Kwik Bond Polymers®
High Friction Surface Treatment

WA-RD 851.1  Keith W. Anderson  December 2015
Mark Russell
Jeff S. Uhlmeyer
Jim Weston

WSDOT Research Report
Experimental Feature Report

Final Report
Experimental Feature 15-01

Kwik Bond Polymers® High Friction Surface Treatment

QE9982
I-5 and I-90 High Friction Surface Treatment
SR 526 EB to I-5 SB and 148th Avenue SE to I-90 WB
Kwik Bond Polymers® High Friction Surface Treatment

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

High friction surface treatment (HFST) was applied to two on-ramps in the Seattle urban area to improve friction resistance. The ramps were high accident locations. The system applied was polyester resin binder and calcined bauxite aggregate. Testing of the completed HFST resulted in average friction numbers (FN40R) ranging from 75 to 86 with no individual value below 72.

An evaluation period of five years is planned to monitor the performance of the HFST. At the end of the five-year period, a final report will be written which summarizes the friction and performance characteristics of the application, its effectiveness at reducing collisions, its cost effectiveness and recommendations on the future use of the high friction surface treatments.
DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.
TABLE OF CONTENTS

Introduction ..................................................................................................................................... 1
Project Objectives ........................................................................................................................... 1
Project Location .............................................................................................................................. 1
Product Description ........................................................................................................................ 3
Construction Process ....................................................................................................................... 4
Post-Construction Testing ............................................................................................................... 9
Cost ............................................................................................................................................... 10
Discussion of Results .................................................................................................................... 10
Future Research ............................................................................................................................ 10
References ..................................................................................................................................... 10
Appendix A  Contract Special Provisions .................................................................................... 11
Appendix B  Manufacturer’s Certificate of Compliance .............................................................. 18
Appendix C  Work Plan ................................................................................................................ 35
LIST OF FIGURES

Figure 1. HFST installation on SB 148th Avenue SE on-ramp to WB I-90 ...................... 2
Figure 2. HFST installation on EB SR 526 on-ramp to SB I-5 .............................. 2
Figure 3. Inlet covered prior to HFST .............................................................. 4
Figure 4. Lane line taped prior to HFST ......................................................... 4
Figure 5. Taped expansion joint ................................................................. 5
Figure 6. Diamond grinding to remove centerline stripe ............................... 5
Figure 7. Application vehicle ...................................................................... 5
Figure 8. Application vehicle, rear view ....................................................... 5
Figure 9. Aggregate bin and circular bucket that service as the source for the augers which
distribute the aggregate ................................................................. 6
Figure 10. Augers distributing aggregate across the width of the machine .......... 6
Figure 11. Binder storage tanks ................................................................. 6
Figure 12. Binder is distributed through a number of rubber hoses to a ribbed plate .... 6
Figure 13. Red plastic squeegee protects ribbed plate from wear. Binder is spread on the
pavement followed by a curtain of aggregate ........................................... 6
Figure 14. Casting of aggregate onto wet spots to make sure of full coverage of the pavement .... 6
Figure 15. Clean-up operation, brushing excess binder and solvent into plastic trays ...... 7
Figure 16. Suctioning excess binder and solvent from the trays ....................... 7
Figure 17. View of the HRST behind the paver on the I-5 section ...................... 7
Figure 18. Completed HFST, on-ramp to I-5 ................................................. 7
Figure 19. HFST on the left, original HMA on the right, on-ramp to I-90 ............... 8
Figure 20. Completed HFST on the ramp to I-5 .............................................. 8

LIST OF TABLES

Table 1. Physical properties of Kwik Bond PPC™HFST ........................................ 3
Table 2. Physical properties of calcined bauxite ................................................. 4
Table 3. Project facts .................................................................................. 9
Table 4. Friction resistance before and after HFS treatment .................................. 9
Introduction

Sharp curves can lead to higher than normal accident rates if the friction between tires and the pavement is not sufficient to keep the car from skidding. Measures are taken to reduce the number of accidents such as special warning signs and lowered speed limits. If these measures are not effective the characteristics of the pavement are improved to increase friction. The friction properties can be improved by replacing the pavement, placing a surface treatment such as a chip seal over the existing pavement, or by grooving the pavement using diamond grinding (concrete pavements). Replacing the pavement or diamond grinding are expensive fixes. Chip seals are a less expensive solution than replacing the pavement or diamond grinding, but may be prone to aggregate loss if applied on sharp curves due to a loss of bond between the aggregate and binder. The alternative is to apply a thin, high friction surface treatment (HFST) on the existing pavement. The special binders used for HFS treatments have higher bond strengths than the asphalt binders used for chip seals. This is the alternative taken to improve the friction resistance of two on-ramps in the Seattle urban area. HFST was part of FHWA’s Center for Accelerated Innovation Every Day Counts program for 2012-2013 (FHWA Every Day Counts).

Project Objectives

The three objectives of the study are:

- To measure the long-term performance of the HFST with respect to friction resistance, wear and aggregate retention.
- To measure any reduction in collisions.
- To develop a recommendation regarding the use of Kwik Bond PPC™HFST on WSDOT roadways.

