APPENDIX A. SURVEY RESPONSES

The raw survey responses as downloaded from the survey tool (SoGoSurvey) are presented in the order listed in Table A.1.

Table A.1. Order of Survey Responses

Responding Agency's Name (Shortened Name)
1. Alberta Ministry of Transportation (Alberta Transportation)
2. California Department of Transportation (Caltrans)
3. Colorado Department of Transportation (CDOT)
4. Michigan Department of Transportation (MDOT)
5. New York State Department of Transportation (NYSDOT)
6. North Carolina Department of Transportation (NCDOT)
7. North Dakota Department of Transportation (ND DOT)
8. Oregon Department of Transportation (OregonDOT)
9. Pennsylvania Department of Transportation (PennDOT)
10. South Dakota Department of Transportation (SDDOT)
11. Utah Department of Transportation (UDOT)
12. Washington Department of Transportation (WSDOT)

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **12** **Email ID: Public Access** **Participation Time: 7/24/2020 11:03**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

Alberta Transportation has used the following overlay products:
- Flexolith System manufactured by Dural
- Flexogrid System manufactured by Polycarb
- Sikadur 81-32 manufactured by Sika Inc.
- Degadur Methyl Methacrylate System by Degussa is an approved alternate for the polymer overlay. The Degussa Degadur Methyl Methacrylate System (MMA) does not meet the compressive strength and physical requirements of the “Specification for the Supply of Polymer Resins used in Polymer Overlay (B405)”, and is applied in a different manner, but all other requirements of the specification B405 shall be met.

They have been in service for up to 35 years (present). An experimental bridge was done in 1984, and the first regular production overlays were 5 sites in 1985. The primary purpose of using polymer overlay systems was to efficiently and cost-effectively heal cracks and extend the services lives of existing older bridge decks without adding dead load, reducing curb height, and strengthening of superstructures to carry extra load. From a skid resistance point of view, the polymer overlays become more slippery over time. Therefore, an application of chip seal coat was usually required after 10 years of installation. From a performance point of view, some polymer overlay systems also exhibited premature failure. These polymer overlays were about ¼ to 3/8” thick, and the chip seal coat added another ½” of thickness. When the polymer began to fail in localized areas, the riding surface became rough, and rainwater was getting trapped in the low spots which slowly propagated the failure of the system. Further issues associated with performance are addressed in question # 8. From a service life and durability standpoint, the polymer overlays typically added 20+ years to the life of the bridge deck by preventing chloride and moisture penetration. Some regions of Alberta with lighter traffic and dryer ambient conditions has allowed polymer overlays to last up to 35 years.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

The following aggregates have been used and approved by Alberta Transportation:
- Indag # 8
- Steilacoom 6X10 Bridge Topping

Alberta Transportation has used various other aggregate types in the past but in terms of acceptable abrasion and skid resistance, Indag # 8 and Steilacoom 6X10 Bridge Topping has performed the best.

Current requirements for overlay aggregates can also be found in the current version of Standard Specifications for Bridge Construction, Section 15.3 (Aggregates)

http://www.transportation.alberta.ca/Content/docType246/Production/StandardSpecificationsforBridgeConstruction2017.pdf

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

Alberta Transportation has used various test methods such as chloride penetration versus time and depth from surface using the Alberta Transportation TLT-520 test method (acid soluble, laboratory titration) and the SHRP program Germann Instruments Rapid Chloride Permeability test to monitor chlorides penetration. Based on our findings by analyzing chlorides data from previously tested bridges, polymer overlays have been effective in preventing chlorides from penetrating near the reinforcing depths. However, the chlorides results are also vastly dependent on the condition of an existing overlay, amount of de-icing bridge receives, cracks frequency and whether locked in old chlorides have penetrated prior to placement of new polymer overlay or not.

Depending on traffic volumes, various geographical weather conditions and whether proper maintenance practices were exercised or not, these polymer overlay systems have lasted from 8 years to 35 years (present).

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

Skid trailer tests in Alberta have been regularly used to monitor skid resistance on in-service pavements and bridges, but the results have not always been accurate on short distances and smaller length bridges. Tests on longer bridges show that polymer overlays result in skid numbers of 70-75 (out of 100 max), as compared with average highway numbers of about 60. As per current pavement design manual, skid number of 46 or greater represents surface having adequate friction characteristics.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency’s ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

Alberta Transportation has observed from past experience that wearing surface coatings, such as chip coats or polymer overlays do not allow the deck surface to be inspected. However, performance-monitoring tests has shown that for bridge decks exposed to de-icing and higher traffic volumes, both polymer overlays and chip seal coating have a positive effect for sealing cracks and extending the service lives of the decks.

Alberta has used most of the various available types of monitoring such as ground penetrating radar, linear polarization for corrosion, infrared thermography, etc. For regular periodic monitoring of bridge conditions, Alberta Transportation has resorted to the less expensive methods. These methods include visual documentation of conditions and quantification of various types of defects including cracks, potholes, delamination, debonding etc., as well as:
- ATSM D-4580 chain drag sounding;
- “Method for Field Determination of Total Chloride Content” and “Standard Test Method for Chloride Content in Concrete Using the Specific Ion Probe” as described in SHRP-S-328, and

SHRP-S-330 Appendix F; and
- Modified ASTM C876 copper sulfate electrode testing.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Current requirements for surface preparation are that deck concrete surface shall be prepared by shotblasting to remove all bond inhibitors including concrete laitance, asphaltic material, sealers and oil, and to expose the coarse aggregate in the substrate concrete. Those areas, which are inaccessible to shotblasting, such as the vertical faces of the curbs, medians, and parapets, shall be similarly prepared by sandblasting. Further surface preparation requirements can also be found in current version of Standard Specifications for Bridge Construction, Section 15.7.1 (Surface Preparation)
ttp://www.transportation.alberta.ca/Content/docType246/Production/StandardSpecificationsforBridgeConstruction2017.pdf

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

Section 15 (Non-Skid Polymer Overlay) of Standard Specifications for Bridge Construction is used in conjunction with the “Specification for the Supply of Polymer Resins used in Polymer Overlays (B405)” and “Specification for Seed Aggregates used in Polymer Membranes and Overlays (B392)”.

For polymer resins used in polymer overlays, all the qualifying tests are outlined in section 2.0 of “Specification for the Supply of Polymer Resins used in Polymer Overlays (B405)”.

http://www.transportation.alberta.ca/Content/docType254/Production/B405JULY13.pdf

For seed aggregate applied to the polymer, all the qualifying tests are outlined in section 2.0 of “Specification for Seed Aggregates used in Polymer Membranes and Overlays (B392)”.

http://www.transportation.alberta.ca/Content/docType254/Production/B392JULY2013.pdf

In addition, there are testing and strength requirements for which the contractor shall be responsible for testing of infrared and gas chromatography analysis for each polymer component, compressive strength of the polymer mortar, modulus elasticity of the polymer, and grain size analysis of the aggregate. These testing and strength requirements can be found in section 15.7.8 (Testing and Strength Requirements) of Standard Specifications for Bridge Construction.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

- Debonding or separation of the overlay at the bond line to deck. This has been caused partly due to the difference in the thermal coefficient of expansion, exacerbated over time by temperature change cycles;
- Premature surface and abrasive wear due to heavy vehicular traffic;
- Effects related to hardening of the material due to ultraviolet exposure (sunlight); and
- Localized debonded areas occurring over time due to incompatibilities of coefficients of thermal expansion between polymer material and concrete substrate. Some contractors attempted to place epoxy mortar patches for partial depth repairs, but those generally failed at the bond line due to effects of thermal coefficient of expansion;
- Delamination occurring due to poor mixing of the epoxy resin, inadequate curing and improper use of primer;
- Early signs of transverse and longitudinal cracking due to fluctuating temperature effects, poor batch of materials and possible movement in joint while material was setting; and
- Improper application by contractors/poor workmanship and inadequate quality control provisions during material application.

To address above-mentioned failures, the Department then introduced various mitigation strategies. Some of the following changes were made:
- The Department assessed the causes of defects and addressed them in their specifications. Provisions were added to assess deck moisture content, surface prep, application methods in Standard Specifications for Bridge Construction and Specification for the Supply of Polymer Resins used in Polymer Overlay (B405);
- The Department implemented a 5-year joint manufacturer-contractor warranty contracts, so any defects were repaired at end of 5 years;
- Chip coats were generally applied by the Department at about 10 years or when minor defects had started to occur.

Alberta Transportation does not have any insights or studies conducted to evaluate effects of studded tires on polymer overlay bridges.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

Initially, back in 1985, the use of thin polymer overlays was considered potentially cost effective in northern environments where de-icing/anti-icing is done with chloride-based materials. This specific type of work required specialized expertise from the contractors and the inspectors who administered the work during the installation of these polymer overlay systems. Much of the potential value of these systems were achieved when these factors were favorable, competition between ‘qualified’ contractors existed, and costs were in line with the costs of alternative deck maintenance solutions. In other words, if the right conditions exist in a particular jurisdiction, these polymer overlay systems can offer good value, but the decision to use them should consider life cycle comparison of polymer overlays and benefit to cost ratio with other locally available methods. In addition, monitoring the long-term performance of these systems is also important to making appropriate decisions in any particular jurisdiction.

The Department has now shifted away from the use of polymer overlay systems due to their frequent premature failures, high cost of long-term maintenance and introduction of new alternative robust systems.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

(Did not answer)

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **4** **Email ID: Public Access** **Participation Time: 7/3/2020 12:00**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

We have been using polymer overlays (HFST) for at least 10 years. We originally thought the material would seal the deck from contaminants (chlorides), but after evaluating a piece of delaminated overlay, found that they are quite porous and do not seal at all. We no longer use them as a deck protection method. We use them only as a surface friction treatment. Although we have been discussing the use of it as a sacrificial layer... we used it on top of a polyester concrete overlay on a couple structures in heavy snow/high truck traffic country and found that it protected the polyester overlay nicely. It only lasted about 3 years in that capacity, but it is also located in one of the highest/heaviest traffic snow zones in the state - near Truckee, CA. If it were used as a routine preventive, I believe it would be quite effective at protecting polyester concrete overlays.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

On the same bridge mentioned before, we did a test of different types of aggregate with a single polymer. We used copper slag, calcined bauxite, basalt, and granite quartz (the control). We found that after the first year, the copper slag section had polished up badly, but after the second year, the snow plows had peeled up large areas of the overlay. The striking thing however, was that the HFST had protected the polyester concrete overlay and it was still in like-new condition. The parallel structure had only gotten polyester concrete (no HFST) and it had badly rutted down to bare deck in the same time period. But as for the aggregate performance, in this example, the copper slag was a poor performer and the others were about equal - the plows did them all in equally.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

Polymer overlays do NOT protect the deck and bridge from chloride penetration. As for skin friction effectiveness, their life is between 2 years (heavy truck traffic with chains - Truckee area) to 10 years (valley locations heavy traffic). We have not directly correlated chloride contents to polymer overlay presence. We have been able to see the porosity of the material first-hand and made the assessment visually - chlorides are not prevented from reaching the deck concrete.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

Our agency assesses skid resistance immediately after placement of HFST's, but does not have a program in place to routinely verify ongoing skid resistance. We assess it visually during routine inspections. For the short life span that they have, they seem to maintain their skid resistance well enough.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

When a deck has a polymer overlay, any underlying unsound concrete is no longer able to be directly identified by visual inspection or sounding. The inspector can't determine if the overlay is giving the hollow sound from the chain or if it's the underlying deck concrete that is the issue. Obviously, visual inspection is affected since the concrete deck is no longer visible. At that time, if the superstructure type allows for the soffit to be visible, then that is our only way to gauge deck performance.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

The requirements for preparation of the deck prior to installation of polymer overlays is outlined in our specifications. And we have State representatives on site during all operations to verify compliance.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

Our specifications outline specific requirements for material qualities and QA/QC tests to be performed before acceptance of the contract. Section 60 of our Standard Specifications has a lot of the requirements. It can be found at: https://dot.ca.gov/programs/design/ccs-standard-plans-and-standard-specifications

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

The most common failure is delamination from the substrate. The best method we've found for mitigation of this is to treat the deck with a methacrylate primer prior to the HFST application. However, we're currently evaluating what affect an increase in the deck concrete profile might have on the long-term adhesion of the overlays. Industry has recommended we specify ICRI profile. We will continue to monitor this, of course.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

(Did not answer)

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

(Did not answer)

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **5** **Email ID: Public Access** **Participation Time: 7/3/2020 16:43**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

Unitex, KwikBond (Polyester Concrete), Sika epoxy overlays.
Flexogrid and safelane as a cdot anti-icing experimental study in 2014, see report" Performance of Thin Bonded Epoxy Overlays on Asphalt and concrete Bridge Deck Surfaces.

The earliest was in 2006/2007 (Sika Epoxy Overlay, low traffic road, Starting to show delaminations.
KwikBond first installation was a 2"+/- thick lift to replace the Asphalt overlay in 2015. Performance is very good.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

Aggregates for Thin Bonded Epoxy Overlays (Non-Bituminous) shall consist of clean, hard durable fragments such as flint, chert, emery, or basaltic sand.
Initial Performance is very good and performed well for the intended life of 7+/- years

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

Products Performed well for the life published by manufacturer. Some like KwikBond are still in progress for evaluation. Sample reports shown below. Please refer to cdot research website for other reports by subject at:
https://www.codot.gov/library

Sample:
Performance of Thin Bonded Epoxy Overlays on Asphalt and concrete Bridge Deck Surfaces. Chloride contents measured.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

CDOT assessed skid numbers in research reports but not on a regular basis in our inspection program. Skid numbers are in the report under question 4.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

No effect. The same as with asphalt overlays. NDT are not affected. We have successfully used Spectral Wave analysis technology by Olson Engineering to detect deficiencies throughout the deck to size the limits and depth of removal. Few cases of GPR to locate rebar depth and thickness of overlays.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

CDOT uses a project special provision for the construction project engineer to follow in the field along with a manufacture's rep. for assistance.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

Follow QA/QC protocols per the CDOT project special provisions/specification.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

Debonding due to minor calibration errors, but mostly corrected and resolved. Debonded areas removed and replaced if they do not meet bonding test per spec.

Curing issues with severe winter climates.
Chains on trucks on mountain passes are an issue. Polyester concrete has a better abrasion resistance than a 4500 psi typical concrete used by CDOT. This material is preferred for end dams or headers of expansion joints.

Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

Review previous projects for performance, evaluate as pilot projects on small areas to start with. Trial applications are required in the spec before application on the actual structure.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

(Did not answer)

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **10** **Email ID: Public Access** **Participation Time: 7/15/2020 06:59**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

MDOT has been using Thin Polymer Overlays for nearly 25 years. Feel free to email me and I will send you the following documents. MDOT's Whitepaper on Thin Polymer Overlays in Michigan, MDOT's Special Provision on Thin Polymer Overlays, and MDOT's Special Provision on Thin Polymer Overlays as High Friction Surface Treatments. These documents contain the lists of approved products. MDOT is very satisfied the performance thin polymer overlays.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

MDOT specs call for an aggregate gradation that meets ACI 548.8-07. We also specify a Mohs hardness of 7 for thin polymer overlays and Calcined Bauxite for HFST. MDOT also hired the National Center for Asphalt Testing to measure the friction of our aggregates as well as wear test them. Please email me for additional information and results.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

MDOT does not test chloride penetration. We have several bridge decks that have been epoxy overlayed, then after 15-20 years of wear, the epoxy overlay has been removed, the decks have been sounded for concrete delaminations and we have found very minimal delaminations in need of repair prior to placing a second epoxy overlay.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

MDOT hired NCAT to test the skid resistance of all of our aggregates. We have also tested the skid resistance of several bridges after placing the epoxy overlay.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency’s ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

MDOT has been using thin polymer overlays extensively for over 20 years. Our inspectors are very adept at sounding and being able to tell the difference between de bonded polymer overlays and delaminated concrete.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

While most thin polymer overlay manufacturers require a CSP 5 deck preparation, MDOT requires a CSP7. This ensures that no areas of the deck fall below CSP 5 and enhances the aggregate bond area, as the polymer overlay bonds to the aggregate, not the cement. MDOT special provision also requires moisture testing per ASTM D4263 and Adhesion Testing per ASTM C1583

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

MDOT has transitioned to requiring a 5 year warranty for the thin polymer overlays and HFST. It has been MDOT's experience that if the thin polymer overlay or HFST fails due to improper installation, failures will begin within 2-3 years. The 5 year warranty forces contractors to prepare the surface properly.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

Snowmobile treads will wear through a thin polymer overlay within 5 years. On bridge decks with thin polymer overlays and heavy snowmobile traffic, the overlay acts as a sacrificial surface and is re-applied once worn. Most common failure mechanism is due to improper surface preparation. The thin polymer overlay will peel off. Other issue is the leading edge of the thin polymer overlay is easily damaged by snow plows. Because of this, MDOT has begun placing the thin polymer overlays 10' onto the bridge approach. The leading edge on the bridge approach becomes sacrificial.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

I believe I have covered everything in previous questions. Definitely the 5 year warranty is a best practice.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

Yes

Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

[redacted]

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
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Deployment Metrics	
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Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **8** **Email ID: Public Access** **Participation Time: 7/13/2020 11:27**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

NYSDOT uses: Polyester Polymer Concrete(PPC), Thin Epoxy Polymer Overlays (multi-layer, 2 coats), and HFST for pavement.
NYSDOT has used Polyester Polymer Concrete Overlay, and the oldest monitored PPC overlay placement was in 2006. While the oldest deck is 14 years old, we haven't extensively used it until the past 9 years, since 2011. Overall, we are fairly satisfied with the PPC overlay field performance. There is no publication report done for PPC overlay, however NYSDOT has participated in surveys done by other State DOTs and AASHTO. Also, NYSDOT participate in AASHTO Product Evaluation Program. See link below to NTPEP.
http://www.ntpep.org/Pages/PCO.aspx
Also, NYSDOT has used TPO for 20+ years. In 2010, an Engineering Instruction allowing only epoxy-based polymer binder resin to be used, and an approved list was created. In 2018 the specification was updated, and the Approved list was split to Epoxy resin manufactures and aggregate type suppliers. See link to AL below:
https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/alme/pages/thn_ovr-1.html
Also, NYSDOT has used HFST in limited projects. HFST use the two-component epoxy or other polymer binder system with a calcined bauxite aggregate. The polymer binder resin must conform to the resin binder requirements, see table in the special specification:
https://www.dot.ny.gov/spec-repository-us/601.02000004.pdf

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

The department is very satisfied with the HFST & polymer overlays performance.
For Polymer Concrete: It's a mixture of aggregate and natural sand. Our special specifications, 584.40000009, lists the aggregate gradation and properties, see link below:
https://www.dot.ny.gov/spec-repository-us/584.40000009.pdf
For Thin (Epoxy) Polymer Overlays: See Approved List for aggregate selection based on AADT and desired friction.
https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/alme/pages/thn_ovr-1.html
For HFST: Calcined Bauxite is the only aggregate type used. One coat/application of resin and aggregate for pavement and 2 coats for bridge decks. See link below for Aggregate requirements:
https://www.dot.ny.gov/spec-repository-us/601.02000004.pdf

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

Note: NYSDOT has not assessed chloride concrete in decks with overlay for it's considered destructive testing.
The polyester polymer concrete, minimum thickness ¾ inch, is water impermeable and effective in sealing the bridge deck. It uses a high molecular weight methacrylate (HMWM) penetrating healer/sealer primer to enhance the chemical bond of the overlay and seal the substrate.
NYSDOT oldest placement is 14 years old and is holding up and performing. Currently, KwikBond PPC 1121 is approved. EPC Overlay by E-Chem was placed in 2 bridges last years and going through field performance evaluation. The resin used for TPO is epoxy-based while HFST is epoxy or polymer based binder, all known to seal the deck if placed properly.
Service life for TPO: 10-12 yrs; a third coat or a second application is needed to restore friction, rideability, and chloride/moisture impermeability. Some wear off sooner than other depending on the aggregate type, AADT and geometry of the structure.
PPC anticipated service life of 25-30 years: Our oldest monitored deck is 14 yrs old, and we hope to live and see at least 30 yrs.
For HFST: Those placements are in recent years and we are hoping for 10-15 years of waterproofing and good skid resistance.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

Materials Bureau performs annual field evaluations on selected bridges with PPC, TPO and HFST (both existing and new placements) for performance and often follow up with friction testing using the Department's Full-Scale Tire Skid Resistance test ASTM E274. The Friction Numbers were mixed depending on the contractor experience, aggregate used, and placement method. NYSDOT has updated the specification to enforce broadcasting aggregate (for TPO &HFST) and top sand (for PPC) to refusal, For PPC, saw-cut grooving is mandatory, and Diamond Grinding as needed for a smoother ride depending on Geometry and AADT of the bridge. For TPO used with high friction aggregate such bauxite retained higher FN. HFST uses only calcined bauxite aggregate and therefore retain high FN.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

Once the TPO/PPC are placed, we do not perform destructive testing beside the Bond Test to substrate for the PPC. In cases where spalling and debonding of the overlay is visible, we may core or perform a bond/pull-off test to help determine the bonding/integrity of the rest of the deck . The department implements visual inspection for cracks, spalls and defects. In addition, hammer sounding to look for debonding of the overlay is used. Visual inspection of the structure underneath is done when there are visible cracks and delamination of the surface.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Preparation for concrete substrate: By shot-blasting in order to remove all existing grease, slurry, oils, paint, dirt, striping, cure compound, rust, membrane, asphalt, weak surface mortar or any other contaminants that could interfere with the proper adhesion of the overlay system. We require a concrete moisture meter reading ≤ 5.0%.
For TPO: we require shot-blasting of the substrate to concrete surface profile (CSP) of 5-6. For

For PPC: to the satisfaction of the Engineer in Charge.
For HFST: for concrete, we require CSP of 5 for concrete. And for Asphalt surface: mechanically sweep all surfaces to remove dirt, loose aggregate, debris, and deleterious material.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

For TPO: Special Specification 584.50010018:
https://www.dot.ny.gov/spec-repository-us/584.50010018.pdf
We require bond strength to structure in accordance to ACI 503R-30 or ASTM C1583/C1583M (minimum 250 psi requirement)

For Polymer Concrete Overlay: Special Specification 584.40000009:
https://www.dot.ny.gov/spec-repository-us/584.40000009.pdf
we require verification of overlay bond to the substrate after 24 hrs of cure.

For HFST: Skid test is performed after the placement to verify a friction value of 65 FN40R or higher when tested in accordance to AASHTO T242.

Note: Acompetent manufacturer representative is required to be on site to provide technical assistance during surface preparation, material placement, and during any necessary remedial work. He can be released at the discretion of the Engineer In Charge(EIC).

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

The most common defect is cracking of the overlay surface due to moving cracks and or movements of the structure. The Department to treat any defects or repair prior to placement of the overlay. Once the overlay is placed, think cracks can be sealed using the nest resin binder for TPO and HFST, and for PPC the primer HMWM is used with sand broadcasting. Spalls/debonded areas are rare and they are determined (perimeter)removed, prepared and replaced the same way as the overlay system.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

An overlay polymer system is only as good as the substrate beneath it. A sound substrate and a proper preparation are required to ensure longer service life, needed skid resistance, waterproofing & protection from chloride intrusion to the deck and almost no maintenance. Experience of the contractor/crew plays a major role in curing of the overlay, quality of the finished surface including rideability, friction and esthetically. Also, the experience of the EIC and attendance of the Manufacturer rep can help in picking potential issues prior and during overlay placements. The type of your structure and condition of the bridge deck will help determine the proper treatment for your deck. Although Thicker overlays such PPC/EPC are more durable then TPOS/HFST, they are not the treatment to a deteriorated deck.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

[redacted]

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **6** **Email ID: Public Access** **Participation Time: 7/7/2020 10:37**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

NCDOT uses the following polymer overlay products:

Polyester Polymer Concrete (PPC) Overlay – First NCDOT use was in Fall 2016
Epoxy Polymer Concrete (EPC) Overlay – First NCDOT use was Fall 2019
Epoxy Overlay System 1 (>=5000 ADT) - Unknown first use
Epoxy Overlay System 2 (<5000 ADT) - Unknown first use

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

NCDOT Special Provisions have the following aggregate requirements:
PPC/EPC Aggregates
Aggregate shall have the following properties:
(1) No more than 45 percent crushed particles retained on the No. 8 sieve when tested in accordance with American Association of State Highway and Transportation Officials (AASHTO) Test Method T335.
(2) Fine aggregate consists of natural sand only.
(3) Weighted-average aggregate absorption of no more than 1.0 percent when tested under AASHTO Test Methods T84 and T85.
(4) At the time of mixing with resin, have moisture content of not more than one-half (½) of the weighted-average aggregate absorption when tested under AASHTO Test Method T255.
(5) Moh's hardness of seven (7) or greater.
(6) Comply with the requirements for the aggregate gradation indicated in Table 3, below:

Sieve Size	Percent Passing
3/8"	100
No. 4	60-85
No. 8	55-65
No. 16	29-50
No. 30	16-36
No. 50	5-20
No. 100	0-7
No. 200	0-3

Sand: Sand for abrasive sand finish shall have the following properties:
(7) Commercial-quality blast sand.
(8) Not less than 95 percent pass the No. 8 sieve and not less than 95 percent retained on the No. 20 sieve when tested under AASHTO Test Method T27.
(9) Shall be dry at the time of application.

Epoxy Overlay System Aggregates
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 T327

AGGREGATE GR

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

With NCDOT's relatively recent (<4 years) use of PPC, we have not yet followed up with chloride content testing to verify the effectiveness of the PPC overlay to prevent chloride penetration.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

We do not regularly assess skid resistance, but in the time we have been placing PPS overlays, we are not aware of any skid resistance issues with its use.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

Typical inspection is visual. If areas of delamination are observed, sounding may be used to determine the extent of the delamination. Chloride and/ or corrosion testing would not be employed until a repair or preservation activity is considered.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

NCDOT Special Provisions require: The application of the overlay shall not begin until the concrete deck is completely surface dry in accordance with ASTM D4263, with a wait time revised from 16 hours to two (2) hours, or as directed by the System Provider's Technical Representative. The concrete surface temperature shall be between 40° and 100° F. Also we indicate that, as a minimum, the bridge deck has to be shotblasted to remove loose or softened concrete, dirt, oils, and other deleterious material. This is required whether or not the bridge deck concrete is milled or scarified. After shotblasting, the deck is visually reviewed to ensure proper preparation has been done. If questionable areas are encountered, additional examination methods, such as chain dragging or soundings, are used to further evaluate and determine the extent of additional repair and/ or preparation work.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

NCDOT Special Provisions require System Provider Qualifications, Contractor Qualifications, System Provider Technical Representative Qualifications, Direct Tension Bond testing and Smoothness Quality testing. Inspector also monitors batching and batch tickets to ensure that resin proportions and aggregate proportions are within specifications.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

Most bond failures seem to be related to improper surface cleanliness and preparation. With PPC overlays, it is not uncommon to encounter issues and failures of the PPC at deck joints. This is typically related to failure by the Contractor and inspectors to sufficiently examine the concrete substrate at the joints to determine if deeper, localized repair and preparation are necessary at the joints, prior to placement of the PPC overlay.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

NCDOT use of polymer overlays has been limited to bridge decks that are relatively good shape (likely an NBI Deck score of 6 or better, although certain decks with a 5 could qualify). If we have chloride contents in excess of 2.0 pcy near the top mat of reinforcing steel, we typically will not use a polymer overlay, and opt to perform hydro-demolition in an effort to remove those chlorides. If we perform hydro-demolition, we typically place a Latex Modified Concrete (LMC) overlay.
If there are excessive patches or repair areas present in the bridge deck concrete that cannot be mostly removed with milling or scarification, we would opt for milling and hydro-demolition for deck surface preparation, and LMC as an overlay.
If a previous overlay exists on the bridge deck, and it is uncertain if the entire overlay can be easily removed with milling or scarification operations, we would not select a PPC overlay. Contractors and PPC material suppliers have indicated that they will not place a PPC overlay on ANY existing overlay, so the entirety of an existing overlay must be removed before placing the PPC. Sometimes, particularly if there were many locations of varying-depth repairs or overlay material, lots of handwork can be necessary to remove the old overlay, and this can significantly drive up costs.
When choosing between a thin polymer overlay and a thicker PPC overlay, the decision is often determined based on ADT and truck traffic. Higher ADT and truck traffic will lead us to a more robust PPC overlay. Also, the desired longevity of the overlay is a factor – approximately 10 years for thin polymer overlays and approximately 25 years for PPC overlays.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

[redacted]

[redacted]

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **1** **Email ID: Public Access** **Participation Time: 6/29/2020 13:19**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

We are currently installing our first polyester polymer bridge deck overlay this construction season, so we have not had a chance to evaluate its performance.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

There are several requirements for aggregate testing that must be met. For example, the aggregates must consist of <= 45% crushed particles retained on No. 8 sieve. and must have a Moh's hardness >=7. We can share our specifications we used if requested. However, this construction season is our first project using a polyester polymer overlay, so we have not had a chance to evaluate its performance.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

We have not had a chance to evaluate the performance. We did take chloride samples and made the decision to grind off 3/8" before installing the overlay on a 12 year old structure.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

Have not had a chance to evaluate.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

Have not had a chance to evaluate. We use primarily visual inspection and some IR thermography.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Scarify all areas to receive the PPC overlay uniformly to an approximate depth of 3/8 inch unless otherwise shown in the plans. After scarification clean these areas by shot blasting, or abrasive sand blasting, as approved by the Engineer, if the shot blaster cannot access certain areas.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

We require a Contractor who has performed a PPC within the last 5 years. We also require a trial run and acceptance testing, including direct tension bond, compression, and smoothness. Sounding is also performing upon completion to identify any areas that may need to be repaired.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

We have no prior experience. This is our first overlay.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

We have no prior experience or opportunity to evaluate performance.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

Yes

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

It is new to us as well, but we would be interested to hear what other states' experience has been.

[redacted]

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
Delivered	0
Bounced	0

Response Metrics	
Completed	12
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Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **11** **Email ID: Public Access** **Participation Time: 7/16/2020 16:39**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

We have considered and used polymer concrete overlay on bridge decks since 1980s. The following reports include detailed information for the documented projects. In general, the polymers that we used in the past are not really used in the same way today. We used single lift thin polymer overlays with urethanes, methacrylates, and epoxies.

Recently, PPC and MPCO overlays are our two active polymer overlays. The 2010 report were used for developing specifications of the current PPC and MPCO overlays.

2010 – FHWA-OR-RD-11-05 Evaluation of Thin Overlays for Bridge Decks
1995 – OR-RD-96-01 – Polymer Concrete Bridge Deck Overlays
1986 – DOT-FH-11-8876, Task Order #11 – Clackamas River Bridge Polymer Concrete Overlay
1984 – DOT-FH-11-8876, Task Order #8 – Type A Polymer Concrete Overlay Field Trials
1983 – DOT-FH-11-8876, Task Order #7 – Polymer Concrete Overlay Test Program Lebanon Ditch Bridge
1981 - DOT-FH-11-8164 – Polymer Concrete Overlay Test Program

In recent years, we have used the following polymer overlay products. The observed service life is identified along with the products.

MPCO –multilayer epoxy 3/8" minimum thickness overlay
5-10 years use, satisfied with performance

PPC – polyester polymer concrete – 3/4" minimum thickness overlay
15-20 years use, satisfied with performance

In addition, we are planning on implementing the following overlay materials soon -
EPC – epoxy polymer concrete – ¾" minimum thickness. Not in use yet in Oregon, but initial testing and specification development has been performed.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

PPC aggregates are performance based. Acceptance criteria are based on the hardened properties (modulus, compressive strength) of the polyester concrete. This creates variability in the aggregate sources and quality, but overall performance of the overlay has been good.

MPCO aggregates are primarily Armorstone from Washington Rock Quarries and Traction Control from Earth Work Solutions. Bauxite has been researched but not substantially used in Oregon. Acceptance criteria are based on gradation and fracture quantities. Performance has been acceptable.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

No specific chloride testing has been performed on decks with polymer overlays in place up to now.

Polymer overlays are believed to be essentially impermeable barriers to water and chloride penetration. They appear to be effective in the state of Oregon.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

For PPC, tining and resin content control are used for adequate skid resistance.

For MPCO, an aggregate product is listed on the QPL. Here are some of the abrasion testing we require:

Aggregate Absorption AASHTO T 84 -Use Preparation of Test Sample 7.2.1 Note 2 Bullet 4. - 1.25 % max.

Abrasion Loss ASTM D 7428(Modified) - 2.8 % max.

Mohs Hardness – 6.0 min.

We perform skid resistance testing with the ODOT skid trailer according to ASTM E 274. The approach and some results are described in 2010 – FHWA-OR-RD-11-05 Evaluation of Thin Overlays for Bridge Decks.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

Polymer overlays are typically installed as part of deck rehabs with Class 2 prep, repairing deck delamination and spalls. Cracks are sealed and do not typically show reflective cracking on the overlay surface. We use the same methods to inspect the bridge decks with visual inspection and sounding. Visual inspection of map cracking from the soffit is also standard.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Requirements for surface preparation are described in ODOT standard specification, Section 00504. Application conditions are found in the specifications of each polymer overlay, Section 00556 for MPCO and 00557 for PPC. See below for some excerpts from these specifications:

Surface Preparation

- Roughen the existing concrete surface to an exposed aggregate surface texture depth profile of at least 1/16 inch for PPC, MPCO, and membrane applications and 1/8 inch for SCO overlays. Determined profile according to ASTM E965 (standard volumetric test). Perform four tests per 500 square yards of concrete surface prepared, with a minimum of four tests per day.

Application Conditions - Apply primer on prepared surfaces when the following conditions are met:

- The deck surface has been visually dry for at least 5 Days.
- The ambient temperate and deck surface temperature are between 50° F and 90° F.
- The deck surface temperature is at least 5° F above the dew point.
- No rain is forecasted within 12 hours from the start of PPC placement.

Please contact us, if you would like to see the actual specifications.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

We have surface preparation specifications (Section 00504) and polymer overlay specifications (Section 00556 and 00557). Some materials are on the QPL, some are prescriptive-based specifications. Field QA/QC testing is required. The highlights of those tests are surface preparation (profile), modulus of elasticity, and bond.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

Low bond values at initial construction significantly impact the long term durability of the overlay. Surface preparation (profile) and a dry surface are critical. Our specifications require a dry surface with wait times after rain events or mechanically heating/drying the deck and testing with moisture meters. Areas where studded tires are more prevalent (high elevation snow zones) show increased rutting. Rut maintenance has been performed in these areas successfully, which uses epoxy or PPC patching material to fill the ruts.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

Proper surface preparation and moisture control are essential for long term durability.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

[redacted]

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Date Metrics	
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Deployment Metrics	
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Response Metrics	
Completed	12
Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **3** **Email ID: Public Access** **Participation Time: 6/29/2020 14:31**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

polyester polymer concrete(PPC)(from quik bond) has recently become fairly popular as an alternate to latex modified concrete in our state. this we predict is due more contractors being approved to install PPC allowing them more control in their schedule. PPC was chosen by the our recent P3 contractor as a preservation method . The P3 contract stipulates the contractor is responsible for maintenance of the bridge for 25 years (minus some select activates such as snow removal) after which point the bridge must be returned with no major element being rated lower than NBIS 6. Basically the contractor is betting the PPC will keep the deck in good shape for 25 years, with little to no additional activates required on their end. These structures are currently 5 years or less in age. The department has recently developed maintenance work items to potentially allow department forces to perform this work. generally positive outcomes with PPC with some adhesion issues due improper prep/install. supposedly another vendor would like to try and use their product in the state.

Thin Epoxy overlays(3/8") are also popular especially in regions where partial width closure is reasonably easy to accommodate. In general we would expect a epoxy overlay to last 8-10 years. we have some maintenance crews within the department with the skillset to perform these activates witch allow for some cost savings. internal testing revealed that the broadcast aggregate has significant impact on skid numbers and wearing requiring us to remove some flinty aggregates from approved sources.

we do some latex they either turn out good and last 20+ years or they crack within the first 5 years

we have one engineering district that favored bituminous with waterproofing membranes they prescribed to a specific maintenance schedule that kept the bituminous fresh.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

epoxy overlays this aggregate consists of angular silica sand, basalt, or other highly siliceous metamorphic or igneous rock. with a mhos hardness of minimum of 6.5

PPC is a bag mix controlled by the supplier of sand and non angular aggregrate.mohs hardness minimum of 7

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

no solid information on how effective polymer overlays are in controlling chloride penetration. service life is 20-25 years for PPC and 8-10 years for Epoxy overlays.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

most effective life for epoxy overlays is based on delaminations . skid numbers can control after 6 years in high traffic areas.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

we do not use GPR , or active corrosion monitoring. Visual inspection on thin overlays normally is not impacted as defects that occur typically migrate through the overlay. Sounding can be an issue if the material has rebound properties (such as PPC)

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

washed with degreaser, followed by drying with compressed air, then shot blasted.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

product sampling before activates commence. test strips can be required and normally are unless the contractor has significant history.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

delamination is the main failure mode. we put stringent control on surface prep. studded tires are not typical in the majority of our state. severe winter climate itself does not seem to impact these surfaces so long as the bond was a good quality.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

prep is the biggest thing . you can have the best material in the world if the surface does not have the correct roughness and cleanliness your throwing money on the ground.

if you can afford it PPC is looking like a good option . if you have full time maintenance workers that can potentially apply its really attractive

Epoxy overlays are good for setting a maintenance schedule. if you can commit to 8-10 year reapplications they are a strong option. Same with department force and PPC. if getting a warranty make sure the product manufacture will support the warranty.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

(Did not answer)

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
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Deployment Metrics	
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Bounced	0

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Individual Responses

Response No : **2** **Email ID: Public Access** **Participation Time: 6/29/2020 13:22**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

We have an approved products list for contractors to choose a product from.
https://apps.sd.gov/HC60ApprovedProducts/ProductList.aspx?args=114157ABD016950B233E2E6881E0C0EC0B4ACFF6FB1EEC6D7BFCAF9FAF9D7393

Initial epoxy chip seal trials were installed by Maintenance Forces about 1992-1993 on a few bridges in Mitchell Region, SE South Dakota. Used a one-coat Transpo T-48 polysulfied epoxy system (broom & seed). Quartzite was used as the aggregate. Overlay thickness of 40 mils. Minimal surface prep of cleaning the bridge deck/slab and a light sandblast.

- Performance was monitored for about five years with good results. Looked at expanding to contract work in the late 1990's.
- Worked on specifications in 1998 and 1999 and began producing contract plans for epoxy chip seal work in 1999. Placement was with hand labor using a grid system for coverage. Required an abrasive blast surface preparation.
- Results were mixed with some good applications and others that struggled. Problems encountered were incorrect mixing of epoxy, epoxy storage, inadequate coverage and dirty aggregate. Some of this improved with gaining education and experience of contractors and inspectors.
- Went to a basalt aggregate in 2004 for two reasons: Better performance in the winter with dark aggregate; Cleaner aggregate that did not have quite the fine dust issues that quartzite had.
- Better results overall but still had storage, coverage and mixing issues off and on. Coverage issues happened mainly on decks with heavy tining.
- Placed a couple of trial two coat systems on interstate bridges: A Polycarb Mark 163 was placed on a bridge on I90/Rowley St near Mitchell in 2006. This system was placed by the vendor. A Transpo T48 system was placed on two bridges on I90/Maple St in Rapid City in 2007. This was placed by a contractor. These have performed very well.
- In 2010 to help mitigate coverage issues, we required a diamond ground surface prior to the abrasive blast.......

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

For polymer chip seals is called out in Section 805 of our Standard Specifications.
https://dot.sd.gov/media/documents/2015_SDDOT_SpecBook.pdf

For HFST - we are using Calcined Bauxite. We could provide our standard note upon request.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

We do not have any research data to support effectiveness. We do have an active research project looking into polymer chip seals.
Effective life seems to depend upon traffic and winter weather (more snow plow passes appears to diminish life) and the ability for the polymer chip seal to remain effectively bonded. 10-15 years might be a reasonable expectation of life.
Following the completion of our research project we hope to have data of chlorides before and after application of polymer chip seals. Before COVID-19 - anticipated completion was Summer 2022. That may be delayed due to the current world situation.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

We believe they have improved skid resistance. We no longer test for skid resistance so we don't have any current data.
Our current research project is taking a look at the skit resistance in addition to the effectiveness of preventing chlorides from penetrating.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

We try to have good deck inspection data prior to application. If all delamination's are repaired prior - we have a good idea on the deck condition.
It can be difficult to inspect what you can not see.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Section 491 of our Standard Specifications. We do have seasonal limitations, require manufacturer representative, etc.
We hope our research project will identify any areas that could be strengthened if necessary.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

See Section 491 of Standard Specifications.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

We seem to get some failures of the polymer chip seals to bond to the concrete substrate. Estimate maybe 10% by deck area we get some type of failure. We have a research project to help us identify what the problem and solutions might be.
At one point the majority of all failures were related to one specific product. But we don't allow that product any more and we still are getting some failures.
If it's going to fail - it's typically in the first couple of years. And when it fails - it comes off in large sheets, normally for a whole phase done at one time. (Such that one lane might fail and the one next to it is fine).

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

Hope to have more information when our research project is completed in a couple of years.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

I might be interested if there are additional informal discussions. I may include others as determined by the agenda of the meeting.

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
Sent	0
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Response Metrics	
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Individual Responses

Response No : **9** **Email ID: Public Access** **Participation Time: 7/13/2020 15:49**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

[redacted]

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

Thin Bonded Polymer Overlay (TBPO): TBPO have been used in Utah 30+ years. UDOT has found that TBPO have met or exceeded expectations when proper surface preparation and placement has been performed. No reports specific to TBPO.

High Friction Surface Treatment (HFST): A limited number of HFST have been placed in Utah in the last 5 years, with no know placements prior. Effectiveness/satisfaction of the performance of HFST is still being evaluated due to its relatively new and limited use. No reports specific to HFST.

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

TBPO: Flint rock has been used in the past with poor performance polishing. Basalt has been consistent in its performance. Calcine Bauxite has also been used to provide a high friction surface with the TBPO, this treatment has had limited use, therefore the performance is still being evaluated.

HFST: Calcine Bauxite has been used, this treatment has had limited use, therefore the performance is still being evaluated.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

TBPO: No research has been performed on the effectiveness of TBPO and chloride penetration. Estimated TBPO service treatment life is 10 to 15 years.
Know Products: Dayton Superior, E-Chem, and Sika. No chloride related research/tests have been performed related to TBPO.

HFST: No research has been performed on the effectiveness of HFST and chloride penetration. Estimated HFST service treatment life is 15 years.
Know Products: Kwikbond. No chloride related research/tests have been performed related to HFST.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

TBPO: Skid resistance has been improved over a bare deck. Retaining the improved skid resistance appears to be affected by the aggregate used. Flint rock polished faster than anticipated. Basalt (Armor Stone) has been used with apparent success with retaining skid resistance. Calcine Bauxite has had limited use and is still being evaluated.

HFST: Skid resistance appear to improved over a bare deck and roadway prior to placement. As previously noted, HFST has had limited use and is still being evaluated for long term performance.

All state routes are evaluated for skid resistance annually. Skid values for specific structures are evaluated based on request.

No memo or reports on TBPO's or HFST's

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

A TBPO or HFST does affect the ability to visually inspect the surface of the deck. The underside of the deck becomes important to be able to visually inspect when a TBPO or HFST have been placed.

Effective Evaluation Techniques: Sounding, Ground Penetrating Radar (GPR), Thermal Imaging

Ineffective Evaluation Techniques: Half Cell Potential

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Proper surface preparation is essential for performance. Shot blasting is required with an specific surface roughness required. Decks are required to be free from dust and debris. Moisture content of the deck is evaluated with the use of a moisture meter or plastic sheet. Weather and temperature restrictions are also in place.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

UDOT Standard Specification: 03372 (Thin Bonded Polymer Overlay)

UDOT Special Provision: 02762 High Friction Surface Treatment (HFST) 9/2018

Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

TBPO: Reflective cracking and aggregate polishing.
Reflective cracking: UDOT is currently looking at using a healer/sealer as a primer for a TBPO to try and seal existing cracking and preventing reflective cracking.
Aggregate polishing: UDOT is working to remove Flint rock from approved aggregate due to its poor performance in regards to polishing.

HFST: Still being evaluated.

Utah does allow the use of studded tires. No evaluation has been performed to determine the impact of snow tire and severe winter climates on TBPO and HFST.

Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

No additional comments.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

[redacted]

Survey Metrics

Date Metrics	
Start Date	16-Jun-20
End Date	10-Jun-30

Deployment Metrics	
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Bounced	0

Response Metrics	
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Unique Access Rate	0.00%
Incomplete	0
Incomplete Incl. in Report	0

Individual Responses

Response No : **7** **Email ID: Public Access** **Participation Time: 7/9/2020 13:13**

[redacted]

Q 1 This survey has a total of 10 questions. Please provide the name and contact information of the respondent.

1 a **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Full Name**

[redacted]

1 b **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Telephone**

[redacted]

1 c **This survey has a total of 10 questions. Please provide the name and contact information of the respondent.: Email Address**

(Did not answer)

Q 2 1. Has your agency used polymer overlays or polymer-based high friction surface treatments (HFSTs) on bridge decks or pavement?

Yes

Q 3 2. What polymer overlay products has your agency used previously on bridge decks, how many years have they been in service, and how satisfied has your agency been with their performance? Please identify any relevant reports that your agency has published.

A variety of products. WSDOT has 29 bridges with Polymer Overlays. They were installed from 1986 - 2003.

They generally had a service life of 5-7 years before experiencing a significant loss in friction or debonding.

Here is a link to a report published in 1995:
https://www.wsdot.wa.gov/Research/Reports/300/374.1.htm

A Q 4 3. What types of aggregates have been used for HFSTs or polymer overlays and how satisfied has your agency been with their performance?

Generally local aggregates from WSDOT pits. The aggregate would mostly be pulled out of the overlay by studded tires.

A Q 5 4. How effectively have the polymer overlays protected the deck and bridge from chloride (deicer) penetration? How long have they been effective (service life)? Please describe any specific examples and products that you are aware of and identify or provide any relevant test reports or memos that your agency has published related to chloride penetration and overlay performance. If your agency has not assessed chloride contents in decks with polymer overlays, please note so.

WSDOT did some initial investigation and the polymer overlays provided protection for 10+ years until partial or total failure. The biggest issue was a loss of friction. WSDOT has not assessed chloride content in bridge decks after a polymer overlay was installed.

A Q 6 5. How well have the polymer overlays or HFSTs improved and retained skid resistance? Please describe any specific examples and products that you are aware of and identify any relevant reports or memos that your agency has published related to skid resistance. If your agency does not assess skid resistance, please note so.

Not well. Review the 1995 WSDOT report for information.

A Q 7 6. How much does the application of a thin polymer overlay affect your agency's ability to inspect and maintain bridge decks? What deck evaluation techniques used are affected, if any: visual inspection, sounding, ground penetrating radar surveys, corrosion monitoring, etc.?

Deck inspection is done visually. Area of Spalls and maintenance patches are recorded.

A Q 8 7. How does your agency ensure the concrete substrate is adequately prepared, dry and clean, prior to installation of the polymer overlay?

Inspection during construction. Specifications detail requirements.

A Q 9 8. What specification and QA/QC procedures does your agency specify to ensure the quality of the applied overlay?

Previous projects required pull off testing.

A Q 10 9. In your experience, what are common failure mechanisms and distress observed in polymer overlays or HFSTs and how does your agency prevent or mitigate them? Please include any experiences or insight you may have regarding the effects of studded tires and severe winter climates, if applicable.

Aggregate gets removed which reduces the friction. WSDOT tried a variety of remedies but none provided more than a couple of years of service.

A Q 11 10. Please provide any other insight or experience that may be helpful related to the selection, specification, installation, evaluation, and performance of polymer overlays or HFSTs on bridge decks.

The bridge deck must be in good condition with limited deterioration. WSDOT will use a thin polymer on a movable bridge but has generally discontinued their use.

Q 12 Do you have additional information to send to the researchers? If so, please send to Kate Hawkins (khawkins@wje.com) and Paul Krauss (pkrauss@wje.com) and indicate that you plan to send additional information below.

No

A Q 13 If you would be interested in participating in a web-meeting with other DOT staff for an informal discussion of this topic, please provide names, positions, and emails for whomever is interested.

(Did not answer)

APPENDIX B. SPECIFICATIONS AND APPROVED PRODUCTS LISTS

The approved products lists, standard specifications, and special provisions identified by the survey respondents are compiled in this appendix. The documents or document sections are organized by agency:

Alberta Transportation:

- Standard Specifications for Bridge Construction, Section 15 Non-Skid Polymer Overlay
- B405-July 00: Specification for Polymer Resins Used in Polymer Overlays
- B392 – July 2000: Specification for Seed Aggregates Used in Polymer Membranes and Overlays

Caltrans:

- Standard Specifications, Section 60-3.04 Deck Overlays
  - 4-19-2019 Revision: Replace the 9th paragraph of Section 60-3.04B(3)(c) with:
    Protect the overlay from moisture and do not allow traffic or equipment on the overlay (1) for a minimum of 4 hours cure time after final finishing and (2) until each rebound test result for the final finish shows a reading of at least 28 when tested under ASTM C805. The cure time must be extended if ordered. The rebound test may not be used to reduce the 4-hour cure time of the overlay.

MDOT:

- Special Provision for Thin Epoxy Polymer Bridge Deck Overlay
  - Contains approved products list for two-component 100 percent solids epoxy systems
  - Contains list of approved aggregate suppliers
- Special Provision for High Friction Surface Treatment

NYSDOT:

- Technical Services – Materials – Approved List, Thin Overlays, Structural
  - Thin Polymer (Epoxy) Overlay Wearing Surface for Structural Slabs (584.50010018)
  - Approved Aggregates for Use with (584.50010018)
  - High Friction Aggregate
- Item 584.40000009 – Polymer Overlay Wearing Surface for Structural Slabs (PPC)
- Item 584.50010018 – Thin Polymer (Epoxy) Overlays for Structural Slabs
- Item 601.03000004 – Specialty Friction Surface Treatment for Concrete

NCDOT:

- Epoxy Overlay System I
- Epoxy Overlay System II

OregonDOT:

- Oregon Standard Specifications for Construction
  - Section 00556 – Multi-Layer Polymer Concrete Overlay
  - Section 00557 – Premixed Polymer Concrete Overlays

SDDOT:

- Standard specifications for Roads and Bridges
  - Section 491 Bridge Deck Polymer Chip Seal
  - Section 805 Materials for Polymer Chip Seals

UDOT:

- 2020 Standard Specifications for Road and Bridge Construction, Section 03372 Thin Bonded Polymer Overlay

SECTION 15 NON-SKID POLYMER OVERLAY

TABLE OF CONTENTS

15.1 General

Resurfacing concrete bridge decks with non-skid polymer wearing surface consists of the repair of deck concrete, and application of a thin, flexible, multi layered, polymer aggregate wearing surface. This specification shall be used in conjunction with the "Specification for the Supply of Polymer Resins used in Polymer Overlays (B405)" and "Specification for Seed Aggregates used in Polymer Membranes and Overlays (B392)". The work includes mobilization, traffic accommodation, surface preparation and patching.

The Degussa Degadur System (MMA) is an approved alternate for the polymer overlay as specified. The Degussa Degadur System (MMA) does not meet the compressive strength and physical requirements of the "Specification for the Supply of Polymer Resins used in Polymer Overlay (B405)", and is applied in a different manner, but all other requirements of the specification shall still apply.

15.2 Materials

All polymer materials including aggregates shall be protected from moisture, dust, or other contaminants. Any wet or otherwise contaminated materials will be rejected.

15.2.1 Polymer

The polymer and the polymer mortar shall meet the requirements of the "Specification for the Supply of Polymer Resins used in Polymer Overlay (B405)".

The following products are currently approved by the Department for use in this work:

- Flexolith
- Flexogrid Degadur System (MMA)

15.2.2 Degadur System (MMA)

The DEGADUR B71 primer, DEGADUR 330 basecoat, and DEGADUR 410 sealer resins shall have the specified properties at the age of seven days conforming to Table 15-1: Properties of Degadur Resins.

Table 15-1: Properties of Degadur Resins

Property	Units	Primer	Basecoat	Sealer	Test Method
Density	g/cm^3	1.05	1.01	0.98	--
Viscosity @ time of mixing	cps	220-330	1100-1300	450-550	ASTM D2393
Hardness	Shore D	83	56	61	ASTM D2240
Water Absorption	%	0.1	0.1	0.1	ASTM D570
Tensile Strength	MPa	29	8	9	ASTM D638
Elongation @ Break	%	3	300	140	ASTM D638

15.2.2.1 Initiator (MMA)

The initiator for the MMA resins shall be a 50% Benzoyl Peroxide powder such as AKZO Chemicals Inc., CADOX BFF 50, or an approved equivalent. Dosage rates shall be in accordance with the MMA Manufacturer's recommendations issued in the Degadur Catalyst Design Table.

15.2.2.2 Promoter (MMA)

The promoter required for use with the MMA resins at application temperatures below 4°C shall be N, N Dimethyl-p-toluidine such as R.S.A. Corporation DMPT or an approved equivalent. Dosage rates shall be according to the MMA Manufacturer's recommendations.

15.2.2.3 Degadur Basecoat (MMA)

The basecoat shall have the specified properties at the age of seven days conforming to Table 15-2: Properties of Degadur Basecoat:

Table 15-2: Properties of Degadur Basecoat

Property	Units	Required Value	Test Method
Compressive Strength (1)	MPa	16-21	ASTM C109
Tensile Strength	MPa	3-5	ASTM D638
Elongation @ Break	%	6	ASTM D638
Flexural Strength	MPa	9-10	ASTM C580 mod
Freeze/Thaw Resistance	- -	Pass	ASTM C666
Bond Strength to Concrete	MPa	1.7 minimum	ACI 503R
Coefficient of Thermal Expansion	10E-5/K	7.9	DIN
Vicat Temperature	°C	50	DIN

Notes:

(1) Samples shall consist of 1 volume of Degadur Basecoat to 1 volume of Steilacoom.

The tests listed shall be conducted by a CSA approved testing lab, and shall include infrared and gas chromatography analysis (in accordance with BT008 Test Procedure for Finger Printing Sealers Using Infrared Spectroscopy and Gas Chromatographic Separation) for each component. All tests, including the spectro analysis, shall be done on the same samples of material.

15.3 Aggregates

15.3.1 Seed Aggregate

The overlay aggregate provided by the Contractor shall conform to the current "Specification for Seed Aggregates Used in Polymer Membrane and Overlays" (B392). The seed aggregates currently approved by the Department are Indag # 8 and Steilacoom 6X10 Bridge Topping.

15.3.2 Basecoat Filler Aggregate (Degussa Degadur System MMA)

Materials used in the basecoat shall consist of clean, dry (less than 0.2% moisture), angular grained silica sand and shall be free from dirt, clay, asphalt, and other organic materials. Materials sieve analyses shall conform to Table 15-3: Gradation of Basecoat Filler Aggregates (MMA):

Table 15-3: Gradation of Basecoat Filler Aggregates (MMA)

Gradation	Basaltic Sand	Ground Silica Flour
Sieve Size (mm)	% Passing	% Passing
4.750	99 – 100	n/a
2.360	92 – 100	n/a
1.000	61 – 70	n/a
0.600	45 – 65	n/a
0.300	10 – 20	n/a
0.150	0 – 10	n/a
0.045	n/a	90 - 100

15.4 Patching Materials

Type NH patching materials meeting the requirements of "Specification for the Supply of Bridge Concrete Patching Materials" (B391) may be used in place of concrete in partial depth repair provided they are used in accordance with the manufacturer's instructions.

Samples of the mixed patching material will be tested by the Contractor according to ASTM C109 and in compliance with the Frequency of Test Table included in Subsection 15.7.8, Testing and Strength Requirements. The average of three cubes will be used for acceptance and determination of payment range or rejection of the work as specified in Table 15-4: Patching Materials Payment Range.

Table 15-4: Patching Materials Payment Range

28 Day Minimum Compressive Strength as per Manufacturers Specified Strength Requirement	Amount of Payment
100% and above	Full bid price
90% to 99.9%	Bid price less $25.00 per square metre
80% to 89.9%	Bid price less $50.00 per square metre
70% to 79.9%	Bid price less $100.00 per square metre
65% and below	Will be rejected

The Contractor shall pay all costs for testing, including but not limited to making test cubes, transporting cubes to an independent certified testing laboratory of his choice, storage, curing, breaking and providing written reports of the test results to the Consultant.

All patches consisting of Type NH patching materials shall be cured for 14 days and tested for moisture in accordance with Subsection 15.7.3, Weather Conditions, Dryness of Concrete Substrate and Polymer Layers prior to the application of polymer overlay.

15.5 Crack Repair

All deck cracks more than 2 metres in length and greater than 0.3 mm wide shall be treated with a Type 1c sealer meeting the current "Material Testing Specifications for Concrete Sealers" (B388). Application of the sealer shall be prior to shotblasting of the concrete deck, and shall consist of a 100 mm strip applied at the coverage rate as shown on the Approved Type 1c Sealer List. Payment for crack repair will be considered incidental to the Contract and no separate or additional payment will be made.

15.6 Bridge Deck Repair

Bridge deck repair consists of; Surface Patching, Partial Depth Repair, or Full Depth Repair conforming to Table 15-5: Bridge Deck Repair Types, Depths, Materials and Description:

Table 15-5: Bridge Deck Repair Types, Depths, Materials and Description

Type of Patch	Depth of Patch (mm)	Repair Material	Description
Surface Patching	6 to 15	Polymer Mortar	Removal of surface deterioration without exposing rebar
Partial Depth Repair	15 to 200	Concrete	Chipping below corroded rebar and sandblasting of rebar is required
Full Depth Repair	Full depth of deck	Concrete	Forming of the underside of the deck is required

The concrete to be used for Partial and Full Depth Repair shall be Class HPC as specified in Section 4, Cast-In-Place Concrete.

15.6.1 Surface Patching

The Contractor shall patch surface voids and depressions in excess of 6 mm. The Consultant shall determine the area to be patched.

Polymer mortar, applied in accordance with the Manufacturer's instructions and these specifications, shall be used where surface patching is required. The patching polymer mortar shall consist of 3½-4½ volumes of an approved aggregate to each volume of polymer. The mortar shall yield a 40 MPa minimum compressive strength when tested at 7 days using 50 mm cube specimens, as described in Subsection 15.7.8, Testing and Strength Requirements.

Prior to placement of the polymer mortar, the surface of the concrete shall be shotblasted and/or sandblasted in accordance with Subsection 15.7.1, Surface Preparation.

The areas to be patched shall be primed with a 75 mm wide band of liquid polymer along their perimeter. The polymer mortar surface patch shall be placed while the liquid polymer primer is liquid or tacky, and to the original gradeline or as directed by the Consultant.

Measurement and mixing of polymer components and aggregates shall be done in accordance with Subsection 15.7.4, Batching and Mixing of Polymer.

Aggregate shall be placed over the fresh patch in sufficient quantity to ensure a rough surface for bonding to the polymer overlay. Smooth textured patches will be rejected.

When the Degussa Degadur System is used, the surface patching of the deck and curb shall be done with an approved 100% solids MMA mortar supplied by the Manufacturer of the methacrylate polymer overlay. Application shall be completed according to the Manufacturer's instructions.

Payment for Surface Patching will be made at the unit price bid per square metre of surface patching, which price shall include surface preparation, full compensation for the cost of furnishing all labour, equipment, materials, tools and incidentals necessary to complete the work.

15.6.2 Partial and Full Depth Repair

In areas where partial depth and full depth repair are required, Subsection 20.4.2, Partial Depth Repair and Subsection 20.4.3, Full Depth Repair shall apply.

All concrete shall be cured for 28 days and tested for moisture in accordance with Subsection 15.7.3, Weather Conditions, Dryness of Concrete Substrate and Polymer Layers prior to the application of polymer overlay.

15.6.3 Surface Defects and Tolerances

The requirements for all new surface patching, partial and full depth repair shall conform to Subsection 4.16.6, Surface Defects and Tolerances.

All patching and levelling requires acceptance by the Consultant prior to commencing the overlay. Failure to obtain acceptance may be cause for rejection of the overlay.

15.7 Polymer Construction

The polymer coverage rates shown in Table 15-6: Minimum Polymer Coverage Requirements, and Table 15-7: Minimum MMA Polymer Coverage Requirements for Degussa Degadur System (MMA) are based on undiluted polymer applied to a clean shotblasted deck surface or previously applied seeded polymer layer. Where the deck surface is spalled, scaled, or roughened by surface preparation, to depths up to 6 mm, the coverage rates shall be increased. Additional polymer material may also be required due to coarse texturing or grooving of the deck surface, or porosity of the concrete. The first layer shall extend up the full height of the vertical face of curbs and medians, and up 200 mm on the vertical faces of parapets. The Contractor shall obtain the Consultant's acceptance prior to increasing, for any reason, the minimum polymer coverage requirements. No separate or additional payment will be made for any additional polymer required.

Table 15-6: Minimum Polymer Coverage Requirements

Wearing Surface Class	1st Layer (ℓ/m²)	2nd Layer (ℓ/m²)	3rd Layer (ℓ/m²)
A	1.33	2.00	0.30
B	1.33	2.00	N/A
C	1.33	0.30	N/A

Table 15-7: Minimum MMA Polymer Coverage Requirements for Degussa Degadur System (MMA)

Wearing Surface	Primer Layer (ℓ/m²)	Premixed Basecoat Layer (ℓ/m²)	Sealer Layer (ℓ/m²)
Degussa Degadur System	0.40	5.00	0.67

15.7.1 Surface Preparation

In order to prevent bond failures at overlay edges at high impact locations, 10 mm deep by 10 mm wide grooves shall be cut by router or saw and sandblasted in close proximity and parallel to all deck joints, snow slots, deck drains and all other transverse edges. These grooves or keys are intended to provide increased anchorage for the overlay and shall be filled with polymer and seeded in conjunction with application of the first layer. Rough spots exceeding 3 mm in height on or adjacent to, deck joints shall be ground to provide a smooth transition prior to placement of the overlay.

Proper surface preparation is essential to ensure adequate bond strength between the polymer wearing surface and deck concrete. The deck concrete surface shall be prepared by shotblasting to remove all bond inhibitors including concrete laitance, asphaltic material, sealers and oil, and to expose the coarse aggregate in the substrate concrete. Those areas which are inaccessible to shotblasting, such as the vertical faces of the curbs, medians, and parapets shall be similarly prepared by sandblasting.

If in the opinion of the Consultant, reblasting is required in the event of rain, delay in applying the overlay, or subsequent leakage onto the deck of other contaminants, it shall be done at the Contractor's expense.

15.7.2 Deck Layout for the Overlay

Prior to the application of each layer, the Contractor shall submit a sketch to the Consultant showing the deck surface divided into segments which will be covered by each polymer batch. The length of each segment shall be determined by taking into account the overlay width, vertical faces, surface roughness, coverage rate, the amount of polymer in each batch, and losses in application equipment and containers.

After review of the sketches by the Consultant, the Contractor shall apply masking tape to the boundaries of the work area, except where these boundaries abut an existing polymer overlay mat of the same layer. The end of each overlay segment shall be marked at these boundaries. For the first layer only the layout area shall extend up the full height of the vertical curb and median faces and up 200 mm on the vertical faces of parapets. No overlay work shall commence until all layout by masking tape has been acceptably completed.

15.7.3 Weather Conditions, Dryness of Concrete Substrate and Polymer Layers

The work shall be done in suitable conditions of temperature, wind, dust, and moisture. If weather factors or moisture conditions of the substrate concrete are detrimental to the acceptable placement of overlay, the work shall be suspended until suitable conditions exist. Mixing, placing and curing of polymer shall be done at ambient air and substrate concrete temperatures between 10°C and 27°C.

The concrete substrate, including concrete patching and repairs shall be completely dry before the first layer of polymer is applied. Subsequent layers of polymer shall not be applied until previous layers are completely cured. Presence of moisture will be determined by the modified ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by Plastic Sheet Method". This test shall be carried out on the concrete substrate as well as on previous placed polymer overlays. The Contractor shall place a minimum of four test windows, per application area, at different time periods. The test windows shall consist of three layers of clear and one layer of black heavy duty 6 mil poly, 1000 mm x 500 mm located in moisture prone areas. The test windows shall be heated at a temperature of 55°C continuously for a time period of 6 hours for each test and at a time duration, period and frequency of test, as determined by the Consultant. Timing of the test windows shall not start until the temperature of the concrete surface has reached 55°C. This will not relieve the Contractor from his responsibility to ensure that the overlay does not debond. The Contractor shall provide four, 500 watt halogen lamp and a portable electric generator (3500 watt) and carry out the required testing which will be considered incidental to the Contract and no separate or additional payment will be made.

Application of the first layer is recommended when there is sufficient evidence of declining deck concrete temperatures.

15.7.4 Batching and Mixing of Polymer

Batching and mixing shall be done in accordance with the Manufacturer's instructions. The polymer shall be completely and thoroughly mixed before being deposited onto the deck. Any polymer not meeting the specification will be rejected, removed, and replaced at the Contractor's expense.

The temperature of the unmixed polymer constituents shall be between 10°C and 27°C. The polymer material shall be mixed in batches no larger than 20 ℓ. Each component shall be measured to within an accuracy of 3%. All containers shall be clean and free of contaminants of hardened polymer. Containers used for mixing and blending shall not be used for measuring.

In the absence of the Manufacturer's time limit for mixing, the minimum time for mixing shall be 3 minutes, however, for the Degussa Degadur System, the mixing time is a function of temperature. Attention shall be taken to blend the polymer adjacent to the mixing container surfaces. The presence of air, water bubbles or other contaminants in the mixed polymer will be cause for rejection of that batch.

The deck and adjacent areas shall be protected from spillage of polymer, solvents, and other materials. Any spilled materials shall be removed by the Contractor.

15.7.5 Application of Polymer Resin

Upon the Consultant's acceptance of the prepared deck surface and completion of the layout, the polymer shall be applied in accordance with the Manufacturer's instructions regarding mixing, blend time, temperature, time between layers, pot life, method of application, condition of substrate and any other requirements.

All cold joints in the overlay shall be offset 25 mm from cold joints of previous layers of the overlay. To ensure straightness, masking tape shall be applied along the perimeter of all areas to be overlay as well as along all steel deck joints, drains, curb faces or other edges of the layers of overlay. The first layer of polymer shall extend up the full height of the concrete curb and median faces and up 200 mm on the vertical faces of parapets. All masking tape used to define the boundaries of each segment shall be completely removed prior to gelling of the polymer.

The Contractor shall spread the polymer uniformly over the premeasured area using a squeegee and roller brush to carefully work the polymer into the surface and obtain the required coverage. Spiked footwear will be permitted for use by workers involved in the application work, but only prior to gelling of the polymer and with the constraint that all damage or defects in the surface will be repaired. Spreading and levelling of fresh polymer shall be completed while the material is in a state of low viscosity, and within seven minutes of batching. Failure to comply with the seven minute limit may result in rejection of the batch. Application of material which has begun to gel and increase in viscosity will not be permitted.

Application of the third layer of polymer (tie coat) shall be by airless spraying only. The polymer shall not be cut back with any solvents. This does not apply to the Degussa Degadur System, where the sealer layer may be applied with a roller.

The Contractor shall prevent or repair all bubbles, blisters, pinholes or other defects.

15.7.5.1 Degadur Base Coat (MMA)

The basecoat mixture shall be prepared by blending the silica flour and basaltic sand components with the resin in a suitable container (e.g. 20 ℓ pail), followed by the addition and subsequent blending of the initiator. The mixture shall be applied over clean, dry, cured primer surfaces at the coverage rate specified in Subsection 15.7, Polymer Construction, using an approved spreading method. The applicator shall take care to allow the ridges between passes to self-level before broadcasting aggregate. Small areas may be touched up with a steel trowel.

The deck layout may be subdivided into coverage areas corresponding to a maximum of 150 ℓ of MMA mix rather than 20 ℓ as specified in Subsection 15.7.2, Deck Layout for the Overlay.

Applicators shall not walk on a polymer layer after 4 minutes from time of placement.

15.7.5.2 Degadur Sealer (MMA)

The sealer mixture shall be applied to the cured and swept basecoat using paint rollers and brushes. Application shall be in a "dip and roll" manner from containers holding no more than 8 ℓ at a time; sealer shall not be poured directly onto the deck.

15.7.6 Seeding of Aggregate

The Contractor shall seed the first and second layer of polymer for Class A and B wearing surfaces and the first layer for Class C wearing surfaces. When the Degussa Degadur System (MMA) is used, the basecoat layer shall be seeded. The full height of the vertical face of curbs and median and up 200 mm of the vertical faces of the parapets shall not be seeded. The aggregate shall be seeded into the fresh polymer before gelling or increase in viscosity occurs. It shall be broadcast into the fresh polymer in such a manner that no ripples or waves are created and no segregation of the aggregate occurs. The aggregate shall impact the fresh polymer surface in a near vertical direction. Improper seeding technique will result in the work being suspended until proper methods are employed. The aggregate shall be placed so that an excess quantity covers the entire surface of the fresh polymer, no polymer is visible, and the surface has a dry appearance. As the aggregate settles into the fluid polymer, all "wet" spots which appear in the surface shall be promptly re-seeded before the polymer becomes viscous. At no time shall the Contractor disturb previously placed aggregate in an effort to cover "wet" surface spots. Once gelling begins, walking on the overlay will not be permitted until it has properly cured.

If insufficient aggregate has been placed and the "wet" areas harden to form glassy, resin rich areas, the Contractor shall remove these areas to sound concrete, redo the deck surface preparation and replace the overlay.

After curing of the previous placed overlay and on acceptance of the Consultant, all excess aggregate or other contaminants shall be removed by power sweeping and air blasting. After cleaning to the satisfaction of the Consultant, the subsequent layer of polymer shall be applied.

Additional cleaning will be required if application of the subsequent layer of polymer is delayed and the overlay surface has become contaminated.

In the event that any layer of polymer material is subjected to rain or any other form of damage, the contractor shall do vertical pull out tests to confirm the adequacy of the material. This test consists of bonding a 64 mm diameter sandblasted steel disk to the prepared substrate by using an approved polymer, and pulling it from the substrate by applying a vertical force.

The polymer overlay in question will not be accepted unless at least 75% of the bonded steel disk surface has retained substrate concrete exceeding 3 mm in depth. At the discretion of the Consultant the pull out test may be carried out on any polymer layer. The minimum acceptable bond strength on normal weight concrete shall be 3.0 MPa. The Contractor shall repair all bond test locations with polymer overlay in accordance with this specification. The pull out equipment and repair of the polymer overlay will be considered incidental to the Contract.

15.7.7 Smoothness of Overlay Surface

Larger smoothness defects of the bridge deck, as determined by the Consultant shall be repaired by surface patching. Minor defects inherent in the concrete deck shall be smoothened by the application of the polymer overlay.

Roughness attributable to the overlay will be tested with a 3 m long straight edge. When placed anywhere in any direction on the surface except across the crown, the gap between the bottom of the straight edge and the surface of the overlay shall not exceed 3 mm. Overlays not meeting the criteria will be rejected, removed and replaced at the Contractor's expense.

The location and number of measurements taken will be at the discretion of the Consultant.

15.7.8 Testing and Strength Requirements

Two weeks prior to commencement of work, the Contractor shall be responsible for testing of infrared and gas chromatography analysis (in accordance with BT008) for each polymer component, compressive strength of the polymer mortar, modulus elasticity of the polymer, and grain size analysis of the aggregate. These results shall be provided to the Consultant for review.

During placement of the polymer, samples of the mixed polymer material will be randomly selected by the Consultant and the Contractor shall cast sets of three 50 mm cubes for compressive strength testing in accordance with test method ASTM C 109. These tests will be used for acceptance and determination of payment range or rejection of the work as specified in the applicable table below entitled "Partial Payment Schedule". The test cubes will be cast at a ratio of 22 volumes of approved aggregate to 1 volume of mixed polymer and cured for seven days in dry lab conditions. When the Degussa Degadur System is used, the test cubes will be cast at a ratio of 1 part base coat and 1 part approved aggregate, by volume and cured for seven days.

The compressive strength will be the maximum load measured or the load causing a 2.5 mm deflection, whichever occurs first. (This modified ASTM C 109 test method will also be used for acceptance testing of proposed overlay materials.) The compression test will be done using a steady loading rate of 0.5 MPa ±0.05 MPa per second.

The acceptable range of 7 day compressive strength for the polymer shall be 40 MPa to 70 MPa.

The MMA product shall have a 7 day compressive strength range of 16 MPa or over.

The Department reserves the right to reject any overlay whatsoever which does not meet the applicable strength requirements. The Department may however, at the discretion of the Consultant, accept overlay which fails to meet the compressive strength range. In this case payment will be made in accordance with Table 15-8: Partial Payment Schedule for Low Strength Polymer and Table 15-9: Partial Payment Schedule for Low Strength MMA Overlay.

Table 15-8: Partial Payment Schedule for Low Strength Polymer

7-Day Compressive Strength (MPa)	Percentage of Unit Price
Between 40.0 and 70.0	100
38.0 to 40.0 or 70.0 to 72.0	90
36.0 to 38.0 or 72.0 to 74.0	80
34.0 to 36.0 or 74.0 to 76.0	70
32.0 to 34.0 or 76.0 to 78.0	60
30.0 to 32.0 or 78.0 to 80.0	50
Below 30.0 or over 80.0	Rejected

Table 15-9: Partial Payment Schedule for Low Strength MMA Overlay

7-day Compressive Strength (MPa)	Percentage of Unit Price
16 and Over	100
15.0 to 15.9	90
14.0 to 14.9	80
13.0 to 13.9	70
12.0 to 12.9	60
11.0 to 11.9	50
Below 11.0	Rejected

Compressive strength tests may be carried out on any layer of the overlay. If a test result of any layer is below that specified, the reduced unit price shall apply to the full overlay thickness. Where compressive strength tests have been done on more than one layer, the lowest strength test result will be used to determine adjustment of the unit price. Each test will represent the 100 m^2 area poured during that batching operation. The Consultant will determine the test location of each test. The Contractor shall cast a set of three cubes to the frequency of test listed in Table 15-10: Frequency of Test.

Table 15-10: Frequency of Test

Deck Area (m^2)	No. of Tests (Set of 3 Cubes)
1 - 500	4
501 - 1000	8
1001 - 2000	14
2001 - 3000	20
3001 - 4000	24

The Contractor shall pay all costs for testing, including but not limited to making test cubes, transporting cubes to an independent certified testing laboratory of his choice, storage, curing, breaking, and providing written reports of the polymer test results to the Consultant.

15.7.9 Opening to Traffic

The polymer overlay surfaces shall not be opened to traffic until a minimum of 60% of the 7 day compressive strength or 3.0 MPa of tensile strength is achieved based on the last batch of the day. It is recommended that the Contractor casts one additional set of cubes from the last batch of the day and have these tested at his cost. The cubes shall be cured in the field at ambient air temperature prior to testing.

No traffic will be allowed on the polymer overlay until all layers are acceptably placed and confirm to the strength requirement.

15.8 Payment

Measurement for payment of non-skid polymer overlay will be by the square metre of acceptably treated area, measured to the nearest 0.1 m^2.

