surface preparation by the Contractor. Additional test locations will be determined by the Engineer.

In addition to start-up and lot testing, the Department may require surface pull-off testing of areas inaccessible to shotblasting equipment and blast cleaned with hand-held equipment. The Engineer will determine each test location, and each individual test shall have a minimum strength of 175 psi (1,200 kPa).

(b) Application of Overlay

- (1) Overlay Placement. The handling and mixing of the epoxy resin and hardening agent shall be performed in a safe manner to achieve the desired results according to the manufacturer's written recommendations. Overlay materials shall not be placed when ambient air temperatures are below 55°F (13°C) or above 90°F (32°C), or when deck temperature is below 60°F (16°C). All components shall have a temperature no less than 60°F (16°C) immediately before mixing and placement. Overlay materials shall not be placed when rain is forecast within 24 hours of application.

There shall be no visible moisture present on the surface of the concrete at the time of application of the thin polymer overlay. A plastic sheet left taped in place for a minimum of two hours, according to ASTM D 4263, shall be used to identify moisture in the deck.

Construction traffic shall not be allowed on any portion of the deck that has been shotblasted or on the overlay without approval from the Engineer. Overlay placement shall begin as soon as possible after the surface preparation operation. In no case shall the time between surface preparation and application of the first lift exceed 24 hours.

The polymer overlay shall consist of a two-course application of epoxy and aggregate. Each of the two courses shall consist of a layer of epoxy covered with a layer of aggregate in sufficient quantity to completely cover the epoxy. The total thickness of the overlay shall not be less than 1/4 inch (6 mm). The dry aggregate shall be applied in such a manner as to cover the epoxy mixture completely within five minutes of application. The dry aggregate shall be sprinkled or dropped vertically in a manner such that the level of the epoxy mixture is not disturbed. First course applications that do not receive enough aggregate prior to gel shall be removed and replaced. A second course applied with insufficient aggregate may be left in place, but will require additional applications before opening to traffic.

The preceding course of thin polymer overlay shall be cured until brooming or vacuuming can be performed without tearing or otherwise damaging the surface prior to application of succeeding courses. No traffic or equipment shall be permitted on the overlay surface during the curing period.

After the curing period, all loose aggregate shall be removed by brooming or vacuuming before the next overlay course is applied. This procedure is repeated until the minimum overlay thickness is achieved.

Unless otherwise specified, the thin polymer overlay courses may be applied over the expansion joints and joint seals of the bridge deck. The expansion joints and joint seals shall be protected by a bond breaker. Prior to opening any application to traffic, the overlay over each joint shall be removed.

Before opening to traffic, at least one pull-off test location per lane, per 100 feet (30 m) of bridge length will be designated by the Engineer. Pull-off testing shall be performed according to the Illinois Pull-off Test (Overlay Method). The Contractor shall provide the test equipment. Each individual test shall have a minimum strength of 150 psi (1,000 kPa). Unacceptable test results will require removal and replacement of the overlay at the Contractor's expense, and the locations will be determined by the Engineer.

The thickness of the overlay shall be verified to be at least 1/4 inch (6 mm) thick, as measured from the deck surface to the top of the resin. Cores from pull-off tests shall be used to determine overlay thickness. Thin areas shall be re-coated and re-tested at no additional cost to the Department.

If additional applications are required due to deficient thickness or insufficient aggregate, the Engineer may require additional pull-off strength tests to verify the Contractor's procedures.

Pull-off test locations, thickness test locations, and any debonded areas shall be repaired before final acceptance.

- (2) Curing. The Contractor shall plan and prosecute the work so as to provide at least eight hours of curing or the minimum cure as prescribed by the manufacturer prior to opening that section to public or construction traffic.
- (3) Storage and Handling. Resin materials shall be stored in their original containers inside a heated warehouse in a dry area. Storage temperatures shall be maintained between 60 – 90°F (16 – 32°C)

The resin material shall be stored on the job site in a trailer, protected from moisture, and maintained within a temperature range of 60 – 90°F (16 – 32°C).

Protective gloves and goggles shall be provided by the Contractor to workers that are directly exposed to the resin material. Product Safety Data Sheets from the manufacturer shall be provided for all workers by the Contractor.

All aggregates shall be stored in a dry environment and shall be protected from contaminants on the job site. Aggregate that is exposed to rain or other moisture shall be rejected.

Method of Measurement. The area of scarification on the bridge deck will be measured for payment in square yards (square meters).

The area of thin polymer overlay will be measured in square yards (square meters) of horizontal deck area, completed and accepted.

Basis of Payment. This work shall be paid for at the contract unit price per square yard (square meter) for BRIDGE DECK THIN POLYMER OVERLAY of the thickness specified.

The concrete bridge deck scarification will be paid for at the contract unit price per square yard (square meter) for CONCRETE BRIDGE DECK SCARIFICATION of the thickness specified.

Iowa Specifications



Iowa Department of Transportation

SPECIAL PROVISIONS FOR MULTI-LAYER POLYMER CONCRETE OVERLAY

Johnson County
IMN-080-6(311)242--0E-52

Effective Date
January 16, 2013

THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

120012.01 DESCRIPTION.

Prepare the surface of the existing reinforced concrete bridge deck, and construct a multi-layer polymer concrete overlay for bridge preservation.

120012.02 MATERIALS.

A. Epoxy.

1. Provide an AASHTO M 325 Type III, Grade 1 or 2, 100% solids, thermosetting, moisture-insensitive epoxy with the following additional requirements of Table 120012.02-1:

Table 120012.02-1: Epoxy Requirements

Property	Requirement	Test Method
Viscosity	7-25 poises	ASTM D 2393, Brookfield RVT, Spindle no. 3 at 20 RPM
Gel Time	14-45 minutes	ASTM C 881, para. 11.2.1 modified, 50 to 100 ml sample
Compressive Strength*, 3 hr.	1000 psi min.	ASTM C 109, w/ plastic inserts
Compressive Strength*, 24 hr.	5000 psi min.	ASTM C 109, w/ plastic inserts
Tensile Strength, 7 day	2000-5000 psi	ASTM D 638
Elongation, 7 days	30-70 percent	ASTM D 638
Adhesive Strength, 24 hr.	250 psi min.	ACI 503R, Appendix A

*Mixed with aggregate

2. The epoxy formulation supplied must have a minimum application history of 3 years in a state or states in the northern half of the U.S. Include a list of bridges on which the material has been applied, the name of the owner agency and a contact at the owner agency for each structure submitted. Provide independent laboratory reports documenting that the epoxy binder meets the requirements of this section.
3. Provide the Engineer with a copy of the epoxy materials manufacturer's installation recommendations.

B. Aggregate.

1. Provide singly crushed aggregate that is free of dirt, clay and foreign or organic material and meets the requirements of Table 120012.02-2 and Table 120012.02-3.

Table 120012.02-2: Aggregate Requirements

Property	Requirement	Test Method
Sodium Sulfate Soundness, Max loss	0.12	AASHTO T104
Wear, Maximum	30%	AASHTO T96
Acid Insoluble Residue, Minimum	55%	ASTM D 3042
Fine Aggregate Angularity, Minimum	45%	AASHTO T304
Moisture Content, Maximum	0.20%	IM 381

Table 120012.02-3: Gradation Requirements for Aggregates (Percent Passing)

3/8"	No. 4	No. 8	No. 16	No. 30
100	100	75-30	5-0	0

120012.03 CONSTRUCTION.

This procedure may involve hazardous materials, operations and equipment.

A. Contractor Qualifications.

The contractor shall have at least 3 years experience applying multi-layer polymer concrete overlays. Submit a list of projects with owner contact information for multi-layer polymer concrete overlay projects placed within the past 3 years.

B. Equipment.

Equipment is subject to approval of the Engineer and must comply with these requirements:

1. General.

Provide an overall combination of labor and equipment with the capability of proportioning and mixing the epoxy components, and placing the epoxy and aggregate in accordance with this specification and the manufacturer's recommendations.

2. Surface Preparation Equipment.

- a. Shot-blasting equipment capable of removing all loose disintegrated concrete, dirt, paint, oil, asphalt, laitance carbonation and curing materials from the deck surface.
- b. Sandblasting equipment capable of removing all oxidation, dirt, paint, oil and asphalt from the metal expansion joints.

3. Mechanical Application Equipment.

Use the following equipment.

- a. An epoxy distribution system capable of accurate and complete mixing of the epoxy resin and hardening agent, verification of the mix ratio and uniform and accurate distribution of the epoxy materials at the specified rate on 100% of the work area;

- b. A mechanical aggregate spreader capable of uniform and accurate application of the dry aggregate over 100% of the work area;
 - c. An air compressor capable of producing a sufficient amount of oil free and moisture free compressed air to remove all dust and loose material; and
 - d. Adequate additional hand tools to facilitate the placement of the surface treatment according to this specification and the manufacturer's recommendations.
4. Do not use power driven tools heavier than a 15 pound chipping hammer, during deck preparation.

C. Proportioning.

- 1. Proportion all epoxy materials according to the manufacturer's recommendations.
- 2. Follow all manufacturer suggested safety precautions while mixing and handling epoxy components.

D. Preparation of Surface.

- 1. Before preparation of the surface remove deteriorated concrete and repair the area with suitable patch material, as per the Developmental Specifications for Partial Depth Bridge Patching. Portland cement concrete patches require a minimum cure period of 28 days before application of the overlay.
- 2. As the final preparation for the placement of the surface treatment, make a complete cleanup by shot blasting and/or other approved means, followed by an air blast with dry, oil free air or vacuum. Brooming is not acceptable. Remove all loose disintegrated concrete, dirt, paint, oil, asphalt, laitance carbonation and curing materials from patches and other foreign material from the surface of the deck.
- 3. Produce a surface relief equal to the International Concrete Repair Institute (ICRI) Surface Preparation Level 6 or 7 or ASTM E 965 Pavement Macrotexture Depth of 0.04 to 0.08 inch. The following Tensile Rupture test will determine if additional surface preparation is necessary. Tensile Rupture tests shall be performed by the Contractor and observed by the Engineer.
 - a. Place a polymer concrete test patch a minimum of 0.5 square yards for each bridge deck surface or every 300 square yards of prepared deck surface, whichever is smaller. The test patch shall be full depth, placed by the normal construction sequence. The Engineer may waive the test patch and permit the Tensile Rupture tests to be performed on the finished surface at a location near the bridge rail. After testing, the Contractor will be required to fill the test locations with epoxy and aggregate.
 - b. Final acceptance will be based on the following results of the test outlined in ACI 503R Appendix A:
 - Minimum Tensile Rupture Strength of 250 psi from an average of three tests on a test patch regardless of depth of failure; or
 - Failure in the concrete at a depth greater than or equal to 1/4 inch over more than 50% of the test area for three of the four tests in the test patch.
 - c. If failure in the concrete is at a depth less than 1/4 inch and the Minimum Tensile Rupture Strength is less than 250 psi, or the failure in the concrete is less than 50% of the test area, additional surface preparation is necessary.
 - d. A failure in the concrete below 250 psi and greater than 1/4 inch deep indicates weak concrete, not poor polymer concrete bond.
 - e. Do not perform tensile adhesion tests when temperatures are above 85°F.

4. Remove any contamination of the prepared deck surface or surface of subsequent courses. Sand blast or bush hammer contaminated areas to produce an acceptable surface for placement of the surface treatment.
5. Protect any areas of the bridge deck that are not to be treated from the shot blast.
6. Close deck drains so the epoxy and aggregate shall not pass through the drains.
7. Rain will not necessarily contaminate the surface. However, care must be taken so no contamination occurs.
8. Visible moisture on the prepared deck at the time of placing the surface treatment is unacceptable. Identify moisture in the deck by taping a plastic sheet to the deck for a minimum of 2 hours (ASTM D 4263). Moisture tests shall be performed by the Contractor and Observed by the Engineer.
9. Place the surface treatment within 24 hours of preparing the deck surface. Deck surfaces exposed for more than 24 hours must be sand blasted prior to application of the surface treatment.
10. The use of scarifiers, scrubbers or milling machines will not be allowed unless approved by the Engineer.
11. Wet sand blasting shall not be allowed.
12. Sandblast expansion joints prior to placing surface treatment. Mask off all gaps in expansion joints to prevent epoxy and aggregate from collecting in joints.

E. Placing the Polymer Concrete Overlay.

1. Place the polymer concrete overlay to the grades, thickness and cross sections as shown in the contract documents. Provide a technical representative of the epoxy manufacturer on the job site during the placement of the surface treatment. The representative is to provide technical expertise to the Contractor and the Engineer regarding safe handling, placement and curing of the surface treatment.
2. Follow all manufacturer suggested safety precautions while mixing and handling epoxy components. Place the overlay in two separate courses at the application rates shown in table 120012.03-1.

Table 120012X.03-1: Polymer Concrete Overlay Application Rates

Course	Epoxy Rate	Aggregate Rate*
1	Not less than 0.22 gal./sq yd	10 lbs./sq yd
2	Not less than 0.45 gal./sq yd	14.5 lbs./sq yd

*Apply enough aggregate to completely cover the epoxy

3. Use notched squeegees or mechanical application equipment to place the prepared epoxy on the deck immediately and uniformly at the prescribed rate. If mechanical application equipment is used, take 2 ounce samples for each 100 gallons of material placed to verify mix ratios and curing times. Place samples on the bridge rail or deck and note time to cure.
4. Use a paintbrush or roller to apply the epoxy on the face of curbs to the top of the curb. On bridges with continuous concrete barrier rails apply the epoxy to the first break in the

- geometry of the barrier to a minimum height of 6 inches above the deck. Apply the epoxy to the curb or barrier as each of the overlay applications are performed.
5. The bridge deck and all epoxy and aggregate components must be a minimum of 60°F at the time of application.
 6. Apply the dry aggregate to cover the epoxy completely within 10 minutes of application. Remove and replace any first course areas that do not receive enough aggregate before gelling of the epoxy occurs.
 7. Vacuum or broom excess aggregate from the first course after sufficiently cured. If damage or tearing occurs stop brooming or vacuuming.
 8. Do not open the first course to traffic.
 9. Place the epoxy and aggregate for the second course at the prescribed rate and in the same manner as the first course. Second course areas that do not receive enough aggregate before gelling of the epoxy may be re-coated with epoxy and aggregate.
 10. Locate any longitudinal joints along lane lines, or as approved by the Engineer. Keep the joints clear of wheel paths as much as practical.
 11. Produce and place the overlay within the specified limits in a continuous and uniform operation.
 12. Correct surface variations exceeding 1/4 inch in 10 feet unless directed otherwise by the Engineer.
 13. Tape all construction joints to provide a clean straight edge for adjacent polymer concrete placement. This includes joints between previously placed polymer overlay materials and at centerline.
 14. Finish the exposed edges at the ends of the bridge and at expansion joints to minimize bridge deck roughness.
 15. Apply a bond breaker to all expansion joints.
 16. Remove masking material from expansion joints as soon as practical after aggregate application to ensure binder does not harden and bond the masking material to the joints.

F. Curing.

1. Minimum curing times are noted in Table 120012.03-2.

Table 120012.3-2: Polymer Concrete Overlay Cure Times

Course	Average Temperature of Overlay Components, degrees F						
	55-59	60-64	65-69	70-74	75-79	80-85	85+
	Minimum Cure Time (hours)						
1	5	4	3	2.5	2	1.5	1
2	6.5	6.5	5	4	3	3	3

2. Cure the second course for 8 hours if the air temperature falls below 55°F during the curing period.
3. Plan and perform the work in such a way as to provide for the minimum curing times as specified in this specification or as specified by the material manufacturer.

G. Weather Limitations.

1. Do not place the polymer concrete prior to April 1 or after September 30. The polymer concrete may be placed outside of the allowable dates with approval of the Engineer and the material supplier.
2. Do not place the overlay when conditions are such that the deck temperature will exceed 100°F.
3. Do not place the overlay if conditions are such that gel time is less than 10 minutes.
4. Do not place the overlay if the air temperature is expected to drop below 55°F within 8 hours of placement.

H. Correction of Unbonded or Damaged Areas.

Repair areas discovered to be unbonded (by tapping or chaining) and areas of the overlay damaged by the Contractor's operation. Saw cut the unbonded or damaged areas to the top of the deck surface, remove the overlay with small air tools (15 pounds maximum) or shotblasting. Shotblast the concrete bridge deck surface at the unbonded area to remove contaminants, and replace the overlay according to these specifications at no additional compensation.

120012.04 METHOD OF MEASUREMENT.

The Engineer will measure the area of Multi-Layer Polymer Concrete Overlay placed in square yards.

120012.05 BASIS OF PAYMENT.

Payment for Multi-Layer Polymer Concrete Overlay will be at the contract unit price per square yard. Payment is full compensation for the specified work, including preparation of the bridge surface (including expansion joints), furnishing and applying the epoxy, furnishing and applying the aggregate, and any corrective action required.

Kansas Specifications

729 - MULTI-LAYER POLYMER CONCRETE OVERLAY

SECTION 729

MULTI-LAYER POLYMER CONCRETE OVERLAY

729.1 DESCRIPTION

Prepare the surface of the existing reinforced concrete bridge deck, and construct a multi-layer polymer concrete overlay (overlay).

BID ITEM

Multi-Layer Polymer Concrete Overlay

UNITS

Square Yard

729.2 MATERIALS

a. Epoxy. Provide a Type III overlay epoxy as defined in **SECTION 1705**.

The epoxy supplied must have a minimum application history of 3 years in the State of Kansas. Include a list of bridges in Kansas on which the material has been applied, the name of the owner agency and a contact at the owner agency for each structure submitted.

b. Aggregate. Provide aggregates meeting **SECTION 1102**.

729.3 CONSTRUCTION REQUIREMENTS

This procedure may involve hazardous materials, operations and equipment.

a. Equipment. Equipment is subject to approval of the Engineer and must comply with these requirements:

(1) Surface Preparation Equipment. Shot-blasting equipment capable of producing a surface relief equal to the International Concrete Repair Institute (ICRI) Surface Preparation Level 6 to 7 or ASTM E 965 Pavement Macrotexture Depth of 0.04 to 0.08 inch. Final acceptance is based on testing procedures as outlined in KT-70, Part V.

(2) Mechanical Application Equipment. Use the following equipment.

- An epoxy distribution system capable of accurate and complete mixing of the epoxy resin and hardening agent, verification of the mix ratio and uniform and accurate distribution of the epoxy materials at the specified rate on 100% of the work area;
- A self propelled aggregate spreader capable of uniform and accurate application of the dry aggregate over 100% of the work area;
- An air compressor capable of producing a sufficient amount of oil free and moisture free compressed air to remove all dust and loose material; and
- Adequate additional hand tools to facilitate the placement of the overlay according to this specification and the manufacturer's recommendations.

(3) Hand Application Equipment. Use the following equipment.

- Calibrated containers for accurate measurement of epoxy components;
- A paddle type or other mixing device capable of accurate and complete mixing of the epoxy resin and hardening agent;
- Notched squeegees and brooms capable of spreading the epoxy material according to this specification and the manufacturer's recommendations;
- An aggregate spreader capable of uniform and accurate application of the dry aggregate; and
- Adequate additional hand tools to facilitate the placement of the overlay according to this specification and the manufacturer's recommendations.

(4) General. Provide an overall combination of labor and equipment with the capability of proportioning and mixing the epoxy components, and placing the epoxy and aggregate in accordance with this specification and the manufacturer's recommendations.

(5) Provide the Engineer with a copy of the epoxy materials manufacturer's recommendations.

729 - MULTI-LAYER POLYMER CONCRETE OVERLAY

(6) Do not use power driven tools heavier than a 15 pound chipping hammer, during deck preparation.

b. Proportioning. Proportion all epoxy materials according to the manufacturer's recommendations.

c. Preparation of Surface.

(1) Before preparation of the surface remove deteriorated concrete and repair the area with suitable patch material. Polymer concrete bridge deck material is acceptable. Strike off patches so they are level with the existing deck and finish with wooden floats.

Portland cement concrete patches require a minimum cure period of 28 days before application of the overlay.

(2) As the final preparation for the placement of the overlay, make a complete cleanup by shot blasting and/or other approved means, followed by an air blast with dry, oil free air or vacuum. Brooming is not acceptable. Remove all loose disintegrated concrete, dirt, paint, oil, asphalt, laitance carbonation and curing materials from patches and other foreign material from the surface of the deck.

(3) Produce a surface relief equal to the International Concrete Repair Institute (ICRI) Surface Preparation Level 6 to 7 or ASTM E 965 Pavement Macrotexture Depth of 0.04 to 0.08 inch. The following test will determine if additional surface preparation is necessary.

(a) Place a polymer concrete test patch a minimum of 0.5 square yards for each span or every 300 square yards of prepared deck surface, whichever is smaller. The test patch shall be full depth, placed by the normal construction sequence.

(b) Final acceptance will be based on the following results of the test outlined in KT-70, Part V:

- Minimum Tensile Rupture Strength of 250 psi from an average of 3 tests on a test patch regardless of depth of failure (See KT-70); or
- Failure in the concrete at a depth greater than or equal to 1/4 inch over more than 50% of the test area for 3 of the 4 tests in the test patch.

(c) If failure in the concrete is at a depth less than 1/4 inch and the Minimum Tensile Rupture Strength is less than 250 psi, or the failure in the concrete is less than 50% of the test area, additional surface preparation is necessary.

(d) A failure in the concrete below 250 psi and greater than 1/4 inch deep indicates weak concrete, not poor overlay bond.

(e) Do not perform tensile adhesion tests when temperatures are above 85°F.

(4) Remove any contamination of the prepared deck surface or surface of subsequent courses. Sand blast or bush hammer contaminated areas to produce an acceptable surface for placement of the overlay.

(5) Protect metal deck drains and areas of the curb or railing above the proposed surface from the shot blast.

(6) Close deck drains so the epoxy and aggregate shall not pass through the drains.