Project Location

The two ramps are located on I-90 and I-5. The I-90 HFST was applied to the on-ramp from 148th Avenue SE to westbound I-90 in Eastgate (Figure 1). The I-5 HFST was applied to the on-ramp from SR 526 eastbound to I-5 southbound south of Everett (Figure 2).
Figure 1. HFST installation on SB 148th Avenue SE on-ramp to WB I-90.

Figure 2. HFST installation on EB SR 526 on-ramp to SB I-5.
Product Description

The HFST system selected for this project was provided by Kwik Bond Polymers, Benicia, CA. The system consists of a polyester resin binder and calcined bauxite aggregate. Great Lakes Minerals, Wurtland, KT was the source of the bauxite aggregate. Kwik Bond’s PPCT™HFST is a polymer-based resin binder system designed specifically to get into the pores of high friction aggregates and bond to various pavement substrates. The system can be mixed by hand and applied with serrated squeegees, or with automated installation equipment which was used on this project. The binder gains strength very quickly, so it can be applied to a roadway and returned to traffic within a normal production shift. The specifications and actual test results for the HRST are noted in Table 1 (see Appendix B for additional information).

<table>
<thead>
<tr>
<th>Test</th>
<th>Specification</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>1,000 – 2,000 cps</td>
<td>1,390 cps</td>
</tr>
<tr>
<td>Tensile Strength (ASTM D-638)</td>
<td>2,650 – 3,900 psi</td>
<td>4,888 psi</td>
</tr>
<tr>
<td>Tensile Elongation at Break (ASTM D-638)</td>
<td>&gt;30% min</td>
<td>52%</td>
</tr>
<tr>
<td>Compressive Strength (ASTM C-579)</td>
<td>5,000 psi at 24 hrs.</td>
<td>7,852 psi at 3 hrs.</td>
</tr>
</tbody>
</table>

Bauxite is composed of aluminum oxide, silicon oxide, titanium oxide and iron oxide, and is the source mineral for aluminum. Calcined bauxite is formed from a heating process that removes the crystalline water. The heat transforms the bauxite rock from a hardness of between 1.0 and 3.0 on the Mohs scale to a hardness of 9.0 (Mohs scale of mineral hardness runs from talc at 1.0 to diamond at 10.0, with 9.0 being corundum, Wikipedia). The physical properties of calcined bauxite are listed in Table 2 (Bond Minerals, 2015).
### Construction Process

The HFST was installed on the two ramps in the last two weeks of June, 2015. The process is captured in a series of photographs. Figures 3-6 show the preparation prior to the application of the HFST. The pavement receiving the HFST was cleaned to remove all dirt, sand, oils and other debris using a combination of street sweepers and brooms. The paint stripes were removed by diamond grinding if they were in the center of the roadway, or if they were the edge stripes they were left in place or covered with duct tape. If the stripes were of the thermal variety with raised lane marker bumps, duct tape was applied to prevent covering by the HFST.

![Figure 3](image3.jpg)  ![Figure 4](image4.jpg)

Figure 3. Inlet covered prior to HFST.  Figure 4. Lane line taped prior to HFST.
The application process is shown in Figures 7-18. The starting area is covered with plastic to prevent spills from contaminating the existing pavement and to provide a starting point for the HFST. The aggregate from the storage tank on the application vehicle is fed by a conveyer to a central bucket (Figure 9). Augers distribute the aggregate across the width of the paver (Figure 10). The two part binder, also carried on the paver (Figure 11), is distributed through a series of hoses to a ribbed plate (Figure 12). The ribbing on the plate distributes the liquid binder evenly across its width. A replaceable plastic squeegee is attached to the bottom of the ribbed plate to prevent wear on the plate (Figure 13). The binder is distributed onto the pavement followed by a curtain of aggregate (Figure 13). Additional aggregate is broadcast by hand onto the HRST to cover any wet spots of binder (Figure 14).
Figure 9. Aggregate bin and circular bucket that service as the source for the augers which distribute the aggregate.

Figure 10. Augers distributing aggregate across the width of the machine.

Figure 11. Binder storage tanks.

Figure 12. Binder is distributed through a number of rubber hoses to a ribbed plate.

Figure 13. Red plastic squeegee protects ribbed plate from wear. Binder is spread on the pavement followed by a curtain of aggregate.

Figure 14. Casting of aggregate onto wet spots to make sure of full coverage of the pavement.
The clean-up operation is shown in Figures 15 and 16. Organic peroxide is circulated through the hoses to remove the binder. Brushes are used to clean the ribbed plate and plastic squeegee (Figure 15). The peroxide and binder residue is collected in trays and then suctioned into a 55 gallon drum for disposal (Figure 16).

The finished HFST from the on-ramp to I-5 is shown in Figures 17-19 and the I-90 section in Figure 20. Note the excellent coverage with no streaking. Table 3 lists important facts concerning the installation.