Payment will be made at the unit price bid for "Non-Skid Polymer Overlay", and will be full compensation for surface preparation; the supply and application of polymer overlay; and all labour, equipment, tools and incidentals necessary to complete the Work as shown on the Drawings and to the satisfaction of the Consultant.

ALBERTA INFRASTRUCTURE AND TRANSPORTATION

TECHNICAL STANDARDS BRANCH

B405-JULY 00

SPECIFICATION FOR POLYMER RESINS USED IN POLYMER OVERLAYS

1.0 INTRODUCTION

This Specification is for the supply of polymer resin used in Non-Skid Polymer Overlays (Section 15).

The polymer, when applied on a concrete deck and seeded with an approved aggregate (B392), shall create a durable polymer-aggregate composite that exhibits thermal compatibility, waterproofing ability, and skid resistance. The polymer shall be UV resistant (BT007), flexible, have good bond to concrete and polymer to polymer, and meet the physical properties for polymer listed below. Table 1 summarizes all the requirements for the physical properties of the polymer resin.

1.1 Related Documents

The following documents are to be used in conjunction with B405, Specification for the Supply of Polymer Resins used in Polymer Overlays.

B392	Specification for Seed Aggregates used in Polymer Membrane and Overlays
BT007	Test Procedure for Ultraviolet Resistance of Polymer Resins used in Bridge Deck Wearing Surfaces.
BT008	Test Procedure for Finger Printing Sealers using Infrared Spectrography and Gas Chromatographic Separation

2.0 QUALIFYING TESTS

The Supplier/Manufacturer shall engage an independent, CSA certified laboratory for the purpose of sampling, testing, and completing the qualifying tests at his own expense.

2.1 **Samples and Mixing**

The sample of product submitted to the testing lab shall be large enough to allow all the samples for the required tests to be cast from the same batch. The polymer resin shall be mixed in accordance with the manufacturer's instruction. The manufacturer's product data sheet and safety data sheet shall also be submitted along with the sample.

2.2 **Spectrographic and Chromatographic Analysis**

For each component, the polymer resin shall be subjected to an infrared spectrographic analysis test (a graph of frequency versus amplitude) and a gas chromatographic analysis test (a graph of separation versus time) shall be plotted for all components and submitted to the Department for review.

2.3 **Solids Content**

The solid content of the mixed polymer resin shall be tested in accordance with ASTM D2369, at 60°C for 2 hours, "Standard Test Method for Volatile Content of Coatings". The solids content shall not be less than 98%.

2.5 **Density**

The density of each component shall be determined in accordance with ASTM D1475 "Standard Test Method for Density of Liquid Coatings, Inks, and Related Products".

2.5 **Bond Strength**

The bond strength to concrete when tested in accordance with ASTM C882, •Bond Strength of Epoxy-Resin Systems used with Concrete by Slant Shear• shall not be less than 10 MPa at an age of 7 days.

The interlayer bond strength to polymer when tested in accordance with ASTM C882, •Bond Strength of Epoxy-Resin Systems used with Concrete by Slant Shear• at an age of 2 days shall not be less than 7.0 MPa.

2.6 Tensile Strength

The tensile strength when tested in accordance with ASTM D638, •Tensile Properties of Plastics• shall be within the specified range of 10 MPa to 17 MPa at an age of 7 days.

The tensile strength after 365 days of UV exposure when tested in accordance with ASTM D638 •Tensile Properties of Plastics• shall have an equivalent tensile strength at 7 days, ∀ 3 MPa.

2.7 Tensile Elongation

The tensile elongation when tested in accordance with ASTM D638, •Tensile Properties of Plastics• shall not be less than 30% at an age of 7 days.

The tensile elongation after 365 days of UV exposure when tested in accordance with ASTM D638, •Tensile Properties of Plastics•, shall not be less than 20%.

2.8 Modulus Elasticity and Unit Weight

The modulus of elasticity (secant) of the mixed polymer resin when tested in accordance with ASTM C-109, •Test Method for Compressive Strength of Hydraulic Cement Mortars•, shall not be greater than 900 MPa. The samples shall be tested at a loading rate of 0.5 MPa ∀ 0.05 MPa per second. The unit weight shall be recorded prior to testing and a plot of the stress-strain curve shall be included with the report.

2.9 Compressive Strength and Unit Weight

The compressive strength of the polymer mortar, when tested in accordance with ASTM C109, •Test Method for Compressive Strength of Hydraulic Cement Mortars•, shall not be less than 40.0 MPa at an age of 7 days. The unit weight of the samples shall be recorded prior to testing. The samples shall be tested at a loading rate of 0.5 MPa ∀ 0.05 MPa per second, cubes cast with 1 volume of polymer to 2.5 volumes of Indag # 8 aggregate.

2.10 **Thermal Compatibility**

The thermal compatibility of the polymer mortar when tested in accordance with ASTM C884, •Thermal Compatibility between Concrete and an Epoxy-Resin Overlay•, shall not fail after 10 cycles of -21°C to 60°C.

2.11 **Absorption**

The polymer mortar when tested in accordance with ASTM C642, •Specific Gravity, Absorption, and Voids in Hardened Concrete•, shall be less than 1.25%.

3.0 EVALUATION OF POLYMER RESIN

To further evaluate the product, the Supplier/Manufacturer shall provide a list of projects where the material has been in service for at least 5 years, and shall include performance data, traffic volumes, and the clients' names and phone numbers.

The polymer resin shall meet or exceed all qualifying tests, and shall perform adequately in the field. The Department will continue to evaluate performance over a two-to five-year period. Approval of the polymer resin will be conditional only; unsatisfactory performance, whether short term or long term, shall be grounds for withdrawal of the approval.

4.0 ADDITIONAL REQUIREMENTS

4.1 **Quality Control**

The Supplier/Manufacturer shall be responsible for quality control of the product. He shall sample and test the polymer resin as necessary during production to ensure that all polymer resin conforms to these specifications, and is consistent with the sample of material that was tested and approved. When requested by the Department, the manufacturer shall submit the quality control test data within 30 days. Any change in the product will require a re-test at the Supplier•s/ Manufacturer's expense.

4.2 **Labelling**

The following information shall be labelled on the outside of each container for each component.

(a) Dangerous Goods Warning
(b) Product Name
(c) Manufacturer
(d) Batch and/or Lot Number
(e) Date Material Manufactured
(f) Shelf Life
(g) Volume of Material
(h) Mix Ratio

5.0 RIGHT TO REJECT

The Department reserves the right to run laboratory tests, reject materials, and withdraw the approval of the product should it not meet the requirements of the specification.

The material shall meet or exceed all qualifying tests, and shall perform adequately in the field. Unsatisfactory performance, whether short term or long term, shall be grounds for withdrawal of the approval.

6.0 LABORATORY TEST REPORT

The report prepared by the testing laboratory shall include all the results of the qualifying tests, product data sheet and safety data sheet.

The test results shall be submitted by the Supplier/Manufacturer to:

Alberta Infrastructure and Transportation
Technical Standards Branch
2nd Floor, Twin Atria Building
4999 - 98 Avenue
Edmonton, Alberta T6B 2X3
Attention: Clarence Wong, Materials Engineer
Telephone: (780)415-1029 FAX: (780)422-5426

TABLE 1

PHYSICAL REQUIREMENTS OF POLYMER			
Material	**Physical Property**	**Required Value**	**Test Method**
Polymer	Solids Content	minimum 98% solids	ASTM D2369 at 60°C for 2 hours
Polymer	Specific Gravity of Each Component		ASTM D1475
Polymer	Infrared Spectrography and Gas Chromatographic Separation		BT008
Polymer	Bond Strength to Concrete @ 7 days	10.0 MPa (minimum)	ASTM C882 Non-sandblasted surface.
	Interlayer Bond Strength to Polymer @ 2 days. Tested @ 23°C	7.0 MPa (minimum)	
Polymer	Tensile Strength @ 7 days	10.0 - 17.0 MPa	ASTM D638 Speed 4-6 mm/min. Sample type M-1. Use 10 x 10 mm sample.
	Tensile Strength after 365 days UV exposure	Equivalent of tensile strength @ 7 days ∀ 3 MPa	
Polymer	Tensile Elongation @ 7 days	30.0% (minimum)	ASTM D638 Speed 4-6 mm/min Use 10 x 10 mm sample.
	Tensile Elongation after 365 days UV exposure	20% (minimum)	
Polymer	Modulus of Elasticity @ 7 days (Secant)	900 MPa (maximum)	ASTM C109 (Modified) 50 x 50 mm cubes.
Polymer Mortar	Compressive Strength @ 7 days	40.0 MPa (minimum)	ASTM C109 (Modified) 50 x 50 mm cubes
Polymer Mortar	Thermal Compatibility @ 7 days	10 cycles of -21°C to 60°C (minimum)	ASTM C884 6 mm depth.
Polymer Mortar	Absorption Volume of Permeable Voids @ 7 days	1.25% (maximum)	ASTM C642 50 x 50 mm cubes oven dry @ 60°C for 48 hours.

(1) Polymer shall be mixed in accordance with the Manufacturer's instructions.
(2) All polymer mortar samples shall consist of 1 volume of polymer to 2.5 volumes of Indag #8 aggregate.
(3) All tests will be carried out using the most recent test method.
(4) UV test to be carried out in accordance with Alberta Infrastructure and Transportation BT007, Test Procedure for Ultraviolet Resistance of Polymer Resins used in Bridge Deck Wearing Surfaces.
(5) Infrared Spectrography and Gas Chromatographic Separation to be carried out in accordance with Alberta Infrastructure and Transportation BT008, Test Method for Finger Printing Sealers using Infrared Spectrography and Gas Chromatographic Separation.

ALBERTA TRANSPORTATION

TECHNICAL STANDARDS BRANCH

B392 - JULY 2000

SPECIFICATION FOR SEED AGGREGATES USED IN POLYMER MEMBRANES AND OVERLAYS

1.0 GENERAL

1.1 INTRODUCTION

This Specification is for the supply of seed aggregate to be used in "Resurfacing of Bridge Decks with Polymer Membrane and A.C.P. Wearing Surface (B386)", and "Non-Skid Polymer Overlay" (Section 15).

The seed aggregate, when applied to the polymer, shall create a durable polymer-aggregate composite that exhibits thermal compatibility and waterproofing ability. When used with polymer membrane the aggregate shall also provide a bond between the membrane and the asphaltic concrete wearing surface. When used in a non-skid polymer wearing surface the aggregate shall provide acceptable abrasion and skid resistance. The aggregate shall be gap graded, clean and free of deleterious substances and have the properties listed below.

1.2 CLASSIFICATION OF SEED AGGREGATES

Seed aggregates shall be mined and manufactured by crushing hard rock.

2.0 QUALIFYING TESTS

The Manufacturer shall engage an independent engineering testing laboratory for the purpose of sampling the aggregate, and completing the qualifying tests at his own expense. The results of the qualifying tests shall be submitted to the Engineer, for review.

2.1 SAMPLING

The sample of aggregate submitted for testing shall accurately represent the seed aggregate material, and shall comply with ASTM D75 except that the sample size shall be 40 kg.

2.2 GRAIN SIZE DISTRIBUTION

Grain size distribution shall be tested in accordance with ASTM C136, "Sieve Analysis of Fine and Coarse Aggregates", and shall meet the gradation requirements shown below.

GRADATION REQUIREMENTS
SIEVES

US Standard Designation	Metric Designation	% Retained
#6	3.35	0 – 3
#8	2.36	
#10	2.00	70-97*
#12	1.70	
#20	0.85	3-20
Passing #20	0.85	0-3

* Combined #8, #10 and #12

2.3 COMPRESSIVE STRENGTH

The compressive strength of the rock, when tested in accordance with ASTM C170 Compressive Strength of Dimension Stone , shall not be less than 200 MPa.

2.4 SPECIFIC GRAVITY AND ABSORPTION

The bulk specific gravity shall be greater than 2.6, and absorption shall be less than 1.5% when tested in accordance with ASTM C128, "Specific Gravity and Absorption of Fine Aggregate".

2.5 ABRASION

The aggregate loss shall be less than 12% when tested in accordance with ASTM C131, "Standard Test Method for Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact" in the Los Angeles machine, Grade "D".

2.6 SOUNDNESS

The soundness of the aggregate, when tested according to ASTM C88, "Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate", shall be 2.0% maximum loss using Sodium Sulfate.

2.7 HARDNESS

The aggregate shall have a minimum Mohs hardness of 6.0.

2.8 VOID SPACE

The minimum void space produced by the aggregate, when tested in accordance with ASTM C29/C29M, "Standard Method for Unit Weight and Voids in Aggregate", shovelling procedure, shall be 47%.

2.9 CHEMICAL ANALYSIS

The aggregate shall be tested for the percentage of the following chemical compositions:

- silica (S_iO_2)
- aluminum oxide (Al_2O_3)
- iron oxide (Fe_2O_3)
- magnesium oxide (MgO)
- calcium oxide (CaO)

The aluminum oxide (Al_2O_3) shall not be less than 10%.

2.10 COLOUR TEST

The colour plate number, when tested in accordance with ASTM C40, "Organic Impurities in Fine Aggregates for Concrete", shall not be greater than 1.

2.11 FRACTURE FACE COUNT

The fracture face count shall be 97% for 2 or more fractured faces when tested in accordance with California Transportation Test Method No. Calif. 205.

2.12 MOISTURE CONTENT

The moisture content shall be less than 0.3% when tested in accordance with ASTM D2216. "Laboratory Determination of Water Content of Soils, Rock, and Soil Aggregate Mixtures".

2.14 ABSORBED ENERGY

Cylindrical specimens (75 mm by 150 mm) shall be made in accordance with ASTM C192 using Flexolith polymer resin at an aggregate to polymer ratio of 2.5 to 1 by volume, and tested in accordance with ASTM C39 at an age of 7 days. The absorbed energy at point of failure obtained from the area under the stress-strain curve shall not be less than 8.0 MPa.

3.0 EVALUATION OF AGGREGATE

To further evaluate the product, the Manufacturer shall provide a list of projects where the material has been in service for at least 5 years, and shall include performance data, traffic volumes, and the clients' names and phone numbers.

The aggregate shall meet or exceed all qualifying tests, and shall perform adequately in the field. The Engineer will continue to evaluate performance over a two-to five-year period. Approval of the aggregate will be conditional only; unsatisfactory performance, whether short term or long term, shall be grounds for withdrawal of the approval.

4.0 ADDITIONAL REQUIREMENTS

4.1 PACKAGING

Seed aggregate shall be packaged in tear resistant and moisture resistant bags, which filled, do not exceed 50 kg.

4.2 QUALITY CONTROL

The Manufacturer shall be responsible for quality control of the product. He shall sample and test the aggregate as necessary during production to ensure that all aggregate conforms to these specifications, and is consistent with the sample of material that was tested and approved.

4.3 CONFIRMING AGGREGATE QUALITY

The Contractor shall engage an approved independent engineering testing laboratory to take aggregate samples from the delivered aggregate, and to provide aggregate analyses of the grain size distribution and moisture content to confirm compliance with these specifications prior to commencement of work. The bagged aggregates will be separated into lots of 800 kilograms each and one properly identified sample shall be taken and analysed from each lot. Failure of the sample to meet the aggregate specifications will result in the entire 800 kilogram lot represented by that sample being rejected. The Engineer may request additional aggregate tests.

5.0 RIGHT TO REJECT

The Department reserves the right to run laboratory tests, reject material, and withdraw approval of the aggregate should it not meet the requirements of the specification.

The material shall meet or exceed all qualifying tests, and shall perform adequately in the field. Unsatisfactory performance, whether short or long term, shall be grounds for withdrawal of the approval.

6.0 LABORATORY TEST REPORT

The report prepared by the testing laboratory shall include all the results of the qualifying tests.

The test results shall be submitted by the Manufacturer to:

Alberta Transportation
Technical Standards Branch
2nd Floor, Twin Atria Building
4999 - 98 Avenue
Edmonton, Alberta T6B 2X3
Attention: Dave Besuyen, Bridge Materials Engineer
Telephone: (780) 415-1037 ; Fax: (780) 422-5426

60-3.03B(4) Payment

The payment quantity for furnish bridge deck treatment material is the volume of mixed high-molecular-weight methacrylate resin placed.

60-3.03C–60-3.03J Reserved

60-3.04 DECK OVERLAYS

60-3.04A General

60-3.04A(1) General

Section 60-3.04 includes specifications for overlaying concrete bridge decks.

60-3.04A(2) Materials

Not Used

60-3.04A(3) Construction

Not Used

60-3.04A(4) Payment

Not Used

60-3.04B Polyester Concrete Overlays

60-3.04B(1) General

60-3.04B(1)(a) Summary

Section 60-3.04B includes specifications for placing polyester concrete overlays on concrete bridge decks.

Placing polyester concrete overlay includes placing a prime coat of methacrylate resin to the bridge deck before placing the polyester concrete overlay.

Furnishing polyester concrete includes furnishing and placing the trial overlay and concrete base for the trial overlay.

60-3.04B(1)(b) Definitions

Reserved

60-3.04B(1)(c) Submittals

Submit a work plan for the placement of the deck overlay. Include the following in the work plan:

1. Schedule of overlay work for each bridge and a schedule of work for any trial overlays
2. Method for storage and handling of methacrylate resin and polyester concrete components
3. Description of equipment for applying methacrylate resin
4. Description of equipment for measuring, mixing, placing, and finishing the polyester concrete overlay
5. Method for isolating expansion joints and drainage
6. Cure time for polyester concrete
7. Description of equipment for applying sand
8. Method for avoiding spills or discharges of methacrylate and polyester concrete, including materials and equipment
9. Method for cleaning up spills or discharge of methacrylate and polyester concrete, including materials and equipment
10. Procedure for preventing resin from dripping from the structures
11. Method for disposal of excess methacrylate resin, polyester concrete, and containers

For each shipment of methacrylate and polyester concrete, submit an SDS for each component.

Submit test samples of methacrylate resins, polyester resins, and aggregates with a certificate of compliance and manufacturer's test results at least 15 days before use.

Submit aggregate and resin volumes recorded from the volumetric mixer at the end of each work shift.

60-3.04B(1)(d) Quality Assurance

Complete a trial polyester concrete overlay before starting overlay activities. Notify the Engineer at least 15 days before constructing the trial overlay.

The trial overlay must be:

1. At least 12 by 12 feet and the same thickness as the overlay shown
2. Constructed on a prepared concrete base within the project limits at an authorized location
3. Constructed (1) using the same materials, equipment, and construction methods to be used in the work and (2) under conditions similar to those anticipated when the work will be performed

Use the trial overlay to determine the initial polyester-concrete set time.

The Engineer performs friction testing of the trial overlay under California Test 342. After completion of the trial overlay, allow 10 days for the Engineer to perform the testing.

The completed trial overlay must demonstrate (1) compliance with these specifications and (2) that the work will be completed within the time allowed.

Do not perform overlay activities until the trial overlay is authorized. The authorized trial overlay is the standard of comparison in determining the acceptability of the overlay.

The Engineer may perform testing under California Test 342 to verify the coefficient of friction of the overlay surfaces.

Dispose of the trial overlay and concrete base after acceptance of all polyester concrete overlay surfaces.

Place polyester concrete overlay on:

1. Portland cement concrete no sooner than 28 days after concrete placement
2. Portland cement based RSC no sooner than 14 days after concrete placement and your test results for prequalification of RSC show that the concrete attained at least 3,500 psi compressive strength
3. RSC using hydraulic cement other than portland cement no sooner than 3 days after concrete placement and your test results for prequalification of RSC show that the concrete attained at least 3,500 psi compressive strength
4. Magnesium phosphate based rapid setting concrete patch material no sooner than 3 days after final set
5. Modified high alumina based rapid setting concrete patch material no sooner than 30 minutes after final set

60-3.04B(2) Materials

Polyester concrete consists of polyester resin binder and aggregate.

Polyester resin binder must:

1. Be an unsaturated isophthalic polyester-styrene copolymer
2. Contain not less than 1 percent by weight gamma-methacryloxypropyltrimethoxysilane, an organosilane ester silane coupler
3. Be used with a promoter compatible with suitable methyl ethyl ketone peroxide and cumene hydroperoxide initiators
4. Comply with the requirements shown in the following table:

Quality characteristic	Test method	Requirement
Viscosity[a] (cP, RV, no. 1 spindle, 20 RPM, at 25 °C)	ASTM D2196	75–200
Specific gravity[a] (at 25 °C)	ASTM D1475	1.05–1.10
Elongation (min, %) Type I specimen, 0.25 ± 0.03 inch thick Rate = 0.45 in/min Sample Conditioning: 18/25/50+5/70	ASTM D638 ASTM D618	35
Tensile strength (min, psi) Type I specimen, 0.25 ± 0.03 inch thick Rate = 0.45 in/min Sample conditioning: 18/25/50+5/70	ASTM D638 ASTM D618	2,500
Styrene content[a] (%, by weight)	ASTM D2369	40–50
PCC saturated surface-dry bond strength (min, psi, at 24 hours and 70 ± 2 °F)	California Test 551	500
Static volatile emission[a] (max, gram/sq m loss)	SCAQMD Method 309-91	60

[a]Test must be performed before adding initiator.

Aggregate for polyester concrete must:

1. Comply with sections 90-1.02C(1), 90-1.02C(2), and 90-1.02C(3), except fine aggregate must consist of natural sand
2. Have not more than 45 percent crushed particles retained on the no. 8 sieve when tested under California Test 205
3. Have a weighted-average aggregate absorption of not more than 1 percent when tested under California Tests 206 and 207
4. At the time of mixing with resin, have a moisture content of not more than one half of the weighted-average aggregate absorption when tested under California Test 226
5. Comply with the percentage passing limits for one of the aggregate gradations shown in the following table:

Aggregate Gradation

Sieve size	Percentage passing	
	3/8 inch maximum	No. 4 maximum
1/2"	100	100
3/8"	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

High-molecular-weight methacrylate for the resin prime coat must comply with section 60-3.03B except:

1. Methacrylate resin must be free of wax
2. Tack-free time requirements do not apply
3. Friction testing is not required for the resin prime coat

Sand for abrasive sand finish must:

1. Be commercial-quality blast sand

2. Be graded such that not less than 95 percent passes the no. 8 sieve and not less than 95 percent is retained on the no. 20 sieve when tested under California Test 205
3. Have an average absorption of not more than 1 percent when tested under California Test 207

60-3.04B(3) Construction

60-3.04B(3)(a) General

Notify the Engineer at least 15 days before delivery of methacrylate resin components in containers larger than 55 gallons to the job site.

The Engineer provides the final grade and cross slope before the start of overlay work.

The Engineer tests existing deck surface smoothness under section 51-1.01D(3)(b)(ii) and may require you to modify the existing deck smoothness under section 42-3. Modifying the existing deck smoothness is change order work.

Complete the construction of approach slabs before placing polyester overlay.

New concrete deck surfaces must comply with section 51-1.03F(5) before starting overlay work.

60-3.04B(3)(b) Placing Methacrylate Resin

The Engineer determines the exact percentage of polyester resin binder at the time of placing.

The deck must be dry before placing the methacrylate prime coat. The concrete surface must be from 50 to 100 degrees F and the relative humidity must be not more than 85 percent.

Clean the deck by vacuuming, then blow the deck clean with high-pressure oil-free air. Dust must not be blown into the air while blowing the deck.

Thoroughly mix all components of the methacrylate resin. Apply the resin to the deck surface within 5 minutes of mixing. Apply the resin uniformly and spread to completely cover surfaces to be overlaid.

Apply methacrylate resin at an approximate rate of 55 sq ft/gal.

60-3.04B(3)(c) Placing Polyester Concrete

Use a continuous mixer to mix polyester concrete. The continuous mixer must:

1. Employ an auger screw device with a discharge chute
2. Be equipped with an automatic metering device that measures and records aggregate and resin volumes
3. Have a visible readout gage that displays volumes of aggregate and resin being recorded
4. Be certified under California Test 109 before use
5. Produce a satisfactory mix consistently during a demonstration

Record polyester concrete volumes at least every 5 minutes, including time and date.

Finishing equipment for polyester concrete must:

1. Have grade control capabilities resulting in a roadway surface that meets the smoothness requirements of section 51-1.01D(3)(b)(ii) and is capable of adjusting for a variable thickness overlay along and across the existing deck surface. The use of fixed height skid-supported strike off equipment is not allowed.
2. Be used to consolidate the polyester concrete.
3. Have a 12-foot minimum paving width.
4. Be self-propelled and equipped with automatic screed controls and sensing devices that control the thickness, longitudinal grade, and transverse screed slope. Advancing the finishing equipment with winches or a pulling device is not allowed.

Place polyester concrete:

1. Immediately after applying the methacrylate prime coat
2. Before gelling occurs
3. Within 15 minutes of adding the initiator

The weight of resin binder must be approximately 12 percent of the weight of the aggregate. Polyester concrete must have an initial set time from 30 to 120 minutes when tested using an initial-setting-time Gillmore needle under ASTM C266.

Consolidate and finish the overlay to the required grade and cross section using finishing equipment. Polyester concrete must be consolidated to a relative compaction of not less than 97 percent when tested under California Test 552.

Texture the polyester concrete surface before gelling occurs by longitudinal tining under 51-1.03F(5)(b)(iii), except do not perform initial texturing.

Apply a sand finish of not less than 0.8 lb/sq yd before gelling occurs.

Protect the overlay from moisture for at least 4 hours after finishing. Do not allow traffic or equipment on the overlay for at least 4 hours after final finishing.

Completed polyester concrete deck surfaces must have a uniform surface texture with a coefficient of friction of at least 0.35 when tested under California Test 342 and a surface smoothness complying with section 51-1.01D(3)(b)(ii).

Taper the polyester concrete overlay edges if the overlay (1) is not completed within the allowable lane closure time and (2) is more than 1/2 inch higher in elevation than the adjacent pavement. Taper the edges that are longitudinal to the direction of traffic at a 4:1 (horizontal:vertical) slope.

Tapers may remain and be overlaid with polyester concrete overlay.

60-3.04B(4) Payment

The payment quantity for furnish polyester concrete overlay is the volume determined using:

1. Quantity of resin binder used
2. Percentage by weight of resin binder in the polyester concrete
3. Unit weight of 135 lb/cu ft

60-3.04C Polyester Concrete Expansion Dams

60-3.04C(1) General

60-3.04C(1)(a) Summary

Section 60-3.04C includes specifications for constructing polyester concrete expansion dams.

Polyester concrete expansion dams must comply with the specifications for polyester concrete overlays in section 60-3.04B, except a trial overlay is not required.

Reinforcement must comply with section 52.

60-3.04C(1)(b) Definitions

Reserved

60-3.04C(1)(c) Submittals

Reserved

60-3.04C(1)(d) Quality Assurance

Reserved

60-3.04C(2) Materials

Not Used

60-3.04C(3) Construction

For new asphalt concrete overlays, place the asphalt concrete overlay before starting polyester concrete activities. Saw cut and remove asphalt concrete at expansion dam locations.

For existing asphalt concrete overlays, remove expansion dams and asphalt concrete to the limits shown. Removing expansion dams must comply with section 60-2.02, except a bridge removal work plan is not required.

Where a portion of the asphalt concrete overlay is to remain, saw cut a 2-inch-deep true line along the edge to remain in place before removing the asphalt concrete. Do not damage the existing surfacing to remain in place.

Prepare the deck surface under section 60-3.02C(7).

You may use a mechanical mixer to mix the polyester concrete for expansion dams. The mixer capacity must not exceed 9 cu ft unless authorized. Initiate the resin and thoroughly blend it immediately before mixing it with the aggregate. Mix the polyester concrete for at least 2 minutes before placing.

The application rate of methacrylate resin must be approximately 100 sq ft/gal.

You may place and finish expansion dams using hand methods.

Protect expansion dams from moisture, traffic, and equipment for at least 4 hours after finishing.

For expansion dams over 6 feet long, install 1/4-inch-wide joint material at 6-foot intervals across the width of the expansion dam. Joint material must be either expanded polyurethane or expanded polyethylene.

60-3.04C(4) Payment

The payment quantity for polyester concrete expansion dam is the volume determined from the dimensions shown.

60-3.04D Concrete Overlays

60-3.04D(1) General

Section 60-3.04D includes specifications for overlaying bridge decks with concrete.

Constructing concrete overlays must comply with section 51.

60-3.04D(2) Materials

Not Used

60-3.04D(3) Construction

Not Used

60-3.04D(4) Payment

Not Used

60-3.04E Multilayer Polymer Overlays

Reserved

60-3.04F–60-3.04M Reserved

60-3.05 REPAIRING STRUCTURES

60-3.05A General

60-3.05A(1) General

Section 60-3.05 includes specifications for repairing structures.

60-3.05A(2) Materials

Not Used

60-3.05A(3) Construction

Not Used

60-3.05A(4) Payment

Not Used

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
THIN EPOXY POLYMER BRIDGE DECK OVERLAY

a. Description. This work consists of cleaning/preparing entire deck surface and applying a two-coat epoxy overlay. Ensure all work is completed in accordance with section 712 of the Standard Specifications for Construction except as modified herein. Bring any discrepancies between the two to the attention of the Engineer

b. Materials. Use a solvent-free, moisture insensitive, 100 percent solids, low-modulus, and two-component epoxy system to overlay the structure. Ensure containers are marked clearly "Part A" or "Part B". The epoxies that are approved for thin overlays are in Table 1.

Table 1: Approved Two Component 100 Percent Solids Epoxy Systems

Supplier	Product	Telephone
BASF	MasterSeal 350	(800) 433-9517
E-Bond	526 Lo-Mod	(616) 532-0782
E-Chem	EP50	(505) 217-2121
Euclid Chemical	Flexolith Flexolith Summer Grade Flexolith HD	(800) 321-7628
Poly-Carb	Flexogrid Mark – 163 Flexogrid Mark - 154	(817) 797-1113
Sika	Sikadur 22-Lo Mod	(248) 866-8956
Transpo	T-48 Chip Seal	(573) 808-1040
Unitex	Propoxy Type III DOT	(800) 745-3700

Ensure aggregate meets the gradation requirements in Table 2 and has a hardness of seven or higher on the Mohs hardness scale. Ensure aggregate is angular, consists of natural silica sand, basalt, or other nonfriable aggregate, and contains less than 0.2 percent moisture when tested in accordance with *ASTM C566*.

Table 2: Angular Aggregates Gradation Requirements

Sieve Size	Minimum % Passing	Maximum % Passing
3/8	100	100
4	98	100
8	30	75
16	0	5
30	0	1
Pan	0	0

Unless otherwise approved, ensure the aggregate is chosen from an approved supplier from Table 3.

Table 3: Approved Aggregate Suppliers

Aggregate Supplier	Telephone
Earth Work Solutions	(307) 682-4346
Flint Rock Products	(918) 673-1737
Red Flint Sand and Gravel	(800) 238-9139
Sand Products Corp.	(906) 292-5432
Washington Rock Quarries, Inc.	(253) 262-1661
Imerys Refractory Minerals	(478) 472-7581

Provide general certification per the MDOT's *Materials Quality Assurance Procedures Manual* to the Engineer that the materials meet the requirements specified herein.

c. Equipment. For the epoxy overlay, provide a distribution system or distributor capable of accurately blending the epoxy resin and hardening agent, and uniformly and accurately applying 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. Provide a fine aggregate spreader capable of uniformly and accurately applying dry aggregate to cover 100 percent of the epoxy material. Provide a self-propelled vacuum truck.

For hand applications, provide calibrated containers, a Jiffy® type mixer, and notched squeegees which are suitable for mixing and applying the epoxy and aggregate.

For mechanical applications, provide mixing equipment that will automatically and accurately proportion the components in accordance with the manufacturer's recommendations, mix and continuously place the epoxy overlay. Ensure the operation proceeds in such a manner that will not allow the mixed material to segregate, dry, be exposed or otherwise harden in such a way as to impair the retention and bonding of broadcasted aggregate.

d. Construction.

1. Surface Preparation. The Engineer will inspect patching and cleaning operations. The Engineer's approval is required prior to placement of the overlay. Protect utilities, drainage structures, curbs, bridge joints, and any other structure within or adjacent to the epoxy overlay from surface preparation activities and application of the surface treatment materials. For the purposes of this special provision, the term *bridge joints* does not include sawed construction joints.

Verify that the compressed air used for any work is free of oil and moisture contamination in accordance with *ASTM D4285*. Use either an absorbent or a nonabsorbent white collector positioned within 24 inches of the air-discharge point, centered in the air stream. Allow air to discharge onto the collector for a minimum of 1 minute. Visually examine the collector for the presence of oil and/or water. Conduct the test at least one time per shift for each compressor system in operation in the presence of the Engineer. If air contamination is evident, make adjustments to achieve clean, dry air. Examine the work performed since the last acceptable test for evidence of defects or contamination due to contaminated compressed air. Repair contaminated work at no additional cost to the Department.

Do not perform surface preparation or installation of epoxy overlay on concrete less than 28 days of age. Ensure that all traffic paint lines are removed. Ensure that all tining is removed. Clean the entire concrete surface by abrasive blasting or shotblasting to remove all materials that may interfere with the bonding or curing of the binder. The cleaned concrete surface must meet the *International Concrete Repair Institute Guideline 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays and Concrete Repair,* concrete surface profile (CSP) 7. To ensure prepared surface is adequate for epoxy adhesion, perform a direct tension test per *ASTM C1583/C1583M*. Perform one direct tension test for every 500 square feet of overlay area. Minimum bond strength must be 250 pounds per square inch (psi) for the surface preparation to be considered adequate. Use a vacuum truck or oil-free moisture-free air blast to remove all dust and other loose material. Brooms are prohibited. Remove any oil or other contamination after initial cleaning.

Ensure both courses of epoxy overlay are applied within 24 hours of the final cleaning, and prior to opening the area to traffic.

No visible moisture can be present on the surface of the concrete at the time of epoxy overlay application. Oil-free moisture-free compressed air may be used to dry the deck surface. Use a plastic sheet left taped in place in accordance with *ASTM D4263* to identify moisture in the epoxy overlay area except as modified herein. Tape an 18 inch by 18 inch transparent polyethylene sheet (4 mil) to the deck every 500 square feet. Ensure all edges are sealed with tape that will stick to the concrete substrate. Leave the plastic sheet in place for a minimum of 3 hours or the manufacturer's recommended cure time for the conditions, whichever is longer. Ensure there is no moisture visible on the polyethylene sheet. Ensure alternate methods to detect moisture are approved by the Engineer.

Remove all debris from the bridge joints. Protect the bridge joints, and any other areas not to be overlaid, from damage during preparation of the surface. Ensure the protection is removed once the epoxy and aggregate has been applied and prior to initial set. Ensure removing the protection is done soon enough to in no way harm the adjacent overlay. Ensure protection is applied again prior to the second coat and removed again prior to initial set as to not damage adjacent surfaces. Ensure the protection meets the approval of the Engineer.

2. Application. 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 or as directed by the Engineer. Do not place epoxy overlay materials when the concrete surface is less than 50 degrees Fahrenheit (F) or ambient air temperature is forecast to fall below 50 degrees F within 8 hours of application. Do not place epoxy overlay materials if weather or surface conditions are such that the material cannot be properly handled, placed, and cured in accordance with the manufacturer's requirements and the 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. Ensure the first course is no less than 2½ gallons per 100 square feet. Ensure the second course is no less than 5 gallons per 100 square feet.

Ensure application of aggregate to both the first and second courses is of sufficient quantity so the entire surface is covered in excess. Ensure no bleed through, or wet spots are visible in the overlay. Remove and replace any areas within course applications with wet spots or where epoxy has bled through.

After the epoxy mixture has been prepared for the overlay, immediately and uniformly apply it 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 be done with steel spiked shoes approved by the Engineer. 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 overlay. Ensure the minimum curing periods are in accordance with the manufacturer's recommendations, as shown in Table 4, or as directed by the Engineer. Remove by vacuuming or brooming all loose aggregate after the second course curing period. Ensure all bridge joints are free of loose aggregate, epoxy and other debris resulting from overlay operations.

Table 4: Anticipated Cure Time (Hours)

Average Temperature of Deck, Epoxy and Aggregate Components, Degrees F	1st Course	2nd Course
<60		(a)
60-64	2	2
65-69	2	2
70-74	1.75	1.75
75-79	1.75	1.75
80-84	1.5	1.5
>85	1	1
a. Second course must 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 execute the work to provide the minimum curing periods as specified in Table 4, or other longer minimum curing periods as recommended by the manufacturer prior to opening to public or construction traffic, unless otherwise permitted. Ensure first course applications are not opened to traffic. Remove any contamination, detrimental to adhesion of the second course, 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, and
- time open to traffic.

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

Pay Item	Pay Unit
Epoxy Ovly	Square Yard

Epoxy Ovly includes preparing and cleaning the concrete surface, preparing and applying a two-coat epoxy overlay system on the concrete surface, and including miscellaneous clean-up. This pay item also includes cleaning and protecting bridge joints.

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
HIGH FRICTION SURFACE TREATMENT

OFS:CER APPR:SJS:TEH:07-13-16
FHWA:APPR:07-29-16

a. Description. This work consists of providing all labor, materials, and equipment required for cleaning/preparing pavement surfaces and applying a one coat high friction surface treatment (HFST). Ensure preparation of pavement surfaces and application of materials are in accordance with this special provision and the manufacturer's recommendations. Bring any discrepancies between the two to the attention of the Engineer

b. Materials. Ensure the physical requirements of the properly proportioned and mixed binder meet the requirements in Table 1:

Table 1: Physical Requirements of the Binder

Property	Test Method	Testing Details	Polymeric Resin Requirements	Methyl Methacrylate Resin Requirements
Viscosity	*ASTM D 2556*	Use 1 pint sample. Mix 2 to 3 minutes before testing.	Class C: 7 - 30 poises	Class C: 12-20 poises
Gel Time	*AASHTO M 235*	Prepare a 60 gram sample.	Class C: 10 minutes minimum	Class C: 10 minutes minimum
Ultimate Tensile Strength	*AASHTO M 235*	Prepare Type I specimens per *ASTM D 638*. Cure for 7 days.	2500 - 5000 psi	700 - 1000 psi
Elongation at break point	*AASHTO M 235*		30 – 70%	30 – 70%
Durometer Hardness (shore D)	*ASTM D 2240*	Cure for 7 days. Use Type 1 stand –Type D Durometer.	60 - 80	40 - 75
Compressive Strength	*AASHTO M 235*		1600 psi minimum	1600 psi minimum
Compressive Strength	*ASTM C 579*	Prepare specimens per Method "B" (2" cube) using 2.75 parts of sand to one part mixed binder by volume. Sand must meet *ASTM C 778*, 20-30 sand. Short duration cure for 3 hours maximum. Long duration cure for 7 days.	1,000 psi minimum at 3 hours 5,000 psi minimum at 7 days	1,000 psi minimum at 3 hours 2000 psi minimum at 7 days
Cure Rate (Dry through time)	*ASTM D 1640*	Prepare a specimen of 50-55 wet mil thickness. Cure for 3 hours maximum.	3 hours maximum	3 hours maximum
Water Absorption	*AASHTO M 235*		1% maximum	1% maximum

Adhesive Strength at 24 hours	*ASTM C 1583*	Cure for 24 hours.	250 psi minimum or 100% substrate failure	250 psi minimum or 100% substrate failure

Cure all specimens at 73 degrees Fahrenheit (F) and at 50 degrees F for the noted time. Tolerances for testing and curing temperatures will be ±2 degrees Fahrenheit (F). Run all resin binder tests at 73 degrees F. Run tests without delay if testing temperature does not match curing temperature.

Provide surface aggregate that is calcined bauxite (minimum of 87 percent aluminum oxide per *Section 15 of ASTM C 25*) which is clean, dry, and free from foreign matter. Ensure the aggregate meets the gradation shown in Table 2.

Table 2: Aggregate Gradation

Sieve Size	Minimum % Passing	Maximum % Passing
3/8	100	100
4	98	100
8	30	75
16	0	5
30	0	1
Pan	0	0
	Minimum	Maximum
Fineness Modulus	2.28	2.81

Provide a test data certification to the Engineer that the materials meet the requirements specified herein.

c. Construction.

1. Equipment. Provide a distribution system or distributor capable of accurately blending the resin and hardening agent, and uniformly accurately applying the binder materials at the specified rate to the pavement in such a manner as to cover 100 percent of the work area. Provide an aggregate spreader capable of uniformly and accurately applying clean dry aggregate to cover 100 percent of the binder material.

Ensure a system is in place to remove excess debris and aggregate.

For hand applications, provide calibrated containers, a Jiffy® type mixer, and notched squeegees which are suitable for mixing and applying the binder. Use of brooms or straight floor squeegees for binder application is prohibited.

For mechanical applications, provide mixing equipment that will automatically and accurately proportion the components in accordance with the manufacturer’s recommendations, mix and continuously place the binder. Ensure the operation proceeds in such a manner that will not allow the mixed material to segregate, dry, be exposed or otherwise harden in such a way as to impair the retention and bonding of broadcasted aggregate.

2. Surface Preparation. Ensure patching and cleaning operations are inspected and approved prior to HFST installation. Protect utilities, drainage structures, curbs, bridge expansion joint devices, and any other structure within or adjacent to the HFST location from surface preparation activities and application of the surface treatment materials. Protect all existing pavement markings that are adjacent to the HFST location from surface preparation activities and application of the surface treatment materials. Remove no more surface material than will be replaced during installation of the HFST, however ensuring the surface profile requirements of 2A and 2B are still met.

A. Concrete. Do not perform surface preparation or installation of HFST on concrete less than 28 days of age. Ensure that traffic paint lines and tining are removed. Clean the entire concrete surface by abrasive blasting or shotblasting to remove all materials that may interfere with the bonding or curing of the binder. The cleaned concrete surface must meet the *International Concrete Repair Institute Guideline 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays and Concrete Repair,* concrete surface profile (CSP) 7. Ensure mortar is sound and sufficiently bonded to the coarse aggregate, and presents a uniform CSP necessary for adequate bond. Use a vacuum truck or oil-free moisture-free air blast to remove all dust and other loose material. Brooms are prohibited. Remove any oil or other contamination after initial cleaning.

B. Asphalt. Ensure that traffic paint lines are removed. Ensure existing crack seal treatments are removed flush to the asphalt surface. Clean the entire asphalt surface by abrasive blasting or shotblasting to remove all materials that may interfere with the bonding or curing of the binder. The cleaned asphalt surface must meet the *International Concrete Repair Institute Guideline 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays and Concrete Repair*, concrete surface profile (CSP) 5. Ensure abrasive blasting or shotblasting system is calibrated before operation on the traveled way. Use a vacuum truck or oil-free moisture-free air blast to remove all dust and other loose material. Brooms are prohibited. Remove any oil or other contamination after initial cleaning.

Control and minimize airborne dust and similar debris generated by surface preparation and cleanup to prevent a hazard to motor vehicle operation or nuisance to adjacent property. Meet the requirements of subsection 107.15.A.1 of the Standard Specifications for Construction and other applicable contract requirements regarding dust control.

3. Application. Ensure surface is visibly dry and no capillary moisture is present according to *ASTM D 4236* (modified to 2 hours). Ensure handling and mixing of the binder is performed in a safe manner to achieve the desired results in accordance with the manufacturer's recommendations for a one-coat system or as directed by the Engineer. Apply the binder at a coverage rate of no less than 4 gallons per 100 square foot or a uniform binder thickness of 65 mils.

Do not place binder 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. In the event of unexpected precipitation all uncured HFST must be immediately covered and protected with plastic sheeting. Areas exposed to precipitation or that have cured prior to receiving broadcast aggregate must be removed and replaced at no additional cost to the Department.

A. Mechanized Binder Application. Apply the binder by a truck or trailer mounted application machine that is capable of continually mixing and delivering the binder components on demand within the temperature range specified in varying widths at a uniform application thickness. Ensure that the mechanically applied distributing equipment includes accurate measuring devices and/or calibrated containers and thermometers for measuring the binder temperature prior to placement, should heating be required. Do not allow the binder material to separate in the mixing lines, cure, dry, or otherwise impair retention bonding of the high friction surfacing aggregate. Uniformly spread the mechanically applied binder with a notched squeegee.

B. Hand Binder Application. Ensure that after the binder mixture has been prepared for the overlay, it is immediately and uniformly applied to the pavement with a notched squeegee.

C. Aggregate Application. Apply the clean dry aggregate in such a manner as to cover the binder mixture completely within 5 minutes. No bleed through, or wet spots should be visible in the overlay. Minimize all foot traffic on the uncured binder and ensure any foot traffic will only be done with steel spiked shoes approved by the Engineer. Remove and replace applications which do not receive enough aggregate at no additional cost to the Department. Remove all loose aggregate by vacuuming or brooming after the curing period.

Ensure the minimum curing periods are in accordance with the manufacturer's recommendation or longer if directed by the Engineer. Ensure HFST is applied within 24 hours of the final cleaning, and prior to opening the area to traffic. Do not allow traffic or equipment on the overlay surface during the curing period.

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 (if applicable)
- location of batches as placed on pavement, referenced by stations (if applicable)
- batch time (if applicable)
- temperature of air, pavement surface, binder components, and aggregates
- loose aggregate removal time
- time open to traffic.

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

Pay Item	**Pay Unit**
High Friction Surface Treatment	Square Yard

High Friction Surface Treatment includes all material, labor, and equipment required for cleaning, preparing, and applying a HFST to asphalt or concrete pavement including any protection to adjacent areas and miscellaneous clean-up.

Technic l Services - M teri ls - Approved List

Thin Overl ys, Structur l

THIN POLYMER (EPOXY) OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS (584.50010018)

BRAND NAME	SUPPLIER / LOCATION	MATERIAL DETAILS NO. (APPROVAL DATE)	SAFETY DATA SHEET
E-Bond 526	Transpo Industries, Inc. New Rochelle, NY	TPO-009 (11/23/2020)	SDS
EPX50-OVERLAY[1]	E-Chem, LLC Albuquerque, NM	TPO-007 (03/13/19)	SDS
EP50-OVERLAY[1]		TPO-008 (03/13/19)	SDS
Flexolith/Flexolith Summer Grade (SG)[1]	The Euclid Chemical Company Cleveland, OH	TPO-002 (06/09/2016)	SDS
MARK-163 FLEXOGRID	POLY-CARB, Inc. Roberta, GA	TPO-005 (06/09/2016)	SDS
MasterSeal® 350	Master Builders Solutions US LLC Shakopee, MN	TPO-001 (06/09/2016)	SDS
Pro-Poxy Type III DOT[1]	Unitex Chemicals Kansas City, MO	TPO-004 (06/09/2016)	SDS
Sikadur 22 Lo-Mod FS[1]	Sika Corporation Lyndhurst, NJ	TPO-006 (03/28/2017)	SDS
SSI RE-DECK	C.S. Behler, Inc. Lancaster, NY	TPO-003 (06/09/2016)	SDS

NOTES:

1. The manufacturer may use a fast setting or lower temperature version of the epoxy to allow for placement at <50° F and/or faster cure time.

APPROVED AGGREGATES FOR USE WITH (584.50010018)

A. Lower Volume Bridge Deck: AADT ≤ 10000 nd Less Th n 20% Trucks

AGGREGATE	SOURCE/LOCATION

Best S nd 612	F irmount S ntrol Inc., OH
Best S nd 620	F irmount S ntrol Inc., OH

B. Higher Volume Bridge Deck: AADT > 10,000 or More Than 20% Trucks

AGGREGATE	SOURCE/LOCATION
Armorstone (crushed non c rbon te gr vel)	W shington Rock Qu rries, Inc Gr h m, WA
# 8 or #9 Flint Rock	Flint Rock Products Picher, OK
# 8 or #9 Dyn grip	S int-Gob in Abr sives Inc. St fford, Engl nd
# 8 or #9 B s lt (Tr p Rock)	AGSCO Corp. Pine Brook, NJ
Okl hom Flint Rock 65-8 Blend	Flint Rock Products Picher, OK
Flint Rock (Chert With 8% Dolomite)	Flint Rock Products Picher, OK
# 8 or #9 Di b se (Tr p Rock)	Ont rio Tr p Rock Ltd. C n d

C. High Friction Aggregate

AGGREGATE	SOURCE/LOCATION
N tur l C lcined B uxite	E rth Work Solutions Gillette, WY

Revised on: November 25, 2020

ITEM 584.40000009 – POLYMER OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS (PPC)

DESCRIPTION.
This work shall consist of furnishing and placing a polyester polymer concrete (PPC) overlay with High Molecular Weight Methacrylate (HMWM) resin primer on concrete surfaces where indicated in the Contract Documents. The work shall include the preparation of receiving surfaces.

MATERIALS.
The polyester concrete shall consist of polyester resin binder and aggregates with a compatible primer meeting the component and composite material properties specified. All components shall be supplied collectively through the same provider, qualified as defined herein, referred to as the System Provider.

1. Primer. The prepared surface shall receive a wax-free low odor, high molecular weight methacrylate (HMWM) primer consisting of a resin, initiator and promotor and conforming to the following:

High Molecular Weight Methacrylate (HMWM) Primer Resin		
Property	**Requirement**	**Test Method**
Volatile Content*	30%, maximum	ASTM D 2369
Viscosity* (Brookfield RVT with UL adapter, 50 RPM at 77°F)	25 cps, maximum	ASTM D 2196
Specific Gravity* (at 77°F)	0.90, minimum	ASTM D 1475
Flash Point*	180°F, minimum	ASTM D 3278
Vapor Pressure* (at 77°F)	1.0 mm Hg, maximum	ASTM D 323
PCC Saturated Surface-Dry Bond Strength, with primer (at 24 hours and 70 ± 1°F)**	700 psi, minimum	CA Test 551, part 5

*Tested prior to adding initiator.
**Initiated polyester concrete tested at 12% resin content by weight of the dry aggregates.

The prime coat promoter/initiator shall consist of a metal drier and peroxide. If shipped separately from the resin, **at no time shall the metal drier be mixed directly with the peroxide – a violent exothermic reaction will occur.** 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.

2. Aggregate. Aggregate for polyester concrete shall meet the following properties:

1. Aggregate retained on the #8 sieve shall have a maximum of 45% crushed particles when tested in accordance with AASHTO Test Method T335.
2. Fine aggregate shall consist of natural sand only.
3. Weighted average aggregate absorption shall not exceed 1.0% as determined by AASHTO Test Methods T84 and T85.
4. At the time of mixing with the resin, the moisture content of the aggregate, as determined by AASHTO Test Method T255, shall not exceed one half of the aggregate absorption.
5. Aggregate shall have a minimum Mohs hardness of 7.
6. Aggregate shall meet the following gradation:

Aggregate Gradation	
Sieve Size	**Percent Passing**
3/8”	100
No. 4	62-85
No. 8	45-67
No. 16	29-50
No. 30	16-36
No. 50	5-20
No. 100	0-7
No. 200	0-3

Sand for abrasive sand finish shall meet the following properties:

1. Shall be a commercial-quality blast sand.
2. Shall not have less than 95% pass the No. 8 sieve and not less than 95 retained on the No. 20 sieve when tested under AASHTO T27.
3. Shall be dry at the time of application.

3. Polyester Resin Binder. The polyester binder resin shall have the have the following properties:

1. Be an unsaturated isophthalic polyester-styrene co-polymer suitable for a polyester concrete mixture with a resin content of 12% ± 1% of the weight of the dry aggregate.
2. Contain at least 1% by weight gamma-methacryloxypropyltrimethoxysilane, an organosilane ester silane coupler.
3. Be used with a promoter that is compatible with suitable methyl ethyl ketone peroxide and cumene hydroperoxide initiators.
4. Shall meet the following material properties:

Polyester Resin Binder		
Property	**Requirement**	**Test Method**
Viscosity* (RVT No. 1 spindle, 20 RPM at 77°F)	75-200 cps	ASTM D 2196
Specific Gravity* (at 77°F)	1.05 to 1.10	ASTM D 1475
Styrene Content*	40-50%, by weight	ASTM D 2369
Silane Coupler*	1.0%, by weight	NMR Spectrum
Elongation	35%, minimum (Type I specimen, thickness 0.25± 0.03” at Rate = 0.45 inch/minute)	ASTM D 638
	Sample Conditioning: 18/25/50+5/70	ASTM D 618
Tensile Strength	2,500 psi, minimum (Type I specimen, thickness 0.25± 0.03” at Rate = 0.45 inch/minute)	ASTM D 638
	Sample Conditioning: 18/25/50+5/70	ASTM D 618

*Tested prior to adding initiator.

4. Polyester Concrete. The polyester concrete composite mixture shall meet the following properties:

Polyester Concrete Composite Mixture		
Property	**Requirement**	**Test Method**
PCC Saturated-Surface Dry Bond Strength, without primer* (at 24 hours and 70 ± 1°F)	500 psi, minimum	CT 551
Abrasion Resistance	2g weight loss, maximum	CT 550
Modulus of Elasticity	1,000 to 2,000 ksi	ASTM C 469

*Initiated polyester concrete mixture tested at 12% resin content by weight of dry aggregates.

5. **Packaging and Shipment.** A 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. Polyester resin binder and primer resin shall bear the System Provider's label specifying lot/batch number, brand name and quantity. In addition, the mixing ratio shall be provided to the Contractor by the System Provider prior to shipment.

6. **Storage of Materials.** All materials shall be stored in a cool, dry location and in their original containers in accordance with the System Provider's recommendation to ensure their preservation until used in the work. The shelf life for liquid materials stored out of direct sunlight and at temperatures 80 °F and below shall be at least twelve (12) months. All aggregates shall be stored in a clean, dry location away from moisture. Applicable fire codes may require special storage facilities for some components of the overlay system.

7. **Basis of Acceptance.** Project acceptance of the polyester concrete 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 6. Packaging and Shipment.
   2. System Provider certifications and written instructions submitted by the Contractor to the Engineer thirty (30) days prior to overlay placement including the following information:
      a. Materials – statement that the primer, aggregate and polyester binder are compatible with one another and meet the material requirements found under MATERIALS, 1-4
      b. Experience – documented evidence of having successfully supplied a complete polyester polymer concrete overlay system meeting this specification on at least five (5) projects of similar size and scope within the last five (5) years.
      c. Technical Representative – having successfully provided technical support on at least five (5) projects of similar size and scope within the last five (5) years
   3. Approval by the Materials Bureau based on conformance with the Material requirements above.

CONSTRUCTION DETAILS.

A. General. A System Provider's competent technical representative shall be made available for up to three (3) working days to make recommendations to facilitate the overlay installation

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. 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. Equipment.

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 sand 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. In those areas not accessible to this machinery the surface may, with the Engineer's approval, be cleaned with sand blast cleaning equipment.

Mixing. Polyester concrete shall be mixed in either mechanically operated mixers or continuous automated mixers meeting the following requirements:

a. Employ an auger screw/chute device capable of completely blending catalyzed binder resin and aggregates.
b. Employ a plural component pumping system capable of handling polyester binder resin and catalyst, adjustable to maintain proper ratios to achieve set/cure times within the specified limits.
c. Be equipped with an automatic metering device that measures and records aggregate and resin volumes. Record volumes at least every 5 minutes, including time and date. Submit recorded volumes at the end of shift.
d. Have a visible readout gage that displays volumes of aggregate and resin being recorded.
e. Produce a satisfactory mix consistently during the entire application process.
f. Be calibrated per Caltrans California Test CT 109 or similar. Submit current certificate of calibration to the Engineer.

Portable mechanically operated mixers of appropriate size, as recommended by the System Provider and approved by the Engineer, may be used unless otherwise noted on the Plans.

Application and Finishing. Polyester concrete shall be placed by a vibratory screed on preset forms or rails or by self-propelled slip-form paving machine, which is modified or specifically built to effectively place polyester concrete overlays in a manner meeting the following requirements:

a. Employ a vibrating pan to consolidate and finish the polyester concrete overlay.
b. Be fitted with hydraulically controlled grade automation to establish the finished profile. The automation shall be fitted with substrate grade averaging devices on both sides of the new placement; the device shall average 15 feet in front and behind the automation sensors; or the sensor shall be constructed to work with string-line control. It is acceptable to match grade when placing lanes adjacent to previously placed polyester overlay.
c. Have sufficient engine power and weight to provide adequate vibration of the finishing pan while maintaining consistent forward speed.
d. Be capable of forward and reverse motion under its own power.

Roller screeds will not be permitted.

C. Trial Application. Prior to constructing the overlay, one or more trial applications shall be placed on the prepared substrate to demonstrate proper initial set time and the effectiveness of the surface preparation, mixing, placing and finishing equipment proposed. Each trial application shall be at least 10 feet long and at the planned paving width and specified overlay thickness. The location(s) of the trial applications shall be approved by the Engineer.

If the cleaning practice, materials, installation, finishing and/or texturing are not acceptable, the Contractor shall remove the failed trial application and reinstall the trial application at no additional cost to the Department until satisfactory results are obtained.

The number of trial applications required shall be as many as necessary for the Contractor to demonstrate the ability to construct an acceptable trial overlay section and competency to perform the work. The installer, System Provider and/or proposed equipment/techniques may be rejected by the Engineer if not shown to be acceptable after three (3) failed trial applications.

Vertical axis pull test shall be performed twenty-four (24) hours after the placement of the trial application in accordance with ASTM C 1583 to assure that the overlay adheres to the prepared surface. The test result shall be the average of 2 successful tests. Test cores shall be drilled through the overlay and into the substrate a minimum of 0.25". The minimum tensile pull strength on normal weight concrete substrates shall be 250 psi. An acceptable test will demonstrate that the overlay bond strength is sufficient by producing a concrete subsurface failure area greater than 50% of the test area. The Contractor shall repair all bond test locations with polyester concrete in accordance with this specification.

D. Surface Preparation. All structural slab surfaces that will be in contact with the overlay shall be prepared by shotblasting in order to remove all existing grease, slurry, oils, paint, dirt, striping, cure compound, rust, membrane, asphalt, weak surface mortar or any other contaminants that could interfere with the proper adhesion of the overlay system.

The final prepared surface shall meet the following requirements:

Areas to receive the polyester overlay shall be cleaned by shotblasting. Areas that cannot be accessed by shotblast may be cleaned by abrasive sandblast. Cleaning shall not commence until all work involving the repair of the concrete substrate surface has been completed and repair materials have cured. All contaminants shall be picked up and stored in a vacuum unit, and dust shall not be created during the cleaning operation that will obstruct the view of motorists. 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 free of weak or loose surface mortar, exposing the aggregates within the substrate concrete and visibly changing the color of the substrate concrete. Mortar which is sound and firmly bonded to the coarse aggregate must have open pores due to cleaning to be considered adequate for bond.

Cleaned surfaces shall not be exposed to vehicular traffic unless required by the overlay operation and approved by the Engineer. Cleaned concrete substrates that have been contaminated such that contaminates might interfere with the bonding or curing of the overlay must be cleaned to the satisfaction of the Engineer prior to placing the overlay at no additional cost to the Department. The cleaned concrete substrate shall be dry at the time of application of the primer and overlay.

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.

E. Application. Prior to the primer and overlay application, moisture content reading must be ≤ 5.0% using a moisture meter, or you can use ASTM D4263 - Indicating Moisture in Concrete by the Plastic Sheet Method for a minimum of 2 hours. If using ASTM D4263, no visible moisture is considered acceptable. The substrate surface temperature shall be between 40-100°F at the time of primer and overlay placement. Night work may be required when temperatures cannot be met during the day.

1. Prime Coat
   Prior to applying the HMWM prime coat, the area shall be completely dry and blown clean with oil-free compressed air. Primer shall be mixed and applied in accordance with the System Provider's recommendations. Primer shall be applied within 5 minutes of mixing initiator and resin at a rate of approximately 90-100 ft^2/gal or as otherwise recommended by the System Provider.

   Primer shall be applied by flooding and uniformly spread to completely cover all surfaces to receive overlay, including any adjacent vertical surfaces. Care should be taken to avoid heavy application that results in excess puddling. Excess material shall be removed or distributed to meet the recommended application rate. Primer shall be reapplied to any areas that appear visibly dry prior to overlay placement.

2. Polyester Concrete.
   The polyester concrete shall be mixed and applied in accordance with the System Provider's recommendations. The polyester concrete shall be placed prior to gelling or within 15 minutes after the addition of the initiator, whichever occurs first, or as recommended by the System Provider. Polyester concrete shall be placed no sooner than 15 minutes and no later than 2 hours after the beginning of the application of the primer.

   The polyester concrete mixture shall achieve an initial set time between 30 minutes and 90 minutes. For the purposes of this specification, initial set is defined as when the in-place polyester concrete cannot be deformed when firmly pressed with a finger. Material not achieving initial set within this time frame shall be removed and replaced at no additional cost.

   The polyester concrete shall be consolidated and finished using placement equipment as defined herein to strike off the polyester concrete to the required grade and cross-section as shown in the Contract Plans.

   The polyester overlay shall be placed at a profile necessary to meet the desired grade and cross-section as shown in the Plans with a minimum thickness of 0.75 inch. Termination edges of the overlay may require application and finishing by hand trowel due to obstructions such as a curb. Expansion joints shall be adequately isolated prior to overlaying or may be sawed within four (4) hours after overlay placement, as approved by the Engineer.

3. Abrasive Finish Sand.
   Immediately following the overlay placement and before gelling, a layer of abrasive finish sand shall be evenly spread over the entire overlay surface such that the surface is completely covered and no wet spots are visible. The surface shall be continuously monitored to ensure sufficient finish sand coverage until initial set has occurred. If wet area(s) become visible through the sand, the Contractor shall apply, to refusal, additional finish sand on surface. After the overlay has cured, use an electric broom and/or compressed air to remove excess sand prior to opening the bridge to traffic. Any buildup of sand on the roadway shoulders or drainage shall be completely cleaned before closing the job.

4. Texturing.
   When full diamond grinding of the riding surface is required, the requirements of §505shall be followed. Longitudinally saw cut the PPC surface in accordance with section 558.02 - Longitudinal Saw-Cut Grooving of Structural Slab Surface. Grooving shall occur 24-hours after placement or anytime thereafter. No tining is allowed.

5. Curing.
   The overlay shall be allowed to cure sufficiently before being subjected to loads or traffic of any nature that may damage the overlay. Cure time is dependent on ambient and substrate temperatures and also initiator/accelerator levels used at the time of mixing. The overlay shall be considered cured to a traffic ready state after four (4) hours following finishing or when a minimum reading of twenty-five (25) on a properly calibrated Schmidt hammer is achieved, whichever occurs first.

F. Surface and Thickness Requirements. Variable thickness overlay placement may be required to account for variations in substrate profile to meet the desired grade and cross-section as shown in the Plans. Unless otherwise noted on the Plans the overlay surface shall not vary more than ¼ inch from the lower edge of a 12'± 2" long straight edge placed in any direction. Surface area larger than 30,000 ft^2 may require an inertial profiler as indicated in the Plans. Any surfaces which fail to conform to the specified tolerance shall be re-profiled by diamond grinding in accordance with the requirements of§505. Diamond grinding shall not occur until at least 24 hours after placement of the overlay.

If the Engineer determines that the minimum thickness has not been attained, an additional layer shall be applied after the overlay has cured for a minimum of four (4) hours. This layer shall be a minimum of ¼" and shall be applied as recommended by the System Provider and approved by the Engineer at no additional cost to the State.

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 abrasive finish sand. Any such surface defects shall be repaired as recommended by the System Provider and approved by the Engineer at no additional cost to the State. Areas less than 4.0 ft^2 shall be ground using a hand grinder. Larger areas and frequency representing more than 20% of the surface shall be diamond-ground in accordance with Full Diamond Grinding of Structural Slab and Structural Approach Slab with Slurry Removal specification. If material remains protruding above the diamond ground surface sufficient to interfere with the sawcut grooving, that material shall be removed and cleaned to the Engineer's satisfaction.

Surface cracks in sound, bounded polyester concrete overlays may be filled with properly catalyzed HMWM primer material.

METHOD OF MEASUREMENT.

The polyester concrete overlay will be measured by the square foot as shown in the Plans.

BASIS OF PAYMENT.

Pay Item		Pay Unit
584.40000009	Polymer Overlay Wearing Surface for Structural Slabs (PPC)	Square Foot

The unit price bid per square foot shall include the cost of all labor, materials, equipment, and incidentals necessary to complete the work. The unit price bid shall also include the cost of having the polymer manufacturer's representative present as required.

ITEM 584.50010018 – THIN POLYMER (EPOXY) OVERLAYS FOR STRUCTURAL SLABS

DESCRIPTION

Furnish and apply a two course thin polymer (epoxy) overlay wearing surface on an existing bridge deck surface in accordance with the Contract Documents and as directed by the Engineer.

MATERIALS

A. Thin Polymer (Epoxy) Overlay System. Shall meet Materials Requirements of 734-01.

B. Packaging and Shipment. All components shall be shipped in appropriate containers, bearing the manufacturer's label specifying date of manufacture, batch number, brand name, quantity, and date of expiration or shelf life.

CONSTRUCTION DETAILS

A. General. The Materials Details and Material Safety Data Sheets (MSDS) for the thin polymer (epoxy) overlay system are readily available on the Department Approved List on the internet @ www.dot.ny.gov under Approved List of Materials and Equipment. The materials details will provide the following:

- Product Information
- Surface Preparation
- Application Procedure
- Curing Procedure

For Epoxy and Aggregate Suppliers, use NYSDOT Materials and Equipments Approved List: Thin Polymer (Epoxy) Overlays for Structural Slabs

A technical representative from the overlay manufacturer shall be on-site during all phases of the work to make recommendations and to facilitate the overlay installation. This shall include, but not be limited to, surface preparation, deck surface repairs, overlay application, and overlay cure.

Contractor shall provide adequate shielding to protect traffic and surrounding environment from rebound and dust during surface preparation and shot-blast cleaning work. Any spent shot blast beads, shot blast waste shall be removed from the project by the end of the day.

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

B. Storage of Materials. All materials will be stored in accordance with the Materials Details.

C. Installation Procedure:

1. Surface Preparation. The Contractor will perform all necessary deck repair work prior to placement of the epoxy overlay. Once the required repair area(s) have been identified, confer with the preapproved selected supplier of the Thin Polymer (Epoxy) Overlay system to ensure that the repair material is compatible with the selected system. Allow for all repair materials to properly cure prior to placement of Thin Polymer (Epoxy) Overlay system. The deck repairs will be made where indicated on the plans or where directed by the Engineer. Repairs will be paid for under the appropriate structural concrete removal item. Concrete patches will be completely cured prior to placement of the epoxy overlay. After deck repairs are completed, cured and prior to placement of the overlay, the Contractor will blast the entire deck surface to remove asphaltic materials, oil, grease, dirt, sealers, rust, laitance, curing compounds, paint and weak concrete materials that would inhibit successful bonding of the epoxy overlay to the wearing surface.

Automatic shot-blast units will use a vacuum to recover spent abrasives. Magnetic rollers or other devices will be used to remove any spent shot remaining on the deck after vacuuming. Traffic paint lines shall be completely removed prior to placement of the overlay and reapplied upon completion of the overlay. Freshly repaired and cured concrete areas will be cleaned per Section 584-3.02A of the Standard Specifications. All steel surfaces that will be in contact with the overlay will be cleaned according to SSPC-SP No.10, Near-White Blast Cleaning. A profile of CSP5-6 is desired

The bridge deck surface must be dry prior to the application of the thin polymer (epoxy) overlay system. No visible moisture shall be present on the bridge deck at the time of placement. Prior to overlay application, moisture content reading must be ≤ 5.0% using a moisture meter, or you can use ASTM D4263 - Indicating Moisture in Concrete by the Plastic Sheet Method for a minimum of 2 hours. If using ASTM D4263, no visible moisture is considered acceptable.

Do not apply overlay if rain is expected during installation or curing time.

Bond Strength to structure: Acceptability of the surface preparation may be determined by the use of a vertical axis pull bond test. Test shall be performed in accordance to ACI 503R-30 or ASTM C1583/C1583M and shall have a minimum bond strength of 250 psi or achieve failure of the concrete. The test should be performed every 100 linear feet (LF) minimum or 300 LF maximum. Minimum 4 pull-off tests are required per structure. The Engineer will determine the test locations or per manufacturer representative recommendation.

Immediately prior to application of the overlay, the Contractor shall request and receive approval to proceed from the Engineer to assure that the surface is acceptable for application of the thin polymer (epoxy) overlay.

2. Application The thin polymer (epoxy) overlay shall be applied in accordance with this specification and the Manufacturer Materials Detail Sheets (MDS).

Epoxy Resin Application Rate:
Course #1: Epoxy rate is 30 ft^2/gal
Course #2: Epoxy rate is 20 ft^2/gal

Aggregate Application Rate: Approximately ~ 1.5 lb/ft^2 or to refusal per course.

The two courses of the thin polymer (epoxy) overlay shall be applied within 24 hours following final surface preparation. If the overlay is not applied within 24 hours, or the accepted prepared surface is opened to traffic and/or contaminated in any way, the pavement shall be re-cleaned to the satisfaction of the Engineer at no additional cost to the State. Traffic may be allowed prior to completion of 2^{nd} course at discretion of EIC and manufacture's representative.

Expansion joints shall be protected from contaminates by masking or other methods as approved by the Engineer. Consult with manufacturer's representative and approved Material Details to address details at joints and drainage structures. The Contractor will demonstrate that these requirements are met to the Engineer's satisfaction.

3. Finishing The Contractor shall use methods and equipment for finishing the overlay materials in accordance with the Materials Details. The completed overlay surface shall be free of any smooth or "glassy" areas such as those resulting from insufficient quantities of surface aggregate. Contractor shall repair such surfaces as recommended by the manufacturer and approved by the Engineer at no additional cost to the State.

4. Surface and Thickness Requirements. The specified thickness requirements will be verified by the manufacturer's representative to the Engineer's satisfaction.

D. **Curing.** The thin polymer (epoxy) overlay will be cured before subjecting it to traffic or any loads that would damage the overlay. Cure time is dependent upon both ambient and deck temperatures. Material shall not be placed if ambient temperature is less than 50°F or is expected to fall below 50°F during the placement period. The degree of cure and suitability of the overlay for traffic loads shall be determined by the manufacturer representative and approved by the Engineer.

METHOD OF MEASUREMENT

This work will be measured as the number of square feet of thin polymer (epoxy) overlay system satisfactorily applied as determined by deck measurements and as shown in the Contract Documents.

BASIS OF PAYMENT

The unit price bid per square foot shall include the cost of all labor, materials and equipment necessary to satisfactorily complete the work. The unit price bid shall include the cost of having the epoxy overlay manufacturer's representative onsite during the work as required.

ITEM 601.02000004 – SPECIALTY FRICTION SURFACE TREATMENT FOR ASPHALT
ITEM 601.03000004 – SPECIALTY FRICTION SURFACE TREATMENT FOR CONCRETE

DESCRIPTION

Install a Specialty Friction Surface Treatment (SFST) at the locations noted in the plans and as specified in the contract documents.

MATERIALS

SFST: Binder resin, aggregate and primer (if required) provided as a system by a single supplier/manufacturer.

Binder Resin.

- Composed of a two component epoxy or other polymer binder system.
- Resist deterioration when exposed to sunlight, gasoline, oil, salt, water or adverse weather conditions.
- Shelf life of 1 year minimum after manufacture.
- Be compatible with and provide a firm bond to the surface it is being applied to (asphalt or concrete).
- Be compatible with and provide a firm bond to the aggregates being applied to the surface.
- Not contain 0.1% or more of any chemical listed by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP), or regulated by the US Occupational Safety and Health Administration (OSHA) as a carcinogen.
- Conform to current Federal, State and Local air pollution regulations, including those for the control (emission) of volatile organic compounds (VOC) as established by the U.S. EPA and the NYSDEC.
- Packaged in suitable, well-sealed containers clearly labeled as to the type material and the ratio of the components to be mixed by volume as well as showing resin or hardener components, brand name, name of manufacturer, lot or batch number, temperature range for storage, expiration date and the quantity contained. Include any special instructions regarding mixing and Material Safety Data Sheets.
- Physical requirements:

BINDER RESIN REQUIREMENTS		
Property	**Requirement**	**Test Method**
Ultimate Tensile Strength	2,000 psi min.	ASTM D638
Compressive Strength	@ 3 hours: 1,000 psi min @ 7 days: 5,000 psi min	ASTM C-579
Elongation at break point	30 - 70 %	AASHTO M-235
Peak Exothermic Temperature	150°F min.	ASTM D2471
Gel Time	10 Minutes, Min.	AASHTO M-235
Water Absorption	1.0 % Max.	AASHTO M-235
Shore Hardness	70 min.	ASTM D2240
Adhesive Strength @ 24 hours	250 psi min or 100% substrate failure	ASTM D-4541
Cure Rate	3.0 hours max.	ASTM D-1640 @ 75°F

Primer. When use of a primer is recommended by the SFST manufacturer:

- Be compatible with the surface it is being applied to and to the binder resin.
- Conform to current Federal, State and Local air pollution regulations, including those for the control (emission) of volatile organic compounds (VOC) as established by the U.S. EPA and the NYSDEC.
- Packaged in suitable, well-sealed containers clearly labeled as to the type material and showing components, brand name, name of manufacturer, lot or batch number, temperature range for storage, expiration date and the quantity contained. Include any special instructions regarding mixing and

Material Safety Data Sheets.

Aggregates.

Calcined Bauxite meeting the following requirements:
- Be clearly labeled and in a dry and clean condition upon delivery to the job site.
- Be maintained and stored in a dry and clean condition prior to use.
- Meet the requirements of the table below:

AGGREGATE REQUIREMENTS		
Property	Requirements	Test Method
Resistance to Degradation	20% max	AASHTO T-96
Moisture Content	0.2% max	AASHTO T-255
Aluminum Oxide	87% min	ASTM C-25
Aggregate Grading	AASHTO T-27	
Sieve Designation	Mass Percent Passing	
No. 4 Sieve Size No. 6 Sieve Size No. 16 Sieve Size	100% Passing 95 - 100% Passing 0 - 5% Passing	

Applicator Requirements:

Manufacturer certified applicator, or show evidence of a minimum of 3 projects using the same SFST, installed on at least 5000 square yards, cumulative, placed within the past 3 years. These installations must have demonstrated a friction value of 65 FN40R or higher when tested in accordance to AASHTO T 242.

Ensure that a manufacturer’s representative is on site to provide technical assistance during surface preparation, material placement, and during any necessary remedial work.

Follow all exposure, respiratory and personal protective equipment controls, handling and safety precautions and spill and disposal procedures as identified by materials safety data sheets (MSDS), labels and other manufacturer’s recommendations for the products used. Provide the Engineer copies of all applicable MSDS sheets and safety literature.

CONSTRUCTION DETAILS

Store all materials in a clean, dry environment, and in accordance with the manufacturer’s recommendations.

Protect all existing joints, utilities, drainage structures, curbs and any other structure within or adjacent to treatment location, from the surface preparation and installation of the SFST. Restore all damaged and/or contaminated joints, utilities, drainage structures, curbs and any other structure to an acceptable working condition, to the satisfaction of the Engineer at no additional cost to the State.

Surface Preparation:
Prepare all surfaces immediately prior to the installation of SFST. Surfaces contaminated with oils, greases, or other deleterious materials not removed by the surface preparation shall be washed with a mild detergent solution, rinsed with clean potable water, and dried using a hot compressed air lance. Install

suitable traps or devices on the compressed air equipment to prevent moisture and oil from contaminating the surface. Maintain these devices and see that they are functioning properly. Do not burn, scorch or ignite the adjoining surface when using a hot air lance. Adequate cleaning of all surfaces will be determined by the Engineer.