(7) Rain will not necessarily contaminate the surface. However, care must be taken so no contamination occurs.

(8) Visible moisture on the prepared deck at the time of placing the overlay is unacceptable. Identify moisture in the deck by taping a plastic sheet to the deck for a minimum of 2 hours (ASTM D 4263).

(9) Place the first course within 24 hours of preparing the deck surface. Deck surfaces exposed for more than 24 hours must be sand blasted prior to application of the overlay.

(10) The Engineer must approve the use of scarifiers, scrubbers or milling machines.

(11) Wet sand blasting shall not be allowed.

d. Placing the Polymer Concrete Overlay. Place the wearing course to the grades, thickness and cross-sections as shown in the Contract Documents. Provide a technical representative of the epoxy manufacturer on the job site during the placement of both courses of the overlay at no additional cost to KDOT. The representative is to provide technical expertise to the Contractor and the Engineer regarding safe handling, placement and curing of the overlay.

Follow all manufacturer suggested safety precautions while mixing and handling epoxy components.

Place the overlay in 2 separate courses at application rates shown in **TABLE 729-1**.

729 - MULTI-LAYER POLYMER CONCRETE OVERLAY

TABLE 729-1: POLYMER CONCRETE OVERLAY APPLICATION RATES

Course	Epoxy Rate	Aggregate Rate *
1	Not Less Than 0.22 gal./sq yd	10 lbs./sq yd
2	Not Less Than 0.45 gal./sq yd	14.5 lbs./sq yd

*Apply enough aggregate to completely cover the epoxy.

Use notched squeegees or mechanical application equipment to place the prepared epoxy on the deck immediately and uniformly at the prescribed rate.

If mechanical application equipment is used, take 2 ounce samples for each 100 gallons of material placed to verify mix ratios and curing times. Place samples on the bridge rail or deck and note time to cure.

Use a paintbrush or roller to apply the epoxy on the face of curbs to the top of the curb. On bridges with continuous concrete barrier rails apply the epoxy to the first break in the geometry of the barrier to a minimum height of 6 inches above the deck.

Apply epoxy to the curb or barrier as each of the overlay applications are performed.

The bridge deck and all epoxy and aggregate components must be a minimum of 60°F at the time of application.

Apply the dry aggregate to cover the epoxy completely within 10 minutes of application.

Remove and replace any first course areas that do not receive enough aggregate before gelling of the epoxy occurs.

Vacuum or broom excess aggregate from the first course after sufficiently cured. If damage or tearing occurs, stop brooming or vacuuming.

Do not open the first course to traffic.

Place the epoxy and aggregate for the second course at the prescribed rate and in the same manner as the first course.

Second course areas that do not receive enough aggregate before gelling of the epoxy may be re-coated with epoxy and aggregate.

Locate any longitudinal joints along lane lines, or as approved by the Engineer. Keep the joints clear of wheel paths as much as practical.

Produce and place the overlay within the specified limits in a continuous and uniform operation.

Correct surface variations exceeding 1/8 inch in 10 feet unless directed otherwise by the Engineer.

Tape all construction joints to provide a clean straight edge for adjacent polymer concrete placement. This includes joints between previously placed polymer overlay materials and at centerline.

Finish the exposed edges at the ends of the bridge and at expansion joints to minimize bridge deck roughness.

Apply a bond breaker to all expansion joints.

e. Curing. Minimum curing times are noted in **TABLE 729-2**.

TABLE 729-2: POLYMER CONCRETE OVERLAY CURE TIMES

Course	Average Temperature of Overlay Components, °F						
	55-59	60-64	65-69	70-74	75-79	80-85	85+
	Minimum Cure Time (hours)						
1	5	4	3	2.5	2	1.5	1
2	6½	6.5	5	4	3	3	3

Cure the second course for 8 hours if the air temperature falls below 55°F during the curing period.

Plan and perform the work in such a way as to provide for the minimum curing times specified in this specification or as specified by the material manufacturer.

f. Weather Limitations. Do not place polymer concrete prior to April 1 or after September 30. The polymer concrete may be placed outside of the allowable dates with approval of the Engineer and the material supplier.

Do not place the overlay when conditions are such that the deck temperature will exceed 100°F.

Do not place the overlay if conditions are such that gel time is less than 10 minutes.

729 - MULTI-LAYER POLYMER CONCRETE OVERLAY

Do not place the overlay if the air temperature is expected to drop below 55°F within 8 hours of placement.

g. Correction of Unbonded or Damaged Areas. Repair newly overlain areas (discovered to be unbonded by tapping or chaining) and areas of the overlay damaged by the Contractor's operation. Saw cut the unbonded or damaged areas to the top of the deck surface, remove the overlay with small air tools (15 pounds maximum) or shotblasting. Shotblast the concrete bridge deck surface at the unbonded area to remove contaminants, and replace the overlay according to standard placement procedures at no additional compensation.

729.4 MEASUREMENT AND PAYMENT

The Engineer will measure multi-layer polymer concrete overlay by the square yard.

Payment for "Multi-Layer Polymer Concrete Overlay" at the contract unit price is full compensation for the specified work.

Michigan Specifications

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
THIN EPOXY POLYMER BRIDGE DECK OVERLAY

OPR:CER

1 of 4

C&T:APPR:TDM:EMB:08-01-12

a. Description. Provide all labor, materials, and equipment for cleaning/preparing entire deck surface and applying a two-coat epoxy overlay.

b. Materials. Use a two component, high solids epoxy system to overlay the structure. Containers must be marked clearly “**Part A**” or “**Part B**”. The epoxies that are approved by MDOT for thin overlays are as follows:

Table 1: MDOT Approved Epoxies

Euclid Chemical	Flexolith 216	The Euclid Chemical Co. (Tim Brewer) 20416 Harper Avenue Harper Woods, MI 48225 (313) 886-9700
Unitex	Propoxy Type III DOT	Unitex, Inc. (Marty O'Mara) 3101 Gardner Kansas City, MO 64120 (816) 507-2789
Poly-Carb	Flexogrid Mark – 163 Flexogrid Mark - 154	Poly-Carb, Inc. (Brad Ehle) 33095 Brainbridge Road Cleveland, OH 44139 (440) 715-3065
E-Bond	526-Lo-Mod	Ridgemoor Supply Inc. (Stan Bosscher) 4484 Roger B. Chaffee Dr. Kentwood, MI 49548 616-532-0782
Axson	Akabond 811	Axson North America Inc. 1611 Hults Drive Eaton Rapids, MI 48827 (517) 663-8191

Use an angular aggregate, having less than 0.2 percent moisture and free of dirt, clay, asphalt, and other foreign or organic materials. The aggregate must have a minimum Mohs' hardness of 7. Unless otherwise approved, the aggregate must be chosen from the following list:

Table 2: MDOT Approved Aggregate

Vendor	Product Gradation	Type
Best Sand Chris Calhoun P.O. Box 87 Chardon, OH 44024 (800) 237-4986 Fax: (216) 285-4109	#612	Quartz
Unimin Corp. Ken Booz P.O. Box 254 Mauricetown, NJ 08329 (800) 257-7034 Fax: (856)327-4107	EP-5 Modified	Quartz
Manufacturers Minerals Co. Jim Adderson 1215 Monster Road Renton, Washington 98055 (425) 228-2120 Fax: (425) 228-2199	BT - 6x10	River Rock
Flint Rock Products Tammy Epps 800 S. College Road, P.O. Box 217 Picher, Oklahoma 74360 (918) 673-1737 Fax: (918) 673-1749	Size: #7	Chipped Flint

c. Equipment. For the epoxy overlay, the distribution system or distributor must accurately blend the epoxy resin and hardening agent, and must uniformly and accurately apply the epoxy materials at the specified rate to the bridge deck in such a manner as to cover 100 percent of the work area including 1 inch of the vertical face of curb/barrier. The fine aggregate spreader must uniformly and accurately apply dry aggregate to cover 100 percent of the epoxy material. The vacuum truck must be self-propelled.

For hand applications, equipment must consist of calibrated containers, a paddle type mixer, notched squeegees, and stiff bristle brooms, which are suitable for mixing and applying the epoxy and aggregate.

d. Construction.

1. Surface Preparation. Clean the entire deck surface by shotblasting before placement of the overlay. The prepared deck must meet the International Concrete Repair Institute Guideline No. 03732, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays, concrete surface profile 7 (CSP 7). Mortar which is sound, and soundly bonded to the course aggregate, must have open pores due to cleaning to be considered adequate for bond. Traffic paint lines must be removed and replaced at the completion of the overlay. A vacuum cleaner or oil-free moisture-free air blast should be used to remove all dust and other loose material. Brooms must not be used.

Do not place the epoxy overlay on concrete deck patches less than 28 days of age. Patching and cleaning operations must be inspected and approved prior to placing the

overlay. Any contamination of the deck, or to intermediate courses, after initial cleaning, must be removed. Both courses must be applied within 24 hours following the final cleaning and prior to opening area to traffic. There must be no visible moisture present on the surface of the concrete at the time of application of the epoxy overlay. A transparent polyethylene sheet (4 mil) must be taped to the deck in accordance with ASTM D 4263. All edges will be sealed with tape that will stick to the concrete substrate. The plastic sheet will be left in place for a minimum of 2 hours to detect the presence of moisture in the deck concrete. Alternate methods to detect moisture must be approved by the Engineer. There must be no moisture visible on the polyethylene sheet. Compressed air may be used to dry the deck surface providing it is moisture and oil free.

Protect the expansion joints, and any other areas not to be overlayed, from damage during preparation of the surface. The protection must be removed once the epoxy and aggregate has been applied and prior to initial set. Removing the protection must be done soon enough to in no way harm the adjacent overlay. Protection must be applied again prior to the second coat and removed again prior to initial set as to not damage adjacent surfaces. The protection must meet the approval of the Engineer.

2. Application. Handling and mixing of the epoxy resin and hardening agent must be performed in a safe manner to achieve the desired results in accordance with the manufacturer's recommendations for a two-coat system or as directed by the Engineer. Do not place epoxy overlay materials when surface is less than 50 degrees F or ambient air temperature is forecast to fall below 50 degrees F within 8 hours after application. Do not place epoxy overlay materials if weather or surface conditions are such that the material cannot be properly handled, placed, and cured within the manufacturer's requirements and specified requirements of traffic control.

Apply the epoxy overlay in two separate courses in accordance with the manufacturer's recommendation for a two-coat system with the following rate of application. First course must be no less than 40 ft²/gal. The second course must be no less than 20 ft²/gal.

Application of aggregate to both the first, and second courses must be of sufficient quantity so the entire surface is covered in excess. No bleed through, or wet spots should be visible in the overlay.

After the epoxy mixture has been prepared for the overlay, it must be immediately and uniformly applied to the surface of the bridge deck with a notched squeegee. Apply the dry aggregate in such a manner as to cover the epoxy mixture completely within 5 minutes. Minimize all foot traffic on the uncured epoxy and ensure any foot traffic will only done with steel spiked shoes approved by the Engineer. Remove and replace first course applications, which do not receive enough aggregate. A second course application which does not receive sufficient aggregate may be left in place, but will require additional applications before opening to traffic. Cure each course of epoxy overlay until vacuuming or brooming can be performed without tearing or damaging the surface. Do not allow traffic or equipment on the overlay surface during the curing period. Remove by vacuuming or brooming all loose aggregate after the first course curing period. Immediately apply the next overlay course to complete the surfacing. The minimum curing periods must be according to the manufacturer's recommendations, as shown in Table 3, or as directed by the Engineer.

Table 3: Anticipated Cure Time (Hours)

Average Temp. of Deck, Epoxy and Aggregate Components, Degrees F.							
Temp Range	<60	60-65	65-70	70-75	75-80	80-85	>85
1 st Course		4	3	2.5	2	1.5	1
2 nd Course	(a)	6.5	5	4	3	3	3
a. Second course shall be cured for minimum of 8 hours if the air temperature drops below 60 degrees F during the curing period, or per the manufacturer's recommendations.							

Plan and prosecute the work to provide the minimum curing periods as specified herein, or other longer minimum curing periods as recommended by the manufacturer prior to opening to public or construction traffic, unless otherwise permitted. First course applications must not be opened to traffic. Any contamination, detrimental to adhesion of the second course, must be removed from the first course at Contractor's expense prior to the application of the second course.

Remove and replace any areas damaged or marred by the Contractor's operations in accordance with this special provision at no additional cost to the Department.

Provide the Engineer with all records including, but not limited to, the following for each batch provided:

- batch numbers and sizes
- location of batches as placed on deck, referenced by stations
- batch time
- temperature of air, deck surface, epoxy components, including aggregates
- loose aggregate removal time
- time open to traffic

e. Measurement and Payment. The complete work as described will be measured and paid for at the contract unit price using the following pay item:

Pay Item	Pay Unit
Epoxy Overlay	Square Yard

Epoxy Overlay includes all material, labor, and equipment required for cleaning, preparing and applying a two-coat overlay system including miscellaneous clean-up.

Missouri Specifications



SECTION 623

CONCRETE BONDING COMPOUND, EPOXY MORTAR AND EPOXY POLYMER CONCRETE OVERLAY

SECTION 623.10 CONCRETE BONDING COMPOUND.

623.10.1 Description. This work shall consist of preparing the surface, furnishing and applying the concrete bonding compound to be used to bond plastic concrete mortar to hardened concrete as shown on the plans or as directed by the engineer.

623.10.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type II Epoxy	1039

623.10.3 Construction Requirements.

623.10.3.1 Surface Preparation. The surface of the hardened concrete to which the plastic concrete mortar is to be bonded shall be surface dry and thoroughly cleaned such that all loose and unsound concrete is removed prior to application of the bonding agent.

623.10.3.2 Application. The bonding agent shall be applied when both the air and surface temperature is within the manufacturer's written recommendations.

623.10.3.2.1 Components shall be mixed in accordance with manufacturer's written recommendations. The components may be warmed with indirect heat to a maximum temperature of 100 F to reduce the viscosity. No solvents shall be added to the compound.

623.10.3.2.2 The mixed bonding agent shall be applied in such a manner as to thoroughly work the bonding compound into the hardened concrete surface. The thickness of the application shall be 20 to 25 mils. If the concrete absorbs the bonding agent, additional coats shall be applied until the correct thickness is attained.

623.10.3.2.3 The plastic concrete mortar shall be placed while the bonding agent is still tacky. If there is a delay in placing the plastic concrete mortar and the bonding agent becomes tack free, another coat of bonding agent shall be applied.

623.10.4 Basis of Payment. No direct payment will be made for furnishing material, surface preparation or application.

SECTION 623.20 EPOXY MORTAR.

623.20.1 Description. This work shall consist of preparing the surface, furnishing and applying epoxy mortar as shown on the plans.

623.20.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Type III Epoxy	1039
Sand for Mortar	1039

623.20.3 Construction Requirements.

623.20.3.1 Surface Preparation. The surfaces to which the epoxy mortar is to be applied shall be free of dust, water or any other material that may affect the adhesion.

623.20.3.2 Application. The epoxy mortar shall be prepared and placed when the weather is dry and the air temperature is in accordance with the manufacturer's written recommendations.

623.20.3.2.1 The contractor shall mix only the number of containers of material that can be placed in 20 to 40 minutes.

623.20.3.2.2 Epoxy shall be thoroughly mixed in accordance with the manufacturer's written recommendations. Mixing shall continue as permitted to ensure uniformity.

623.20.3.2.3 When the epoxy material has been thoroughly mixed, sand shall be added at the manufacturer's recommended rate while mixing continues. After the proper quantity of sand has been added, mixing shall continue until the mixture is uniform.

623.20.3.2.4 Areas to be patched or leveled shall be thoroughly primed with an application of neat epoxy. After the area is primed, the mortar shall be placed and struck off to grade. The surface shall have a rough finish equal to that of a Portland cement concrete deck.

623.20.3.2.5 The patched or leveled area shall be protected during the curing period to prevent damage. Material shall be cured in accordance with the manufacturer's written recommendations. Curing acceleration by direct flame application will not be permitted.

623.20.4 Basis of Payment. No direct payment will be made for furnishing material, surface preparation or application.

SECTION 623.30 EPOXY POLYMER CONCRETE OVERLAY.

623.30.1 Description. This work shall consist of furnishing and applying thin polymer concrete overlays in a prime coat, plus two courses on designated bridge structures as shown on the plans or as directed by the engineer.

623.30.2 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Epoxy Resin for Epoxy Polymer Concrete Overlay	1039
Aggregate for Epoxy Polymer Concrete Overlay	1039

623.30.3 Construction Requirements.

623.30.3.1 Manufacturer Representation. The overlay manufacturer's representative shall witness the entire testing phase of each field test. The manufacturer's representative shall verify that all operations are performed by acceptable practices.

623.30.3.2 Handling and Storage of Material. Handling and storage of material shall be in

accordance with the manufacturer's written recommendations.

623.30.3.3 Field Test. Prior to the start of the overlay operation, a test area of the complete overlay system shall be placed on the bridge deck in a contractor proposed location that is approved by the engineer. When multiple bridges are included in a project, a test area will be required on each bridge. The contractor may utilize one-half of the bridge deck or an area equal to one day's placement operation, whichever is smaller, as a field test. The degree of cleaning used on the test area shall be the minimum used on the remainder of the structure. The surface for the test overlay shall be prepared in accordance with the test method prescribed in ACI 503R - Appendix A of the ACI Manual of Concrete Practice to establish an approved cleaning practice. The approved cleaning practice shall remove all potentially detrimental material which may interfere with the bonding or curing of the overlay. Concrete shall be sound, with mortar soundly bonded to the coarse aggregate, with clean and open pores to be considered adequate for bond. All areas of asphalt and pavement markings shall be removed. Preparation of the surface shall produce a surface relief equal to International Concrete Repair Institute (ICRI) surface preparation level 6 or 7 or ASTM E 965 pavement macrotexture depth of 0.04 to 0.08 inch.

623.30.3.3.1 Visible moisture on the prepared deck at the time of placing the overlay will not be permitted. Moisture in the deck shall be checked by taping a plastic sheet to the deck for a minimum of 2 hours in accordance with ASTM D4263.

623.30.3.3.2 In addition to the above requirements, the cleaning practice shall provide an adhesion strength test result greater than 250 psi or a failure area into the base concrete that is greater than 50 percent of the test area. After the test area has cured for a minimum of 72 hours, adhesion shall be checked in accordance with ACI 503R. A test result will be the average of three tests on a sample area of the test patch. A minimum of three sample areas per test patch shall be tested. Successful test results will be required from each sample area.

623.30.3.3.3 If the test of a sample area fails to meet the above requirements due to a cohesive failure of the substrate concrete, the adhesive strength of the sample area will be considered acceptable.

623.30.3.3.4 Successful completion of the adhesion strength tests will be required before the full-scale overlay operation is to begin. All cleaning operations shall equal those used for the adhesion strength test areas, in both profile and cleanliness. If changes are made to the established cleaning practice, new adhesion strength testing shall be performed at the contractor's expense.

623.30.3.3.5 Test patches shall be installed with the same material, equipment, personnel, timing, sequence of operations and curing period that will be used for the installation of the overlay.

623.30.3.3.6 If the test fails, the contractor shall remove the material represented by the failed test patches and provide another test patch, at the contractor's expense, until satisfactory test results are obtained.

623.30.3.4 Surface Preparation. Before placement of the overlay, the entire deck surface shall be prepared by the cleaning practice established in the field adhesion strength tests in accordance with [Sec 623.30.3.3](#).

623.30.3.4.1 If the engineer determines that the weather has changed significantly since the application of the field test patch, the contractor shall verify through adhesion strength tests that the practice is acceptable, at the contractor's expense.

623.30.3.4.2 No traffic of any kind shall be permitted on any portion of the deck which has been shot blasted or on the overlay without approval from the engineer. The time between surface preparation and application of the first course shall not exceed 24 hours.

623.30.3.4.3 All patching and cleaning operations shall be inspected and approved prior to placing the overlay.

623.30.3.4.4 If the deck or intermediate course is contaminated by foreign material or water after initial cleaning, the contamination and any detrimentally affected overlay material shall be removed. Both courses shall be applied prior to opening the area to traffic.

623.30.3.5 Equipment. The contractor's equipment shall be as recommended by the epoxy manufacturer.

623.30.3.6 Epoxy Mixture. Mixing of epoxy components shall be in accordance with the manufacturer's recommendations. When mineral fillers are specified, the mineral fillers shall be inert and non-settling or readily dispersible. Material showing a permanent increase in viscosity or the settling of pigments that cannot be readily dispersed with a paddle shall be replaced at the contractor's expense. At least 95 percent of the filler shall pass the No. 200 sieve.

623.30.3.7 Application. Application of epoxy shall be performed by the supplier or by a factory trained or licensed applicator with written approval from the manufacturer of the epoxy system.

623.30.3.7.1 The handling and mixing of epoxy shall be in accordance with the manufacturer's written recommendations. The overlay material shall not be placed when weather or surface conditions are such that the material cannot be properly handled, placed and cured within the specified requirements of traffic control, or when rain is forecasted within 24 hours of application.

623.30.3.7.2 The overlay shall consist of a thin prime coat and a two-course application of epoxy and aggregate. The first course shall be applied before the prime coat has gelled. The prime coat and first course shall not be placed as one application. Each of the two courses shall consist of a layer of epoxy covered with a layer of aggregate in sufficient quantity to completely cover the epoxy. The thickness of each course shall be approximately equal. The total thickness of the overlay shall be no less than 1/4 inch.

623.30.3.7.3 The temperature of the bridge deck surface at the time of application shall be less than 90 F and in accordance with the manufacturer's recommendation.

623.30.3.7.4 Dry aggregate shall be applied in such a manner as to cover the epoxy mixture completely within 5 minutes of application. The dry aggregate shall be placed in a manner such that the level of the epoxy mixture is not disturbed.