Figure 15. Clean-up operation, brushing excess binder and solvent into plastic trays.  
Figure 16. Suctioning excess binder and solvent from the trays.

Figure 17. View of the HRST behind the paver on the I-5 section.  
Figure 18. Completed HFST, on-ramp to I-5.
Figure 19. Completed HFST on the ramp to I-5.

Figure 20. HFST on the left, original HMA on the right, on-ramp to I-90.
Table 3. Project facts.

<table>
<thead>
<tr>
<th>State Route</th>
<th>I-90, Eastgate and I-5, Everett</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Number</td>
<td>QE9982</td>
</tr>
<tr>
<td>Binder Material</td>
<td>Kwik Bond PPC™HFST</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Calcined bauxite</td>
</tr>
<tr>
<td>Quantity</td>
<td>6605 S.Y.</td>
</tr>
<tr>
<td>Bid Price</td>
<td>$35.50 S.Y.</td>
</tr>
<tr>
<td>Contractor</td>
<td>American Civil Constructors West Coast, LLC.</td>
</tr>
<tr>
<td>Construction Period</td>
<td>June 22 – Jun 30, 2015</td>
</tr>
</tbody>
</table>

Post-Construction Testing

The horizontal curves in each of the ramps and vehicle acceleration maneuvers mandate that the friction resistance of the pavement be higher than tangent sections or areas with steady speeds. Friction testing of the two locations was conducted on May 13, 2015, prior to the application of the HFST, and on July 7, 2015, after completion of the treatment (Table 4). The values for the HMA prior to treatment on both locations average between 38 and 40 with low readings between 34 and 36. Although neither of the ramps had values of 30 or less, which is the threshold at which a review of the location is mandated by the WSDOT Skid Accident Reduction Program guidelines, the values were lower than desired for the ramps.

Table 4. Friction resistance before and after HFS treatment.

<table>
<thead>
<tr>
<th>Location</th>
<th>Before Treatment (5/13/2015)</th>
<th>After Treatment (7/7/2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Range</td>
</tr>
<tr>
<td>SB 148th Avenue SE on-ramp to WB I-90 Lane 2</td>
<td>39</td>
<td>34 - 42</td>
</tr>
<tr>
<td>SB 148th Avenue SE on-ramp to WB I-90 HOV</td>
<td>40</td>
<td>36 – 42</td>
</tr>
<tr>
<td>EB SR 526 on-ramp to SB I-5 Lane 1</td>
<td>38</td>
<td>36 – 41</td>
</tr>
</tbody>
</table>

The after treatment results were excellent for both locations with averages between 75 and 86 and low values in the 72 to 77 range. The after treatment values should provide all of the friction needed at both of these locations for traffic.
Cost

The bid price for the HFST was $35.50 per square yard. The original quantity of 6,225 square yards was increased to 6,605 square yards. More material was placed on the I-5, Everett section and a bit less on the I-90, Eastgate section as adjustments were made in the field to make sure that the problem areas at each location were covered. As a result, the total cost of the treatment was $234,477.50. This project was similar to the $36.50 per square yard cost of the Tyregrip® installed on SR 14 in 2010 (Anderson et al, 2012).

Discussion of Results

The HFST treatment was installed according to manufacturer’s recommendations in a timely manner and without notable problems. The post-construction friction results are excellent and the visual appearance of the HFST on both ramps is excellent.

Future Research

The ramps will be friction tested and visually evaluated on a yearly basis for a minimum of five years as noted in the Experimental Feature Work Plan (Appendix C). Collision data will be collected and analyzed for the same five year period. At the end of the five-year period, a final report will be written which summarizes the friction and performance characteristics of the application, its effectiveness at reducing collisions, its cost effectiveness and recommendations on the future use of the high friction surface treatments.

References


Appendix A

Contract Special Provisions
**HIGH FRICTION SURFACE TREATMENT**

**DESCRIPTION**

This work consists of constructing a High Friction Surface Treatment (HFST) over an existing asphalt pavement surface.

**MATERIALS**

The Binder Resin System shall be suitable for use on the intended pavement surface and for the potential range of atmospheric exposure.

The Binder Resin System shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Polymeric Resin</strong></td>
</tr>
<tr>
<td>Viscosity</td>
<td>ASTM D2556 (note 1)</td>
<td>Class C:7-30 poises</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>MMA Resin</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class C 12-20 poises</td>
</tr>
<tr>
<td>Gel Time</td>
<td>AASHTO M 235 (note 2)</td>
<td>Class C:10 minutes min.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class C: 10 minutes min.</td>
</tr>
<tr>
<td>Ultimate Tensile Strength</td>
<td>AASHTO M 235 (note 3)</td>
<td>2,500 – 5,000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,500-5,000 psi</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>AASHTO M 235 (note 4)</td>
<td>30-70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-70%</td>
</tr>
<tr>
<td>Durometer Hardness (Shore D)</td>
<td>ASTM D2240 (note 5)</td>
<td>60-80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40-75</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>ASTM C579 (note 6)</td>
<td>1,000 psi min. @ 3 hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,000 psi min. @ 7 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,000 psi min. @ 3 hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,000 psi min. @ 7 days</td>
</tr>
<tr>
<td>Cure Rate (Dry through time)</td>
<td>ASTM D1640 (note 7)</td>
<td>3 hours max.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 hours max.</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>AASHTO M 235 (note 8)</td>
<td>1% max.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1% max.</td>
</tr>
<tr>
<td>Adhesive Strength @ 24 hr</td>
<td>ASTM C1583 (note 9)</td>
<td>250 psi min. or 100% substrate failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 psi min. or 100% substrate failure</td>
</tr>
</tbody>
</table>