Protect the public from potentially objectionable and/or hazardous airborne debris.

Asphalt Surfaces:
Clean asphalt surfaces using mechanical sweepers and high pressure air wash with sufficient oil traps. Mechanically sweep all surfaces to remove dirt, loose aggregate, debris, and deleterious material. Vacuum sweep or air wash all surfaces using a minimum of 180 cfm of clean and dry compressed air, to remove all dust, debris and deleterious material. Maintain air lance perpendicular to the surface and the tip of the air lance within 12 inches of the surface.
For applications on new asphalt surfaces a mandatory 30 day cure period shall take place prior to the installation of the SFST.

Concrete Surfaces**:**
Clean concrete surfaces by shot blasting and vacuum sweeping. Shot blast all surfaces to remove all curing compounds, loosely bonded mortar, surface carbonation, and deleterious material. The prepared surface shall comply with the International Concrete Repair Institute (ICRI) standard for surface roughness CSP 5. After shot blasting, vacuum sweep or air wash, with a minimum of 180 cfm of clean and dry compressed air, all surfaces to remove all dust, debris, and deleterious material. Maintain air lance perpendicular to the surface and the tip of the air lance within 12 inches of the surface.

Weather Limitations. Do not apply binder resin on a wet surface, when the ambient and/or surface temperature is below 50ºF or above 95ºF, when anticipated weather conditions would prevent the proper application or curing of the SFST, or if there has been rain or other wet conditions on the surface in the past 24 hours, as determined by the manufacturer.

General Installation.

Pre-treat cracks greater than 1/4 inch in width and depth with the mixed binder resin. Once the binder resin in the pre-treated areas has gelled, proceed with the installation.

A second application of the SFST may be required on open-graded pavement surfaces.

Submit quality assurance samples of aggregate and binder components used during installation, at a minimum rate of 1 quart can sample per placement location or as directed by the Engineer, not to exceed more than one sample per day of each component.

Wet spots must be covered with the aggregate prior to the gelling of the binder resin.

Repair any areas displaying exposed binder resin according to manufacturer's recommendations at no additional cost to the State.

Primer:
If a primer is recommended by the manufacturer, apply primer according to manufacturers recommended procedures.

Mechanical Application:
Apply system using a SFST manufacturer's approved automated continuous application device meeting the following requirements:

- Mechanically mix, meter, monitor and apply the binder resin and aggregate in one continuous pass.
- Feature volumetric metering pumps that continuously mix, meter, and monitor and apply the resin binder. Be equipped with heated metering pumps if recommended by the SFST manufacturer.
- Have continuous pumping and portioning devices that blend the binder resin within a controlled system.
- Blend and mix the binder resin in the ratio per the manufacturer's specification (+/- 2% max by volume) and be continuously applied once blended.
- Be capable of applying a uniform application thickness of 50-65 mils (25-32 sf / gal). Coverage rate is based upon expected variances in the surface profile of the surface.

Apply in a manner that will not allow the mixed material to separate, cure, dry, be exposed or otherwise harden in such a way as to impair retention and bonding of the aggregate.

Mechanically apply the aggregate at a rate of 12 -15 lbs/sqyd (achieving saturation), within 5 minutes of applying the base binder resin, in such a manner that there is no disruption to the leveled binder.

Hand Mixing and Application:
For areas where mechanical forms of application are not conducive or economical, hand-mix binder resin in accordance to the manufacturer's recommendations.

Uniformly spread the binder resin onto the surface using a serrated edge squeegee at a uniform application thickness of 50-65 mils (25-32 sf. /gal.). Coverage rate is based upon expected variances in the surface profile of the surface.

Immediately broadcast aggregate at a rate of 12 -15 lbs. /sq. yd. (Achieving saturation) in such a manner that there is no disruption to the leveled binder.

Curing. Allow the treatment to cure in accordance with manufacturer's recommendations, a minimum of 3 hours, at an ambient temperature between 50ºF and 95ºF.

Walking, standing or any form of contact or contamination with the wet uncured binder resin prior to application of the aggregate without the use of spiked shoes to minimize the disturbance to the binder layer will result in that section of binder resin being removed and replaced at the installer's expense.

Do not allow equipment and/or traffic on the SFST during curing period.

Post Installation work:
Three days after the initial installation is completed on high speed highways such as interstate ramps and bridge decks, sweep excess loose aggregate off the surface.

Reusable excess aggregate can be reclaimed by a vacuum sweeper. The recovered aggregate must be clean, uncontaminated and dry.

Basis of Approval.

Submit to the Department product data, MSDS sheets on the proposed system, and samples of the system displaying the color and texture. Provide a 10 lb. sample of the proposed aggregate to be used on the project to the Materials Bureau for evaluation as well as two - 1 quart samples of each component of the binder resin at least 90 days prior to use. Provide source information on the supplied aggregate.

Provide information on a minimum of 3 projects completed using the same SFST, on at least 5000 square yards, cumulative, placed within the past 3 years. These installations must have demonstrated a friction value of 65 FN40R or higher when tested in accordance to AASHTO T 242.

Provide a project specific Quality Control (QC) Plan detailing installer's key personnel, equipment, materials, proposed methods of installation, materials blending procedures, and proposed methods of curing.

Provide certification that the material meets the requirements of this specification.

The proposed SFST system will be evaluated by the Department at least 45 days prior to use.

Basis of Acceptance.

Within 90 days after construction of the surface treatment, or prior to contract acceptance, whichever comes first, the Department will evaluate that the aggregate coverage is complete and there is no exposed binder visible.

To ensure the quality of the installation, the Department will test the installation approximately 2 weeks after construction. The installation must meet a minimum requirement of 65 FN40R when tested in accordance to AASHTO T 242.

METHOD OF MEASUREMENT

This work will be measured as the number of square yards of surface treatment material installed satisfactorily.

BASIS OF PAYMENT

The unit price bid per square yard shall include the cost of all labor, materials and equipment necessary to satisfactorily complete the work.

Payment will be made under:

Item No.	Item	Pay Unit
601.02000004	– Specialty Friction Surface Treatment for Asphalt	Square Yard
601.03000004	– Specialty Friction Surface Treatment for Concrete	Square Yard

EPOXY OVERLAY SYSTEM I (2-11-19)

GENERAL

This special provision is intended for use on bridges with an Average Daily Traffic (ADT) exceeding 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 ⅜"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.

PERFORMANCE GUARANTEE

The Contractor shall provide a warranty bond to the Department, guaranteeing the wearing surface for a period of 36 months against the following defects: delamination of the epoxy overlay from the deck surface, and skid resistance less than 40 as measured by AASHTO T242. The performance bond will be invoked if 25 square feet of the deck surface meets the defect criteria prior to the end of the warranty. The guarantee period will start on the date of Department final acceptance of the project. At the end of the guarantee period, the warranty bond will be invoked if any part of deck surface meets the defect criteria, regardless of quantity.

The Contractor shall replace defective materials and workmanship at no cost to the Department. 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.

The warranty bond amount shall be the bid quantity of epoxy overlay multiplied by the statewide average unit bid price for the epoxy overlay. The guarantee period of 36 months and bond value shall be specified in the warranty bond provided to the Department prior to final acceptance of the project.

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 (1:1) or two to one (2:1) 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.

The Contractor shall submit a Certified Test Report from independent labs for all of the materials associated with the overlay in accordance with this special provision.

All components shall be shipped in strong, substantial containers, bearing the manufacturer's label specifying batch/lot number, brand name, and quantity. If bulk resin is to be used, the contractor shall notify the Engineer in writing ten (10) working 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.

(A) 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	AASHTO T237
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

(B) 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 T327

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

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 special 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 shot-blasting until all grinding or milling operations are completed. Use sandblasting equipment on areas that cannot be reached by the shot-blasting operation. If expansion joints are not being replaced or have been replaced prior to shot-blasting they shall be protected from damage from the shot-blasting 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 shot-blasting 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 shot-blasting 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 (2) 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 ¼” 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.

EQUIPMENT

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.

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 two (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 ⅜”. 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 eight (8) hours after application or if air temperatures would cause the gel time to be less than ten (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 special provision 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.

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 36-month warranty bond, and all tools, labor, materials, bond strength testing and any incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Epoxy Overlay System I	Square Feet

EPOXY OVERLAY SYSTEM II (2-11-19)

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 ⅜"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.

PERFORMANCE GUARANTEE

The Contractor shall provide a warranty bond to the Department, guaranteeing the wearing surface for a period of 36 months against the following defects: delamination of the epoxy overlay from the deck surface, and skid resistance less than 40 as measured by AASHTO T242. The performance bond will be invoked if 25 square feet of the deck surface meets the defect criteria prior to the end of the warranty. The guarantee period will start on the date of Department final acceptance of the project. At the end of the guarantee period, the warranty bond will be invoked if any part of deck surface meets the defect criteria, regardless of quantity.

The Contractor shall replace defective materials and workmanship at no cost to the Department. 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.

The warranty bond amount shall be the bid quantity of epoxy overlay multiplied by the statewide average unit bid price for the epoxy overlay. The guarantee period of 36 months and bond value shall be specified in the warranty bond provided to the Department prior to final acceptance of the project.

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 (1:1) or two to one (2:1) 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.

The Contractor shall submit a Certified Test Report from independent labs for all of the materials associated with the overlay in accordance with this special provision.

All components shall be shipped in strong, substantial containers, bearing the manufacturer's label specifying batch/lot number, brand name, and quantity. If bulk resin is to be used, the contractor shall notify the Engineer in writing ten (10) working 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.

(A) 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	AASHTO 7237
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

(B) 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 T327

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

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 special 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 shot-blasting until all grinding or milling operations are completed. Use sandblasting equipment on areas that cannot be reached by the shot-blasting operation. If expansion joints are not being replaced or have been replaced prior to shot-blasting they shall be protected from damage from the shot-blasting 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 shot-blasting 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 shot-blasting 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 (2) 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 ¼” 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.

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. Equipment 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 shall be applied in such a manner as to uniformly and accurately 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.

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 two (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 ⅜”. 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 eight (8) hours after application or if air temperatures would cause the gel time to be less than ten (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 special provision 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.

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 36-month warranty bond, and all tools, labor, materials, bond strength testing and any incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Epoxy Overlay System II	Square Feet

Section 00556 - Multi-Layer Polymer Concrete Overlay

Description

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

00556.03 Submittals - At least 21 Calendar Days before the pre-placement conference, provide the following information to the Engineer for approval:

- 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.
- Equipment information according to 00556.20.
- Personnel Qualifications according to 00556.30.
- An Inclement Weather Plan according to 00556.04.

00556.04 Inclement Weather Plan - Submit an inclement weather plan when application conditions of 00556.40(b) are not met. The inclement weather plan includes all Materials, Equipment, and methods to be used to heat the substrate, Aggregate, and resin. If concrete moisture content or capillary moisture is to be tested, provide Equipment information and calibration certificates.

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 2 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 Project Site 1/2 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 Materials - Furnish Materials meeting the following requirements:

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

Resin shall meet the requirements of ASTM C881, Type III.

(b) Multi-Layer Polymer Concrete Overlay Aggregate - Furnish MPCO Aggregate from the QPL.

Sample the furnished Aggregate and test according to the following:

Property	Test Method	Requirements
Moisture Content *	AASHTO T 255	0.20% max.
Moisture Content **	AASHTO T 255	1.00% max.

* At time of aggregate production.
** Field test at time of mixing the polymer resin.

Equipment

00556.20 Equipment - Provide approved Equipment to place the MPCO. Remove all Equipment that leaks oil or other contaminants from the Work area until they are repaired.

00556.21 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:

- Meets the requirements of ASTM D4541 Type V
- 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.

(d) Resin Conditioning Equipment - Furnish Equipment capable of conditioning resin to between 65 °F and 85 °F.

(e) Aggregate Heating Equipment - Furnish heating Equipment capable of pre-heating Aggregate to a minimum of 70 °F as measured at the time of placement.

(f) MPCO Heating Equipment - If required, or as a means to accelerate curing, furnish heating Equipment that:

- Can apply indirect heat to ensure that the entire completed membrane will meet the bond test requirements of 00556.43.
- Can maintain a minimum temperature of 70 °F within the heated area and does not exceed 110 °F.
- Will not segregate, shove, tear or gouge the MPCO system.

(g) Concrete Moisture Meter - Furnish a pin-type, instant read, concrete moisture meter meeting ASTM F2659. Provide current calibration documentation.

(h) Dew Point Measurement Equipment - Furnish dew point measurement Equipment that:

- Measures deck surface temperature accurate to ± 1 °F
- Measures ambient temperature and dew point accurate to ± 1 °F

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 deck surface preparation quality control activities.
- Be at the Project Site during overlay placements and monitor the placement for MPCO quality control activities.

Construction

00556.40 Construction:

(a) General - Do not begin MPCO installation until all Materials and Equipment necessary to perform the installation and required repairs, and qualified personnel are at the Project Site. 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.

(b) Application Conditions - Apply the MPCO on prepared surfaces when the following conditions are met:

- The deck surface has been visually dry for at least 72 hours.
- The ambient temperature and deck surface temperature are between 50 °F and 90 °F, or as specified by the resin manufacturer's product data sheet, whichever is more restrictive.
- The deck surface temperature is at least 5 °F above the dew point.
- No rain is forecasted for the duration of the estimated MPCO cure time, based on ambient and surface temperatures.

(c) Inclement Weather Plan - When an inclement weather plan is approved, apply MPCO on prepared surfaces when the following conditions are met:

- If the deck has been dry for less than 72 hours, mechanically heat the deck to a minimum of 300 °F and a maximum temperature of 350 °F. Perform one of the following tests after applying heat:
  - Test for capillary moisture using the plastic sheet method, according to ASTM D4263, with a minimum test time of 2 hours. Perform one test per 500 square feet.

- Test for concrete moisture content using a pin-type moisture meter according to 00556.21(g). Maximum allowable deck moisture content is 4 percent. Perform number of tests and locations according to ASTM F2659, with a minimum of eight tests per primer placement. Test additional locations as directed by the Engineer.
- The ambient temperature and deck surface temperature are between 40 °F and 90 °F. If the temperature falls, or is forecasted to fall below 50 °F perform the following:
  - Pre-heat the Aggregate to a minimum of 70 °F.
  - Heat the MPCO to a minimum of 70 °F to facilitate curing. Do not exceed 110 °F on the MPCO surface.
- The deck surface temperature is at least 3 °F and rising above the dew point.
- No rain is forecasted for the duration of the estimated MPCO cure time, based on ambient and surface temperatures.
- Do not place MPCO when temperatures are below 40 °F.

(d) Deck and MPCO Materials Heating - Do not use manually operated propane torches to heat the deck surface or MPCO Material. When the deck surface is mechanically heated, do not proceed with Work until the surface temperature is less than 90 °F.

00556.41 Surface Preparation: Prepare all surfaces that are to be in contact with the MPCO according to Section 00504.

Block out interior expansion joints with rigid polyethylene foam or other approved Material and place MPCO over joints.

00556.42 Placing Multi-Layer Polymer Concrete Overlay:

(a) Thickness - Place MPCO in Lifts to achieve a total nominal thickness of 3/8 inch.

(b) Mixing the Polymer Resin - Condition the polymer resin to between 65 °F and 85 °F and mix as recommended by the manufacturer.

(c) Overlay Application - With the Engineer's approval of the surface preparation, apply the MPCO according to the approved submittals and meeting the requirement of 00556.40(b).

After each Lift, before gelling of the polymer resin occurs, broadcast a layer of Aggregate at a rate of 1-2 pounds of Aggregate per square foot, as required to achieve refusal with no visible wet spots.

For each Lift, sweep the entire deck surface after the polymer has cured and remove all loose material.

Feather the MPCO to the end bridge joints located at end panels. Sawcut interior joints to allow for expansion joint installation prior to opening to traffic.

If application of the MPCO surface does not meet the requirements of the approved submittals in 00556.03, stop the operation until revised methods, changes in Equipment, or correction of procedures are proposed and approved.

(d) Curing - Allow the MPCO to cure for the amount of time stated in the submitted tabulated curing time and temperature chart before subjecting it to loads or traffic. Only allow traffic on portions of the MPCO with the final lift complete and fully cured.

Heating MPCO Materials to facilitate cure and decrease cure times may be performed, at no additional cost to the Agency, when application conditions of 00556.40(b) are met and heating is performed according to 00556.40(d).

00556.43 Bond Strength Test - Perform at least two bond tests for each Day of placement in the presence of and at locations designated by the Engineer. Test the bond strength within 48 hours after placing the MPCO overlay. Cut 2 inch to 3 inch diameter cores from in-place MPCO at least 1/2 inch into concrete substrate and conduct bond tests on the cores. Test according to ASTM D4541, Method “E”, using Type “V” tester.

The bond test consists of:

- Coring through the MPCO overlay and approximately 1/2 inch into the existing concrete.
- Attaching a 50 mm (2-inch) test dollie to the top of the core.
- Exerting a tensile load to the core sufficient to cause failure or achieve 300 psi, whichever occurs first.
- Avoid taking cores in the wheel tracks.

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.

00556.44 Delamination Survey and Repair - Perform a deck delamination survey, in the presence of the Engineer, using chain drag, coring, or other approved methods. If directed by the Engineer, perform additional bond tests according to 00556.43, at locations directed.

Repair all delaminated areas of 1 square foot or greater. Delaminated areas of less than 1 square foot will not require repair. Repair limits to be approved by the Engineer. 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.

00556.45 Use of New Surface:

(a) Vehicles - Do not allow vehicles or construction Equipment on the MPCO surface until curing is complete according to 00556.42(d).

(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:

- **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)	Furnish MPCO Material	Square Yard
(b)	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 the inclement weather plan or heating deck surface or MPCO Materials.

Section 00557 - Premixed Polymer Concrete Overlays

Description

00557.00 Scope - This work consists of constructing premixed polymer concrete (PPC) pavement overlays as shown or specified.

00557.01 Definitions:

PPC System - The combination of compatible resins and primers, mixed with aggregates and other specified ingredients and applied as specified, that produces an acceptable PPC pavement overlay.

System Provider - The polymer concrete supplier experienced in PPC mix design and the application of PPC systems.

00557.02 Submittals - At least 21 Calendar Days before the pre-placement conference, provide the following information and samples to the Engineer for approval:

- The inclement weather plan according to 00557.04.
- Test results, from an independent testing laboratory, for the first lot of primer manufactured for use on this Project, showing that the primer complies with the requirements of 00557.10. Provide a Certificate of Compliance from the manufacturer for each subsequent lot of primer, indicating that the primer was manufactured to the same formulation as the first lot.
- Test results, from an independent testing laboratory, for the first lot of polyester resin binder manufactured for use on this Project, showing that the binder complies with the requirements of 00557.12(a). Provide a Certificate of Compliance from the manufacturer for each subsequent lot of resin binder, indicating that the polyester resin binder was manufactured, to the same formulation as the first lot.
- A Certificate of Compliance for each lot stating that the primer and resin binder will not expire prior to use on this Project based on the published shelf life and manufacture date.
- A detailed work plan for the PPC preparation, application, and cleanup. Include estimated dates and timeframes.
- The finishing equipment according to 00557.22.
- Rebound Hammer calibration documentation and correlation number established per ASTM C805 used to determine when to open the overlay to traffic.
- The type of scarifying Equipment that will be used for deck preparation according to Section 00504.
- The method and materials used to contain, collect, and dispose of all concrete debris generated by the scarifying process, including provisions for protecting adjacent traffic from flying debris.
- The method and materials used to contain the high molecular weight methacrylate (HMWM) resin and the PPC mixture within the deck area that will receive the overlay.
- The PPC mix design.
- Certification from the System Provider stating that the polyester resin and the primer are approved and are fully compatible with one another and that they are compatible with the PCC repair material used for repairing Class 2 and Class 3 areas.
- Notice when bulk resin will be used on the Project. Bulk resin is resin that is stored in containers exceeding 55 gallons.
- A Material Safety Data Sheet for the polyester resin binder and HMWM resin.
- The personnel qualifications according to 00557.30.

- Two 50-pound samples of the blended aggregate.
- Heating plan according to 00557.44.

Provide all material delivery receipts upon availability, but no later than one hour after the end of the work shift.

00557.04 Inclement Weather Plan - Submit an inclement weather plan when application conditions of 00557.40(b)(1) are not met. The inclement weather plan includes all Materials, Equipment, and methods to be used to heat the substrate. If concrete moisture content or capillary moisture is to be tested, provide Equipment information and calibration certificates.

00557.05 Pre-placement Conferences:

(a) Supervisory Personnel - Hold a mandatory pre-placement conference with all supervisory personnel, Subcontractors, suppliers, the system provider's technical representative (SPTR), the quality control technician (ACI Concrete Field Testing Technician Grade 1), and all other personnel who will be involved in the PPC pavement overlay work. Meet at a mutually agreed time at least 14 Calendar Days before placing the PPC pavement overlay including the trial overlay. Schedule the pre-placement conference after all submittals have been reviewed and approved. Present and discuss all phases of the PPC pavement overlay work.

(b) Placement Crew - Hold a second pre-placement conference with the Engineer, the entire PPC pavement overlay crew, the quality control technician (ACI Concrete Field Testing Technician Grade 1), and the SPTR at the Project Site 1/2 hour before the first placement begins to discuss placement duties and procedures. Do not begin PPC pavement overlay work until this meeting is held.

Materials

00557.10 Resin Primer - Furnish a wax-free, low odor, high molecular weight methacrylate resin prime coat that has a maximum volatile content of 30 percent before adding an initiator, when tested according to ASTM D2369, and meeting the following requirements:

High Molecular Weight Methacrylate (HMWM) Resin		
Property	**Requirement**	**Test Method**
Viscosity*	25 cps max. (Brookfield RVT with UL adaptor, 50 RPM at 77 °F)	ASTM D2196
Specific Gravity*	0.90, min. at 77 °F	ASTM D1475
Flash Point*	180 °F, min.	ASTM D3278
Vapor Pressure*	0.039 in. Hg, max. at 77 °F	ASTM D323
Tack-free time	400 minutes, max. at 77 °F	California Test 551**
* Perform test before adding initiator. ** Copies of California Test 551 are available from the Engineer.		

00557.12 Concrete - Furnish premixed polymer concrete consisting of polyester resin binder and dry aggregate.

(a) Polyester Resin Binder - Furnish unsaturated isophthalic polyester-styrene co-polymer resin binder meeting the following requirements:

Polyester Resin Binder		
Property	**Requirement**	**Test Method**
Viscosity*	75 - 200 cps (RVT, No. 1 Spindle, 20 RPM at 77 °F)	ASTM D2196
Specific Gravity*	1.05 to 1.10 at 77 °F	ASTM D1475
Elongation	35% min. Type I at 0.45 in./min. Thickness = 0.25 ± 0.03 inch	ASTM D638
	Sample Conditioning: 18/25/50 + 5/70	ASTM D618
Tensile Strength	2,500 psi min. Type I at 0.45 in./min. Thickness = 0.25 ± 0.03 inch	ASTM D638
	Sample Conditioning: 18/25/50 + 5/70	ASTM D618
Styrene Content*	40 to 50 % (by weight)	ASTM D2369
Silane Coupler**	1.0% min. (by weight of polyester styrene resin)	n/a
PCC Saturated Surface-Dry Bond Strength	500 psi, min. at 24 hours and 70 ± 2 °F	California Test 551***
* Perform test before adding initiator. ** An organosilane ester, gammamethacryloxypropyltrimeth-oxysilane. *** Copies of California Test 551 are available from the Engineer. Perform bond test using mixed PPC and primer.		

Provide a promoter that is compatible with suitable methyl ethyl ketone peroxide.

Initiate and thoroughly blend the polyester resin binder just prior to mixing with aggregate.

(b) Initiator - Provide an initiator system for the methacrylate resin consisting of a metal drier and peroxide. If the initiator is supplied separately from the resin, do not directly mix the metal drier with the peroxide.

Store containers in a manner that prevents leakage or spillage from one material to contact the containers or material of the other.

(c) Accelerators and Inhibitors - Provide accelerators and inhibitors, if required, as recommended by the system provider.

(d) Aggregate - Furnish washed, clean, and dry 3/8" - 0 size aggregate meeting the following requirements:

- Meets the following combined gradation according to AASHTO T 27 and AASHTO T 11:

Sieve Size	Percent Passing (by Weight)
3/8"	100
No. 4	62 - 85
No. 8	45 - 67
No. 16	29 - 50
No. 30	16 - 36
No. 50	5 - 20
No. 100	0 - 7
No. 200	0 - 3

- Combined aggregate absorption does not exceed 1 percent according to AASHTO T 84 and AASHTO T 85.
- Moisture content does not exceed 0.2 percent at the time of aggregate production according to AASHTO T 255.
- Field tested moisture content does not exceed 1.00 percent according to AASHTO T 255. Test field moisture content prior to production Work, during the trial overlay strip. Perform additional field moisture tests, as directed by the Engineer
- The largest size aggregate does not exceed one-half the minimum depth of the overlay.
- Aggregate retained on the No. 8 to No. 200 sieves only consists of natural sand.
- When aggregate retained on the No. 4 and No. 8 sieves is combined, the aggregate shall have a maximum of 45 percent crushed particles with at least one fractured face when tested according to AASHTO T 335.

Deliver aggregate to the mixer in containers that maintain the specified moisture content.

(e) Surface Texture Sand - Furnish dry commercial quality blast sand, meeting the absorption and moisture content requirements of the aggregate with 95 percent of the sand passing the No. 8 sieve, and 95 percent of the sand retained on the No. 20 sieve.

00557.14 PPC Mixture Tolerances and Limits - Provide a uniform, consistent, workable PPC mixture with a polyester resin content, by weight, of 12 ± 1 percent of the aggregate weight.

00557.16 Acceptance of Premixed Polymer Concrete:

(a) General - Acceptance of PPC will be based on Contractor’s modulus of elasticity and bond strength test results.

(b) Required Properties and Tolerances - The properties and requirements of the PPC are:

Property	Requirement	Test Method
Compressive Strength for Traffic	2,000 psi, min. before opening to traffic	ASTM C805
Surface Tolerance	See 00557.45(c)	n/a
Bond Strength	250 psi, min.	See 00557.44(f)
Set Time	30 to 90 minutes	Visual
Density	See (c) below	ASTM C138
Modulus of Elasticity at 7 Days	1,000 ksi, min. 2,000 ksi, max.	ODOT TM 759
Surface Preparation Depth	1/16 inch, min.	ASTM E965

Perform acceptance testing according to the referenced tests, and furnish samples to the Engineer as required. Failing test results may be cause for rejection of the mix with removal and replacement of the affected material at no additional cost to the Agency. If the Engineer determines that the PPC is suitable for the intended purpose, the PPC may be allowed to remain in place, subject to a price adjustment according to 00150.25.

(c) Density - Determine the unit weight of the PPC mixture according to AASHTO T 121 (ASTM C138). Submit test results to the Engineer. The correlation factor established through density testing will be used to determine equivalency between weight and volume for purposes of payment. Perform density testing at the rate of one test per batch.

Equipment

00557.20 General - Remove all Equipment that leaks oil or other contaminants from the Project Site until they are repaired.

00557.21 Mixing Equipment - Furnish mechanically operated continuous mixers specifically built or modified for PPC that:

- Employ an auger screw or chute device.
- Is equipped with a positive-displacement pump that is calibrated yearly and is connected to an adjustable catalyst pump.
- Is equipped with a metering device that is calibrated yearly and automatically measures and records the aggregate weight and the corresponding resin weight. Repeat calibration at the beginning of the project and when changes are made to the mix truck that may affect the accuracy of the truck measurements.
- Has a readout gage, visible to the Engineer at all times, which displays the weights being recorded.

00557.22 Finishing Equipment - Furnish slip-form finishing equipment with an automatic grade control device to strike off the PPC mixture to the established grade and cross section, or other Equipment such as 30 foot floating beams as approved by the Engineer. Fit the finishing equipment with vibrators or other means of consolidating the PPC.

00557.23 Miscellaneous Equipment:

(a) Hand Tools - Furnish hand tools for placing and finishing the PPC. Use manual type screeds with approved vibrators attached to consolidate and finish smaller areas where it is impractical to use a finishing machine.

(b) Straightedge - Furnish a 12 foot metal straightedge.

(c) Coring Equipment - Furnish core cutting equipment that can cut a core at least 2 inches in diameter.

(d) Bond Testing Equipment - Furnish bond testing equipment that:

- Meets the requirements of ASTM D4541 Type V
- Is compatible with the core tested.
- Can exert a tensile load to the core sufficient to exceed 250 psi.
- Is equipped with a measuring device capable of reading tensile force exerted within 1 percent accuracy.

(e) Diamond Grinders - Furnish power-driven self-propelled machines with the cutting head made up of diamond cutting blades to correct non-specification surface variations.

(f) Concrete Moisture Meter - Furnish a pin-type, instant read, concrete moisture meter meeting ASTM F2659. Provide current calibration documentation.

(**g) Dew Point Measurement Equipment** - Use dew point measurement equipment that:

- Measures deck surface temperature accurate to ± 1 °F.
- Measures ambient temperature and dew point accurate to ± 1 °F.

Labor

00557.30 Personnel Qualifications - Perform the PPC pavement overlay work using a company and personnel experienced in PPC pavement overlay work. Demonstrate the company's qualifications and experience and the qualifications of personnel scheduled to perform the PPC pavement overlay work by providing the Engineer the following:

- The name of the company that will be performing the PPC pavement overlay work.
- A project reference list of at least three PPC pavement overlay project, successfully completed within the last five years, that has used the same PPC pavement overlay system and materials that will be used on this Project. The minimum PPC overlay qualification area is 2,000 square feet. Include the following information for each qualifying project:
  - A brief description of each project.
  - Each project's name.
  - The owner’s contact person’s name, title, and current phone number for each project.
  - Alternate owner's contact person's name, title, and current phone number for each project.
  - The amount of PPC overlay material used on each project.
- Identify a SPTR, the mixer operators, and the finishing machine operators that will perform the PPC pavement overlay work. Include documentation that they have relevant experience with PPC pavement overlay work and that they have completed at least one PPC pavement overlay project within the last three years.

- A brief description of experience using slip-form screeds for either PPC or PCC roadway wearing surfaces.

The Engineer may suspend the PPC pavement overlay work if the Contractor substitutes unapproved personnel during construction. Submit requests for substitution of SPTR, mixer operators, and finishing machine operators to the Engineer. The Engineer will respond within seven Calendar Days of each request.

00557.32 Quality Control Personnel - Provide the following certified technicians:

(a) Certified Aggregate Technician (CAgT) - Duties:

- Sample and test the blended aggregate from the conveyor belt during the trial overlay to verify gradation, and moisture content.
- Provide split of blended aggregate samples to the Engineer.
- Provide test results to the Engineer before placing PPC overlay.

(b) PPC Field Testing Technician (ACI Concrete Field Testing Technician Grade 1) - Duties:

- Attend pre-placement meetings.
- Be at the PPC placement site when PPC placement is in progress.
- Performs applicable field testing.
- Notify the Contractor and the Engineer immediately when the PPC is not in compliance with Specifications.

(c) Concrete Strength Testing Technician (CSTT) - Duty:

- Modulus testing.

(d) System Provider's Technical Representative (SPTR) - Duties:

- Guide development of the PPC mix design.
- Attend pre-placement meetings and be present at the trial overlay placement.
- Verify that the primer gels, as mixed and applied.
- Guide the calibration of each mechanically operated mixer used on the Project.
- Be present throughout all mixing to control adjustments to the mix, if necessary.
- Be at the PPC placement site during PPC placement and evaluate each batch delivered and control adjustments to the mix, if necessary.

Construction

00557.40 Construction :

(a) General - Do not begin primer or PPC installation until all Materials and Equipment necessary to perform the installation and required repairs, and qualified personnel are at the Project Site.

(b) Application Conditions - Apply primer on prepared surfaces when the following conditions are met:

- The deck surface has been visually dry for at least 5 Days.
- The ambient temperature and deck surface temperature are between 50 °F and 90 °F.

- The deck surface temperature is at least 5 °F above the dew point.
- No rain is forecasted within 12 hours from the start of PPC placement.

(c) Inclement Weather Plan - When an Inclement Weather Plan is approved, apply primer on prepared surfaces when the following conditions are met:

- If the deck has been dry for less than 5 Days, mechanically heat the deck to a minimum of 300 °F and a maximum temperature of 350 °F. Perform one of the following tests after applying heat and the surface temperature is less than 110 °F:
  - Test for capillary moisture using the plastic sheet method, according to ASTM D4263, with a minimum test time of 2 hours. Perform one test per 500 square feet.
  - Test for concrete moisture content using a pin-type moisture meter according to 00557.23(f). Maximum allowable deck moisture content is 4 percent, or the primer manufacturer's recommendation, whichever is lower. Perform number of tests and locations according to ASTM F2659, with a minimum of eight tests per primer placement. Test additional locations as directed by the Engineer.
- The ambient temperature and deck surface temperature are between 40 °F and 90 °F.
- The deck surface temperature is at least 3 °F above the dew point and rising. Deck surface temperature may be mechanically heated to raise the temperature to at least 5 °F above the dew point.
- No rain is forecasted within 12 hours.

(d) Deck Heating - Do not use manually operated propane torches to heat the deck surface. When the deck surface is mechanically heated, do not proceed with Work until the surface temperature is less than 110 °F.

00557.41 Trial Overlay Strip - Before constructing the trial overlay strip, in the presence of the Engineer, verify weights of resin and aggregate being recorded by calibrating each mechanical mixer used on the Project using certified scales. Use the calibrated mixer to conduct one or more trial overlays on a concrete base approved by the Engineer to determine the initial set time and to demonstrate the effectiveness of deck preparation, mixing, placing, and finishing equipment proposed. Roughen the surface of the trial overlay strip leaving an exposed aggregate surface texture depth profile of at least 1/16 inch, determined according to ASTM E965 (standard volumetric test).

Construct trial overlays meeting the acceptance criteria of 00557.16, except test the modulus of elasticity at 24 ± 1 hours. Perform testing at locations designated by the Engineer. Construct each trial overlay 12 feet wide by at least 20 feet long, and at the same thickness as the final PPC overlay. Construct trial overlays when weather conditions are similar to those expected during construction of the PPC overlay. Use the same equipment, including deck preparation equipment, that will be used for the PPC overlay.

Sample the blended aggregate from the conveyor belt and test according to 00557.12(d) while constructing the trial overlay strip.

Do not proceed with PPC overlay work until the Engineer approves the trial overlay strip.

Remove and dispose of the trial overlay and the concrete base according to 00290.20.

00557.42 Surface Preparation - Prepare all surfaces that are to be in contact with the PPC according to Section 00504.

Block out expansion joint openings with rigid polyethylene foam or other approved Material, compatible with the resin and primer, before constructing the overlay. Place the PPC over the blocked out joint openings. Create the expansion joint openings by saw cutting the overlay along each joint edge. Saw cut expansion joint openings each shift prior to allowing traffic.

00557.43 Placing Prime Coat - When conditions of 00557.40 are met, apply primer according to the following:

- Blow clean with compressed air to remove accumulated dust and all other loose material.
- Flood the deck surface with the resin primer at a rate of 75 to 100 square feet per gallon.
- Allow the resin primer to penetrate into the concrete and fill all cracks.
- Do not allow the primer coat to leak from cracks or other openings in the deck.
- Redistribute and work the applied resin primer into cracks with squeegees or brooms in a manner that does not cause foaming.
- Maintain free flowing consistency of the resin primer at all times. Only use enough initiated promoted resin that is needed to apply a prime coat.
- A noticeable increase in viscosity of the prime coat resin before it is placed will be cause for rejection.
- Do not allow traffic on the primed surface.
- Allow the prime coat to pond and penetrate into the deck surface a minimum of 15 minutes before placing the PPC.
- If the primed surface becomes contaminated, or if the prime coat fails, clean the contaminated area by abrasive blasting, and re-prime at no additional cost to the Agency.

00557.44 Premixed Polymer Concrete Pavement:

(a) Placement Conditions - Place PPC only when the ambient temperature, surface temperature and relative humidity meet the requirements on the manufacturer's written data sheet.

(b) Mixing - Mix PPC on-site. Do not allow packaging to enter the mix.

Use initiators to produce a set time of between 30 and 90 minutes after placement. Use accelerators or inhibitors, if required for the 30 to 90 minute set time, as recommended by the resin supplier.

Initiate and thoroughly blend the polyester resin binder before introduction of aggregate to the binder. Use all bags or other containers of aggregate that are opened at the time of mixing, otherwise discard them.

(c) Placing PPC - Place premixed polymer concrete:

- Before it gels or within 15 minutes after the addition of the initiator, whichever is first. Discard the PPC if it is not placed within this time.
- During the same work shift the prime coat is applied.
- Place PPC with a minimum thickness of 3/4 inches or as shown.
- Place PPC in Panel widths which hold the location of the longitudinal joints to the lane lines.

(d) Set Time - Use an appropriate amount of initiator to achieve the required set time. Accelerators or inhibitors may be required as recommended by the polyester resin binder supplier and as approved by the Engineer.

(e) Modulus of Elasticity - Sample PPC within one minute of mixing. Cast one set of three 4 by 8 inch cylinder specimens from each batch of PPC placed on the Project.

Cast one additional set of three 4 by 8 inch cylinder specimens for every ten batches of PPC placed on the project, minimum of one set per day. Submit the additional set to the Engineer for verification testing.

Cast the PPC cylinders with a minimum of two lifts, rodding 25 times for each lift. Keep the cylinders level and stationary until PPC overlay rebound test has been completed.

A batch is defined as "per mixer" or "portion of it placed". Test each set according to ODOT TM 759 to determine modulus of elasticity at 7 Days. Use a CSTT to perform modulus testing.

Do not allow traffic and Equipment on the PPC overlay until the overlay has reached a minimum compressive strength of 2,000 psi as verified by the rebound number determined according to ASTM C805. Test the deck surface at locations as directed.

(f) Bond Strength - Perform at least two bond tests for each day of placement in the presence of and at locations designated by the Engineer. Test the bond strength within 48 hours after placing the PPC overlay. Cut 2 inch to 3 inch diameter cores from in-place PPC at least 1/2 inch into concrete substrate and conduct bond tests on the cores. Test according to ASTM D4541, Method “E”, using Type “V” tester

The bond test consists of:

- Coring through the PPC overlay and approximately 1/2 inch into the existing concrete.
- Attaching a 50 mm (2-inch) test dollie to the top of the core.
- Exerting a tensile load to the core sufficient to cause failure or achieve 250 psi, whichever occurs first.
- Avoid taking cores in the wheel lines.

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

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

(g) Batch Weight - Record the batch weights at no greater than five minute intervals along with the time and date of each recording.

Furnish a batch ticket to the Engineer at the end of each Work shift or as requested. Batch tickets shall contain the following information:

- Name of PPC supplier.
- Serial number of the delivery ticket.
- Date; starting time, and finishing time.
- Identification number of batching and mixing Equipment.
- Name of purchaser.
- Specific designation of the job (Name, Location and Contract Number).
- Aggregate weight in pounds.
- Resin weight in pounds.
- Sampled PPC Unit Weight in pounds per cubic yard.
- Amount of PPC in cubic yards.

- Signature or initials of the person operating the batching or mixing equipment.

Batch tickets may be computer generated, hand written, or a combination of both.

00557.45 Roadway Finish:

(a) Sand Surface Treatment - After overlay strike-off and before gelling occurs, uniformly apply surface texture sand or PPC fine aggregate to the overlay surfaces at a rate of 1.8 pounds per square yard.

(b) Surface Texturing - Before gelling occurs, texture the PPC by one of the following methods:

- A steel-tined tool with 1/8 inch wide tines that will mark the finished PPC to a depth of 1/8 to 3/16 inch. Randomly space the markings from 3/4 to 1 1/2 inch as approved.
- Orient the texturing perpendicular or longitudinal to the roadway centerline and full width of the roadway width except leave smooth strips 14 inches wide along each curb faces. Do not overlap texturing.

Correct all non-specification surface texturing, at no additional cost to the Agency, according to the following:

- Correct texturing after PPC curing and before opening the roadway to traffic.
- Cut grooves 1/8 inch wide and 1/8 to 3/16 inch deep.
- Unequally space grooves from 3/4 to 1 1/2 inch apart.
- Remove saw slurry and laitance from the sawing operation while cutting the grooves.
- Orient the grooves perpendicular or longitudinal to the roadway centerline and full width of the roadway width except leave smooth strips 14 inches wide along each curb faces. Do not overlap grooves.

(c) Surface Tolerance - The finished surface of the PPC overlay, when tested with a 12 foot straightedge, shall not vary by more than 1/4 inch. Furnish the straightedge and operate it under the direction of the Engineer.

Correct all non-specification surface tolerance with a diamond grinder at no additional cost to the Agency.

Measurement

00557.80 Measurement - The quantities of work performed under this Section will be measured according to the following:

(a) Furnishing Premixed Polymer Concrete - Furnishing premixed polymer concrete material will be measured on the volume basis. The quantities will be determined by converting the weight identified on the mixer's automatic metering device to volume, using the yield factor according to AASHTO T 121 (ASTM C138).

(b) Constructing Premixed Polymer Concrete Overlay - Constructing premixed polymer concrete overlays will be measured on the area basis. Field measurement of the area will not be made. The area will be determined by calculating the area from the dimensions shown.

Payment

00557.90 Payment - The accepted quantities of work performed under this Section will be paid for at the Contract unit price, per unit of measurement, for the following item(s):

	Pay Item	Unit of Measurement
(a)	Furnish Premixed Polymer Concrete	Cubic Yard
(b)	Construct PPC Overlay	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 constructing and disposing of the trial overlays.

491.1 DESCRIPTION

This work consists of preparation of the plans specified existing bridge deck surface and furnishing and placing two coats of a polymer chip seal on the prepared bridge deck surface.

491.2 MATERIALS

Materials shall conform to the following Sections:

A. Concrete Patching Material: Concrete patching material shall be packaged, dry, rapid-hardening cementitious mortar or concrete materials conforming to the requirements of ASTM C 928, Type R-3 and shall contain a bonding agent and shall not contain any chlorides, magnesium, or phosphates.

B. Water: Section 790

C. Polymer: Section 805

D. Cover Aggregate: Section 805

491.3 CONSTRUCTION REQUIREMENTS

A. Surface Preparation

1. Removal and Replacement of Loose and Delaminated Concrete:

a. Concrete Removal Classification: Concrete removal shall be divided into one of the following two classes:

1) Concrete Removal, Class A: Concrete removal, Class A shall consist of the removal of delaminated and visibly loose concrete and any bituminous patches (when present) from the top of existing bridge deck down to a depth no deeper than the top of the top bar in the top mat of bridge deck reinforcing steel. Unintentional concrete removal below the top of the top bar in the top mat of bridge deck reinforcing steel during the concrete removal, Class A process will be considered a part of concrete removal, Class A. When grinding is specified, the concrete removal, Class A shall be done after the bridge deck has been ground.

2) Concrete Removal, Class B: Concrete removal, Class B areas shall be determined by the Engineer after completion of the concrete removal, Class A has been accomplished. Concrete removal, Class B shall consist of the removal of delaminated and visibly loose concrete that exists below the bottom limits of the concrete removal, Class A (below the top of the top bar in the top mat of bridge deck reinforcing steel).

b. Concrete Removal: Concrete removal shall be accomplished by jackhammers and chipping hammers or other methods as approved by the Engineer. Jackhammers and chipping hammers shall be used as follows:

1) Jackhammers heavier than 30 pounds will not be permitted.

2) Chipping hammers heavier than 15 pounds will not be permitted for removing concrete below the top of the top mat of reinforcing steel.

3) Jackhammers and chipping hammers shall not be operated at an angle in excess of 45 degrees measured from the surface of the concrete.

4) Extreme care shall be taken when using jackhammers and chipping hammers to assure that existing reinforcing steel is not damaged or debonded from the sound concrete.

Removal shall begin near the center of the loose or delaminated concrete and shall progress outwardly until the loose or delaminated concrete is removed and sound concrete is encountered such that the amount of concrete removal is minimized.

The edges of removed concrete shall be defined with a 3/4 inch deep saw cut where practical, as approved by the Engineer. If saw cutting is not practical, the use of jackhammers or chipping hammers may be required around the edges of the removal area to attain satisfactory results.

Care shall be taken during concrete removal to not nick, gouge, or in any other way damage the in place reinforcing steel. Any inadvertent damage to the in place reinforcing steel shall be brought to the attention of the Department's Bridge Construction Engineer and shall be repaired by the Contractor as directed by the Engineer at no additional cost to the Department.

c. Concrete Replacement: Upon completion of the concrete removal and immediately prior to placing any concrete patching material into the concrete removal areas, the removal areas shall be thoroughly cleaned of loose and foreign material by abrasive blasting. The surface profile of the area to receive the concrete patching material shall be in accordance with the manufacturer's recommendations. The abrasive blasting shall be to the extent that all surface laitance is removed. Abrasive blast cleaning shall expose the coarse aggregate and remove rust from any exposed reinforcing steel. After abrasive blasting, the surface shall be cleaned by the use of compressed air to the satisfaction of the Engineer. The air compressor used for cleaning shall be equipped with trap devices capable of providing moisture-free and oil-free air at a pressure of 90 psi.

The existing surface at the time of placement of the concrete patching material shall be at least 40°F, measured by a thermometer placed against the concrete surface and covered with an insulating blanket. The concrete patching material shall be mixed and placed in accordance with the manufacturer's technical data sheet. The Contractor shall provide a manufacturer's technical data sheet to the Engineer prior to performing the work. The concrete patching material shall be maintained at or above 45°F for at least 72 hours after placement.

Immediately after finishing the concrete patching material, the surface of the concrete patching material shall be covered with a double layer of wet curing blanket. Within one hour of covering with wet curing blanket, polyethylene sheeting shall be placed on the wet curing blanket. The surface shall be wet cured for a minimum of 48 hours or in accordance with the manufacturer's recommendations, whichever is more stringent. Following the wet cure, the curing blanket and polyethylene sheeting shall be removed and the surface allowed to air dry for a minimum of 48 hours after removal of the curing blanket and polyethylene sheeting before application of the polymer chip seal is permitted.

2. **Bridge Deck Grinding:** If specified in the plans, the bridge deck surface shall be ground prior to placement of polymer chip seal.

   The grinding shall remove the existing surface conditions as defined by the plan notes including, but not limited to; rubberized asphalt chip seal, epoxy chip seal, polymer chip seal, pavement markings, and tining and shall be to the satisfaction of the Engineer.

   The grinding shall be performed in the longitudinal direction and shall not damage bridge joints. The grinding shall result in a parallel corduroy texture consisting of grooves between 0.090 and 0.130 inches wide. The distance between the grooves shall be between 0.060 and 0.125 inches. The peaks of the ridges shall not be greater than 1/16 inch 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 ride 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.

3. **Abrasive Blasting of Bridge Deck:** After grinding, the entire bridge deck surface shall be thoroughly shot blasted to 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 polymer 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 polymer chip seal. In the event that the polymer 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 polymer chip seal will be allowed on any portion of the bridge deck which has been cleaned and prepared for application of the polymer 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 Polymer Chip Seal

1. **Seasonal Limitations:** Polymer chip seals shall only be applied within the seasonal limitation of May 1 to October 15 (inclusive).

2. **Manufacturer's Representative:** A manufacturer approved representative shall be present on the jobsite during application of the polymer chip seal. The representative shall provide technical expertise to the Contractor and Engineer regarding the safe handling, correct placement, and proper curing of the polymer chip seal.

   The manufacturer's representative shall provide the Engineer and the Contractor a copy of the written application 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 polymer materials.

3. **Polymer Application Requirements:** The Contractor shall store, mix, handle, and apply the polymer in accordance with the manufacturer's recommendations, or as approved by the Engineer, unless otherwise specified by the following requirements:

   a. Polymer shall not be applied unless the ambient air temperature and the application area surface temperature is between 50°F and 100°F with the air temperature at least 5°F 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 with the air temperature at least 5°F above the dew point temperature.

   b. The application of the polymer 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 polymer placement as approved by the Engineer.

d. The surfaces of existing bridge joints shall be masked with duct tape or other material, as approved by the Engineer. The masking shall be completely removed before the polymer achieves initial set. Removal shall not damage the adjacent polymer or the surface of the underlying joint.

e. When phased construction of the polymer chip seal is required, the Contractor shall maintain a straight line between the phases of polymer 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 polymer achieves initial set and shall be removed in a manner that will not damage the adjacent polymer. Overlapping the new polymer chip seal onto existing polymer chip seal shall not be done.

f. Prior to mixing, the application area shall be marked in a grid to ensure proper spread rates are achieved.

g. 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 polymer chip seal.

h. A coat of polymer shall be distributed at the manufacturer's recommended application rate. The application rate shall be a minimum of 1 gallon per 40 square feet.

4. Cover Aggregate Application Requirements:

a. After the polymer is distributed on the application area, 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 polymer chip seal thickness and a poor ride).

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) The aggregate falls vertically to the application area surface to prevent pushing of the polymer resin.

2) Aggregate coverage is uniform over the application area.

5. **Clean up of Excess Cover Aggregate Requirements:** The polymer shall be allowed to cure before excess cover aggregate is removed. Cure the polymer for 2 to 6 hours depending on temperature or based on the manufacturer's recommendations before removing excess cover aggregate. The polymer 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 Application:** A second coat of polymer shall be distributed at the manufacturer's recommended application rate. The application rate shall be a minimum of 1 gallon per 20 square feet. Cover aggregate shall be broadcast as per Section 491.3 B.4. In the event of rain before second coat is applied, the surface shall be dried prior to application. If second coat is not applied within 24 hours or traffic is allowed on the first coat, the application area must be abrasive blasted prior to application.

7. **Testing:** Pull-off tests shall be performed after the final coat of polymer chip seal is cured and excess aggregate is removed to verify adequate bond strength of the polymer 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 determined 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. One pull-off test shall be performed for each 75 linear feet of polymer chip seal application width, up to 24 feet 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.

   b. Pull-off tests with a resulting load of 250 psi or more shall be considered passing.

   c. All pull-off tests with a resulting load of less than 250 psi 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 1 foot of the failing test to verify concrete failure.

      2) Detaching assembly adhesive failure (adhesive failure) - The Contractor shall perform one additional test within 1 foot of the failing test. The Contractor shall repeat the test until the adhesive no longer fails.

      3) Separation of the polymer chip seal from the concrete surface (polymer failure) - the Contractor shall perform two additional pull-off tests as described below.

4) Pullout of the aggregate from the polymer (polymer 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 feet and 15 feet back from the failing test and one test shall be performed between 10 feet and 15 feet ahead of the failing test. If either of these two additional pull-off tests fails, the polymer chip seal fails and the failing polymer chip seal shall be removed and replaced at the Contractor's expense. The limits of the failing polymer chip seal shall be defined as the polymer 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 polymer and aggregate used in the polymer chip seal.

491.4 METHOD OF MEASUREMENT

A. Remove and Replace Deteriorated Concrete: Removal of deteriorated concrete will be measured by the class of concrete removal. Replacement of deteriorated concrete will be measured by the concrete patching material, bridge deck item.

1. **Concrete Removal, Class A:** Concrete removal, Class A will be measured to the nearest 0.1 foot and the area computed to the nearest 0.1 square yard.

2. **Concrete Removal, Class B:** Concrete removal, Class B will be measured to the nearest 0.1 foot and the area computed to the nearest 0.1 square yard.

3. **Concrete Patching Material, Bridge Deck:** Concrete patching material, bridge deck will be measured to nearest 0.1 cubic feet as determined from the theoretical yield per bag of concrete patching material.

B. Bridge Deck Grinding: Measurement will not be made for bridge deck grinding. The plan quantity will be the basis of payment.

C. 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.

D. Two Coat Bridge Deck Polymer Chip Seal: Measurement will not be made for two coat bridge deck polymer chip seal. The plan quantity will be the basis of payment.

E. Pull-Off Test: Measurement will not be made for pull-off tests.

491.5 BASIS OF PAYMENT

A. Remove and Replace Deteriorated Concrete: Removal of deteriorated concrete will be paid for under the class of concrete removal. Replacement of deteriorated concrete will be paid for under the concrete patching material, bridge deck item.

1. **Concrete Removal, Class A:** Concrete removal, Class A will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to remove the specified concrete, concrete sawing, and disposing of removed material.

2. **Concrete Removal, Class B:** Concrete removal, Class B will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to remove the specified concrete, concrete sawing, and disposing of removed material.

3. **Concrete Patching Material, Bridge Deck:** Concrete patching material, bridge deck will be paid for at the contract unit price per cubic foot. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to abrasive blast clean the removal areas, and furnish, place and cure the concrete patching material within the removal areas.

B. **Bridge Deck Grinding:** Bridge deck grinding, when specified in the plans, will be paid for at the contract unit price per square yard. 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.

C. **Abrasive Blasting of Bridge Deck:** Abrasive blasting of bridge deck will be paid for at the contract unit price per square yard. 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.

D. **Remove and Replace Deteriorated Concrete:** Remove and Replace Deteriorated Concrete, when specified in the plans, will be paid for at the contract unit price per square yard. Payment shall be full compensation for equipment, materials, labor and incidentals necessary to remove loose, deteriorated concrete or bituminous material, cleaning removal areas, disposal of removed materials and furnishing, placing and curing new concrete place within the removal areas.

E. **Two Coat Bridge Deck Polymer Chip Seal:** Two coat bridge deck polymer chip seal will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to furnish and install the two coat bridge deck polymer chip seal and to remove and dispose of the excess cover aggregate. Payment will also be full compensation for all manufacturer approved representative expenses.

F. **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 bridge deck polymer chip seal.

805.1 POLYMER

Polymer shall be a two component polymer 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 polymer shall be one of the polymers from the Department's Approved Products List or as approved by the Department's Bridge Construction Engineer.

805.2 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:

A. The Mohs hardness must be 6.0 minimum.

B. The gradation shall conform to the following:

Sieve Size	Percent Passing
#4	100
#8	30 – 75
#16	0 – 5
#30	0 – 1

C. The maximum aggregate moisture at the time of application shall not exceed 0.5%.

D. 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.

E. 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.

SECTION 03372

THIN BONDED POLYMER OVERLAY

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Thin bonded polymer overlay system applied to concrete bridge decks and approach slabs.

B. Removal of existing polymer overlay from concrete bridge decks and approach slabs.

C. Repair of damaged areas of a polymer overlay system.

1.2 RELATED SECTIONS Not Used

1.3 REFERENCES

A. ASTM C 25: Chemical Analysis of Limestone, Quicklime, and Hydrated Lime

B. ASTM C 88: Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

C. ASTM C 131: Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

D. ASTM C 566: Total Evaporable Moisture Content of Aggregate by Drying

E. ASTM C 579: Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes

F. ASTM C 881: Epoxy-Resin-Base Bonding Systems for Concrete

G. ASTM D 570: Water Absorption of Plastics

H. ASTM D 638: Tensile Properties of Plastics

I. ASTM D 790: Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

J. ASTM D 2240: Rubber Property – Durometer Hardness

K. ASTM D 4285: Indicating Oil or Water in Compressed Air

L. ASTM D 4580: Measuring Delaminations in Concrete Bridge Decks by Sounding

M. ASTM D 5821: Determining the Percentage of Fractured Particles in Coarse Aggregate

N. ASTM D 6928: Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus

O. ASTM E 274: Skid Resistance of Paved Surfaces Using a Full-Scale Tire

P. American Concrete Institute (ACI)

Q. International Concrete Repair Institute (ICRI)

1.4 DEFINITIONS

A. Polymer Overlay System – A thin bonded polymer overlay applied as a wearing surface consisting of a two-part polymer resin broadcasted with aggregate to refusal before it cures.

B. Installer – The entity preparing the surface and installing and finishing the polymer overlay system.

C. Provider – The manufacturer furnishing the polymer overlay system.

1.5 SUBMITTALS

A. Provider Qualifications for review at least 10 calendar days before ordering material.
   1. Include at least the following:
      a. Company name.
      b. Name and phone number of the Provider's Technical Support Representative.
      c. List of projects using the submitted products with at least two years of satisfactory performance under similar environmental conditions as the project in which it is to be applied. Refer to this Section, Article 1.6 B. List the following for each project:
         1) Project name
         2) Bridge locations (state routes and bridge identifiers)
         3) Scope of work
         4) Products used
         5) Approximate date of the system opening to traffic.

B. Materials
1. The following information at least 10 calendar days before ordering material:
    a. Manufacturer’s Product Data Sheets and recommended installation instructions.
    b. Material Safety Data Sheets.
    c. The Provider's certification stating that the provider is the sole provider of the components of the polymer overlay system and that the components are:
        1) In accordance with this Section.
        2) Fully compatible with one another.
    d. The Installer’s certification with the Provider’s written concurrence that the polymer overlay system is fully compatible with all deck repair materials.
2. Certified test report from an independent nationally recognized laboratory stating that the polymer resins in the polymer overlay system components meet the requirements in this Section.
    a. Test results must be from within a three year period of the submittal.
3. Certified Test Report from an AASHTO accredited testing laboratory confirming the compliance of the aggregate material with the test requirements of this Section.
    a. Test results must be from within a one year period of the submittal.

C. Method for mixing of the polymer resins
1. The Provider’s written concurrence that the selected mixing method is acceptable and compatible with the polymer overlay system.
2. Mixing ratio of the polymer resins.

D. A warranty letter to the Engineer and the Department Bridge Management Engineer stating that the Contractor guarantees the polymer overlay system against material and installation defects incurred under traffic for a period of 5 years.
1. The guarantee period starts on the date of Physical Completion.
2. Include in the letter:
    a. State Project Designation
    b. State Project Name
    c. State Structure Numbers
    d. Contractor, Provider, and Installer Name
3. Defects (performance failures) include:
    a. Spalling: Broken or missing pieces of polymer overlay system.
    b. Scaling: Visible, exposed, rough surface texture resulting from a loss of aggregate or resin.

c. Delamination: Visible or audible debonding of the polymer overlay system at the bond line (interface) with the existing bridge receiving surface.
d. Cracking: Visible cracks not reflected from a crack in the existing deck.
e. Loss of skid resistance: Skid resistance less than 40 as measured according to ASTM E 274.

4. The guarantee covers 100 percent of the polymer overlay system materials and installation costs.
5. Removal and replacement of the polymer overlay system for failed sections.
6. The Department will notify the Contractor of defects to be repaired during the guarantee period.
   a. Submit detailed plans and procedures of corrective work according to Provider's recommendations and obtain the Department's authorization before commencing work.
   b. Perform corrective work within 60 days of notification.

1.6 QUALITY CONTROL

A. Technical Support Representative
1. Provide a Technical Support Representative from the Provider onsite during surface preparation and application of the polymer overlay system on the first day the polymer overlay system is installed on a structure.
   a. The Technical Support Representative must have a minimum of 3 years of experience with the system and with guiding and assisting installers in the polymer overlay system installation.
   b. The Technical Support Representative will instruct the workers in proper mixing, application technique, safety precautions, traffic opening time, and environmental requirements.
   c. The Technical Support Representative must be available for consultation but not necessarily present at the job site for the remaining work.
2. The Department reserves the right to require the Technical Support Representative to be onsite if at any time the Engineer is concerned with the product installation quality.

B. Prior Performance
1. The selected polymer overlay system must have at least two years of satisfactory performance for non-interstate use and four years of satisfactory performance for interstate use in similar environmental conditions as the project in which it will be applied.

2. Products without the required years of prior satisfactory performance will only be considered for use with approval.
   a. Do not use for bidding purposes.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Polymer Resin
   1. 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
   2. Transport to and store on the job site in a dry, weather protected environment away from moisture, and within the maintained temperature range of 60 to 100 degrees F and according to Provider's recommended installation instructions.

B. Broadcast Aggregate
   1. Store aggregate in a clean, dry location, protected from rain and other moisture sources.
   2. Protect the aggregate from contaminants on the job site.

C. Handling Liquid Materials
   1. Use protective gloves, clothing, boots, and goggles when directly exposed to the material.
   2. Provide manufacturer's safety data sheets to workers and inspectors.

PART 2 PRODUCTS

2.1 POLYMER OVERLAY SYSTEM

A. Use a thin bonded polymer overlay system that chemically cures to provide an impervious wearing surface consisting of the following:
   1. Penetrating Crack Filler
   2. Polymer Resin
   3. Broadcast Aggregate

B. Penetrating Crack Filler
   1. Provide a penetrating crack filler as required by the Provider.

C. Polymer Resin
1. Two-part Epoxy-Urethane Co-Polymer (Type 1) that meets the requirements of Table 1.
2. Free of fillers, volatile solvents, and external/conventional flexibilizers.

Table 1

PHYSICAL PROPERTIES OF THE CURED POLYMER RESIN		
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	

D. Broadcast Aggregate
1. Thoroughly washed and kiln dried to maximum moisture content of 0.2 percent by weight according to ASTM C 566.

2. Use aggregate with the properties shown in Table 2 with aggregate gradation according to the requirements in Table 3, or use aggregate with the properties shown in Table 4 with aggregate gradation according to the requirements in Table 5.

Table 2

BASALT OR FLINT AGGREGATE PROPERTIES	
Soundness, ASTM C 88	3.0 max
LA Abrasion, Grade D, ASTM C 131	20.0% max.
Micro Deval Abrasion, ASTM D 6928	10.0% max.
Mohs Scale Hardness	7.0 min.

Table 3

BASALT OR FLINT 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
* 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.	

Table 4

CALCINED BAUXITE AGGREGATE PROPERTIES	
Soundness, ASTM C 88	3.0 max
LA Abrasion, Grade D, ASTM C 131	20.0% max.
Micro Deval Abrasion, ASTM D 6928	5.0% max.
Mohs Scale Hardness	8.0 min.
Aluminum Oxide, ASTM C 25	87.0% min.

Table 5

CALCINED BAUXITE AGGREGATE GRADATION	
Sieve Size	**Percent Passing**
0.187 inch; No.4	100
0.132 inch; No.6	95 - 100
0.046 inch; No.16*	0 - 5
* 100 percent of the aggregate has at least one mechanically fractured face for materials being retained on the #16 sieve according to ASTM D 5821.	

2.2 EQUIPMENT

A. Polymer Overlay Removal
   1. Use a diamond tipped grinder or approved method to remove an existing polymer overlay system from the deck.

B. Metered Mixing
   1. Use equipment capable of metering, mixing, and distributing the polymer resin.
      a. Use equipment that features positive displacement volumetric metering pumps controlled by a hydraulic power unit.
      b. Use motionless, in-line mixing.
   2. Use equipment that is approved by the Provider.

C. Hand Mixing
   1. Use equipment that is approved by the Provider.

D. Broadcasting Aggregate
   1. Use mechanical equipment capable of dispensing the aggregate onto the deck in a uniform manner as required by the Provider.

PART 3 EXECUTION

3.1 POLYMER OVERLAY REMOVAL

A. Remove the existing polymer overlay as shown or as required by the Engineer.
   1. Do not damage concrete deck when removing polymer overlay.

3.2 SURFACE PREPARATION

A. Surface Defects
   1. Repair deck surface defects before installing the polymer overlay system.
      a. Use a concrete repair material that meets Provider's recommendations and is compatible with the polymer overlay system being used.
      b. Use concrete repair materials free of magnesium phosphate.

B. Shot-Blasting
   1. Clean the entire concrete deck surface with steel shot blast to remove oil, dirt, rubber, and other materials that may be detrimental to the polymer overlay bonding and curing according to the Provider's recommendations.
      a. Use sandblasting equipment or mechanical grinders only in areas that cannot be reached with steel shot-blasting.
         1) Sandblast or grind before shot-blasting. Refer to ASTM D 4285.
   2. Produce a surface relief that meets the International Concrete Repair Institute (ICRI) Surface Preparation CSP 5-7.

C. Traffic
   1. Do not allow traffic on the deck that has been shot-blasted.
   2. Only allow the polymer overlay system equipment on cleaned surfaces.

3.3 APPLICATION

A. Concrete Surface
   1. Complete deck repairs and surface preparation before applying the polymer overlay system.
   2. Clean the concrete surface and apply a penetrating crack filler as required by the Provider.
   3. Do not apply the polymer overlay system when it has rained within 24 hours or is expected to rain within 8 hours of application.
   4. Verify the moisture content in the concrete substrate does not exceed 4.0 percent when measured by an electronic meter.
   5. Apply the polymer overlay system only when the deck and ambient air temperature is a minimum 50 degrees F and rising.
   6. Verify that treated surfaces are dry at the time of second application.

B. Mixing
   1. Measure and mix the polymer resin components as recommended by the Provider.
      a. Maintain mix ratios according to the Provider's recommendations.
   2. Mix polymer resin immediately before dispensing.
   3. Verify the mix ratio by volumetric sampling at the beginning of the application, mid operation, and at the end of the application of each layer.
      a. Use containers with graduated markings with not less than 5 gallon capacity.
      b. Remove the static mixer and dispense each component into separate containers.
         1) Dispense at least five gallons of the primary component for ratio comparison.
         2) Uncontaminated samples may be returned to the reservoirs they were originally dispensed from.
      c. The Engineer or Technical Support Representative may request additional sampling.

C. First and Second Layers of Overlay
   1. Evenly distribute the polymer resin on the clean, dry deck surface at the rate recommended by the Provider.
      a. Use new notched squeegees, $^{3}/_{16}$ inch minimum, on the first lift of every application to verify sufficient thickness of the overlay.

D. Overlay Thickness

1. Provide the number of layers and application rates of the liquid in each layer according to the Provider's recommendations.
2. Provide a total overlay thickness of at least 3/8 inch.

E. Time Limits for Broadcast Aggregate

1. Use the following maximum time allowed after application of liquid before broadcasting the aggregate in Table 6 unless directed otherwise by the Provider.

Table 6

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

F. Broadcasting Aggregate

1. Broadcast the aggregate before the polymer begins to gel.
   a. Cover the surface until no wet spots remain.
2. Drop the aggregate vertically so the level of the liquid is not disturbed.

G. Remove Excess Aggregate

1. Completely remove excess and loose aggregate after the overlay has hardened by vacuum or with compressed air before applying subsequent layers according to the Providers recommendations. Refer to ASTM D 4285.
2. Aggregate may be reused for subsequent lifts if it is removed directly into containers, screened to required gradation, and stored free of contaminants.

H. Longitudinal Joints in the Overlay

1. Stagger and overlap joints between successive layers 6 to 12 inches so that no ridges appear between two adjacent lanes.
2. Maintain straight construction joints between adjacent placements and lifts.

I. Traffic

1. Do not allow vehicles on the polymer 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 Provider, and after removal of excess and loose aggregate.
   a. Brush blast the surface with shot blast according to the Provider's recommendations before applying additional layers when traffic has been allowed on the cured surface between layers.

J. Work performed contrary to the Technical Support Representatives instructions will be deemed nonconforming.

3.4 LIMITATIONS

A. New Bridge Decks and Approach Slabs
   1. Cure newly placed concrete for at least 28 calendar days before beginning installation of polymer overlay system.

B. Bridges constructed offline and moved into their final location by self-propelled modular transporters (SPMT)
   1. Apply the polymer overlay system no sooner than 30 calendar days after setting the bridge in its final location.

C. Prevent material and debris from falling into streams, pedestrian areas, live traffic, or railroad tracks.

3.5 POLYMER OVERLAY REPAIR

A. Locate and mark visible polymer overlay repair areas as shown and in the presence of the Engineer.
   1. Sound the polymer overlay around repair area for delamination of the polymer overlay to determine repair limits.
   2. Square off the edges of polymer overlay system repair area six inches beyond the determined limits and parallel to the travel lane.
   3. Saw cut the perimeter of polymer overlay system repair area with a ½ inch deep saw cut.

B. Remove existing polymer overlay within the repair area according to this Section, Article 3.1.
   1. Sound the concrete deck in the repair area for delamination of the concrete deck to determine the need for structural pothole patching. Refer to ASTM D 4580.

C. Prepare the deck surface within the repair area according to this Section, Article 3.2.
   1. Do not substitute sandblasting or mechanical grinding where shot blasting is required.

D. Apply the polymer overlay system within the repair area according to this Section.

END OF SECTION

APPENDIX C. MATERIAL SUBMITTALS AND PRODUCT DATASHEETS FOR HFSTS USED BY MDT

This appendix contains the following: (1) the special provisions related to deck repair and overlay operations for Contract No. JCC16, under which many of the Missoula District bridges were overlaid; (2) the project submittals from L & J Construction Group, LLC for Project JOC STPB STWD (477) in which many of the Missoula District bridges were overlaid; and (3) the submitted datasheet and supporting info for the Armorstone aggregates used on the bridges in the Billings District. The project submittal for the Missoula District bridge overlays includes the technical datasheets, material safety datasheets, and supporting laboratory test reports for all of the products used in the project, i.e., the primer Pro Poxy 45, the resin binder for the overlays Pro-Poxy Type III DOT, the epoxy repair mortar kit Sure Patch, the calcined bauxite aggregates from the Lake Ranch pit, and the expansion joint sealant MasterSeal SL 1.

21. NOTICE TO BIDDERS [108] (ADDED 11-21-08)

This project is funded in whole or in part by funds received from the Federal Highway Administration (FHWA), and its construction is wholly contingent on the state's continued receipt of those federal funds. If the federal funds are reduced or not received, the Department may choose to terminate the contract for convenience under the provisions of Subsection 108.10. Any bidder on this project, by submitting its bid, understands and accepts the possibility of the contract being terminated in the event federal funds are reduced or not available and by submitting a bid, each bidder waives any claims for costs or damages other than as specifically allowed by Subsection 108.10.2. In particular, bidders understand and accept that no payment will be allowed for any claimed anticipated profit for work not performed.

22. TRAFFIC CONTROL AND SEQUENCE OF OPERATIONS

A. General. Coordinate and conduct bridge work to minimize inconvenience to the traveling public. Accomplish traffic control in accordance with the plans, these special provisions, standard specifications, Detailed Drawings, and the Manual on Uniform Traffic Control Devices (MUTCD) in addition to the following:

B. Sequence of Operations.

1) Submit a proposed Traffic Control Plan fitting the geometries of each location according to 618.03.2. Traffic control devices must be removed immediately and normal traffic flow restored upon completion of work and completion of required material cure times at each bridge.

2) Interstate and one-way multi-lane structures. Maintain at least one lane of traffic in each direction through the work zone at all times.

3) Structures with two-way traffic. Do not detour traffic without written approval from the Project Manager. Maintain traffic through the work zone in both directions using temporary traffic signals or flaggers to alternate traffic across the structure.

C. Method of Measurement.

1) Traffic control for will be measured according to 618.05.1 Traffic Control Devices-Units.

2) Temporary Barrier Rail and Temporary Impact Attenuator. If barrier rail and temporary impact attenuator is required as part of the traffic control set up on a bridge, that Temporary Barrier Rail and Temporary Impact Attenuator will be measured and paid for separately.

D. Basis of Payment. The unit price paid for Temporary Barrier Rail will be $300.00 per each and will provide full compensation for all costs to install, maintain, and remove Temporary Barrier Rail. The unit price for and Temporary Impact Attenuator will be $3,000.00 per each and will provide full compensation for all costs to install, maintain, and remove Temporary Impact Attenuator. All other traffic control will be paid for under the unit price bid item Traffic Control Devices (Units). Payment for the completed and accepted quantities is made under the following pay items:

Pay Item	Pay Unit
Traffic Control Devices	Units
Temporary Barrier Rail	Each
Temporary Impact Attenuator	Each

23. POLYMER OVERLAY

A. Description. This work is the preparation of concrete deck surfaces and concrete approach slabs, application of a polymer overlay primer to the bridge deck and concrete approach slabs, and the furnishing and applying two layers of a two-component polymer overlay system to the bridge deck and concrete approach slabs.

B. Materials. Furnish materials specifically designed for use on concrete bridge decks.

1) Polymer Overlay Primer. Furnish a primer compatible with the polymer overlay that is 100% solids, 100% reactive with the following properties:

Property	Requirements	Test Method
Viscosity [A]	<225 cps	ASTM D2393, Brookfield RVT, Spindle No. 3, 20 rpm
Tensile Elongation [B]	> 30%	ASTM D638
Tensile Strength [B]	>2000 psi @ 7 days	ASTM D638

[A] Uncured, mixed primer
[B] Cured, mixed primer

2) Polymer Resin for Polymer Overlay. Use a polymer resin base and hardener composed of a two-component, 100% solids, 100% reactive, thermosetting compound with the following properties:

Property	Requirements	Test Method
Gel Time [A]	10 - 45 minutes @ 73° to 75° F	ASTM C881
Viscosity [A]	7 - 70 poises	ASTM D2393, Brookfield RVT, Spindle No. 3, 20 rpm
Absorption [B]	1% maximum at 24 hr	ASTM D570
Tensile Elongation [B]	30% - 70% @ 7 days	ASTM D638
Tensile Strength [B]	>2000 psi @ 7 days	ASTM D638
Chloride Permeability [B]	<100 coulombs @ 28 days	AASHTO T277

[A] Uncured, mixed polymer binder
[B] Cured, mixed polymer binder

3) Aggregates. Furnish natural or synthetic aggregates which have a proven record of performance in applications of this type. Furnish aggregates that are non-polishing, clean, free of surface moisture, fractured or angular in shape; free from silt, clay, asphalt, or other organic materials; and meet the following properties and gradation requirements:

Aggregate Properties:

Property	Requirement	Test Method
Moisture Content [A]	≤ 0.20%	AASHTO T255
Hardness	≥ 6.5	Mohs Scale
Fine Aggregate Angularity	45% Minimum	AASHTO T304 Method A
Absorption	≤ 1%	AASHTO T84
Aggregate Gradation[B]	100% passing No. 4 15-25% passing No. 8 0-5% passing No. 16 0-1% passing No. 30	MT 202

[A] Sampled and tested at the time of placement.

[B] Or recommended gradation per manufacturer of polymer resin and approved by the Project Manager.

4) Required Properties of the Overlay System.

Property	Requirement [A]	Test Method
Minimum Compressive Strength (psi)	1,000 psi @ 8 hrs 5,000 psi @ 24 hrs	ASTM C 579 Method B, Modified [B]
Thermal Compatibility	No Delaminations	ASTM C 884
Minimum Pull-off Strength	250 psi @ 24 hrs	ACI 503R, Appendix A

[A] Based on samples cured or aged and tested at 75°F

[B] Plastic inserts that will provide 2-inch by 2-inch cubes shall be placed in the oversized brass molds.

C. Construction Requirements.

1) Manufacturer's Representative. Provide a manufacturer's representative on site for the duration of the work, to provide expert assistance on compatibility of materials, storage, mixing, surface preparation, application, clean-up and disposal of materials.

2) Material Delivery and Storage. Store resin materials in their original containers in a dry area. Store and handle materials according to the manufacturer's recommendations. Store all aggregates in a dry environment and protect aggregates from contaminants on the job site.

3) Pre-installation Conference. Conduct a pre-installation conference with the manufacturer's representative prior to construction to establish procedures for maintaining optimum working conditions and coordination of work. Furnish the Project Manager a copy of the recommended procedures and apply the overlay system according to the manufacturer's instructions. Ensure the manufacturer's representative familiar with the overlay system installation procedures is present at all times during surface preparation and overlay placement to provide quality assurance that the work is being performed properly.