623.30.3.7.5 The first course shall be swept to remove loose aggregate prior to the second course application. Sweeping shall be done without removing embedded aggregate. First course applications which do not receive enough aggregate prior to gelling shall be removed and replaced. A second course applied with insufficient aggregate may be left in place, but additional applications shall be placed at the contractor's expense before opening to traffic.

623.30.3.7.6 The thickness of the overlay shall be verified to be at least 1/4-inch, measured from the deck surface to the top of the resin. The contractor shall provide a minimum 1/2-inch diameter hole at a rate of at least one hole per 100 feet of traffic lane. Hole placement shall be at locations designated by the engineer. Thin areas shall be recoated and reverified at the

contractor's expense.

623.30.3.7.7 When additional applications or recoating are required, the engineer may require additional adhesion strength tests by the contractor, at the contractor's expense, in accordance with ACI 503R to verify the contractor's procedure.

623.30.3.7.8 All adhesion strength test areas, thickness test holes or any debonded areas shall be repaired by filling with overlay material before final acceptance.

623.30.3.7.9 The epoxy concrete overlay shall be cured at least one hour, or until brooming or vacuuming can be performed without tearing or otherwise damaging the surface. No traffic or equipment shall be permitted on the overlay surface during the curing period.

623.30.3.7.10 After the curing period, all loose aggregate shall be removed by brooming or vacuuming and the next overlay course applied as specified in the contract documents.

623.30.3.7.11 The polymer mixture shall not be permitted to run into drains.

623.30.3.7.12 Unless otherwise specified, the epoxy concrete overlay courses shall be applied over the expansion joints and joint seals of the bridge deck. The expansion joints and joint seals shall be provided with a bond breaker. Prior to opening to traffic, the overlay shall be removed over each joint by removal of the bond breaker in accordance with the overlay manufacturer's recommendations.

623.30.3.7.13 Prior to opening a section to public or construction traffic, the overlay shall be allowed to cure in accordance with the manufacturer's recommendations. First course applications shall not be opened to traffic.

623.30.3.7.14 Damaged or debonded areas of an epoxy concrete overlay course shall be removed and repaired prior to acceptance. Repair shall consist of saw-cutting in rectangular sections to the top of the concrete deck surface and replacing the various courses in accordance with this specification at the contractor's expense.

623.30.4 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, the area of polymer concrete overlay will be measured and computed to the nearest square yard. This area will be measured longitudinally from end to end of bridge deck and transversely between the roadway face of curbs, excluding the area of the expansion device, if any. The revision or correction will be computed and added to or deducted from the contract quantity.

623.30.5 Basis of Payment. The accepted quantity of epoxy polymer concrete overlay will be paid for at the contract unit price.

SECTION 623.40 POLYMER CONCRETE.

623.40.1 Description. This work shall consist of furnishing and placing polymer concrete as shown on the plans or as directed by the engineer.

623.40.2 Manufacturer Representation. The manufacturer's representative shall be present at the start of surface preparations and polymer concrete installation for at least one day. The contractor shall furnish the manufacturer's recommendations to the engineer as to the acceptability of all aspects of the operation. The contractor shall contact the manufacturer's representative at least two weeks prior to installation.

623.40.3 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Polymer Concrete	1039

623.40.4 Construction Requirements.

623.40.4.1 Equipment. The contractor's equipment shall be in accordance with the manufacturer's recommendations.

623.40.4.2 Surface Preparation. Portland cement concrete shall be allowed to cure and dry for a minimum of seven dry days prior to installing the polymer concrete. Days with cold, wet or inclement weather which may be a detriment to curing of the Portland cement concrete will not count in this seven day minimum curing and drying time. The concrete surface shall be dry when placing the polymer concrete. The substrate shall be structurally sound and sandblasted to be free of all foreign matter, grease, dirt and laitance for all areas that will be in contact with the polymer concrete. Steel surfaces shall be cleaned in accordance with SSPC-SP 10 surface preparation requirements. After sandblasting is completed, the joint shall be cleaned of debris by using oil and water free compressed air at a minimum of 90 psi or by vacuuming. These areas shall then be primed in accordance with the manufacturer's recommendations.

623.40.4.3 Placement. The polymer concrete shall be mixed, placed and cured in accordance with the manufacturer's recommendations and as shown on the plans. Before opening to traffic, the material shall be tack free and fully cured as determined by the engineer.

623.40.5 Method of Measurement. Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. Where required, the volume of polymer concrete will be measured to the nearest 1.0 cubic feet of accepted, in-place polymer concrete. The revision or correction will be computed and added to or deducted from the contract quantity.

623.40.6 Basis of Payment. The accepted quantity of polymer concrete will be paid for at the contract unit price.

Nebraska Specifications

MULTI-LAYER EPOXY POLYMER OVERLAY

DESCRIPTION

The work shall consist of preparing the surface of the reinforced concrete bridge deck, and furnishing and placing a multi-layer epoxy polymer overlay (EPO).

MATERIALS

The EPO shall be comprised of a two component epoxy (resin and hardener), combined with aggregate as described in the following:

1. Epoxy:

- a. The epoxy shall be Type III, for use in bonding skid resistant materials to hardened concrete.
- b. Type III epoxy shall comply with AASHTO M 235 (ASTM C 881), and shall meet additional requirements shown in Table 1.0, and is the class appropriate for the temperature at the time of application, as designated by the manufacturer.
- c. Provide Grade 1 or 2, 100 percent solids, thermosetting, moisture-insensitive epoxy.

Table 1.0

ADDITIONAL REQUIREMENTS FOR TYPE III EPOXY POLYMER OVERLAY		
Property	Requirement	Test Method
Viscosity	7-25 poises	ASTM D2393, Brookfield RVT, Spindle 3 at 20 RPM
Gel Time	15-45 min.	ASTM C 881, ¶ 11.2.1 modified, 50 to 100 ml sample.
Compressive Strength*, 3 hr.	1000 psi min.	ASTM C 109, w/ plastic inserts
Compressive Strength*, 24 hr.	5000 psi min.	ASTM C 109, w/ plastic inserts
Tensile Strength, 7 days	2000-5000 psi	ASTM D 638
Elongation, 7 days	30-70%	ASTM D 638
Pull-Off Strength, after 24 hr. min. Cure Time of Layer 2.	250 psi min.	ASTM C1583-04

*Mixed with aggregate.

d. The contractor shall submit for approval the following information:

- (1) Name, address and telephone number of the epoxy manufacturer. Include the name of the preferred contact person.
- (2) Brand name of the material.

- (3) Type, Grade and Class of the material.
- (4) Manufacturer's certificate of compliance.
- (5) Information regarding recommended usage and application instructions.
- (6) Material Safety Data Sheets.
- (7) Test results shall be submitted by a Cement and Concrete Reference (CCRL) or AASHTO Materials Reference (AMRL) accredited Laboratory. The certified lab will show test results of AASHTO M 235 (ASTM C 881) and requirements of Table 1.0.
- (8) A Fourier Transform Infrared Spectrophotometry (FTIR) spectrum in transmittance mode must be included and a bulk sample of each component tested and sent to Materials and Research Division.
- (9) Six 3 oz. resin samples, representative of the material must be provided for testing to the Materials and Research Division. All liquid components will be "fingerprinted" using infrared spectroscopy for use in screening future verification samples to verify that materials submitted for use are of an identical formulation as originally approved.
- (10) Verification that the testing apparatus used for bond tests has been calibrated within the last year according to ASTM C900-06, Annex A1.

2. Aggregate:

- a. Provide a singly crushed siliceous gravel or chat that is free of dirt, clay and foreign of organic material.
- b. The Engineer shall collect a 60 lb. sample of the aggregate for use in quality assurance testing. This sample shall be collected from the material delivered to the jobsite.
- c. The aggregates provided shall meet the requirements of Tables 2.0 & 3.0 below:

Table 2.0

QUALITY REQUIREMENTS FOR EPOXY POLYMER OVERLAY		
Property	Requirement	Test Method
Sodium Sulfate Soundness, Maximum Loss	12%	AASHTO T104
Maximum Wear	30%	AASHTO T96
Acid Insoluble Residue, Minimum	55%	NDOR C25
Fine Aggregate Angularity, Minimum	40%	AASHTO T304, Method C
Moisture Content, Maximum	0.20%	AASHTO T255

Table 3.0

GRADATION REQUIREMENTS FOR AGGREGATES (percent passing)				
Sieve	4	8	16	30
% Passing	100	30-75	0-5	0-1

EQUIPMENT

The Contractor may request the use of other equipment or methods. The Contractor shall submit a list to the Engineer of all equipment to be used at least two weeks prior to construction. Equipment must comply with the following requirements.

- 1. Surface Preparation Equipment:** Steel Shot-blasting equipment capable of producing a surface relief equal to the International Concrete Repair Institute (ICRI) Concrete Surface Profile (CSP) 6 to 7. The shot-blast equipment shall be capable of providing a uniform surface texture. The equipment shall be inspected before use, and worn blasting wheels and liners are required to be replaced. Loose shot shall be collected using a magnet, magnetic broom, air blast, vacuum or stiff bristle broom. Wet sand blasting is not allowed.
- 2. Mechanical Distribution Equipment:**
 - a. All equipment to enter or cross the prepared surface, such as work vehicles, trailers, carts, etc., that contain motor oil, transmission fluid, gear oil, radiator fluid, lubricants, etc. shall be accompanied by a protection membrane such as plastic tarps or rolled plastic placed on the prepared deck surface under equipment to protect the prepared deck surface from contamination.
 - b. An epoxy distribution system shall be capable of accurate and complete mixing of the epoxy resin and hardening agent, verification of the mix ratio and uniform and accurate distribution of the epoxy at the specified rate on 100% of the prepared surface.
 - c. To minimize the formation of air bubbles produced during mechanical mixing of the epoxy components, the mixer shall only use "Jiffy" or "Sika" paddle types, or approved equal.
 - d. An aggregate spreader shall be capable of uniform and accurate application of the dry aggregate over 100% of the prepared surface.
 - e. An air compressor shall be capable of producing a sufficient amount of oil-free and moisture-free compressed air to remove all dust and loose material.
- 3. Hand Application Equipment:**
 - a. Calibrated containers for accurate measurement of epoxy components shall be used.
 - b. To minimize the formation of air bubbles produced during mechanical mixing of the epoxy components, the mixer shall only use paddle types "Jiffy" or "Sika" paddle types, or approved equal.
 - c. Notched squeegees and brooms shall be capable of spreading the epoxy material according to this specification and the manufacturer's recommendations.
 - d. Adequate additional hand tools may be used to facilitate the placement of the EPO according to this specification and the manufacturer's recommendations.

4. Do not use power driven tools heavier than a 15 pound chipping hammer, during surface preparation.

CONSTRUCTION METHOD

1. Preparation of Surface:

- a. The Contractor shall determine the size of shot, flow of shot, forward speed of shot blast machine and number of passes to achieve a surface preparation that will satisfy the required pull-off strength of the EPO.
- b. Deteriorated and/or delaminated concrete shall be removed and repaired with EPO slurry (epoxy and aggregate combined) or approved patch material.
- c. In all cases, the EPO shall not be placed on any Portland cement concrete less than 28 days old.
- d. All bridges will require, at minimum, a single-pass shot blast of the preparation surface. The Contractor shall produce a surface relief equal to the International Concrete Repair Institute (ICRI) Concrete Surface Profile 6 to 7. The width of overlap of successive passes of the machine shall be as minimal as possible to limit double exposure. The contractor must make available to the Engineer, a set of ICRI surface profile cards to verify the shot blast profile.
- e. Metal deck drains and areas of the curb or railing above the proposed surface from the shot blast shall be protected.
- f. All dirt, paint, oil, asphalt, laitance, carbonation, curing materials and other deleterious material from the surface of the deck and bridge rails (6" above deck or first break in the case of a continuous rail) shall be removed.
- g. The Contractor shall clean all prepared surfaces by air blasting with dry, oil free air or vacuuming. Sweeping with brooms for final cleaning is not acceptable.
- h. Any contamination of the prepared deck surface or surface of subsequent layers shall be removed. Contaminated areas shall be sand-blasted or bush hammered to produce an acceptable surface for placement of the EPO.
- i. The Contractor shall prevent rain water from transporting objectionable materials from surrounding paving onto the bridge deck.
- j. Visible moisture on the prepared deck at the time of placing the EPO is unacceptable. The Contractor shall identify moisture in the deck by taping an 18"x18" plastic sheet to the deck per ASTM D 4263 specifications. The plastic sheet test shall be performed only when surface temperatures and ambient conditions are within the established parameters for application of the coating system. This test shall be performed by the contractor and observed by the Engineer.

- k. The first layer shall be placed within 24 hours of preparing the deck surface. Deck surfaces exposed for more than 24 hours must be sand blasted prior to application of the EPO.
- 2. **Proportioning:** All epoxy materials shall be proportioned according to the manufacturer's recommendations.
- 3. **Placing the Epoxy Polymer Overlay:**
 - a. The EPO shall be placed in two separate layers to the surfaces shown in the Contract at application rates shown in Table 4.0:

Table 4.0

EPOXY POLYMER OVERLAY APPLICATION RATES		
Layer	Epoxy Rate	Aggregate Rate*
1	Not Less Than .22 gal./sq. yd.	10 lb./ sq. yd. min.
2	Not Less Than .45 gal./sq. yd.	14 lb./ sq. yd. min.

*Apply enough aggregate to completely cover the epoxy.

- b. Notched squeegees or mechanical application equipment shall be used to place the mixed epoxy on the deck surfaces immediately and uniformly at the prescribed rate.
- c. The Contractor shall continually monitor the gel time of the mixed epoxy. The EPO shall not be placed if conditions are such that gel time is less than 10 minutes.
- d. Deck drains shall be closed so the epoxy and aggregate shall not enter the drains.
- e. A paintbrush or roller shall be used to apply the epoxy on the face of curbs to the top of the curb. On bridges with continuous concrete barrier rails, apply the epoxy to the first break in the geometry of the barrier or 6 inches above the deck or existing overlay whichever is greater. On bridges with open concrete barriers, apply the epoxy to the following surfaces:
 - (1) All 4 faces of the posts a minimum of 6 inches above the deck or existing EPO.
 - (2) The outside edge of deck
 - (3) A minimum of 8 inches on the underside of the deck or slab overhangs.
- f. Epoxy and aggregate shall be applied to curbs, barriers or posts as each of the layer applications are placed. No aggregate is required for the outside edge or underside of deck overhangs.
- g. The bridge deck and all mixed epoxy and aggregate components must be a minimum of 60°F at the start of application. See paragraph 4.a.
- h. The dry aggregate shall be applied to cover the epoxy completely within 10 minutes of application.

- i. Any first layer surfaces of epoxy that do not receive enough aggregate before gelling of the epoxy occurs must be removed and replaced.
- j. Excess aggregate from the first layer after sufficiently cured shall be vacuumed or swept. If damage or tearing occurs, halt sweeping or vacuuming operation.
- k. Traffic must not be allowed on the first EPO layer.
- l. The epoxy and aggregate for the second layer shall be placed at the prescribed rate and in the same manner as the first layer.
- m. Second layer surfaces that do not receive enough aggregate before gelling of the epoxy may be re-coated with epoxy and aggregate.
- n. All longitudinal joints will be at the edge of one lane or as indicated by the Engineer. No joints will be allowed on the wheel path.
- o. The EPO shall be produced and placed within the specified limits in a continuous and uniform operation.
- p. All construction joints shall be taped to provide a clean straight edge for adjacent EPO placement. This includes joints between previously placed EPO materials and at centerline.
- q. The exposed edges at the ends of the bridge and at expansion joints shall be finished to minimize bridge deck roughness.
- r. A bond breaker shall be applied to all expansion joints.

4. Curing: Minimum curing times are noted in Table 5.0:

Table 5.0

EPOXY POLYMER OVERLAY CURE TIMES							
	Average Temperature of Deck, Mixed Epoxy, and Aggregate, F deg.						
Layer	55-59	60-64	65-69	70-74	75-79	80-85	85+
	Minimum Cure Time (hours)						
1	5	4	3	2.5	2	1.5	1
2	6.5	6.5	5	4	3	3	3

- a. The average temperatures listed in Table 5.0 are to be taken immediately prior to placement of epoxy on deck surfaces. The second layer shall be cured for 8 hours if the air temperature falls below 55°F during the curing period. The cure times listed for the 55-59°F temperature range are provided for the case where the deck, mixed epoxy, and aggregate satisfy the 60°F min. temperature at the start of placement and subsequently decrease during placement.

- b. The work shall be planned and performed in such a way as to provide for the minimum curing times specified in this provision or as specified by the epoxy manufacturer.

5. Temperature Limitations:

- a. The minimum temperature of deck, mixed epoxy, and aggregate at the start of placement of the EPO shall be 60°F.
- b. If the manufacturer's temperature requirements are more restrictive than provided in this provision they will govern.
- c. The EPO must not be placed when conditions are such that the deck temperature will exceed 100°F.
- d. The EPO must not be placed if conditions are such that gel time is less than 10 minutes.
- e. The EPO must not be placed if the air temperature is expected to drop below 55°F within 8 hours of placement.

- 6. Correction of Unbonded or Damaged Areas:** Any areas of the EPO discovered to be unbonded by sounding or chaining and areas of the EPO damaged by the contractor's operation shall be repaired before payment is made. A squared perimeter of areas to be repaired shall be saw cut to the top of the concrete surface and the EPO shall be removed with small air tools (15 pounds maximum) or shot blasting. The underlying concrete area shall be shot blasted to remove contaminants, and the EPO shall be replaced according to standard placement procedures. There is no additional cost to the department for unbonded or damaged areas.

BOND (PULL-OFF) TESTING

- 1. The Contractor shall record the results of the pull-off tests.
- 2. The Contractor shall perform pull-off tests of three specimens on each lot of the completed overlay in accordance with ASTM C1583-04 under the observation of the Engineer. **A lot shall be defined as one lane of traffic for each span of the bridge measured in square yards, with the following stipulations:**
 - a. Shoulders 8 feet and under shall be included in the lot containing the adjacent lane.
 - b. Shoulders exceeding 8 feet shall be considered a separate lot for each span.
 - c. Each lane of the bridge approach shall be considered a separate lot.

3. The location of the three pull-off specimens per lot shall be determined by the Engineer.
4. The loading disk used in the pull-off tests shall be adhered to the finished surface of the EPO following core drilling operation to a depth at least ½" into the concrete substrate.
5. The pull-off tests shall not start any sooner than 24 hours after placement of the second layer of the EPO.
6. The pull-off test shall not be performed when the deck temperature exceeds 85° F.

METHOD OF MEASUREMENT

1. Epoxy Polymer Overlay will be measured for payment by the square yard of deck surface and bridge approach surface area overlaid as determined by field measurement.
2. Epoxy Polymer Overlay applied to bridge rail or barrier and epoxy applied to the deck edge or underside will not be measured directly and will be considered subsidiary to the Multi-Layer Epoxy Polymer Overlay.

BASIS OF PAYMENT

1. Pay Item	Pay Unit
Multi-Layer Epoxy Polymer Overlay	Square Yard (yd ²)

2. For each lot, the EPO unit price is multiplied by bond strength pay factor for the item "Multi-Layer Epoxy Polymer Overlay"
3. The bond strength of the three (3) pull-off specimens will be averaged to determine the pay factor for each lot with the following exception:

If the tensile strength of a specimen is less than 250 psi and failure is in the concrete at a depth of at least 1/4 inch over more than 50% of the test surface, then the tensile strength used for that single specimen will be 250 psi.

4. The pay factors for the average bond strength test are as shown in Table 6.0:

Table 6.0

BOND STRENGTH PAY FACTORS	
Average Bond Strength of Lot *	Percent Pay
Greater than 245 psi	100%
235 psi - 245 psi	90%
225 psi - 234 psi	75%
Less than 225 psi	40% or Reject

*245 psi allows for a 2% margin of error (with 250 psi required)

5. Any lot rejected by the Engineer will be removed and replaced at no additional cost to the Department.
6. Payment is full compensation for all work in this Section.

New Mexico Specifications

SECTION 536: POLYMER CONCRETE BRIDGE DECK OVERLAY

536.1 DESCRIPTION

This Work consists of providing and applying a polymer concrete Bridge deck overlay.

536.2 MATERIALS

536.2.1 Epoxy

Provide a two-part epoxy, or epoxy urethane resin base, composed of a 100% solid, thermosetting, moisture-insensitive, flexible, high-elongation compound in accordance with Table 536.2.1:1, "Epoxy Physical Requirements," or Table 536.2.1:2, "Epoxy Urethane Physical Requirements."