Notes:

1. Prepare a one pint sample per manufacturer’s recommendation and mix for 2 to 3 minutes before testing. Use X1.1 for Spindle Selection. Perform testing at a temperature of 73 ± 2°F [23 ± 1°C].
2. Prepare a 60g sample per manufacturer’s recommendation. Perform testing at a temperature of 73 ± 2°F [23 ± 1°C].
3. Prepare sample as per manufacturer’s recommendation. Prepare Type I specimens in accordance with ASTM D638. Cure specimens for 7 days at 73 ± 2°F [23 ± 1°C] and 50 ± 2°F [10 ± 1°C]. Test specimens at 73 ± 2°F [23 ± 1°C] without delay.
4. Prepare sample as per manufacturer’s recommendation. Prepare Type I specimens in accordance with ASTM D638. Cure specimens for 7 days at 73 ± 2°F [23 ± 1°C] and 50 ± 2°F [10 ± 1°C]. Test specimens at 73 ± 2°F [23 ± 1°C] without delay.

5. Prepare sample as per manufacturer’s recommendation. Prepare Type I specimens in accordance with ASTM D638. Cure specimens for 7 days at 73 ± 2°F [23 ± 1°C] and 50 ± 2°F [10 ± 1°C]. Test specimens at 73 ± 2°F [23 ± 1°C] without delay.


7. Prepare sample as per manufacturer’s recommendation. Prepare a specimen at 50-55 wet mil thickness. Cure specimens for 3 hours at 73 ± 2°F [23 ± 1°C] and 50 ± 2°F [10 ± 1°C]. Test specimens at 73 ± 2°F [23 ± 1°C] without delay.

8. Prepare sample as per manufacturer’s recommendation. Cure specimens for 7 days at 73 ± 2°F [23 ± 1°C] and 50 ± 2°F [10 ± 1°C]. Test specimens at 73 ± 2°F [23 ± 1°C] without delay after immersion.

9. Prepare sample as per manufacturer’s recommendation. Use Method D, E, or F with a 2 inch loading fixture. Cure specimens for 24 hours at 73 ± 2°F [23 ± 1°C] and 50 ± 2°F [10 ± 1°C]. Test specimens at 73 ± 2°F [23 ± 1°C] without delay.

**Aggregate**

The aggregate used for the HFST shall consist of calcined bauxite that is clean, dry, free of foreign matter and conforms to the following requirements:

### Gradation

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>99-100</td>
</tr>
<tr>
<td>No. 6</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 16</td>
<td>0-5</td>
</tr>
</tbody>
</table>

### Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polish Stone Value</td>
<td>AASHTO T 279</td>
<td>38 min.</td>
</tr>
<tr>
<td></td>
<td>AASHTO T278</td>
<td></td>
</tr>
<tr>
<td>LA Wear</td>
<td>AASHTO T 96</td>
<td>20 max.</td>
</tr>
<tr>
<td>Moisture Content (at time of placement)</td>
<td>AASHTO T 255</td>
<td>0.2% max.</td>
</tr>
<tr>
<td>Aluminum Oxide</td>
<td>ASTM C25</td>
<td>87% min.</td>
</tr>
</tbody>
</table>

**Manufacturer’s Certificate of Compliance**

The Contractor shall submit a Manufacturer’s Certificate of Compliance and supporting tests in accordance with Standard Specification 1-06.3 for the Binder Resin System and HFST aggregate demonstrating compliance with these specification requirements 14 calendar days prior to the start of HFST work.

**CONSTRUCTION REQUIREMENTS**

**Contractor Qualifications**
A minimum of 10 calendar days prior to the Pre-Activity meeting, the Contractor shall submit these following qualifications: a minimum of 3 projects with the owner’s contact information on which the HFST Contractor has installed a cumulative minimum of 10,000 square yards of HFST within the past three years demonstrating a friction reading of 65 FH40R or higher when tested in accordance to ASTM E 274. An installer who does not meet this minimum shall be allowed if they are certified by the manufacturer to install and a manufacturer’s representative is onsite during all installations.

**Resin Binder System Manufacturer’s Recommendations**

The Contractor shall submit a copy of the manufacturer’s application recommendations for the Resin Binder system a minimum of 10 calendar days prior to the Pre-Activity meeting. The application recommendations shall at a minimum include:

- Method of surface preparation and required surface conditions for adequate bonding
- Crack repair requirements
- Weather, moisture and temperature requirements
- Mixing ratio and application rates for polymer resin and aggregate
- Application methods
- Requirements for opening to traffic

The Contractor shall follow the manufacturer’s recommendations unless required otherwise by this specification.