4) Sequence of Operations. Use the following sequence of operations when a Polymer Overlay is required:

a) Deck Repair.

b) Surface Preparation

c) Polymer Overlay Primer

d) Polymer Overlay

5) Material Compatibility. Ensure products used for the Deck Repair, Polymer Overlay Primer, and Polymer Overlay are all compatible with each other.

6) Deck Repair. Perform Class A and B deck repair work as specified elsewhere in the contract. Use products for deck repair which are compatible with the polymer overlay primer and polymer overlay system. Follow all manufacturer published recommendations, including recommended substrate cure times.

7) Surface Preparation. Determine an acceptable shotblasting machine operation (size of shot, flow of shot, forward speed, and/or number of passes) that provides a surface profile meeting CSP 5 according to the International Concrete Repair Institute Technical Guideline No. 03732. If the Project Manager requires additional verification of the surface preparation, test the tensile bond strength according to ACI 503R, Appendix A of the ACI *Manual of Concrete Practice*. The surface preparation will be considered acceptable if the tensile bond strength is greater than or equal to 250 psi or the failure area at a depth of ¼ inches or more is greater than 50% of the test area. Continue adjustment of the shotblasting

machine and necessary testing until the surface is acceptable to the Project Manager or a passing test result is obtained.

Prepare the entire deck using the final accepted adjustments to the shotblasting machine as determined above. Thoroughly blast-clean with hand-held equipment any areas inaccessible by the shotblasting equipment. Do not perform surface preparation more than 24 hours prior to the application of the overlay system.

Prepare the vertical concrete surfaces adjacent to the deck a minimum of 2” above the overlay according to SSPC-SP 13 by sand blasting, using wire wheels, or other approved method.

Just prior to polymer overlay primer placement, clean all dust, debris, and concrete fines from the prepared surfaces including the vertical surfaces with compressed air. When using compressed air, the air stream must be free of oil. Completely remove any grease, oil, or other foreign matter that rests on or has absorbed into the concrete. If any prepared surfaces (including the polymer overlay primer or the first layer of the polymer overlay) are exposed to rain or dew, lightly sandblast (breeze blast) the exposed surfaces.

Protect drains, expansion joints, access hatches, or other appurtenances on the deck from damage by the shot and sand blasting operations and from materials adhering and entering. Tape or form all construction joints to provide a clean straight edge.

Create a transition area adjacent to the ends of the deck and any transverse expansion joints using a grinder or other approved method. Remove 0.375-inches of concrete adjacent to the joint or end of deck and taper a distance of 3 feet.

The Project Manager may consider alternate surface preparation methods per the overlay system manufacturer’s recommendations. Do not place the polymer overlay primer or polymer overlay prior to Project Manager approval of the final surface profile and deck cleanliness.

8) Polymer Overlay Primer. Place polymer overlay primer in accordance with Section 552.03.19 of the Standard Specifications, except that the sand requirement is rescinded.

9) Overlay Application. Perform the handling and mixing of the polymer resin and hardening agent in a safe manner to achieve the desired results according to the manufacturer’s instructions. Do not apply the overlay system if any of the following conditions exist:

a) Ambient air temperature is below 50°F;

b) Deck temperature is below 50°F;

c) Moisture content in the deck exceeds 4.5% when measured by an electronic moisture meter or shows visible moisture after 2 hours when measured in accordance with ASTM D4263;

d) Rain is forecast during the minimum curing periods listed under C.5 ;

e) Material component temperatures are below 50°F or above 99°F;

f) Class B repair material concrete age is less than 28 days, unless approved by the Project Manager.

g) The deck temperature exceeds 100°F.

h) The polymer gel time is less than 10 minutes at the predicted high air temperature for the day.

After the deck has been shotblasted and during the polymer overlay primer and overlay curing periods, only necessary surface preparation and overlay application equipment will be allowed on the deck. Begin the polymer overlay primer placement as soon as possible after surface preparation operations, followed by the polymer overlay placement as soon as possible after placement of the polymer overlay primer placement. A wet on wet application of the polymer overlay primer and polymer overlay is allowed.

Use a polymer overlay consisting of a two course application of polymer and aggregate, consisting of a layer of polymer covered with a layer of aggregate in sufficient quantity to completely cover the polymer. Apply the polymer and aggregate according to the manufacturer's requirements. Apply the overlay using equipment designed for this purpose. Use an application machine that features positive displacement volumetric metering and is capable of storing and mixing the polymer resins at the proper mix ratio. Disperse the aggregate using a standard chip spreader or equivalent machine that can provide a uniform, consistent coverage of aggregate. If the Project manager determines that the course application does not receive enough aggregate before the polymer gels, remove and replace the course.

After completion of the course, cure the overlay according to the manufacturer's instructions. Remove the excess aggregate from the surface treatment by sweeping, blowing, or vacuuming without tearing or damaging the surface; the material may be re-used if approved by the Project Manager and manufacturer. Do not allow traffic on the treated area until directed by the Project Manager.

Prior to opening to traffic, clean expansion joints and joint seals of all debris and polymer. If required by the Project Manager, a minimum of 3 days following opening to traffic, remove loosened aggregates from the deck, expansion joints, and approach pavement.

10) Application Rates. Apply the polymer overlay in accordance with the manufacturer's instructions, but not less than the following rate of application:

Course	Minimum Polymer Application Rate (GAL/100 SF)	Aggregate [A] (LBS/SY)
1	2.5	10+
2	5.0	14+

[A] Apply aggregate in sufficient quantity to completely cover the polymer.

11) Minimum Curing Period. Satisfy the minimum curing period specified by the polymer manufacturer for each course.

12) Repair of Polymer Overlay. Repair all areas of unbonded, uncured, or damaged polymer overlay at no cost to the State. Submit repair procedures from the manufacturer to the Project Manager for approval. Absent a manufacturer's repair procedures and with the approval of the Project Manager, complete repairs according to the following: Saw cut the limits of the area to the top of the concrete; remove the overlay by scarifying, grinding, or other approved methods; shot blast or sand blast and air blast the concrete prior to placement of polymer overlay; place the polymer overlay according to the application procedures required in this special provision.

D. Submittals. Submit two copies of the following to the Project Manager. Do not begin work prior to receiving approval from the Project Manager.

1) Product data sheets and specifications from the manufacturer, and a certified test report. The Project Manager may request samples of the primer, polymer, and aggregate prior to application, for the purpose of acceptance testing by the department. Product data sheets and specifications from the manufacturer consists of literature from the manufacturer showing general instructions, application recommendations/methods, product properties, general instructions, or any other applicable information.

2) Product history/reference projects and a certified test report from an independent testing laboratory showing compliance with the requirements of the specification. The product history/reference projects consist of a minimum of 5 bridges / locations where the proposed overlay system has been applied in Montana or other locations with a similar climate. Include contact names for the facility owner, current phone number or e-mail address, and a brief description of the project.

E. Method of Measurement. Deck repair is measured and paid for as described in the BRIDGE DECK REPAIR special provision. Deck surface preparation is measured by square yard of deck surface area treated. Bridge Polymer Overlay Primer is measured by the square yard of deck surface area. Polymer Overlay is measured by square yard of deck surface area treated.

F. Basis of Payment. Payment for the completed and accepted quantities is made under the following:

Pay Item	Pay Unit
Prepare Deck	Square Yard
Polymer Overlay	Square Yard
Polymer Overlay Primer	Square Yard

24. BRIDGE DECK REPAIR

A. Description. Repair areas of unsound concrete in accordance with section 562 of the Standard Specifications, the requirements of these specifications and prepare the deck to receive an overlay. Areas of repair will be marked and classified by the Project Manager as Class A or Class B.

B. Class A Repair.

1) The Project Manager will designate and mark areas of Class A repair if present. Remove existing deck concrete as deeply as necessary, while stopping short of the top of the bottom mat of reinforcing steel. Dispose of removed concrete and replace it with new polymer concrete to the level of the existing deck surface.

2) Class A Materials. Provide a Class A polymer repair material that is immediately compatible with the required polymer overlay primer and polymer overlay and requires minimal wait between curing of the Class A polymer material and installing the polymer overlay primer and polymer overlay material. Compatibility will be determined by the polymer overlay manufacturer's representative and the Project Manager.

a) All new polymer concrete placed in these repair areas must come in a pre-packaged kit that includes all materials for the product.

b) Provide a polymer concrete that, after completion of mixing, provides a minimum manufacturer specified working time of 10 minutes at 80 degrees Fahrenheit.

c) Do not install the product below the manufacturer specified temperature, or 40 degrees Fahrenheit, whichever is higher.

d) Use a polymer concrete designed to have a compressive strength of at least 3,000 psi at 24 hours.

e) Submit two copies of the product documentation for the polymer concrete being used to the Project Manager at least 14 calendar days prior to starting the work. Include the following information in the submittal:

(1) Product Specifications
(2) Material safety data sheet
(3) Manufacturer's recommended application procedure
(4) Contractor's work plan for placing the polymer concrete.

Do not place the polymer concrete until written authorization is received from the project manager.

C. Class B Repair

1) The Project manager will designate and mark areas for Class B repair if present. Remove existing concrete full depth through the slab and repair in accordance with section 562 of the Standard Specifications and these provisions. Dispose of removed concrete, set form work, and replace the removed concrete volume with new Class Structure Concrete to the level of the existing concrete deck surface.

2) Placing, Finishing, and Curing Concrete

a) For Class B repair, place new Class Structure Concrete in repaired areas to the existing concrete deck surface. Cover the repaired surface with a single layer of clean, wet burlap immediately after completion of concrete placement. Place a polyethylene film at least

0.004 inch thick over the burlap, as the beginning of the wet cure. The Project Manager will allow up to a maximum of one hour between placement of the burlap and the polyethylene, provided the burlap remains wet. Otherwise, place the polyethylene immediately. Maintain the wet cure for 14 days. Add water to the burlap as necessary to maintain in a wet condition. If an overlay is specified, wait a minimum of 28 days after the Class B repair concrete placement before placing the Polymer Overlay Primer and Polymer Overlay in accordance with the POLYMER OVERLAY specification.

b) If a polymer overlay is specified, do not broom finish or transverse grove the repair area. If no polymer overlay is specified, provide a broom finish.

3) Class B Materials. Use class Structure Concrete for all Class B repairs. Do not submit requests to use alternate rapid setting material.

D. Method of Measurement and Basis of Payment

1) Class A Repair. The Project Manager will measure Class A repair areas for payment before the work of filling them with new polymer concrete takes place. The Job Orders will estimate the quantity of Class A, but final quantity will be determined by the Project Manager, subject to the guaranteed minimum paid for quantities. The estimates may vary significantly from final measured areas. The unit price bid for Class A Bridge Deck Repair will provide full compensation for furnishing all tools, labor, equipment and materials, including Polymer Concrete.

2) Class B Repair. The Project Manager will measure Class B repair areas for payment before the work of filling them with new Class Structure concrete takes place. The Job Orders will estimate the quantity of Class B, but final quantity will be determined by the Project Manager. The estimates may vary significantly from final measured areas. The unit price paid for Class B Bridge Deck Repair will be $900.00 per square yard and will provide full compensation for furnishing all tools, labor, equipment and materials, including Class Structure Concrete.

25. JOINT SEALS - POLYURETHANE

A. Description. This work is furnishing and installation of a polyurethane joint system in the gap between bridge ends and concrete approach slabs (or concrete pavement) and other specified locations. Do not install a polyurethane joint system at bridge ends adjacent to asphalt pavement.

B. Materials.

1) Polyurethane Sealant. Use a one-component, self-leveling, polyurethane-based material in conjunction with a closed cell expanded polyethylene backer rod. Do not use asphalt-based or silicone sealants. Use a polyurethane-based joint sealant that accommodates movements of +/- 25% of joint opening size.

2) Furnish a joint system that functions properly between -40°F to 113°F.

C. Construction Requirements.

1) Submit two copies of the product documentation for the joint system being used to the Project Manager at least fourteen calendar days prior to starting the work. Include the following information in the submittal:

a) Product specifications

b) Material safety data sheet

c) Manufacturer's recommended application procedure

d) Contractor's work plan for installing the joint system

Do not install the joint system until written authorization is received from the Project Manager.

2) Install the joint system after completing any necessary concrete repair work along the joint opening (Class A or Class B repairs).

3) Remove any existing sealant material and clean out all dirt and debris in the gap.

Construction Group, LLC
Bridge preservation specialists

2/9/17

To: **Montana Department of Transportation**

Project: **JOC STPB STWD (477)**

RE: **Submittals for Bridge Work**

Special Provision 23 - Polymer Overlay

1) Primer
2) Polymer Overlay
3) Aggregates

Special Provision 24 – Bridge Deck Repair
Dayton Superior Surepatch

Special Provision 25 – Joint Seals – Polyurethane
MasterSeal SL-1

If you have any questions, please call Kevin at 581-7217

Thank You

Kevin Helling CE

PO Box 396, Ennis, Montana 59729 P.(406)599-7776 F.(406)682-3010
l-n-j@3rivers.net ◦ www.landjconstructiongroup.com

TECHNICAL DATA SHEET

DESCRIPTION

Pro-Poxy™ 45 is a 100% solids, low modulus, highly penetrating, epoxy polymer. Pro-Poxy™ 45, when applied to cracked concrete bridge decks and elevated slabs, seals the cracks against the intrusion of chlorides and moisture, protecting the concrete from degradation and the corrosion of steel reinforcements. Pro-Poxy™ 45 can also be used as a primer for Pro Poxy Type III DOT overlay systems.

USE

Sealing cracks in concrete bridge decks and parking deck slabs. Protection and sealing of concrete in splash zone areas. Sealing and protection of interior concrete slabs. Can be used as a primer for Pro Poxy Type III DOT overlay systems.

FEATURES

- Can be used as a primer for epoxy overlaysaa
- V.O.C. Compliantaa
- Low Modulusaa
- Moisture tolerantaa
- Low viscosity for deep penetrationaa

PROPERTIES

Gel Time (60 g mass): ASTM D2472
14-20 min at 73° ± 2°F (23°C)
Viscosity: ASTM D2393
approximately 200 cps (RV3 @ 20 rpm)
Tensile Elongation: ASTM D638, > 30%
Tensile Strength: ASTM D638, 2,500 psi (10.34 MPa)
Compressive Strength: ASTM D 695, >5500 psi at 7 days
Adhesive to Concrete: ASTM C 1583
100% failure in concrete
Shore D Hardness: ASTM D2240, 73
Mix ratio – 2:1, Part A to Part B by volume

VOC

Pro-Poxy™ 45 has a VOC content of 0 g/L.
Compliant with all Canadian and US VOC regulations including Federal EPA, OTC, LADCO, SCAQMD & CARB.

Estimating Guide

Broom Finish
65-100 sq. ft. /gallon (6.0-9.3 sq m/L)
Steel Troweled
150-200 sq. ft. / gallon (13.9-18.6 sq m/L)
As a Primer
200-300 sq. ft / gallon (18.6 sq m/L-27.9 sq m/L)aa

*Texture and absorption of surface will determine final coverage rates. Porous concrete surfaces may require additional material.

Packaging

PRODUCT CODE	PACKAGE	SIZE	
		Gallons	Liters
145436	Unit	165	624.60
145437	Unit	15	56.78
145465	Unit	750	2839

STORAGE

The material should be stored at 40°- 95°F (5°-35°C). Shelf life of properly stored, unopened containers is 24 months

APPLICATION

Placement Healer/Sealer: Apply by pouring Pro-Poxy™ 45 on to the deck surface. Distribute the material evenly with a squeegee or a broom by maintaining a liquid head over the cracks during distribution. Continue the application over the cracks until refusal. Remove all excess (ponded) material with a squeegee, or a broom. While still wet, broadcast oven-dried silica sand at a rate to allow even coverage and provide proper skid resistance. Minimum application temperature 50°F (10°C).

Placement as a Primer: Apply by pouring the mixed Pro-Poxy™ 45 on to the deck surface. Distribute the material evenly with a squeegee, broom or roller. Remove all excess (ponded) material with a squeegee, or a broom. Immediately apply overlay system while the Pro-Poxy™ 45 is still wet. Minimum application temperature 50°F (10°C).

Surface Preparation:

Clean surface by shotblasting or sandblasting in order to create a CSP of 3-4 according to ICRI GUIDELINE NO. 03732.

Remove any pervious coatings, curing compounds, sealers and all contaminants (dirt, oil, grease, laitance, etc.). Remove dust and debris by blowing off with oil-free compressed air.

Mixing:

Condition material to 65â- 85°F (18°- 29°C) before using. Premix each component separately, then mix two parts by volume of Part A with one part by volume of Part B with a Jiffy mixer and low-speed drill at 300 rpm for a minimum of three minutes, moving mixer around edges of container to ensure complete mix. Mix only the quantity that can be used within its gel time.

CLEAN UP

Uncured material can be removed with the Unitex Citrus Cleaner or other approved solvent. Cured material can only be removed mechanically.

Sec

LIMITATIONS

Minimum age of concrete must be 28 days or less than 4% moisture when tested with a moisture pin meter before applying product.
Material is a vapor barrier after curing.
Not for exterior slabs on grade.
Do not thin. Solvents will prevent proper cure.

PRECAUTIONS

READ SDS PRIOR TO USING PRODUCT

- Minimum age of concrete must be 28 days or less than 4% moisture when tested with a moisture pin meter before applying product.
- Material is a vapor barrier after curing. Not for exterior slabs on grade.
- Do not thin. Solvents will prevent proper cure.

MANUFACTURER

Dayton Superior Corporation
1125 Byers Road
Miamisburg, OH 45342
Customer Service: 888-977-9600
Technical Services: 877-266-7732
Website: www.daytonsuperior.com

WARRANTY

Dayton Superior Corporation ("Dayton") warrants for 12 months from the date of manufacture or for the duration of the published product shelf life, whichever is less, that at the time of shipment by Dayton, the product is free of manufacturing defects and conforms to Dayton's product properties in force on the date of acceptance by Dayton of the order. Dayton shall only be liable under this warranty if the product has been applied, used, and stored in accordance with Dayton's instructions, especially surface preparation and installation, in force on the date of acceptance by Dayton of the order. The purchaser must examine the product when received and promptly notify Dayton in writing of any non-conformity before the product is used and no later than 30 days after such non-conformity is first discovered. If Dayton, in its sole discretion, determines that the product breached the above warranty, it will, in its sole discretion, replace the non-conforming product, refund the purchase price or issue a credit in the amount of the purchase price. This is the sole and exclusive remedy for breach of this warranty. Only a Dayton officer is authorized to modify this warranty. The information in this data sheet supersedes all other sales information received by the customer during the sales process. THE FOREGOING WARRANTY SHALL BE EXCLUSIVE AND IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND ALL OTHER WARRANTIES OTHERWISE ARISING BY OPERATION OF LAW, COURSE OF DEALING, CUSTOM, TRADE OR OTHERWISE.

Sec

Dayton shall not be liable in contract or in tort (including, without limitation, negligence, strict liability or otherwise) for loss of sales, revenues or profits; cost of capital or funds; business interruption or cost of downtime, loss of use, damage to or loss of use of other property (real or personal); failure to realize expected savings; frustration of economic or business expectations; claims by third parties (other than for bodily injury), or economic losses of any kind; or for any special, incidental, indirect, consequential, punitive or exemplary damages arising in any way out of the performance of, or failure to perform, its obligations under any contract for sale of product, even if Dayton could foresee or has been advised of the possibility of such damages. The Parties expressly agree that these limitations on damages are allocations of risk constituting, in part, the consideration for this contract, and also that such limitations shall survive the determination of any court of competent jurisdiction that any remedy provided in these terms or available at law fails of its essential purpose.

TECHNICAL DATA SHEET

DESCRIPTION

Pro-Poxy™ Type III D.O.T. is a 100% solids, low modulus, moisture tolerant, low viscosity epoxy/urethane binder and adhesive meeting the requirements of ASTM C-881, Type III, Grade I, Classes B & C.

USE

Pro-Poxy™ Type III D.O.T. Is used primary for bonding skid-resistant overlays and high friction surfaces to bridges and elevated slabs and as a low modulus binder for epoxy mortars where thermal change is a consideration. Material can also be used to seal interior and exterior above grade slabs and as a low modulus crack filler

ADVANTAGES

- Low modulus, high strength adhesive meeting ASTM C-881 Type III Requirements
- Moisture tolerant
- Can be used as a High Friction Surface
- V.O.C. compliant
- Shock absorbing ability
- Easy blending of aggregates for mortar repairs

PROPERTIES

Meets Specification: ASTM C-881, Type III, Grade 1, Classes B & C
Mix ratio – 1:1, by volume
Gel time – ASTM D-2393, 60 gm sample @ 73°F (23°C): 15 min.
Color (mixed) - Gray
Viscosity – 1,500 cps
Final Cure-7 days
Compressive Modulus – ASTM D-695: 80,000 psi (551.6 MPa)
Bond Strength – ASTM C-882: 14 days 3,200 psi (22.1 MPa)
Tensile Strength - ASTM D-638: 3000 psi (20.7 MPa)
Elongation at Break – ASTM D-638: 50.0%
Water Absorption – ASTM D-570: 0.20%
Thermal Compatibility – Passes Test
AASHTO T-222 Chloride Ion Permeability 0.9 Coulombs

VOC

Pro-Poxy™ Type III D.O.T. has a VOC content of 0 g/L. Compliant with all US VOC regulations including Federal EPA, OTC, LADCO, SCAQMD & CARB.

ESTIMATING GUIDE

Broadcast Overlays:

Course #1: Epoxy rate: 40 ft²/gal. (1 L/m²);Aggregate rate: 1-1.5 lb/ft², (4.88-7.32 kg/m²).
Course #2: Epoxy rate: 20 ft²/gal. (2 L/m²); Aggregate rate: 1-1.5 lb/ft², (4.88-7.32 kg/m²).

HIGH FRICTION SURFACE APPLICATION

Course #2: Epoxy rate: 20 ft²/gal. (2 L/m²); Aggregate rate: 1-1.5 lb/ft², (4.88-7.32 kg/m²).

Coverage rates may very based upon, texture of the concrete, tinning, milling and broom finishes.

Epoxy Mortar: 2 gal/ (7.6 L) epoxy mixed with 10 gal. (37.8 L) of dry sand yields approximately 0.94ft³

PACKAGING

Item #	PackagE	Size Gallons (Liters)	
140302	Unit	1	(3.79)
140304	Unit	2	(7.57)
140313	Unit	10	(37.85)
140324	Unit	110	(416.40)

STORAGE

The material should be stored between 40°-95°F (5°-35°C). Shelf life of properly stored, unopened containers is 24 months

APPLICATION

Surface Preparation: Surface to be bonded must be clean and sound. Remove oil, dirt, grease, laitance, curing compounds and other foreign matter that may cause a problem with bond. Abrasive blast cleaning and mechanical removal methods are recommended. Remove all standing water and dust with clean, oil free, compressed air prior to installation.

Mixing: Condition material to 65°-85°F (18°-29°C) for ease of mixing and optimum flow prior to using. Premix each component then place 1 part by volume of Component A and 1 part by volume of component B into a clean pail and mix for three minutes with a low speed drill using a Jiffy mixer or paddle until uniformly blended. Mix only what can be used within the pot life

(10°C)

Do not thin with any solvents.

Epoxies may yellow, discolor, or chalk upon exposure to strong sources of Ultra-Violet radiation such as from sunlight, and some types of industrial artificial lighting.

Note: High temperatures will accelerate the setting time. As a general rule, the gel time of the epoxy will be cut in half for each 10° to 15° increase in temperature above 75°F (24°C).

PRECAUTIONS
READ MSDS PRIOR TO USING PRODUCT

- Component A – Irritant
- Component B – Corrosive
- Product is a strong sensitizer
- Use with adequate ventilation
- Wear protective clothing, gloves and eye protection (Goggles, Safety Glasses and/or Face Shield)
- Keep out of the reach of children
- Do not take internally
- In case of ingestion, seek medical help immediately
- May cause skin irritation upon contact, especially prolonged or repeated. If skin contact occurs, wash immediately with soap and water and seek medical help as needed
- If eye contact occurs, flush immediately with clean water and seek medical help as needed
- Dispose of waste material in accordance with federal, state and local requirements
- Cured Epoxy Resins Are Innocuous

MANUFACTURER

Dayton Superior Corporation
1125 Byers Road
Miamisburg, OH 45342
Customer Service: 888-977-9600
Technical Services: 866-329-8724
Website: www.daytonsuperior.com

WARRANTY

Dayton Superior Corporation ("Dayton") warrants for 12 months from the date of manufacture or for the duration of the published product shelf life, whichever is less, that at the time of shipment by Dayton, the product is free of manufacturing defects and conforms to Dayton's product properties in force on the date of acceptance by Dayton of the order. Dayton shall only be liable under this warranty if the product has been applied, used, and stored in accordance with Dayton's instructions, especially surface preparation and installation, in force on the date of acceptance by Dayton of the order. The purchaser must examine the product when received and promptly notify Dayton in writing of any non-conformity before the product is used and no later than 30 days after such non-conformity is first discovered. If Dayton, in its sole discretion, determines that the product breached the above warranty, it will, in its sole discretion, replace the non-conforming product, refund the purchase price or issue a credit in the amount of the purchase price. This is the sole and exclusive remedy for breach of this warranty. Only a Dayton officer is authorized to modify this warranty. The information in this data sheet supersedes all other sales information received by the customer during the sales process. THE FOREGOING WARRANTY SHALL BE EXCLUSIVE AND IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND ALL OTHER WARRANTIES OTHERWISE ARISING BY OPERATION OF LAW, COURSE OF DEALING, CUSTOM, TRADE OR OTHERWISE.

Dayton shall not be liable in contract or in tort (including, without limitation, negligence, strict liability or otherwise) for loss of sales, revenues or profits; cost of capital or funds; business interruption or cost of downtime, loss of use, damage to or loss of use of other property (real or personal); failure to realize expected savings; frustration of economic or business expectations; claims by third parties (other than for bodily injury), or economic losses of any kind; or for any special, incidental, indirect, consequential, punitive or exemplary damages arising in any way out of the performance of, or failure to perform, its obligations under any contract for sale of product, even if Dayton could foresee or has been advised of the possibility of such damages. The Parties expressly agree that these limitations on damages are allocations of risk constituting, in part, the consideration for this contract, and also that such limitations shall survive the determination of any court of competent jurisdiction that any remedy provided in these terms or available at law fails of its essential purpose.

Material Safety Data Sheet
acc. to ISO/DIS 11014

1 Identification of substance

· ***Product details***

· ***Trade name:*** ***Pro-Poxy™ Type III DOT - Part A***

· ***Article number:*** *87-140302A*
· ***Application of the substance / the preparation***

· ***Manufacturer/Supplier:***
Unitex®
3101 Gardner
Kansas city, MO 64120
Tel: (800) 821-5846
Fax: (816) 483-3149

Emergency Telephone Number: Use only in the event of an emergency involving a spill, leak, fire, exposure, or accident involving chemicals. Within the U.S., Canada, or the U.S. Virgin Islands, call ChemTrec at (800) 424-9300, 24 hours a day. Or, outside these areas, call (703) 527-3887. Collect calls are accepted.

· ***Information department:*** *Environmental, Health, and Safety department.*

2 Composition/Data on components

· ***Chemical characterization:***
· ***CAS No. Description***
25068-38-6 reaction product: bisphenol-A-(epichlorhydrin) epoxy resin
(number average molecular weight = 700)
· ***Identification number(s)*** *Not applicable*
· ***EINECS Number:*** *500-033-5*
· ***EU Number:*** *603-074-00-8*

3 Hazards identification

· ***Hazard description:*** *May cause eye and skin irritation. Prolonged contact may cause sensitization.*
· ***Information pertaining to particular dangers for man and environment:*** *Not applicable.*
· ***Classification system:***
· ***NFPA ratings (scale 0 - 4)***

Health = 1
Fire = 1
Reactivity = 0

· ***HMIS-ratings (scale 0 - 4)***

Health = 1
Fire = 1
Reactivity = 0

4 First aid measures

· ***After inhalation:***
Supply fresh air and to be sure call for a doctor.
In case of unconsciousness place patient stably in side position for transportation.
· ***After skin contact:***
Immediately wash with water and soap and rinse thoroughly.
If skin irritation continues, consult a doctor.
· ***After eye contact:*** *Rinse opened eye for several minutes under running water.*

(Contd. on page 2)

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/18/2012 *Reviewed on 10/18/2012*

Trade name: Pro-Poxy™ Type III DOT - Part A

(Contd. of page 2)

· ***Eye protection:*** *Wear appropriate eye protection to prevent eye contact.*

9 Physical and chemical properties

· ***General Information***

Form:	*Liquid*
Color:	*Clear to Light Amber*
Odor:	*Mild*
· ***Change in condition***	
Melting point/Melting range:	*Undetermined.*
Boiling point/Boiling range:	*Undetermined.*
· ***Flash point:***	*> 94°C (> 201°F)*
· ***Danger of explosion:***	*Product does not present an explosion hazard.*
· ***Density:***	*Not determined.*
· ***Solubility in / Miscibility with***	
Water:	*Not miscible or difficult to mix.*
Organic solvents:	*0.0 %*
· ***Solids content:***	*100.0 %*
· ***Volatile Organic Compounds:***	*Not determined*

10 Stability and reactivity

· ***Thermal decomposition / conditions to be avoided:*** *No decomposition if used according to specifications.*
· ***Dangerous reactions*** *Reacts with acids, alkalis and oxidizing agents.*
· ***Dangerous products of decomposition:***
Carbon monoxide and carbon dioxide
Nitrogen oxides

11 Toxicological information

· ***Acute toxicity:***
· ***Primary irritant effect:***
· ***on the skin:*** *May cause skin irritation.*
· ***on the eye:*** *Irritating effect.*
· ***Sensitization:*** *Sensitization possible through skin contact.*

12 Ecological information

· ***Ecotoxical effects:***
· ***Remark:*** *Toxic for fish*
· ***General notes:***
Water hazard class 1 (Assessment by list): slightly hazardous for water
Water hazard class 2 (Assessment by list): hazardous for water
Do not allow product to reach ground water, water course or sewage system.
Danger to drinking water if even small quantities leak into the ground.
Also poisonous for fish and plankton in water bodies.

(Contd. on page 4)

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/18/2012 Reviewed on 10/18/2012

Trade name: Pro-Poxy™ Type III DOT - Part A

(Contd. of page 4)

15 Regulations

· **Sara**

· **Section 355 (extremely hazardous substances):**
Substance is not listed.

· **Section 313 (Specific toxic chemical listings):**
This product may contain 1 or more toxic chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 and 40 CFR part 372. If so, the chemicals are listed below.
Substance is not listed.

· **TSCA (Toxic Substances Control Act):**
Substance is listed.

· **Proposition 65**

· **Chemicals known to the State of California (Prop. 65) to cause cancer:**
Substance is listed.

· **Chemicals known to cause reproductive toxicity for females:**
Substance is not listed.

· **Chemicals known to cause reproductive toxicity for males:**
Substance is not listed.

· **Chemicals known to cause developmental toxicity:**
Substance is not listed.

· **Cancerogenity categories**

· **EPA (Environmental Protection Agency)**
Substance is not listed.

· **IARC (International Agency for Research on Cancer)**
Substance is not listed.

· **NTP (National Toxicology Program)**
Substance is not listed.

· **TLV (Threshold Limit Value established by ACGIH)**
Substance is not listed.

· **MAK (German Maximum Workplace Concentration)**
Substance is not listed.

· **NIOSH-Ca (National Institute for Occupational Safety and Health)**
Substance is not listed.

· **OSHA-Ca (Occupational Safety & Health Administration)**
Substance is not listed.

· **Product related hazard informations:**
The product has been classified and marked in accordance with directives on hazardous materials.

· **Hazard symbols:**
Xi Irritant
N Dangerous for the environment

· **Hazard-determining components of labelling:**
reaction product: bisphenol-A-(epichlorhydrin) epoxy resin (number averagemolecular weight = 700)

(Contd. on page 6)

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/18/2012 | *Reviewed on 10/18/2012*

1 Identification of substance

· **Product details**

· **Trade name:** Pro-Poxy™ Type III DOT - Part B

· **Article number:** 87-140302B
· **Application of the substance / the preparation**

· **Manufacturer/Supplier:**
Unitex®
3101 Gardner
Kansas city, MO 64120
Tel: (800) 821-5846
Fax: (816) 483-3149

Emergency Telephone Number: Use only in the event of an emergency involving a spill, leak, fire, exposure, or accident involving chemicals. Within the U.S., Canada, or the U.S. Virgin Islands, call ChemTrec at (800) 424-9300, 24 hours a day. Or, outside these areas, call (703) 527-3887. Collect calls are accepted.

· **Information department:** Environmental, Health, and Safety department.

2 Composition/Data on components

· **Chemical characterization**
· **Description:** Mixture of the substances listed below with nonhazardous additions.
· **Dangerous components:**

84852-15-3	4-nonylphenol, branched	25-50%
694-83-7	cyclohex-1,2-ylenediamine	10-25%
100-51-6	Benzyl alcohol	10-25%
90-72-2	2,4,6-tris(dimethylaminomethyl)phenol	≤ 10%

· **Additional information:** For the wording of the listed risk phrases refer to section 16.

3 Hazards identification

· **Hazard description:** Not applicable.
· **Information pertaining to particular dangers for man and environment:**
The product has to be labelled due to internationally acknowledged calculation procedures using the latest valid versions.
· **Classification system:**
The classification was made according to the latest editions of international substances lists, and expanded upon from company and literature data.
· **NFPA ratings (scale 0 - 4)**

Health = 3
Fire = 1
Reactivity = 2

· **HMIS-ratings (scale 0 - 4)**

Health = 3
Fire = 1
Reactivity = 2

USA
(Contd. on page 2)

(Contd. of page 2)

8 Exposure controls and personal protection

· ***Additional information about design of technical systems:*** *No further data; see item 7.*

· ***Components with limit values that require monitoring at the workplace:***
The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.
· ***Additional information:*** *The lists that were valid during the creation were used as basis.*

· ***Personal protective equipment:***
· ***General protective and hygienic measures:***
Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes and skin.
Breathing equipment:
In case of brief exposure or low pollution use respiratory filter device. In case of intensive or longer exposure use respiratory protective device that is independent of circulating air.
· ***Protection of hands:***

Protective gloves

The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.
· ***Eye protection:*** *Wear appropriate eye protection to prevent eye contact.*

9 Physical and chemical properties

· ***General Information***	
Form:	*Liquid*
Color:	*Amber*
Odor:	*Slight Ammonia*
· ***Change in condition***	
Melting point/Melting range:	*Undetermined.*
Boiling point/Boiling range:	*Undetermined.*
· ***Flash point:***	*> 94°C (> 201°F)*
· ***Ignition temperature:***	*315.0°C (599°F)*
· ***Auto igniting:***	*Product is not selfigniting.*
· ***Danger of explosion:***	*Product does not present an explosion hazard.*
· ***Explosion limits:***	
Lower:	*1.3 Vol %*
Upper:	*13.0 Vol %*
· ***Vapor pressure at 20°C (68°F):***	*0.1 hPa (0 mm Hg)*
· ***Density at 20°C (68°F):***	*0.970 g/cm³*
· ***Solubility in / Miscibility with Water:***	*Not miscible or difficult to mix.*
· ***Solvent content:***	
Organic solvents:	*12.0 %*

(Contd. on page 4)

(Contd. of page 4)

· ***Uncleaned packagings:***
· ***Recommendation:*** *Disposal must be made according to Federal, State, and Local regulations.*

14 Transport information

· ***DOT regulations:***

· ***Hazard class:***	*8*
· ***Identification number:***	*UN1760*
· ***Packing group:***	*III*
· ***Proper shipping name (technical name):***	*CORROSIVE LIQUID, N.O.S. (Nonyl phenol)*
· ***Label***	*8*
· ***Remarks:***	*Add "Marine Pollutant" to end of proper shipping name if shipping in a bulk container (>119 gallons).*
· ***Limited Quantity Exemption:***	*Limited Quantity applies for inner packages 1 gallon or smaller.*
· ***U.S. Domestic Ground Shipments:***	*Same as listed for Standard Shipments above.*
· ***U.S. Domestic Ground Non-Bulk (119 gal or less per container) Shipments:***	*Same as listed for Standard Shipments above.*
· ***Emergency Response Guide (ERG) Number:***	*Not determine*

· ***Land transport ADR/RID (cross-border):***

· ***ADR/RID class:***	*8 Corrosive substances*
· ***UN-Number:***	*1760*
· ***Packaging group:***	*III*
· ***Description of goods:***	*1760 CORROSIVE LIQUID, N.O.S. (Nonyl phenol)*

· ***Maritime transport IMDG:***

· ***IMDG Class:***	*8*
· ***UN Number:***	*1760*
· ***Label***	*8*
· ***Packaging group:***	*III*
· ***Marine pollutant:***	*Yes*
· ***Propper shipping name:***	*CORROSIVE LIQUID, N.O.S. (Nonyl phenol)*

· ***Air transport ICAO-TI and IATA-DGR:***

· ***ICAO/IATA Class:***	*8*

(Contd. on page 6)

(Contd. of page 6)

· ***Hazard symbols:***
C Corrosive
N Dangerous for the environment

· ***Hazard-determining components of labelling:***
cyclohex-1,2-ylenediamine
2-piperazin-1-ylethylamine
4-nonylphenol, branched

· ***Risk phrases:***
22 Harmful if swallowed.
34 Causes burns.
43 May cause sensitisation by skin contact.
62 Possible risk of impaired fertility.
50/53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
63 Possible risk of harm to the unborn child.

· ***Safety phrases:***
2 Keep out of the reach of children.
13 Keep away from food, drink and animal feedingstuffs.
20 When using do not eat or drink.
23 Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer).
25 Avoid contact with eyes.
26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
27/28 After contact with skin, take off immediately all contaminated clothing, and wash immediately with plenty of water.
29/56 Do not empty into drains, dispose of this material and its container at hazardous or special waste collection point.
36/37/39 Wear suitable protective clothing, gloves and eye/face protection.
45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
52 Not recommended for interior use on large surface areas.
57 Use appropriate container to avoid environmental contamination.
60 This material and its container must be disposed of as hazardous waste.
64 If swallowed, rinse mouth with water (only if the person is conscious).

· ***National regulations:***

· ***Water hazard class:*** *Water hazard class 3 (Self-assessment): extremely hazardous for water.*

16 Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· ***Department issuing MSDS:*** *Environmental, Health & Safety Department*
· ***Contact:*** *Environmental, Health & Safety Manager*

Montana DOT

Polymer Overlay Spec

Property	Requirement	Type III DOT Results	Test Method	Third-Party Testing
Gel Time	15-45 Min.	36	ASTM C881	PSI 1/30/06
Viscosity	7-70 Poises	1712	ASTM D2393	PSI 1/30/06
Shore D Hardness	60-75	73	ASTM D 2240	SOR 7/18/2011
Absorption	1% Max @24hr	0.13%	ASTM 570	SOR 7/18/2011
Tensile Elongation	30%-70% @7 Days	31.9	ASTM D 638	SOR 7/18/2011
Tensile Strength	>2000 PSI @ 7 Days	3310	ASTM D 638	SOR 7/18/2011
Chloride Permeability	<100 Coulombs @ 28 Days	0	AASHTO T277	Tec 12/14/10

Product Refrences and Past Projects

Agency & Contacts Name	Contacts Title	Project Name	Address	Phone Number	Used since-(date) month/year	Experimental or Evaluating	Routinely Used
ITD/Dan Gorsly	Bridge Designer	2100 Over I-84	3311 W State Street Boise ID 83707	208-334-8519	Apr-03	No	Yes
UDOT/ Daniel Page, P.E. Bridge Operations Manager	Bridge Operations Manager	I Core Project Over 1,000,000 SFT	4501 S 2700 W. SLC, UT. 84114	(801)-964-4463	Jun-98	No	Yes

psi Information To Build On
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RECEIVED
JAN 3 0 2006
BY:

RESIN & GROUT PROPERTIES TEST RESULTS

TESTED FOR: UNITEX
3101 GARDNER AVENUE
KANSAS CITY, MO 64120

PROJECT: EPOXY TESTING
LABORATORY TESTING SERVICES

DATE: January 17, 2006

PSI REPORT NO.: 353-30006-57

REMARKS: Material ID: UNITEX PRO-POXY Type III DOT
Lab No. 107188

Representatives of Professional Service Industries, Inc. (PSI) witnessed selected specimen preparation and testing at the Unitex Facility. Selected tests were performed at the PSI laboratory. The results are as follows:

RESIN PROPERTIES	
Viscosity, cps - ASTM D2393 (RV3 @ 20rpm	1712
Gel Time, minutes - ASTM C881 (70°F)	36
Water Absorption, % - ASTM D570	
24-hour immersion - average of 2	0.19
7-day immersion - average of 2	0.71
Tensile Test - ASTM D638 - average of 3	
Strength, psi	4080
Elongation, %	57.5
Flexural Strength, psi - ASTM D790 average of 3	5730
Compression Test - ASTM D695	
Yield Strength, psi	5570
Modulus, psi	82300
Shore-D Hardness - ASTM D2240	72
Adhesion (24-hour), psi - ACI 503R - average of 2	388 100% Concrete failure
GROUT PROPERTIES - Sand to resin ratio = 3.5 to 1 by volume	
Compressive Strength, psi - ASTM C579 - average of 3	
3 hour	4330
8 hour	5350
24 hour	9090

NOTE: Gel Time test room temperature at 60-65° F.
Tensile test room temperature 65°F.
Flexural test specimen 1 dimensions measured. Room temperature 68°F.

respectfully submitted,
Professional Service Industries, Inc.

S.Bennie Benson
Construction Services Manager

cc: 2-CLIENT

TEC Services
Testing • Engineering • Consulting

December 14, 2010

Mr. Julian Yan
Unitex Chemical Corporation
3101 Gardner Avenue
Kansas City, MO 64120

Phone: 800-821-5846
Fax: 816-483-3149
Email: julian@unitex-chemicals.com

Subject: **Final Report on Testing of Pro-Poxy Type III**
IL DOT Bridge Deck Thin Polymer Overlay Specification
TEC Services Project No: 10-0789
TEC Services Laboratory No: 10-123

Dear Mr. Yan:

Testing, Engineering, and Consulting Services, Inc. (TEC Services) is pleased to present this report on the compliance testing of Pro-Poxy Type III D.O.T. to the Illinois DOT specification for Epoxy Binders and Bridge Deck Thin Polymer Overlays. This work was performed in accordance with the terms and conditions of our Service Agreement (TEC-PRO-10-0789) dated February 17, 2010. The results of this testing pertain only to the samples tested.

Testing was performed on the epoxy binder in accordance with the following test methods:

- ASTM D 2393-86 — *Standard Test Method for Viscosity of Epoxy Resins and Related Components*
- ASTM C 881-02 — *Standard Specification for Epoxy-Resin Base Bonding Systems for Concrete*
- ASTM D 638-08 — *Standard Test Methods for Tensile Properties of Plastics*
- ASTM D 570-05 — *Standard Test Method for Water Absorption of Plastics*
- ASTM D 2240-05 — *Standard Test Method for Rubber Property – Durometer Hardness*
- AASHTO T 277-07 — *Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.*

Testing was performed on the polymer overlay system in accordance with the following test methods:

- ASTM D 579-06 — *Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars and Polymer Concretes*
- ASTM C 884-98 — *Standard Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay*
- ACI 503R — *Epoxy Compounds; Appendix A – Test Methods (A.1 Field test for surface soundness and adhesion.)*

Table 2 – Absorption Results

Sample ID	Initial Weight	Weight After 24hr Soak	Absorption, %
1	5.017	5.033	0.32
2	5.233	5.250	0.32
3	5.593	5.611	0.31
		Average	0.32

Shore D Hardness

Shore D hardness was determined in accordance with ASTM D2240. The test specimens (½" thick) were cast by TEC Services and the testing was performed by Applied Technical Services. Results are reported in Table 3.

Table 3 – Shore D Hardness Results

Sample ID	Reading Number	Shore D Hardness	Average
Pro-Poxy Type III D.O.T.	1	75	75
	2	76	
	3	76	
	4	75	
	5	74	

Chloride Permeability

The resistance of the epoxy to chloride ion penetration was measured in accordance with AASHTO T 277. Two specimens, 4" in diameter and approximately 2" tall were cast for testing. The specimens were cured for 28 days prior to testing. Results are reported in Table 4.

Table 4 – Resistance to Chloride Ion Penetration

Set Identification	Specimen Reading (coulombs)	Time Completed (minutes)	Adjusted Average (coulombs)[1]	Chloride Ion Penetrability[2]
Pro-Poxy Type III D.O.T.	0	360	0	Negligible
	0	360	0	Negligible
		Average	0	Negligible

[1] Values were adjusted to represent a specimen diameter of 3.75 in. per Section 11.2 of AASTHO T 277
[2] This assessment is based on Table 1 (Cl Ion Penetrability Based on Charge Passed) in AASTHO T 277

Thermal Compatibility

The thermal compatibility of the polymer overlay system was determined in accordance with ASTM C 884. Two concrete blocks were fabricated and cured in accordance with ASTM C672 except that they were allowed to air dry for at least 14 days. The surface of the concrete blocks was sand-blasted and loose material was removed with a bristle-brush; the surface was cleaned with compressed air to ensure it was free from dust prior to the application of the epoxy mortar. The epoxy mortar was prepared by combining 1 part of the mixed epoxy binder with 3 parts standard sand. A ½ inch layer of epoxy mortar was applied to the surface of the concrete blocks and allowed to cure for 7 days. After the curing period, the specimens were placed in a freezer for 24 hours and then removed to room temperature for 24 hours; this cycle was repeated 5 times.

After the completion of the freezing and thawing cycles, no delaminations of the epoxy mortar from the concrete blocks were observed, nor were there any cracks observed in the concrete near the interface.

Pull-Off Strength

The pull-off strength of the polymer overlay system was determined in accordance with ACI 503R, Appendix A. The polymer overlay was prepared using the aggregate listed in Table 5. The substrate used for testing was a high strength fiber reinforced concrete with approximate dimensions of 4' x 4' x 4". Approximately 28 days after casting the surface of the concrete test slab was cleaned using a wire brush and compressed air. A $^3/_8$ inch layer of epoxy mortar was applied to the surface of the concrete and allowed to cure for 24 hours. Six 2.75" diameter aluminum pucks were adhered to the surface of the epoxy mortar using a secondary epoxy binder.

Table 7 – Pull-Off Strength of Polymer Overlay System

Sample ID	Age	Peak Pull Off Load (lbs)	Sample Diameter (in)	Bond Area (in²)	Bond Strength (psi)	Type of Failure*
1	24 hrs	2506	2.75	5.94	420	Adhesion
2	24 hrs	2161	2.75	5.94	365	Adhesion
3	24 hrs	2370	2.75	5.94	400	Adhesion
4	24 hrs	2229	2.75	5.94	375	Adhesion
5	24 hrs	2724	2.75	5.94	460	Adhesion
6	24 hrs	2745	2.75	5.94	460	Adhesion
				Average	415	

a) Failure in the concrete (cohesive concrete failure)
b) Separation of the epoxy compound from the concrete surface (adhesive failure)
c) Failure in the epoxy compound (cohesive resin failure)

STRATA

A PROFESSIONAL SERVICES CORPORATION

Integrity from the Ground Up

July 18, 2016
File: WY16055A

Earthwork Solutions
Mr. E.O. Sowerwine
P.O. Box 1007
Gillette, Wyoming 82717-1007
e.o.sowerwine@earthwork.us.com

RE: **Aggregate Quality Testing**
Lake Ranch Aggregate
Crook County, Wyoming

Dear Mr. Sowerwine:

In accordance with your request, STRATA has conducted testing of the phonolite source rock, naturally occurring calcined bauxite, from your Lake Ranch quarry located near the Missouri Buttes in northeastern Wyoming. Several samples of the produced aggregate which were delivered to our laboratory by you have been tested for various properties between August, 2010 and the present. This report summarizes the results of these tests which were previously submitted under separate cover at the time the tests were conducted. The tests performed, date, and results are summarized below.

STRATA has reviewed the results and compared them to the Department of Transportation State of Georgia Special Provision Section 419 – High Friction Surface Treatment Specifications for the Aggregate. Test results for this aggregate source have met the aggregate gradation requirements in Part B (95-100% passing by weight), the percent wear using test method AASHTO T-96 (10% maximum), and the soundness percent loss using test method AASHTO T104 Sulfate Soundness. The test results are outlined in the table below, and in the attached sieve analysis.

Date	Sample No.	Test/Standard	Result
August 2010	GI15059 3/4" x #8	AASHTO T85 Relative Density (Specific Gravity) and Absorption of Coarse Aggregate	2.496 0.8% absorption
August 2010	GI15060 3/8" x #8	AASHTO T104 Soundness of Aggregate by Use of Magnesium Sulfate	1% loss
April 2011	Not Reported	ASTM D3042 Insoluble Residue	96%
August 2013	GI1300458	MOH's Hardness	8
August 2014	Not Reported 3/8" Aggregate	ASTM E965 Test Method for Measuring Pavement Macrotexture Depth Using Volumetric Technique	2.22 mm
August 2014	Not Reported #4 Aggregate	ASTM D965 Test Method for Measuring Pavement Macrotexture Depth Using Volumetric Technique	2.80 mm
November 2015	GI15335	AASHTO T96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine (100 revolutions)	5.3% loss
May 2016	GI16057	AASHTO T-11, T-27 Sieve Analysis	98% Passing No. 6 Sieve; 2% Passing No. 16

As requested, we have included specific results of tests conducted by other firms, the reports of which you have transmitted to STRATA. These reports are appended. These test results include:

Tests by Others				
Date	**Sample No.**	**Tested By**	**Test/Standard**	**Result**
November 2015	GI15347	Kumar and Associates Denver, CO	AASHTO T327-15 Resistance of Coarse Aggregate to Degradation by Micro-Deval Apparatus (9.5 mm by 4.75 mm)	5.1% loss
August 2014	1408-1521	Sotter Engineering Corporation, Mission Viejo, CA	AASHTO T 278 Dynamic Slip Resistance Using Pendulum Test Method	Avg. wet BPN: 78
April 5, 2016	4195701	CTL Group	ASTM C25 Standard Test Method	83.56% Al_2O_3
Not Reported	Not Applicable	Wyoming Department of Transportation*	ASTM E274 Skid Resistance of Paved Surfaces Using a Full Scale Tire	Skid Number = 73.9 – 74.4
May 4, 2016	GI16027 1 of 5	Kumar and Associates Denver, CO	ASTM D7428, Micro Deval, Oregon Modified (Passing No. 4 to Retained on No. 8 and Passing No. 8 to Retained on No. 16)	2.2% Cumulative Loss
May 16, 2016	GI16027 2 of 5	Kumar and Associates Denver, CO	ASTM D7428, Micro Deval, Oregon Modified (Passing No. 4 to Retained on No. 8 and Passing No. 8 to Retained on No. 16)	1.9% Cumulative Loss
May 19, 2016	GI16027 3 of 5	Kumar and Associates Denver, CO	ASTM D7428, Micro Deval, Oregon Modified (Passing No. 4 to Retained on No. 8 and Passing No. 8 to Retained on No. 16)	1.9% Cumulative Loss
May 24, 2016	GI16027 4 of 5	Kumar and Associates Denver, CO	ASTM D7428, Micro Deval, Oregon Modified (Passing No. 4 to Retained on No. 8 and Passing No. 8 to Retained on No. 16)	1.7% Cumulative Loss
May 25, 2016	GI16027 5 of 5	Kumar and Associates Denver, CO	ASTM D7428, Micro Deval, Oregon Modified (Passing No. 4 to Retained on No. 8 and Passing No. 8 to Retained on No. 16)	1.6% Cumulative Loss
May 25, 2016	GI16027 Average	Kumar and Associates Denver, CO	ASTM D7428, Micro Deval Oregon Modified, (Average of 5 Tests)	1.9% Cumulative Loss (Average of Five Tests)
July 18, 2016	GI16121	STRATA	ASTM D5821 Fractured Face	100% for 2 or more faces
July 18, 2016	GI16121	STRATA	ASTM C128, Fine Aggregate Specific Gravity and Absorption	0.8% absorption

*Client e-mail forwarded from Mr. Andy Freeman, Wyoming Department of Transportation.

If you have any questions or concerns about these test results, please contact Dennis Russell (drussell@strategeotech.com) at (307) 686-6409 in the Gillette, WY office or Jim Murphy (jmurphy@strategeotech.com) in the Spokane office (509) 891-1904.

Sincerely,

James P. Murphy
Chief Operations Officer
STRATA, Inc.

Dennis A. Russell, P.E.
Geotechnical Engineer
STRATA, Inc.

enclosures

JPM/DAR/cm

STRATA

Laboratory Report

Project: 2016 Miscellaneous Testing

Project Number: WY16055A
Date: 07/18/16
Tested By: J. Frey

Client: Earthwork Solutions
PO Box 1007
Gillette, Wyoming 82717

Sample Source: Lake Ranch Pit
Sample Location: Bagger
Sample Description: Epoxy Overlay Aggregate

Sample Number: GI16120
Sampled By: CLIENT
Date Sampled: 07/18/16
Date Received: 07/18/16

Sieve Size	Metric	Percent Passing	Spec
No. 4	4.75 mm	100	100
No. 10	2.00 mm	15	10-35
No. 20	0.85 mm	0.1	0-10

Reviewed By: Dennis A. Russell

Dennis A. Russell, P.E.
Wyoming Engineering Manager

STRATA

Laboratory Report

Project: 2016 Miscellaneous Testing

Project Number: WY16055A
Date: 01/31/17
Tested By: J. Frey

Client: Earthwork Solutions
PO Box 1007
Gillette, Wyoming 82717

Sample Source: Lake Ranch
Sample Location: Stockpile
Sample Description: #4 x #9 Crushed Aggregate

Sample Number: GI17005
Sampled By: Earthworks
Date Sampled: 01/27/17
Date Received: 01/27/17

Standards: AASHTO T-11, T-27

Sieve Size	Metric	Percent Passing
2"	50 mm	100
11/2"	37.5 mm	100
1"	25 mm	100
3/4"	19 mm	100
1/2"	12.5 mm	100
3/8"	9.5 mm	100
No. 4	4.75 mm	100
No. 8	2.36 mm	36
No. 16	1.18 mm	0
No. 30	0.6 mm	0
No. 50	0.3 mm	0

Moisture Content %: 0

Reviewed By: Jason W. Gillespie
Jason W. Gillespie, P.E.
Staff Engineer

TECHNICAL DATA SHEET

DESCRIPTION

Sure Patch™ is a 100% solids, low modulus epoxy resin system containing specially selected aggregates. A unit consists of three parts: component "A" epoxy resin, component "B" modified amine curing agent and component "C" specially graded aggregate.

USE

Use for epoxy interior or exterior concrete repair and overlays on interior horizontal surfaces. For interior industrial / commercial applications subjected to abrasion and or chemical spills.

FEATURES

- Pre-measured proportions
- Trowelable
- Rapid strength gain
- Open to foot traffic in 2 hours
- Open to vehicle traffic in 3-5 hours
- Superior ultimate strength
- Moisture insensitive
- Solvent free
- Superior wearing surface
- Chemical resistant
- Two convenient packaging sizes
- Meets the requirements for FAA P-501, Section 501-4.19 (F)

PROPERTIES

Resin Properties:

% Solids: 100%
Gel time: 15 minutes @ 73°F (23°C)
Bond Strength, ASTM C-882: 14 day cure 3,200 psi (22.6 MPa)
Compressive Modulus, ASTM D-695: 80,000 psi (551.6 MPa)
Tensile Strength, ASTM D-638: 3,000 psi (20.7MPa)
Tensile Elongation, ASTM D-638: 50.0%
Flexural Yield Strength, ASTM D-790: 2,500 psi (17.2 MPa)
Absorption, ASTM D-570: 0.2%

Mortar Properties:

Compressive Strength, ASTM C-579

3 hrs. 1,500 psi (10.3 MPa)
24 hrs. 7,000 psi (48.3 MPa)
48 hrs. 7,000 psi (48.3 MPa)

VOC

V.O.C. compliant: 0 g/l

ESTIMATING GUIDE

Small unit mixed yields 0.5 cu. ft. (0.014 cu m) of patching mortar.
Large unit mixed yields 2.0 cu. ft. (0.056 cu m) of patching mortar.

PACKAGING

ITEM #	PACKAGE	SIZE	
		cu. ft.	(cu. m)
139890	Unit	0.5	(0.014)
139891	Unit	2.0	(0.056)

STORAGE

Sure Patch™ should be stored in a dry environment between 40°-95°F (5°-35°C). Under these conditions the shelf life is 24 months in unopened, damage-free containers

APPLICATION

Surface Preparation: Surface to receive the Sure Patch™ must be clean and sound. Remove oil, dirt, grease, laitance, curing compounds and other foreign matter that may cause a problem with bond. Saw cut approx. 1/2 in. (1.3 cm) deep around perimeter of area to be patched and remove all deteriorated and unsound concrete with chipping hammers not to exceed 30 lb. (13.6 kg). Thoroughly clean patch area and exposed reinforcing steel by sandblasting to white metal finish. Abrasive blast cleaning or other mechanical removal methods are recommended for providing a roughened profile. Vacuum all dust and loose particles from area.

Mixing: Condition material to 65°-85°F (18°- 29°C) before using. Premix each component after which you mix equal volumes of Part A and Part B for three minutes, or until thoroughly blended, with a low speed drill using a Jiffy mixer or paddle, then slowly add the entire amount of aggregate (component C). Keep mixer at bottom of pail to avoid introducing air. Mix complete units only.

Placement: Place the material immediately after mixing. Trowel material into the prepared area then tamp well (the blunt end of a 2x4 board works well for this) to eliminate any voids. Screed or float to the desired level, strike off then thoroughly compact and finish the surface.

CLEAN UP

Clean tools and equipment before the epoxy sets up, using Xylene or the Dayton Superior Citrus Cleaner J48.

LIMITATIONS

FOR PROFESSIONAL USE ONLY

Mix complete units only

Do not expose stored product to cold or freezing temperature (below 35°F, 2°C)

Precondition material to 65°-85°F (18°-29°C).

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/26/2011 *Reviewed on 10/26/2011*

1 Identification of substance

· ***Product details***

· ***Trade name:*** *Sure Patch™ - Part A*

· ***Article number:*** *139890A*
· ***Application of the substance / the preparation***

· ***Manufacturer/Supplier:***
Dayton Superior
4226 Kansas Avenue
Kansas City, KS 66106
Tel.: (866) 329-8724

Emergency Telephone Number: Use only in the event of an emergency involving a spill, leak, fire, exposure, or accident involving chemicals. Within the U.S., Canada, or the U.S. Virgin Islands, call ChemTrec at (800) 424-9300, 24 hours a day. Or, outside these areas, call (703) 527-3887. Collect calls are accepted.

· ***Information department:*** *Environmental, Health, and Safety department.*

2 Composition/Data on components

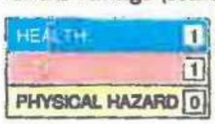
· ***Chemical characterization:***
· ***CAS No. Description***
25068-38-6 reaction product: bisphenol-A-(epichlorhydrin) epoxy resin
(number average molecular weight = 700)
· ***Identification number(s)*** *Not applicable*
· ***EINECS Number:*** *500-033-5*
· ***EU Number:*** *603-074-00-8*

3 Hazards identification

· ***Hazard description:*** *May cause eye and skin irritation. Prolonged contact may cause sensitization.*
· ***Information pertaining to particular dangers for man and environment:*** *Not applicable.*
· ***Classification system:***
· ***NFPA ratings (scale 0 - 4)***

Health = 1
Fire = 1
Reactivity = 0

· ***HMIS-ratings (scale 0 - 4)***



Health = 1
Fire = 1
Reactivity = 0

4 First aid measures

· ***After inhalation:***
Supply fresh air and to be sure call for a doctor.
In case of unconsciousness place patient stably in side position for transportation.
· ***After skin contact:***
Immediately wash with water and soap and rinse thoroughly.
If skin irritation continues, consult a doctor.
· ***After eye contact:*** *Rinse opened eye for several minutes under running water.*

(Contd. on page 2)

Material Safety Data Sheet
acc. to ISO/DIS 11014

(Contd. of page 2)

· ***Eye protection:*** *Wear appropriate eye protection to prevent eye contact.*

9 Physical and chemical properties

· ***General Information***

Form:	*Liquid*
Color:	*Grey*
Odor:	*Mild*
· ***Change in condition***	
Melting point/Melting range:	*Undetermined.*
Boiling point/Boiling range:	*Undetermined.*
· ***Flash point:***	*> 94°C (> 201°F)*
· ***Danger of explosion:***	*Product does not present an explosion hazard.*
· ***Density:***	*Not determined.*
· ***Solubility in / Miscibility with***	
Water:	*Not miscible or difficult to mix.*
Organic solvents:	*0.0 %*
· ***Solids content:***	*100.0 %*
· ***Volatile Organic Compounds:***	*Not determined*

10 Stability and reactivity

· ***Thermal decomposition / conditions to be avoided:*** *No decomposition if used according to specifications.*
· ***Dangerous reactions*** *No dangerous reactions known.*
· ***Dangerous products of decomposition:*** *No dangerous decomposition products known.*

11 Toxicological information

· ***Acute toxicity:***
· ***Primary irritant effect:***
· ***on the skin:*** *May cause skin irritation.*
· ***on the eye:*** *Irritating effect.*
· ***Sensitization:*** *Sensitization possible through skin contact.*

12 Ecological information

· ***Ecotoxical effects:***
· ***Remark:*** *Toxic for fish*
· ***General notes:***
Water hazard class 1 (Assessment by list): slightly hazardous for water
Water hazard class 2 (Assessment by list): hazardous for water
Do not allow product to reach ground water, water course or sewage system.
Danger to drinking water if even small quantities leak into the ground.
Also poisonous for fish and plankton in water bodies.

(Contd. on page 4)

(Contd. of page 4)

· ***Chemicals known to cause reproductive toxicity for females:***
Substance is not listed.

· ***Chemicals known to cause reproductive toxicity for males:***
Substance is not listed.

· ***Chemicals known to cause developmental toxicity:***
Substance is not listed.

· ***Cancerogenity categories***

· ***EPA (Environmental Protection Agency)***
Substance is not listed.

· ***IARC (International Agency for Research on Cancer)***
Substance is not listed.

· ***NTP (National Toxicology Program)***
Substance is not listed.

· ***TLV (Threshold Limit Value established by ACGIH)***
Substance is not listed.

· ***MAK (German Maximum Workplace Concentration)***
Substance is not listed.

· ***NIOSH-Ca (National Institute for Occupational Safety and Health)***
Substance is not listed.

· ***OSHA-Ca (Occupational Safety & Health Administration)***
Substance is not listed.

· ***Product related hazard informations:***
The product has been classified and marked in accordance with directives on hazardous materials.

· ***Hazard symbols:***
Xi Irritant
N Dangerous for the environment

· ***Hazard-determining components of labelling:***
reaction product: bisphenol-A-(epichlorhydrin) epoxy resin (number averagemolecular weight = 700)

· ***Risk phrases:***
36/38 Irritating to eyes and skin.
43 May cause sensitisation by skin contact.
51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

· ***Safety phrases:***
2 Keep out of the reach of children.
28 After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer).
37/39 Wear suitable gloves and eye/face protection.
61 Avoid release to the environment. Refer to special instructions/safety data sheets.

· ***Special labeling of certain preparations:***
Contains epoxy constituents. See information supplied by the manufacturer.

(Contd. on page 6)

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/26/2011 | *Reviewed on 10/26/2011*

1 Identification of substance

- ***Product details***
- ***Trade name:*** *Sure Patch™ - Part B*
- ***Article number:*** *139890B*
- ***Application of the substance / the preparation***
- ***Manufacturer/Supplier:***

Dayton Superior
4226 Kansas Avenue
Kansas City, KS 66106
Tel.: (866) 329-8724

Emergency Telephone Number: Use only in the event of an emergency involving a spill, leak, fire, exposure, or accident involving chemicals. Within the U.S., Canada, or the U.S. Virgin Islands, call ChemTrec at (800) 424-9300, 24 hours a day. Or, outside these areas, call (703) 527-3887. Collect calls are accepted.

- ***Information department:*** *Environmental, Health, and Safety department.*

2 Composition/Data on components

- ***Chemical characterization***
- ***Description:*** *Mixture of the substances listed below with nonhazardous additions.*
- ***Dangerous components:***

112-57-2	*3,6,9-triazaundecamethylenediamine*	*10-25%*
112-24-3	*3,6-diazaoctanethylenediamin*	*10-25%*

- ***Additional information:*** *For the wording of the listed risk phrases refer to section 16.*

3 Hazards identification

- ***Hazard description:*** *Not applicable.*
- ***Information pertaining to particular dangers for man and environment:***
  The product has to be labelled due to internationally acknowledged calculation procedures using the latest valid versions.
- ***Classification system:***
  The classification was made according to the latest editions of international substances lists, and expanded upon from company and literature data.
- ***NFPA ratings (scale 0 - 4)***

Health = 3
Fire = 1
Reactivity = 2

- ***HMIS-ratings (scale 0 - 4)***

Health = 3
Fire = 1
Reactivity = 2

4 First aid measures

- ***General information:***
  Immediately remove any clothing soiled by the product.
  Symptoms of poisoning may even occur after several hours; therefore medical observation for at least 48 hours after the accident.

(Contd. on page 2)

Material Safety Data Sheet
acc. to ISO/DIS 11014

(Contd. of page 2)

112-57-2 3,6,9-triazaundecamethylenediamine

WEEL 5 mg/m³

· ***Additional information:*** *The lists that were valid during the creation were used as basis.*

· ***Personal protective equipment:***

· ***General protective and hygienic measures:***
Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes and skin.

· ***Breathing equipment:***
In case of brief exposure or low pollution use respiratory filter device. In case of intensive or longer exposure use respiratory protective device that is independent of circulating air.

· ***Protection of hands:***

Protective gloves

The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.

· ***Eye protection:*** *Wear appropriate eye protection to prevent eye contact.*

9 Physical and chemical properties

· ***General Information***	
Form:	*Liquid*
Color:	*Amber*
Odor:	*Distinctive*
· ***Change in condition***	
Melting point/Melting range:	*Undetermined.*
Boiling point/Boiling range:	*333°C (631°F)*
· ***Flash point:***	*> 94°C (> 201°F)*
· ***Ignition temperature:***	*335.0°C (635°F)*
· ***Auto igniting:***	*Product is not selfigniting.*
· ***Danger of explosion:***	*Product does not present an explosion hazard.*
· ***Vapor pressure at 20°C (68°F):***	*0.0 hPa (0 mm Hg)*
· ***Density:***	*Not determined.*
· ***Solubility in / Miscibility with Water:***	*Not miscible or difficult to mix.*
· ***Solvent content:***	
Organic solvents:	*0.0 %*
· ***Solids content:***	*100 %*
· ***Volatile Organic Compounds:***	*Not determined*

(Contd. on page 4)

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/26/2011 *Reviewed on 10/26/2011*

Trade name: Sure Patch™ - Part B

(Contd. of page 4)

· ***Uncleaned packagings:***
· ***Recommendation:*** *Disposal must be made according to Federal, State, and Local regulations.*

14 Transport information

· ***DOT regulations:***

· **Hazard class:**	8
· **Identification number:**	UN2735
· **Packing group:**	III
· **Proper shipping name (technical name):**	AMINES, LIQUID, CORROSIVE, N.O.S. (AMINOPROPYLDIETHANOLAMINE)
· **Label**	8
· **Limited Quantity Exemption:**	Limited Quantity applies for inner packages 1.3 gallons or smaller.
· **U.S. Domestic Ground Shipments:**	Same as listed for Standard Shipments above.
· **U.S. Domestic Ground Non-Bulk (119 gal or less per container) Shipments:**	Same as listed for Standard Shipments above.
· **Emergency Response Guide (ERG) Number:**	153

· ***Land transport ADR/RID (cross-border):***

· **ADR/RID class:**	8 Corrosive substances
· **UN-Number:**	2735
· **Packaging group:**	III
· **Description of goods:**	2735 AMINES, LIQUID, CORROSIVE, N.O.S. (AMINOPROPYLDIETHANOLAMINE)

· ***Maritime transport IMDG:***

· **IMDG Class:**	8
· **UN Number:**	2735
· **Label**	8
· **Packaging group:**	III
· **EMS Number:**	F-A,S-B
· **Marine pollutant:**	No
· **Propper shipping name:**	AMINES, LIQUID, CORROSIVE, N.O.S. (AMINOPROPYLDIETHANOLAMINE)

(Contd. on page 6)

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/26/2011 *Reviewed on 10/26/2011*

Trade name: Sure Patch™ - Part B

(Contd. of page 6)

· ***Product related hazard informations:***
The product has been classified and marked in accordance with directives on hazardous materials.

· ***Hazard symbols:*** *C Corrosive*

· ***Hazard-determining components of labelling:***
3,6-diazaoctanethylenediamin
3,6,9-triazaundecamethylenediamine

· ***Risk phrases:***
21 Harmful in contact with skin.
34 Causes burns.
43 May cause sensitisation by skin contact.
52/53 Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

· ***Safety phrases:***
2 Keep out of the reach of children.
13 Keep away from food, drink and animal feedingstuffs.
20 When using do not eat or drink.
23 Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer).
25 Avoid contact with eyes.
26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
27/28 After contact with skin, take off immediately all contaminated clothing, and wash immediately with plenty of water.
29/56 Do not empty into drains, dispose of this material and its container at hazardous or special waste collection point.
36/37/39 Wear suitable protective clothing, gloves and eye/face protection.
45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
52 Not recommended for interior use on large surface areas.
60 This material and its container must be disposed of as hazardous waste.
64 If swallowed, rinse mouth with water (only if the person is conscious).

· ***National regulations:***

· ***Water hazard class:*** *Water hazard class 2 (Self-assessment): hazardous for water.*

16 Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· ***Department issuing MSDS:*** *Environmental, Health & Safety Department*
· ***Contact:*** *Environmental, Health & Safety Manager*

Material Safety Data Sheet
acc. to ISO/DIS 11014

Printing date 10/26/2011 *Reviewed on 10/26/2011*

1 Identification of substance

· **Product details**

· **Trade name:** Sure Patch™ - Part C

· **Article number:** 139890C

· **Application of the substance / the preparation**

· **Manufacturer/Supplier:**
Dayton Superior
4226 Kansas Avenue
Kansas City, KS 66106
Tel.: (866) 329-8724

Emergency Telephone Number: Use only in the event of an emergency involving a spill, leak, fire, exposure, or accident involving chemicals. Within the U.S., Canada, or the U.S. Virgin Islands, call ChemTrec at (800) 424-9300, 24 hours a day. Or, outside these areas, call (703) 527-3887. Collect calls are accepted.

· **Information department:** Environmental, Health, and Safety department.

2 Composition/Data on components

· **Chemical characterization**

· **Description:** Mixture of the substances listed below with nonhazardous additions.

· **Dangerous components:**

14808-60-7	Quartz (SiO2)	50-75%
7727-43-7	barium sulphate, natural	25-50%

· **Additional information:** For the wording of the listed risk phrases refer to section 16.

3 Hazards identification

· **Hazard description:** May cause eye and skin irritation. Prolonged contact may cause sensitization.

· **Information pertaining to particular dangers for man and environment:**
The product has to be labelled due to internationally acknowledged calculation procedures using the latest valid versions.

· **Classification system:**
The classification was made according to the latest editions of international substances lists, and expanded upon from company and literature data.

· **NFPA ratings (scale 0 - 4)**

Health = 1
Fire = 0
Reactivity = 0

· **HMIS-ratings (scale 0 - 4)**

Health = 1
Fire = 0
Reactivity = 0

4 First aid measures

· **After inhalation:**
Supply fresh air and to be sure call for a doctor.
In case of unconsciousness place patient stably in side position for transportation.

(Contd. on page 2)

(Contd. of page 2)

7727-43-7 barium sulphate, natural

PEL	15*; 5** mg/m³ *Total dust **Respirable fraction
REL	10*; 5** mg/m³ *Total dust **Respirable fraction
TLV	10 mg/m³ (e)

· ***Additional information:*** *The lists that were valid during the creation were used as basis.*

· ***Personal protective equipment:***
· ***General protective and hygienic measures:***
Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes and skin.
· ***Breathing equipment:*** *Suitable respiratory protective device recommended.*
· ***Protection of hands:***

Protective gloves

The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.
· ***Penetration time of glove material***
The exact break trough time has to be found out by the manufacturer of the protective gloves and has to be observed.
· ***Eye protection:*** *Wear appropriate eye protection to prevent eye contact.*

9 Physical and chemical properties

· General Information	
Form:	Solid
Color:	White
Odor:	Odorless
· Change in condition	
Melting point/Melting range:	Undetermined.
Boiling point/Boiling range:	Undetermined.
· Flash point:	Not applicable.
· Auto igniting:	Product is not selfigniting.
· Danger of explosion:	Product does not present an explosion hazard.
· Density at 20°C (68°F):	3.200 g/cm³
· Solubility in / Miscibility with Water:	Insoluble.
· Solvent content:	
Organic solvents:	0.0 %
· Solids content:	100.0 %

(Contd. on page 4)

(Contd. of page 4)

· **Emergency Response Guide (ERG) Number:**	Not determine
· **Land transport ADR/RID (cross-border):**	Not Regulated
· **ADR/RID class:**	N/A
· **Maritime transport IMDG:**	Not Regulated
· **IMDG Class:**	N/A
· **Marine pollutant:**	No
· **Air transport ICAO-TI and IATA-DGR:**	Not Regulated
· **ICAO/IATA Class:**	N/A

15 Regulations

· **Sara**

· **Section 355 (extremely hazardous substances):**
None of the ingredient is listed.

· **Section 313 (Specific toxic chemical listings):**
This product may contain 1 or more toxic chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 and 40 CFR part 372. If so, the chemicals are listed below.
None of the ingredients is listed.

· **TSCA (Toxic Substances Control Act):**
All ingredients are listed.

· **Proposition 65**

· **Chemicals known to the State of California (Prop. 65) to cause cancer:**
14808-60-7 Quartz (SiO2)

· **Chemicals known to cause reproductive toxicity for females:**
None of the ingredients is listed.

· **Chemicals known to cause reproductive toxicity for males:**
None of the ingredients is listed.

· **Chemicals known to cause developmental toxicity:**
None of the ingredients is listed.

· **Cancerogenity categories**

· **EPA (Environmental Protection Agency)**
None of the ingredients is listed.

· **IARC (International Agency for Research on Cancer)**

14808-60-7	Quartz (SiO2)	1

· **NTP (National Toxicology Program)**

14808-60-7	Quartz (SiO2)	K

· **TLV (Threshold Limit Value established by ACGIH)**

14808-60-7	Quartz (SiO2)	A2

· **MAK (German Maximum Workplace Concentration)**

14808-60-7	Quartz (SiO2)	1

· **NIOSH-Ca (National Institute for Occupational Safety and Health)**
14808-60-7 Quartz (SiO2)

(Contd. on page 6)

BASF

The Chemical Company

Technical Data Guide

7 | 07 92 00 **Joint Sealants**

MasterSeal® SL 1™

One-component elastomeric, self-leveling polyurethane sealant

FORMERLY SONOLASTIC® SL 1™

PACKAGING

– 2 gallon pails (7.6 L)

– 825 ml cartridges, 12 cartridges per carton

– 300 ml cartridges, 30 cartridges per carton and 12 cartridges per carton

COLOR

Limestone, Gray and Stone

YIELD

See page 3 for charts

STORAGE

Store in unopened containers in a cool, clean, dry area. Storing at elevated temperatures will reduce shelf life.