**Table 536.2.1:1
Epoxy Physical Requirements**

Property	Test method	Minimum	Maximum	Remarks
Viscosity	ASTM D 2393 Brookfield RVT, Spindle #3 @ 20 rpm	7 poises	25 poises	—
Gel time	ASTM C 881, Paragraph 11.2 modified	15 min	45 min	—
Compressive strength @ 3 h	ASTM C 579 modified (with plastic inserts)	1,000 psi	—	Mixed with aggregate
Compressive strength @ 24 h	ASTM C 579 modified (with plastic inserts)	5,000 psi	—	Mixed with aggregate
Tensile strength (neat) @ seven (7) Days	ASTM D 638	2,200 psi	5,000 psi	—
Elongation (neat) @ seven (7) Days	ASTM D 638	30%	80%	—
Adhesive strength @ 24 h	ACI 503R, Appendix A, VTM 92	250 psi	—	Mixed with aggregate with 100% failure in concrete
Permeability to chloride ion @ 28 Days	AASHTO T 277	—	100 coulombs	—
Absorption (neat) @ 24 h	ASTM D 570	—	one percent (1%)	—
Thermal compatibility	ASTM C 884	No delamination of overlay		Mixed with aggregate
Infrared spectrum	AASHTO T 237, Paragraphs 5 and 6	To be established for each component		—

Table 536.2.1:2
Epoxy Urethane Physical Requirements

Property	Test method	Minimum	Maximum	Remarks
Viscosity	ASTM D 2393 Brookfield RVT, Spindle #3 @ 20 rpm	35 poises	70 poises	—
Gel time	ASTM C 881, Paragraph 11.2 modified	15 min	45 min	—
Compressive strength @ 3 h	ASTM C 579 modified (with plastic inserts)	1,000 psi	—	Mixed with aggregate
Compressive strength @ 24 h	ASTM C 579 modified (with plastic inserts)	5,000 psi	—	Mixed with aggregate
Tensile strength (neat) @ seven (7) Days	ASTM D 638	2,200 psi	5,000 psi	—
Elongation (neat) @ seven (7) Days	ASTM D 638	30%	100%	—
Adhesive strength @ 24 h	ACI 503R, Appendix A, VTM 92	250 psi	—	Mixed with aggregate with 100% failure in concrete
Permeability to chloride ion @ 28 Days	AASHTO T 277	—	100 coulombs	—
Shore D hardness	ASTM D 2240	60	70	—
Flexural creep, total movement in seven (7) Days	California Test Method 419	0.0065 in	—	—
Flexural yield strength	ASTM D 790	5,000 psi	—	—
Absorption (neat) @ 24 h	ASTM D 570	—	one percent (1%)	—
Thermal compatibility	ASTM C 884	No delamination of overlay		Mixed with aggregate
Infrared spectrum	AASHTO T 237, Paragraphs 5 and 6	To be established for each component		—

536.2.2 Submittals

Submit the manufacturer's recommendations for the proposed Material to the Project Manager 14 Days before use. Provide a certified report from a Department approved Laboratory and the manufacturer certification verifying the Materials are in accordance with this specification. Include a Fourier Transform Infrared Spectrophotometry spectrum in transmittance mode and a bulk sample of each component tested in the manufacturer's certification. The Department will maintain confidentiality of the data.

536.2.2.1 Certificates of Compliance and Product Data Sheets

At least 15 Days before using the polymer concrete Bridge deck overlay, submit a notarized certificate of Material compliance to the Project Manager. List batch numbers and the manufacture date for all components of each Material in the Certificate of Compliance and on the Material containers. Submit detailed MSDS for polymer concrete Bridge deck overlay components.

536.2.3 Testing

The Project Manager will accept the Materials based on the certified Laboratory report.

536.2.4 Aggregate

Provide angular grained, stone aggregate free of dirt, clay, and Deleterious Material in accordance with Table 536.2.4:1, "Required Aggregate Properties," and Table 536.2.4:2, "Required Aggregate Gradation."

**Table 536.2.4:1
Required Aggregate Properties**

Property	Test method	Minimum	Maximum	Remarks
Soundness loss, 5 cycles in magnesium sulfate	AASHTO T 104	—	eight percent (8%)	—
Micro-Deval	AASHTO T 327	—	ten percent (10%)	Aggregate must meet the gradation shown in Table 536.2.4:2, "Required Aggregate Gradation"
Moh's hardness	—	7	—	—
Moisture content	AASHTO T 255	—	0.2%	—

**Table 536.2.4:2
Required Aggregate Gradation**

Sieve size	% passing	
	Minimum	Maximum
No. 4	100	—
No. 8	15	25
No. 16	0	5
No. 30	0	1
No. 200	0	0.2

536.2.4.1 Acceptance of Aggregate

The Department will base Acceptance of aggregate on the State Materials Bureau recommendations and Table 536.2.4:1, "Required Aggregate Properties."

536.3 CONSTRUCTION REQUIREMENTS

536.3.1 Surface Preparation

536.3.1.1 Surface Preparation

Prepare the concrete to produce a surface relief equal to the International Concrete Repair Institute (ICRI) Surface Preparation CSP 5-7, or ASTM E 965 pavement macrotexture depth of from 0.04 inch to 0.08 inch. Provide concrete surface profile chips to the Project Manager for inspection and Acceptance of prepared surface. ICRI concrete surface profile chips will become the property of the Department.

536.3.1.2 Mechanical Application Equipment

Use an epoxy or epoxy urethane distribution system that completely mixes the epoxy or epoxy urethane resin with hardening agent, and provides a uniform distribution of the

Materials at the required application rate. The use of hand held machine mixing equipment or hand mixing equipment is prohibited.

Use a self-propelled aggregate spreader that uniformly applies the dry aggregate at the manufacturer's recommended application rate.

Use an air compressor that produces oil-free and moisture-free compressed air to remove dust and loose material from the application surface before applying epoxy or epoxy urethane.

536.3.1.3 Hand Application Equipment

Use notched squeegees and brooms that spread the epoxy or epoxy urethane Material in accordance with the manufacturer's requirements. Periodically inspect squeegees during application for wear of the notch depth, replace any defective squeegees.

Use hand tools, as necessary, for placing the overlay.

536.3.1.4 Vacuum Trucks

Use vacuum trucks that are clean and do not drip engine fluids, or install drip pans to protect the clean deck and overlay.

536.3.1.5 Power Brooms

Use power brooms that are clean and do not drip engine fluids, or install drip pans to protect the clean deck and overlay.

536.3.2 Pre-construction

536.3.2.1 Deck Preparation

Complete deck repairs for patches, delamination, and crack filling before applying the overlay per Section 533, "Concrete Structure Repair" and Section 534, "Epoxy Injection" as specified in the Contract.

Identify moist areas by taping an 18 inch x 18 inch plastic sheet to the deck for at least two (2) h in accordance with ASTM D 4263. If moisture appears on the bottom of the plastic sheet, do not proceed with the overlay process. Use compressed air to dry the deck surface.

Close and protect deck drains and areas of curb or railing above the proposed surface to ensure epoxy or epoxy urethane and aggregate does not pass through the drains.

536.3.2.2 Cleaning

Obtain Project Manager's approval of Bridge deck cleaning and preparation before placing the first course.

Before placing the overlay, clean the deck surface to remove Materials that may interfere with bonding or curing.

The Department will consider cleaning acceptable when the color of the concrete and mortar changes and coarse aggregate particles are exposed. Cleaning shall open the pores of sound mortar. The Department will consider pavement markings clean when exposed aggregate shows through the markings. Use a vacuum cleaner or air compressor to remove dust and other loose material. Do not use brooms.

536.3.3 Safety Provisions

Use personnel certified in the safe handling of Materials in accordance with the manufacturer's requirements. Submit written documentation of Material handlers' training to

the Project Manager before applying the overlay.

536.3.4 Storage of Materials

Store Materials in accordance with the manufacturer's recommendations.

536.3.5 Temperature Limitations

Follow the manufacturer's deck temperature recommendations. Do not use artificial methods to raise the deck temperature.

Follow the manufacturer's temperature requirements for epoxy or epoxy urethane and aggregate components. The Contractor shall not apply epoxy or epoxy urethane for the following reasons:

1. The Contractor expects the air temperature to drop below the manufacturer-required temperature within eight (8) h after application; or
2. The epoxy or epoxy urethane's gel time is less than ten (10) min.

536.3.6 Usage Limitations

Do not overlay Bridges constructed with unventilated stay-in-place forms, unless forms are ventilated at a minimum rate of 1/2 square inch for every square foot or on PCC that is less than 56 Days of age with polymer concrete overlay. Additionally, manufacturer's recommendations concerning moisture content must be followed.

536.3.7 Application

Materials shall be applied using mechanical metering, mixing and distribution machinery as recommended by the manufacturer of the overlay system. Components A and B shall be applied within the temperature range recommended by the manufacturer. Broadcasting on concrete shall be performed in accordance with the manufacturer's directions and the method approved by the Project Manager.

Apply the overlay as two (2) separate applications with a total coverage of at least 7.5 gal per 100 ft².

Apply the first application of polymer at a rate of at least 2.5 gal per 100 ft². Cover with a minimum of ten (10) pounds of aggregate per square yard, or enough to completely cover the epoxy or epoxy urethane.

Apply the second application of polymer at a rate of at least five (5.0) gal per 100 ft². Cover with at least 14 pounds of aggregate per square yard, or enough to completely cover the epoxy or epoxy urethane.

Remove and replace first applications that do not receive enough aggregate before the polymer gels, at no additional cost to the Department. The Department will allow second applications not covered with enough aggregate to remain in place, but the Contractor must apply additional applications before opening to traffic, at no additional cost to the Department.

536.3.8 Curing

No vehicular traffic or equipment shall be allowed on the overlay during the curing period.

Cure each application of overlay (polymer and aggregate) free from vehicular traffic as recommended by the manufacturer and approved by the Project Manager and until a vacuuming or broom does not tear or damage the surface.

After the first application cures, remove loose aggregate with a vacuum or broom, then apply the second application.

536.3.9 Expansion Joints

Place expansion joints with bond breakers in Bridge deck expansion joints. Apply polymer over the expansion joints. Within 12 h after application and before opening to traffic, remove the polymer over the expansion joints using the following procedure:

1. Remove the bond breakers;
2. Score the polymer before gelling; or,
3. Saw cut after the cure.

536.3.10 Corrective Work

Correct surface variations that exceed $\pm 1/4$ inch per three (3) ft, unless otherwise directed by the Project Manager.

Repair the damaged overlay areas by saw cutting in rectangular sections to the top of the concrete deck surface and replacing the Material at no additional cost to the Department.

536.3.11 Warranty

Provide a five (5) year warranty for the overlay Material and installation.

In addition to the requirements set forth in Section 103.6 "Requirement of Contract Bonds", provide a maintenance bond or warranty bond for the time frame indicated in this section.

The maintenance bond or warranty bond shall commence upon the Departments Acceptance of the Work.

A Department representative, Project Manager or District designee, will evaluate the overlay performance annually using a pre-established joint team consisting of a Contractor and the Department representative. The evaluation will take place on the same date, ± 30 Days, as the previous year for the life of the warranty. No spalling, scaling, cracking or delamination is acceptable during the warranty period, as defined by the following:

1. **Spalling.** Broken or missing pieces of concrete overlay;
2. **Scaling.** The Bridge deck overlay surface has a visible, exposed, rough surface texture resulting from a loss of aggregate or mortar;
3. **Delamination.** There is visible or audible debonding of the concrete Bridge deck overlay from the existing Bridge deck surface;
4. **Cracking.** Any visible crack.

At the end of each yearly evaluation period, the Department will provide the Contractor with a report that describes occurrences of spalling, scaling, cracking, or delamination.

The Department will perform an annual skid in accordance with AASHTO T 242. For the warranty period, an average skid number of 45 or higher is acceptable.

If the overlay is not acceptable, the Department will direct the Contractor, in writing, to perform corrective Work within 180 Days, at no additional cost to the Department. Corrective Work application and method shall be approved by the Department prior to the execution of the corrective work.

536.4 METHOD OF MEASUREMENT—Reserved

536.5 BASIS OF PAYMENT

Pay Item

Pay Unit

Section 536: Polymer Concrete Bridge Deck Overlay

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<i>Epoxy Polymer Concrete Bridge Deck Overlay</i>	Square
<i>Yard Epoxy Urethane Polymer Concrete Bridge Deck Overlay</i>	Square Yard

536.5.1 Work Included in Payment

The following Work and items will be considered as included in the payment and will not be measured or paid for separately:

- A. Concrete surface profile chips

SECTION 537: POLYESTER CONCRETE BRIDGE DECK OVERLAY

537.1 DESCRIPTION

This Work consists of providing and applying polyester concrete overlay for Bridge deck, approach slab, transition slab, and PCCP repairs and/or grade corrections.

537.2 MATERIALS

537.2.1 Prime Coat

The prime coat used with the polymer concrete shall be a wax free, high molecular weight methacrylate resin conforming to the requirements in Table 537.2.1:1, "Prime Coat Physical Requirements:"

Table 537.2.1:1
Prime Coat Physical Requirements

Property	Test method	Minimum	Maximum	Remarks
Viscosity	ASTM D 2196	—	0.25 poise	—
Specific Gravity	ASTM D1475	0.90 min	—	—
Flash Point	ASTM D3278	180 F	—	—

The promoter/initiator system for the methacrylate resin shall consist of a metal drier and peroxide. If supplied separately from the resin, at no time shall the metal drier be mixed with or allowed to contact the peroxide directly. Do not store the containers in a manner that will allow leakage or spillage from one (1) material to contact the container or material of the other.

537.2.2 Polyester Resin Binder

Polymer concrete shall consist of polyester resin binder. The resin shall be an unsaturated isophthalic polyester-styrene co-polymer and shall conform to the requirements in Table 537.2.2:1, "Polyester Resin Physical Requirements:"

Table 537.2.2:1
Polyester Resin Binder Physical Requirements

Property	Test method	Minimum	Maximum	Remarks
Viscosity	ASTM D 2196	0.75 poise	2.0 poise	Test before addition of initiator
Specific Gravity	ASTM D 1475	1.05	1.10	Test before addition of initiator
Tensile strength (neat) @ 7 Days	ASTM D 638	2,200 psi	5,000 psi	—
Elongation (neat) @ 7 Days	ASTM D 638	35%	80%	—

Table 537.2.2:1
Polyester Resin Binder Physical Requirements

Property	Test method	Minimum	Maximum	Remarks
Adhesive strength @ 24 h	ACI 503R, Appendix A, VTM 92	250 psi	—	Mixed with aggregate with 100% failure in concrete
Absorption (neat) @ 24 h	ASTM D 570	—	one percent (1%)	—
Styrene Content	ASTM D 2369	40%	50%	% mass as volatiles before addition of initiator
Infrared spectrum	AASHTO T 237, Paragraphs 5 and 6	To be established for each component		—

The silane coupler shall be an organosilane ester, gammamethacryloxy-propyltrimethoxysilane. The promoter shall be compatible with suitable methyl ethyl ketone peroxide (MEKP) and cumene hydroperoxide (CHP) initiators.

537.2.3 Aggregate

Aggregate for polyester concrete shall conform to the requirements of Section 509.2.4, "Aggregate," of the Standard Specifications, except the gradation shall meet the following:

Table 537.2.3:1
Polyester Concrete Aggregate Gradation

COMBINED AGGREGATE		
Sieve Size	Percentage Passing	
	3/8 inch Max.	No. 4 Max.
1/2 inch	100	100
3/8 inch	83 - 100	100
No. 4	65 - 82	62 - 85
No. 8	45 - 64	45 - 67
No. 16	27 - 48	29 - 50
No. 30	12 - 30	16 - 36
No. 50	6 - 17	5 - 20
No. 100	0 - 7	0 - 7
No. 200	0 - 3	0 - 3

Aggregate retained on the #8 sieve shall have a maximum of 45 percent crushed particles when tested in accordance with AASHTO Test Method T 27. Fine aggregate shall consist of natural sand only.

Aggregate absorption shall not exceed one (1) percent as determined by AASHTO Test Methods T 84 and T 85.

At the time of mixing with the resin, the moisture content of the aggregate, as determined by AASHTO Test Method T 255, shall not exceed one half of the aggregate absorption.

537.2.3 Submittals

Submit the manufacturer's recommendations for the proposed material to the Project Manager 14 Days before use. Provide a certified report from a Department approved Laboratory and the manufacturer certification verifying the Materials are in accordance with this specification.

Submit a list of at least three (3) previous Projects in which the polyester concrete system from the proposed Supplier has been used and satisfactory performance has been achieved. The previous Projects must have been completed within the last five (5) years and have been open to traffic for not less than one (1) year. Include in the submittal, location of Bridge (state, route, and Bridge identifier), name of polyester concrete system Supplier, approximate date of Project opening to traffic, owner, and contact person with phone number.

537.2.4 Confirmation Testing

The Supplier shall test the polyester resin binder and prime coat Materials the Contractor proposes to use, and will provide results to the Project Manager within 14 Days before use. The Project Manager will accept the Materials based on the certified Laboratory report.

537.3 CONSTRUCTION REQUIREMENTS

537.3.1 Equipment

537.3.1.1 Concrete Cleaning Equipment

Prepare the concrete to produce a surface relief equal to the International Concrete Repair Institute (ICRI) Surface Preparation CSP 5-7, or ASTM E 965 pavement macrotexture depth from 0.04 inch to 0.08 inch. Use of scabblers, milling machines, or sandblasting will be at the discretion of the Project Manager. Provide ICRI concrete surface profile chips to the Project Manager for inspection and Acceptance of prepared surface. ICRI concrete surface profile chips will become the property of the Department.

The use of air compressors and/or vacuum trucks is permitted. Use an air compressor that produces oil-free and moisture-free compressed air to remove dust and loose material from the application surface before applying the prime coat. Use vacuum trucks that are clean and do not drip engine fluids, or install drip pans to protect the clean concrete surfaces and overlay.

537.3.1.2 Placing and Finishing Equipment

A continuous mixer, employing an auger screw/chute device, will be approved for use by the Project Manager contingent on a demonstration that the device can consistently produce a satisfactory product. The continuous mixer shall 1) be equipped with a metering device that automatically measures and records the aggregate volumes and the corresponding resin volumes, and 2) have a readout gage, visible to the Project Manager at all times, that displays the volumes being recorded. The volumes shall be recorded at no greater than five (5) minute intervals along with the time and date of each recording. A printout of the recording shall be furnished to the Project Manager at the end of each Work shift.

Furnish slip-form finishing Equipment with an automatic grade control device to strike off the overlay to the established grade and cross section. Finishing machines shall be self-propelled and capable of forward and reverse movement under positive control. Finishing machines shall be operated normal to the longitudinal Bridge or Roadway centerline.

Equipment shall be fitted with suitable traps, filters, drip pans, or other devices as necessary to prevent oil or other Deleterious Material from being deposited onto the existing concrete surfaces.

537.3.2 Pre-construction

537.3.2.1 Material Suppliers

The polyester concrete overlay system Supplier shall make available a technical representative for a minimum of three (3) Days to make recommendations to facilitate overlay installation. This shall include, but not be limited to, trial batch preparation, trial overlay placement, surface preparation, overlay application and overlay cure.

The system Supplier shall also provide health and safety training for personnel who are to handle the Materials.

537.3.2.2 Trial Batches and Trial Overlay

Mix one (1) or more trial batches of polyester concrete for various percentages of resin binder according to manufacturer's recommendations. The approximate percentage of polyester resin binder to use will be determined from the trial batches.

The Materials, methods and Equipment used in the trial batches shall be the same as those intended for use in the trial overlay. If at any time different Materials, methods or Equipment are to be used, new trial batches will be required.

Place one (1) or more trial overlays on a previously constructed concrete base to demonstrate the effectiveness of the proposed mixing, placing, and finishing Equipment. Each trial overlay shall be 12 ft wide, at least six (6) ft long, and the same thickness as the overlay to be constructed. The trial overlay area shall be within the Project limits and at a location approved by the Project Manager.

Remove and dispose of all Materials used in the trial batches, including the concrete base.

537.3.2.3 Concrete Repairs

Complete concrete repairs for patches, delamination, and crack filling per Section 533, "Concrete Structure Repair" as specified in the Contract, before applying the overlay. Use polyester concrete as a patching material. Apply patch material at least one (1) hour before placing the overlay or place the patch material and overlay monolithically.

After repairs are complete, clean concrete surfaces by shotblasting.

537.3.2.4 Cleaning and Preparation

Before placing the overlay, clean the concrete surface to remove Materials that may interfere with bonding or curing.

The Department will consider cleaning acceptable when the color of the concrete and mortar changes and coarse aggregate particles are exposed. Cleaning shall open the pores of sound mortar. The Department will consider pavement markings clean when exposed aggregate shows through the markings. Use a vacuum truck or air compressor to remove dust and other loose material. Do not use brooms.

Close and protect Bridge deck drains and areas of curb or railing above the proposed surface to ensure that the prime coat, polyester concrete and aggregate do not contaminate these areas.

Adequately isolate expansion joints and weakened plane joints before overlaying or saw them by approved methods within 4 hours after overlay placement.

Obtain Project Manager's approval of concrete cleaning and preparation before placing the prime coat.

537.3.3 Safety Provisions

Use personnel certified in the safe handling of Materials in accordance with the manufacturer's requirements. Provide a soap and water wash station for the workers at the

job site. Submit written documentation of material handlers' training to the Project Manager before applying the overlay.

537.3.4 Storage of Materials

Store Materials in accordance with the manufacturer's recommendations.

537.3.5 Usage Limitations

Do not overlay Bridges constructed with unventilated stay-in-place forms, unless forms are ventilated at a minimum rate of $\frac{1}{2}$ in² per square foot, or on Portland cement concrete that is less than 56 Days of age with polymer concrete overlay. Always follow manufacturer's recommendations concerning moisture content.

Submit proposed locations of the longitudinal and transverse joints for approval. Do not locate the longitudinal joints in wheel lines.

537.3.6 Application

Before applying the prime coat, the concrete area to receive the prime coat shall be dry when tested according to ASTM D 4263. The concrete surface temperature shall be between 50 degrees F and 100 degrees F during application of the prime coat. Follow the manufacturer's deck temperature recommendations. Do not use artificial methods to raise the deck temperature.

Follow the manufacturer's temperature requirements for polyester resin and aggregate components. The Contractor shall not apply polyester resin if either of the following conditions exists:

1. The air temperature is expected to drop below the manufacturer-required temperature within 8 h after application; or
2. The polyester resin gel time is less than ten (10) min.

The prime coat shall be uniformly applied to completely cover the surface to receive the polyester concrete. Apply the prime coat at an approximate rate of 0.09 to 0.11 gal/yd² prior to placement of polymer concrete. Flood concrete surfaces with the prime coat, allowing penetration into the concrete and filling of all cracks. Redistribute the applied prime coat in cracks by squeegees or brooms. The quantity of initiated, promoted resin shall be no more than what is needed to apply a prime coat. A noticeable increase in viscosity prior to placement will be cause for rejection. If the primed surface becomes contaminated, or if there is a failure of the material, clean the contaminated or failed area by abrasive blasting and re-prime.