**Equipment**

Application of the Binder Resin System shall be performed using an applicator vehicle equipped with an automated continuous application device approved by the Binder Resin System manufacturer for use with their material. The application device shall mechanically mix, meter, monitor and apply the Binder Resin System and high friction aggregate in one continuous pass. The application vehicle shall be equipped with volumetric metering pumps that continuously mix, meter, and monitor and apply the resin binder. If recommended by the manufacturer, metering pumps shall be heated. The automated continuous application vehicle shall have continuous pumping and portioning devices that blend the Binder Resin System within a controlled system. The application vehicle shall be capable of applying a uniform application thickness of 50-65 mils (25-32 sf. / gal.).

**Weather Limitations**

Weather, moisture, and temperature requirements shall be in accordance with the manufacturer’s recommendations.
HFST shall not be placed during weather and temperature condition with will not allow the Resin Binder System to adequately cure prior to the required time for opening to traffic.

**Surface Preparation**

Prior to placement of the HFST, the existing HOV diamond pavement markings and solid wide lane line on the Everett ramp shall be removed from pavement surfaces. Drainage structures, utility covers, and transverse expansion joints, within the enclosed surface area of HFST shall be covered or otherwise protected prior to HFST placement. The surface to receive the HFST shall be thoroughly clean, dry and free of all dust, oil, debris and deleterious other. Pavement surfaces contaminated with oils, greases, or other deleterious materials not removed by the surface preparation shall be washes with a detergent solution, rinsed with clean water, and dried using a hot compressed air lance.

Clean asphalt pavement 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 using a minimum of 180 cfm of clean and dry compressed air, all surfaces to remove all dust, debris, and deleterious material. Maintain the tip of the air lance within 12 inches of the surface.

Cracks greater than 1/4 inch in width shall be filled with the mixed Binder Resin System. Prior to HFST application, the Engineer will mark all cracks that require treatment and will review these areas with the Contractor. Once the binder resin in the pre-treated areas has gelled, the installation may proceed.

**Application**

The Binder Resin System shall be mixed and placed onto the pavement using a Truck Mounted Application machine at a uniform application thickness of 50-65 mils (25-32 sf./gal.). The Binder Resin System shall be blended and mixed within 2% of the ratio recommended by the manufacturer and shall be continuously applied once blended.

The calcined bauxite aggregate shall be immediately applied using the same integrated application truck and at a uniform rate of 12-15 lbs. per square yard. The aggregate shall completely cover the Binder Resin System to achieve a uniform surface with no exposed resin binder visible on the surface. It is the responsibility of the HFST installer to ensure full embedment of the calcined bauxite aggregate.

Irregular areas or areas inaccessible to truck mounted application machine may be placed by hand methods in accordance with the Binder Resin system manufacturer's recommendations. Wet spots must be covered with the aggregate prior to the gelling of the Binder Resin System.
Equipment and traffic shall not be allowed on the HFST until curing is complete.

**Opening to Traffic**
Prior to opening to traffic the roadway shall be swept clean with loose aggregate removed and disposed of in accordance with Section 2-03.3(7) C.

As shown in the plans, all existing pavement markings either immediately adjacent to, or within the treated lanes, shall be reinstalled after placement of HSFT and roadway sweeping.

All HFST areas, as well as untreated shoulders adjacent to the HFST, shall be re-swept three to five days after the initial installation is completed.

**Application of HFST**
The finished HFST surface shall have a uniform coverage of aggregate without streaks or areas of exposed polymer resin binder.

After completion of the HFST, the Contractor shall notify the Project Engineer that the HFST is ready for testing. WSDOT State Materials Lab will perform the testing. Conditions permitting: testing will be completed within 30 calendar days of notification. No testing will be done unless the roadway surface temperatures is a minimum of 40°F and rising, and the requirements of ASTM E 274 are satisfied.

The completed HFST shall attain an average friction number (FH40R) of 65 or greater when tested in accordance with ASTM E 274 with no individual test less than a friction number (FH40R) of 60. The average friction number will be based on a minimum of five tests points in each lane.

The Engineer may isolate areas of exposed resin binder, insufficient aggregate of that otherwise appear defective for additional testing. These areas shall attain a friction number (FN40R) of 60 or greater.

If the HFST fails to meet the requirements of this section, the contractor shall remove and replace the defective areas at the Contractor’s expense. The areas selected for reinstallation will be retested using the same methods and subject to the acceptance criteria as outlined above.

**Measurement**
High friction surface treatment shall be measured by the square yard. No deduction will be made for drainage structures or utility appurtenances within the HFST placement area.

**Payment**
“High Friction Surface Treatment”, per square yard.

The area to be paid for will be based on the dimensions shown on the plans. No additional payment will be made for reinstallation of HFST where the initial installation was determined to be defective.