SHELF LIFE

IN BULK

6 months when properly stored

CARTRIDGES

1 year when properly stored

VOC CONTENT

29 g/L

less water and exempt solvents

DESCRIPTION

MasterSeal SL 1 is one component, non-priming, self-leveling elastomeric polyurethane designed for expansion joints in concrete floors and decks. Use it where flexibility as well as abrasion and puncture resistance are required.

PRODUCT HIGHLIGHTS

- Movement capability of ±25% allows expansion and contraction with joint movement
- Abrasion resistant to provide for longer wearing and durability
- Easy to gun for quick installation
- Variety of types and sizes of packaging to help reduce jobsite waste
- No priming needed on most surfaces, offering excellent adhesion
- Self-leveling, so no tooling needed
- Wide application temperature range makies MasterSeal SL1 suitable for all climates
- Excellent weatherability for long-lasting performance

APPLICATIONS

- Horizontal
- Interior and exterior
- Expansion joints
- Control joints
- Pavers
- Plaza decks
- Industrial floors
- Driveways/garages
- Sidewalks
- Decks
- Parking structures
- Pitch pans

SUBSTRATES

- Concrete
- Metal

HOW TO APPLY

JOINT PREPARATION

1. The product may be used in sealant joints designed in accordance with SWR Institute's Sealants - The Professional's Guide.
2. In optimal conditions, the depth of the sealant should be ½ the width of the joint. The sealant joint depth (measured at the center) should always fall between the maximum depth of ½" and the minimum depth of ¼". Refer to Table 1.
3. In deep joints, the sealant depth must be controlled by closed cell backer rod or soft backer rod. Where the joint depth does not permit the use of backer rod, a bond breaker (polyethylene strip) must be used to prevent three-point bonding.

Technical Data

Composition

MasterSeal SL 1 is a single-component polyurethane sealant, which cures by reaction with atmospheric moisture.

Compliances

- ASTM C 920, Type S, Grade P, Class 25, Use T, M, NT, A and O*
- Federal Specification TTS- 00230C, Type 1, Class A
- Corps of Engineers CRD-C-541
- Canadian Specification CAN/CGSB 19.13-M87, Classification C-1-40-B-N and C-1-25-B-N, No. 81028
- CFI accepted
- USDA compliant for use in areas that handle meat and poultry

* Refer to substrates in Where to Use.

Test Data

PROPERTY	RESULTS	TEST METHOD
Movement Capability, %	±25	ASTM C 719
Tensile strength, psi (MPa)	300 (2.1)	ASTM D 412
Elongation, %	800	ASTM D 412
Hardness, Shore A	25	ASTM C 661
Artificial weathering, Xenon arc, 1,000 hrs	Excellent	ASTM G 26
Low temperature flexibility, ° F (° C)	-15 (-26)	ASTM C 793
Viscosity, poise	325	Brookfield

Test results are typical values obtained under laboratory conditions. Reasonable variations can be expected.

Typical Properties

PROPERTY	VALUE
Service temperature range, ° F (° C)	-40 to 180 (-40 to 82)
Shrinkage	Nil

TABLE 1

Joint Width and Sealant Depth

JOINT WIDTH, IN (MM)	SEALANT DEPTH AT MIDPOINT, IN (MM)
¼–½ (6–13)	¼ (6)
½–¾ (13–19)	¼–⅜ (6–10)
¾–1 (19–25)	⅜–½ (10–13)
1–1½ (25–38)	½ (13)

4. To maintain the recommended sealant depth, install backer rod by compressing and rolling it into the joint channel without stretching it lengthwise. Closed cell backer rod should be about ⅛" (3 mm) larger in diameter than the width of the joint to allow for compression. Soft backer rod should be approximately 25% larger in diameter than the joint width. The sealant does not adhere to it, and no separate bond breaker is required. Do not prime or puncture the backer rod.

SURFACE PREPARATION

Substrates must be structurally sound, fully cured, dry and clean. Substrates should always be free of the following: dirt, loose particles, oil, grease, asphalt, tar, paint, wax, rust, waterproofing or curing and parting compounds, membrane materials and sealant residue.

NEW CONCRETE

Remove all loose material from joints by wire brushing. Sandblast surfaces in contact with form-release agents. Fresh concrete must be fully cured. Laitance must be removed by abrading.

OLD CONCRETE

For previously sealed joints, remove all old material by mechanical means. If joint surfaces have absorbed oils, remove sufficient concrete to ensure a clean surface.

PRIMING

1. For most applications, priming is not required; joints subject to periodic water immersion, however, must be primed with MasterSeal P 173. On surfaces other than concrete, conduct a test application to verify adhesion.
2. Apply primer in a thin, uniform film. Avoid buildup of excess primer.
3. Avoid applying primer beyond joint faces. To minimize the contamination of adjacent surfaces, apply masking tape before priming and remove before the sealant has begun to thicken and set.
4. Allow approximately 15–30 minutes drying time before applying sealant (primer should be tack-free). Priming and sealing must be done on the same day.

APPLICATION

1. Fill joints by pouring the sealant from a spouted container.
2. Fill joints from the bottom; avoid bridging of the joint, which may form air voids. Sealant will self-level to form a clean joint surface.

CURING TIME

The cure of MasterSeal SL 1 varies with temperature and humidity. The following times assume 75° F (24° C), 50% relative humidity, and a joint ½" width by ¼" depth (13 by 6 mm).

- Skins: overnight or within 24 hours
- Full cure: approximately 1 week
- Immersion service: 21 days

Yield

LINEAR FEET PER GALLON*

JOINT DEPTH, (INCHES)	¼	⅜	½	⅝	¾	⅞	1	1½	JOINT WIDTH (INCHES) 2	3
¼	308	205	154	122	–	–	–	–	–	–
⅜	–	–	–	82	68	58	51	–	–	–
½	–	–	–	–	51	44	38	26	19	12

METERS PER LITER

JOINT DEPTH, (MM)	6	10	13	16	19	22	25	38	JOINT WIDTH (MM) 50	75
6	24.8	16.5	12.4	9.8	–	–	–	–	–	–
10	–	–	–	6.6	5.5	4.7	4.1	–	–	–
13	–	–	–	–	4.1	3.5	3.0	2.2	1.5	0.7

LINEAR FEET PER 825 ML CARTRIDGE

JOINT DEPTH, (INCHES)	¼	⅜	½	⅝	¾	⅞	JOINT WIDTH (INCHES) 1
¼	72	48	36	28.5	–	–	–
⅜	–	–	–	19.25	16	13.5	12
½	–	–	–	–	12	10.2	8.8

LINEAR METER PER 825 ML CARTRIDGE

JOINT DEPTH, (MM)	6	10	13	16	19	22	JOINT WIDTH (MM) 25
6	20.5	13.6	10.2	8.1	–	–	–
10	–	–	–	5.4	4.5	3.9	3.4
13	–	–	–	–	3.4	2.9	2.5

CLEANUP

Clean equipment with MasterSeal 990 or xylene immediately after use and before sealant has cured. Cured sealant may be removed by cutting with a sharp-edged tool, thin films by abrading.

FOR BEST PERFORMANCE

- Do not allow uncured MasterSeal SL 1 to come into contact with alcohol-based materials or solvents.
- Do not apply polyurethane sealants in the vicinity of uncured silicone sealants or uncured MasterSeal NP 150™.
- MasterSeal SL 1 is not intended for continuous water immersion. Contact Technical Service for recommendations.
- Backer rods, joint fillers and bond breakers must be tightly installed to prevent loss of sealant through joint bottoms.
- Joints subject to puncture by high heels or umbrella points require a stiffer or higher density backup material; cork or rigid non-impregnated cane-fiber joint fillers are suitable. Separate materials from the sealant by a non-adhering bond breaker (polyethylene tape).
- High temperatures or humidity may cause uncured material to bubble.
- Sealant may bubble if substrates are not dry or if material is applied too deep.
- Do not use other caulks, sand, or incompressibles as a bottom bed in a joint.
- Do not install when rain is expected before the sealant develops a substantial skin.
- For joint widths over 1½" (38 mm), use MasterSeal SL 2.
- Proper application is the responsibility of the user. Field visits by BASF personnel are for the purpose of making technical recommendations only and not for supervising or providing quality control on the jobsite.

HEALTH, SAFETY AND ENVIRONMENTAL

Read, understand and follow all Safety Data Sheets and product label information for this product prior to use. The SDS can be obtained by visiting www.master-builders-solutions.basf.us, e-mailing your request to basfbscst@basf.com or calling 1(800)433-9517. Use only as directed. **For medical emergencies only, call ChemTrec® 1(800) 424-9300.**

LIMITED WARRANTY NOTICE

BASF warrants this product to be free from manufacturing defects and to meet the technical properties on the current Technical Data Guide, if used as directed within shelf life. Satisfactory results depend not only on quality products but also upon many factors beyond our control. BASF MAKES NO OTHER WARRANTY OR GUARANTEE, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO ITS PRODUCTS. The sole and exclusive remedy of Purchaser for any claim concerning this product, including but not limited to, claims alleging breach of warranty, negligence, strict liability or otherwise, is the replacement of product or refund of the purchase price, at the sole option of BASF. Any claims concerning this product must be received in writing within one (1) year from the date of shipment and any claims not presented within that period are waived by Purchaser. BASF WILL NOT BE RESPONSIBLE FOR ANY SPECIAL, INCIDENTAL, CONSEQUENTIAL (INCLUDING LOST PROFITS) OR PUNITIVE DAMAGES OF ANY KIND.

Purchaser must determine the suitability of the products for the intended use and assumes all risks and liabilities in connection therewith. This information and all further technical advice are based on BASF's present knowledge and experience. However, BASF assumes no liability for providing such information and advice including the extent to which such information and advice may relate to existing third party intellectual property rights, especially patent rights, nor shall any legal relationship be created by or arise from the provision of such information and advice. BASF reserves the right to make any changes according to technological progress or further developments. The Purchaser of the Product(s) must test the product(s) for suitability for the intended application and purpose before proceeding with a full application of the product(s). Performance of the product described herein should be verified by testing and carried out by qualified experts.

BASF Corporation
Construction Systems

889 Valley Park Drive, Shakopee, MN 55379
www.master-builders-solutions.basf.us

Customer Service 1(800)433.9517
Technical Service 1(800)243.6739

ARMORSTONE

Epoxy Overlay Aggregate

The Process

Our manufacturing process in tells crushing and washing high quality Basalt stone with the latest technology in processing equipment. The material is 100% fractured face stone that is screened to customer / agency specifications, and then kiln dried and thoroughly inspected by our Quality Control technician prior to packaging.

	ASTM TESTED
MOHS Hardness	8
LA Abrasion	9.53%
Durability Index	80
Specific Gravity	2.6884
Absorption	0.73%
Soundness	3.7%
Acid Insolubility	98%
Moisture	<0.02%

Exceeding Your Expectations

WASHINGTON ROCK QUARRIES INC.
EST. 1990

21711 103rd Ave Ct E #C302
Graham, WA 98338
Office: (253) 262-1661
Fax: (253) 262-1664
www.wa-rock.com
Greg Lanphere (235) 377-3438

WASHINGTON ROCK QUARRIES INC.
EST. 1990

Gradation Test With Sieve Chart Report

Plant P003-King Creek
Product 980-3-Epoxy Chips
Specification US 4-16

1996584517

Sample Information

Sample No 1996584517
Date Sampled 05/30/2017 12:47
Sampled By RYAN HOGG
Type Production
Method Belt-Stream

Split Sample ☐
Resample ☐

Gradation Results

Date Completed 05/30/2017 12:47

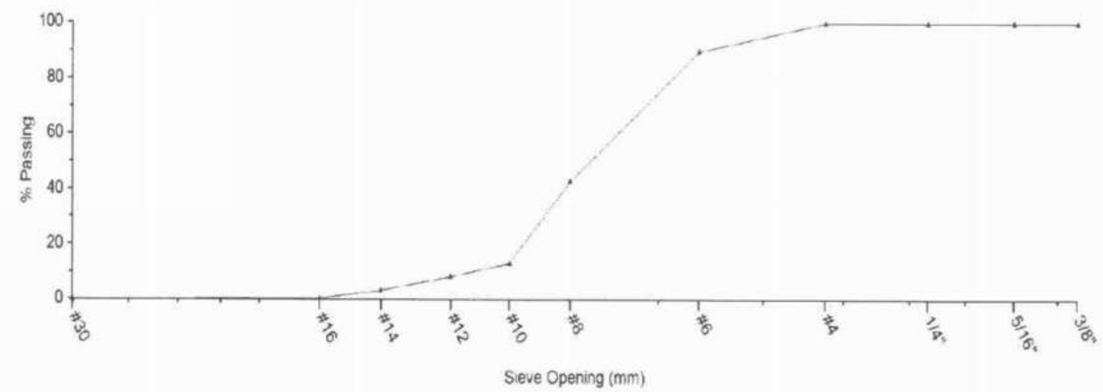
Tested By RYAN HOGG

Unit	Moist Mass	Dry Mass	Wash Mass	Moisture %	Wash Loss %	Procedure
lb		341.20				

Sieve	Mass Retained	Cum Mass Retained	Ind % Retained	% Retained	% Passing	Target	Specification	Comment
3/8" (9.5mm)	0.00	0.00	0.0	0.0	100.0			
5/16" (8mm)	0.00	0.00	0.0	0.0	100.0			
1/4" (6.3mm)	0.00	0.00	0.0	0.0	100.0			
#4 (4.75mm)	0.00	0.00	0.0	0.0	100.0		100-100	
#5 (4mm)								
#6 (3.35mm)	35.50	35.50	10.4	10.4	89.6			
#8 (2.36mm)	160.50	196.00	47.0	57.4	42.6		30-75	
#10 (2mm)	100.70	296.70	29.5	87.0	13.0			
#12 (1.7mm)	17.00	313.70	5.0	91.9	8.1			
#14 (1.4mm)	17.30	331.00	5.1	97.0	3.0			
#16 (1.18mm)	9.20	340.20	2.7	99.7	0.3		0-5	
#18 (1mm)								
#20 (0.85mm)								
#30 (0.6mm)	0.60	340.80	0.2	99.9	0.1		0-1	
#35 (0.5mm)								
#40 (0.425mm)								
#50 (0.3mm)								
#60 (0.25mm)								
#100 (0.15mm)								
#200 (75µm)								
#270 (53µm)								
Pan	0.40	341.20	0.12	100.00	0.00			

WASHINGTON ROCK QUARRIES INC.
EST. 1990

Gradation Test With Sieve Chart Report



Tests: 1 D10(ES): 1.811 D15: 2.022 D30: 2.199 D50: 2.494 D60: 2.687 D85: 3.237 D90: 3.360 Cu: 1.484 Cc: 0.994

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION
FORENSIC INVESTIGATION

December 21, 2011

KA No. 096-11028
Lab Report No. 5.8

Mr. Greg Lanphere (E-mail)
WASHINGTON ROCK QUARRIES, INC.
21711 103rd Avenue Ct. E., Suite C-302
Graham, Washington 98338

RE: **AGGREGATE LABORATORY TESTING**
2011 Control Samples, Bothell, Washington

In accordance with your request and authorization, we have performed laboratory tests for the above referenced project. Laboratory testing was performed in accordance with ASTM standards.

Sample ID No:	41760
Description	River Rock & Crushed River Rock
MOHS Hardness	
Results	8

If you have any questions; or if we can be of further assistance, please do not hesitate to contact our office.

Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Corbett Mercer
Project Manager
Pacific Northwest Division
CM/lm

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION
FORENSIC INVESTIGATION

December 21, 2011

KA No. 096-1 028
Lab Report No. 5.3
Page 1 of 1

Mr. Greg Lanphere (E-mail)
WASHINGTON ROCK QUARRIES, INC.
21711 103rd Avenue Ct. E., Suite C-302
Graham, Washington 98338

RE: **AGGREGATE LABORATORY TESTING**
2011 Control Samples, Bothell, Washington

In accordance with your request and authorization, we have performed laboratory tests for the above referenced project. Laboratory testing was performed in accordance with ASTM standards.

Sample ID No:	41760
Description	River Rock & Crushed River Rock
Bulk Specific Gravity & Absorption Percent (ASTM C127)	
Results	2.6884 & 0.73% Absorption

If you have any questions; or if we can be of further assistance, please do not hesitate to contact our office.

Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Corbett Mercer
Project Manager
Pacific Northwest Division
CM/lm
ATTACHMENTS

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION
FORENSIC INVESTIGATION

December 21, 2011

KA No. 096-11028
Lab Report No. 5.5

Mr. Greg Laaphere (E-mail)
WASHINGTON ROCK QUARRIES, INC.
21711 103rd Avenue Ct. E., Suite C-302
Graham, Washington 98338

RE: **AGGREGATE LABORATORY TESTING**
2011 Control Samples, Bothell, Washington

In accordance with your request and authorization, we have performed laboratory tests for the above referenced project. Laboratory testing was performed in accordance with ASTM standards.

Sample ID No:	41760	
Description	River Rock & Crushed River Rock	
Direct Shear (ASTM D3080)		
Direct Shear	Friction Angle	Cohesion
(See Attached)	47.5°	0.36 KSF

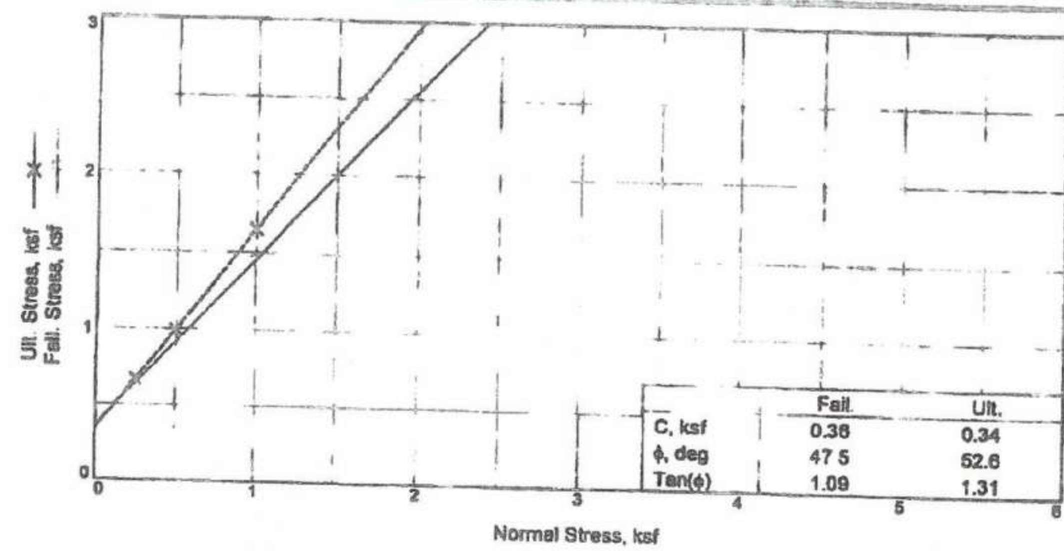
If you have any questions; or if we can be of further assistance, please do not hesitate to contact our office.

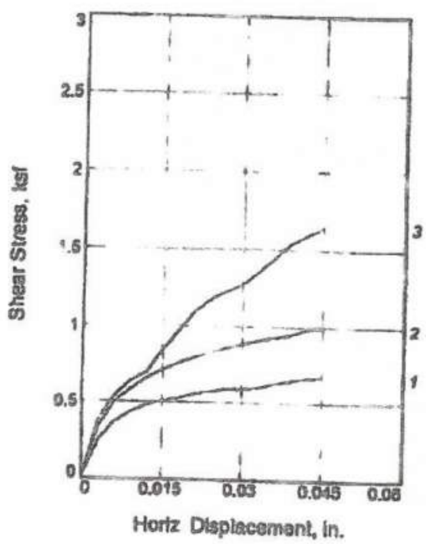
Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Corbett Mercer
Project Manager
Pacific Northwest Division
CM/lm
ATTACHMENTS

11715 N. Creek Parkway S., Suite C-106 Bothell, Washington 98011 • (425) 485 5519 • FAX (425) 485-6837
With Offices Serving the Western United States

096-11028 LAB 05.5 doc





Sample No.		1	2	3
Initial	Water Content, %	1.2	1.2	1.2
	Dry Density, pcf	113.6	111.1	110.0
	Saturation, %	6.8	6.3	6.1
	Void Ratio	0.4669	0.5001	0.5143
	Diameter, in	2.50	2.50	2.50
	Height, in.	1.10	1.10	1.10
At Test	Water Content, %	10.7	8.4	9.4
	Dry Density, pcf	113.7	111.2	110.1
	Saturation, %	61.1	44.9	48 8
	Void Ratio	0.4656	0.4987	0.5130
	Diameter, in.	2.50	2.50	2.50
	Height, in.	1.10	1.10	1.10
Normal Stress, ksf		0.25	0.50	1.00
Fail. Stress, ksf		0.62	0.93	1.45
Displacement, in.		0.04	0.04	0.04
Ult. Stress, ksf		0 67	0.99	1.65
Displacement, in.		0.05	0.05	0.05
Strain rate, in./min.		0.01	0.01	0.01

Sample Type: Disturbed/Remolded
Description: Crushed River Rock

LL= NV PI= NP
Assumed Specific Gravity= 2.669
Remarks: Sample ID 41760

Client: Washington Rock Quarries, Inc.

Project: 2011 Control Samples

Location: Client Supplied
Sample Number: 41760
Proj. No.: 09611028 **Date Sampled:** 1/4/11

Krazan

Tested By: Corbett Mercer Checked By: Corbett Mercer

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION
FORENSIC INVESTIGATION

December 21, 2011

KA No. 096-11028
Lab Report No. 5.7
Page 1 of 1

Mr. Greg Lanphere (E-mail)
WASHINGTON ROCK QUARRIES, INC.
21711 103rd Avenue Ct. E., Suite C-302
Graham, Washington 98338

RE: **AGGREGATE LABORATORY TESTING**
2011 Control Samples, Bothell, Washington

In accordance with your request and authorization, we have performed laboratory tests for the above referenced project. Laboratory testing was performed in accordance with ASTM standards.

Sample ID No:	41760
Description	River Rock & Crushed River Rock
Accelerated Expansion (CRD 148)	
Expansion	0.186%

If you have any questions; or if we can be of further assistance, please do not hesitate to contact our office.

Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Corbett Mercer
Project Manager
Pacific Northwest Division
CM/lm
TACHMENTS

Krazan & Associates, Inc.

Rock Classification for: Washington Rock Quarries, Inc.

File No. 096-11028

November, 2011

Rock samples from Washington Rock Quarries, Inc. were generally classified with respect to the three major rock types (igneous, metamorphic, and sedimentary) using a visual inspection. The sampling was conducted by others, and the following classifications relate to the samples that were provided to Krazan & Associates, Inc. The rock classification procedure generally included counting the number of rocks within a rock-type category. Most rocks were of gravel size, and a minor amount was of cobble size. Some rocks were fractured during compression index testing, and the fractured faces of the rocks were also observed for our interpretations.

Most of the rocks in the sample, approximately 90 percent, were classified as extrusive igneous rocks. In particular, these rocks were identified as porphyritic andesite, which is a type of dark-colored volcanic rock that has a high content of iron and magnesium minerals. Small to medium-sized crystal grains of light-colored feldspar, or feldspar phenocrysts, were observed within many of the mostly dark-colored rock samples.

Approximately 9 percent of the rocks in the sample were classified as plutonic igneous rocks. More specifically, these rocks primarily consisted of medium-grained, light-colored quartz and feldspar minerals, and were identified as granodiorite.

Approximately 1 percent of the rocks in the sample were classified as metamorphic rocks. The samples included nearly parallel bands of alternating light and dark-colored minerals. Specifically, these rocks were interpreted as gneiss, which is a type of high-grade metamorphic rock.

Sedimentary rocks, such as siltstone or sandstone, were not observed within the provided samples.

Laboratory Test Report

8613 Cross Park Dr., Austin, Tx 78754
Phone: 512-977-1800 Fax: 512-873-8866

Project Name:	Washington Rock Quarries Misc Testing	Report Date:	8/1/13
Project No:	04.30132044	Date Sampled:	N/A
Client:	Washington Rock Quarries	Sampled By:	Client
Client Project:	Miscellaneous Testing	Date Received:	7/30/13
Sample Location:	King Creek Quarry	Date Test Started:	7/31/13
Material Source:	King Creek Quarry	Tested By:	DLM
Material Description:	Armor Stone - Fine Aggregate	Sample ID:	8894
Proposed Use:	Bridge Deck Coatings	Lab ID:	8894

	Result	Specification
Acid Insolubility (TEX-612-J)	99%	--
Organic Impurities (TEX-408-A)		--
Unit Weight (TEX-404-A, Rodded)		--
Specific Gravity (TEX-403-A)		--
Specific Gravity, SSD (TEX-403-A)		--
Absorption (TEX-403-A)		--
Sieve Analysis (ASTM D422, D1140)		
% Passing 3/8" Sieve		
% Passing No. 4 Sieve		
% Passing No. 8 Sieve		
% Passsing No. 16 Sieve		
% Passing No. 30 Sieve		
% Passing No. 50 Sieve		
% Passing No. 100 Sieve		
% Passing No. 200 Sieve		
Fineness Modulus (TEX-402-A)		

Submitted By: DRM

David R. Mason, P.G.

Date: 8/1/2013

THE ABOVE TEST RESULTS APPLY ONLY TO THE ITEMS TESTED

National Center for Asphalt Technology

NCAT

at AUBURN UNIVERSITY

Project: Washington Rock

Date: 1/19/2015

Project #:

Sample ID:

Skid Resistance of Aggregates Using The British Pendulum Tester			
	British Pendulum No. (BPN) @ 10 hours		
Sample No.	0 Hours	10 Hours	Remarks:
1	48	40	
	48	40	
	48	40	
	48	39	
Average	48.0	39.8	
2	50	40	
	50	40	
	50	40	
	50	40	
Average	50.0	40.0	
3	54	45	
	54	45	
	54	45	
	54	45	
Average	54.0	45.0	
4	49	40	
	48	40	
	48	40	
	48	40	
Average	48.3	40.0	
5	47	40	
	47	40	
	46	39	
	46	39	
Average	46.5	39.5	
Average	49.4	40.9	

WASHINGTON ROCK QUARRIES INC.

ARMORSTONE

Overlay Aggregate

Product Quality Control Plan

Material Description: ARMORSTONE
Company/Manufacturer: Washington Rock Quarries, Inc.
Company Phone: 253-262-1661
Company Fax: 253-262-1664
Company Address: 21711 103rd Ave Ct. E, Graham, WA 98338
WSDOT source reference: King Creek Pit #PSB-344
Pit Location: W ½ W 1/2 Section 28 T18N R5E, Pierce County, WA
Product Type: Crushed Stone
Quality Control Manager: Ryan Hogg
Quality Control Manager Phone: 253-377-5446

Sampling Plan

Frequency: ARMORSTONE minimum sampling requirements are:

-Once per day of wash plant production

-Once per 100T of wash plant production

-Once per every 25T of drying/bagging plant production

-Product to be sampled in accordance with AASHTO method T 2

-Samples to be reduced to test size in accordance with AASHTO T 248

Sampling description: Pass a clean loader bucket through the full main stream of production material as it comes off conveyer belt at a 90 degree angle and perpendicular to the belt. The clean loader bucket shall pass through the main stream at least twice, once in each direction without overfilling and maintaining a consistent speed during the sampling process. When emptying the sample into the sample container all fines are to be swept from the loader bucket to be included in the sample testing. Combine the increments to form a single representative sample. Samples to be tracked using the date of production, sample number, and technician performing test. Data will be stored electronically using Stonemont Agg. QC software.

ARMORSTONE

MSDS

Other Particulates: 2001 ACGIH TLV® 10mg/m^3 (inhalable/total particulate, not otherwise specified), 2001 ACGIH TLV® 3mg/m3 (respirable particulate, not otherwise specified); OSHA PEL = 15mg/m^3 (total particulate, not otherwise regulated), OSHA PEL = 5mg/m^3 (respirable particulate, not otherwise regulated).

Respirable Crystalline Silica (SiO_2/quartz): ACGIH TLV® = 0.05mg/m^3; MSHA and OSHA PEL = 10mg/m^3 ÷ (%SiO_2 + 2) for respirable dust containing crystalline silica.

Total dust, respirable and nonrespirable: 1973 ACGIH TLV® = 30mg/m^3 ÷ (%quartz + 3).

Total Dust: MSHA PEL = 10mg/m^3 (for nuisance particulates listed in Appendix E of the 1973 ACGIH TLV® booklet).

Per ACGIH, adverse effects are not likely to occur in the workplace provided exposure levels do not exceed the appropriate TLVs/PELs. However, because of the wide variation in individual susceptibility, lower exposure limits may be appropriate for some individuals including persons with pre-existing medical conditions such as those described below.

Medical Conditions Aggravated By Exposure: Inhaling respirable dust and/or crystalline silica may aggravate existing respiratory system disease(s) and/or dysfunction. Exposure to dust may aggravate existing skin and/or eye conditions.

Primary Route(s) of Exposure

X Inhalation Skin Ingestion

Acute Toxicity

EYE CONTACT: Direct contact with dust may cause irritation by mechanical abrasion.
SKIN CONTACT: Direct contact may cause irritation by mechanical abrasion.
SKIN ABSORPTION: Not expected to be a significant exposure route.
INGESTION: Expected to be practically non-toxic. Ingestion of large amounts may cause gastrointestinal irritation and blockage.
INHALATION: Dusts may irritate the nose, throat, and respiratory tract by mechanical abrasion. Coughing, sneezing, and shortness of breath may occur following exposures in excess of appropriate exposure limits.

Use of natural sand and gravel for construction purposes is not believed to cause additional acute toxic effects. However, repeated overexposures to very high levels of respirable crystalline silica (quartz, cristobalite, tridymite) for periods as short as six months have caused acute silicosis. Acute silicosis is a rapidly progressive, incurable lung disease that is typically fatal. Symptoms include (but are not limited to): shortness of breath, cough, fever, weight loss, and chest pain.

First Aid

EYES: Immediately flush eye(s) with plenty of clean water for at least 15 minutes, while holding the eyelid(s) open. Occasionally lift the eyelid(s) to ensure thorough rinsing. Beyond flushing, do not attempt to remove material from the eye(s). Contact a physician if irritation persists or later develops.
SKIN: Wash with soap and water. Contact a physician if irritation persists or later develops.
INGESTION: If person is conscious, give large quantity of water and induce vomiting; however, never attempt to make an unconscious person drink or vomit. Get immediate medical attention.
INHALATION: Move to fresh air. Dust in throat and nasal passages should clear spontaneously.
Contact a physician if irritation persists or later develops.

For emergencies, contact ______________________________
(your company's designated emergency contact)

Other Control Measures

Respirable dust and quartz levels should be monitored regularly. Dust and quartz levels in excess of appropriate exposure limits should be reduced by all feasible engineering controls, including (but not limited to) wet suppression, ventilation, process enclosure, and enclosed employee work stations.

8. STORAGE AND HANDLING PRECAUTIONS

This product is not intended or designed for use as an abrasive blasting medium or for foundry applications, and should not be used for these purposes.

Follow the personal protection and controls set forth in Section 7 of this MSDS when handling this product. Respirable crystalline silica-containing dust may be generated during processing, handling, and storage.

Do not store near food and beverages or smoking materials.

9. SPILL, LEAK AND DISPOSAL PRACTICES

Steps to be Taken in Case Material is Released or Spilled

The personal protection and controls identified in Section 7 of the MSDS should be used as appropriate. Spilled material, where dust can be generated, may overexpose cleanup personnel to respirable crystalline silica-containing dust. Wetting of spilled material and/or use of respiratory protective equipment may be necessary. Do not dry sweep spilled material.

Prevent spilled materials from inadvertently entering streams, drains, or sewers.

For emergencies, contact ______________________________

(your company's designated emergency contact)

Waste Disposal Method

Pick up and reuse clean materials. Dispose of waste materials only in accordance with applicable federal, state, and local laws and regulations.

10. TRANSPORTATION

DOT Hazard Classification: None

Placard Required: None

Label Required: Label as required by the OSHA Hazard Communication Standard [29 CFR 1910.1200 (f) and applicable state and local laws and regulations.

For Further Information Contact: Place here the name, address, and telephone number of the operator or responsible party who can provide more info about the hazardous chemical.

Date of Preparation:

Emergency Information: Your company's designated emergency contact.

Notice: ________________ believes the information contained herein is accurate; however, ________________ makes no guarantees with respect to such accuracy and assumes no liability in connection with the use of the information contained herein by any party. The provision of the information contained herein is not intended to be and should not be construed as legal advice or as ensuring compliance with any federal, state or local laws and regulations. Any party using this product should review all such laws, rules or regulations prior to use.

NO WARRANTY IS MADE, EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OTHERWISE.

APPENDIX D. FIELD NOTES FROM 2020 AND 2022 INSPECTIONS

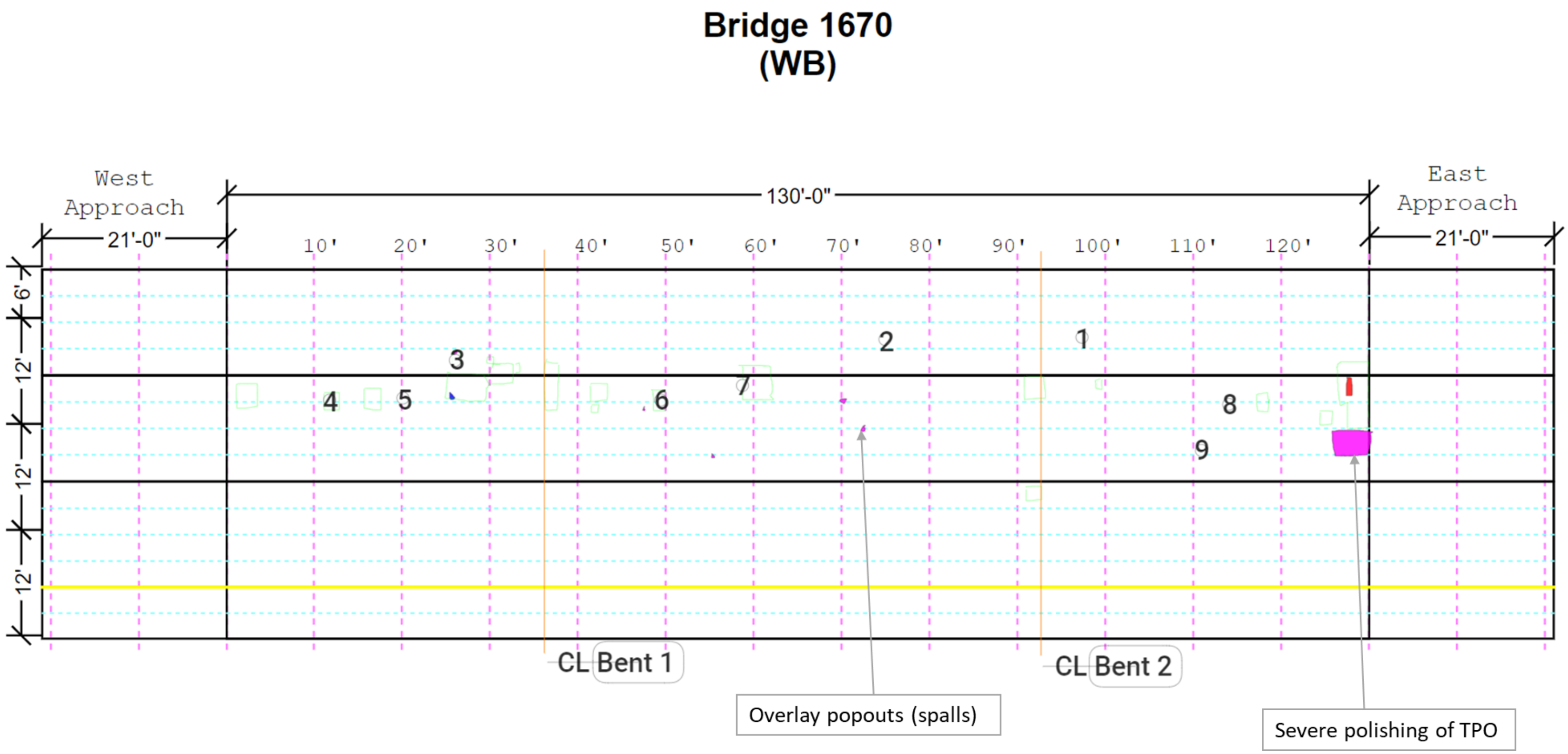


Figure D.1. Field notes for Bridge 1670, 2020 inspection, HFST.

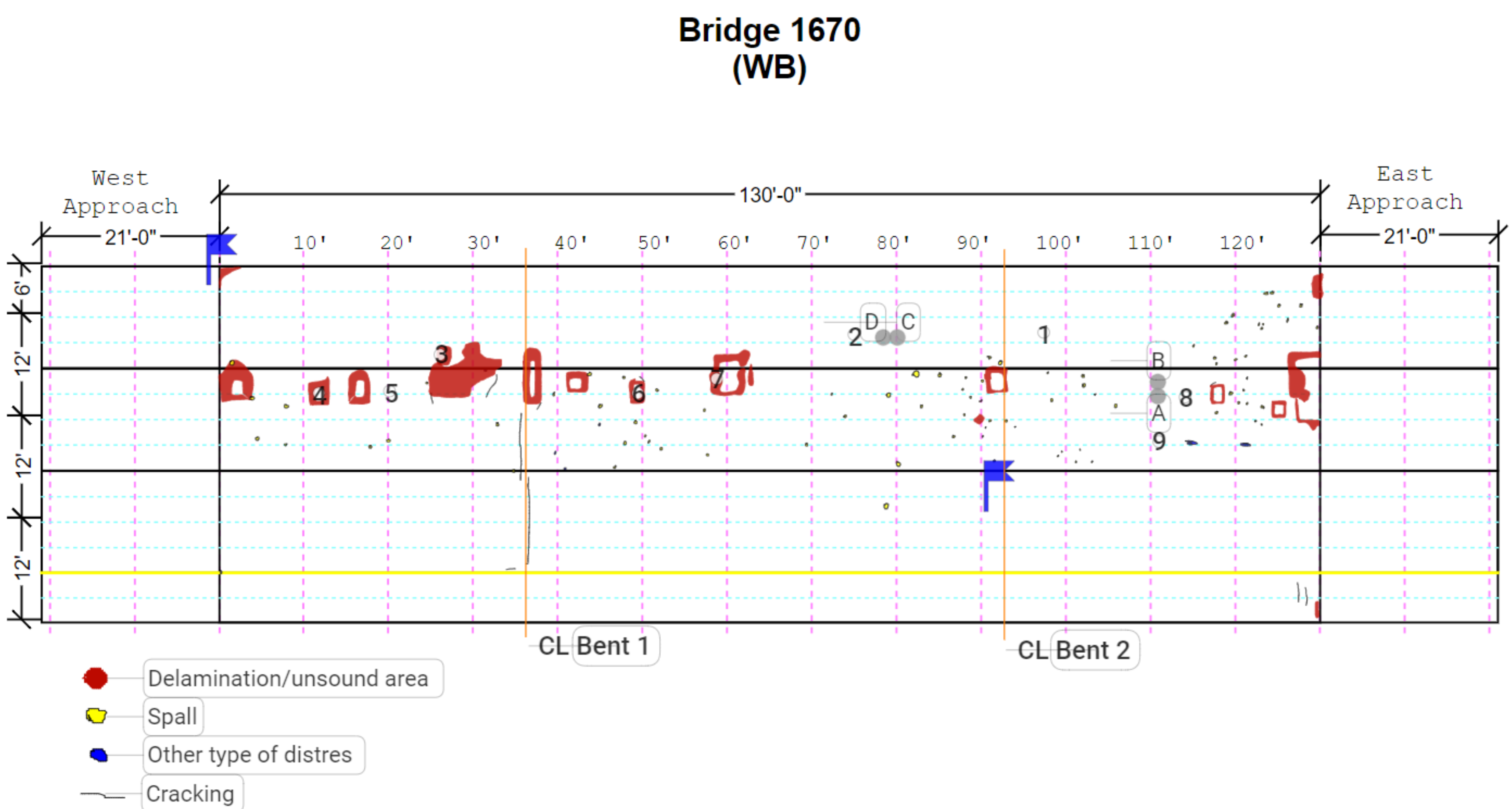


Figure D.2. Field notes for Bridge 1670, 2022 inspection, HFST.

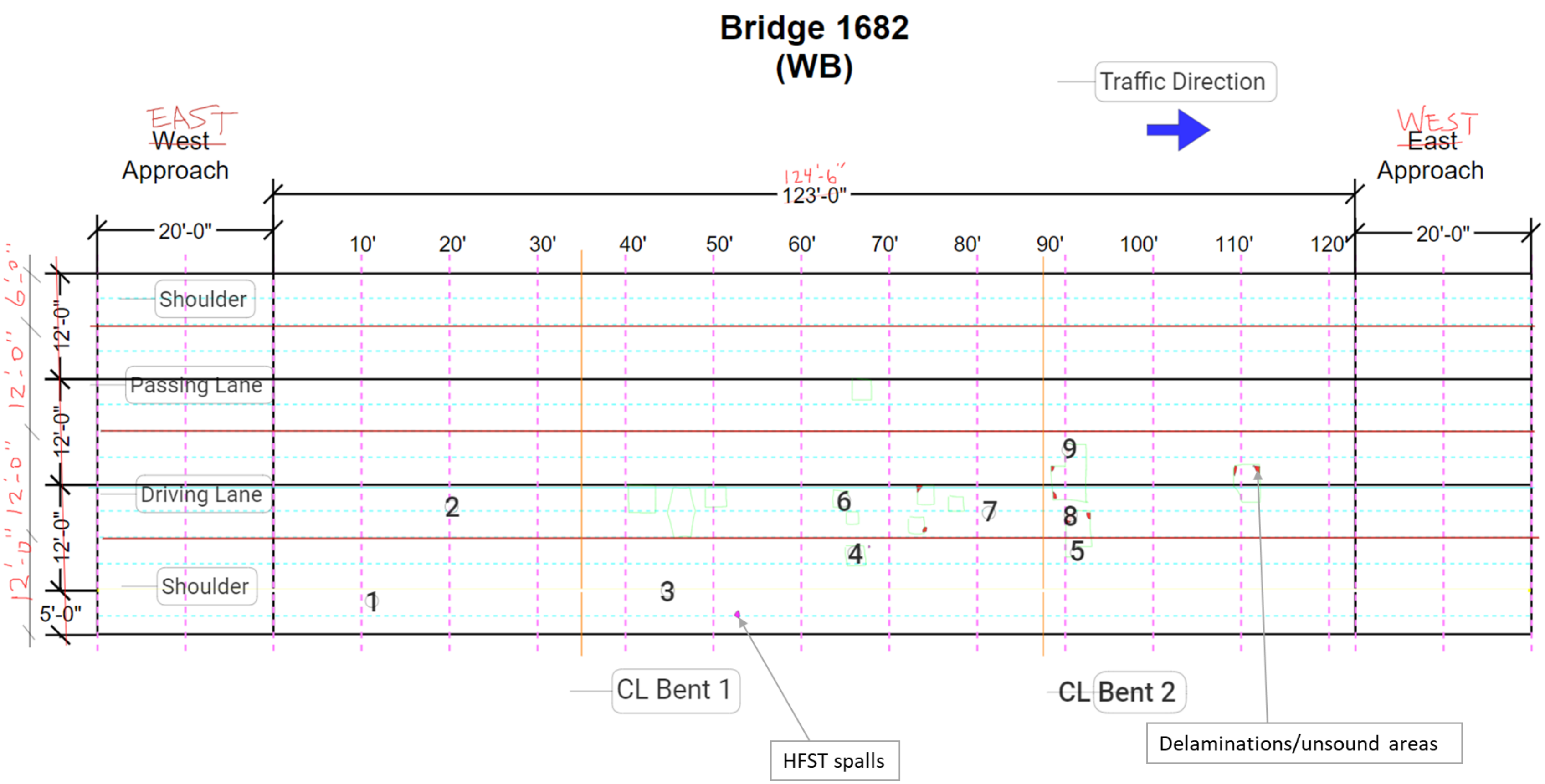


Figure D.3. Field notes for Bridge 1682, 2020 inspection, HFST.

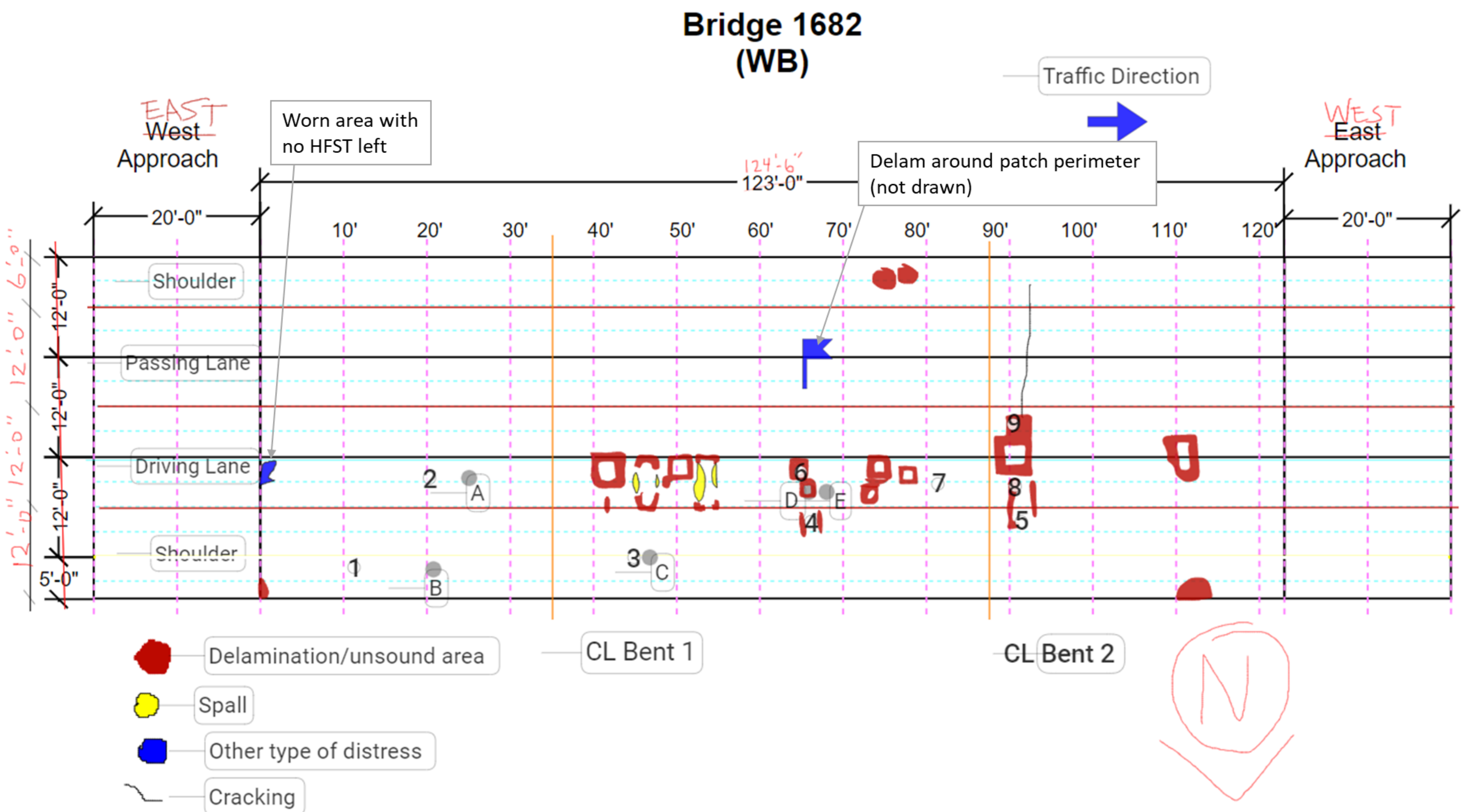


Figure D.4. Field notes for Bridge 1682, 2022 inspection, HFST.

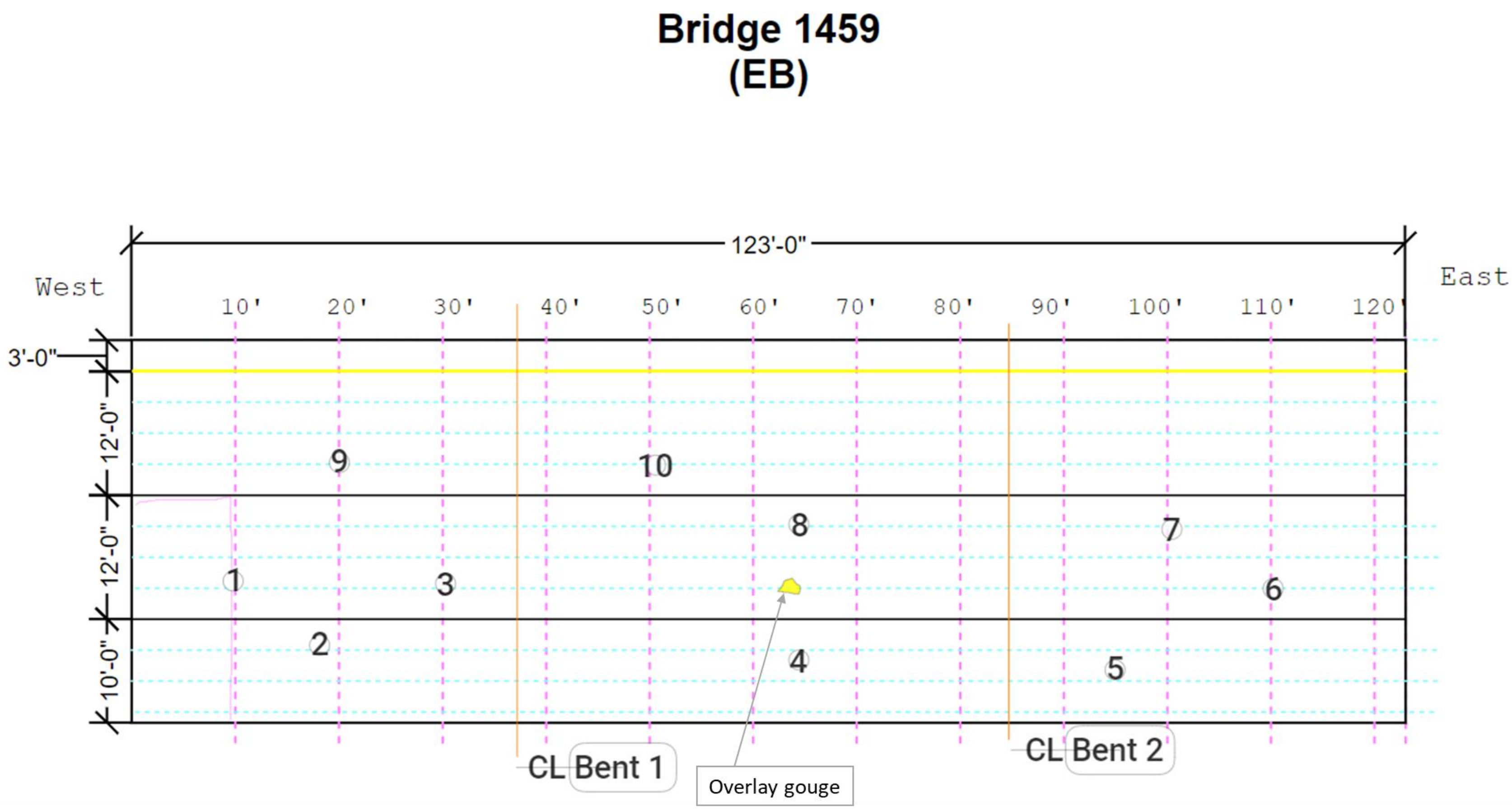


Figure D.5. Field notes for Bridge 1459, 2020 inspection, HFST.

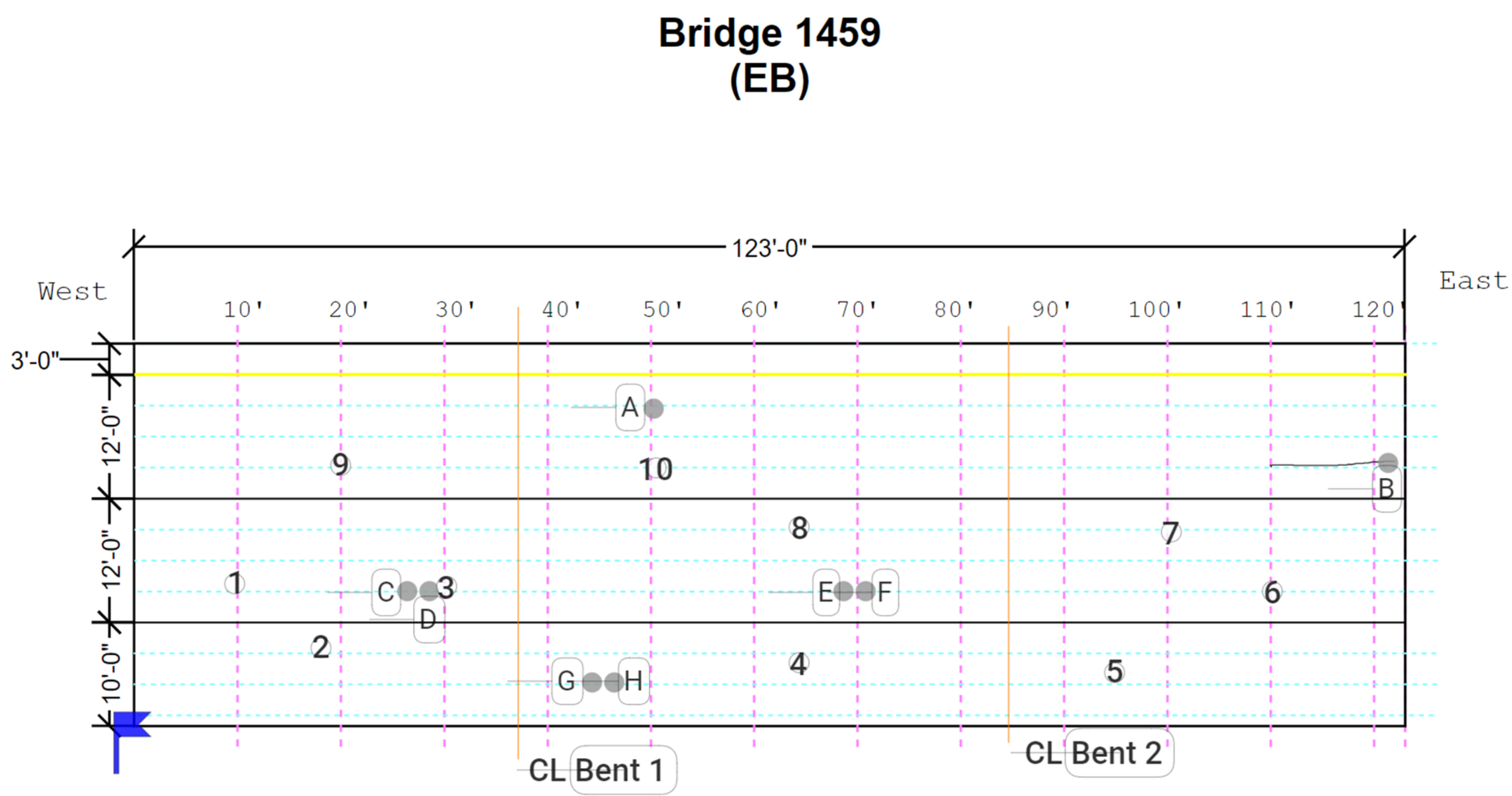


Figure D.6. Field notes for Bridge 1459, 2022 inspection, HFST.

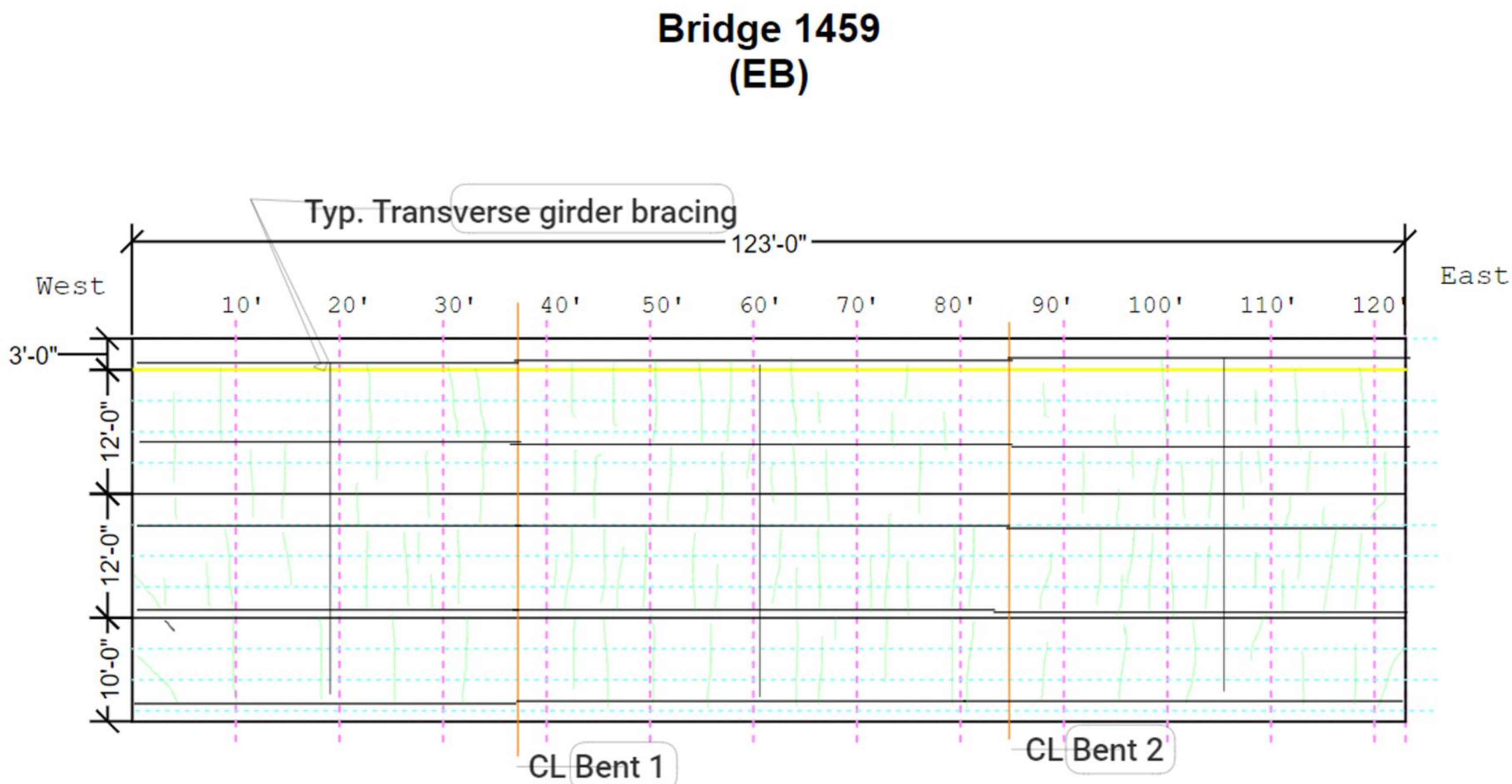


Figure D.7. Field notes for Bridge 1459, 2020 inspection, soffit.

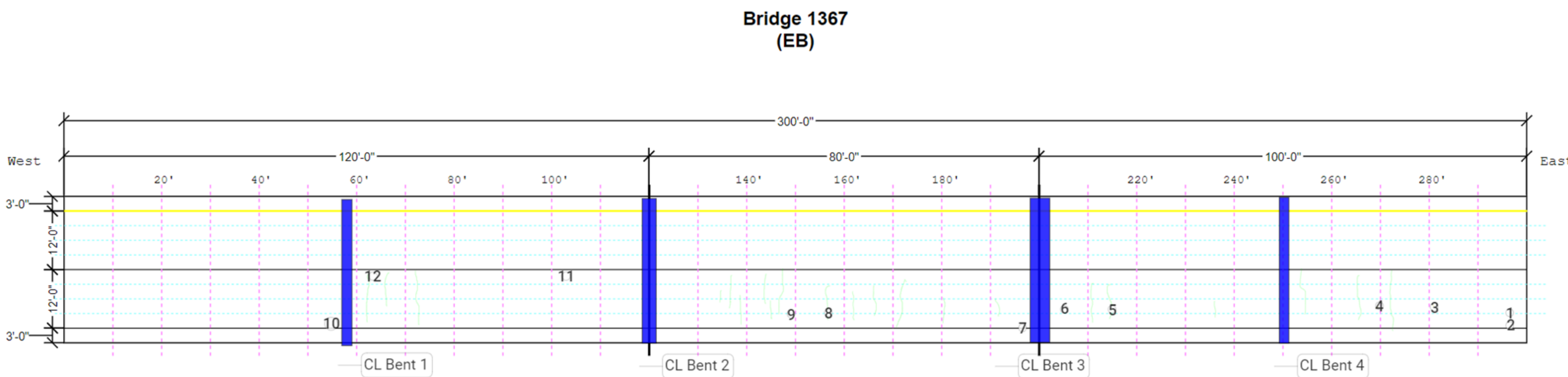


Figure D.8. Field notes for Bridge 1367, 2020 inspection, HFST.

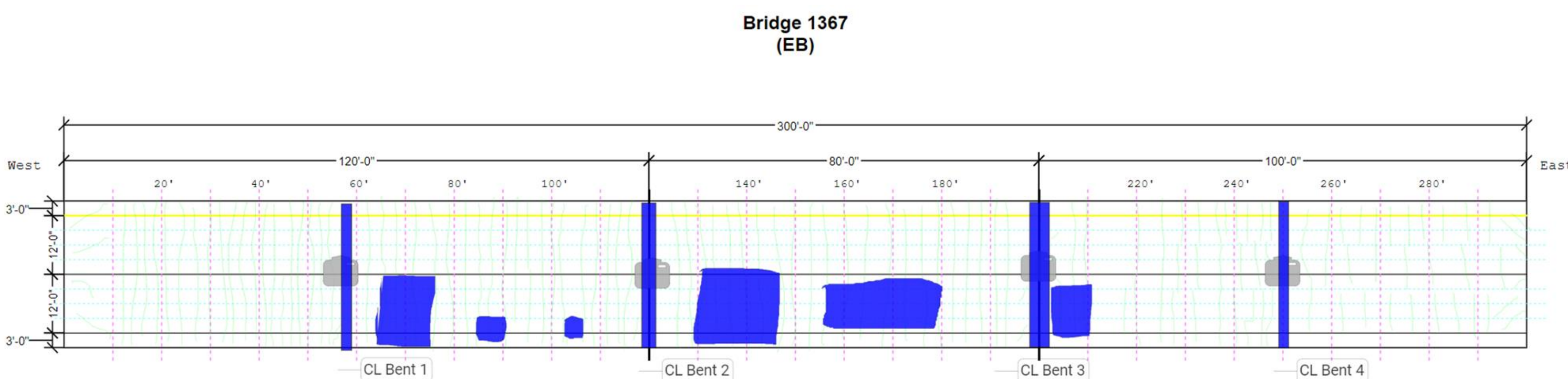


Figure D.9. Field notes for Bridge 1367, 2020 inspection, soffit.

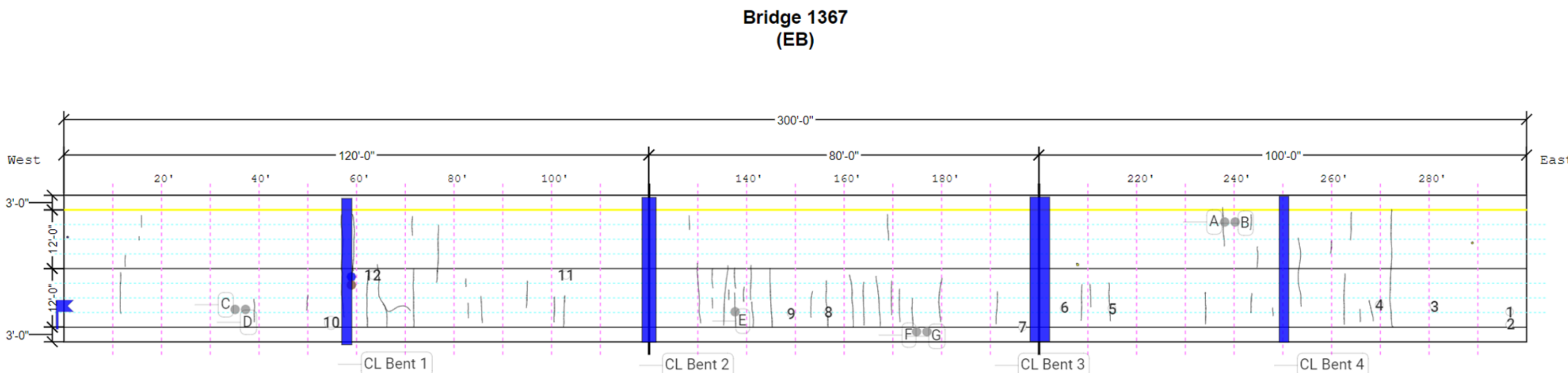


Figure D.10. Field notes for Bridge 1367, 2022 inspection., HFST.

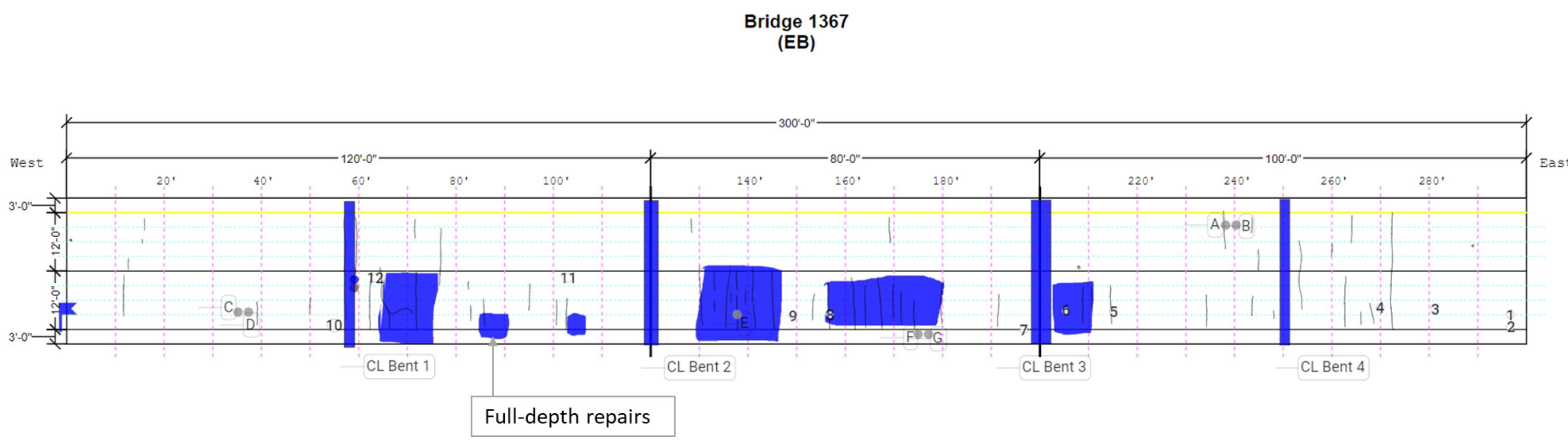


Figure D.11. Field notes for Bridge 1367, 2022 inspection, HFST, with full-depth repairs as identified from 2020 soffit inspection for comparison.

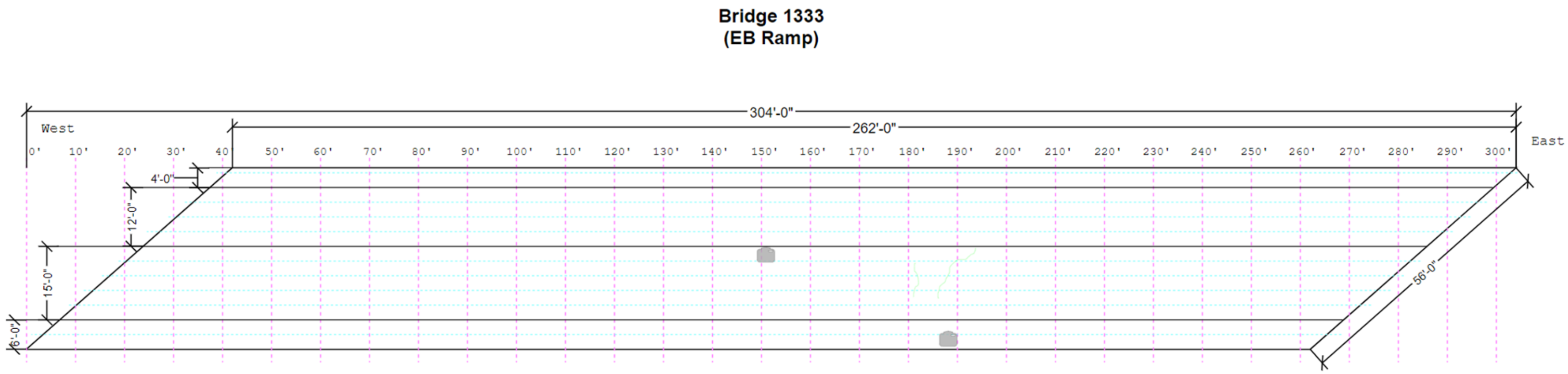


Figure D.12. Field notes for Bridge 1333, 2020 inspection, HFST.

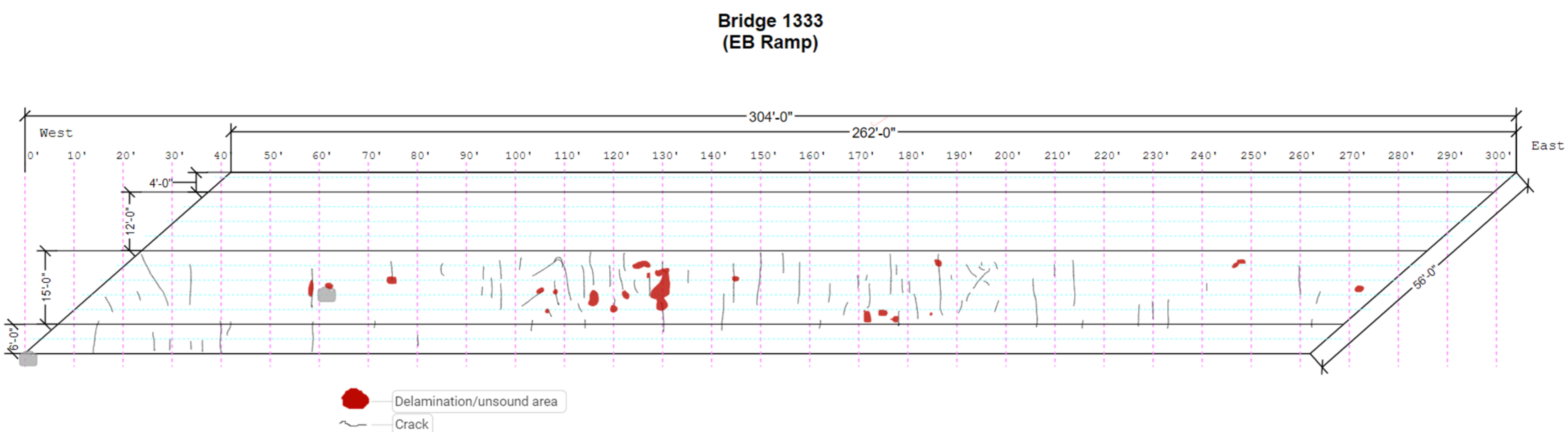


Figure D.13. Field notes for Bridge 1333, 2022 inspection, HFST.

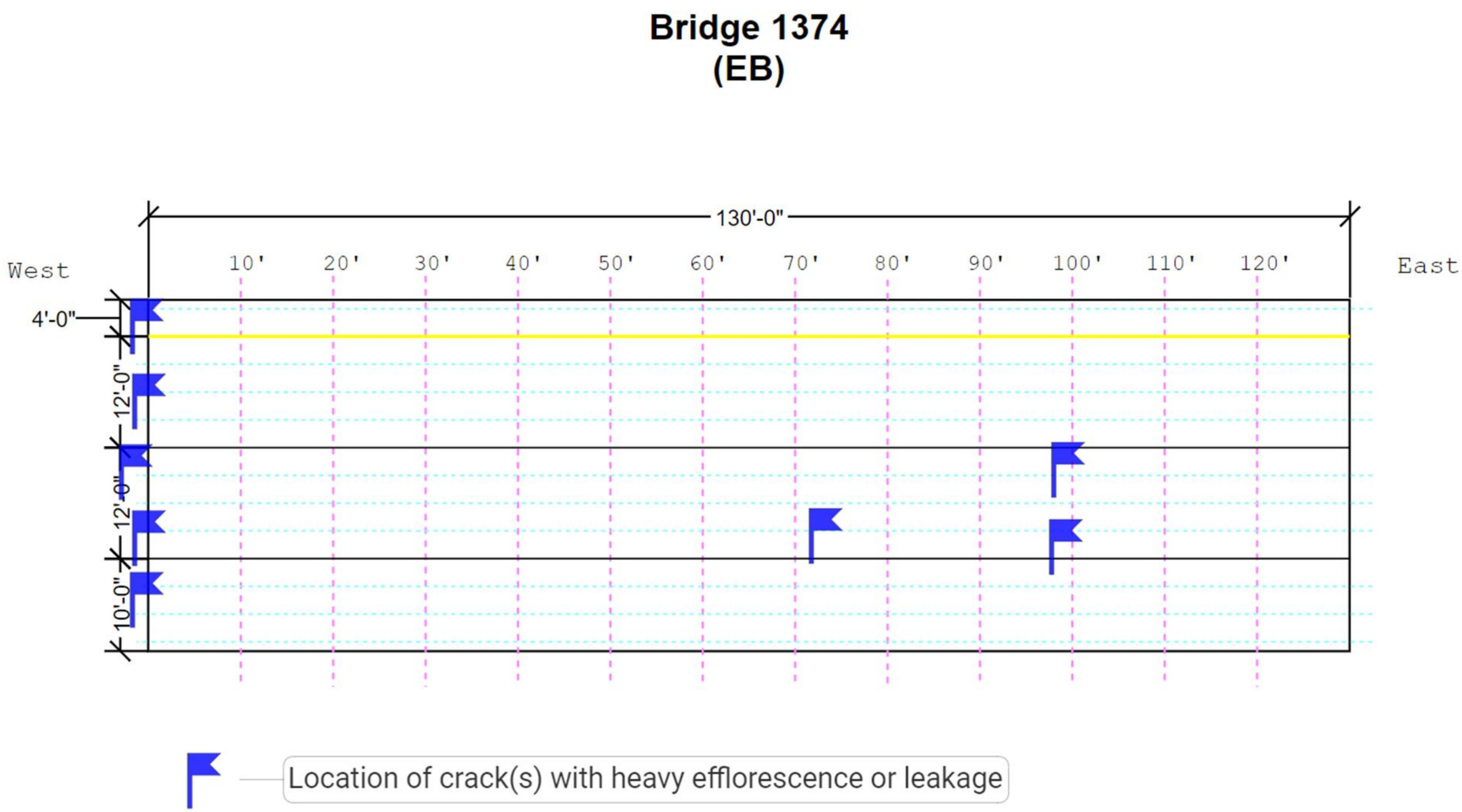


Figure D.14. Field notes for Bridge 1374, 2022 inspection, soffit.