Immediately after the prime coat has been applied, the polyester concrete overlay shall be placed, in accordance with manufacturer's guidelines.

Mix polyester concrete in mechanically operated mixers. Use a sufficient amount of initiator in the polyester concrete to produce set times between 30 and 120 minutes after placement. Accelerators or inhibitors may be required to achieve proper set times and shall be used as recommended by the resin Supplier.

Place and finish polyester concrete before gelling or within 15 minutes following addition of the initiator, whichever occurs first. Discard polyester concrete not placed within this time.

Use finishing Equipment that strikes off the polyester concrete to the established grade, cross section, and nominal depth. Fit finishing Equipment with vibrators or other means of consolidating the overlay material. Construct longitudinal joints parallel to the Roadway alignment at the approved locations. Construct vertical joints perpendicular to the deck surface.

The smoothness of the polyester concrete surface will be tested with a straightedge. The surface shall not vary by more than 0.02 feet from the lower edge of a 12 foot +/- 0.2 feet long straightedge placed in any direction. Any surface that fails to conform to the above tolerance shall be ground to meet this requirement.

Apply abrasive sand finish to polyester concrete surfaces. The sand shall be commercial quality blast sand, conforming to the absorption capacity and moisture content requirements of polymer concrete aggregate of this Specification. Provide sand such that 95% shall pass the No. 8 sieve and 95% shall be retained on the No. 20 sieve. Apply the sand finish by mechanical means immediately after overlay strike-off. Broadcast sand uniformly onto the surface before gelling occurs at a minimum rate of 1.5 lb/yd².

After application of the sand finish and before gelling occurs, texture the overlay by grooving with a steel-tined rake with tines 1/8 inch wide and spaced from 3/4 inch to 1 1/2 inch apart. Groove to a depth of 1/8 to 3/16 inch.

The surface texture of the overlay shall be uniform and shall have a coefficient of friction of not less than 0.35. If the coefficient of friction is less than 0.35, grind or groove, parallel to the centerline, those portions of surfaces until the coefficient of friction requirement is met.

537.3.7 Curing

Protect the finished overlay from moisture, Equipment, and public traffic until the overlay achieves an average Schmidt hammer reading of 24. The Schmidt hammer test shall consist of the average of ten (10) readings (strikes), all taken in an area approximately 18 inches in diameter. Perform one (1) such test per 500 sq ft of overlay. Traffic may be allowed on the overlay when the reading of 24 is achieved.

Do not contaminate concrete surfaces during clean-up of tools and Equipment. Do not dump or spill polyester concrete Materials or cleaning solvents in areas that will cause environmental or fire hazards.

537.3.9 Testing

Provide the necessary Equipment and supplies for conducting adhesion tests on the completed overlay. Perform adhesion tests according to ACI 503R - Appendix A of the ACI Manual of Concrete Practice. Adhesion tests shall obtain a 250 psi minimum pulloff or cohesive failure within existing concrete. Perform tests at a frequency of one (1) test per every 1600 sq ft of deck surface in a random location. Prime and patch test holes with polyester concrete immediately after testing.

537.3.10 Corrective Work

Correct surface variations that exceed ± 0.02 ft per 12 ft, unless otherwise directed by the Project Manager.

Repair damaged overlay areas by saw cutting in rectangular sections to the top of the concrete surface and replacing the material at no additional cost to the Department.

In the event that the testing performed under 537.3.9 does not meet minimum pulloff, the material shall be removed and replaced in the areas in which low adhesion is determined from additional testing. Any additional testing required shall be Incidental to the Work.

537.3.11 Warranty

In addition to the requirements of Section 106.10, "Guarantees and Warranties," provide a five (5)-year warranty for the overlay material and installation.

The Department will evaluate the Work and photographically document the overlay performance annually, using a pre-established joint team consisting of a Contractor and a Department representative. The evaluation will take place on the same date, ± 30 Days, as

the previous year for the life of the warranty. No spalling, scaling, cracking or delamination is acceptable during the warranty period, as defined by the following:

1. **Spalling:** Broken or missing pieces of concrete overlay due to material degradation.
2. **Scaling:** The concrete overlay surface has a visible, exposed, rough surface texture resulting from a loss of aggregate or resin.
3. **Delamination:** Visible or audible debonding of the polyester concrete Bridge deck overlay at the bond line with the existing concrete surface.
4. **Cracking:** Any visible crack not reflected from a crack in the existing concrete.

At the end of each yearly evaluation period, the Department will provide the Contractor with a report that describes occurrences of spalling, scaling, cracking, or delamination.

The Department will perform an annual skid test in accordance with AASHTO T 242. For the warranty period, an average skid test number of 0.35 or higher is acceptable.

If the overlay is not acceptable, the Department will direct the Contractor, in writing, to perform corrective Work within 180 Days, at no additional cost to the Department.

537.4 METHOD OF MEASUREMENT

Polyester concrete will be measured by the cubic yard. The volume to be paid for will be determined from calculations based on the quantity of resin binder used, the percent by weight of resin binder in the polyester concrete, and a unit weight of 135 pcf. The Contractor shall furnish suitable measuring devices to assure correct proportioning of Materials and accurate measurement for calculating payment quantities. The payment quantity shall be the calculated quantity of polyester concrete used in the Work, exclusive of material used in trial overlay and any wasted or unused material. Payment quantity will include patches.

The Contract price paid per cubic yard for polyester concrete shall include full compensation for furnishing all labor, Materials, tools, Equipment, and Incidentals, and for doing all the Work involved in placing polyester concrete, including furnishing methacrylate resin prime coat and furnishing Materials for trail overlays, removal of unsound concrete and preparation of repair areas when polyester concrete is used as the patching material, and as shown on the Plans, as specified in the Standard Specifications and as directed by the Project Manager.

Removal of loose concrete and preparation of repair areas for patching material other than polyester concrete will be measured by the square yard in accordance with Section 533, "Concrete Structure Repair."

537.5 BASIS OF PAYMENT

The accepted quantities, measured as provided above, will be paid for at the Contract price per unit of measurement for the pay items listed below that are shown in the proposal. Payment will be full compensation for the Work described in this Section.

Pay Item	Pay Unit
<i>Polyester Concrete Bridge Deck Overlay</i>	Cubic Yard

537.5.1 Work Included in Payment

The following Work and items will be considered as included in the payment for polyester concrete and will not be measured or paid for separately:

- A. ICRI concrete surface profile chips, and
- B. Removal of unsound concrete and preparation of repair areas when polyester concrete is used as the patching material.

North Carolina Specifications

1.0 GENERAL

This special provision is intended for use on bridges with an Average Daily Traffic (ADT) less than or equal to 5,000. This work shall consist of furnishing and applying an epoxy overlay system over the concrete bridge deck in accordance with the contract documents and consists of a minimum of two (2) layers of hybrid polymer resins with a special blend of extremely hard aggregate designed to provide a 3/8 inch thick overlay for the purpose of crack treatment, complete waterproofing, and providing a non-skid surface. The overlay system shall be formulated and applied to withstand continuous heavy traffic, extreme changes in weather conditions, and deformations due to structure loading and temperature changes.

2.0 PERFORMANCE GUARANTEE

A warranty letter shall be submitted to the Department stating that the epoxy manufacturer and the Contractor jointly guarantee the epoxy overlay system against all defects incurred during normal traffic for a period of (5) years. The Contractor shall provide a warranty performance bond for the total bid price of the installed material. The Contractor shall guarantee materials and workmanship against latent and patent defects arising from faulty materials, faulty workmanship or negligence for a period of ten (5) years following the date of initial acceptance of the work and shall replace defective materials and workmanship at no cost to the Department. Provide the Department with the warranty letter and warranty performance bond within 14 calendar days after notice of award is received. The bond shall be in conformance with NCGS §44A-33. The corporate surety furnishing the bonds shall be authorized to do business in the State.

The performance guarantee shall be invoked for the following defects: delamination of the epoxy overlay to the bridge surface, skid resistance less than 40 as measured by AASHTO T242 or 25 square feet of the deck surface meets the defect criteria prior to the end of the warranty. The Contractor will not be responsible for damage due to normal wear and tear, negligence on the part of the Department, or use in excess of the design. All defects shall be repaired prior to final acceptance and releasing of the warranty bond. The warranty bond will be released at the end of the warranty period or after all warranty work has been satisfactorily completed, whichever is later.

3.0 MATERIALS

This two-part epoxy polymer overlay system shall be on the NCDOT Approved Products List (APL) and be free of any fillers or volatile solvents and shall be formulated to provide a simple volumetric mixing ratio of two components such as one to one or two to one by volume. The epoxy overlay system shall be formulated to provide flexibility in the system without any sacrifice of the hardness, chemical resistance or strength of the system. Use of external/conventional flexibilizers will not be accepted. Flexibility shall be by interaction of elastomers which chemically link during the process of curing so the flexibility of the

molecule is least affected during the low temperature conditions that are confronted in actual use.

Epoxy

When the two component system is mixed at the appropriate ratio, the cured resin shall conform to the following requirements:

EPOXY PROPERTIES		
Property	Requirement	Test Method
Viscosity-Poises at 77°F ± 2°F	7-25	ASTM D2393 (Spindle No.3 at 20 rpm)
Pot Life	15-45 minutes @ 75° F	ASTM C881
Min. Tensile Strength at 7 days	2000 psi	ASTM D638
Tensile Elongation at 7 days	30-70%	ASTM D638
Min. Compressive Strength @ 3 hrs.	1,000 psi	ASTM C109
Min. Compressive Strength @ 24 hrs.	5000 psi	ASTM C109
Min. adhesion strength @ 24 hrs.	250 psi @ 75° F	ASTM C1583
Max. Water Absorption	1%	ASTM D570

Aggregate

Aggregate used for all layers shall be non-friable, non-polishing, clean and free from surface moisture. The aggregate shall be flint rock, 100% fractured, thoroughly washed and kiln dried to a maximum moisture content of 0.2% by weight, measured in accordance with ASTM C566. The fracture requirements shall be at least one mechanically fractured face and will apply to materials retained on a U.S. No. 10 sieve. Aggregate shall conform to the following requirements:

AGGREGATE PROPERTIES		
Property	Value	Test Method
Moisture Content, max.	0.2% by weight	AASHTO T255
Mohs Hardness, min.	7	
Soundness Loss, 5 cycles in Sodium Sulfate, max.	5.4%	AASHTO T104
Micro-Deval, max.	10%	AASHTO TP58

AGGREGATE GRADATION	
Sieve	Percent Passing
No. 4	100
No. 8	30-75
No. 16	Max. 5
No. 30	Max. 1

4.0 SURFACE PREPARATION

Remove all existing overlays if applicable, and all loose, disintegrated, unsound or contaminated concrete from the bridge deck. Prepare the bridge deck prior to applying the overlay system, in accordance with the manufacturer's recommendations, the special provision *Concrete Deck Repair for Epoxy Overlay*, and this provision.

Prior to overlay placement and upon completion of the deck repairs, clean the entire deck surface by steel shot blasting and other means to remove asphaltic material, oils, dirt, rubber, curing compounds, pavement markings, paint carbonation, laitance, weak surface mortar and other materials that may interfere with the bonding or curing of the overlay. Do not begin shotblasting until all grinding or milling operations are completed. Use sandblasting equipment on areas that cannot be reached by the shotblasting operation. If expansion joints are not being replaced or have been replaced prior to shotblasting they shall be protected from damage from the shotblasting operation. Pavement markings shall be considered clean when the concrete has exposed aggregate showing through the paint stripe. Deck drains and areas of curb or railing above the proposed surface shall be protected from the shotblasting operation. Mortar that is soundly bonded to the coarse aggregate shall have open pores to be considered adequate for bond. Provide a self-propelled vacuum capable of picking up dust and other loose material from the shotblasting operation. Provide air compressors equipped with oil/water separator capable of drying all moisture from the bridge deck. Care shall be taken and methods used to fully capture and collect the excess material.

Prior to overlay placement and upon completion of surface preparation, perform bond testing of the epoxy overlay material in accordance with ASTM C1583 on two pre-selected 1.5' x 3' test patches. Test locations will be determined by the Engineer. The tensile strength shall be at least 250 psi and the depth of failure into the concrete deck for 50% of the test patch area shall be 1/4" or greater. Install test sections with the same materials, equipment, personnel, timing and sequence of operations and curing time that will be used for the installation of the overlay. Test locations shall be repaired with approved repair materials.

If the cleaning method, materials and installation procedure do not produce acceptable test results, the contractor must remove failed test patches, make the necessary adjustments, and retest all patches at no additional cost to the Department until satisfactory test results are obtained.

Epoxy based overlays shall not be placed on hydraulic cement concrete that is less than 28 days old. Patching and cleaning operations shall be inspected and approved prior to placing each layer of the overlay. Any contamination of the deck or intermediate courses, after initial cleaning, shall be removed.

The deck shall be completely dry at the time of application of the epoxy concrete overlay. Deck drains shall be closed off during application of epoxy overlay.

5.0 EQUIPMENT

For mechanical applications, equipment shall consist of no less than an epoxy distribution system, aggregate spreader, application squeegee, vacuum truck, and a source of lighting if work is to be performed at night. The distribution system shall accurately measure and mix the epoxy resin and hardening agent, and shall uniformly and accurately apply the epoxy materials at the specified rate to the bridge deck in such a manner as to cover 100% of the work area. The aggregate spreader shall be propelled in such a manner as to uniformly and accurately apply the aggregate to cover 100% of the epoxy material. Aggregate shall be sprinkled or dropped vertically in a manner such that the level of the epoxy mixture is not disturbed. The vacuum truck shall be self-propelled.

For hand applications, equipment shall consist of calibrated containers, a “jiffy” type paddle mixer or other paddle designed specifically for epoxy mixing, squeegees, rollers and brooms, which are suitable for mixing the epoxy and applying the epoxy and aggregate. Paddle shall remain submerged when mixing to avoid entraining air.

6.0 APPLICATION

Handling and mixing of the epoxy resin and hardening agent shall be performed in a safe manner to achieve the desired result in accordance with the manufacturer's recommendations as approved and as directed by the Engineer. Epoxy overlay materials shall not be placed when weather or surface conditions are such that the material cannot be properly handled, placed, spread and cured within the specified requirements of traffic control.

The application rates of the liquid and stone in the 2 layers shall be as recommended by the manufacturer, but not less than the following rate of application.

TABLE 4		
APPLICATION RATES		
Course	Min. Epoxy Rate (Gal./100 SF)	Min. Aggregate Rate (Lbs./Sq.Yd)
1	2.5	10
2	5	14

The final overlay thickness shall be a minimum of 3/8". Once the epoxy mixture has been prepared, immediately and uniformly applied it to the surface of the bridge deck. There shall be no longitudinal joints of the epoxy overlay in the wheel path. The temperature of the bridge deck surface and all epoxy and aggregate components shall be 60°F or above at the time of application. Epoxy shall not be applied if the air temperature is expected to drop below 55°F within 8 hours after application or if air temperatures would cause the gel time to be less than 10 minutes. Consult with the manufacturer when placing overlay at temperatures above 90°F. The dry aggregate shall be applied in such a manner as to completely cover the epoxy mixture so that no wet spots appear and before it begins to gel. First course applications that do not receive enough aggregate prior to gel shall be removed and replaced. A second course insufficiently covered with aggregate may be left in place, but will require

additional applications before opening to traffic. After each course is fully cured, all loose aggregate shall be removed by vacuuming or brooming. Traffic shall not be allowed on the first course of the overlay. Traffic and equipment shall not be permitted on the overlay surface during the curing period. The minimum curing periods shall be as follows:

Course: Average temperature of deck, epoxy and aggregate components in °F

	60-64	65-69	70-74	75-79	80-84	85+
Course 1	4 hrs.	3 hrs.	2.5 hrs.	2 hrs.	1.5 hrs.	1 hr.
Course 2	6.5 hrs.*	5 hrs.	4 hrs.	3 hrs.	3 hrs.	3 hrs.

*Course 2 shall be cured for 8 hrs. if the air temperature drops below 60°F during the curing period.

The Contractor shall plan and execute the work to provide the curing periods as specified herein, or manufacturer proposed curing periods may be submitted to the Engineer for review and approval.

Do not apply epoxy overlay courses over modular joints, metal expansion joints, or foam joint seals. A bond breaker shall be placed on all expansion joints.

In the event the Contractor's operation damages the epoxy overlay, the Contractor shall remove the damaged areas by saw-cutting in rectangular sections to the top of the concrete deck surface and replacing the various courses in accordance with this Specification at no additional cost to the Department.

Prior to acceptance, perform bond testing for each span or 300 square yards, whichever is smaller, in accordance with ASTM C1583 on 1.5' x 3' test patches. Test locations will be determined by the Engineer. The tensile strength shall be at least 250 psi and the depth of failure into the concrete deck for 50% of the test patch area shall be ¼" or greater. Unacceptable test results will require removal and replacement of overlay as directed by the Engineer at no cost to the Department. Test locations shall be repaired with approved repair materials.

7.0 MEASUREMENT & PAYMENT

Epoxy Overlay System will be measured and paid for at the contract unit price per square feet. The price shall include surface preparation, furnishing and placing the overlay system, providing a 5 year warranty, and all tools, labor, materials, bond strength testing and any incidentals necessary to complete the work.

Payment will be made under:

Pay Item

Epoxy Overlay System

Pay Unit

Square Feet

Oregon Specifications

SECTION 00556 - MULTI-LAYER POLYMER CONCRETE OVERLAY

Section 00556, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00556.00 Scope - This work consists of preparing bridge decks and sealing and resurfacing them with a multi-layer polymer concrete overlay (MPCO).

00556.04 Submittals - Submit the following at least two weeks before beginning the overlay work:

- A manufacturer's safety data sheet for each MPCO component.
- Manufacture dates and shelf-life expiration dates for each production lot of primer/sealer and polymer components.
- Tabulated data indicating the estimated cure time, in minutes, for the allowable ambient temperature range, in increments of 10 °F.
- A detailed work plan for the MPCO preparation, application, and cleanup. Include estimated dates and timeframes.
- A fourier transform infra-red spectrum analysis of each polymer component.
- Aggregate (except moisture content) and polymer resin test results.

00556.05 Pre-placement Conferences:

(a) Supervisory Personnel - Hold a pre-placement conference with all supervisory personnel, subcontractors, suppliers, MPCO manufacturer and other personnel who will be involved in the overlay work. Meet at a mutually agreed time approximately two weeks in advance of the work. Present and discuss all phases of the overlay work.

(b) Placement Crew - Hold a second pre-placement conference with the Engineer and the entire overlay work crew at the job site one-half hour before overlay work begins to discuss placement duties and procedures. Do not begin the overlay work until this meeting is held.

Materials

00556.10 General - Furnish materials meeting the following requirements:

(a) Multi-Layer Polymer Concrete Overlay - Furnish an MPCO from the QPL.

Sample the furnished aggregate according to AASHTO T 2, and test it by performing sieve analysis according to AASHTO T 27, and additional testing according to the following:

Sieve Size	Percent Passing
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(by Weight)

4	100
8	30 – 75
16	0 – 5
30	0 – 1

Property	Test Method	Requirements
Aggregate Absorption	AASHTO T 84	1% max.
Abrasion Loss	AASHTO T 327	9.5% max.
Moisture Content *	AASHTO T 255	0.20% max.
Mohs Hardness	—	6.0 min.

* At time of mixing the polymer resin.

Package all aggregate material so that it arrives at the project site clean, dry, and at the specified moisture content.

Sample and test the elongation of the mixed polymer resin according to ASTM D 638.

(b) PCC Repair - Furnish PCC repair material according to Section 02015.

00556.16 Bond Strength - Before opening to traffic, perform two bond tests for each complete placement in the presence of and at locations designated by the Engineer. Cut 3 inch diameter cores and conduct bond tests on the cores.

The bond tests consist of:

- Coring through the MPCO approximately 1 inch into the existing concrete.
- Attaching a device to the top of the core.
- Exerting a tensile load to the core sufficient to cause failure or achieve 300 psi, whichever occurs first.

Perform bond tests when the deck surface temperature is less than 80 °F.

A successful test is the failure of the concrete substrate or bond failure at or above 250 psi.

After coring and testing, restore the area voided by the cores by blowing with compressed air and filling with MPCO material.

Equipment

00556.20 Equipment - Provide equipment to place the MPCO that meets the requirements of the manufacturer. Remove all equipment that leaks oil or other contaminants from the work area until they are repaired. Before placing the MPCO, cover the prepared deck with clear plastic, overlapping it to prevent contaminants from contacting the deck. Do not use equipment until approval is obtained.

00556.21 Surface Preparation Equipment:

(a) Sawing Equipment - Furnish power-driven concrete saws adequate for sawing joints.

(b) Scarifying Equipment - Furnish power-operated micro-milling and shot-blasting scarifying equipment capable of uniformly removing the existing surface to depths required.

(1) Micro-milling - Furnish cold plane or rotomill grinding machines using carbide cutting tools in a rotary drum. Provide equipment with tooth spacing of not more than 1/4 inch, capable of leaving a smooth, uniform pattern of striations. Limit machines to a gross operational weight of no more than 35 tons and a forward speed of 2.5 feet per minute. Operate at a drum speed of at least 120 RPM.

(2) Shot-Blasting - Furnish mono-directional or bi-directional electric-powered shot blast machines with single or multiple blast wheels that cover a width of at least 2.5 feet per pass, and conform to EPA air pollution requirements by containing dust and steel abrasive media. If the equipment is not equipped for simultaneous bi-directional blasting, make separate passes in opposite directions to ensure equal cleaning on all sides of the exposed aggregate.