The contract price paid per square yard for high friction surface treatment (HFST) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in HFST, complete in place, including the submittals, surface preparation, roadway sweeping, and other work, all in accordance with the attached Contract Plans, these Contract Provisions, the Standard Specifications, and as directed by the Engineer.
Appendix B

Manufacturer’s Certificate of Compliance
Manufacturer’s Certificate of Compliance Check List

Instructions: This form is to be completed by the PEO. It is NOT required for concrete delivery tickets, asphalt bill of lading, or admixtures.

Contract Number SR Number Section Date
QE9982 I-5 & I-90 High Friction Surface Treatment 5/19/2015

Project Engineer: Client Name: Mark Sawyer American Civil Constructors West Coast, Inc.

The attached Manufacturer’s Certificate of Compliance for a quantity of 

Material: High Friction Surface Treatment

for Bid Item #: 4 has been checked for conformance to Section 1-06.3 of the Standard Specifications per the check list shown below.

1. Is a Mfg. Cert. proper documentation for this item of Material? See Note 1
2. Is the certification being provided PRIOR to the material being installed?
3. If the answer to No. 2 above is “NO,” attached is a copy of the contractor’s approved request for permission to install prior to providing a Mfg. Cert. for acceptance.
4. Has an approved RAM/GPL been received for this item?
5. Does this Mfg. Cert. identify the name of the manufacturer and/or fabricator?
6. Does the Mfg. Cert. identify the quantity of material being certified and/or placed by type, size, lot, or heat number? See Note 2
6a. Does the material being placed match the certification provided?
7. Does the Mfg. Cert. identify the applicable contract specification (i.e., WSDOT, AASHTO, ASTM) that the material is to meet? See Note 3
8. Does the Mfg. Cert. provide show the material conforms to the required specifications? (i.e., WSDOT, AASHTO, ASTM) See Note 4
9. Is the Mfg. Cert. signed by a corporate official?
10. When more than a single delivery is made, are the lot numbers identified?
11. Is a supporting mill test attached showing the physical and chemical test values meeting applicable specifications? See Note 3.

Remarks:
MFR-0001

Notes:
1. Check the Record of Materials (ROM), Special Provisions, or the ‘Approved’ Request for Approval of Material (RAM).
2. Rebar cut sheets may be used in lieu of bill of lading or invoice.
3. Test values required to be supplied with Manufacturer’s Certificate for steel reinforcing bars and structural steel.
   Manufacturer’s Certificate for some steel items, such as steel culvert pipe items, may reference heats used.
4. If answer is “NO,” submit Manufacturer’s Certificate to State Materials Laboratory for approval.

☑ Accepted as proper documentation per Section 1-06.3 of the Standard Specifications.
☐ Manufacturer’s Certificate of Compliance submitted to State Materials Laboratory for “Approval Action.”
☐ Returned to contractor for correction of “NO” answers recorded in items

Signed: Date: 5/19/15

DOT Form 396-872 EF
Revised 6/2004
Certificate of Compliance

Date: May 15, 2015

Contract No: NWR-ELJ201501 High Friction Surface Treatments, Division 5-Surface Treatment & Pavements

Material Quantity – Per Bid Item #4 – 6,225 Sq Yards HFS T

Contractor: ACC West Coast

Kwik Bond Polymers, LLC is both a manufacturer and System Provider for Polyester Polymer Concrete Applications. Kwik Bond Polymers, LLC certifies that the components listed below have been tested and/or known to comply with the Special Provisions for the materials referenced in the contract number above.

<table>
<thead>
<tr>
<th>Product</th>
<th>Lot No.</th>
<th>Quantity</th>
<th>Ship Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPC HFS T</td>
<td>0000912421</td>
<td>8 totes / 3 drums / 3-4 gal pails</td>
<td>6-2-2015</td>
</tr>
<tr>
<td>DDM 9</td>
<td></td>
<td>52 gallons</td>
<td>6-2-2015</td>
</tr>
<tr>
<td>Z-ure</td>
<td></td>
<td>36 gallons</td>
<td>6-2-2015</td>
</tr>
<tr>
<td>Glass Beads Calcined Bauxite</td>
<td>031115</td>
<td>24 5/8</td>
<td>6-2-2015</td>
</tr>
</tbody>
</table>

If you have any questions, please contact Pati Fosneca at 707-373-4073. Thank you.

Pati Fosneca
Corporate Secretary
Kwik Bond Polymers
pati@kwikbondpolymers.com
MTL 3786-32

Kwik Bond Polymer

Martin Testing Laboratories, Inc.

P.O. Box 2019
North Highlands, CA 95660
(916) 920-4110
(916) 920-4390 fax

Customer: Kwik Bond Polymer
923 Teal Dr.
Benecia, CA 94510

Attn: Daniel Tikusis
(707) 330-9227
(707) 746-7981 fax

www.martintesting.com

May 14, 2015
MTL MJO: 3766-32
P.O. No: verbal

RE: Testing of KBP HFST 32042-11, Batch # 912421-7 day cure

The following are test results for testing of KBP HFST as specified by customer. Testing included:

Water Absorption, Tensile Strength, Compression, and Hardness.