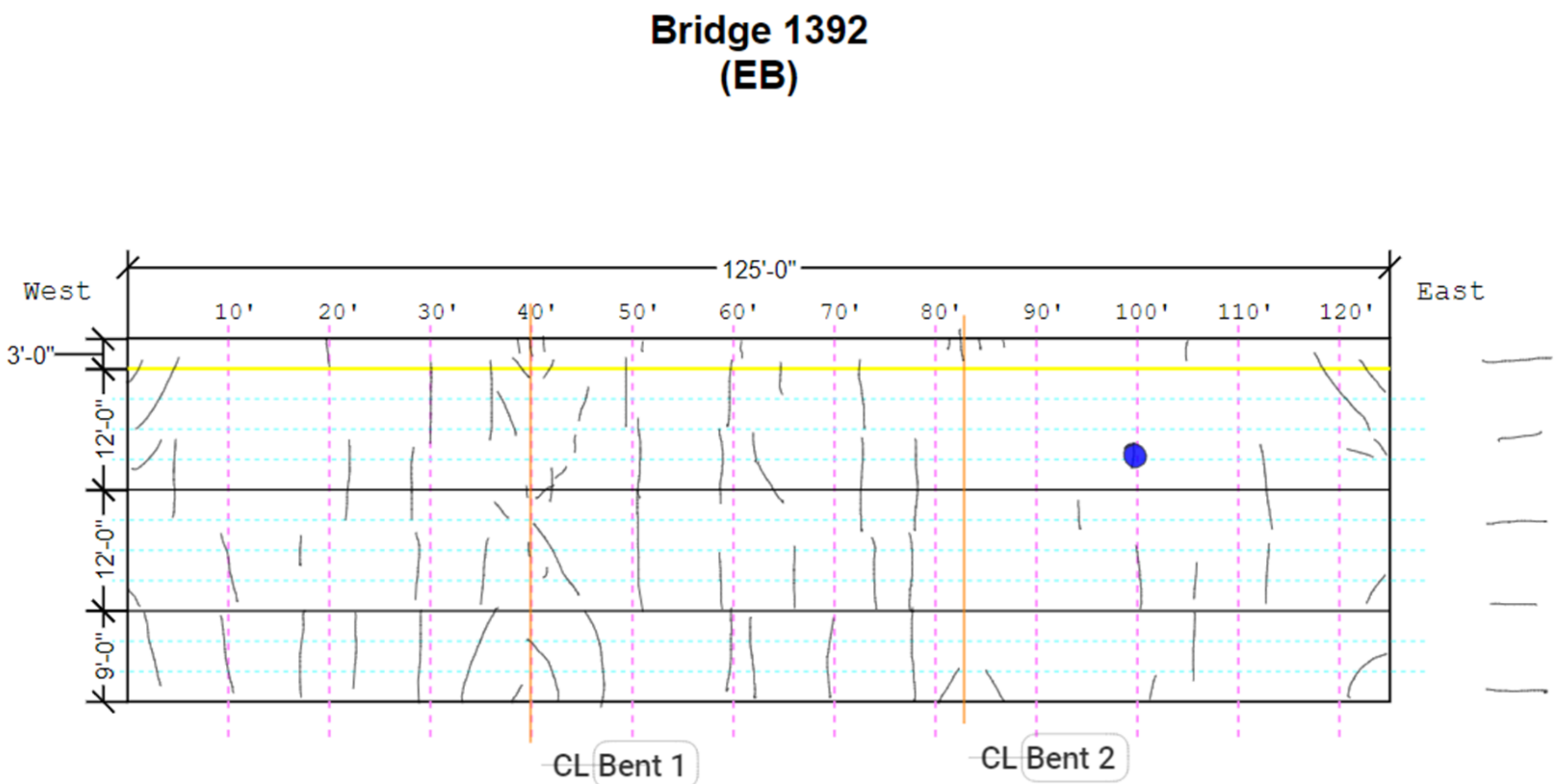


Figure D.15. Field notes for Bridge 1392, 2022 inspection, soffit.

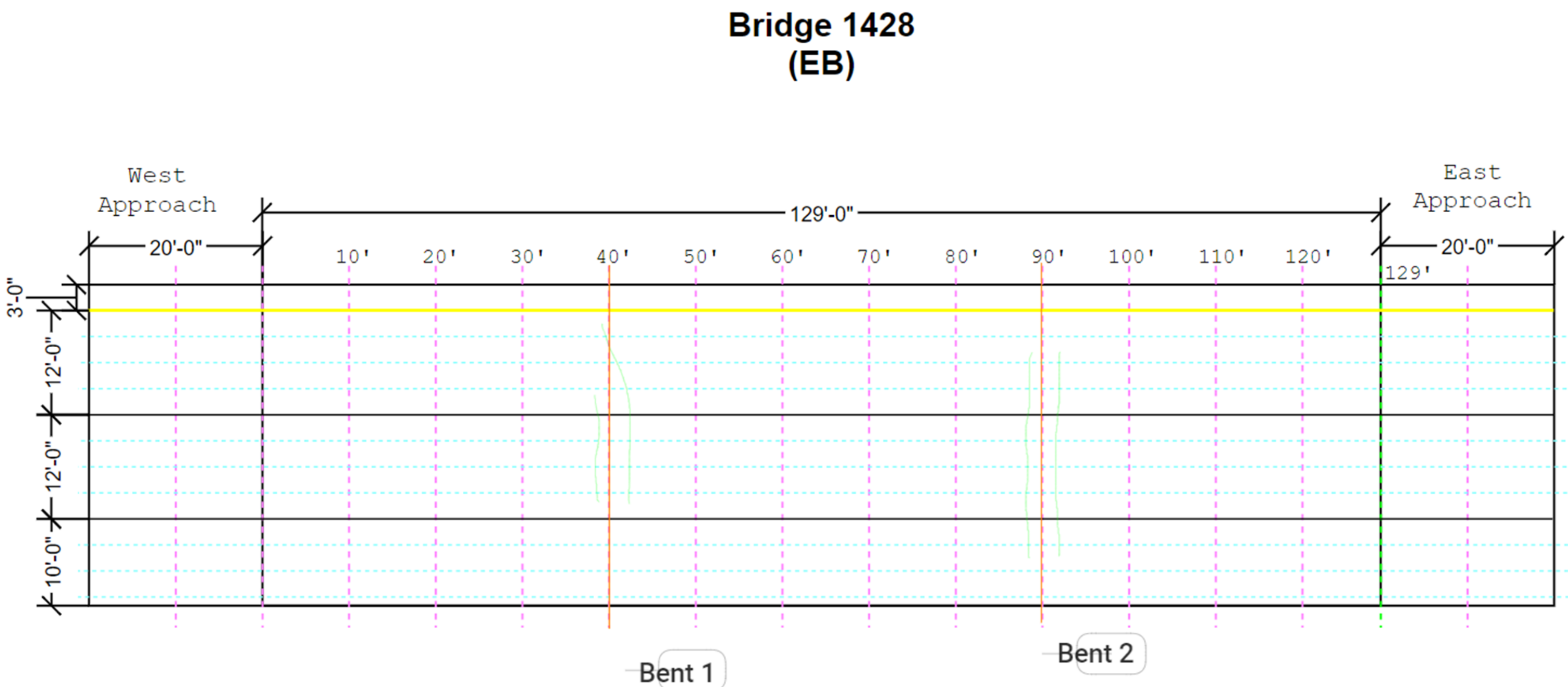


Figure D.16. Field notes for Bridge 1428, 2020 inspection, HFST.

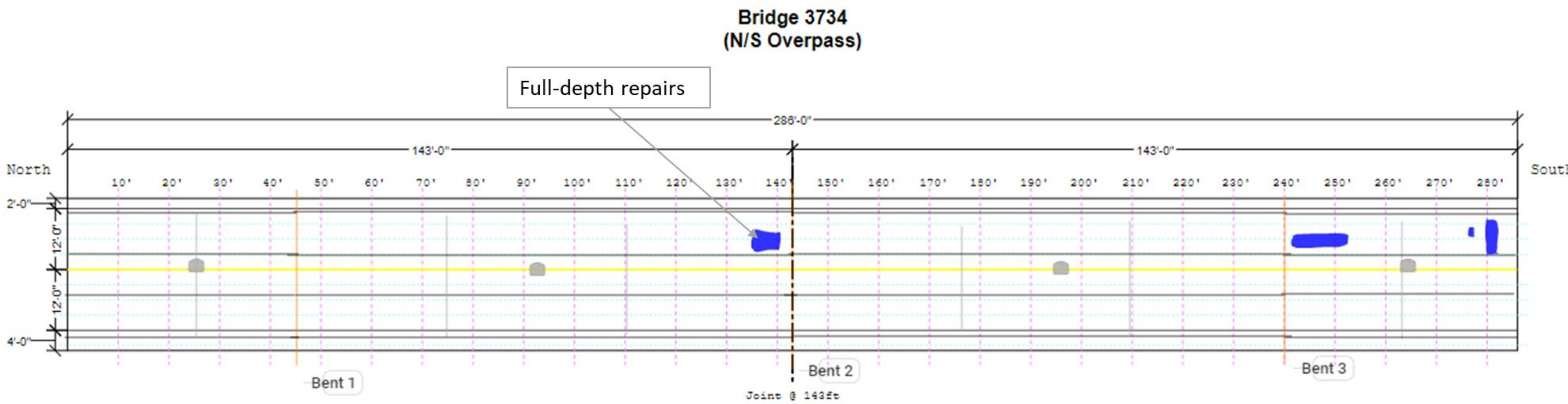


Figure D.17. Field notes for Bridge 3734, 2020 inspection, soffit.

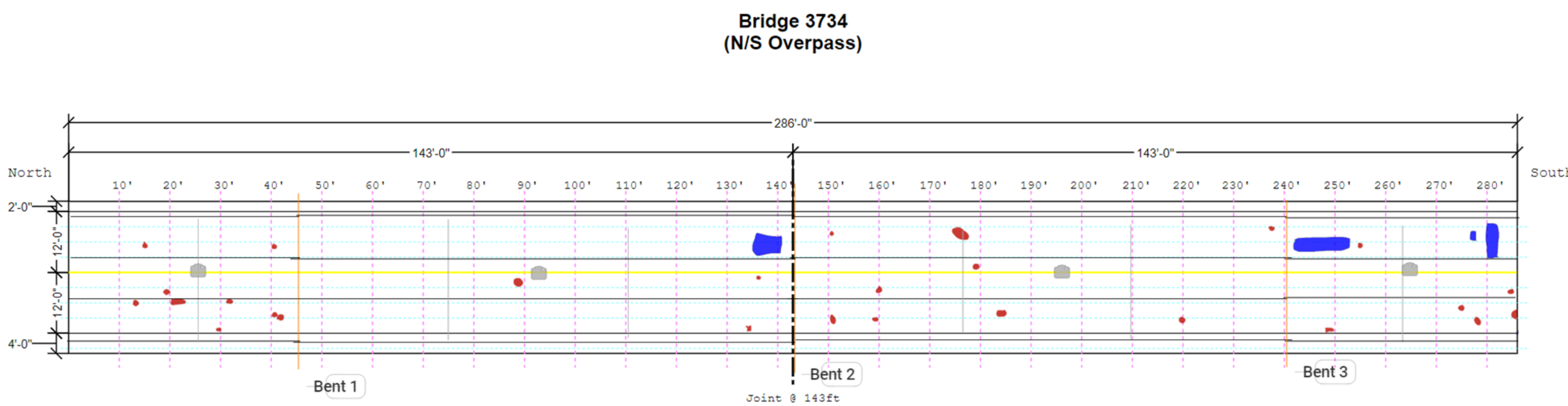


Figure D.18. Field notes for Bridge 3734, 2022 inspection, HFST with full-depth repairs from 2020 inspection shown.

APPENDIX E. LABORATORY TEST RESULTS

Core ID	Dia. (in.)		Weight Before (g)	Weight After (g)	Edge Void 1		Edge Void 2		Edge Void 3		Edge Void 4		Edge Void 5		Edge Void 6		Edge Void 7		Area (in.^{2})			Difference in Weight (g)	Notes:	Sand Weight (lb)	Sand Volume (in.^{3})	MTD (in.)
1670-1	3.677	3.671	1850.6	1860.2	0.413	0.062	0.339	0.128											10.601521	0.068998	10.53252	9.6		0.0212	0.3483	0.132
1670-2	3.699	3.683	1117.3	1128.3	0.140	0.109													10.699857	0.01526	10.6846	11		0.0243	0.3991	0.149
1670-4	3.685	3.69	989.1	997	0.576	0.143	0.156	0.074	0.242	0.070									10.679574	0.110852	10.56872	7.9		0.0174	0.2866	0.108
1670-5	3.708	3.667	2065.6	2070.9	0.122	0.059	0.212	0.107	0.227	0.173									10.679574	0.069153	10.61042	5.3		0.0117	0.1923	0.072
1670-6	3.686	3.676	1233.5	1239.2	0.165	0.085													10.641957	0.014025	10.62793	5.7		0.0126	0.2068	0.078
1670-8	3.678	3.673	265.1	270.7	0.143	0.092	0.119	0.061											10.61018	0.020415	10.58976	5.6		0.0123	0.2032	0.077
1670-9	3.685	3.69	1506.5	1514.6	0.141	0.053	0.406	0.062	0.142	0.059	0.150	0.102							10.679574	0.056323	10.62325	.1		0.0179	0.2939	0.111
1459-1	3.74	3.751	2194.7	2204.3	0.215	0.165	0.295	0.122											11.01817	0.071465	10.94671	9.6	*Unlevel	0.0212	0.3483	0.127
1459-2	3.74	3.745	2226.7	2235	0.178	0.041													11.000527	0.007298	10.99323	.3		0.0183	0.3011	0.110
1459-3	3.741	3.741	2050.8	2057.5	0.144	0.059	0.106	0.057											10.991711	0.014538	10.97717	6.7		0.0148	0.2431	0.089
1459-4	3.739	3.745	2189.1	2201.2	0.075	0.040	0.118	0.078	0.095	0.040	0.035	0.014							10.99758	0.016494	10.98109	12.1		0.0267	0.4390	0.160
1459-5	3.74	3.744	2319.5	2330.9	0.136	0.055	0.134	0.041	0.184	0.072	0.127	0.039							10.99758	0.031175	10.96641	11.4		0.0251	0.4136	0.151
1459-6	3.745	3.745	2087.3	2093	0.147	0.050													11.015229	0.00735	11.0078	5.7		0.0126	0.2068	0.075
1459-8	3.74	3.74	2230.4	2234.1	0.117	0.074	0.086	0.074											10.985835	0.015022	10.97081	3.7		0.0082	0.1342	0.049
1459-9	3.74	3.747	2206.2	2215	0.133	0.062	0.109	0.079	0.251	0.062	0.152	0.075							11.006407	0.043819	10.96259	.8		0.0194	0.3193	0.116
1459-10	3.726	3.738	2133.6	2141.7	0.250	0.043	0.175	0.041	0.195	0.053									10.938887	0.02826	10.91063	.1		0.0179	0.2939	0.108
1367-1	3.747	3.744	2323.2	2329.6	0.175	0.074	0.184	0.075	0.099	0.041	0.169	0.075	0.158	0.038	0.336	0.050	0.230	0.089	11.01817	0.086758	10.93141	6.4		0.0141	0.2322	0.085
1367-2	3.741	3.734	2316.3	2325.7	0.162	0.079	0.104	0.022											10.971153	0.015086	10.95607	9.4		0.0207	0.3410	0.125
1367-5	3.742	3.746	2302.4	2310.2	0.210	0.040	0.127	0.040	0.269	0.082	0.157	0.034	0.351	0.065	0.235	0.140	0.141	0.081	11.009347	0.108012	10.90134	7.8		0.0172	0.2830	0.104
1367-6	3.739	3.738	2287.8	2293.9	0.185	0.150	0.314	0.054	0.133	0.111									10.977025	0.059469	10.91756	6.1		0.0134	0.2213	0.081
1367-7	3.744	3.737	1403.7	1415.6	0.196	0.062	0.143	0.139	0.137	0.042									10.988773	0.037783	10.95099	11.9		0.0262	0.4318	0.158
1367-10	3.743	3.744	2084.6	2091.9															11.006407	0	11.00641	7.3		0.0161	0.2649	0.096
1367-11	3.744	3.747	2117.7	2124.3	0.195	0.081	0.181	0.108	0.277	0.054	0.145	0.067							11.01817	0.060016	10.95815	6.6		0.0146	0.2395	0.087
1367-12	3.739	3.73	2157.6	2164.2	0.160	0.056	0.190	0.100	0.100	0.310	0.100	0.130	0.100	0.320	0.060	0.270			10.953548	0.12016	10.83339	6.6		0.0146	0.2395	0.08
1682-1	3.743	3.745	2333	2342.5	0.170	0.126	0.068	0.077											11.009347	0.026656	10.98269	9.5		0.0209	0.3447	0.126
1682-2	3.748	3.742	2084.3	2090.9	0.175	0.066	0.091	0.033	0.138	0.076	0.171	0.041	0.244	0.077					11.015229	0.05084	10.96439	6.6		0.0146	0.2395	0.087
1682-3	3.752	3.745	2085.4	2094.7	0.171	0.051	0.286	0.060	0.225	0.096									11.035828	0.047481	10.98835	9.3		0.0205	0.3374	0.123
1682-4	3.737	3.743	1937.8	1947.6	0.416	0.054	0.207	0.085	0.195	0.070	0.209	0.100							10.985835	0.074609	10.91123	9.8		0.0216	0.3556	0.130
1682-7	3.736	3.745	1973.4	1978.2	0.106	0.051	0.066	0.028											10.988773	0.007254	10.98152	4.8		0.0106	0.1742	0.063
1682-9	3.753	3.742	1191.9	1197	0.192	0.085													11.02994	0.01632	11.01362	5.1		0.0112	0.1850	0.067

Core ID	Dia. 1 (in.)	Dia. 2 (in.)	Weight Before (g)	Weight After (g)	Edge Void 1		Edge Void 2		Edge Void 3		Edge Void 4		Edge Void 5		Edge Void 6		Edge Void 7		Area ($in.^2$)			Difference in Weight (g)	Notes:	Sand Weight (lb)	Sand Volume ($in.^3$)	MTD (in.)
1367-B	3.896	3.898	2414.4	2425.2	0.216	0.094	0.246	0.050	0.364	0.047									11.927535	0.049228	11.87831	10.8		0.0238	0.3918	0.132
1367-C	3.895	3.892	2306.7	2310.5															11.90612	0	11.90612	3.8		0.0084	0.1379	0.046
1367-D	3.893	3.904	2236.7	2240.5															11.936719	0	11.93672	3.8		0.0084	0.1379	0.046
1367-F	3.897	3.897	2165.6	2176.3															11.927535	0	11.92753	10.7		0.0236	0.3882	0.130
1367-G	3.895	3.888	2142.8	2150.6															11.893891	0	11.89389	7.8		0.0172	0.2830	0.095
1459-A	3.886	3.9	2462.5	2468.6															11.903062	0	11.90306	6.1	*Unlevel	0.0134	0.2213	0.074
1459-C	3.899	3.898	2310	2315.8	0.298	0.128													11.936719	0.037995	11.89872	5.8		0.0128	0.2104	0.071
1459-D	3.896	3.9	2215.9	2221.3	0.096	0.091	0.483	0.129											11.933657	0.07095	11.86271	5.4		0.0119	0.1959	0.066
1459-E	3.895	3.895	2217.4	2222.2															11.915295	0	11.9153	4.8		0.0106	0.1742	0.058
1459-F	3.892	3.896	2319.9	2324.2	0.227	0.138	0.285	0.083											11.909178	0.054615	11.85456	4.3		0.0095	0.1560	0.053
1459-G	3.897	3.897	2223.1	2241.9															11.927535	0	11.92753	18.8		0.0414	0.6821	0.229
1459-H	3.886	3.902	2232.9	2252.1															11.909178	0	11.90918	19.2		0.0423	0.6966	0.234
1670-A	3.888	3.892	2295.3	2300.7															11.884724	0	11.88472	5.4		0.0119	0.1959	0.066
1670-B	3.892	3.877	2314.9	2318.9															11.85114	0	11.85114	4		0.0088	0.1451	0.049
1670-C	3.892	3.894	2216.7	2227.6															11.903062	0	11.90306	10.9		0.0240	0.3955	0.133
1670-D	3.9	3.892	1463.6	1475.9															11.921414	0	11.92141	12.3		0.0271	0.4463	0.150
1682-A	3.893	3.906	2240	2244.9	0.464	0.141													11.942843	0.065192	11.87765	4.9		0.0108	0.1778	0.060
1682-B	3.891	3.891	2362.7	2373.6															11.890835	0	11.89083	10.9		0.0240	0.3955	0.133
1682-C	3.89	3.891	2277.4	2287.6															11.887779	0	11.88778	10.2		0.0225	0.3701	0.125
1682-D	3.889	3.903	1748.6	1755.1	0.137	0.097	0.157	0.077											11.921414	0.025251	11.89616	6.5		0.0143	0.2358	0.079
1682-E	3.89	3.889	1967	1973.6	0.586	0.171													11.881669	0.099913	11.78176	6.6		0.0146	0.2395	0.081

WJE

TEST REPORT

AASHTO T357-15, Predicting Chloride Penetration of Hydraulic Cement Concrete by the Rapid Migration Procedure

Sample Designation:	2019.5465 MDT TPO/HFST Year 1 RMTs
Sample Description:	Seven concrete cores approximately 3. inches in diameter from 4 bridge decks
Sample Curing:	n/a; cores
Test Requested By:	Montana Department of Transportation
Sample Supplier:	Samples cored by WJE in August, 2020
Date Received:	September 14, 2020
Testing Agency:	Wiss, Janney, Elstner Associates, Inc. 330 Pfingsten Road, Northbrook, IL 60062
Test Date:	July 8, 2021
Tested By:	L. Zegler
Reviewed By:	K. Hawkins

Specimen Dimensions

Specimen ID	Diameter in	Thickness 1 mm	Thickness 2 mm	Thickness 3 mm	Thickness 4 mm	Average Thickness mm
1367-2	3.6875	52	49	51	49	**50**
1367-11	3.6875	49	52	50	51	**51**
1459-3	3.6875	51	52	52	50	**51**
1459-5	3.6875	51	51	50	52	**51**
1670-1	3.625	51	51	51	51	**51**
1670-5	3.625	53	50	51	51	**51**
1682-1	3.625	51	51	53	50	**51**

Test Information

Start of Test:	July 8, 2021 12:45 pm
End of Test:	July 9, 2021 6:48 am
Test Duration:	18 hr
Applied Voltage:	60 V

Specimen ID	Initial Current at 60 V mA	Final Current at 60 V mA	Initial Temperature, °F		Final Temperature, °F	
			NaOH	NaCl	NaOH	NaCl
1367-2	7.8	24.6	69.6	74.5	71.8	72.0
1367-11	16.2	21.8	70.0	73.4	75.0	75.2
1459-3	3.1	15.3	71.4	71.4	72.1	72.1
1459-5	0.4	1.7	71.8	71.4	72.0	72.1

Specimen ID	Initial Current at 60 V mA	Final Current at 60 V mA	Initial Temperature, °F		Final Temperature, °F	
			NaOH	NaCl	NaOH	NaCl
1670-1	0.6	3.7	71.2	73.8	71.6	71.8
1670-5	0.2	2.2	71.2	74.1	71.4	71.4
1682-1	1.6	5.0	71.1	74.5	71.4	71.4

Chloride Penetration

Specimen ID	Penetration Depth, mm								Average Penetration mm	Rate of Penetration mm/V-h
	1	2	3	4	5	6	7	8		
1367-2 (SH)	5	3	5	6	4	2	0	*	4	0.003
1367-11 (DR)	3	29	48	46	46	44	44	45	38	0.035
1459-3 (DR)	45	45	16	*	*	34	37	32	35	0.032
1459-5 (SH)	19	24	24	30	26	34	25	37	27	0.025
1670-1 (SH)	9	0	*	6	*	5	7	4	5	0.005
	43	32	27	31	45	44	45	45	39	0.036
1670-5 (DR)	47	47	32	28	29	31	35	45	37	0.034
1682-1 (SH)	34	40	41	42	44	45	39	*	41	0.038

** Measurement obstructed by aggregate.*

Note: no averages are shown due to the general lack of a distinct chloride front.

APPENDIX F. FULL PETROGRAPHIC REPORT

Wiss, Janney, Elstner Associates, Inc.
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MEMORANDUM | February 2, 2021

Montana PPC Overlay - HFST

Petrographic Examination of Cores

WJE PROJECT NO. 2019.5465

TO Kate Hawkins
Associate II
WJE

FROM Hugh Hou

As requested, limited microscopical examinations were conducted on 10 composite cores of polymer overlay and substrate concrete to assess the characteristics of the overlay and the substrate concrete. Microscopical examinations were conducted in general accordance with ASTM C856, *Standard Practice for Petrographic Examination of Hardened Concrete*, and observations were mainly made on the as-received cores and lapped cross sections of 5 of the 10 cores (Table C.1). No sample preparation was conducted on the remaining 5 cores and examination of these 5 cores was made solely on as-received samples. Major findings based on the 5 lapped samples are summarized in the the table, illustrated in attached figures, and described below. Descriptions of the 5 unprepared cores are at the last paragraph of the memo.

Overlay

- Each core consists of a sand-resin polymer overlay 0.2 to 0.3 inches thick and substrate concrete. The two layers of materials were generally well bonded.
- General appearance of overlay, substrate concrete, and the surface preparation of the substrate can be seen from the photographs of the across-diameter sections. Thickness measurements of the overlay, cracks, crack sealers, and voids are shown in close-up stereomicroscopic photos.
- The sand-polymer overlay appeared to have performed well or satisfactorily. No major cracks or other forms of distress were observed in the overlay. No anomaly or unusual features were noticed.
- Vertical, hairline or thicker cracks were observed in the substrate of the 5 cores examined in greater detail. The vertical cracks (it was a vertical joint in Core 1367-5) generally did not appear to be reflected into the sand-polymer overlay.
- The sand-polymer overlay appeared to be similar overall among cores studied. Minor differences were noticed in amounts of air voids, thickness, and possibly sand-resin ratios.
- The sand-resin bond of the overlay was generally tight. Sockets left by dislodged or plucked sand particles were observed on the top surface but occurances were infrequent. The top surface appeared to be skid-resistant overall.
- The resin/polymer binder appeared to be polished, smooth, clear, amber colored and somewhat brittle on the top surface due to exposure to traffic and weathering. The binder below the top surface at greater depth appeared to be milky, less transparent, and less brittle when tested by a steel pick.
- Sand was generally similar among the cores. Sand in the overlay is mainly composed of various siliceous volcanic rocks and appeared to be dense and durable. However, fractures or microcracks

were frequently observed on exposed sand particles on the top surface. Sand particles in the overlay were frequently angular and occasionally near-elongated or near-flat. More equant and spherical sand would be desirable.

- A crack sealer or the resin component of the overlay appeared to have penetrated to significant depths in the vertical cracks. The sealer may or may not necessarily be the same material as the resin/polymer. The crack sealer appeared to be darker in color than the resin/polymer and possibly contained a filler material. Thin section examination or chemical analysis would be needed to assess the similarity or dissimilarity.
- The sand-polymer overlay contains varying amounts of entrapped air voids, which occurred as holes on the top surface and contributed to the surface roughness.
- Core 1367-3 exhibited localized scaling, spalling, or loss of the overlay. The surface loss was not observed in other cores.

Substrate Concrete

- The substrate concrete is mainly composed of siliceous gravel (nominal top size 1/2-inch) and natural siliceous sand dispersed in a well-air-entrained cementitious paste. Air voids are generally small, spherical, and abundant. The air-void system appeared to be adequate to protect the concrete from distress caused by cyclic freeze-thaw.
- The concrete is well consolidated and distribution of aggregate, paste and air voids appeared to be fairly uniform overall.
- No evidence of materials-related distress such as alkali-silica reaction or freeze-thaw damage was observed in the substrate concrete or the overlay.
- Substrate concrete was roughened or prepared to a CSP estimated at 3 to 5 in Core 1367-3 to 5 to 6 in Cores 1367-5 and 1670-8. Microcracks or bruising related to surface preparation appeared to be infrequent overall.

Findings from Examinations of 5 As-Received Cores (1367-10, 1459-4, 1459-6, 1670-2, and 1628-3)

Brief examinations of the 5 cores show that the overlay and the substrate appeared to be similar to the other 5 cores in overall composition. The top surface of these cores exhibited minimal or none to moderate traffic-related smoothening and erosion. No cracks were observed in the substrate or in the overlay based on brief visual examinations. Core 1459-6 appeared to exhibit a worn, grooved concrete top surface. The bond between the overlay and the substrate concrete appeared to be tight and intact in these cores.

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Table C.1. Findings and Observations from Limited Microscopical Examinations

Core ID	1367-3	1367-5	1459-1	1670-8	1682-7
Figures	Figure C.1, Figure C.2, Figure C.3	Figure C.4 through Figure C.7	Figure C.8 through Figure C.12	Figure C.13 through Figure C.19Figure C.16	Figure C.17, Figure C.18, Figure C.19
General Surface and Core Features	Cored over a hairline crack that was observed in the top 2.5 inches of substrate concrete. PPC overlay was scaled or spalled at three small areas with a total area approximately 1 square inch. The spalled locations still exhibited small amounts of resin on concrete surface.	Cored over a joint or interface between the "typical substrate concrete" and a small portion of a darker, likely repair concrete that was 1-1/4 inch thick. Top surface of the overlay exhibited many large voids.	Cored over a vertical crack. Estimated 60% top surface was rough, exposed aggregate particles standing proud of resin with voids and occasionally pockets left by plucked aggregate. The remaining 40% was less rough but smoother, where the majority of aggregate particles are embedded in resin exhibit evidence of smoothening by traffic.	Cored over a vertical crack. Surface was moderately rough; exposed aggregate particles were moderately smoothed by traffic.	Cored over a hairline crack that was at far edge of core to observed depth of 2.3 inches in the substrate concrete. Smoothed sand tops were roughly on the same plane as polished resin, except for at locations of large air voids and occasional sockets left by plucked sand particles.

Core ID	1367-3	1367-5	1459-1	1670-8	1682-7
Resin Quality	Resin on top surface is polished/smoothed by traffic, amber-colored, clear, and somewhat brittle when pushed by a steel needle; while milky and semi-translucent at greater depth. The surface discoloration is probably related to light exposure and consistent with the change in brittleness. The resin was probably less brittle than in other cores.	Generally similar to resin in other cores. Top surface appeared rough due mainly to large voids. Small areas free of large voids were overall flat, exhibiting smoothened sand particles and polished resin.	Resin on top surface is amber-colored, clear, and brittle when pushed by a steel needle; while milky and semi-translucent at greater depth. The surface discoloration is probably related to light exposure and consistent with the change in brittleness.	Resin on top surface is amber-colored, clear, and brittle when pushed by a steel needle; while milky and translucent at greater depth. The surface discoloration is probably related to light exposure and consistent with the change in brittleness.	Typical and similar to resin in remaining cores.
Aggregate Durability (Abrasion)	Sand of mainly various volcanic rocks with small amounts of other siliceous rocks/minerals. Appeared durable, but a small portion is fractured.	Typical and generally similar to sand in other cores.	Sand is composed of mainly various volcanic rocks with small amounts of other siliceous rocks/minerals. Appeared durable, but a small portion is fractured.	Sand is mainly composed of various volcanic rocks with small amounts of other siliceous rocks/minerals. Appeared durable, but a small portion is fractured. Frequently angular.	Typical and similar to sand in remaining cores; mainly angular to rounded; composed of various volcanic rocks.
Resin-Aggregate Bond	Appeared to be tight.	Tight, generally similar to sand-resin bond in other cores.	Generally tight; when sand particles are exposed and standing proud of the resin, a few appeared to have been plucked off of the resin, leaving recessed pockets.	Generally tight; when sand particles are exposed and standing proud of the resin, a few appeared to have been plucked off of the resin, leaving recessed pockets.	Typical and similar to other cores.

Core ID	1367-3	1367-5	1459-1	1670-8	1682-7
Overlay/Substrate Bond	Well bonded, with localized short subsurface microcracking observed within top region of substrate concrete. Localized scaling/spalling observed near the interface of two layers.	Well-bonded to the substrate. A few entrapped voids observed at the interface. A few short surface-parallel cracks were observed within the top region of substrate concrete near an edge (core side surface).	Well-bonded.	Well-bonded; a few short surface-parallel cracks were observed within the top region of substrate concrete near an edge of the core.	Well-bonded. No debonding or surface parallel microcracking observed.
Presence of Reflective Cracking	The hairline crack in substrate did not appear to extend through or be reflected onto the PPC overlay.	A thinner short crack was visible over the joint.	Not reflective; cracks were invisible in overlay.	Not reflective; cracks were invisible in overlay.	Likely no reflective cracking. A small portion of PPC overlay exhibited a short fracture over a hairline crack. The fracture appeared fresh and likely caused by coring or handling.
Polymer Penetration in Cracks	A dark sealer material lined in the top 2 inches of the hairline crack.	Sealer similar to the overlay resin lined the joint but did not fully fill the width of the joint. Minor spacing observed between resin and joint side surface.	Polymer observed to 4 inches along the crack.	Polymer and associated yellow discoloration observed in the thin substrate concrete layer.	The top 1 inch of the crack at core edge was lined by a dark sealant.
Resin and Crack Sealaer Similarity	Crack sealer observed may be the same as the overlay resin.	Appeared similar.	Maybe different, pending thin-section studies. Darker color and may contain finely-grained filler materials.	Too little to assess using stereomicroscope.	Crack sealer observed may be the same as the overlay resin.
Substrate Surface Preparation	CSP estimated 3 to 5	CSP estimated 5 to 6	CSP estimated 4 to 6	CSP estimated 5 to 6	CSP estimated 3 to 5

Core ID	1367-3	1367-5	1459-1	1670-8	1682-7
Quality of Substrate Concrete	Abundant, small, spherical air voids that appeared to be adequate for cyclic F/T resistance. Minor subsurface parallel microcracks below polymer overlay/concrete interface, prpbably due to surface preparation.	Abundant, small, spherical air voids that appeared to be adequate for cyclic F/T resistance. No distress was observed in the substrate concrete. The small portion of repair concrete was darker and likely consistent with a lower w/cm ratio, exhibiting surface-parallel cracks below polymer overlay/concrete interface, probably due to coring damage.	Abundant, small, spherical air voids that appeared to be adequate for cyclic F/T resistance. Mainly siliceous aggregates, 1/2-inch top size. No distress apart from the full core length, 20-mils wide crack. Imprint of rebar at bottom end is clean and free of rust.	Abundant, small, spherical air voids that appeared to be adequate for cyclic F/T resistance. Mainly siliceous aggregates, 1/2-inch top size. No distress apart from the hairline crack in the substrate concrete.	Abundant, small, spherical air voids that appeared to be adequate for cyclic F/T resistance. Mainly siliceous aggregates, 1/2-inch top size. No materials-related distress observed.

Figure C.1. Core 1367-3. Lapped cross section shows the overall appearance of the PPC overlay and top ~4 inches of the substrate concrete. Arrows indicate a vertical crack, futher shown in the figure below.

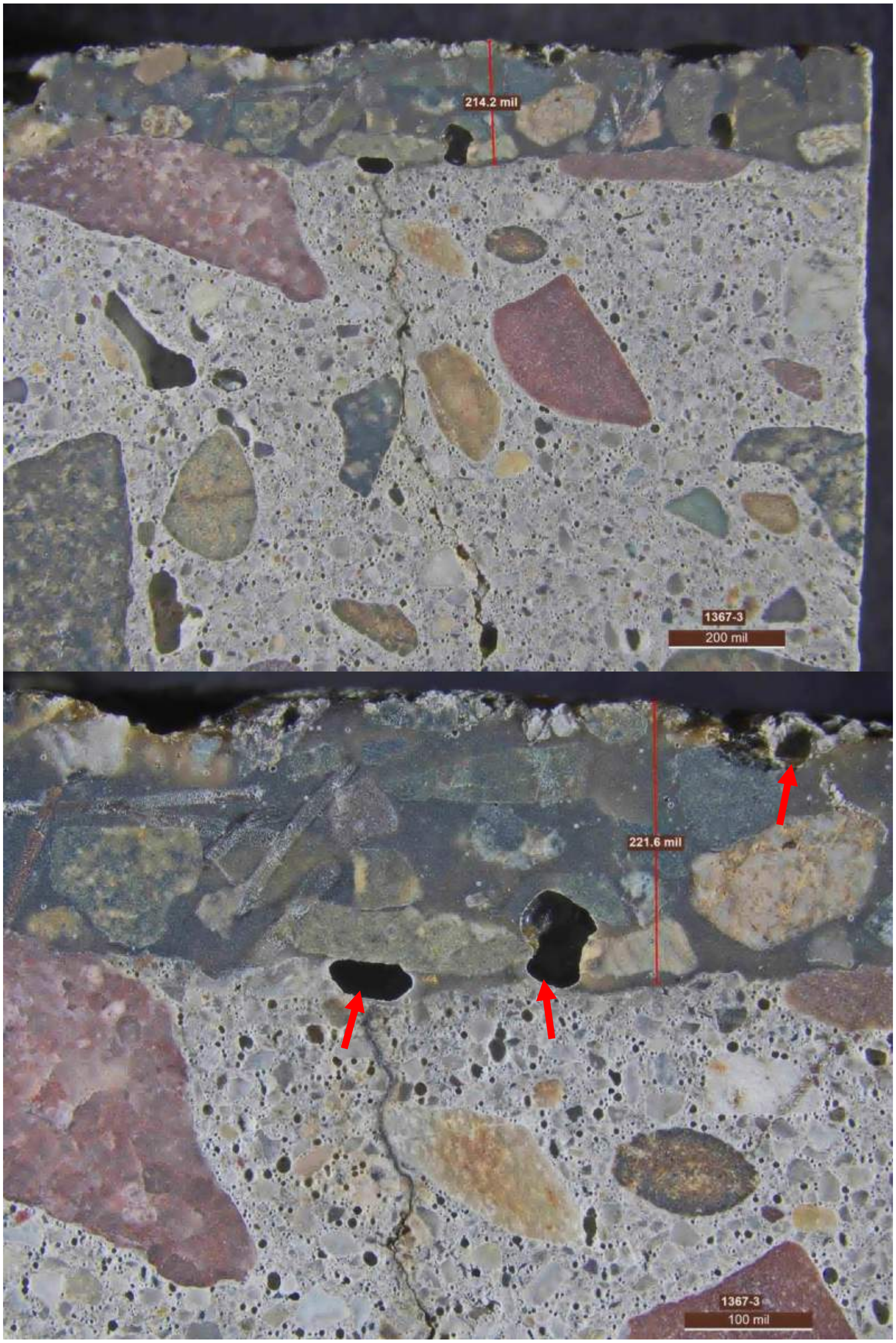


Figure C.2. Core 1367-3. Closeup views show the PPC overlay and a hairline crack in the concrete. The crack did not appear to be reflected into the overlay. Arrows indicate air voids in the overlay.

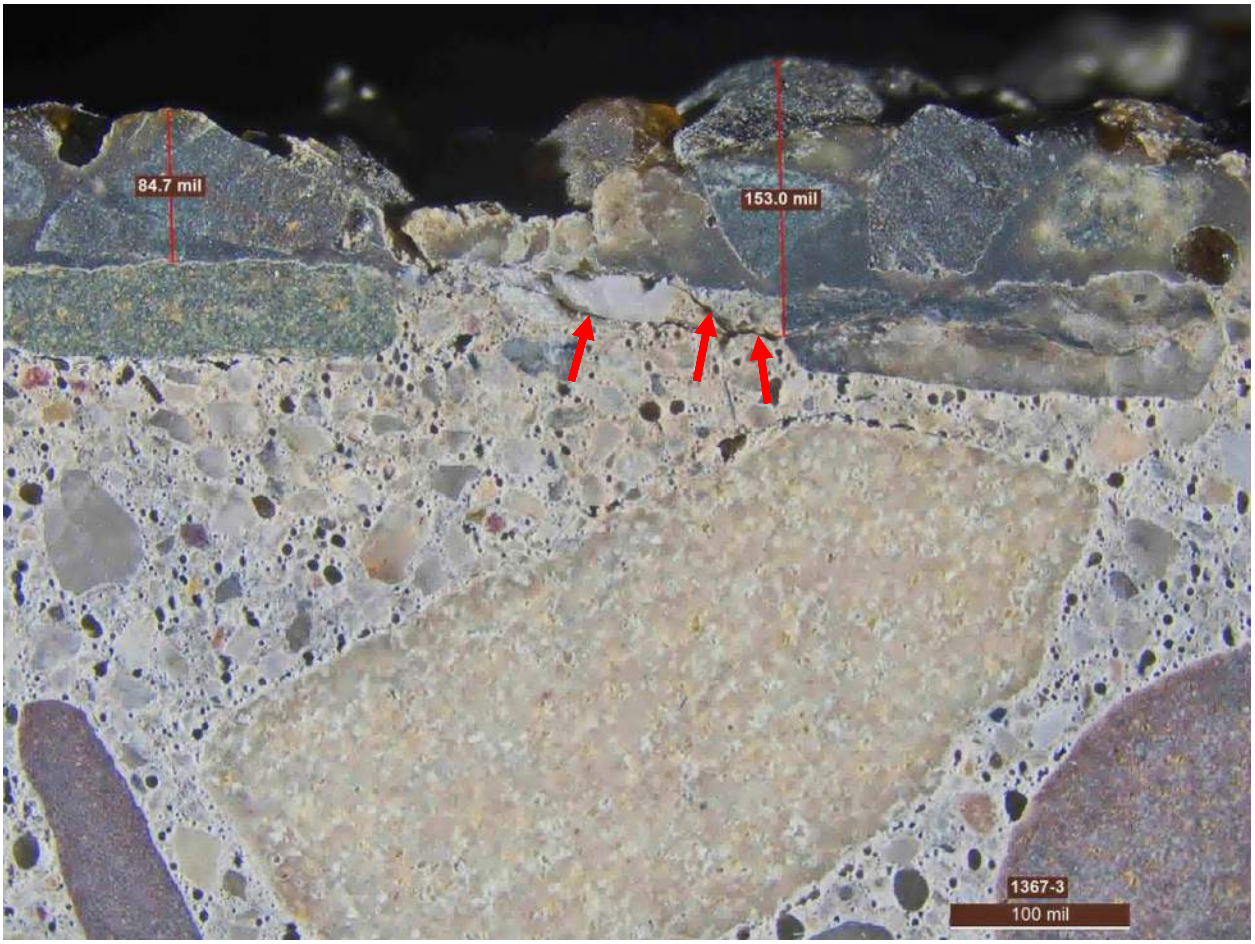


Figure C.3. Core 1367-3. Closeup view shows the PPC overlay and top region of substrate concrete. Minor subsurface microcracking was observed in the substrate concrete.

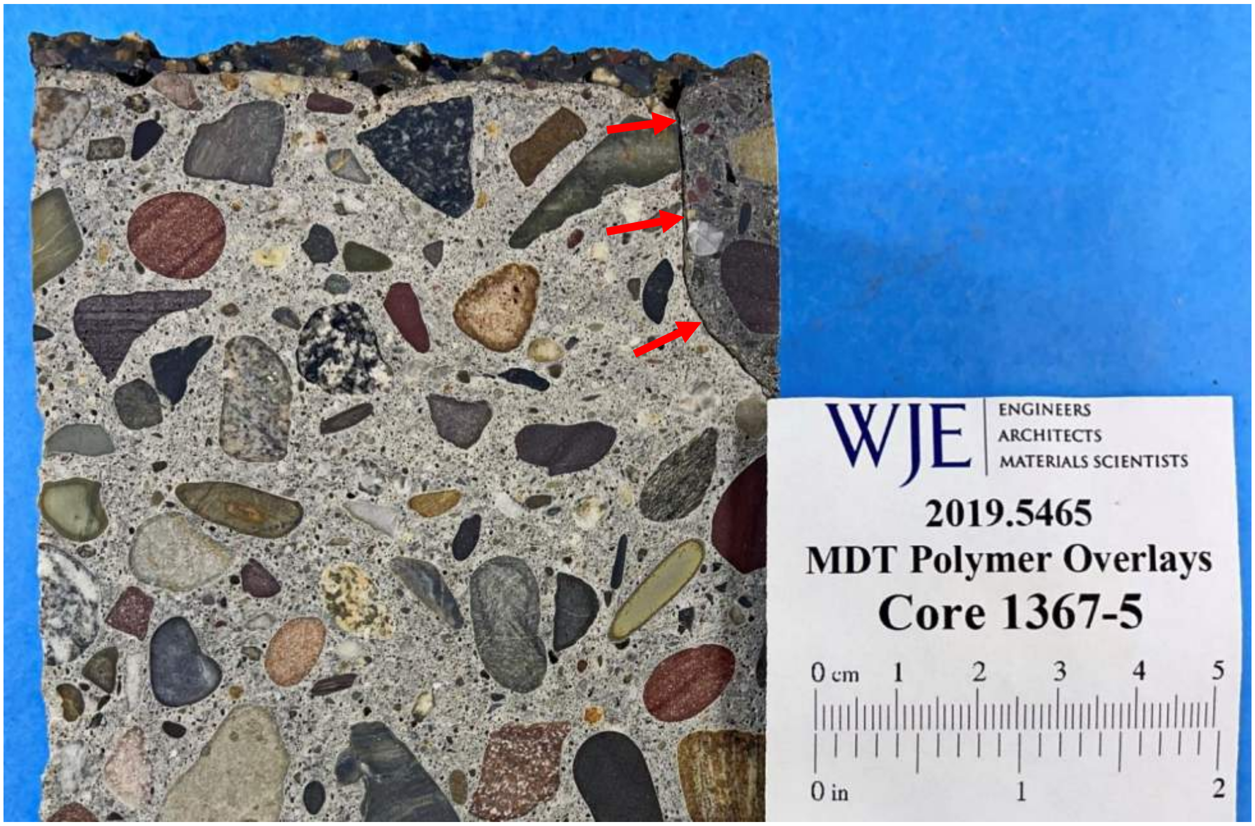


Figure C.4. Core 1367-5. Lapped cross section shows the overall appearance of the PPC overlay and top ~5 inches of the substrate concrete. Arrows indicate concrete dissimilar to the majority of substrate concrete in the core, futher shown in the figure below.

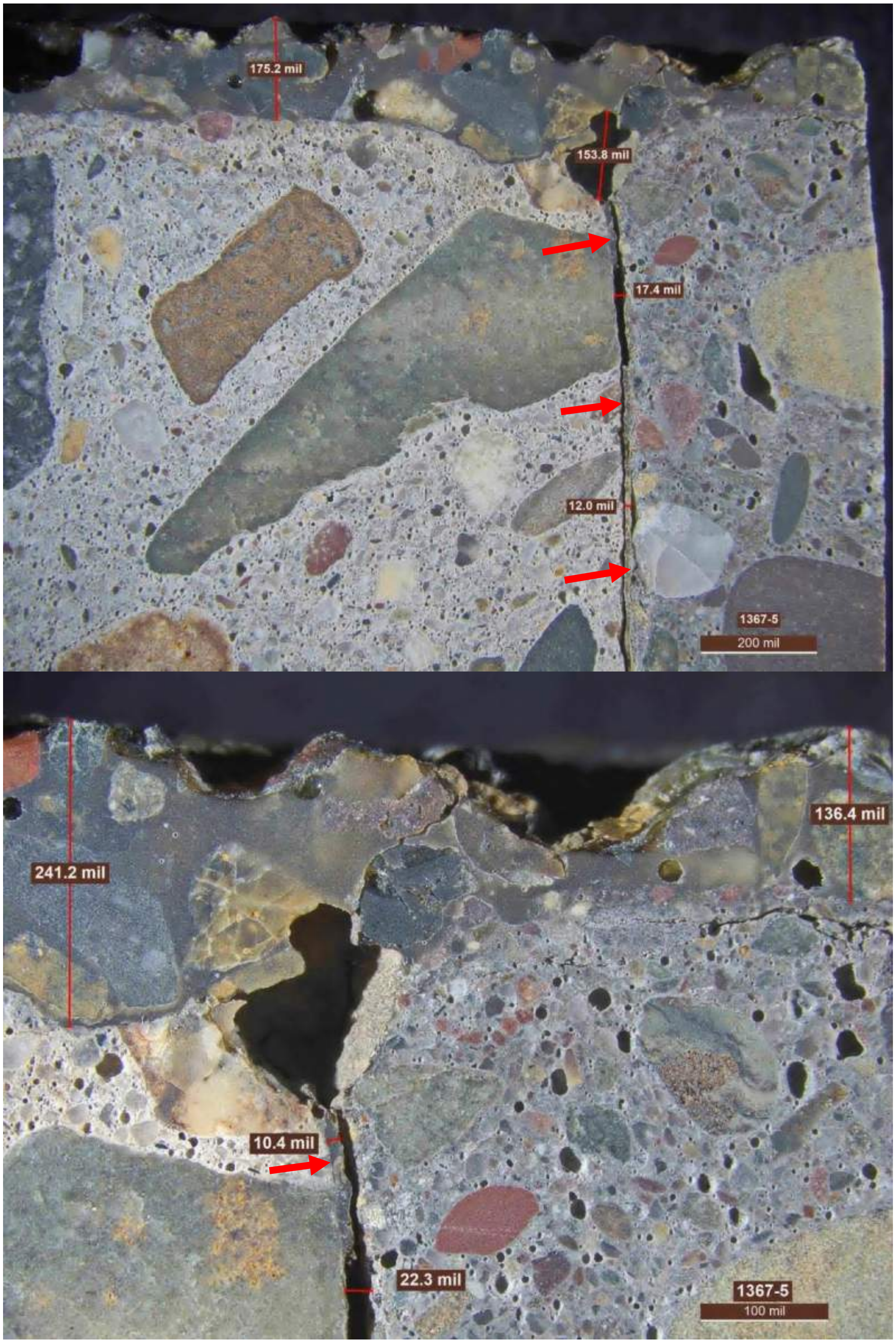


Figure C.5. Core 1367-5. Closeup views show the PPC overlay and a likely repair concrete. The crack did not appear to be reflected into the overlay. Arrows indicate a sealer or overlay resin lining the crack.

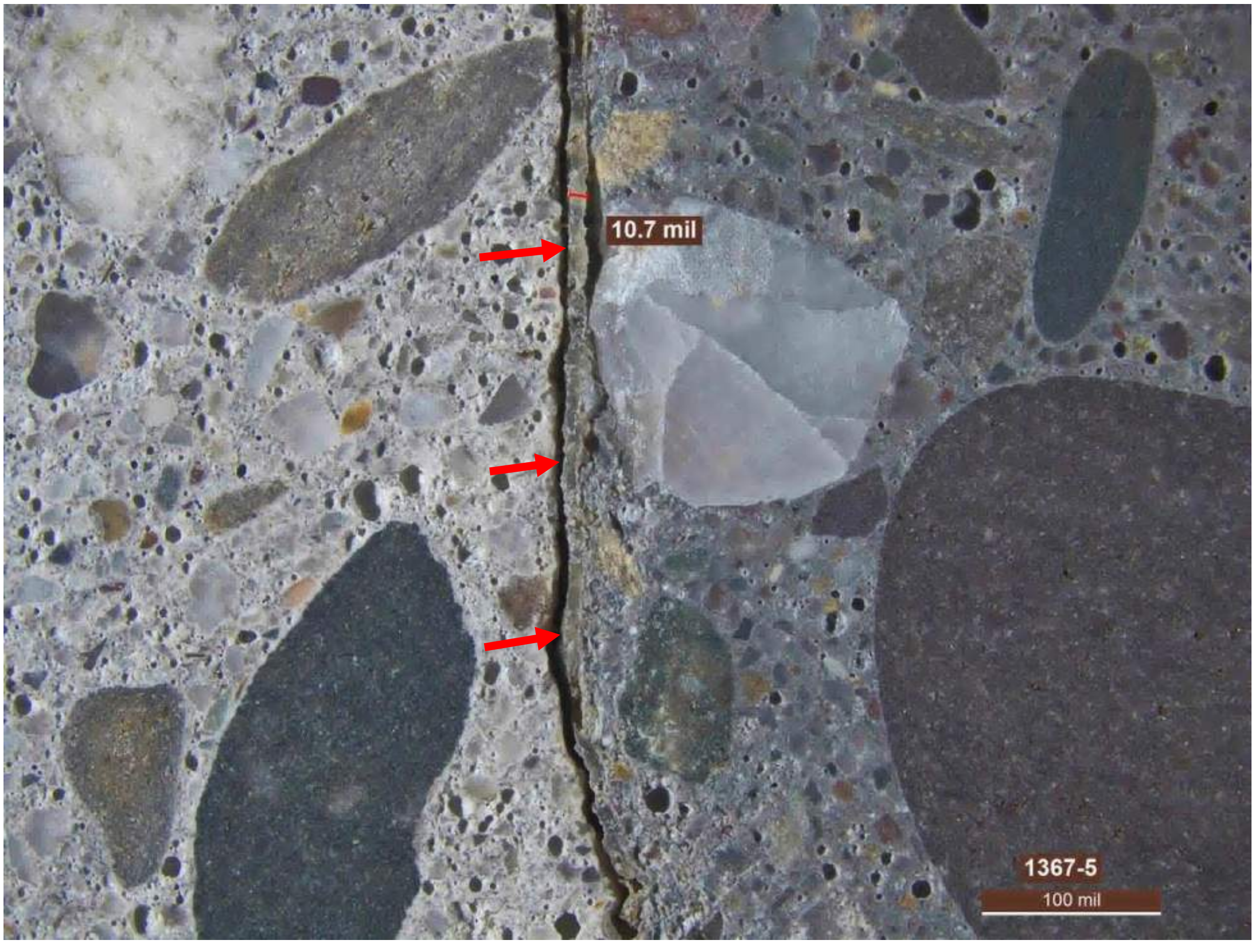


Figure C.6. Core 1367-5. Closeup view shows the crack sealer or PPC resin lining the crack.

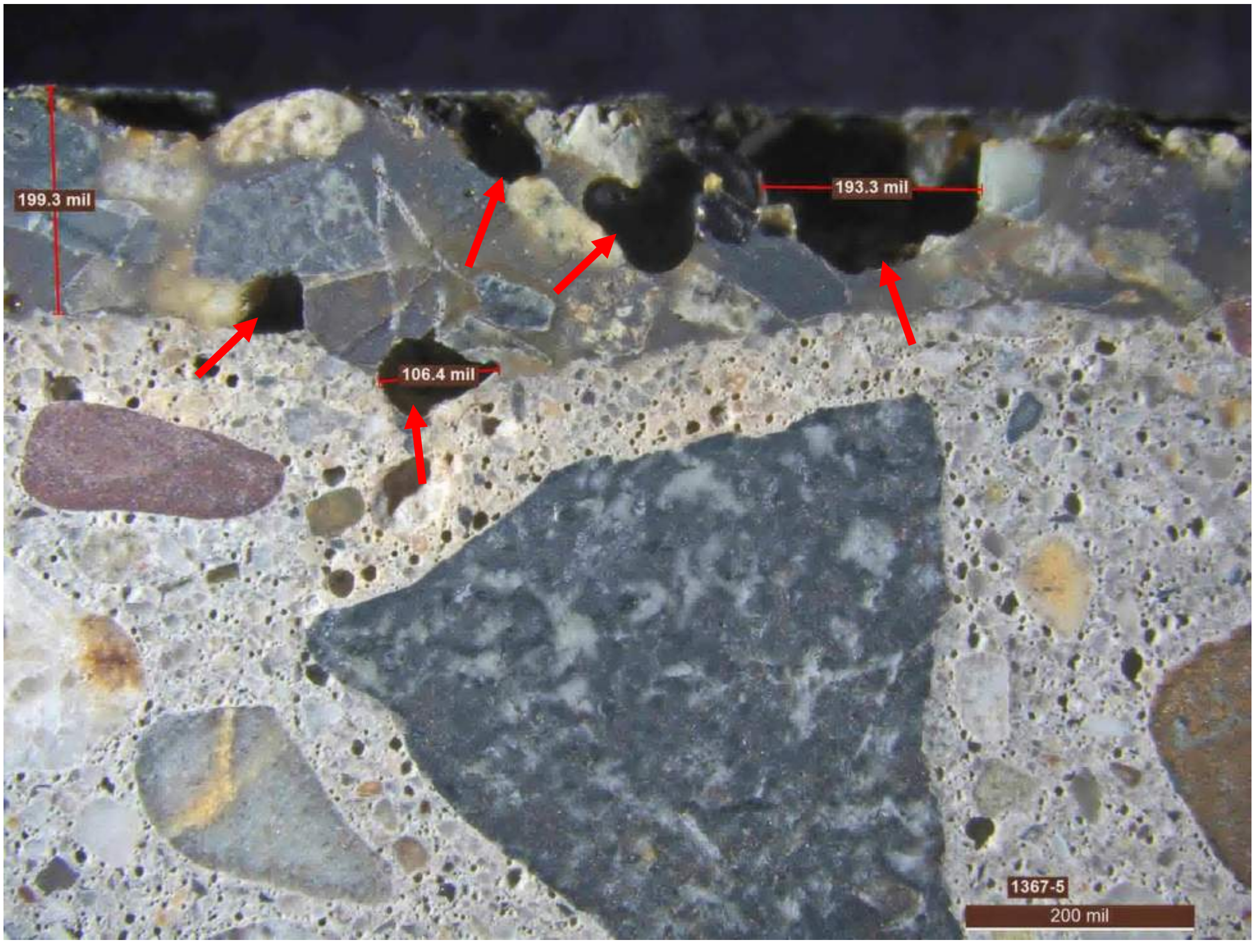


Figure C.7. Core 1367-5. Closeup view shows a few entrapped air voids in the PPC overlay.

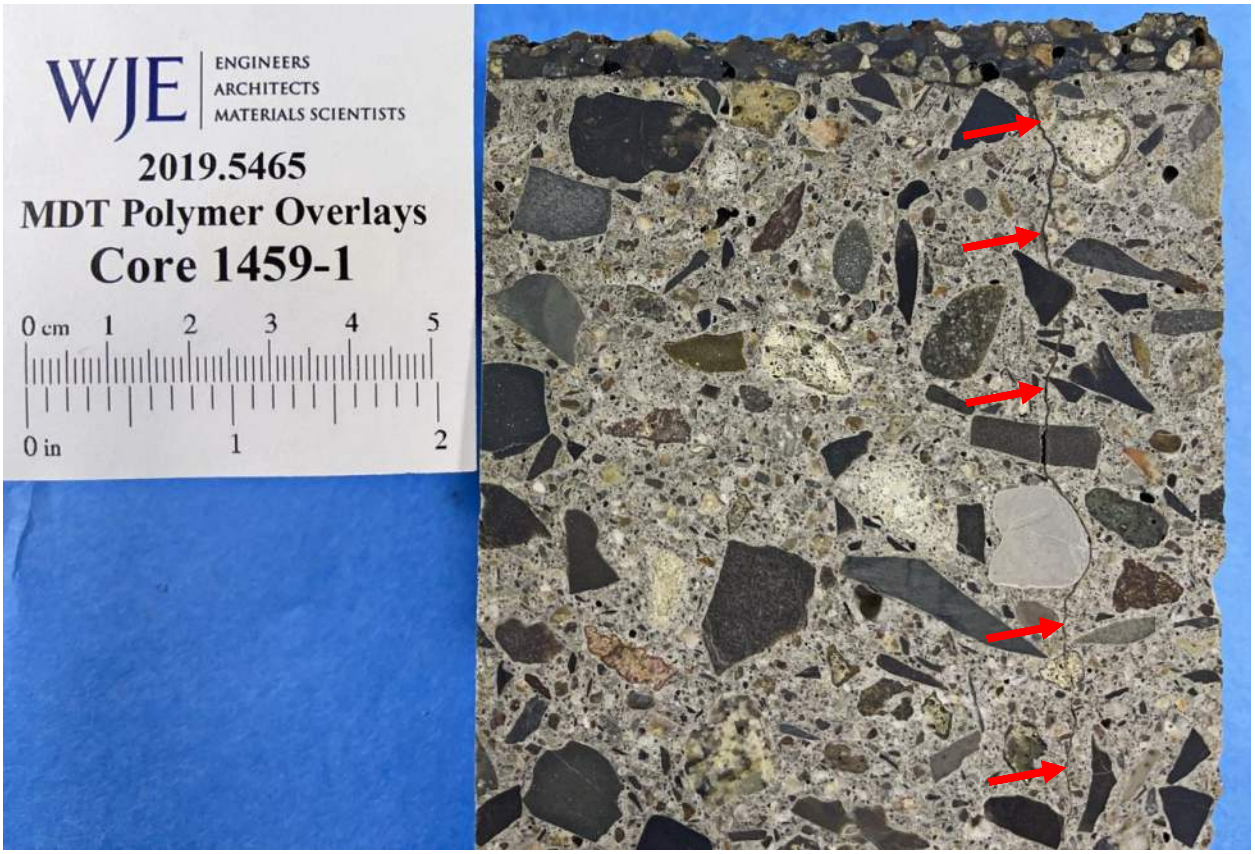


Figure C.8. Core 1459-1. Lapped cross section shows the overall appearance of the PPC overlay and top ~4 inches of the substrate concrete. Arrows indicate a vertical crack, futher shown in the figure below.

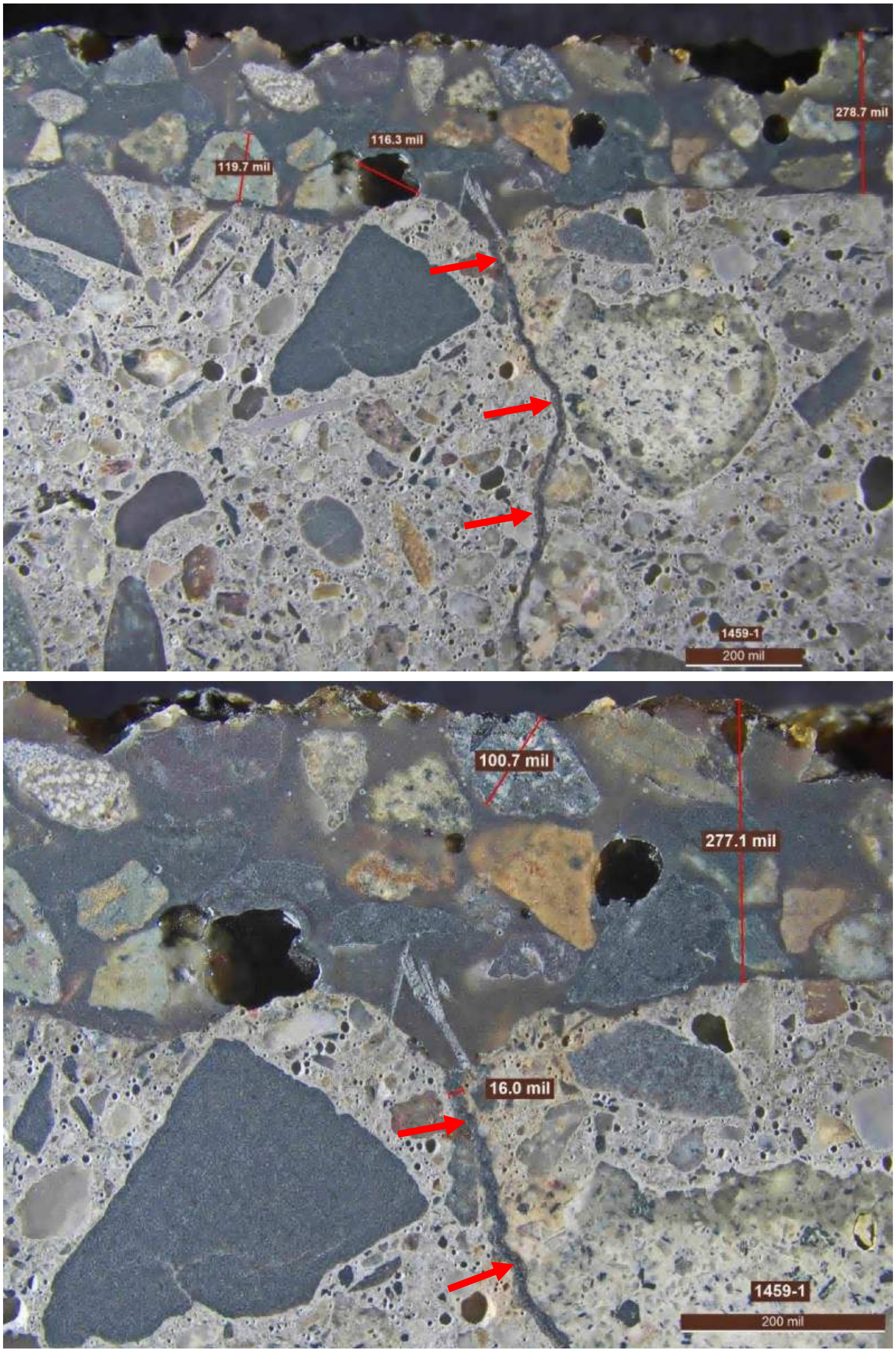


Figure C.9. Core 1459-1. Close-up views show the PPC overlay and a vertical crack in the substrate concrete that did not reflect into the overlay.

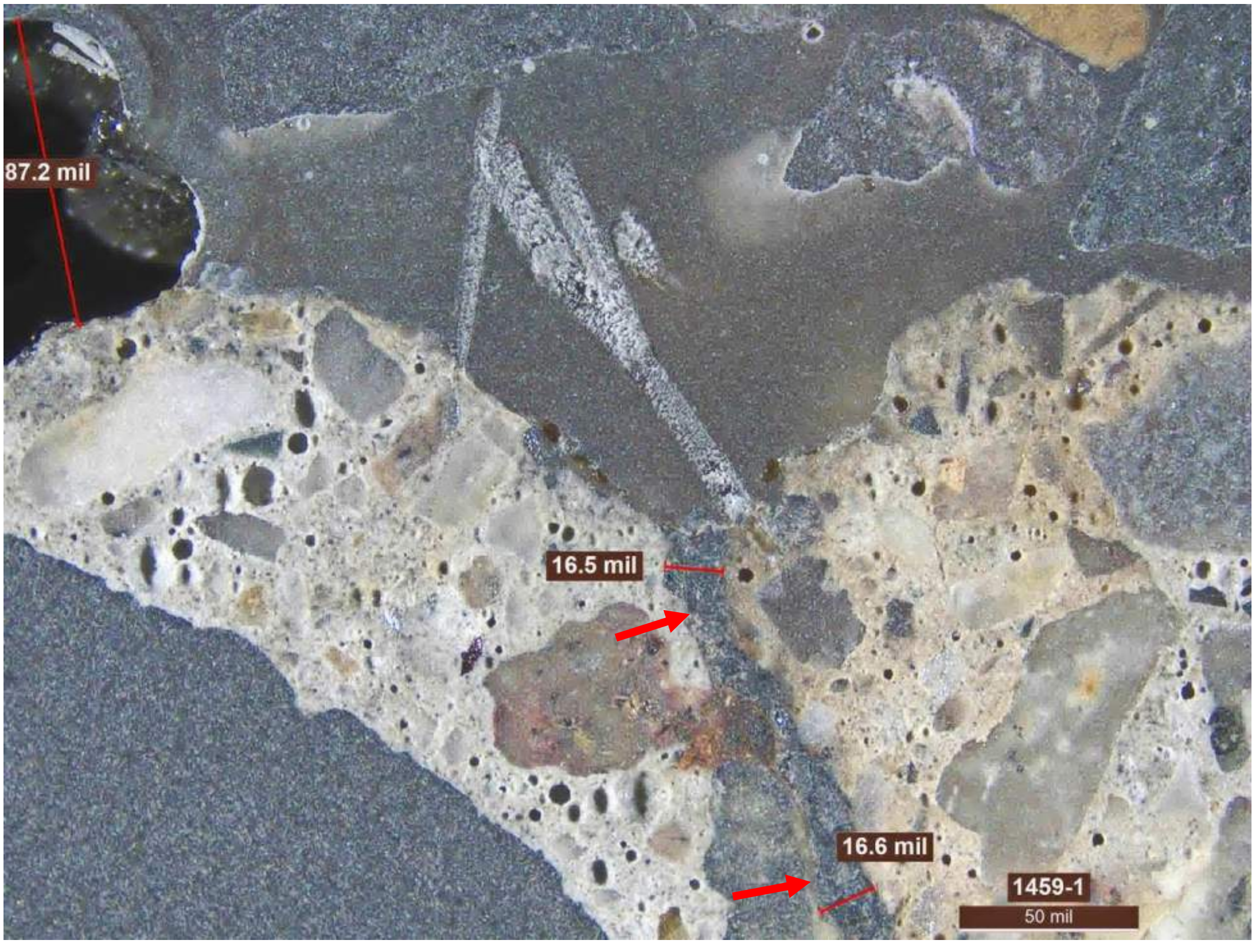


Figure C.10. Core 1459-1. Close-up view showing the PPC overlay and a crack sealer (red arrows) that appeared darker than the resin in the PPC overlay.

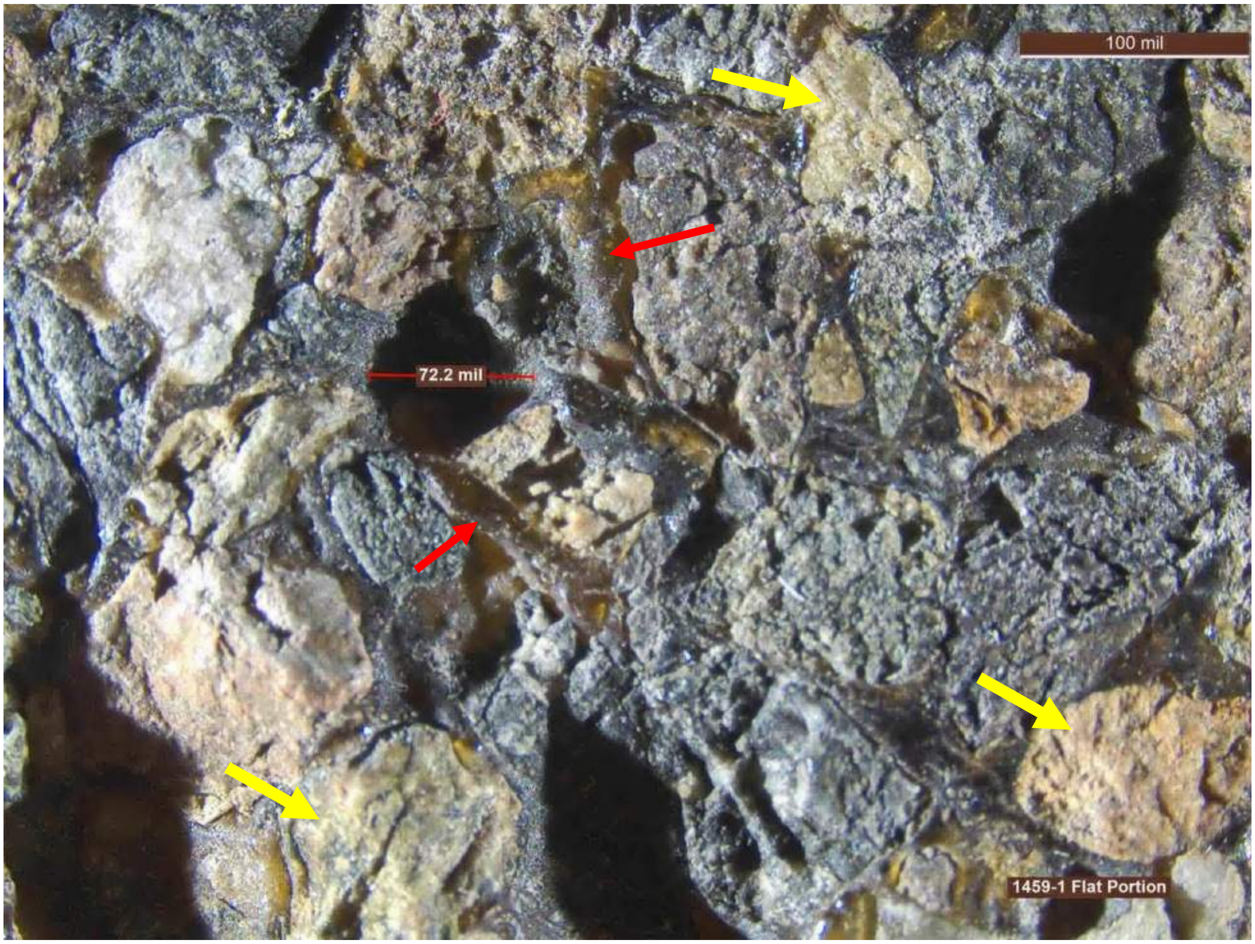


Figure C.11. Core 1459-1. Close-up view of top surface shows a smoothed area of the PPC overlay. Amber-colored resin (red arrows) and smoothened sand particles (yellow arrows) are flushed to the same horizon or height.