(c) Power-Driven Hand Tools - Furnish power-driven hand tools for removal of unsound concrete meeting the following requirements:

- **Class 2 Preparation Equipment** - For Class 2 deck preparation, use chipping hammers equal to or less than a nominal 15 pound class.
- **Class 3 Preparation Equipment** - For Class 3 deck preparation, use chipping hammers equal to or less than a nominal 30 pound class.

(d) Hand Tools - Furnish hammers and chisels to remove final particles of unsound concrete or to achieve the required depth.

(e) Air Compressor - Furnish air compressors equipped with functioning oil traps. Ensure air used for blow-down of prepared surfaces is free of oil.

00556.24 Miscellaneous Equipment:

(a) Tools - Furnish squeegees, rollers, and other approved tools to apply the primer/sealer and the polymer resin.

Furnish a power broadcaster to uniformly apply the MPCO aggregate.

Furnish pickup type power brooms capable of removing loose aggregate.

(b) Coring Equipment - Furnish core cutting equipment that can produce a core at least 3 inches in diameter.

(c) Bond Testing Equipment - Furnish bond testing equipment that:

- Is compatible with the core tested.

- Can exert a tensile load to the core sufficient to exceed 300 psi.
- Is equipped with a measuring device capable of reading tensile force exerted within 1 percent accuracy.

Labor

00556.30 Personnel Qualifications - Provide employees meeting the following requirements:

- Workers that are certified, in writing, by the MPCO manufacturer that they are qualified to place the MPCO.
- A MPCO manufacturer technical representative that is experienced in MPCO application and mix designs.

The MPCO manufacturer technical representative duties include:

- Be present at both pre-placement conferences.
- Be at the project site and verify the deck is prepared to the manufacturer's satisfaction.
- Be at the project site during overlay placements and monitor the placement to ensure the manufacturer's recommendations are met.

Construction

00556.40 General - Prepare the entire deck surface, including the deck edge against the curb, to receive the MPCO. Remove all grease, oil, paint, dirt, laitance, rust, and all other contaminants that would affect adhesion of the MPCO.

00556.41 Surface Preparation:

(a) General - Remove surface concrete by approved hand methods that cannot be reached by power-driven equipment.

Remove existing asphalt wearing surfaces according to Section 00503.

Dispose of all materials according to 00290.20.

Perform a de-lamination deck survey using chain drag or other approved methods to determine limits of Class 2 preparation required.

(b) Bridge Deck Drains - Temporarily block all deck drains and catch basins while preparing the surface and placing MPCO. Do not allow scarifying, chipping, sawing, sandblasting, shot-blasting, sweeping, water blasting, or flushing material to enter them.

(c) Expansion Joints - Before constructing the MPCO, block out expansion joints with rigid polyethylene foam or other approved material, compatible with the primer/sealer and polymer resin.

Remove material that is within 12 inches of all joints with bush-hammers, scabblers or by other means acceptable to the Engineer. Do not damage the joints.

(d) Initial Surface Preparation - Perform surface preparation far enough in advance of resurfacing so that all further deck preparation can be satisfactorily completed. Prepare bridge decks according to the following:

(1) Class 1 Preparation - Before beginning Class 1 preparation, construct a 50 foot long by 5 foot wide test strip in an area approved by the Engineer. Roughen the existing concrete surface to an exposed aggregate surface texture depth profile of at least 1/16 inch, determined according to ASTM E 965 (standard volumetric test). Do not proceed with Class 1 preparation until the Engineer approves the test strip results.

Continue to roughen the existing concrete surface to match the test strip.

Protect visible reinforcing steel and reinforcing steel where the plans show it to be within 1/2 inch of the surface.

(2) Class 2 Preparation - In Class 2 areas, remove concrete with nominal 15 pound powered chipping hammers as follows:

- Remove all unsound concrete from the lower limit of Class 1 preparation down to a maximum depth of half the total thickness of the existing deck.
- Remove a minimum of 3/4 inch of concrete around and below reinforcing steel that is not at least 50% embedded in the existing concrete surface.
- Sandblast reinforcing steel coated or pitted with rust to a bright finish.

(3) Class 3 Preparation - When Class 3 preparation is required, it will be designated by the Engineer and performed as Extra Work.

Perform Class 3 preparation as follows:

- Remove the full thickness of deck remaining below the lower limit of Class 2 preparation, using jackhammers.
- Sandblast reinforcing bars pitted with rust to remove all rust.

When concrete is removed to the limits of Class 2 and Class 3 preparation, repair the deck with a PCC repair material compatible with the MPCO. Cure the PCC repair material according to the manufacturer's recommendations before placing the MPCO. Prior to production, test the PCC repair material to MPCO bond according to 00556.16.

(e) Final Surface Preparation - Roughen the surface leaving an exposed aggregate surface texture depth profile of at least 1/16 inch, determined according to ASTM E 965 (standard volumetric test). Take at least two tests for each placement or for every 350 square yards of surface area whichever is greater.

(1) Micro-milling - When micro-milling is used, prepare final surfaces by:

- Shot-blasting.

- Sweeping the area magnetically to remove metal residue.
- Cleaning with an air compressor immediately before resurfacing.

(2) Shot blasting - When shot-blasting is used, prepare surfaces by:

- Sweeping the area magnetically to remove shot and metal residue.
- Cleaning with an air compressor immediately before resurfacing.

00556.42 Placing MPCO:

(a) Placement Conditions - Place MPCO on prepared surfaces only when all of the following conditions are met:

- The air temperature and the deck surface temperature are within the manufacturer's recommended range.
- The entire deck surface is dry by visual inspection.
- Moisture is not present on the deck surface by visual inspection and moisture is not visible on a test sheet when tested according to ASTM D 4263.
- During the hours of darkness, work areas are illuminated. Submit an illumination plan for approval at the pre-placement conference.

(b) Thickness - Place MPCO in lifts to achieve a total minimum thickness of 3/8 inch.

(c) Mixing the Polymer Resin - Condition and mix the polymer resin as recommended by the manufacturer. Do not dilute, thin, or add foreign material to either the individual polymer resin components or the mixed polymer resin.

(d) Overlay Application - With the Engineer's approval of the surface preparation, apply the MPCO according to the manufacturer's recommendations.

After each lift, before gelling of the polymer resin occurs, broadcast a layer of aggregate at a rate of 2 pounds of aggregate per square yard or until no wet spots are visible.

Feather the MPCO to the expansion joint edges.

If application of the MPCO surface does not meet the manufacturer's recommendations, stop the operation until revised methods, changes in equipment, or correction of procedures are proposed and approved.

(d) Curing - Cure the MPCO according to the manufacturer's recommendations before subjecting it to loads or traffic.

00556.43 De-lamination Survey and Repair - The completed MPCO surface will be inspected by the Engineer for de-lamination, bond failure, and other damage by use of a chain drag, coring, and other devices. Areas of de-lamination of less than 1 square foot will not require repair. Core samples that do not achieve bond strength of at least 250 psi will be at no additional cost to the Agency. Core samples with a bond strength of 250 psi or greater will be paid as Extra Work.

Repair all surface defects by removing the defective material and reapplying the MPCO. Do not damage adjacent materials or steel substrates. Repair to the satisfaction of the Engineer at no additional cost to the Agency.

Make all repairs before opening to traffic or, if the resurfaced area is opened to traffic at the Contractor's request before completing repairs, all additional traffic control to complete the repairs will be at no additional cost to the Agency.

00556.44 Use of New Surface:

(a) Vehicles - Do not allow vehicles or construction equipment on the MPCO surface until curing is complete.

(b) Traffic - Do not open sections to traffic until approved by the Engineer. Before opening to traffic, remove all loose aggregate by power brooming and open all drains.

Measurement

00556.80 Measurement - The quantities of work performed under this Section will be measured according to the following:

- **Class 2 Preparation** - Class 2 preparation will be measured on the area basis.
- **Furnish MPCO Material and Constructing MPCO** - Furnishing and constructing multi-layer polymer concrete overlay will each be measured on the area basis. The area will be determined by measuring the actual surface area of the resurfaced bridge deck.

Payment

00556.90 Payment - The accepted quantities of work performed under this Section will be paid at the Contract unit price, per unit of measurement, for the following items:

Pay Item	Unit of Measurement
(a) Class 2 Preparation	Square Yard
(b) Furnish MPCO Material	Square Yard
(c) Construct MPCO	Square Yard

Payment will be payment in full for furnishing and placing all materials, and for furnishing all equipment, labor, and incidentals necessary to complete the work as specified.

No separate or additional payment will be made for Class 1 preparation work.

Class 3 preparation will be paid for as Extra Work according to Section 00196.

Pennsylvania Specifications

DESCRIPTION - This work is preparing deck surfaces, furnishing and construction of a multiple layer wearing surface of epoxy resin or epoxy-urethane resin and aggregate on in-service bridge decks.

The indicated or specified depth of the wearing surface is minimum.

II. MATERIAL -

(a) Epoxy Resin. A two-component, (base and hardener), 100% solids, thermosetting, moisture insensitive, flexible, high elongation epoxy resin, from a manufacturer listed in Bulletin 15, and meeting the following physical requirements at 24 +/- 1 C (75 +/- 2 F) when base and hardener are combined:

Viscosity (ASTM D 2393-86, Model RVT Brookfield, Spindle No. 3 at 20 rpm)	10-25 poises
Gel Time (ASTM C 881, para. 11.2 modified, 70 ml sample)	15-45 minutes
Tensile Strength (neat), 7-day (ASTM D 638) (2,500-5,000 psi)	17.2 - 34.4 MPa
Tensile Elongation (neat), 7-day (ASTM D 638)	30-70%
Absorption (neat), 24-hour (ASTM D 570)	1%, Maximum
Compressive Strength (mixed with aggregate), 3 hrs.(1,000 psi, minimum) (ASTM C 109, 50 mm square mortar cube with plastic inserts)	6.9 MPa
Compressive Strength (mixed with aggregate), 24 hrs.(5,000 psi, minimum) (ASTM C 109, 50 mm square mortar cube with plastic inserts)	34.4MPa
Permeability to chloride ion, 28-days (AASHTO T277)	100 coulombs, Maximum
Thermal Compatibility (Mixed with aggregate) (ASTM C 884)	No delamination of overlay or cracks in the concrete
Infrared spectrum (AASHTO T237, para. 4 & 5)	Established for each for each component for each Manufacturer

(b) Epoxy-Urethane Resin. A two-component, (base and hardener), 100% solids, thermosetting, moisture insensitive, flexible, high elongation epoxy-urethane resin, from a Manufacturer listed in Bulletin 15, and meeting the following physical requirements at 24 +/- 1 C when the base and hardener are combined:

Viscosity (ASTM D 2393-86, Model RVT Brookfield, Spindle No. 3 at 20 rpm)	35-70 poises
Gel Time (ASTM C 881, para. 11.2 modified, 70 ml sample)	15-45 minutes
Tensile Strength (neat), 7-day (ASTM D 638) (2,500-5,000 psi)	17.2 - 34.4 MPa
Tensile Elongation (neat), 7-day (ASTM D 638)	30-70%
Absorption (neat), 24-hour (ASTM D 570)	1%, Maximum
Compressive Strength (mixed with aggregate), 3 hrs.(1,000 psi, minimum) (ASTM C 109, 50 mm square mortar cube with plastic	6.9 MPa

inserts)	
Compressive Strength (mixed with aggregate), 24 hrs.(5,000 psi, minimum) (ASTM C 109, 50 mm square mortar cube with plastic inserts)	34.4MPa
Permeability to chloride ion, 28-days (AASHTO T277)	100 coulombs, Maximum
Thermal Compatibility (Mixed with aggregate) (ASTM C 884)	No delamination of overlay or cracks in the concrete
Infrared spectrum (AASHTO T237, para. 4 & 5)	Established for each for each component for each Manufacturer

(c) Certification.

Certify each lot of epoxy or epoxy-urethane resin as specified in Section 106.03(b)3.

Independent quality assurance sampling and testing may be performed by the Bureau of Construction and Materials and will be used for the purpose of making independent checks on the certification acceptance procedure as specified in Section 106.03(b)1.

(d) Fine Aggregate. Provide aggregate from an approved source of Type A fine aggregate listed in Bulletin 14 and/or approved by the Bureau of Construction and Materials, and also approved by the epoxy-based concrete overlay Manufacturer. This aggregate consists of angular silica sand, basalt, or other highly siliceous metamorphic or igneous rock having less than 0.2 percent moisture, and free of dirt, clay asphalt and other foreign or organic materials. Provide an aggregate with a minimum Mohs' scale hardness of 7, and meeting the following gradation:

Sieve Size	Percent Passing by Weight
4.75 mm (#4)	100
2.36 mm (#8)	30 - 75
1.18 mm (#16)	0-5
600 m (#30)	0-1

(e) Manufacturer Technical Representative. Have a trained, Manufacturer Technical Representative present during every phase of the application, unless a factory trained, licensed installer, as indicated by written approval from the Manufacturer, applies the epoxy-based concrete overlay. Manufacturer Technical Representative will provide recommendations to the Engineer on approval or disapproval of deck surface preparation, equipment, mixing of components, type and method of application, and finish.

III. CONSTRUCTION -

(a) Delivery and Storage. Order, stock and store the material necessary to perform the entire overlay application prior to any field preparation. Deliver and store all epoxy-resin and epoxy-urethane resin materials in containers, with the manufacturer's name, date of manufacture, batch number, trade name, quantity and mixing ratio printed on the label.

Store and protect the materials from the elements to insure their quality and fitness for the work. Keep the storage space clean and dry, and do not allow the temperature of the storage space to fall below 16 C (60 F) or exceed 38 C (100 F). Avoid contact with flame.

Immediately remove from the work site any material which is rejected because of failure to meet the required tests or that has been damaged.

(b) Equipment. Have all equipment for the deck preparation, mixing and placement of the epoxy-based concrete overlay approved by the Engineer prior to the start of any work.

1. Surface Preparation Equipment. Provide shotblasting equipment capable of removing partially loosened chips of concrete, cleaning the bridge deck surface, roughening the bridge deck surface, and removing rust and/or corrosion from steel expansion joint assemblies or steel-grid decking. Do not use scarifiers, milling machines, or sandblasting in lieu of shotblasting, unless otherwise approved by the Engineer.

Provide a self-propelled vacuum capable of picking up dust and other loose material from the shotblasting operation.

Provide air compressors equipped with an oil/water separator capable of drying all moisture from the bridge deck.

2. Epoxy Resin or Epoxy-Urethane Resin Application Equipment. Of the following types:

2.a Mechanical Application Equipment. Provide mechanical metering, mixing, and distribution equipment that accurately meters and blends the base and hardening components, and uniformly applies the blended epoxy-based resin at the specified rate to the bridge deck in order to cover 100% of the work area. Provide equipment approved by the epoxy-based overlay Manufacturer.

Provide a fine aggregate spreader that uniformly applies the aggregate at the specified rate in order to cover 100% of the epoxy-based resin material.

Provide a self-propelled vacuum truck.

Provide lighting for work performed at night.

2.b Hand Application Equipment. Provide calibrated containers for proper proportioning of the base and hardening components.

Provide a clean, dry, container large enough to blend and mix the proper proportions of base and hardening components.

Provide a powered, paddle-type mixer for blending the base and hardening components.

Provide squeegees, rollers or brooms that are suitable for applying the mixed epoxy-based resin on the bridge deck surface at the specified application rate.

Provide shovels, hand spreaders, and/or other hand tools that are suitable for applying the aggregate at the specified rate.

Provide brooms or air compressors equipped with an oil/water separator to remove excess aggregate after each layer of the overlay has cured.

(c) Surface Preparation. Remove any unsound concrete and repair the areas in accordance with Section 1040, as directed by the Engineer. Do not use patching material containing magnesium phosphate.

Do not apply the epoxy-based concrete overlay on hydraulic cement concrete that is less than 28 days of age. Not more than 24 hours before overlay placement begins, clean the surface of the bridge deck by shotblasting and/or other approved methods to expose the coarse aggregate, and to remove any asphaltic material, oils, dirt, rubber, curing compounds, paint carbonation, laitance, weak surface mortar, and other detrimental materials that would interfere with the bond or cure of the overlay. After shotblasting, vacuum the bridge deck surface to remove all dust and other loose material. Brooms are not to be a substitute for the vacuum. Protect the existing expansion dams in a manner acceptable to the engineer during surface preparation.

Use compressed air that is free of oil and water to remove all moisture from the surface of the bridge deck before application of the overlay. Maintain a completely dry surface during the application of the epoxy-based concrete overlay.

Protect the deck against damage, contamination and traffic until the overlay operation is completed. Satisfactorily repair damaged areas prior to placing succeeding construction.

(d) Placing Epoxy-Based Concrete Overlay. Satisfy the Engineer that all necessary equipment, tools, materials, and manpower are on hand at the site of work, and that all workers are familiar with the blending and application of the overlay.

If required by the Engineer, place the overlay on a small test strip not to exceed 9 square meters (100 square feet) off the project site. Use the test strip for equipment calibration and to establish procedures, and techniques for the actual overlay placement on the bridge deck.

Cover exposed areas not to be overlaid with the epoxy-based concrete overlay, such as curbs, sidewalks, railings, parapets, or inlets with suitable coverings.

Premark the bridge deck surface as a guide to obtain the proper application rate when applying the mixed epoxy-based resin by hand.

Combine and mix the base and hardener components as specified by the Manufacturer. Immediately after mixing, apply the mixed epoxy-based resin by a distributor, squeegee, or paint roller, or combinations thereof. Apply the material smoothly, uniformly and continuously over 100 percent of the deck surface. do not allow the mixed epoxy-based resin to puddle or accumulate in holes or depressions in the deck.

Apply the epoxy-based concrete overlay using a minimum of two (2) separate courses at the following application rates:

Course	Mixed Epoxy-Based Resin Application Rate	Aggregate Application Rate
	Liters/Sq. Meter (gal./100 sq. ft.)	Liters/Sq. Meter (lbs./sq.yd.)
1	1.0 (2.5) minimum	5.4+
2+	2.0 (5.0) minimum	7.6+

Apply the aggregate at the specified rate, in a uniform manner, such that the aggregate just covers the epoxy base resin. Apply the aggregate within five minutes after application of the mixed epoxy-based resin or as recommended by the Manufacturer.

Repair areas of individual courses identified by the engineer that did not receive a uniform and sufficient application of aggregate before the epoxy based resin is cured. Sandblast areas identified as having insufficient aggregate. Clean sandblasted areas of all loose material. Apply the epoxy-based resin and aggregate to the clean, sandblasted areas in accordance with these specifications.

Remove the excess aggregate from each course after the course has completely cured. Use brooms, vacuums, compressed air free from oil and water, or other approved methods to remove the excess aggregate. Do not remove excess aggregate until vacuuming or brooming can be performed without tearing or damaging the surface.

Protect the existing expansion dams with suitable covers during application of the multilayer epoxy based concrete overlay.

(e) Limitation of Operations. Do not apply the epoxy-based concrete overlay at surface, air, or resin and aggregate component temperatures lower than 16 C (60 F). Do not apply the epoxy-based concrete overlay if the temperature is expected to drop below 13 C (55 F) within 8 hours after application, or the gel time of the mixed epoxy-based resin experienced becomes less than 10 minutes.

Do not allow vehicular traffic on the first course. Do not allow vehicular traffic on any course during the cure period.

Cure each course for the minimum cure period as follows unless longer periods are recommended by the Manufacturer.

Average temperature of deck surface, resin, and aggregate components in C (degree F):

Course	16-18 (60-64)	19-21 (65-69)	22-23 (70-74)	24-26 (75-79)	27-29 (80-84)	30 + (85 +)
1	4 hrs	3 hrs	2.5 hrs	2 hrs	1.5 hrs	1 hr
2+	6.5 hrs	5 hrs	4 hrs	3 hrs	3 hrs	3 hrs

(f) Defective Work. In accordance with Section 105.12 and as follows:

If temperatures fall below 16 C (60 F), the Engineer will require a longer curing period. If, at any time during the curing period, the temperature falls below 10 C (50 F), the work may be considered unsatisfactory and rejected.

Protect freshly applied epoxy-based concrete overlays from sudden or unexpected rain Contractor operations. Stop all application operations when it starts to rain. The Engineer may order removal and replacement of any material damaged by rainfall or Contractor operations that cannot be satisfactorily repaired.

Remove the replace rejected or damaged epoxy-based concrete overlay in rectangular sections by milling or saw cutting to the top of the concrete deck surface. Remove and replace at no additional cost to the Department.

(g) Application of Live Loads. Do not allow vehicular equipment or the traveling public on the epoxy-based concrete overlay before the overlay is cured.

IV. MEASUREMENT AND PAYMENT - Square Meter (Square Yard).

Payment includes surface preparation, furnishing and applying all courses and saw cutting the joints.

Repairs to the bridge deck will be paid separately for type of concrete bridge deck repair indicated

South Dakota Specifications

**STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION
FOR
TWO COAT EPOXY BRIDGE DECK CHIP SEAL**

OCTOBER 21, 2012

Delete Section 491 of the Standard Specifications for Roads and Bridges and replace with the following:

491.1 DESCRIPTION

This work consists of the preparation of the plans specified existing bridge deck surface and furnishing and placing two coats of an epoxy chip seal on the prepared bridge deck surface.

491.2 MATERIALS

A. Epoxy: Epoxy shall be a two component epoxy consisting of a base component and a hardener. Both components shall be supplied in tightly sealed undamaged containers. The containers shall be marked to identify each component and shall be clearly labeled with product name, mixing instructions and proportions, recommended storage temperature, lot number, batch number, date of manufacture and quantity contained. The epoxy shall be one of the epoxies from the Approved Products List.