Data sheets for tensile and compression are attached separately. Please call if you have any questions.

Thank you.

Martin Testing Labs

Debbie Hu
Experimental Feature Report

Customer: Kwik Bond Polymer
923 Teal Dr.
Reneca, CA 94510

Attn: Daniel Tikusis
(707) 330-9227
(707) 746-7981 fax

RE: Testing of KBP HFST 32042-11, Batch 912421

A sample of KBP HFST was submitted for viscosity testing per ASTM D2556. Results are presented below.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Viscosity (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KBP HFST</td>
<td>1390</td>
</tr>
</tbody>
</table>

Sample was tested using a Brookfield RVT Viscosity Tester. Spindle #3 at 20 rpm @ 25°C.

Please call if you have any questions.

Thank you.

Martin Testing Labs

Debbie Hu

Martin Testing Laboratories
A Division of Materials Technology Laboratories, Inc.
4724 Arnold Ave.
McClellan, CA 95652
Ph: (916) 920-4110; Fx: (916) 920-4390

May 06, 2015

MTL MJO: 3766-29
P.O. No: verbal

December 2015
May 06, 2015

Customer: Kwik Bond Polymer
923 Teal Dr.
Benecia, CA 94510

Attn: Daniel Tikusis (707) 330-9227

RE: Testing of KBP HFST 32042-11, Batch 912421

A sample of KBP HFST was submitted for Gel Time and Cure Rate testing. Results are presented below.

### Gel Time per ASTM C881 and AASHTO M 235

<table>
<thead>
<tr>
<th>Sample</th>
<th>Gel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>KBP HFST @ 77F/25C</td>
<td>17 min</td>
</tr>
<tr>
<td>KBP HFST @ 50F/10C</td>
<td>13 min</td>
</tr>
</tbody>
</table>

Components at 77F/25C: 0.175% Z Cure, 2.0% DDM-9
Components at 50F/10C: 1.5% Z Cure, 2.0% DDM-9

### Cure Rate per ASTM D1640

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>KBP HFST @ 77F/25C</td>
<td>&lt;100 min</td>
</tr>
<tr>
<td>KBP HFST @ 50F/10C</td>
<td>&lt;80 min</td>
</tr>
</tbody>
</table>

Components at 77F/25C: 0.175% Z Cure, 2.0% DDM-9
Components at 50F/10C: 2.0% Z Cure, 2.0% DDM-9

Please call with any questions.

Debbie Hu

Martin Testing Laboratories
A Division of Materials Technology Laboratories, Inc.
4724 Arnold Ave.
McClellan, CA 95652
Ph: (916) 920-4110; Fx: (916) 920-4390
## Experimental Feature Report

**Martin Testing Laboratories**

**Tensile Properties of Plastics (Modulus)**

**December 2015**

**May 12, 2015**

**Report No. 3918**

**Vendor:** KwikBord  
**Operator:** RE  
**Description:** 30242-11  
**PIN:** KBF HFST  
**Batch:** 012421

<table>
<thead>
<tr>
<th>Test No</th>
<th>Spec ID</th>
<th>Width (in)</th>
<th>Thickness (in)</th>
<th>Tensile (lbs)</th>
<th>Tensile Str. (psi)</th>
<th>Modulus of Elasticity (ksi)</th>
<th>Break Elong (%)</th>
<th>Tensile Elong (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9483</td>
<td>1-01</td>
<td>0.486</td>
<td>0.127</td>
<td>305.77</td>
<td>4,965.63</td>
<td>3,354,424</td>
<td>47.92</td>
<td>12.34</td>
</tr>
<tr>
<td>9484</td>
<td>1-02</td>
<td>0.485</td>
<td>0.126</td>
<td>295.62</td>
<td>4,838.30</td>
<td>4,397,216</td>
<td>38.85</td>
<td>11.05</td>
</tr>
<tr>
<td>9485</td>
<td>1-03</td>
<td>0.486</td>
<td>0.128</td>
<td>305.96</td>
<td>4,919.00</td>
<td>4,332,393</td>
<td>63.06</td>
<td>11.01</td>
</tr>
<tr>
<td>9486</td>
<td>1-04</td>
<td>0.486</td>
<td>0.131</td>
<td>309.41</td>
<td>4,857.24</td>
<td>4,097,806</td>
<td>53.30</td>
<td>10.73</td>
</tr>
<tr>
<td>9487</td>
<td>1-05</td>
<td>0.487</td>
<td>0.134</td>
<td>318.07</td>
<td>4,870.65</td>
<td>4,024,469</td>
<td>59.29</td>
<td>10.76</td>
</tr>
</tbody>
</table>

**Notes:**

**ASTM D635**  
**7 day cure**

<table>
<thead>
<tr>
<th>Crosshead Speed (Inches/min) or Rate</th>
<th>Displacement Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>XHD-100 (XHD100)</td>
</tr>
</tbody>
</table>