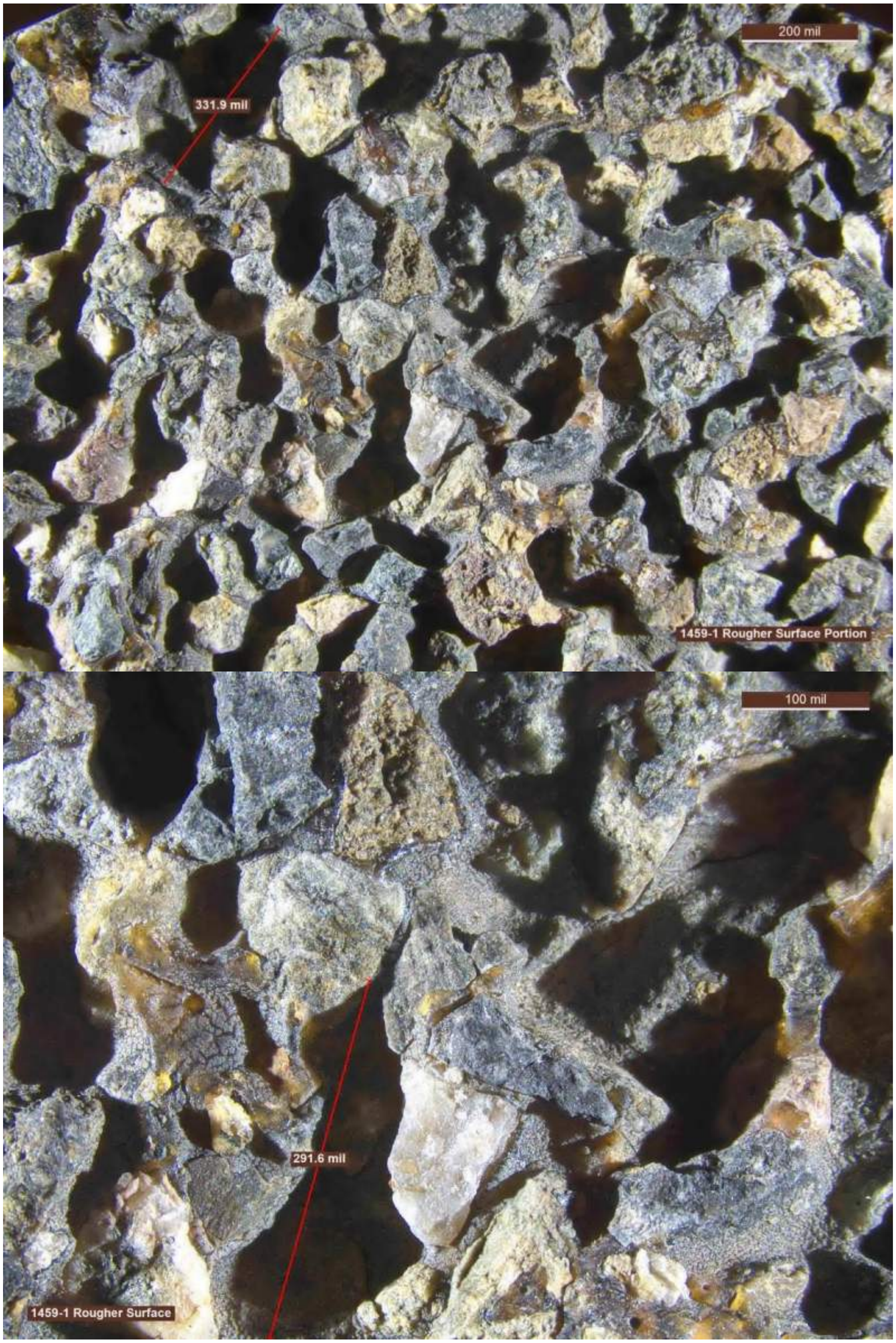


Figure C.12. Core 1459-1. Close-up views of top surface show a rough region of the PPC overlay. Angular sand particles stand proud of the recessed resin.

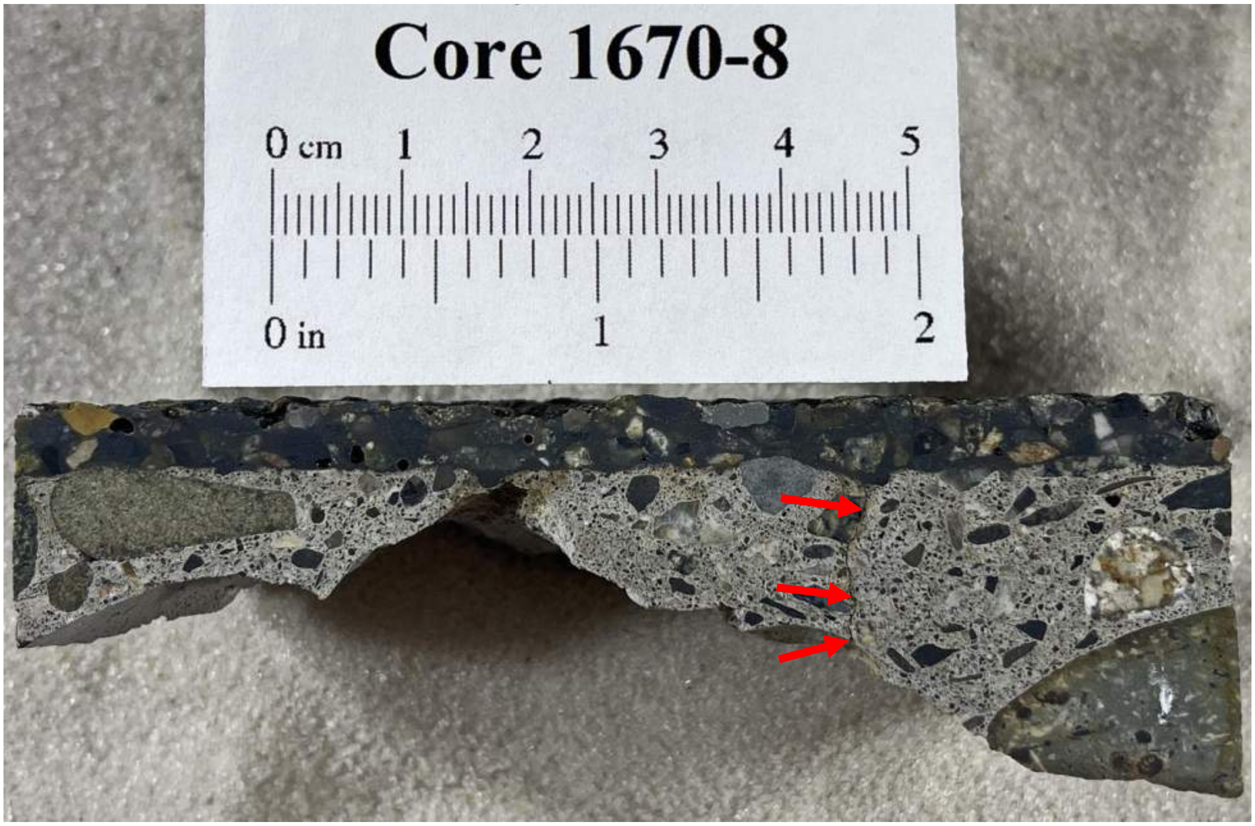


Figure C.13. Core 1670-8. Lapped cross section shows the overall appearance of the PPC overlay and top region of the substrate concrete. Arrows indicate a vertical crack, futher shown in the figure below.

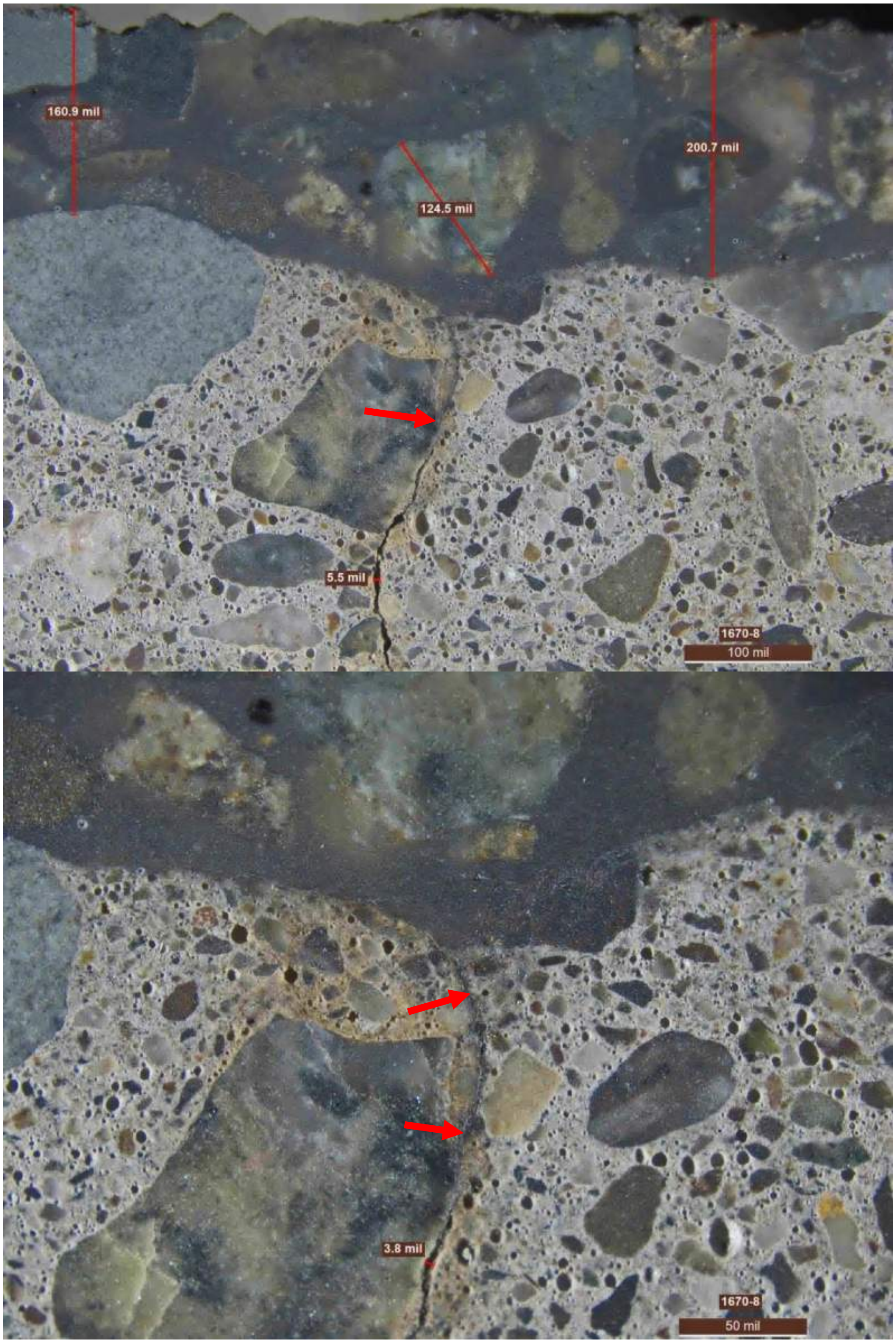
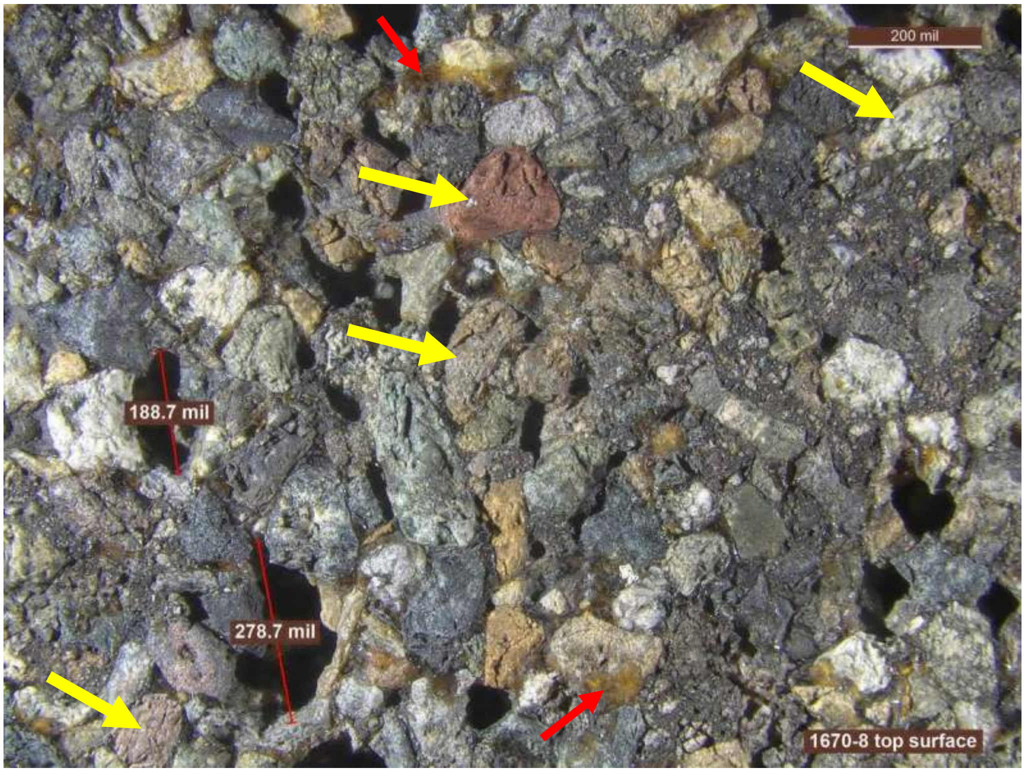


Figure C.14. Core 1670-8. Close-up views show the PPC overlay, a vertical crack and a crack sealer or the resin (red arrows) lining the top portion of the crack.



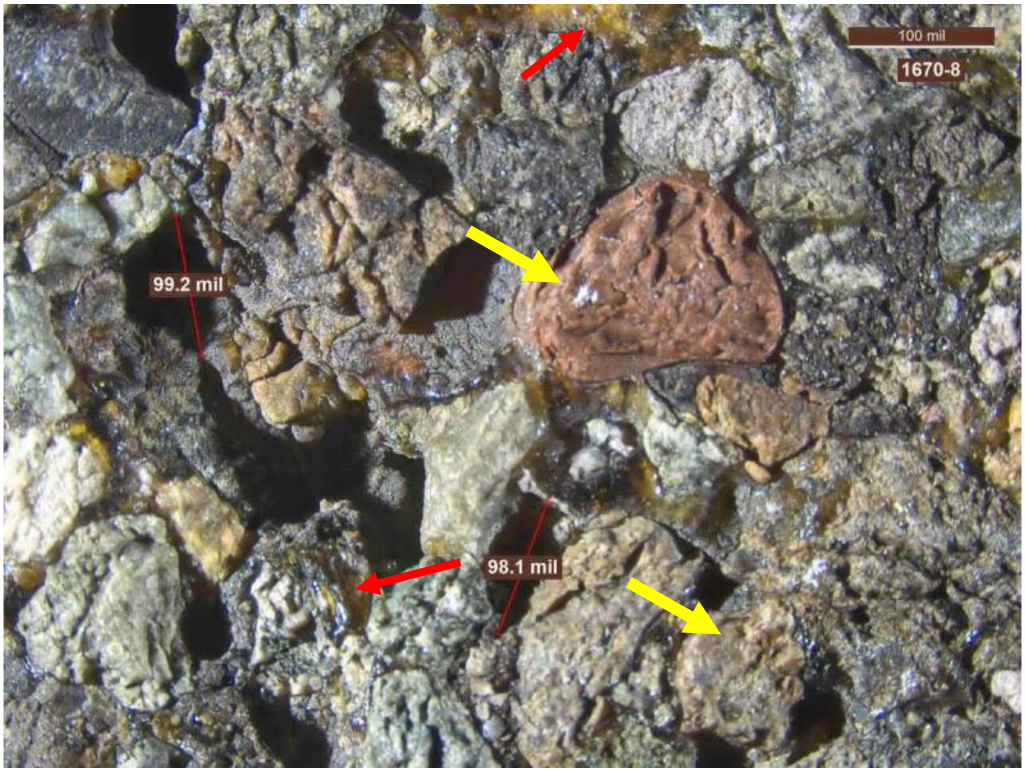


Figure C.15. Core 1670-8. Close-up views of top surface shows well smoothed sand in the PPC overlay. Amber-colored resin (red arrows) and smoothened sand particles (yellow arrows) were eroded to the same horizon or level. Air voids are visble on the top surface.

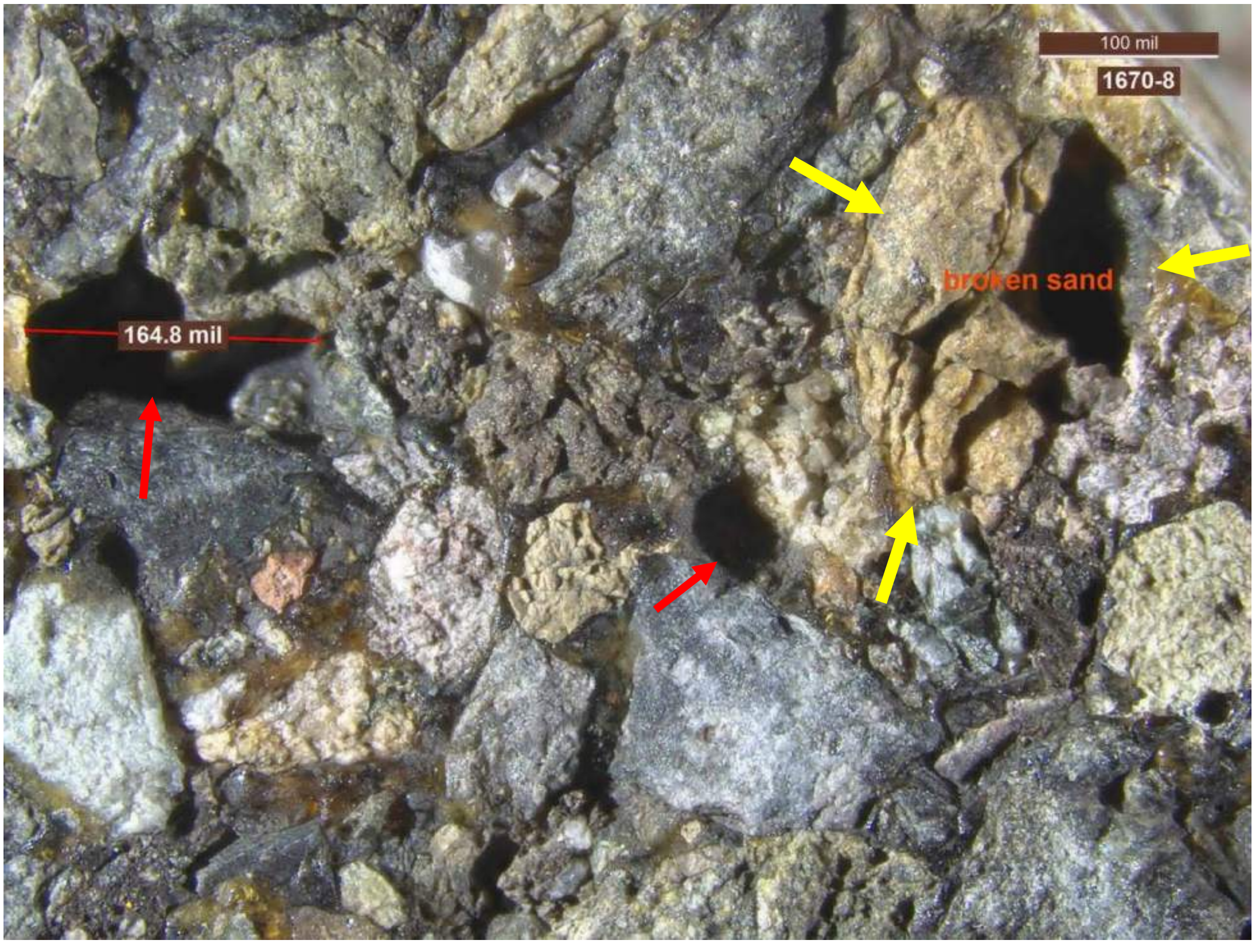


Figure C.16. Core 1670-8. Close-up view of top surface shows well smoothed sand particles and a broken sand (yellow arrows) with many fractures/cracks. A portion of the sand appeared to have been plucked off, leaving a partial socket. Red arrows indicate air voids.

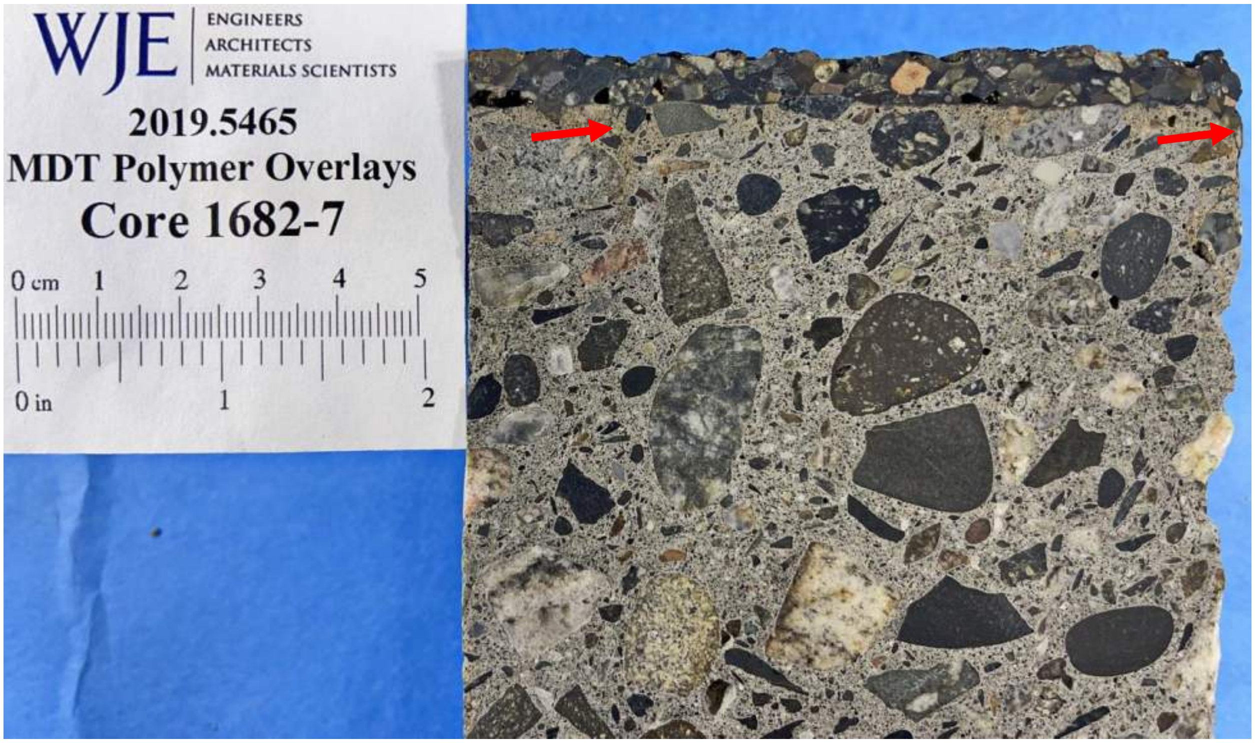
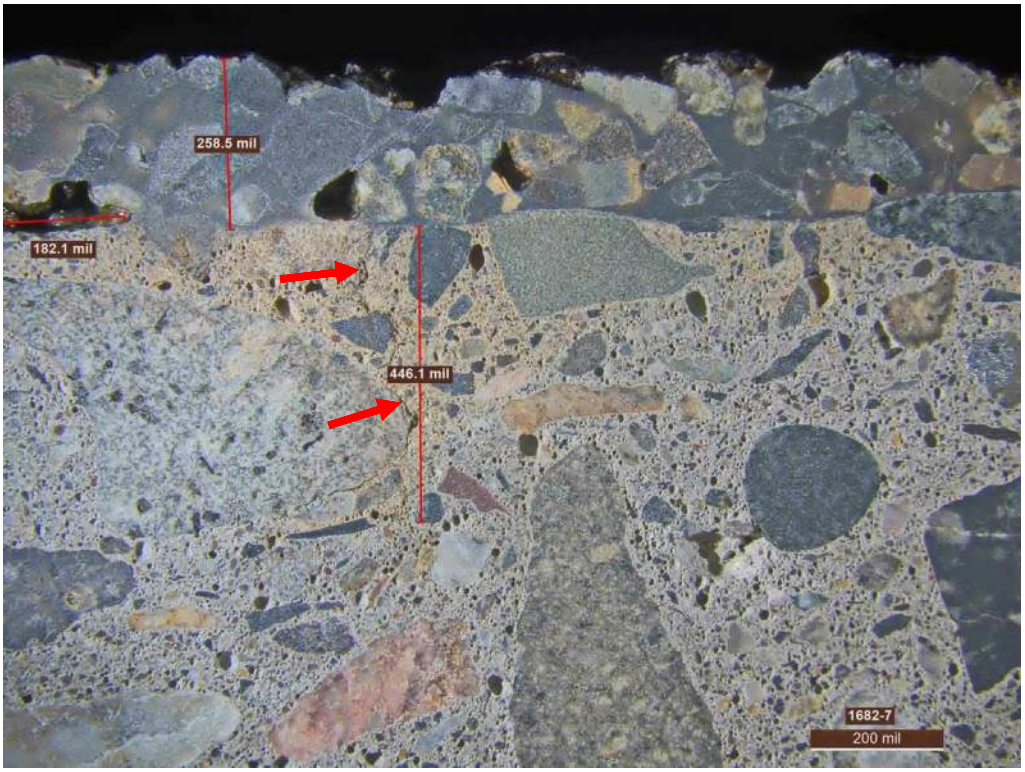


Figure C.17. Core 1682-7. Lapped cross section shows the overall appearance of the PPC overlay and top ~4 inches of the substrate concrete. Arrows indicate vertical cracks, futher shown in the figures below.



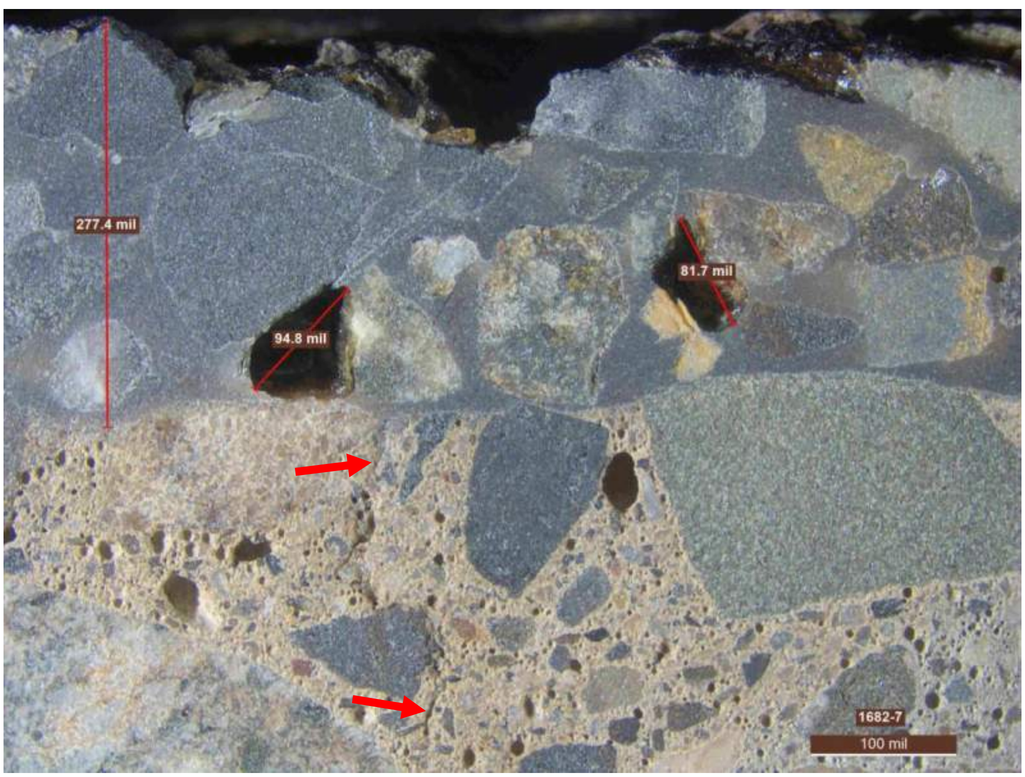
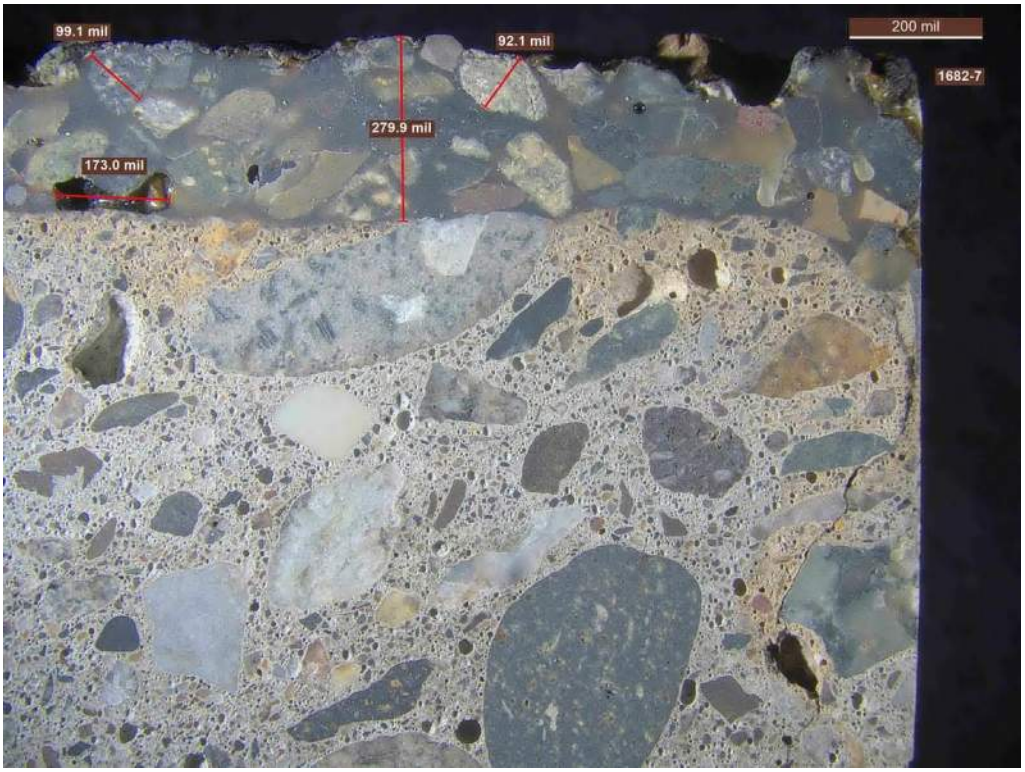


Figure C.18. Core 1682-7. Close-up views show the PPC overlay, a barely visible vertical crack and paste discoloration likely due to carbonation along the crack.



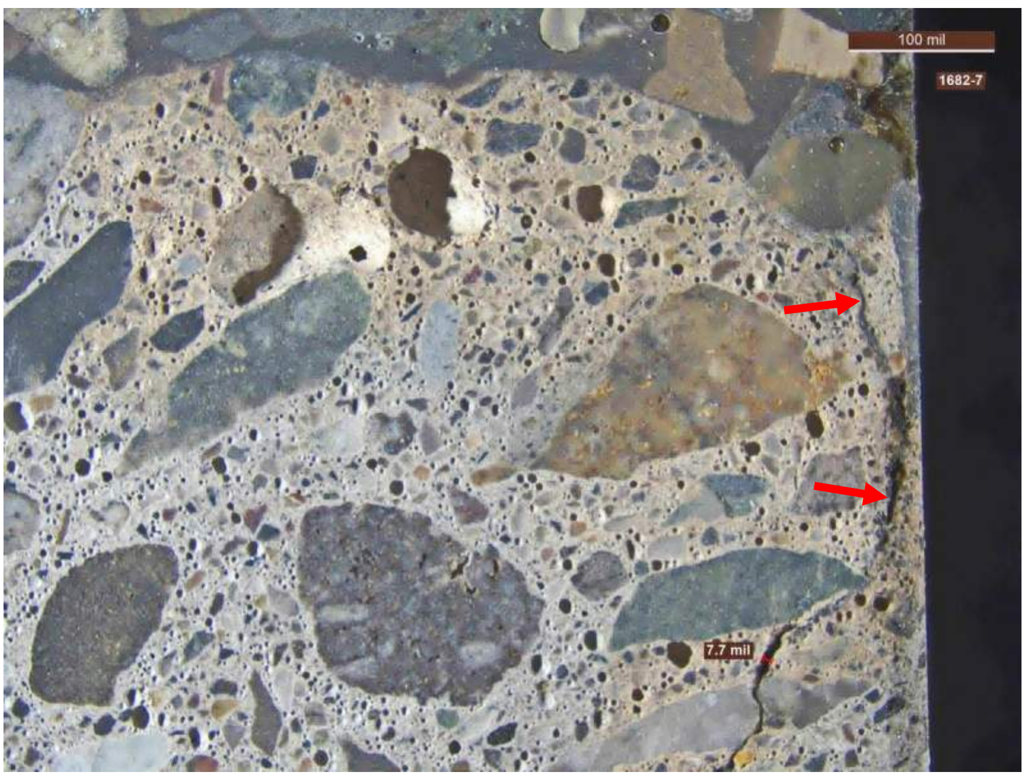


Figure C.19. Core 1682-7. Close-up views show the PPC overlay, a vertical crack near core side surface and paste discoloration, likely due to carbonation along the crack. Arrows indicate crack sealer or resin that penetrated into the crack.

Figure C.20. Core 1459-4. Close-up views of the top surface show angular sand particles stand proud of resin (rarely visible). The texture is consistent with absence or minimal smoothing or erosion by traffic.

APPENDIX G. CURRENT POLYMER OVERLAY SPECIAL PROVISION USED BY MDT (DATED 10-08-2020)

1. POLYMER OVERLAY (REVISED 10-08-20)

A. Description. This work is preparing concrete bridge deck surfaces and applying primer and a two-layer polymer overlay system. This work also applies to concrete approach slabs if indicated on the plans.

B. Materials. Furnish materials specifically designed for use on concrete bridge decks.

1) Polymer Overlay Primer. Furnish a primer compatible with the polymer overlay that is 100% solids, 100% reactive with the following properties:

Property	Requirements	Test Method
Viscosity [A]	<225 cps	ASTM D2556, Brookfield RVT, Spindle No. 3, 20 rpm
Tensile Elongation [B]	> 30%	ASTM D638
Tensile Strength [B]	>2000 psi @ 7 days	ASTM D638

[A] -Uncured, mixed primer

[B] -Cured, mixed primer

2) Polymer Resin for Polymer Overlay. Use a polymer resin base and hardener composed of a two-component, 100% solids, 100% reactive, thermosetting compound with the following properties:

Property	Requirements	Test Method
Gel Time [A]	10 - 45 minutes @ 73°F to 75°F	ASTM C881
Viscosity [A]	7 - 70 poises	ASTM D2556, Brookfield RVT, Spindle No. 3, 20 rpm
Absorption [B]	1% maximum at 24 hr	ASTM D570
Tensile Elongation [B]	30% - 70% @ 7 days	ASTM D638
Tensile Strength [B]	>2000 psi @ 7 days	ASTM D638
Chloride Permeability [B]	<100 coulombs @ 28 days	AASHTO T277

[A] -Uncured, mixed polymer binder

[B] -Cured, mixed polymer binder

3) Aggregates. Furnish natural or synthetic aggregates which have a proven record of performance in applications of this type. Furnish aggregates that are non-polishing, clean, free of surface moisture, fractured or angular in shape; free from silt, clay, asphalt, or other organic materials; and meet the following properties and gradation requirements:

Property	Requirement	Test Method
Moisture Content [A]	≤ 0.20%	AASHTO T255
Hardness	≥6.5	Mohs Scale
Fine Aggregate Angularity	45% Minimum	AASHTO T304 Method A
Absorption	≤ 1%	AASHTO T84
Aggregate Gradation [B]	100% passing No. 4 15-25% passing No. 8 0-5% passing No. 16 0-1% passing No. 30	MT 202

[A] Sampled and tested at the time of placement.

[B] Or recommended gradation per manufacturer of polymer resin and approved by the Project Manager.

Required Properties of the Overlay System.

Property	Requirement [A]	Test Method
Minimum Compressive Strength (psi)	1,000 psi @ 8 hrs 5,000 psi @ 24 hrs	ASTM C 579 Method B, Modified [B]
Thermal Compatibility	No Delaminations	ASTM C 884
Minimum Pull-off Strength	250 psi @ 24 hrs	ACI 503R, Appendix A

[A] Based on samples cured or aged and tested at 75°F

[B] Plastic inserts that will provide 2-inch by 2-inch cubes shall be placed in the oversized brass molds.

C. Construction Requirements.

1) Manufacturer's Representative. Provide a manufacturer's representative on site for the duration of the work, to provide expert assistance on compatibility of materials, storage, mixing, surface preparation, application, clean-up, and disposal of materials.

2) Material Delivery and Storage. Store resin materials in their original containers and in a dry area. Store and handle materials in accordance with the manufacturer's recommendations. Store all aggregates in a dry environment and protect aggregates from contaminants on the job site.

3) Submittals. Submit the following to the Project Manager a minimum of 14 calendar days prior to beginning the polymer overlay:

a) Product data sheets, specifications, and a certified test report from the manufacturer. The Project Manager may request samples of the primer, polymer, and aggregate prior to application, for the purpose of acceptance testing by the Department.

Product data sheets and specifications from the manufacturer consists of literature from the manufacturer showing general instructions, application recommendations/methods, product properties, general instructions, or any other applicable information.

b) Product history/reference projects and a certified test report from an independent testing laboratory showing compliance with the requirements of the specification. The product history/reference projects consist of a minimum of 5 bridges / locations where the proposed overlay system has been applied in Montana or other locations with a similar climate. Include contact names for the facility owner, current phone number or e-mail address, and a brief description of the project.

4) Pre-installation Conference. Conduct a pre-installation conference with the manufacturer's representative prior to construction to establish procedures for maintaining optimum working conditions and coordination of work. Provide a copy of the recommended procedures to the Project Manager and apply the overlay system in accordance with the manufacturer's instructions. Ensure the manufacturer's representative familiar with the overlay system installation procedures is present during surface preparation and overlay placement to provide quality assurance that the work is being performed properly.

5) Sequence of Operations. The following is the sequence of operations when a Polymer Overlay is required:

a) Deck Repair.

b) Surface Preparation

c) Polymer Overlay Primer

d) Polymer Overlay

6) Material Compatibility. Ensure products used for the Deck Repair, Polymer Overlay Primer, and Polymer Overlay are all compatible with each other.

7) Deck Repair. Perform Class A and B deck repair work as specified elsewhere in the contract. Furnish cementitious-based material for deck repair which is compatible with the polymer overlay primer and polymer overlay system. Follow all manufacturer recommendations, including substrate cure times.

8) Surface Preparation. Determine an acceptable shotblasting machine operation (size of shot, flow of shot, forward speed, and/or number of passes) that provides a surface profile meeting CSP 5 according to the International Concrete Repair Institute Technical Guideline No. 03732. If the Project

Manager requires additional verification of the surface preparation, test the tensile bond strength according to ACI 503R, Appendix A of the ACI Manual of Concrete Practice.

The surface preparation will be considered acceptable if the tensile bond strength is greater than or equal to 250 psi or the failure area at a depth of ¼ inch (6 mm) or more is greater than 50% of the test area. Continue adjustment of the shotblasting machine and necessary testing until the surface is acceptable to the Project Manager or a passing test result is obtained.

Prepare the entire deck using the final accepted adjustments to the shotblasting machine as determined above. Thoroughly blast-clean with hand-held equipment any areas inaccessible by the shotblasting equipment. Do not perform surface preparation more than 24 hours prior to the application of the overlay system.

Prepare the vertical concrete surfaces adjacent to the deck a minimum of 2 inches (50 mm) above the overlay according to SSPC-SP 13 by sand blasting, using wire wheels, or other approved method.

Immediately prior to polymer overlay primer placement, clean all dust, debris, and concrete fines from the prepared surfaces including the vertical surfaces with compressed air. When using compressed air, the air stream must be free of oil. Completely remove any grease, oil, or other foreign matter that rests on or has absorbed into the concrete. If any prepared surfaces (including the polymer overlay primer or the first layer of the polymer overlay) are exposed to rain or dew, lightly sandblast (breeze blast) the exposed surfaces.

Protect drains, expansion joints, access hatches, or other appurtenances on the deck from damage by the shot and sand blasting operations and from materials adhering and entering. Tape or form all construction joints to provide a clean straight edge.

The Project Manager may consider alternate surface preparation methods per the overlay system manufacturer's recommendations. Do not place the polymer overlay primer or polymer overlay prior to Project Manager approval of the final surface profile and deck cleanliness.

9) Polymer Overlay Primer. Place polymer overlay primer in accordance with Subsection 552.03.19 of the Standard Specifications, except that the sand requirement is rescinded.

10) Overlay Application. Perform the handling and mixing of the polymer resin and hardening agent in a safe manner to achieve the desired results according to the manufacturer's instructions. Do not apply the overlay system if any of the following conditions exist:

a) Ambient air temperature is below 50°F (10°C).

b) Deck temperature is below 50°F (10°C).

c) Moisture content in the deck exceeds 4.5% when measured by an electronic moisture meter or shows visible moisture after 2 hours when measured in accordance with ASTM D4263.

d) Rain is forecast during the minimum curing periods listed under C.5.

e) Material component temperatures are below 50°F (10°C) or above 99°F (37°C).

f) Class B repair material concrete age is less than 28 days, unless approved by the Project Manager.

g) The deck temperature exceeds 100°F (38°C).

h) The polymer gel time is less than 10 minutes at the predicted high air temperature for the day.

After the deck has been shotblasted and during the polymer overlay primer and overlay curing periods, only necessary surface preparation and overlay application equipment will be allowed on the deck. Begin the polymer overlay primer placement as soon as possible after surface preparation operations, followed by the polymer overlay placement as soon as possible after placement of the polymer overlay primer placement. A wet on wet application of the polymer overlay primer and polymer overlay is allowed.

Use a polymer overlay consisting of a two-course application of polymer and aggregate, consisting of a layer of polymer covered with a layer of aggregate in sufficient quantity to completely cover the polymer. Apply the polymer and aggregate according to the manufacturer's requirements. Apply the overlay using equipment designed for this purpose. Use an application machine that features positive displacement volumetric metering and can store and mix the polymer resins at the proper mix ratio. Disperse the aggregate using a standard chip spreader or equivalent machine that can provide a uniform, consistent coverage of aggregate.

Apply the polymer overlay in accordance with the manufacturer's instructions, but not less than the following rate of application:

Application Rates

Course	Minimum Polymer Application Rate (GAL/100 SF)	Aggregate [A] (LBS/SY)
1	2.5	10+
2	5.0	14+

[A] Apply aggregate in sufficient quantity to completely cover the polymer.

If the Project Manager determines that the course application does not receive enough aggregate before the polymer gels, remove and replace the course.

11) Minimum Curing Period. After completion of the course, cure the overlay in accordance with the manufacturer's recommendations.

12) Opening to Traffic. Remove the excess aggregate from the surface treatment by sweeping, blowing, or vacuuming without tearing or damaging the surface; the material may be re-used if approved by the Project Manager and manufacturer.

Clean expansion joints and joint seals of all debris and polymer.

Do not allow traffic on the treated area until directed by the Project Manager.

The Project Manager may require additional sweeping or cleaning to remove loosened aggregates from the deck following opening to traffic.

13) Repair of Polymer Overlay. Repair all areas of unbonded, uncured, or damaged polymer overlay at no cost to the State. Submit repair procedures from the manufacturer for approval. If no recommendations from the manufacturer, complete repairs in accordance with the following:

a) Saw cut the limits of the area to the top of the concrete.

b) Remove the overlay by scarifying, grinding, or other approved methods.

c) Shot blast or sand blast and air blast the concrete prior to placement of polymer overlay.

d) Place the polymer overlay in accordance with the application procedures required in this special provision.

D. Method of Measurement. Deck surface preparation is measured by square yard of deck surface area treated. Bridge Polymer Overlay Primer is measured by the square yard of deck surface area. Polymer Overlay is measured by square yard of deck surface area treated.

E. Basis of Payment. Payment for the completed and accepted quantities is made under the following:

Pay Item	Pay Unit
Prepare Deck	SQYD
Polymer Overlay Primer	SQYD
Polymer Overlay	SQYD

Payment at the contract unit price is full compensation for all resources necessary to complete the item of work in accordance with the contract.

APPENDIX H. SKID RESISTANCE TESTING TEST REPORT

INTERNATIONAL CYBERNETICS

CLIENT: WISS, JANNEY, ELSTNER ASSOCIATES, INC

MONTANA BRIDGE DECKS:

FRICTION ASSESSMENT REPORT: SEPTEMBER 2023

REPORT: WJE-23-1

Version	Revision	Revision Date	Revision Description	Author	Reviewer
1	0	18th Sep 23	Draft report for client review	James Erskine	Dan Wolney
1	1	22nd Oct 23	Revised lane naming convention	James Erskine	Dan Wolney

EXECUTIVE SUMMARY

International Cybernetics Company, LP (ICC) was engaged by Wiss, Janney, Elstner Associates, Inc. to undertake friction testing to determine the Friction Number (FN40R) on bridge decks throughout Montana.

Testing was performed between 12th and 14th September 2023 in clear to partly cloudy conditions with ambient temperatures ranging from 53°F to 93°F. The average Friction Number (FN40R) results for each lane of the bridge decks tested ranged from a low of 24.4 to a high of 66.2 as shown below.

Site Number	Location	Direction	Lane	FN40R	Test Cycles
01	I-90 Ramp over St Regis River (Bridge No. 1333)	Eastbound	DL	46.9	5
02	I-90 over Railroad (Bridge No. 1367)	Eastbound	PL	56.8	5
			DL	43.4	5
03	I-90 over Nemote Creek Rd (Bridge No. 1374)	Eastbound	PL	54.8	5
			DL	38.7	5
04	I-90 over Big Horn Rd (Bridge No. 1392)	Eastbound	PL	58.6	5
			DL	55.6	5
05	I-90 over Deer Creek Rd (Bridge No. 1428)	Eastbound	PL	43.7	5
			DL	24.4	5
06	Rock Creek Rd over I-90 (Bridge No. 3734)	Northbound	DL	62.4	5
		Southbound	DL	66.2	5
07	I-90 over Rt 1 (Bridge No. 1459)	Eastbound	PL	57.2	5
			DL	43.0	5
08	I-15 over Boulder River (Bridge No. 1137)	Northbound	PL	46.8	5
			DL	40.7	5
		Southbound	PL	53.7	5
			DL	44.1	5
09	I-15 over Boulder River (Bridge No. 1138)	Northbound	PL	42.8	5
			DL	38.4	5
		Southbound	PL	50.8	5
			DL	34.6	5
10	I-15 over Boulder River (Bridge No. 1139)	Northbound	PL	52.8	5
			DL	34.4	5
		Southbound	PL	42.7	5
			DL	38.6	5
11	Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)	Northbound	DL	48.7	5
		Southbound	DL	51.5	5
12	I-90 over Greycliff Rd (Bridge No. 1670)	Westbound	PL	65.3	5
			DL	46.8	5
13	I-90 over Bridger Creek Rd (Bridge No. 1682)	Westbound	PL	58.7	5
			DL	51.3	5
14	Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)	Northbound	DL	47.7	5
		Southbound	DL	51.1	5

Table of Contents

1. INTRODUCTION

1.1 Introduction and Background

International Cybernetics Company, LP (ICC) was engaged by Wiss, Janney, Elstner Associates, Inc. to undertake friction testing to determine the Friction Number (FN40R) on bridge decks throughout Montana. Testing was performed between 12th and 14th September 2023 in clear to partly cloudy conditions with ambient temperatures ranging from 53°F to 93°F.

1.2 Objective

The objective of this report is to evaluate the friction resistance of the thin polymer overlays on the bridge decks.

1.3 Scope of Work

The scope of work covered:

- Testing of the nominated sites using a Locked Wheel Friction Tester in the nominated lanes and directions of each site with a test interval of 528 feet (0.1 mi) for the determination of Friction Number with a minimum of 5 tests in each lane.

1.4 Location Details

The bridge decks tested were located throughout Montana as described in Table 1-1 and indicatively shown in Figure 1-1 following.

Table 1-1 Bridge Deck Location Details

Site Number	Location	Direction	Lane
01	I-90 Ramp over St Regis River (Bridge No. 1333)	Eastbound	DL
02	I-90 over Railroad (Bridge No. 1367)	Eastbound	PL & DL
03	I-90 over Nemote Creek Rd (Bridge No. 1374)	Eastbound	PL & DL
04	I-90 over Big Horn Rd (Bridge No. 1392)	Eastbound	PL & DL
05	I-90 over Deer Creek Rd (Bridge No. 1428)	Eastbound	PL & DL
06	Rock Creek Rd over I-90 (Bridge No. 3734)	Northbound	DL
		Southbound	DL
07	I-90 over Rt 1 (Bridge No. 1459)	Eastbound	PL & DL
08	I-15 over Boulder River (Bridge No. 1137)	Northbound	PL & DL
		Southbound	PL & DL
09	I-15 over Boulder River (Bridge No. 1138)	Northbound	PL & DL
		Southbound	PL & DL
10	I-15 over Boulder River (Bridge No. 1139)	Northbound	PL & DL
		Southbound	PL & DL
11	Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)	Northbound	DL
		Southbound	DL
12	I-90 over Greycliff Rd (Bridge No. 1670)	Westbound	PL & DL
13	I-90 over Bridger Creek Rd (Bridge No. 1682)	Westbound	PL & DL
14	Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)	Northbound	DL
		Southbound	DL

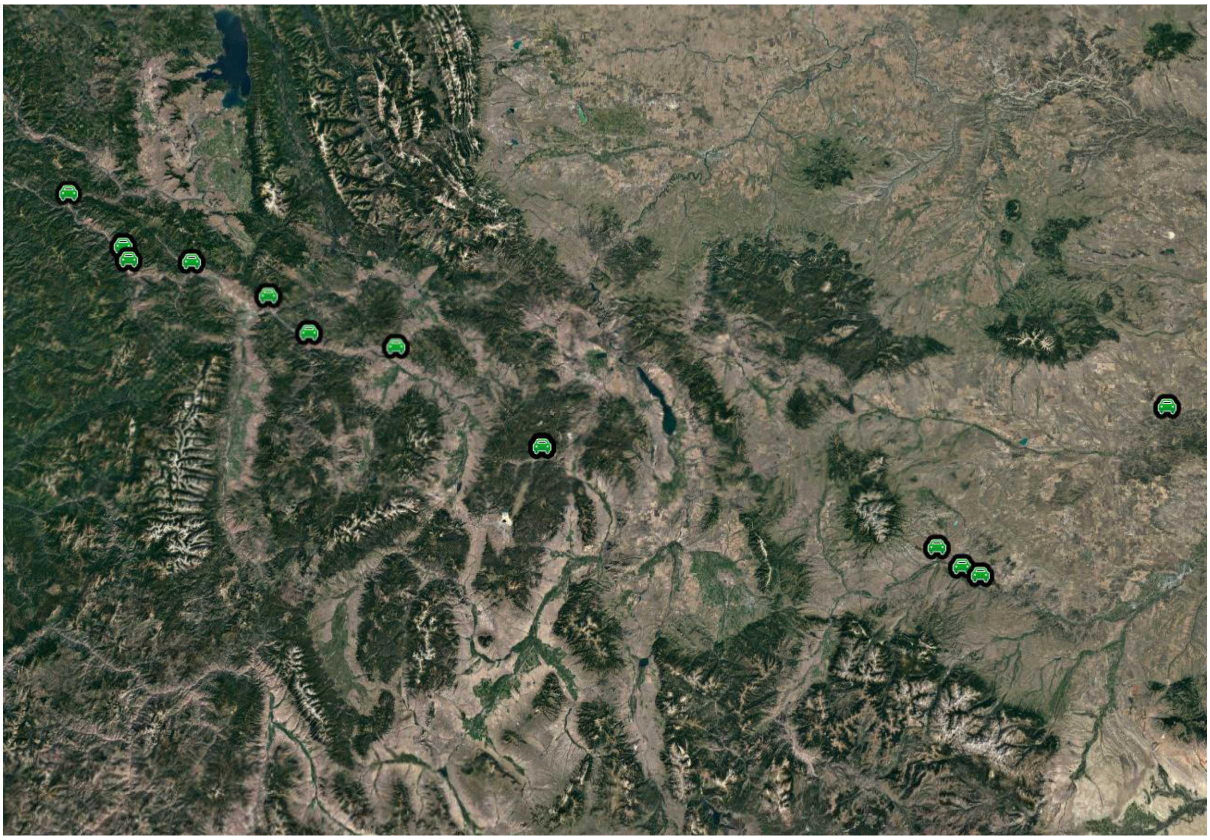


Figure 1-1 Location of Bridges Tested

1.5 Referenced Documents

1. ASTM E274/E274M - 15 “Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire”

2. AASHTO T-242 – 18 “Standard Method of Test for Frictional Properties of Paved Surfaces Using a Full-Scale Tire”.

3. AASHTO M 261 - (2018) “Standard Specification for Rib-Tread Standard Tire for Special Purpose Pavement Frictional-Property Tests”.

2. METHODOLOGY

2.1 Friction Testing

The friction of the pavement surface was measured using an ICC SFT 5041 Pavement Friction Tester in accordance with ASTM E274/E274M [1] and AASHTO T-242 [2] using a ribbed tire in accordance with AASHTO M 261 [3] in the left wheelpath. Prior to mobilization and upon return from site, the friction results measured by the system were verified by conducting testing on ICC's local verification site on Belcher Road, Largo, Florida, the results for which are included in Appendix A. Testing was undertaken at each site with skid cycles of approximately 528 feet (0.1 mi) each. The ICC SFT 5041 pavement friction tester measures average locked wheel (skid) and peak incipient (slip) friction characteristics on paved surfaces. The friction tester consists of a fully instrumented tow vehicle and test trailer that uses a two-axis force transducer to provide dynamic vertical load and horizontal tractive force measurements. Water is delivered ahead of the test tire and the frictional force acting between the pavement surface and vehicle speed is recorded during the test.

Figure 2-1 ICC SFT 5041 Pavement Friction Tester

The system samples the forces at the test wheel, distance travelled and speeds of the trailer & test wheels at 500 times per second and records the data. The skid resistance of the paved surface is determined from the resulting forces and is reported as Skid Number (SN). The SN being determined from the force required to slide the locked test tire over the tested surface, at a stated constant speed, divided by the effective wheel load and multiplied by 100. The tests were conducted at a target speed of 40mph and any cycles having a test speed +/- 2mph were retested or marked accordingly. FN40R values are reported as the integer value of the average FN recorded for the test cycle and have not been normalized to account for any variation in the test speed from that of the target speed. Where the tests could not be completed at 40mph owing to site constraints, they were conducted as close as possible to 30mph, and the FN values normalized to 40mph using the following formula:

$$FN40R = FN_{Avg} + SG \times (S - 40)$$

Where FN40R = Friction Number from locked wheel testing at 40 mph using a ribbed tire

FN_{Avg} = Average Friction Number for cycle at Speed S

S = Speed of test tire during cycle

SG = Speed Gradient with a value of 0.50 adopted.

Testing was performed along the length of each bridge deck described in Table 1-1. For the purposes of this report the following lane naming convention has been used as illustrated in Figure 2-2 following.

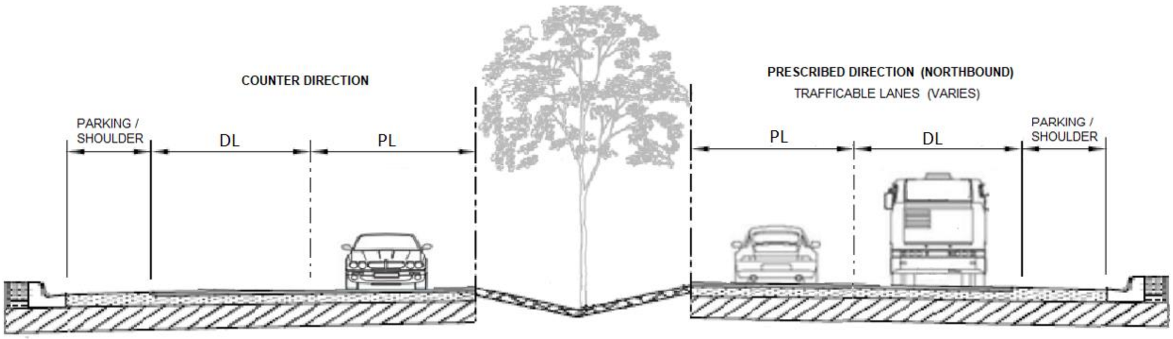


Figure 2-2 Lane Convention

3. SKID RESISTANCE RESULTS

3.1 Friction Number

Friction Number results at a target speed of 40 mph are summarized in Table 3-1 below. The average Friction Number (FN40R) results for each lane of the bridge decks tested ranged from a low of 24.4 to a high of 66.2. Detailed results for each cycle in addition to the summary results for each run and site can be found in Appendix B.

Table 3-1 Friction Number FN40R

Site Number	Location	Direction	Lane	FN40R	Test Cycles
01	I-90 Ramp over St Regis River (Bridge No. 1333)	Eastbound	DL	46.9	5
02	I-90 over Railroad (Bridge No. 1367)	Eastbound	PL	56.8	5
			DL	43.4	5
03	I-90 over Nemote Creek Rd (Bridge No. 1374)	Eastbound	PL	54.8	5
			DL	38.7	5
04	I-90 over Big Horn Rd (Bridge No. 1392)	Eastbound	PL	58.6	5
			DL	55.6	5
05	I-90 over Deer Creek Rd (Bridge No. 1428)	Eastbound	PL	43.7	5
			DL	24.4	5
06	Rock Creek Rd over I-90 (Bridge No. 3734)	Northbound	DL	62.4	5
		Southbound	DL	66.2	5
07	I-90 over Rt 1 (Bridge No. 1459)	Eastbound	PL	57.2	5
			DL	43.0	5
08	I-15 over Boulder River (Bridge No. 1137)	Northbound	PL	46.8	5
			DL	40.7	5
		Southbound	PL	53.7	5
			DL	44.1	5
09	I-15 over Boulder River (Bridge No. 1138)	Northbound	PL	42.8	5
			DL	38.4	5
		Southbound	PL	50.8	5
			DL	34.6	5
10	I-15 over Boulder River (Bridge No. 1139)	Northbound	PL	52.8	5
			DL	34.4	5
		Southbound	PL	42.7	5
			DL	38.6	5
11	Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)	Northbound	DL	48.7	5
		Southbound	DL	51.5	5
12	I-90 over Greycliff Rd (Bridge No. 1670)	Westbound	PL	65.3	5
			DL	46.8	5
13	I-90 over Bridger Creek Rd (Bridge No. 1682)	Westbound	PL	58.7	5
			DL	51.3	5
14	Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)	Northbound	DL	47.7	5
		Southbound	DL	51.1	5

APPENDIX A – LOCKED WHEEL CALIBRATION CERTIFICATE & REPORT

Serial Number: ICC34

INTERNATIONAL CYBERNETICS

E274 Friction Calibration Report

International Cybernetics Company, LP.

Distance Calibration

DMI Type	Date/Time	TestID	DMI	DCF	NewDist	OldDist	Speed	Bias
DMI6		Avg	13040	0.971779	1056.0	1055.9	29.8	
DMI6	08/08/2022 12:16	1	13041	0.971705	1056.1	1056.0	29.9	PASS
DMI6	08/08/2022 12:16	2	13041	0.971705	1056.1	1056.0	29.8	PASS
DMI6	08/08/2022 12:16	3	13040	0.971779	1056.0	1055.9	29.9	PASS
DMI6		StdDev	0	0.000000	0.0	0.0	0.0	
DMI5		Avg	13040	0.971779	1056.0	1055.9	29.8	
DMI5	08/08/2022 12:16	1	13041	0.971705	1056.1	1056.0	29.9	PASS
DMI5	08/08/2022 12:16	2	13041	0.971705	1056.1	1056.0	29.8	PASS
DMI5	08/08/2022 12:16	3	13040	0.971779	1056.0	1055.9	29.9	PASS
DMI5		StdDev	0	0.000000	0.0	0.0	0.0	
LtWheel		Avg	6078	2.084896	1056.0	1062.1	29.8	
LtWheel	08/08/2022 12:16	1	6080	2.084211	1056.3	1062.5	29.9	PASS
LtWheel	08/08/2022 12:16	2	6078	2.084896	1056.0	1062.1	29.8	PASS
LtWheel	08/08/2022 12:16	3	6077	2.085239	1055.8	1061.9	29.9	PASS
LtWheel		StdDev	0	0.000000	0.3	0.3	0.0	
RtWheel		Avg	6030	2.101493	1056.0	1048.0	29.8	
RtWheel	08/08/2022 12:16	1	6031	2.101144	1056.2	1048.2	29.9	PASS
RtWheel	08/08/2022 12:16	2	6030	2.101493	1056.0	1048.0	29.8	PASS
RtWheel	08/08/2022 12:16	3	6030	2.101493	1056.0	1048.0	29.9	PASS
RtWheel		StdDev	0	0.000000	0.1	0.1	0.0	

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Serial Number: ICC34

Force/Load – Left Wheel

Force/Load Calibration:	08/09/2022 09:21:41
Calibration Operator(s):	Scott Igel
Test Wheel:	Left

ForcePreCalBias	ForceBias	ForceGain	ForceZero	ForceStatic	ForceShunt
-65.392157	0.000000	-0.289356	-2.4	57.47	-2637.08
LoadPreCalBias	**LoadBias**	**LoadGain**	**LoadZero**	**LoadStatic**	**LoadShunt**
0.901961	0.000000	-0.273124	85.4	-3683.61	-6364.94

TestID	CalForce	RawForce	RawLoad	T-Force	T-Load	T-SN	M-Force	M-Load	M-SN	ForceErr	LoadErr	Bias
1	0	55.1176	-3688.7451	0.6	1092.6	0.1	0.0	1093.1	0.0	0.0	-0.0	PASS
2	100	-281.3137	-3643.2549	97.9	1080.2	9.1	100.0	1080.3	9.3	0.0	-0.0	PASS
3	200	-626.8235	-3588.8039	197.9	1065.3	18.6	200.0	1064.5	18.8	-1.1	0.1	PASS
4	300	-969.3529	-3545.6275	297.0	1053.6	28.2	300.0	1052.8	28.5	-1.0	0.1	PASS
5	400	-1313.6275	-3495.3529	396.6	1039.8	38.1	400.0	1039.5	38.5	-0.8	0.0	PASS
6	500	-1660.0392	-3445.9412	496.9	1026.3	48.4	500.0	1025.7	48.7	-0.6	0.1	PASS
7	600	-2009.0392	-3394.8824	597.8	1012.4	59.1	600.0	1012.2	59.3	-0.4	0.0	PASS
8	700	-2358.3922	-3345.7647	698.9	999.0	70.0	700.0	999.2	70.1	-0.2	-0.0	PASS
9	800	-2701.1765	-3298.7647	798.1	986.1	80.9	800.0	986.7	81.1	-0.2	-0.1	PASS
10	700	-2367.5098	-3338.3137	701.6	996.9	70.4	700.0	997.5	70.2	0.2	-0.1	PASS
11	600	-2041.6275	-3402.3333	607.3	1014.4	59.9	602.6	1014.5	59.4	0.8	-0.0	PASS
12	500	-1681.1569	-3441.1176	503.0	1025.0	49.1	500.0	1025.5	48.8	0.6	-0.0	PASS
13	400	-1342.1176	-3481.9608	404.9	1036.2	39.1	401.2	1035.8	38.7	0.9	0.0	PASS
14	300	-995.3725	-3533.0784	304.5	1050.1	29.0	302.8	1049.8	28.8	0.6	0.0	PASS
15	200	-645.6078	-3583.2549	203.3	1063.8	19.1	202.5	1062.8	19.1	0.4	0.1	PASS
16	100	-298.7843	-3640.1569	103.0	1079.4	9.5	100.0	1080.0	9.3	0.0	-0.1	PASS
17	0	57.9216	-3684.5882	-0.2	1091.5	-0.0	0.0	1092.8	0.0	0.0	-0.1	PASS

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Serial Number: ICC34

Force/Load – Right Wheel

Force/Load Calibration:	08/09/2022 10:31:09
Calibration Operator(s):	Scott Igel
Test Wheel:	Right

ForcePreCalBias	ForceBias	ForceGain	ForceZero	ForceStatic	ForceShunt
3644.215686	0.000000	-0.255824	-2.4	-3652.22	-6326.67
LoadPreCalBias	**LoadBias**	**LoadGain**	**LoadZero**	**LoadStatic**	**LoadShunt**
-8191.000000	0.000000	-0.221198	279.4	4559.90	1835.33

TestID	CalForce	RawForce	RawLoad	T-Force	T-Load	T-SN	M-Force	M-Load	M-SN	ForceErr	LoadErr	Bias
1	0	-3654.0392	4558.6471	0.2	1082.8	0.0	0.0	1081.9	0.0	0.0	0.1	PASS
2	100	-4034.0588	4614.8824	97.4	1070.4	9.1	100.0	1071.0	9.3	0.0	-0.1	PASS
3	200	-4435.3922	4679.3922	200.0	1056.1	18.9	201.1	1055.7	19.0	-0.5	0.0	PASS
4	300	-4815.3529	4739.0392	297.2	1042.9	28.5	300.0	1043.2	28.8	-0.9	-0.0	PASS
5	400	-5208.8627	4799.9020	397.9	1029.5	38.7	400.0	1029.3	38.9	-0.5	0.0	PASS
6	500	-5601.4314	4862.4510	498.3	1015.6	49.1	500.0	1014.5	49.3	-0.3	0.1	PASS
7	600	-5994.2157	4923.0980	598.8	1002.2	59.7	600.0	1001.5	59.9	-0.2	0.1	PASS
8	700	-6387.4902	4981.9804	699.4	989.2	70.7	700.0	988.8	70.8	-0.1	0.0	PASS
9	800	-6772.9608	5040.8431	798.0	976.2	81.8	800.0	976.8	81.9	-0.2	-0.1	PASS
10	700	-6380.5882	4988.6471	697.7	987.7	70.6	700.0	988.5	70.8	-0.3	-0.1	PASS
11	600	-6017.4314	4936.8824	604.8	999.2	60.5	600.0	998.6	60.1	0.8	0.1	PASS
12	500	-5630.8431	4874.0392	505.9	1013.1	49.9	501.5	1013.5	49.5	0.9	-0.0	PASS
13	400	-5235.0588	4809.1961	404.6	1027.4	39.4	401.2	1027.5	39.0	0.9	-0.0	PASS
14	300	-4832.8039	4745.7451	301.7	1041.5	29.0	300.0	1041.5	28.8	0.6	-0.0	PASS
15	200	-4452.3529	4683.2549	204.4	1055.3	19.4	203.7	1056.2	19.3	0.3	-0.1	PASS
16	100	-4048.0196	4619.7647	100.9	1069.3	9.4	100.0	1071.5	9.3	0.0	-0.2	PASS
17	0	-3654.0980	4559.7647	0.2	1082.6	0.0	0.0	1081.2	0.0	0.0	0.1	PASS

Serial Number: ICC34

Macrotexture Laser Calibration

Block Check:	8/8/2022 10:11:47 AM
Calibration Operator(s):	Scott Igel
Laser:	Selcom 62.5KHz
Block Tolerance (in):	0.010000

TestID	Block Size (in)	Block Ave (in)	Block Diff (in)	Errors	Bias
1	0.00	0.000000	0.000000	0	PASS
2	0.25	0.247206	0.002794	0	PASS
3	0.50	0.501412	0.001412	0	PASS
4	1.00	0.997689	0.002311	0	PASS
5	0.00	0.000627	0.000627	0	PASS

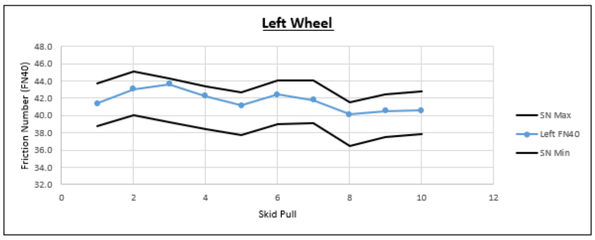
Belcher Verification

Date: 9/1/2023
Operator: Dan Wolney
System ID: ICC34

Baseline FN40 Values

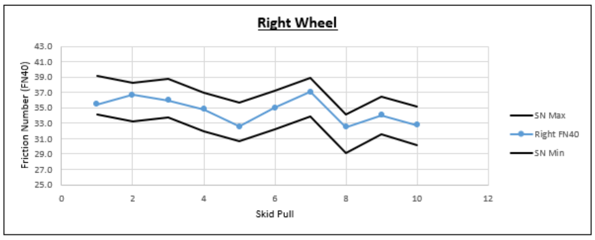
Left Wheel

	Avg FN40 / Lockup	StdDev	FN40 Range Min	FN40 Range Max
1	41.4	0.4	38.8	43.8
2	43.0	2.3	40.0	45.0
3	43.6	1.5	39.3	44.3
4	42.3	0.9	38.4	43.4
5	41.1	1.2	37.7	42.7
6	42.4	1.4	39.0	44.0
7	41.8	0.7	39.1	44.1
8	40.1	0.7	36.5	41.5
9	40.5	0.2	37.5	42.5
10	40.6	0.9	37.8	42.8
Run Avg	41.7	0.4	38.4	43.4



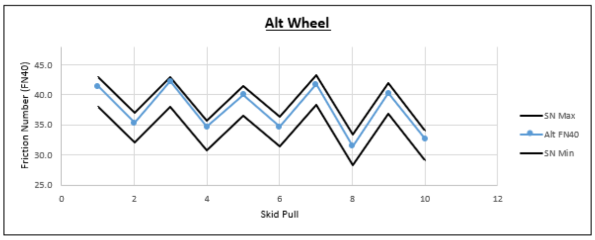
Right Wheel

	Avg FN40 / Lockup	StdDev	FN40 Range Min	FN40 Range Max
1	35.4	0.4	34.1	39.1
2	36.7	2.0	33.2	38.2
3	36.0	0.5	33.8	38.8
4	34.8	0.8	32.0	37.0
5	32.5	1.4	30.7	35.7
6	35.0	1.6	32.2	37.2
7	37.1	1.7	33.9	38.9
8	32.5	1.5	29.1	34.1
9	34.0	1.4	31.5	36.5
10	32.8	1.5	30.2	35.2
Run Avg	34.7	1.1	32.1	37.1



Alt Wheel

	Avg FN40 / Lockup	StdDev		FN40 Range Min	FN40 Range Max
1	41.4	1.5	L	37.9	42.9
2	35.3	0.6	R	32.0	37.0
3	42.2	0.4	L	38.0	43.0
4	34.7	0.9	R	30.7	35.7
5	40.0	0.1	L	36.5	41.5
6	34.7	1.2	R	31.4	36.4
7	41.7	1.5	L	38.3	43.3
8	31.5	0.3	R	28.4	33.4
9	40.2	0.1	L	36.9	41.9
10	32.7	0.4	R	29.1	34.1
L Run Avg / L StdDev	41.1	0.3		37.5	42.5
R Run Avg / R StdDev	33.8	0.6		30.3	35.3



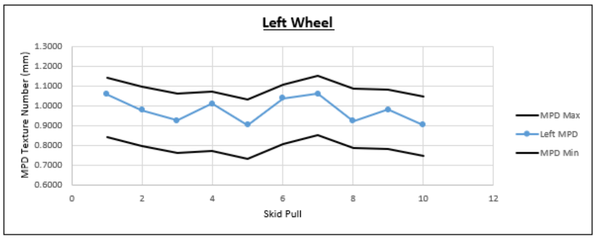
Date: 9/1/2023
Operator: Dan Wolney
System ID: ICC34

Baseline MPD Values

Left Wheel

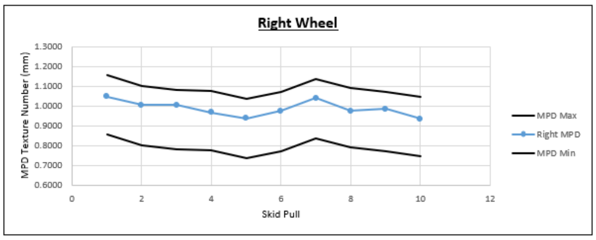
Water: 25.2 - 30.8

	Avg Water / Lockup	Avg MPD / lockup	MPD Range Min	MPD Range Max
1	29.37	1.0567	0.8426	1.1426
2	29.80	0.9773	0.7955	1.0955
3	29.47	0.9230	0.7586	1.0586
4	29.50	1.0090	0.7698	1.0698
5	29.23	0.9027	0.7322	1.0322
6	29.57	1.0377	0.8075	1.1075
7	29.00	1.0600	0.8486	1.1486
8	29.30	0.9223	0.7833	1.0833
9	29.40	0.9797	0.7812	1.0812
10	29.00	0.9027	0.7439	1.0439
Run Avg	29.36	0.9771	0.7863	1.0863



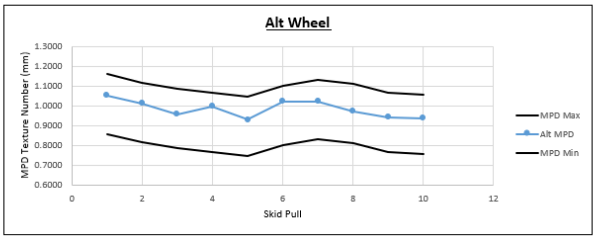
Right Wheel

	Avg Water / Lockup	Avg MPD / lockup	MPD Range Min	MPD Range Max
1	27.80	1.0470	0.8556	1.1556
2	27.87	1.0040	0.7989	1.0989
3	27.57	1.0043	0.7796	1.0796
4	27.67	0.9673	0.7729	1.0729
5	28.00	0.9370	0.7351	1.0351
6	27.73	0.9743	0.7715	1.0715
7	27.73	1.0400	0.8373	1.1373
8	27.57	0.9750	0.7917	1.0917
9	28.13	0.9840	0.7727	1.0727
10	28.10	0.9337	0.7449	1.0449
Run Avg	27.82	0.9867	0.7860	1.0860



Alt Wheel

	Avg Water / Lockup	Avg MPD / lockup	MPD Range Min	MPD Range Max
1	29.77	1.0517	0.8578	1.1578
2	28.30	1.0107	0.8145	1.1145
3	29.37	0.9573	0.7853	1.0853
4	27.97	0.9970	0.7656	1.0656
5	29.50	0.9300	0.7440	1.0440
6	28.23	1.0223	0.8008	1.1008
7	29.27	1.0227	0.8292	1.1292
8	28.37	0.9720	0.8098	1.1098
9	29.60	0.9413	0.7667	1.0667
10	27.53	0.9360	0.7573	1.0573
L Run Avg	29.50	0.9806	0.7966	1.0966
R Run Avg	28.08	0.9876	0.7896	1.0896



APPENDIX B – FRICTION TEST RESULTS

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Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/12/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 Ramp over St Regis River (Bridge No. 1333)

Site Number: 01
Lane: DL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number				Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
				FN	FN40R	Peak FN	Slip %						
1	1	Left	23	51.8	47.6	100.9	4.3	32	23.1	84.3	2:27:58 PM	47.29549375	-115.09911008
2	1	Left	22	51.2	46.4	86.5	19.3	30	21.1	85.3	2:36:27 PM	47.29549844	-115.09914762
3	1	Left	18	50.3	46.0	81.8	21.2	31	21.2	85.7	2:40:36 PM	47.29552671	-115.09921941
4	1	Left	23	51.0	46.8	84.5	16.7	32	22.1	86.2	2:44:16 PM	47.29550838	-115.09915987
5	1	Left	22	52.1	47.6	84.9	17.1	31	21.8	86.5	2:48:09 PM	47.29548567	-115.09909767
Site Average				51.3	46.9			31	21.9				
Standard Deviation				0.7	0.7			1	0.8				
Site Min				50.3	46.0			30	21.1				
Site Max				52.1	47.6			32	23.1				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/12/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-90 Ramp over St Regis River (Bridge No. 1333)

Site Number: 01
Lane: DL
Direction: Eastbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/12/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Railroad (Bridge No. 1367)