B. Cover Aggregate: The cover aggregate shall be processed washed and dried dark grey or black colored aggregate. Washing shall remove dust covering the aggregate. Recycled cover aggregate shall not be used. Cover aggregate shall conform to the following:

1. The Mohs hardness must be 6.0 minimum.
2. The gradation shall conform to the following:

<u>Sieve Size</u>	<u>% Passing</u>
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	30 - 75
No. 16 (1.18 mm)	0 - 5
No. 30 (600 µm)	0 - 1

3. The maximum aggregate moisture at the time of application shall not exceed 0.5 %.
4. The aggregate shall be supplied in waterproof bags and shall be stored in a dry, moisture-free atmosphere. The aggregate shall be fully protected from any contaminants on the job site and shall be stored so as not to be exposed to rain or other moisture sources. Materials shall remain adequately covered and protected from contamination throughout the project. Any material not adequately covered or found to be contaminated shall not be used.
5. The Contractor shall submit a sieve analysis for the processed washed and dried aggregate and documentation of the Mohs hardness with the certified test reports. No field samples for sieve analysis or hardness shall be required.

491.3 CONSTRUCTION REQUIREMENTS

A. Surface Preparation:

1. **Grinding:** The bridge deck surface shall be ground prior to placement of epoxy chip seal.

The grinding shall remove the existing surface conditions as defined by the bridge plan notes including, but not limited to; rubberized asphalt chip seal, epoxy chip seal, pavement markings, and tining and shall be to the satisfaction of the Engineer.

The grinding shall be performed in the longitudinal direction. The grinding shall result in a parallel corduroy texture consisting of grooves between 0.090 and 0.130 inches (2 and 3 mm) wide. The distance between the grooves shall be between 0.060 and 0.125 inches (1.5 and 3 mm). The peaks of the ridges shall not be greater than 1/16 inch (1.5 mm) higher than the bottom of the grooves. The grinding shall be uniform and shall follow the existing profile of the bridge deck. The grinding process shall not introduce dips and bumps that did not previously exist on the bridge deck surface or in any way decrease the existing riding quality of the bridge deck.

Grinding of the bridge deck shall be accomplished utilizing diamond blades mounted on a self-propelled machine designed for grinding and texturing pavement. The equipment shall be operated in such a manner that it will not damage the underlying deck surface. Grinding equipment that causes ravels, aggregate fractures, or spalls shall not be permitted. Residue or excess water generated by the grinding operations shall be removed with vacuum equipment from the deck surface before the residue

has time to set up. Vacuumed residue or excess water shall not be expelled on the approach roadway or shoulder surfaces.

2. **Shot Blast and Abrasive Blast Cleaning:** After grinding and removal and replacement of loose and delaminated concrete, the entire bridge deck surface shall be thoroughly shot blasted to approximately an International Concrete Repair Institute (ICRI) concrete surface profile CSP-5 (medium shot blast) to remove all foreign materials which may interfere with the bonding or curing of the epoxy chip seal. The shot blasting shall remove all surface laitance and shall expose the coarse aggregate to the satisfaction of the Engineer. Small areas where shot blasting is unable to be performed (curb lines, etc.) shall be cleaned by abrasive blast cleaning to the satisfaction of the Engineer.

Upon completion of the shot blasting and abrasive blasting, the entire bridge deck shall be blown clean with dry compressed air to remove all dust and debris.

Cleaning by shot blasting, abrasive blasting, and compressed air shall be done no more than 24 hours prior to the placement of the epoxy chip seal. In the event that the epoxy chip seal is not placed within 24 hours of shot blasting and abrasive blast cleaning or in the event of rain or other inclement weather contaminating the surface, the surface shall be re-cleaned by abrasive blast cleaning and dry compressed air.

Only equipment required for the application of the epoxy chip seal will be allowed on any portion of the bridge deck which has been cleaned and prepared for application of the epoxy chip seal. If equipment is used on the cleaned and prepared bridge deck, the area shall be protected from contamination with plastic.

B. Bridge Deck Epoxy Chip Seal:

1. **Seasonal Limitations:** Epoxy chip seals shall only be applied within the seasonal limitation of May 1 to October 15 (inclusive).
2. **Manufacturer's Representative:** An approved manufacturer's representative shall be present on the jobsite for a minimum of two full production days of epoxy chip seal application.

The manufacturer's representative shall provide the Engineer and the Contractor with a copy of the written recommendations, technical data sheet, and product safety data sheet. In addition, the Contractor shall make a product safety data sheet available to anyone that will be exposed to the epoxy materials.

- 3. Epoxy Application Requirements:** The Contractor shall store, mix, handle, and apply the epoxy in accordance with the manufacturer's recommendations, or as approved by the Engineer, unless otherwise specified by the following requirements:
- a. Epoxy shall not be applied to the bridge deck surface unless the ambient air temperature and the bridge deck surface temperature is between 50°F and 100°F (10°C and 38°C) with the air temperature at least 5°F (2.8°C) above the dew point temperature. In addition, the forecast for the duration of the application period plus four hours after the anticipated completion of the chip seal application shall be such that no rain is expected and temperatures are forecasted to be between 50°F and 100°F (10°C and 38°C) with the air temperature at least 5°F (2.8°C) above the dew point temperature.
 - b. The application of the epoxy chip seal system shall not be made on a wet or damp surface. In the event of rain, the surface shall be dried for 24 hours prior to application. In lieu of waiting the 24 hours, ASTM D 4263 "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method" may be used to determine when all moisture is out of the concrete. The use of a surface moisture meter to determine surface conditions will not be allowed.
 - c. The openings of any bridge deck drains shall be temporarily sealed during epoxy placement as approved by the Engineer.
 - d. When phased construction of the epoxy chip seal is required, the Contractor shall maintain a straight line between the phases of epoxy placement for both layers by masking the line between phases with duct tape, or other material approved by the Engineer. The masking shall be completely removed before the epoxy achieves initial set and shall be removed in a manner that will not damage the adjacent epoxy. Overlapping the new epoxy chip seal onto existing epoxy chip seal shall not be done.
 - e. Prior to mixing the bridge deck needs to be marked in a grid to insure that proper spread rates are achieved.
 - f. A prime coat, if required by manufacturer, shall be applied according to manufacturer's recommendations and will be applied in addition to the two coats of epoxy chip seal.
 - g. A coat of epoxy shall be distributed at the manufacturers' recommended application rate. The application rate shall be a minimum of 1 gallon per 40 square feet (1 liter per 1 square meter).

4. Cover Aggregate Application Requirements:

- a. After the epoxy is distributed on the application area of the bridge deck surface, a broadcast of cover aggregate shall be made to refusal such that:
 - 1) A uniform layer of cover aggregate is attained. *(A non-uniform broadcast will result in an inconsistent epoxy chip seal thickness and a poor riding bridge deck).*
 - 2) There are no visible shiny wet spots after application.
- b. Broadcasting shall be done by hand-seeding or other methods approved by the manufacturer's representative such that the following conditions are met:
 - 1) Cover aggregate is required to be broadcast in such a manner that the aggregate is falling vertically to the bridge deck surface to prevent pushing of the epoxy resin.
 - 2) Aggregate coverage is uniform over the application area.

5. Clean-up of Excess Cover Aggregate: The epoxy shall be allowed to cure before excess cover aggregate is removed. Cure the epoxy for 2 to 6 hours depending on temperature before removing excess cover aggregate. The epoxy must have sufficient strength to retain aggregate. Excess aggregate will be removed by brooming, high pressured dry air, or vacuuming and shall be disposed of by the Contractor as approved by the Engineer.

6. Second Coat Epoxy Application: A second coat of epoxy shall be distributed at the manufacturer's recommended application rate. The application rate shall be a minimum of 1 gallon per 20 square feet (2 liters per 1 square meter). Cover aggregate shall be broadcast as per section 491.3 B.4 of this special provision. In the event of rain before second coat is applied, the surface shall be dried for 24 hours prior to application. If second coat is not applied within 24 hours or traffic is allowed on the first coat, deck must be abrasive blasted prior to application.

7. Testing: Pull-off tests shall be performed after the final coat of epoxy chip seal is cured and excess aggregate is removed to verify adequate bond strength of the epoxy to the cover aggregate and concrete substrate. Pull-off tests shall be performed by the Contractor and shall be witnessed by the Engineer. Placement of pull-off test shall be decided by the Engineer and be performed prior to opening to traffic. Pull-off tests may not be performed when the surface temperature is at or above 90°F (32°C). One

pull-off test shall be performed for each 75 linear feet (23 meters) of epoxy chip seal application width, up to 24 feet (7.5 meters) wide, for each structure. A minimum of 3 pull-off tests will be required for each structure. The testing shall be performed as follows:

- a. Pull-off tests shall be performed according to ASTM D7234-05.
- b. Pull-off tests with a resulting load of 250 psi (1.7 Mpa) or more shall be considered passing.
- c. All pull-off tests with a resulting load of less than 250 psi (1.7 Mpa) shall be retested according to the type of failure. There are four possibilities or combinations thereof as described below:
 - 1) Failure in the concrete substrate (concrete failure) - The Contractor shall perform one additional test within one foot (0.3 meter) of the failing test to verify concrete failure.
 - 2) Detaching assembly adhesive failure (adhesive failure) - The Contractor shall perform one additional test within one foot (0.3 meter) of the failing test. The Contractor shall repeat the test until the adhesive no longer fails.
 - 3) Separation of the epoxy chip seal from the concrete surface (epoxy failure) - the Contractor shall perform two additional pull-off tests as described below.
 - 4) Pullout of the aggregate from the epoxy (epoxy or aggregate failure) - The Contractor shall perform two additional pull-off tests as described below.

For failure 3 or 4, the Contractor shall perform two additional pull-off tests. One test shall be performed between 10 ft. (3 meters) and 15 ft. (4.5 meters) back from the failing test and one test shall be performed between 10 ft. (3 meters) and 15 ft. (4.5 meters) ahead of the failing test. If either of these two additional pull-off tests fails, the epoxy chip seal fails and the failing epoxy chip seal shall be removed and replaced at the Contractor's expense. The limits of the failing epoxy chip seal shall be defined as the epoxy chip seal one-half of the distance back and one-half of the distance ahead to the adjacent passing tests.

When the detaching assembly has been separated from the surface, the damage created by the test shall be repaired using a small amount of the epoxy and aggregate used in the epoxy chip seal.

491.4 METHOD OF MEASUREMENT

- A. Bridge Deck Grinding:** Measurement will not be made for Bridge Deck Grinding. The plan quantity will be the basis of payment
- B. Abrasive Blasting of Bridge Deck:** Measurement will not be made for Abrasive Blasting of Bridge Deck. The plan quantity will be the basis of payment.
- C. Two Coat Epoxy Bridge Deck Chip Seal:** Measurement will not be made for Two Coat Epoxy Bridge Deck Chip Seal. The plan quantity will be the basis of payment.
- D. Pull-Off Test:** Measurement will not be made for Pull-Off Tests.

491.5 BASIS OF PAYMENT

- A. Bridge Deck Grinding:** Bridge Deck Grinding, when specified in the plans, will be paid for at the contract unit price per square yard (square meter). Payment will be full compensation for all labor, equipment, materials, and all incidental work required to grind the bridge deck surface to the required profile and to remove and dispose of the grinding residue and water.
- B. Abrasive Blasting of Bridge Deck:** Abrasive Blasting of Bridge Deck will be paid for at the contract unit price per square yard (square meter). Payment will be full compensation for all labor, equipment, materials, and all incidental work required to shot blast and abrasive blast clean the bridge deck surface of all foreign materials and to remove and dispose of all residue.
- C. Two Coat Epoxy Bridge Deck Chip Seal:** Two Coat Epoxy Bridge Deck Chip Seal will be paid for at the contract unit price per square yard (square meter). Payment will be full compensation for all labor, equipment, materials, and all incidental work required to furnish and install the Two Coat Epoxy Bridge Deck Chip Seal and to remove and dispose of the excess cover aggregate.
- D. Pull-Off Test:** No payment will be made for Pull-Off Tests. All costs related to the testing for labor, test equipment, laboratory, tools and all incidentals required to satisfactorily perform the required work shall be incidental to the contract unit price for Two Coat Epoxy Bridge Deck Chip Seal.

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Utah Specifications

SECTION 03372

THIN BONDED POLYMER OVERLAY

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Materials and procedures for applying a protective crack treatment and bridge deck overlay using either an epoxy-urethane co-polymer (Type 1) or a modified epoxy polymer (Type 2) with a broadcast aggregate wearing surface.
- B. Procedures for removing polymer overlay from concrete deck.

1.2 RELATED SECTIONS

- A. Section 03934: Structural Pothole Patching

1.3 REFERENCES

- A. AASHTO T 242: Frictional Properties of Paved Surfaces Using a Full-Scale Tire
- B. ASTM C 566: Total Evaporable Moisture Content of Aggregate by Drying
- C. ASTM C 579: Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
- D. ASTM C 881: Epoxy-Resin-Base Bonding Systems for Concrete
- E. ASTM D 570: Water Absorption of Plastics
- F. ASTM D 638: Tensile Properties of Plastics
- G. ASTM D 790: Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- H. ASTM D 2240: Rubber Property – Durometer Hardness
- I. ASTM D 4263: Indicating Moisture in Concrete by the Plastic Sheet Method
- J. ASTM D 4285: Indicating Oil or Water in Compressed Air

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- K. ASTM D 5821: Determining the Percentage of Fractured Particles in Coarse Aggregate
- L. ASTM E 965: Measuring Pavement Macrottexture Depth Using a Volumetric Technique
- M. American Concrete Institute (ACI)
- N. International Concrete Repair Institute (ICRI)

1.4 DEFINITIONS

- A. Polymer Overlay System – A two-part polymer resin system applied as a wearing surface and saturated with a broadcast aggregate before it cures. The polymer uses volumetric mixing proportions according to the manufacturer's recommendations.

1.5 SUBMITTALS

- A. Manufacturer
 - 1. The name of the polymer overlay manufacturer and the name and phone number of the manufacturer's Technical Support Representative at the Pre-Construction Meeting.
- B. Certificate of Compliance
 - 1. A certificate of compliance from an independent nationally recognized laboratory stating that the polymer overlay materials meet the requirements contained in this specification, to the Engineer for approval at least 10 days before placement. Additional approval needed for any substitutes.
- C. Furnish at least a one quart sample of each component from each lot to the Department laboratory to verify material supplied.
- D. A warranty letter to the Engineer and the Department Bridge Operations Engineer before acceptance is given stating that the polymer manufacturer and the Contractor jointly guarantee the wearing surface against all defects incurred during normal traffic for a period of five years including any delamination or skid resistance less than 40, as measured according to AASHTO T 242.
 - 1. The guarantee period starts on the date of owner acceptance, typically the date traffic is allowed on the surface.

- E. Warranty Bond
1. Provide a manufacturer warranty bond for the total bid price of the installed material.
 - a. Calculate the total bid price by using the quantity of polymer overlay material listed in the Engineers Estimate and the average unit bid price for the material obtained from the Construction Division's Project Development Business System (PDBS).
 - b. The quantity will be the actual area of the deck and approach slabs in the absence of a quantity specified in the Engineers Estimate.
 2. Warranty period covers the period of time specified in the warranty letter submitted to the Engineer.
 3. Underwriting Limitation is stated in the United States Department of Treasury Circular 570, Surety Companies Acceptable on Federal Bonds. Only companies listed in the Department of Treasury Circular 570 are acceptable.
 4. Proof of bond to the Engineer before placing the material.

PART 2 PRODUCTS

2.1 POLYMER OVERLAY SYSTEM

- A. Use a thin bonded polymer bridge deck overlay system using either an epoxy-urethane co-polymer (Type 1) or modified epoxy polymer (Type 2) as specified on the plan or detail sheets that meet the requirements of Table 1 and includes all materials, penetrating crack filler when required by the manufacturer, and polymer resin broadcast that chemically cures to provide an impervious wearing surface.

Table 1

PHYSICAL PROPERTIES OF THE CURED OVERLAY SYSTEM		
Property	Value	Method
Compressive Strength, min. psi	5,000	ASTM C 579
Tensile Strength, min. psi	2,000	ASTM D 638
Tensile Elongation, min. percent	30-80	ASTM D 638
Water Absorption, max. percent by wt.	1.0	ASTM D 570
Shore D Hardness, min. 77°F	60-75	ASTM D 2240
Gel Time, minutes	15-45	ASTM C 881
Adhesion to Concrete	100% failure in concrete	ACI-503-R, Pull Out Test
Flexural Yield Strength, min. psi	3,000	ASTM D 790
Percent Solids	100	

1. Type 1 – Epoxy-Urethane Co-Polymer
 - a. Provide polymer resins consisting of a blend of epoxy and urethane materials that meet the physical requirements outlined in this Section.
 - b. Provide a polymer overlay free of any fillers and volatile solvents. The use of external/conventional flexibilizers is not permitted.
 - c. Provide penetrating crack filler system as required by the manufacturer.
 - d. Use metered mixing equipment as outlined in this Section with the use of this material.
 2. Type 2 – Modified Epoxy Polymer
 - a. Provide polymer resins consisting of modified epoxy materials that meet the physical requirements outlined in this Section.
 - b. Use of additives, fillers, volatile solvents, and flexibilizers to modify the physical properties of the epoxy to meet physical requirements is acceptable.
 - c. Use of metered mixing equipment as outlined in other parts of this Section is NOT required with the use of this material but is highly recommended.
 - d. A Type 1 epoxy-urethane co-polymer may be substituted for the Type 2 polymer for projects specifying a Type 2 modified epoxy polymer.
- B. Provide a penetrating crack filler system as required by the manufacturer.
- C. Aggregate
1. Clean and free of surface moisture according to the requirements in this Section.
 2. Proven record of durability in this type of application.
 3. 100 percent of the aggregate has at least one mechanically fractured face for materials being retained on the #10 sieve according to ASTM D 5821.
 4. Thoroughly washed and kiln dried to maximum moisture content of 0.2 percent by weight according to ASTM C 566.
 5. Use aggregate with the properties shown in Table 2 or with the aggregate with the properties shown in Table 3 with manufacturer's and Engineer's approval.
 6. Provide aggregate gradation according to the requirements of Table 4.

Table 2

GLACIAL GRAVEL AGGREGATE PROPERTIES (BASALT QUARTZITE GRANITE)	
Properties/Materials	% by Weight
SiO ₂	75.03
Al ₂ O ₃	11.49
Fe ₂ O ₃	3.57
CaO	2.84
MgO	1.59
Na ₂ O	2.58
K ₂ O	0.99
Combined Alkali	1.11
Ignition Loss	0.72
Mohs Scale Hardness	6.50
ASTM 566 (water absorption)	0.2%

Table 3

ABRASIVE FLINT AGGREGATE PROPERTIES	
Properties/Materials	% by Weight
SiO ₂	97.70
Al ₂ O ₃	0.45
Fe ₂ O ₃	0.30
CaCO ₃	0.35

Table 4

AGGREGATE GRADATION	
Sieve Size	Percent Passing
0.187 inch; No.4	100
0.078 inch; No.10	10 – 35
0.033 inch; No.20	0 – 10

PART 3 EXECUTION

3.1 STORAGE AND HANDLING

- A. Job Site Polymer Material Storage
 - 1. Transport to and store on the job site in a dry, weather protected facility away from moisture and within the maintained temperature range of 60 to 100 degrees F or according to manufacturer's recommendations.
- B. Handling Liquid Materials on the Job
 - 1. Use protective gloves, clothing, boots, and goggles when directly exposed to the material.

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2. Provide product safety data sheets obtained from the manufacturer to all workers and inspectors.
- C. Aggregate
1. Store all aggregate in a dry, moisture-free atmosphere.
 2. Fully protect the aggregate from any contaminants on the job site and store so it will not be exposed to rain or other moisture sources.
- D. Packing Requirement
1. Pack all materials in strong, substantial containers.
 2. Identify the containers as Part A and Part B and plainly mark with:
 - a. Manufacturer's name
 - b. Manufacturer's address
 - c. Name of the product
 - d. Mixing proportions and instructions
 - e. Lot and batch numbers
 - f. Date of manufacture
 - g. Quantity

3.2 SURFACE PREPARATION

- A. Deck Repair
1. Repair any minor deck surface defects before installing the polymer system using a patch material that meets manufacturer's recommendations and is compatible with the polymer system being used.
 2. Provide patch materials free of magnesium phosphate.
 3. Verify moisture content of patch meets other requirements of this Section before applying overlay.
- B. Shot-Blasting
1. Clean the entire concrete deck surface with steel shot blast to remove any oil, dirt, rubber, or other materials that may be detrimental to the polymer overlay bonding and curing according to the manufacturer recommendations. Refer to ASTM D 4285.
 2. Use sandblasting equipment or mechanical grinders with approval of the manufacturer and Engineer in areas that cannot be reached with the steel shot-blasting.
 - a. Perform this operation before shot-blasting whenever practical.
 3. Produce a surface relief equal to the International Concrete Repair Institute (ICRI) Surface Preparation Level 5-7 or ASTM E 965 Pavement Macro-Texture Depth of 0.04 to 0.08 inch.

- C. Traffic
 - 1. Do not allow traffic on any portion of the deck that has been shot-blasted.
 - 2. Only allow overlay equipment on cleaned surfaces with manufacturer's supervision.
- D. Weather
 - 1. Verify that all treated surfaces are dry at the time of application.
 - 2. Do not apply the polymer overlay system when it has rained within 24 hours or is expected to rain within 8 hours of application unless otherwise approved by manufacturer and Engineer.
 - 3. Verify the moisture content in the concrete substrate does not exceed 4.5 percent when measured by an electronic meter and that it is completely dry according to the method in ASTM D 4263.
 - 4. Apply the polymer overlay system only when the deck and ambient air temperature is a minimum 50 degrees F.

3.3 APPLICATION

- A. Concrete Surface
 - 1. Clean the concrete surface and apply a penetrating crack filler system as required by the manufacturer.
- B. Use Metered Mixing Equipment for Type 1 Co-Polymers (optional for Type 2 Polymers)
 - 1. Use special equipment capable of metering, mixing, and distributing the polymer.
 - 2. Use machinery that is approved by the manufacturer.
 - 3. Use an application machine that features positive displacement volumetric metering pumps controlled by a hydraulic power unit.
 - 4. Use motionless, in-line mixing so as to not overly shear the material or entrap air in the mix.
 - 5. Maximize material working time by mixing it immediately before dispensing.
- C. Thickness of Individual Layers
 - 1. Provide the number of layers and application rates of the liquid in the various layers according to the manufacturer's recommendations to achieve a minimum overlay thickness of 0.375 inch.
- D. Penetrating Crack Filler System (when required by manufacturer)
 - 1. Install according to manufacturer's recommendations.

- E. First and Second Layers of Overlay
1. Completely remove any excess or loose aggregate by vacuum or with compressed air before the application of each layer.
 2. Manually or mechanically measure and mix the components as recommended by the manufacturer and evenly distribute the liquid on the clean, dry deck surface at the rate recommended by the manufacturer.
- F. Time Limits for Aggregate
1. Use the following maximum time allowed after application of liquid before broadcasting the aggregate unless directed otherwise by the manufacturer.

Table 5

Time Limits	
Temperature	Maximum Time
Above 90°F	10 minutes
80°F to 90°F	15 minutes
70°F to 80°F	20 minutes
60°F to 70°F	25 minutes
50°F to 60°F	35 minutes

- G. Broadcasting Aggregate
1. Use truck mounted equipment capable of dispensing the aggregate onto the deck in a uniform manner as directed or approved by the manufacturer.
 2. Broadcast the aggregate to cover the surface so that no wet spots appear and before the polymer begins to gel.
 3. Drop the aggregate vertically so the level of the liquid is not disturbed.
 4. Broadcast the aggregate according to Tables 2 or 3 and Table 4 to saturate until no wet spots remain.
- H. Remove Excess Aggregate
1. Remove all loose and excess aggregate after the overlay has hardened and before applying subsequent layers using a power vacuum or other method.
- I. Longitudinal Joints in the Overlay
1. Stagger and overlap joints between successive layers so that no ridges appear between two adjacent lanes.
- J. Traffic
1. Do not allow any vehicles on the overlay while it is curing.

2. Allow traffic on the final layer or in between layers after the resin has cured, as determined by the manufacturer, and after removal of all excess and loose aggregate.

3.4 QUALITY CONTROL

- A. Technical Support Representative
 1. Manufacturer's representative must be on the job site at all times and may consult with the Engineer to suspend any item of work that is suspect and does not meet the requirements of this Section.
 2. Work may resume only after the manufacturer's representative and the Engineer are satisfied that the Contractor has taken appropriate remedial action.
- B. Prior Performance
 1. The selected material must have a satisfactory performance in Utah for at least two years from the time of placement.
 2. Products without a two year prior satisfactory performance will be considered as experimental and will only be considered for use with the approval of the Engineer after the award of the contract. Do not use for bidding purposes.

3.5 POLYMER OVERLAY REMOVAL

- A. Remove existing polymer overlay as required by drawings, specifications, manufacturer, or Engineer.
 1. Remove existing thin bonded polymer overlay from deck with a diamond-tipped grinder.
 2. Do not damage concrete deck or underlying rebar when removing thin bonded polymer overlay.
 3. Repair any damage to bridge concrete or reinforcing steel resulting from polymer overlay removal operations.
 - a. Repair concrete at the Contractor's expense.
 - b. Meet the requirements of Section 03934.

END OF SECTION

Virginia Specifications

SU404000A Epoxy Concrete Overlay**GUIDELINES – FOR PROJECTS REQUIRING EPOXY AS AN OVERLAY OVER CONCRETE BRIDGE DECKS.**

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
EPOXY CONCRETE OVERLAY

May 31, 2001a

I. DESCRIPTION

This work shall consist of furnishing and applying epoxy as an overlay over concrete bridge decks in accordance with this Specification, and within the specified tolerances for the lines, grades and details shown on the plans.

II. MATERIALS

- A.** The epoxy shall be modified type EP-5 conforming to Section 243 of the Specifications with the following exceptions:

Property	Requirement	Test Method
Pot life	15 to 45 minutes at 75°F	ASTM C881 (50 ml sample in paper cup)
Tensile strength	2,000 to 5,000 psi at 7 days	ASTM D638
Tensile Elongation	30 to 70 percent at 7 days	ASTM D638
Viscosity	7 to 25 poises	ASTM D2393 (Model RVF Brookfield, Spindle No. 3 at 20 rpm)
Minimum compressive strength at 3 hrs.	1,000 psi at 75°F	ASTM C109 (Use plastic inserts)
Minimum compressive strength at 24 hrs	5,000 psi at 75°F	ASTM C109
Minimum adhesion strength at 24 hrs	250 psi at 75°F	VTM-92

- B.** Aggregate shall be angular grained silica sand or basalt having less than 0.2 percent moisture, and free of dirt, clay, asphalt and other foreign or organic materials.

The silica sand and basalt shall have a minimum Mohs' scale hardness of 7. Unless otherwise approved, silica sand and basalt shall conform to the following gradation:

Percent by Weight of Material Passing			
No. 4	No.8	No. 16	No. 30
Sieve	Sieve	Sieve	Sieve
100	30-75	Max. 5	Max. 1

III. CONSTRUCTION METHODS**A. Safety Provisions**

*These SPECIFICATIONS REVISIONS are subject to change on short notice.



Personnel shall be thoroughly trained in the safe handling of materials in accordance with the Manufacturer's recommendations.

B. Storage of Materials

Materials shall be stored in accordance with the requirements of Section 243 of the Specifications. MSDS and other information pertaining to the safe practices for the storage, handling and disposal of the materials, and to their health hazards shall be obtained from the manufacturer and posted at storage areas. A copy of such information shall be provided to the Engineer.

C. Surface Preparation

Prior to placing the first course, the Contractor shall determine the bridge deck cleaning method in accordance with VTM-92 to obtain the size of shot, flow of shot, forward speed of shotblast machine, and number of passes necessary to provide a tensile rupture strength greater than or equal to 250 psi or a failure area, at a depth of 1/4 inch or more into the base concrete, greater than 50 percent of the test area. A test result shall be the average of three tests on a test patch of at least 1.5 feet by 3 feet consisting of two courses. One passing test result must be obtained for each span or 300 square yard, whichever is the smaller area. Test patches shall be placed in wheel paths, the area between wheel paths or in other areas that represent a worst surface condition as determined by the Engineer. To provide assurance that the cleaning procedure, materials, installation procedure, and curing period will provide the desired overlay, test patches shall be installed with the same materials, equipment, personnel, timing, sequence of operations, and curing period prior to opening to traffic that will be used for the installation of the overlay. The cleaning method, materials, and installation procedure will be approved if one passing test result is obtained from each test area.

If the cleaning method, materials and installation procedure are not acceptable, the Contractor must remove failed test patches and make the necessary adjustments, and retest all test areas at no additional cost to the Department until satisfactory test results are obtained.

Before placement of the epoxy concrete overlay, the entire deck surface shall be cleaned by shotblasting and other means, using the approved cleaning method to remove asphaltic material, oils, dirt, rubber, curing compounds, paint carbonation, laitance, weak surface mortar and other potentially detrimental materials, which may interfere with the bonding or curing of the overlay. Acceptable cleaning is usually recognized by a significant change in the color of the concrete and mortar, and the beginning exposure of coarse aggregate particles. Mortar, that is sound and soundly bonded to the coarse aggregate, must have open pores due to cleaning to be considered adequate for bond. Areas of asphalt larger than one inch in diameter, or smaller areas spaced less than six inches apart, shall be removed. Traffic paint lines shall be considered clean when the concrete has exposed aggregate showing through the paint stripe. A vacuum cleaner shall be used to remove all dust and other loose material. Brooms shall not be used and will not be permitted.

If the Engineer determines that an approved cleaning method has changed prior to the completion of the job, the Contractor must return to the approved cleaning methods and reclean the suspect areas or verify through tests at no additional cost to the Department that the altered method is acceptable.

Epoxy concrete overlay shall not be placed on hydraulic cement concrete that is less than 28 days old. Patching and cleaning operations shall be inspected and approved prior to placing

each layer of the overlay. Any contamination of the deck or intermediate courses, after initial cleaning, shall be removed. Both courses shall be applied within 24 hours following the final cleaning and prior to opening the area to traffic.

There shall be no visible moisture present on the surface of the concrete at the time of application of the epoxy concrete overlay. Compressed air may be used to dry the deck surface.

D. Equipment

For mechanical applications, equipment shall conform to the requirements of Section 243 of the Specifications, and shall consist of no less than a epoxy distribution system, fine aggregate spreader, application squeegee and vacuum trucks, and a source of lighting if work will be performed at night. The distribution system or distributor shall accurately blend the epoxy resin and hardening agent, and shall uniformly and accurately apply the epoxy materials at the specified rate to the bridge deck in such a manner as to cover 100 percent of the work area. The fine aggregate spreader shall be propelled in such a manner as to uniformly and accurately apply the dry silica sand or basalt to cover 100 percent of the epoxy material. The vacuum truck shall be self-propelled.

For hand applications, equipment shall consist of calibrated containers, a paddle type mixer, squeegees, rollers and brooms, which are suitable for mixing the epoxy and applying the epoxy and aggregate in accordance with the requirements of Section 243 of the Specifications.

E. Application

Handling and mixing of the epoxy resin and hardening agent shall be performed in a safe manner to achieve the desired results in accordance with the requirements of Section 243 of the Specifications, and the manufacturer's recommendations as approved or directed by the Engineer. Epoxy concrete overlay materials shall not be placed when weather or surface conditions are such that the material cannot be properly handled, placed, spread and cured within the specified requirements of traffic control.

The epoxy overlay shall be applied in 2 separate courses in accordance with the following rate of application, and the total of the 2 applications shall not be less than 7.5 gals. per 100 square feet

Course	Rate Gal./100 sq.ft.	Aggregate Lbs./Sq.Yd
1	No less than 2.5	10+
2	No less than 5.0	14+

*Application of aggregate shall be of sufficient quantity to completely cover the epoxy.

After the epoxy mixture has been prepared for the epoxy concrete overlay, it shall be immediately and uniformly applied to the surface of the bridge deck with a squeegee or paint roller. The temperature of the bridge deck surface and all epoxy and aggregate components shall be 60 °F or above at the time of application. Epoxy shall not be applied if the air temperature is expected to drop below 55 °F within 8 hours after application, or the gel time is less than 10 minutes. The dry aggregate shall be applied in such a manner as to cover the epoxy mixture completely within 5 minutes. First course applications, which do not receive enough sand prior to gel, shall be removed and replaced. A second course insufficiently sanded may be left in place, but will require additional applications before

opening to traffic. Each course of epoxy concrete overlay shall be cured until vacuuming or brooming can be performed without tearing or damaging the surface. Traffic or equipment shall not be permitted on the overlay surface during the curing period. After the course one curing period, all loose aggregate shall be removed by vacuuming or brooming and the next overlay course applied to completion. The minimum curing periods shall be as follows:

Course	Average temperature of deck, epoxy and aggregate components in °F					
	60-64	65-69	70-74	75-79	80-84	85+
1	4 hrs.	3 hrs.	2.5 hrs.	2 hrs.	1.5 hrs.	1 hr.
2	6.5 hrs.*	5 hrs.	4 hrs.	3 hrs.	3 hrs.	3 hrs.

*Course 2 shall be cured for 8 hrs. if the air temperature drops below 60 °F during the curing period.

The Contractor shall plan and prosecute the work to provide the minimum curing periods as specified herein, or other longer minimum curing periods as prescribed by the manufacturer prior to opening to public or construction traffic, unless otherwise permitted. Course 1 applications shall not be opened to traffic.

Unless otherwise specified, the epoxy concrete overlay courses shall be applied over the expansion joints of the bridge deck. The expansions joints shall be provided with a bond breaker. Within 12 hours of application and prior to opening to traffic, the overlay shall be removed over each joint by removal of the bond breakers, or by scoring the overlay prior to gelling or by saw cutting after cure.

In the event the Contractor's operation damages or mars the epoxy concrete overlay, the Contractor shall remove the damaged areas by saw-cutting in rectangular sections to the top of the concrete deck surface and replacing the various courses in accordance with this Specification at no additional cost to the Department.

For each batch provided, the Contractor shall maintain and provide to the Engineer records including, but not limited to, the following:

1. Batch numbers and sizes
2. Location of batches as placed on deck, referenced by stations
3. Batch time
4. Gel time (50 ml sample)
5. Temperature of the air, deck surface, epoxy components, including aggregates
6. Loose aggregate removal time
7. Time open to traffic

IV. MEASUREMENT AND PAYMENT

Epoxy concrete overlay will be measured and paid for in square yards, which price shall be full compensation for deck preparation and testing, for furnishing and applying the overlay courses including saw cutting joints and any incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Epoxy Concrete Overlay	Square Yard

*These SPECIFICATIONS REVISIONS are subject to change on short notice.

2007

Wyoming Specifications

WYOMING DEPARTMENT OF TRANSPORTATION
SUPPLEMENTARY SPECIFICATION
FOR
BRIDGE DECK OVERLAY (EPOXY)

This supplementary specification supplements, amends, and where in conflict with, supersedes various sections of the 2010 Edition of the Wyoming Department of Transportation's *Standard Specifications for Road and Bridge Construction*.

DESCRIPTION: This supplementary specification describes the requirements of preparing the bridge deck and applying a two coat, $\frac{3}{8}$ inch [9.50 mm] thick bridge deck overlay (epoxy).

MATERIALS: Ensure the bonding resin is a two component 100% reactive epoxy or epoxy/urethane blend consisting of a base component and a hardener. Both components are to be supplied in tightly sealed undamaged containers. Mark the containers to identify each component and clearly label with product name, mixing instructions and proportions, recommended storage temperature, lot number, batch number, date of manufacture, and quantity contained.

Ensure the polymer resin meets the following physical properties and test requirements. Provide independent test results from an AASHTO or CCRL inspected or certified laboratory to the department for approval:

- ASTM C881 Type III
- Gel time 15 – 30 min at 73° F
- Tensile strength (ASTM D 638 @ 7 days) 2,000 psi – 5,000 psi \
- Tensile Elongation (ASTM D 638, 7 day, 73° F cure) 40% - 80% at 73° F
- Viscosity (ASTM D1084) < 3000 cps at 73° F (Mixed product)
- Epoxide Equivalent (ASTM D1652) < 230

Ensure the aggregate contains less than 0.2 percent moisture and is clean and free of dirt, dust or other foreign or organic materials. Ensure the aggregate has a Mohs scale hardness greater than 6 and consists of silica sand or basalt, or other similarly hard, durable, angular shaped aggregate, as recommended by the epoxy system manufacturer and approved by the engineer.

Ensure the aggregate conforms to the following gradation:

Sieve Size	% Passing by Weight
¼ inch	100
No. 4 (4.75 mm)	90 - 100
No. 8 (2.36 mm)	10 - 40
No. 16 (1.18 mm)	0 - 5
No. 30 (0.60 mm)	0 - 1

Ensure aggregate is supplied in bags and stored in a dry moisture-free atmosphere. Fully protect aggregate from contaminants on the job site and store aggregate so it is not exposed to rain or other moisture sources. Do not use any material that was not adequately protected from moisture or other contaminants.

EQUIPMENT: Apply overlay system on all deck areas using metering, mixing and distribution machinery operated by the overlay manufacturer. Do not hand mix materials.

Provide equipment as recommended by the epoxy system manufacturer to provide for the uniform and accurate mixing and distribution of the materials at the specified rate to the bridge deck.

Provide automatic shot-blasting equipment for surface preparation of the bridge deck. Ensure the blasting medium is steel shot. Follow the epoxy system manufacturer's recommendations for the size and hardness of the shot, the flow of the shot, the forward speed and the number of passes. Provide vacuum cleanup equipment that is capable of removing all dust and loose material from the bridge deck.

A representative of the epoxy system supplier is to be present during the preparation and cleaning of the bridge deck surface and during the placement and finish of the bridge deck overlay. Ensure the supplier's representative provides the engineer with a copy of the written equipment, surface preparation and installation recommendations, technical data sheet, and product safety data sheet a minimum of 14 working days prior to starting any portion of the work. In addition, ensure a product safety data sheet is available to anyone that will be exposed to the epoxy materials.

Ensure supplier's representative provides International Concrete Repair Institute's (ICRI) surface preparation texture pucks in order for the engineer to verify adequate surface preparation is achieved.

CONSTRUCTION: Ensure the surface preparation and placing of the bridge deck overlay is under the supervision of the supplier's representative. Prior to placing the overlay, ensure that all deck repairs have cured for the minimum length of time in

accordance with the epoxy supplier's recommendations. Repair any small spalls or defects that result from the preparation of the deck using a material that is compatible with the epoxy overlay system as recommended by the manufacturer.

Use automatic shot-blasting to remove any weak concrete and all foreign materials which may interfere with the bonding or curing of the epoxy overlay. Ensure the shot-blasting removes all surface laitance and exposes the coarse aggregate to the satisfaction of the supplier's representative and the engineer. Ensure the final surface texture meets the ICRI concrete surface profile numbers 5 through 7 as defined in ICRI Guideline No. 03732 and as shown by Surface Profile Samples available from ICRI, or ASTM E 965 Pavement Macrottexture Depth of 0.04 to 0.08 inch. Use abrasive blasting or hand tools to clean small areas where shot-blasting is unable to be performed (curb lines, etc.), to the satisfaction of the engineer.

Upon completion of the shot blasting and abrasive blasting, remove all dust, debris and concrete fines from the bridge deck and the faces of the curbs. Use dry, oil-free compressed air to blow clean the entire bridge deck. Do not use brooms for the final preparation of the deck.

Ensure cleaning by shot-blasting, abrasive blasting, and compressed air is done no more than 24 hours prior to the placement of the epoxy overlay. In the event that the epoxy is not placed within 24 hours of shot blasting and abrasive blast cleaning or in the event of rain or other inclement weather contaminating the surface, re-clean the surface by abrasive blast cleaning and dry compressed air.

Do not allow vehicular traffic on any portion of the deck which has been cleaned and prepared for application of the epoxy overlay. Overlay equipment will be allowed on cleaned surfaces with supervision by the supplier's representative and with the approval of the engineer.

Protect the expansion joints, deck drains, bridge railings and any other areas not to be overlaid from damage during preparation of the surface and placement of the overlay. Remove the protection once the epoxy and aggregate has been applied and prior to initial set. Removing the protection must be done soon enough to in no way harm the adjacent overlay. Reapply protection prior to the second coat and again remove prior to initial set as to not damage adjacent surfaces. The protection must meet the approval of the engineer.

Apply the bridge deck overlay (epoxy) between April 15 and September 30. Ensure handling and mixing of the epoxy resin and hardening agent is performed in a safe manner to achieve the desired results in accordance with the manufacturer's recommendations for a two-coat system. Place epoxy overlay materials when the bridge deck surface temperature is greater than 70° F and there has been 24 hours without precipitation for open bottom decks, or 48 continuous hours without precipitation

for stay-in-place formed decks. Continually monitor surface temperatures during placement. Do not place overlay materials when the forecast is for the ambient temperature to drop below 50° F within 8 hours after application or when rain is forecast within 24 hours of after application. Ensure the substrate moisture content is within the epoxy system manufacturer's recommendations. Do not place epoxy overlay materials if weather or surface conditions are such that the material cannot be properly handled, placed, and cured within the manufacturer's requirements.

Use special equipment capable of metering, mixing, and distributing the polymer. Use an application machine that features positive displacement volumetric metering pumps controlled by a hydraulic power unit. Use motionless, in-line mixing so as to not overly shear the material or entrap air in the mix. Maximize material working time by mixing it immediately before dispensing.

Apply the epoxy and aggregate in a minimum of two separate courses in accordance with the manufacturer's recommendation for a two-coat system to result in a minimum overlay thickness of $\frac{3}{8}$ inch [9.50 mm]. Ensure the epoxy is distributed at the rate of application recommended by the manufacturer with minimum rates of application of 40 ft²/gal on the first course and 20 ft²/gal on the second course. After the epoxy mixture has been prepared for the overlay, immediately and uniformly apply it to the surface of the bridge deck with a $\frac{3}{16}$ inch [5 mm] notched squeegee. Replace squeegee blades frequently so that the application rates are not exceeded.

If required by the epoxy system manufacturer, apply a prime coat according to the manufacturer's recommendations in addition to the minimum two coats of epoxy overlay.

Apply the dry aggregate in such a manner as to cover the epoxy mixture completely within 5 minutes of epoxy application and prior to initial set. Apply dry aggregate vertically or sprinkled to prevent pushing of the epoxy. Application of aggregate to both the first and subsequent courses must be of sufficient quantity so the entire surface is covered in excess. No bleed through, or wet spots should be visible in the overlay. Remove and replace first course applications that do not receive enough aggregate. A second course application which does not receive sufficient aggregate may be left in place, but will require additional applications before opening to traffic.

Cure each course of epoxy overlay until vacuuming or brooming can be performed without tearing or damaging the surface. Do not allow traffic or equipment on the overlay surface during the curing period. Remove by vacuuming or brooming all loose aggregate after the first course curing period and remove all dust and debris with oil-free compressed air. Immediately apply the next overlay course to complete the surfacing. Ensure the minimum curing periods are in accordance with the manufacturer's recommendations. Minimize foot traffic on uncured epoxy.

Remove and replace any areas damaged during the installation at no additional cost to the department.

MEASUREMENT and PAYMENT: The engineer will measure Bridge Deck Overlay (Epoxy) by the square yard. This payment is for the complete overlay in place to include a prime coat if required and all coats of epoxy and aggregate.

The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Bridge Deck Overlay (Epoxy)	SY [m ²]	0.1 ft [0.5 m]	SY [0.1 m ²]

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