Site Number: 02
Lane: DL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	44	48.1	48.4	83.1	14.0	41	27.9	88.9	3:08:12 PM	47.08132136	-114.77406650
2	1	Left	38	42.0	42.5	80.7	17.6	41	28.3	89.2	3:13:47 PM	47.08127495	-114.77394626
3	1	Left	40	42.9	43.7	82.9	16.9	42	29.2	89.8	3:19:41 PM	47.08132085	-114.77407769
4	1	Left	35	37.7	38.4	71.2	18.9	41	29.0	90.2	3:25:17 PM	47.08132328	-114.77408030
5	1	Left	39	43.6	43.9	85.8	15.5	41	29.1	90.7	3:30:48 PM	47.08130714	-114.77403558
			Site Average	42.9	43.4			41	28.7				
			Standard Deviation	3.7	3.6			0	0.6				
			Site Min	37.7	38.4			41	27.9				
			Site Max	48.1	48.4			42	29.2				

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/12/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Railroad (Bridge No. 1367)

Site Number: 02
Lane: DL
Direction: Eastbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/12/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Railroad (Bridge No. 1367)

Site Number: 02
Lane: PL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	41	60.1	60.4	92.2	15.7	41	29.9	90.7	3:36:34 PM	47.08133172	-114.77398300
2	1	Left	45	56.6	57.1	92.9	17.3	41	29.5	91.5	3:42:06 PM	47.08128152	-114.77386219
3	1	Left	45	56.7	57.0	92.3	14.8	41	29.7	91.9	3:47:52 PM	47.08132620	-114.77396508
4	1	Left	42	55.1	55.2	97.2	16.7	40	29.1	92.2	3:53:30 PM	47.08132272	-114.77394881
5	1	Left	44	53.8	54.5	91.8	15.1	41	29.5	92.5	3:58:57 PM	47.08134524	-114.77401692
			Site Average	56.5	56.8			41	29.5				
			Standard Deviation	2.4	2.3			1	0.3				
			Site Min	53.8	54.5			40	29.1				
			Site Max	60.1	60.4			41	29.9				

Friction Resistance Test Results

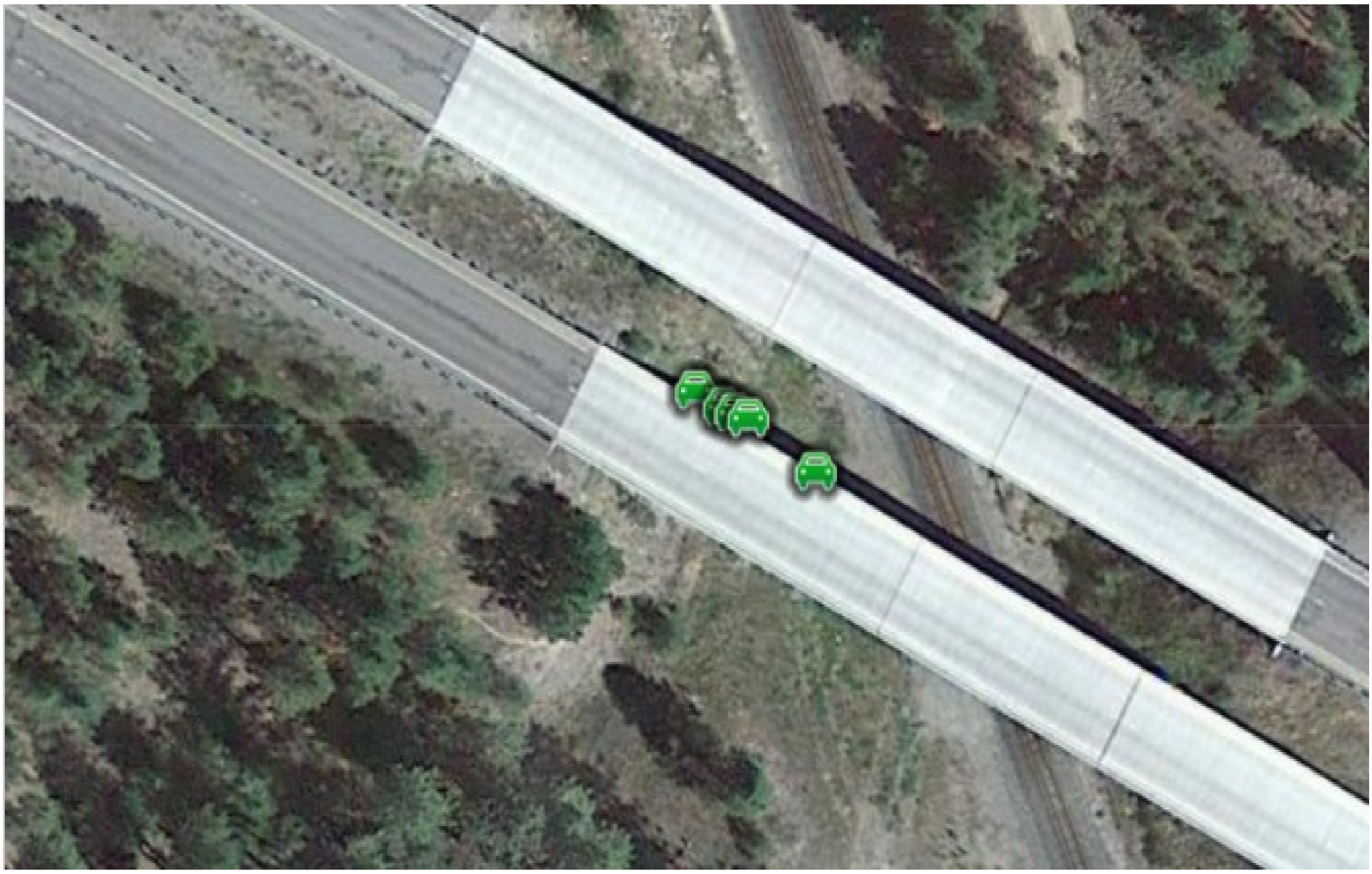
Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/12/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-90 over Railroad (Bridge No. 1367)

Site Number: 02
Lane: PL
Direction: Eastbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1 **Test:** Wet
Test Equipment: ICC34 **Tire:** Ribbed
Test Method: AASHTO-T242
Testing Date: 09/12/2023
Operator: Dan Wolney

I-90 over Nemote Creek Rd (Bridge No. 1374)

Site Number: 03
Lane: DL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	36	40.2	39.9	73.1	13.1	39	27.8	92.9	4:05:03 PM	47.02592314	-114.73941740
2	1	Left	30	34.1	33.8	83.2	9.7	39	28.9	92.8	4:13:19 PM	47.02600193	-114.73946862
3	1	Left	36	39.6	39.9	66.9	6.0	40	29.2	92.9	4:15:25 PM	47.02594532	-114.73943892
4	1	Left	38	41.9	41.7	76.4	20.5	40	28.4	92.9	4:19:42 PM	47.02593142	-114.73942483
5	1	Left	35	38.5	38.1	74.6	6.2	39	28.1	93.1	4:21:49 PM	47.02595078	-114.73943802
			Site Average	38.9	38.7			40	28.5				
			Standard Deviation	2.9	3.0			1	0.6				
			Site Min	34.1	33.8			39	27.8				
			Site Max	41.9	41.7			40	29.2				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1
Test Equipment: ICC34
Test: Wet
Tire: Ribbed
Test Method: AASHTO-T242
Testing Date: 09/12/2023
Operator: Dan Wolney

I-90 over Nemote Creek Rd (Bridge No. 1374)

Site Number: 03
Lane: DL
Direction: Eastbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc		**Test Method:** AASHTO-T242	
Project No: WJE-23-1	**Test:** Wet	**Testing Date:** 09/12/2023	
Test Equipment: ICC34	**Tire:** Ribbed	**Operator:** Dan Wolney	

I-90 over Nemote Creek Rd (Bridge No. 1374)

Site Number: 03
Lane: PL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	31	57.2	57.3	68.5	15.4	40	28.4	93.1	4:23:47 PM	47.02600545	-114.73941554
2	1	Left	38	55.0	55.0	100.7	15.3	40	28.1	92.9	4:25:44 PM	47.02601914	-114.73942630
3	1	Left	30	54.3	54.1	60.3	12.3	40	28.2	93.1	4:28:01 PM	47.02600088	-114.73941140
4	1	Left	34	54.7	54.4	95.1	15.6	40	28.1	93.1	4:30:00 PM	47.02600190	-114.73941545
5	1	Left	31	53.5	53.4	63.3	13.5	40	28.4	93.1	4:32:06 PM	47.02599756	-114.73941317
			Site Average	54.9	54.8			40	28.2				
			Standard Deviation	1.4	1.5			0	0.2				
			Site Min	53.5	53.4			40	28.1				
			Site Max	57.2	57.3			40	28.4				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/12/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-90 over Nemote Creek Rd (Bridge No. 1374)

Site Number: 03
Lane: PL
Direction: Eastbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc **Test Method:** AASHTO-T242
Project No: WJE-23-1 **Test:** Wet **Testing Date:** 09/12/2023
Test Equipment: ICC34 **Tire:** Ribbed **Operator:** Dan Wolney

I-90 over Big Horn Rd (Bridge No. 1392)

Site Number: 04
Lane: DL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	45	55.9	56.2	94.0	16.8	41	29.1	92.6	4:53:29 PM	47.01937657	-114.36756854
2	1	Left	42	56.6	57.0	99.5	19.5	41	28.6	92.2	5:10:40 PM	47.01937472	-114.36755940
3	1	Left	41	54.7	54.8	90.9	8.1	40	28.9	91.8	5:28:21 PM	47.01937880	-114.36754544
4	1	Left	38	55.9	56.1	92.6	9.3	40	28.7	91.6	5:38:04 PM	47.01937390	-114.36755704
5	1	Left	44	53.8	53.8	102.5	18.4	40	28.3	91.5	5:47:37 PM	47.01937873	-114.36755141
			Site Average	55.4	55.6			40	28.7				
			Standard Deviation	1.1	1.3			0	0.3				
			Site Min	53.8	53.8			40	28.3				
			Site Max	56.6	57.0			41	29.1				

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/12/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-90 over Big Horn Rd (Bridge No. 1392)

Site Number: 04
Lane: DL
Direction: Eastbound

Survey Notes

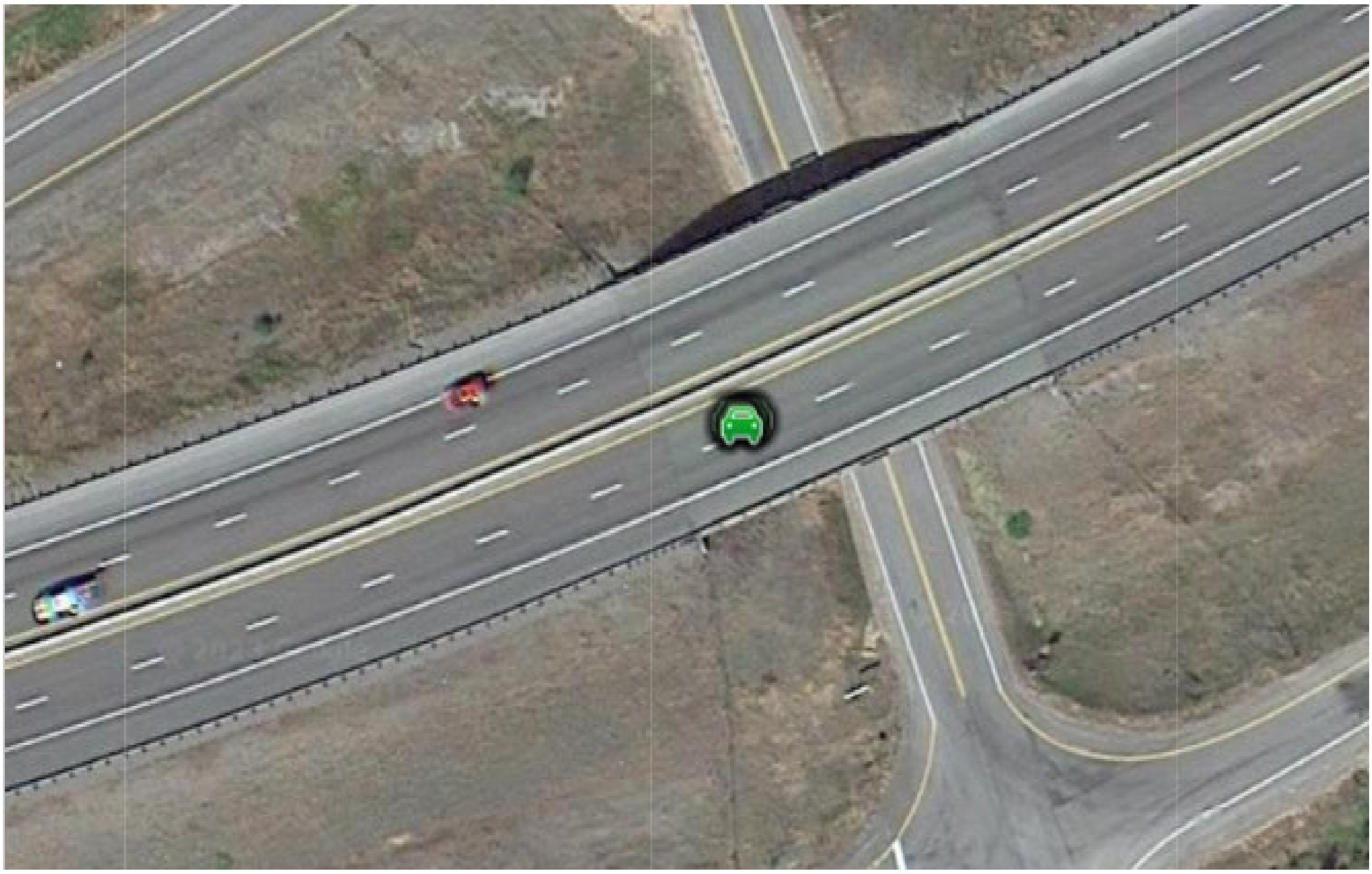
1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc **Test Method:** AASHTO-T242
Project No: WJE-23-1 **Test:** Wet **Testing Date:** 09/12/2023
Test Equipment: ICC34 **Tire:** Ribbed **Operator:** Dan Wolney

I-90 over Big Horn Rd (Bridge No. 1392)

Site Number: 04
Lane: PL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	44	59.4	59.5	90.7	8.8	40	28.4	91.4	5:57:45 PM	47.01942213	-114.36754868
2	1	Left	40	58.4	58.6	100.4	23.4	41	28.7	90.7	6:06:59 PM	47.01940262	-114.36759302
3	1	Left	41	57.5	57.8	91.5	23.1	40	27.9	90.1	6:16:34 PM	47.01941616	-114.36755689
4	1	Left	43	58.2	58.2	102.1	18.4	40	28.3	89.6	6:26:30 PM	47.01940449	-114.36758096
5	1	Left	44	59.3	58.8	94.8	6.4	39	27.3	88.8	6:36:29 PM	47.01942475	-114.36750167
			Site Average	58.6	58.6			40	28.1				
			Standard Deviation	0.8	0.6			1	0.5				
			Site Min	57.5	57.8			39	27.3				
			Site Max	59.4	59.5			41	28.7				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1 **Test:** Wet
Test Equipment: ICC34 **Tire:** Ribbed
Test Method: AASHTO-T242
Testing Date: 09/12/2023
Operator: Dan Wolney

I-90 over Big Horn Rd (Bridge No. 1392)

Site Number: 04
Lane: PL
Direction: Eastbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc **Test Method:** AASHTO-T242
Project No: WJE-23-1 **Test:** Wet **Testing Date:** 09/12/2023
Test Equipment: ICC34 **Tire:** Ribbed **Operator:** Dan Wolney

I-90 over Deer Creek Rd (Bridge No. 1428)

Site Number: 05
Lane: DL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	32	26.6	27.1	49.0	10.0	41	28.9	87.3	6:59:05 PM	46.87715579	-113.91297498
2	1	Left	35	24.4	24.9	51.7	10.5	41	29.7	86.7	7:06:32 PM	46.87715632	-113.91298061
3	1	Left	30	23.3	23.4	49.7	9.8	40	27.5	86.3	7:12:50 PM	46.87715382	-113.91296402
4	1	Left	32	22.7	22.7	47.3	12.1	40	28.4	86.0	7:18:17 PM	46.87715938	-113.91297474
5	1	Left	31	23.6	23.7	49.4	9.8	40	29.1	85.9	7:24:09 PM	46.87715985	-113.91299101
			Site Average	24.1	24.4			41	28.7				
			Standard Deviation	1.5	1.7			1	0.8				
			Site Min	22.7	22.7			40	27.5				
			Site Max	26.6	27.1			41	29.7				

Friction Resistance Test Results

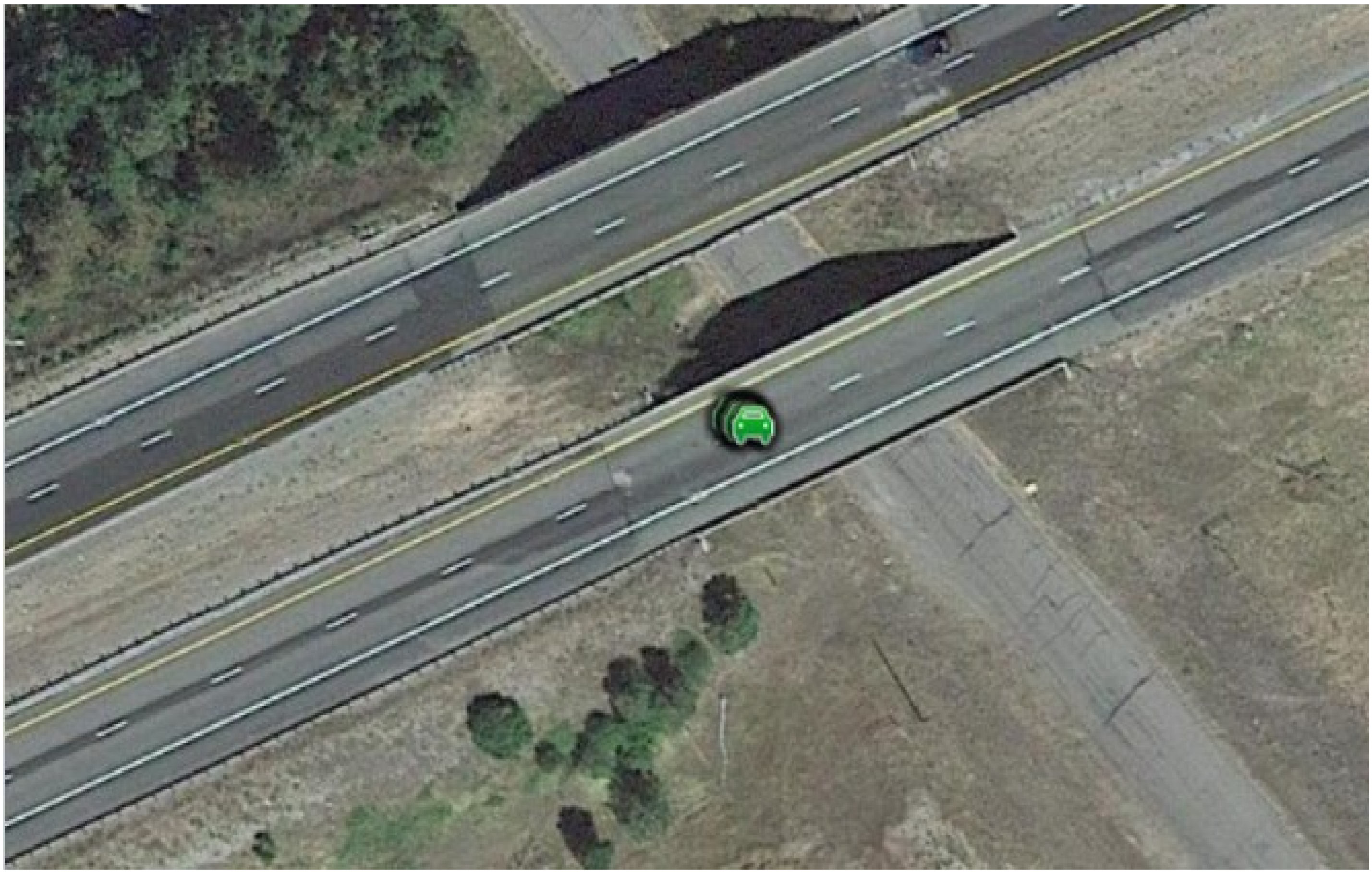
Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1
Test Equipment: ICC34
Test: Wet
Tire: Ribbed
Test Method: AASHTO-T242
Testing Date: 09/12/2023
Operator: Dan Wolney

I-90 over Deer Creek Rd (Bridge No. 1428)

Site Number: 05
Lane: DL
Direction: Eastbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/12/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Deer Creek Rd (Bridge No. 1428)

Site Number: 05
Lane: PL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	35	44.5	44.9	71.7	3.2	41	28.2	85.4	7:30:02 PM	46.87718942	-113.91302150
2	1	Left	37	41.5	41.5	66.2	6.4	40	28.6	85.2	7:35:52 PM	46.87720288	-113.91303292
3	1	Left	36	45.7	45.8	73.6	19.0	40	29.2	84.9	7:41:30 PM	46.87722338	-113.91299302
4	1	Left	38	40.3	40.3	74.6	3.5	40	28.3	84.8	7:47:06 PM	46.87719919	-113.91301288
5	1	Left	38	45.7	45.8	74.9	8.0	40	28.6	84.4	7:52:48 PM	46.87719859	-113.91302029
			Site Average	43.5	43.7			40	28.6				
			Standard Deviation	2.5	2.6			0	0.4				
			Site Min	40.3	40.3			40	28.2				
			Site Max	45.7	45.8			41	29.2				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/12/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Deer Creek Rd (Bridge No. 1428)

Site Number: 05
Lane: PL
Direction: Eastbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1 **Test:** Wet
Test Equipment: ICC34 **Tire:** Ribbed
Test Method: AASHTO-T242
Testing Date: 09/13/2023
Operator: Dan Wolney

Rock Creek Rd over I-90 (Bridge No. 3734)

Site Number: 06
Lane: DL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	23	70.8	66.2	99.3	13.7	31	21.9	53.0	7:59:55 AM	46.72789292	-113.66795455
2	1	Left	25	67.4	62.6	104.2	20.9	31	21.9	53.0	8:01:52 AM	46.72791842	-113.66795342
3	1	Left	25	67.3	62.9	97.9	11.8	31	21.8	53.3	8:04:06 AM	46.72787953	-113.66795468
4	1	Left	24	65.8	61.1	98.3	19.7	31	22.0	53.2	8:06:00 AM	46.72792982	-113.66795821
5	1	Left	22	63.8	59.0	100.2	18.9	30	21.3	53.3	8:07:55 AM	46.72814757	-113.66794851
			Site Average	67.0	62.4			31	21.8				
			Standard Deviation	2.6	2.6			0	0.3				
			Site Min	63.8	59.0			30	21.3				
			Site Max	70.8	66.2			31	22.0				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rock Creek Rd over I-90 (Bridge No. 3734)

Site Number: 06
Lane: DL
Direction: Northbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rock Creek Rd over I-90 (Bridge No. 3734)

Site Number: 06
Lane: DL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	24	73.7	68.8	101.0	12.6	30	20.7	52.9	8:01:00 AM	46.72847886	-113.66798872
2	1	Left	22	71.3	66.3	97.1	18.9	30	22.0	53.0	8:03:10 AM	46.72852222	-113.66798302
3	1	Left	22	69.4	64.5	99.5	24.6	30	21.9	52.9	8:05:09 AM	46.72849343	-113.66798507
4	1	Left	22	70.2	64.7	100.2	23.0	29	21.1	53.3	8:07:03 AM	46.72842256	-113.66799284
5	1	Left	22	71.8	66.5	98.9	17.6	29	20.9	53.2	8:08:55 AM	46.72830491	-113.66799590
			Site Average	71.3	66.2			30	21.3				
			Standard Deviation	1.6	1.7			1	0.6				
			Site Min	69.4	64.5			29	20.7				
			Site Max	73.7	68.8			30	22.0				

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

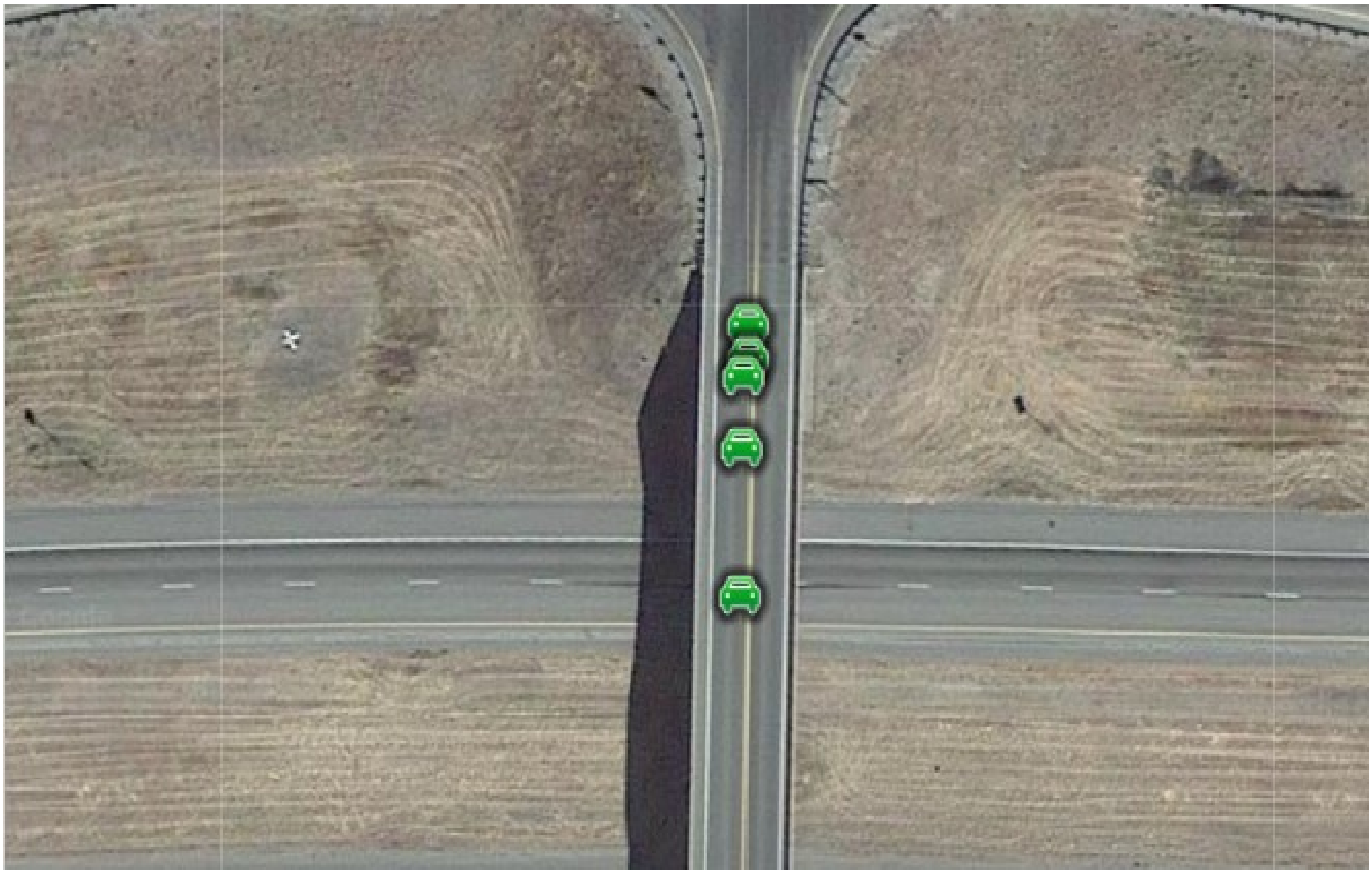
Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rock Creek Rd over I-90 (Bridge No. 3734)

Site Number: 06
Lane: DL
Direction: Southbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Rt 1 (Bridge No. 1459)

Site Number: 07
Lane: DL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	33	41.3	41.4	61.5	27.0	40	29.0	56.7	9:03:48 AM	46.67199818	-113.15385106
2	1	Left	31	51.0	50.6	62.6	5.9	39	27.5	56.7	9:09:15 AM	46.67199667	-113.15386301
3	1	Left	38	42.0	42.0	78.3	10.2	40	28.7	57.1	9:14:15 AM	46.67200201	-113.15382667
4	1	Left	38	40.3	39.8	72.2	16.8	39	28.2	57.7	9:19:29 AM	46.67200124	-113.15379738
5	1	Left	35	41.3	41.1	62.4	7.1	40	28.6	57.9	9:24:53 AM	46.67200167	-113.15386232
Site Average				43.2	43.0			40	28.4				
Standard Deviation				4.4	4.3			1	0.6				
Site Min				40.3	39.8			39	27.5				
Site Max				51.0	50.6			40	29.0				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-90 over Rt 1 (Bridge No. 1459)

Site Number: 07
Lane: DL
Direction: Eastbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Rt 1 (Bridge No. 1459)

Site Number: 07
Lane: PL
Direction: Eastbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	41	59.0	58.4	97.4	6.0	39	28.0	58.4	9:30:21 AM	46.67204167	-113.15381723
2	1	Left	44	57.8	57.4	103.8	10.0	39	27.7	59.1	9:36:14 AM	46.67203822	-113.15386434
3	1	Left	39	58.7	58.6	94.7	5.8	40	28.2	59.4	9:41:35 AM	46.67203667	-113.15385306
4	1	Left	40	55.3	55.1	92.8	7.3	40	28.2	60.1	9:46:33 AM	46.67203500	-113.15385324
5	1	Left	43	57.2	56.6	103.3	4.5	39	27.8	60.9	9:52:26 AM	46.67203667	-113.15383160
			Site Average	57.6	57.2			39	28.0				
			Standard Deviation	1.5	1.4			1	0.2				
			Site Min	55.3	55.1			39	27.7				
			Site Max	59.0	58.6			40	28.2				

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

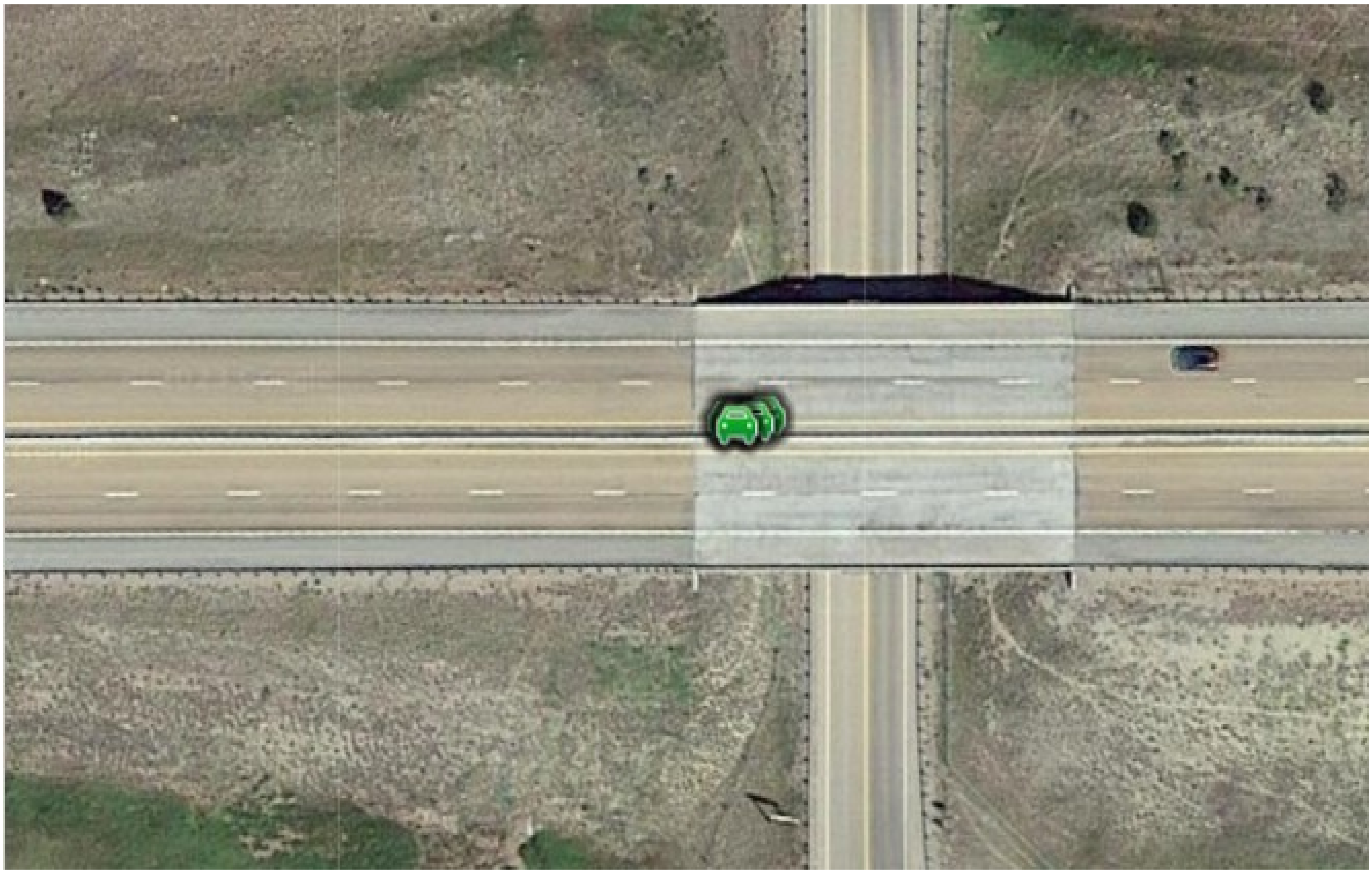
Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Rt 1 (Bridge No. 1459)

Site Number: 07
Lane: PL
Direction: Eastbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: DL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	37	39.6	40.1	81.8	9.4	41	30.0	68.7	11:36:55 AM	46.26223108	-112.28779948
2	1	Left	36	40.3	40.6	77.3	13.7	41	29.7	69.8	11:56:13 AM	46.26222531	-112.28774016
3	1	Left	34	40.6	40.6	79.3	14.3	40	30.6	70.3	12:04:45 PM	46.26222944	-112.28774262
4	1	Left	36	41.7	42.2	91.0	19.9	41	29.5	71.4	12:14:01 PM	46.26223766	-112.28781502
5	1	Left	34	39.7	39.8	89.4	12.4	40	28.8	72.0	12:22:53 PM	46.26223214	-112.28779445
			Site Average	40.4	40.7			41	29.7				
			Standard Deviation	0.8	0.9			0	0.7				
			Site Min	39.6	39.8			40	28.8				
			Site Max	41.7	42.2			41	30.6				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: DL
Direction: Northbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: PL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	37	48.0	47.9	82.1	25.7	40	29.3	73.7	12:38:45 PM	46.26226603	-112.28779484
2	1	Left	39	46.3	46.2	90.8	9.8	40	29.0	74.8	12:54:16 PM	46.26227047	-112.28781097
3	1	Left	38	46.5	46.6	92.4	14.4	40	29.4	75.2	1:02:57 PM	46.26226384	-112.28781943
4	1	Left	38	46.6	46.9	79.2	28.2	41	29.4	75.7	1:11:29 PM	46.26225880	-112.28778984
5	1	Left	36	46.5	46.5	67.9	5.7	40	28.7	76.1	1:19:38 PM	46.26226890	-112.28780192
			Site Average	46.8	46.8			40	29.2				
			Standard Deviation	0.7	0.7			0	0.3				
			Site Min	46.3	46.2			40	28.7				
			Site Max	48.0	47.9			41	29.4				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: PL
Direction: Northbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: DL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	3	Left	39	44.1	44.8	83.0	13.7	41	29.8	69.4	11:56:09 AM	46.26235740	-112.28758487
2	3	Left	41	43.7	44.1	82.1	17.3	41	30.1	70.3	12:05:01 PM	46.26235958	-112.28751133
3	3	Left	43	43.9	44.1	77.7	15.3	40	29.2	71.8	12:23:00 PM	46.26235214	-112.28747425
4	3	Left	42	43.4	43.8	82.5	18.7	41	29.2	72.6	12:31:37 PM	46.26235068	-112.28748052
5	3	Left	43	43.7	43.5	77.1	17.2	40	27.8	73.3	12:39:12 PM	46.26234341	-112.28746600
			Site Average	43.8	44.1			41	29.2				
			Standard Deviation	0.3	0.5			1	0.9				
			Site Min	43.4	43.5			40	27.8				
			Site Max	44.1	44.8			41	30.1				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: DL
Direction: Southbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: PL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	3	Left	35	52.6	53.1	96.0	16.8	41	28.9	73.9	12:47:29 PM	46.26231336	-112.28754404
2	3	Left	43	53.9	53.6	92.5	13.5	39	27.1	75.1	1:02:54 PM	46.26232518	-112.28752412
3	3	Left	42	53.7	53.4	93.5	18.3	39	27.7	75.8	1:11:36 PM	46.26231869	-112.28753367
4	3	Left	37	55.8	56.0	95.5	19.3	40	28.8	76.0	1:20:00 PM	46.26230016	-112.28751244
5	3	Left	37	52.8	52.3	96.4	12.3	39	26.6	76.7	1:28:18 PM	46.26229434	-112.28753959
			Site Average	53.8	53.7			40	27.8				
			Standard Deviation	1.3	1.4			1	1.0				
			Site Min	52.6	52.3			39	26.6				
			Site Max	55.8	56.0			41	28.9				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1137)

Site Number: 08
Lane: PL
Direction: Southbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: DL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	2	Left	36	35.5	36.3	73.3	10.9	42	29.6	68.7	11:38:12 AM	46.26342469	-112.28469407
2	2	Left	41	39.8	40.2	61.7	7.7	41	29.7	69.8	11:57:29 AM	46.26339882	-112.28471372
3	2	Left	44	34.3	34.6	65.9	18.8	41	30.7	70.5	12:06:01 PM	46.26338761	-112.28472547
4	2	Left	42	40.3	40.6	67.2	12.6	41	29.4	71.4	12:15:19 PM	46.26338805	-112.28472720
5	2	Left	42	40.0	40.2	79.1	8.3	41	29.0	72.0	12:24:10 PM	46.26336827	-112.28473282
			Site Average	38.0	38.4			41	29.7				
			Standard Deviation	2.8	2.7			0	0.6				
			Site Min	34.3	34.6			41	29.0				
			Site Max	40.3	40.6			42	30.7				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc		**Test Method:** AASHTO-T242	
Project No: WJE-23-1	**Test:** Wet	**Testing Date:** 09/13/2023	
Test Equipment: ICC34	**Tire:** Ribbed	**Operator:** Dan Wolney	

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: DL
Direction: Northbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: PL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	2	Left	36	44.1	44.1	72.6	25.0	40	29.2	73.6	12:40:02 PM	46.26340455	-112.28476900
2	2	Left	40	44.0	44.3	79.7	16.2	41	29.7	74.9	12:55:33 PM	46.26345035	-112.28474210
3	2	Left	38	42.1	42.0	91.2	4.0	40	28.1	75.2	1:04:14 PM	46.26339910	-112.28477943
4	2	Left	35	41.6	42.0	66.2	9.8	41	29.6	75.9	1:12:45 PM	46.26339997	-112.28477236
5	2	Left	36	41.3	41.8	73.3	6.9	41	29.2	76.2	1:20:56 PM	46.26342342	-112.28475681
			Site Average	42.6	42.8			40	29.2				
			Standard Deviation	1.3	1.2			1	0.6				
			Site Min	41.3	41.8			40	28.1				
			Site Max	44.1	44.3			41	29.7				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1
Test Equipment: ICC34
Test: Wet
Tire: Ribbed
Test Method: AASHTO-T242
Testing Date: 09/13/2023
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: PL
Direction: Northbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
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5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: DL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	2	Left	39	34.9	34.9	63.6	4.2	40	27.6	69.5	11:54:52 AM	46.26369950	-112.28475052
2	2	Left	38	33.7	33.9	63.4	6.1	40	28.6	70.3	12:03:45 PM	46.26370383	-112.28474508
3	2	Left	42	35.1	35.0	95.2	4.6	40	28.4	71.9	12:21:42 PM	46.26371753	-112.28475015
4	2	Left	43	34.8	34.3	79.1	3.7	39	28.3	72.6	12:30:20 PM	46.26371423	-112.28474872
5	2	Left	43	34.9	34.8	83.6	7.1	40	28.3	73.3	12:37:54 PM	46.26371856	-112.28473982
			Site Average	34.7	34.6			40	28.2				
			Standard Deviation	0.6	0.5			1	0.4				
			Site Min	33.7	33.9			39	27.6				
			Site Max	35.1	35.0			40	28.6				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: DL
Direction: Southbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

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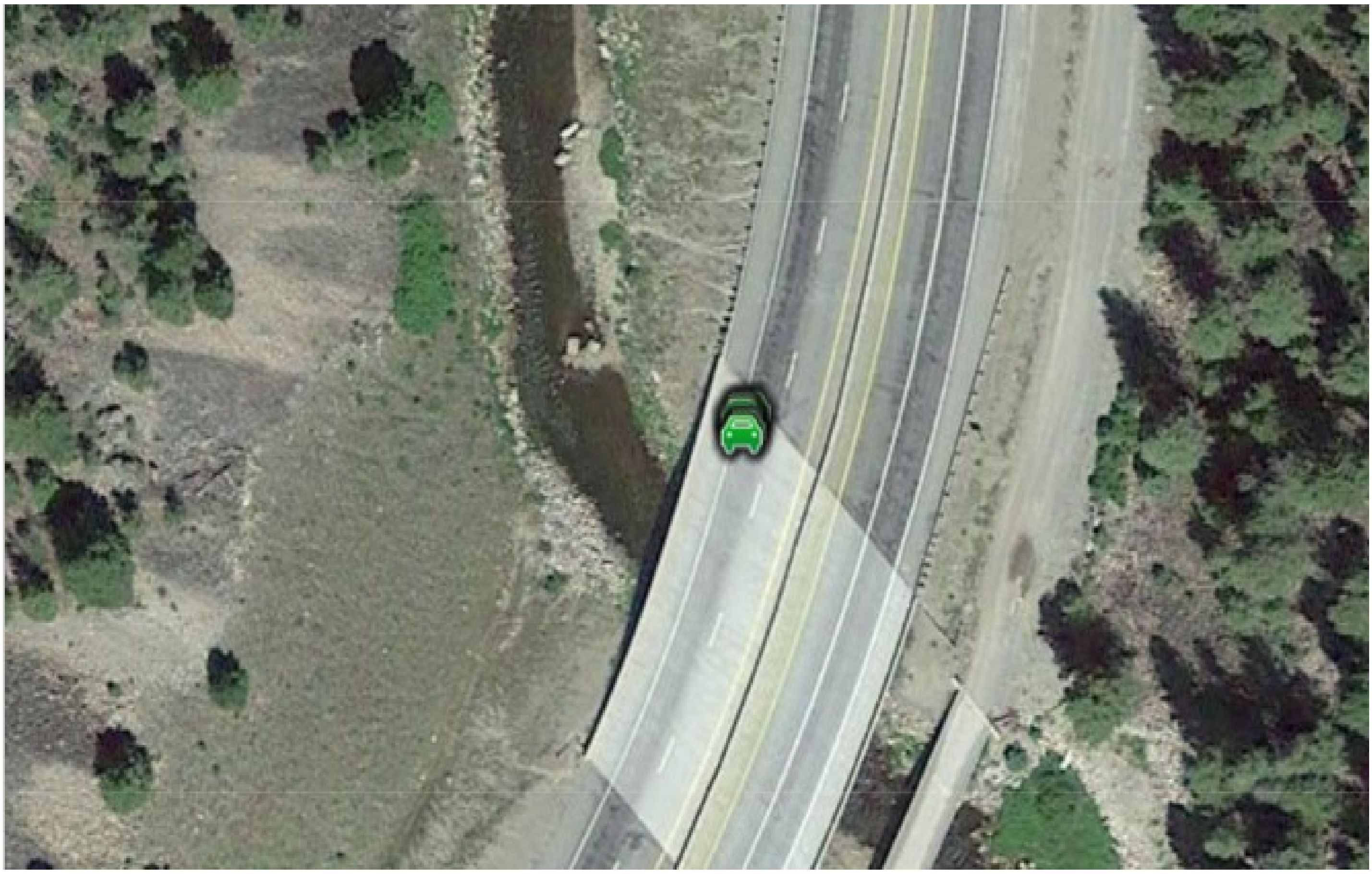
4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: PL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	2	Left	48	52.6	52.5	88.0	9.1	40	28.3	73.9	12:46:10 PM	46.26368282	-112.28470903
2	2	Left	42	51.4	51.0	84.0	8.8	39	27.5	75.0	1:01:35 PM	46.26368812	-112.28470011
3	2	Left	45	49.5	49.5	86.9	21.6	40	28.0	75.7	1:10:18 PM	46.26366273	-112.28471962
4	2	Left	37	50.6	50.5	88.1	24.2	40	28.4	76.0	1:18:43 PM	46.26366435	-112.28471224
5	2	Left	38	50.8	50.6	75.3	49.9	40	28.2	76.7	1:26:59 PM	46.26367439	-112.28470965
Site Average				51.0	50.8			40	28.1				
Standard Deviation				1.1	1.1			0	0.4				
Site Min				49.5	49.5			39	27.5				
Site Max				52.6	52.5			40	28.4				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1138)

Site Number: 09
Lane: PL
Direction: Southbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
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4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: DL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	3	Left	42	33.2	33.3	56.1	28.2	40	27.6	68.7	11:40:32 AM	46.26798112	-112.28491395
2	3	Left	40	32.8	33.0	57.0	5.0	40	28.6	69.8	11:59:50 AM	46.26798306	-112.28491057
3	3	Left	35	32.4	33.0	62.9	5.1	41	30.0	70.4	12:08:17 PM	46.26797426	-112.28492409
4	3	Left	40	33.7	33.7	63.8	12.9	40	29.1	71.4	12:17:40 PM	46.26796754	-112.28493340
5	3	Left	39	38.9	39.2	69.1	13.4	41	28.9	71.9	12:26:37 PM	46.26797348	-112.28492432
Site Average				34.2	34.4			41	28.8				
Standard Deviation				2.7	2.7			0	0.9				
Site Min				32.4	33.0			40	27.6				
Site Max				38.9	39.2			41	30.0				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: DL
Direction: Northbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

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5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Project No: WJE-23-1
Test Equipment: ICC34
Test: Wet
Tire: Ribbed
Test Method: AASHTO-T242
Testing Date: 09/13/2023
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: PL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	3	Left	40	54.0	53.9	85.3	13.4	40	28.8	73.5	12:42:22 PM	46.26797280	-112.28497720
2	3	Left	43	52.5	52.3	94.6	17.2	40	28.0	74.8	12:57:49 PM	46.26795026	-112.28501479
3	3	Left	42	54.4	54.5	93.7	17.5	40	27.5	75.2	1:06:37 PM	46.26799213	-112.28497680
4	3	Left	40	52.2	52.1	84.1	13.4	40	28.5	75.7	1:15:02 PM	46.26797849	-112.28498078
5	3	Left	40	51.7	51.4	84.9	16.5	39	29.0	76.1	1:23:18 PM	46.26797468	-112.28498408
Site Average				53.0	52.8			40	28.4				
Standard Deviation				1.2	1.3			0	0.6				
Site Min				51.7	51.4			39	27.5				
Site Max				54.4	54.5			40	29.0				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: PL
Direction: Northbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
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5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: DL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	36	38.2	38.1	77.7	15.7	40	27.6	69.5	11:52:30 AM	46.26810009	-112.28501361
2	1	Left	31	37.9	37.9	62.1	35.4	40	29.2	70.3	12:01:23 PM	46.26811425	-112.28500284
3	1	Left	38	40.0	39.8	93.1	31.5	40	27.8	71.8	12:19:19 PM	46.26811986	-112.28499916
4	1	Left	36	38.3	38.0	95.8	10.4	39	28.5	72.6	12:27:58 PM	46.26813006	-112.28500836
5	1	Left	40	39.1	39.0	97.7	20.0	40	28.2	73.2	12:35:35 PM	46.26811746	-112.28500593
			Site Average	38.7	38.6			40	28.3				
			Standard Deviation	0.9	0.8			0	0.6				
			Site Min	37.9	37.9			39	27.6				
			Site Max	40.0	39.8			40	29.2				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: DL
Direction: Southbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
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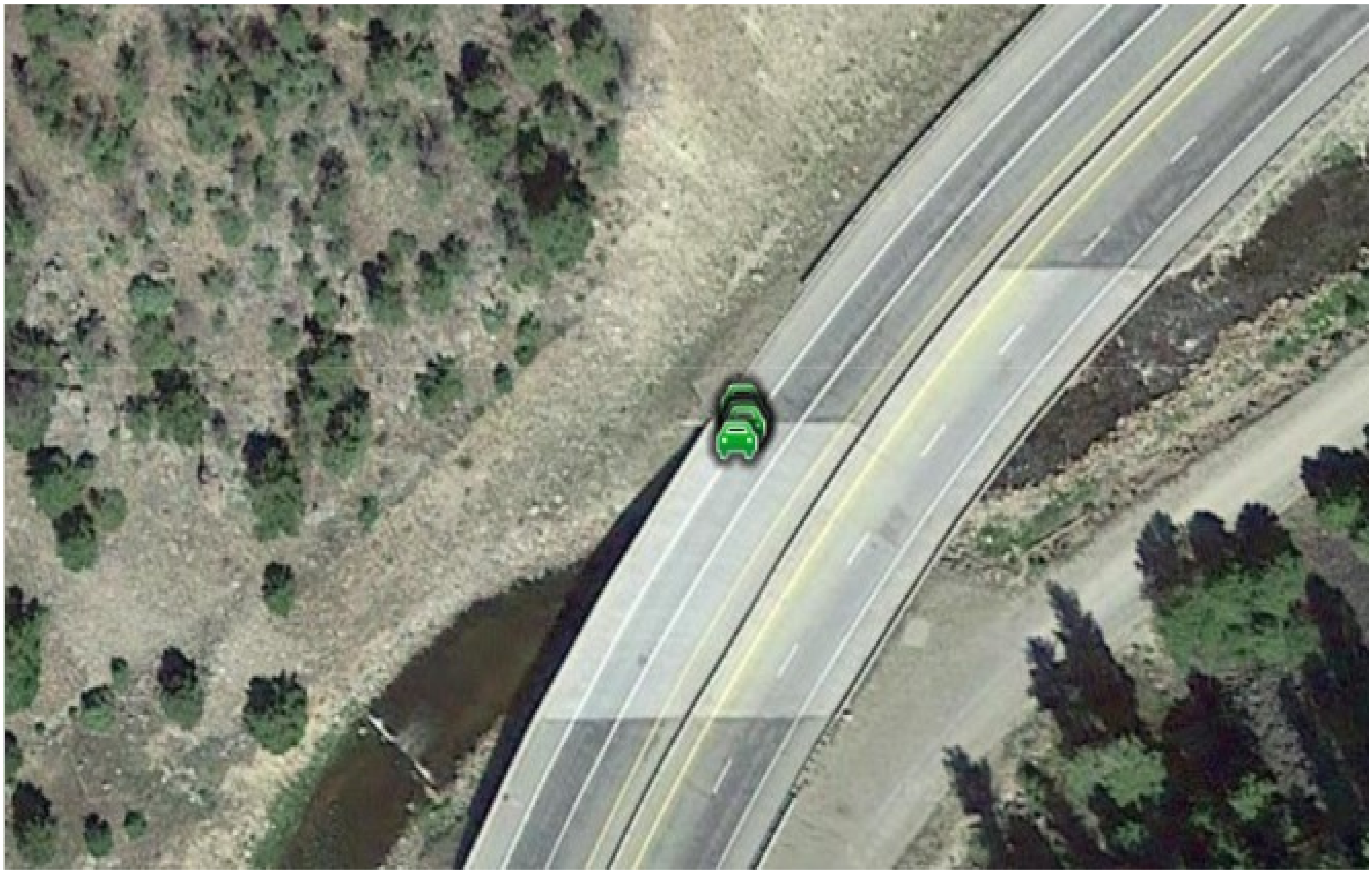

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: PL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	36	44.2	44.0	83.8	17.6	40	29.4	73.7	12:43:47 PM	46.26810032	-112.28495155
2	1	Left	37	43.4	43.4	82.2	13.4	40	27.9	75.0	12:59:12 PM	46.26811898	-112.28493709
3	1	Left	39	42.0	41.8	91.7	15.8	40	28.4	75.7	1:07:53 PM	46.26812015	-112.28493755
4	1	Left	35	42.2	41.9	78.5	10.6	39	27.3	75.9	1:16:20 PM	46.26811318	-112.28494071
5	1	Left	37	42.5	42.4	90.8	15.2	40	28.6	76.6	1:24:36 PM	46.26811230	-112.28493124
			Site Average	42.9	42.7			40	28.3				
			Standard Deviation	0.9	1.0			0	0.8				
			Site Min	42.0	41.8			39	27.3				
			Site Max	44.2	44.0			40	29.4				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-15 over Boulder River (Bridge No. 1139)

Site Number: 10
Lane: PL
Direction: Southbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

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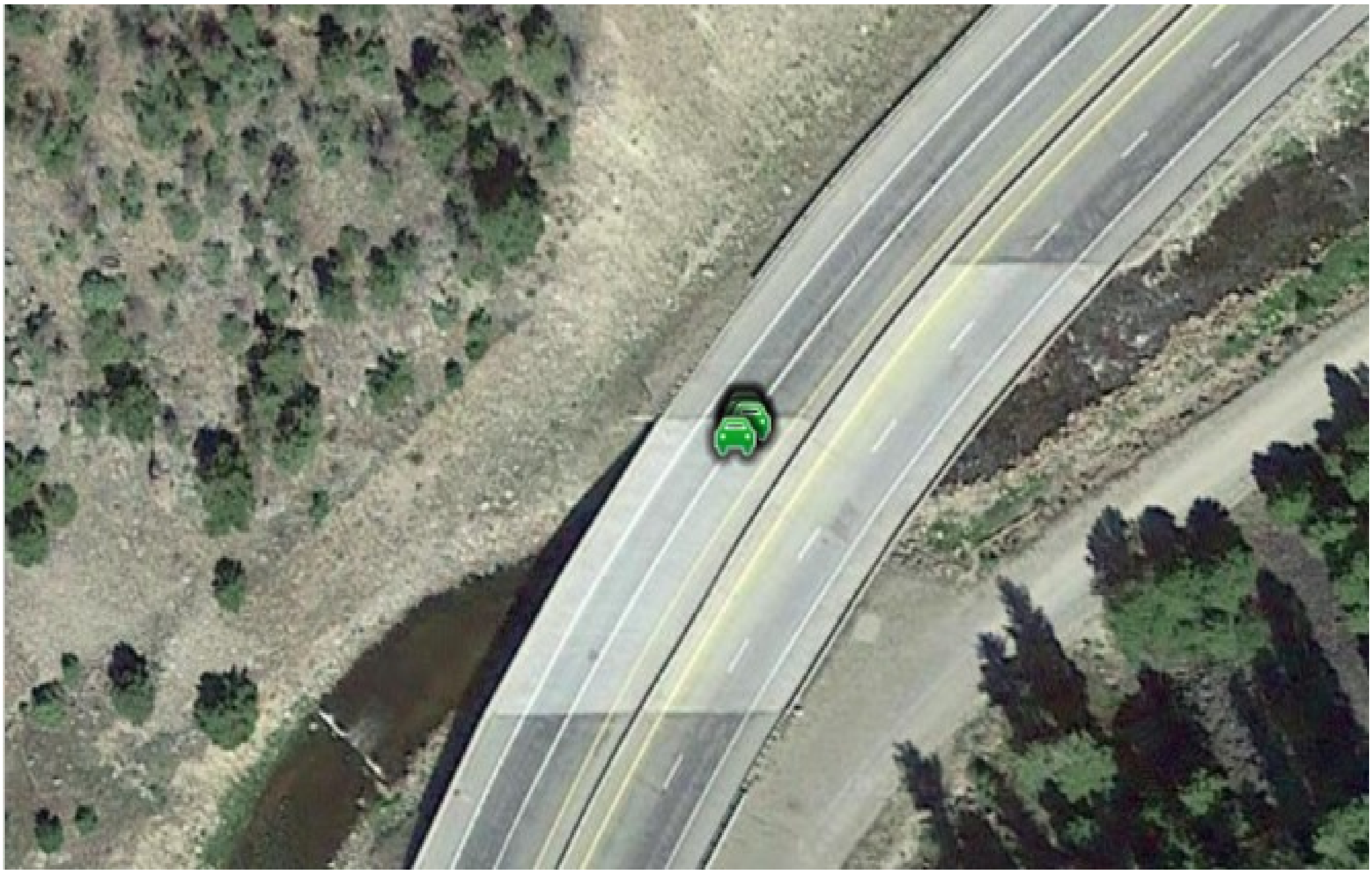

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)

Site Number: 11
Lane: DL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	35	47.8	47.4	83.3	19.9	39	28.1	75.6	4:06:46 PM	45.84653802	-109.93963038
2	1	Left	36	47.3	46.9	83.7	10.6	39	28.3	75.4	4:11:55 PM	45.84653147	-109.93962487
3	1	Left	37	51.8	51.4	77.4	10.7	39	27.9	75.5	4:15:35 PM	45.84654232	-109.93963491
4	1	Left	35	48.3	48.2	77.2	3.8	40	29.1	75.1	4:19:03 PM	45.84651438	-109.93960795
5	1	Left	36	49.7	49.4	76.1	12.0	40	27.6	74.9	4:23:27 PM	45.84661412	-109.93969487
			Site Average	49.0	48.7			39	28.2				
			Standard Deviation	1.8	1.8			0	0.6				
			Site Min	47.3	46.9			39	27.6				
			Site Max	51.8	51.4			40	29.1				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)

Site Number: 11
Lane: DL
Direction: Northbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

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5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)

Site Number: 11
Lane: DL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	40	50.5	50.5	84.6	17.6	40	28.4	75.5	4:09:17 PM	45.84716376	-109.94020363
2	1	Left	42	52.4	52.1	90.4	13.9	40	28.3	75.4	4:13:31 PM	45.84717319	-109.94021707
3	1	Left	41	56.5	56.3	94.7	17.7	40	28.6	75.3	4:16:57 PM	45.84717688	-109.94022022
4	1	Left	38	50.8	50.5	89.3	13.1	40	28.0	75.0	4:20:59 PM	45.84716542	-109.94020521
5	1	Left	40	48.4	48.1	86.6	18.1	40	28.7	74.9	4:25:18 PM	45.84714664	-109.94019202
			Site Average	51.7	51.5			40	28.4				
			Standard Deviation	3.0	3.0			0	0.3				
			Site Min	48.4	48.1			40	28.0				
			Site Max	56.5	56.3			40	28.7				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

Rt-191 over Yellowstone River (Bridge Big Timber-Yellowstone River)

Site Number: 11
Lane: DL
Direction: Southbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Greycliff Rd (Bridge No. 1670)

Site Number: 12
Lane: DL
Direction: Westbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	38	49.4	49.8	83.2	13.3	41	29.2	75.9	5:30:10 PM	45.76925456	-109.79347746
2	1	Left	37	46.2	46.4	81.1	9.4	40	28.5	76.1	5:33:33 PM	45.76924099	-109.79347107
3	1	Left	37	47.5	47.4	85.1	10.3	40	29.4	75.9	5:36:36 PM	45.76921596	-109.79344764
4	1	Left	35	45.9	45.8	75.3	8.0	40	27.5	75.9	5:40:31 PM	45.76922115	-109.79344505
5	1	Left	36	44.8	44.7	83.7	9.8	40	28.7	75.9	5:43:39 PM	45.76922703	-109.79344928
			Site Average	46.8	46.8			40	28.7				
			Standard Deviation	1.8	1.9			0	0.7				
			Site Min	44.8	44.7			40	27.5				
			Site Max	49.4	49.8			41	29.4				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/13/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

I-90 over Greycliff Rd (Bridge No. 1670)

Site Number: 12
Lane: DL
Direction: Westbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Greycliff Rd (Bridge No. 1670)

Site Number: 12
Lane: PL
Direction: Westbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	46	67.0	66.8	96.7	9.9	39	28.8	76.1	5:47:25 PM	45.76920776	-109.79349049
2	1	Left	40	64.6	64.2	96.1	9.3	39	28.0	76.0	5:50:35 PM	45.76921561	-109.79350066
3	1	Left	39	63.8	63.5	101.4	12.8	39	27.6	75.8	5:54:27 PM	45.76918997	-109.79348128
4	1	Left	42	65.7	65.6	95.3	13.2	40	28.6	75.8	5:57:33 PM	45.76919924	-109.79349505
5	1	Left	48	66.0	66.2	106.3	8.6	41	30.0	75.8	6:01:02 PM	45.76921440	-109.79351327
			Site Average	65.4	65.3			40	28.6				
			Standard Deviation	1.2	1.4			1	0.9				
			Site Min	63.8	63.5			39	27.6				
			Site Max	67.0	66.8			41	30.0				

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

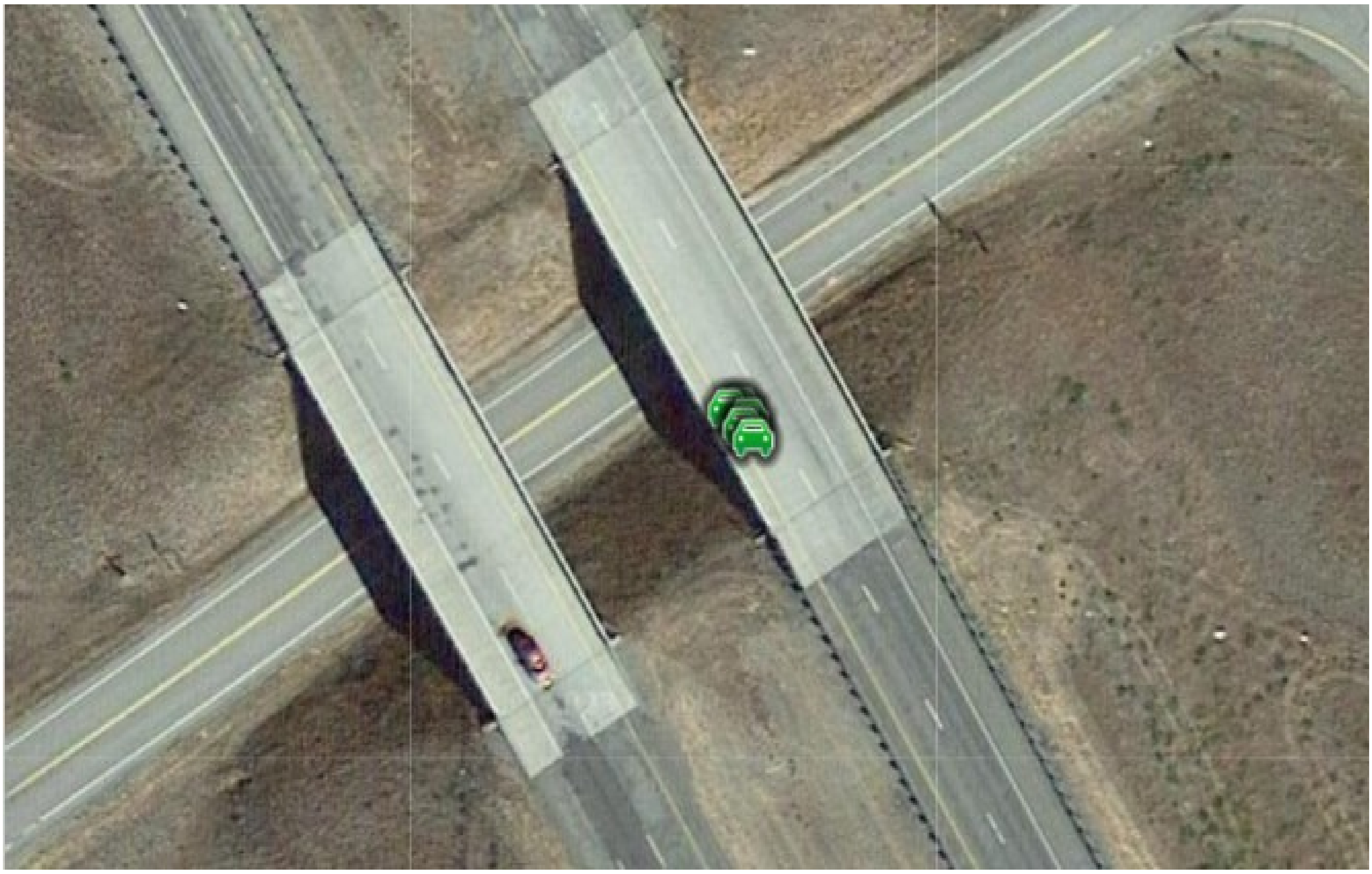
Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Greycliff Rd (Bridge No. 1670)

Site Number: 12
Lane: PL
Direction: Westbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Bridger Creek Rd (Bridge No. 1682)

Site Number: 13
Lane: DL
Direction: Westbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	38	52.9	53.0	89.6	16.3	40	29.4	74.4	4:55:16 PM	45.73130174	-109.68136978
2	1	Left	47	49.8	50.3	87.1	18.9	41	29.8	74.8	4:58:14 PM	45.73129089	-109.68132928
3	1	Left	35	50.3	50.2	86.1	12.5	40	28.2	74.9	5:00:50 PM	45.73128806	-109.68127947
4	1	Left	39	50.3	50.3	84.7	13.1	40	28.7	74.9	5:04:25 PM	45.73128843	-109.68128751
5	1	Left	41	52.8	52.7	90.3	13.9	40	28.9	74.9	5:07:04 PM	45.73128362	-109.68131102
			Site Average	51.2	51.3			40	29.0				
			Standard Deviation	1.5	1.4			1	0.6				
			Site Min	49.8	50.2			40	28.2				
			Site Max	52.9	53.0			41	29.8				

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Bridger Creek Rd (Bridge No. 1682)

Site Number: 13
Lane: DL
Direction: Westbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Bridger Creek Rd (Bridge No. 1682)

Site Number: 13
Lane: PL
Direction: Westbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	44	59.3	59.3	94.5	8.1	40	28.5	75.1	5:09:37 PM	45.73124810	-109.68133799
2	1	Left	45	59.2	59.4	98.4	16.1	40	28.5	75.4	5:12:27 PM	45.73126060	-109.68137552
3	1	Left	38	58.3	58.5	94.1	17.6	40	28.7	75.3	5:15:23 PM	45.73123662	-109.68130537
4	1	Left	43	58.4	58.5	93.9	13.3	40	28.7	75.4	5:20:50 PM	45.73125195	-109.68135715
5	1	Left	45	57.8	57.9	95.6	10.2	40	28.7	75.6	5:23:53 PM	45.73125442	-109.68133896
			Site Average	58.6	58.7			40	28.6				
			Standard Deviation	0.6	0.6			0	0.1				
			Site Min	57.8	57.9			40	28.5				
			Site Max	59.3	59.4			40	28.7				

INTERNATIONAL CYBERNETICS

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/13/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

I-90 over Bridger Creek Rd (Bridge No. 1682)

Site Number: 13
Lane: PL
Direction: Westbound

Survey Notes

1. Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.
2. Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.
3. Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.
4. GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.
5. Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc
Test Method: AASHTO-T242
Project No: WJE-23-1
Test: Wet
Testing Date: 09/14/2023
Test Equipment: ICC34
Tire: Ribbed
Operator: Dan Wolney

Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)

Site Number: 14
Lane: DL
Direction: Northbound

Run	Cycle	Wheel Path	Ref Post (ft)	FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	42	47.3	47.5	87.4	16.8	40	28.9	62.4	10:10:22 AM	46.42765637	-108.57013862
2	1	Left	39	46.2	46.3	83.2	3.0	40	29.3	62.3	10:12:50 AM	46.42763016	-108.57013978
3	1	Left	38	47.4	47.6	83.6	12.7	40	29.1	63.4	10:21:56 AM	46.42766708	-108.57014538
4	1	Left	41	44.6	44.9	84.3	2.1	41	29.9	63.7	10:23:56 AM	46.42763900	-108.57013740
5	1	Left	36	52.3	52.2	89.9	15.5	40	27.9	64.0	10:26:14 AM	46.42764956	-108.57014512
			Site Average	47.6	47.7			40	29.0				
			Standard Deviation	2.9	2.7			0	0.7				
			Site Min	44.6	44.9			40	27.9				
			Site Max	52.3	52.2			41	29.9				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/14/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)

Site Number: 14
Lane: DL
Direction: Northbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

3 Reported Friction Numbers represent only that portion of the skid cycle covering the HFST and have been normalized to 40mph (FN40R) based on the Speed Correction Factors reported in Table 4 of the Specifications – Job Specific for RICN: 2021-CH-070.

4 GPS coordinates represent the start of the cycle at the location of the test tire. The accuracy of the GPS will be degraded where line of sight to the satellites is obstructed and as such should not be relied upon in these circumstances.

5 Lane Convention - DL (Driving Lane), PL (Passing Lane).

Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23

Friction Resistance Test Results

Client: Wiss, Janney, Elstner Associates, Inc | **Test Method:** AASHTO-T242
Project No: WJE-23-1 | **Test:** Wet | **Testing Date:** 09/14/2023
Test Equipment: ICC34 | **Tire:** Ribbed | **Operator:** Dan Wolney

Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)

Site Number: 14
Lane: DL
Direction: Southbound

Run	Cycle	Wheel Path	Ref Post (ft)	Friction Number FN	FN40R	Peak FN	Slip %	Speed (mph)	Water (gals/min)	Air Temp (°F)	Time	Latitude	Longitude
1	1	Left	38	48.6	48.4	85.3	5.1	40	28.4	62.1	10:07:13 AM	46.42822447	-108.57024167
2	1	Left	38	47.7	47.8	80.8	17.8	40	29.1	62.8	10:11:50 AM	46.42820536	-108.57023383
3	1	Left	40	52.9	52.6	85.5	20.2	40	27.8	63.3	10:21:05 AM	46.42821142	-108.57023233
4	1	Left	36	55.1	54.5	91.6	15.3	39	27.6	63.4	10:22:59 AM	46.42822112	-108.57022804
5	1	Left	36	52.6	52.3	92.7	14.8	39	28.6	63.9	10:25:06 AM	46.42820316	-108.57023195
			Site Average	51.4	51.1			40	28.3				
			Standard Deviation	3.1	2.9			1	0.6				
			Site Min	47.7	47.8			39	27.6				
			Site Max	55.1	54.5			40	29.1				

Friction Resistance Test Results

Client:	Wiss, Janney, Elstner Associates, Inc			**Test Method:**	AASHTO-T242
Project No:	WJE-23-1	**Test:**	Wet	**Testing Date:**	09/14/2023
Test Equipment:	ICC34	**Tire:**	Ribbed	**Operator:**	Dan Wolney

Rt-87 over Musselshell River (Bridge Roundup-Musselshell River)

Site Number: 14
Lane: DL
Direction: Southbound

Survey Notes

1 Weather conditions during testing were clear to partly cloudy with air temperatures of 53°F to 93°F.

2 Reported FN values are determined from the portion of the skid cycle where 100% slip is achieved whereas the Slip % values shown represent the critical tire slip % at peak friction and are determined during the start of the skid cycle within the test wheel lock-up phase.

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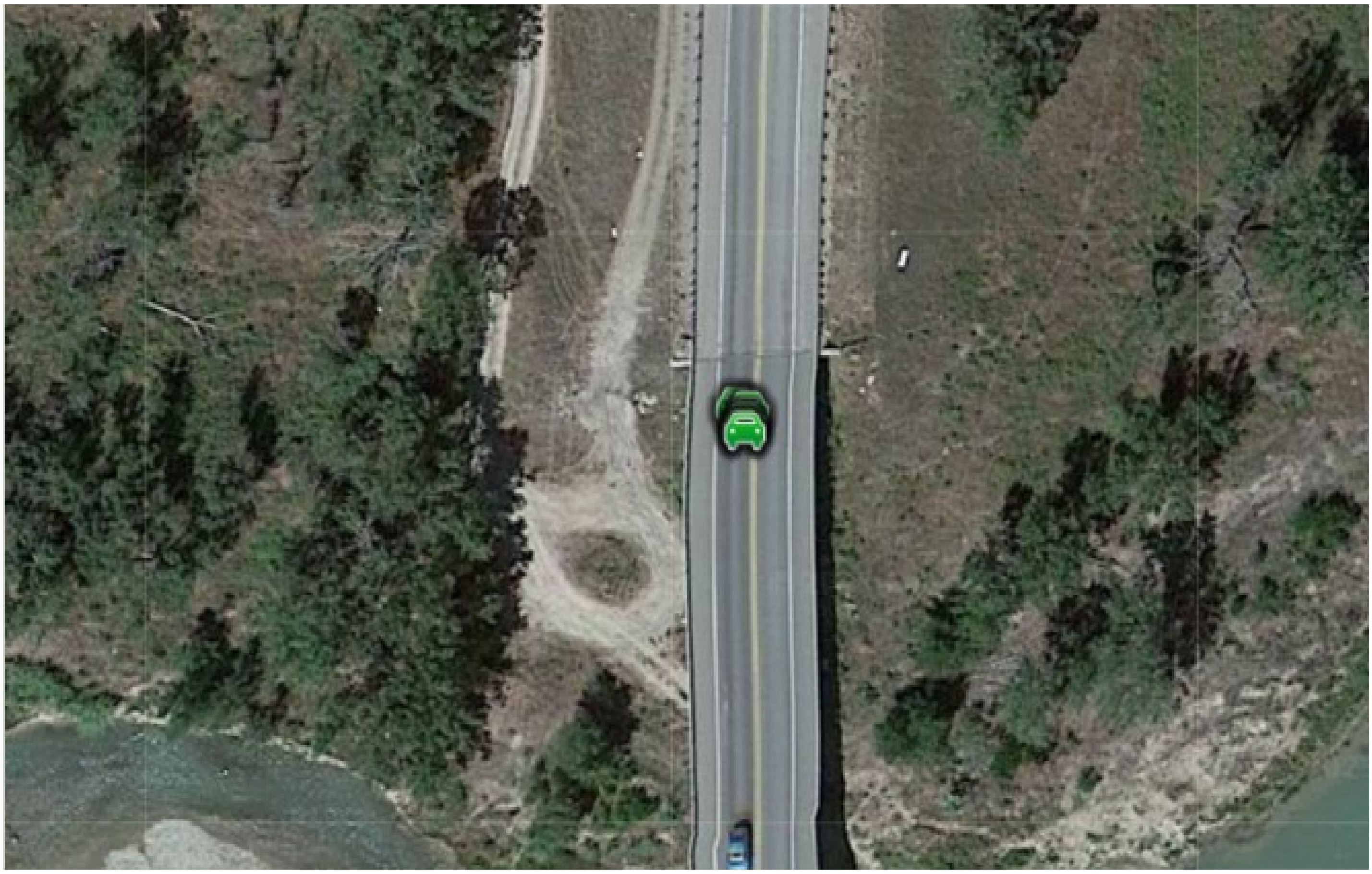
5 Lane Convention - DL (Driving Lane), PL (Passing Lane).



Prepared By: Iryna Kononova
23-Oct-23

Reviewed By: James Erskine
23-Oct-23