**Mean:** 0.486  
**Median:** 0.486  
**Std Dev:** 0.001  
**Maximum:** 0.487  
**Minimum:** 0.485  
**Range:** 0.002

**NOTES:**

1. Tested per ASTM D635 and AASHTO M235
2. Samples are 7 day cure at 73F

**By:** [Signature]  
**Date:** 5/12/15

Martin Testing Laboratories  
4724 Arnold Ave.  
McClellan, CA 95652  
TEL: (916) 627-4110  
FAX: (916) 627-4380
1) Water Absorption – 73F (23C) & 50F (10C), 7 day cure
Sample was tested per ASTM D570 and AASHTO M235

<table>
<thead>
<tr>
<th>Sample</th>
<th>73F Wt. Increase %</th>
<th>50F Wt. Increase %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.478</td>
<td>0.373</td>
</tr>
<tr>
<td>2</td>
<td>0.477</td>
<td>0.347</td>
</tr>
<tr>
<td>3</td>
<td>0.450</td>
<td>0.364</td>
</tr>
<tr>
<td>Average</td>
<td>0.468</td>
<td>0.361</td>
</tr>
</tbody>
</table>

2) Shore D Hardness – 73F (23C) & 50F (10C), 7 day cure
Sample was tested in accordance with ASTM D2240.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Shore D</th>
</tr>
</thead>
<tbody>
<tr>
<td>KBP HFST</td>
<td>75</td>
</tr>
</tbody>
</table>
### ASTM C579-01 Compressive Strength of CR Mortars...

**Test Date:** 07-May-15  
**Testing Machine Smart Series**

<table>
<thead>
<tr>
<th>Test No</th>
<th>Spec ID</th>
<th>Width (in)</th>
<th>Length (in)</th>
<th>Max Comp Load (lbs)</th>
<th>Max Comp Stress (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5470</td>
<td>1-01</td>
<td>2.000</td>
<td>2.000</td>
<td>30,840.64</td>
<td>7,862.41</td>
</tr>
<tr>
<td>5471</td>
<td>1-02</td>
<td>2.000</td>
<td>2.000</td>
<td>31,028.82</td>
<td>7,757.45</td>
</tr>
<tr>
<td>5472</td>
<td>1-03</td>
<td>2.000</td>
<td>2.000</td>
<td>32,547.57</td>
<td>8,136.89</td>
</tr>
</tbody>
</table>

**Mean:** 2.000 | 2.000 | 31,408.01 | 7,852.25  
**Median:** 2.000 | 2.000 | 31,028.82 |  
**Std Dev:** 0.000 | 0.000 | 1,034.18 | 251.04  
**Maximum:** 2.000 | 2.000 | 32,547.57 | 8,136.89  
**Minimum:** 2.000 | 2.000 | 30,840.64 | 7,862.41  
**Range:** 0.000 | 0.000 | 1,697.93 | 474.48  

**By:** R. Elsner  
**Date:** 5/21/15  

Martin Testing Laboratories  
4724 Arnold Ave.  
McClellan, CA 95652  
TEL (916) 920-4110  
FAX (916) 920-4390
# Experimental Feature Report

## ASTM C679-01 Compressive Strength of CR Mortars...

**Report No. 3920**

**Test Date:** May 13, 2015

**Customer Name:** KwikBond

**Operator:** RE

**Product #:** KBP, HRBT

**Description:** 7 Day @ 50F/10C

### Load Cell S/N (SB168509), Units (Lbs) 110000

<table>
<thead>
<tr>
<th>Test No</th>
<th>Spec ID</th>
<th>Width (in)</th>
<th>Length (in)</th>
<th>Max Comp Load (lbs)</th>
<th>Max Comp Stress (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9453</td>
<td>1-61</td>
<td>2.000</td>
<td>2.000</td>
<td>27,669.26</td>
<td>6,687.32</td>
</tr>
<tr>
<td>9454</td>
<td>1-62</td>
<td>2.000</td>
<td>2.000</td>
<td>20,486.52</td>
<td>7,121.63</td>
</tr>
<tr>
<td>9456</td>
<td>1-03</td>
<td>2.000</td>
<td>2.000</td>
<td>28,072.76</td>
<td>7,018.19</td>
</tr>
</tbody>
</table>

### Crosshead Speed (Inches / min) or Rate of Displacement Sensor: 0.2

### XHD 100 (XHD100)

<table>
<thead>
<tr>
<th>Test No</th>
<th>Width (in)</th>
<th>Length (in)</th>
<th>Max Comp Load (lbs)</th>
<th>Max Comp Stress (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.000</td>
<td>2.000</td>
<td>28,142.85</td>
<td>7,035.71</td>
</tr>
<tr>
<td>Median</td>
<td>2.000</td>
<td>2.000</td>
<td>28,072.76</td>
<td>7,018.19</td>
</tr>
<tr>
<td>Std Dev</td>
<td>0.000</td>
<td>0.000</td>
<td>314.54</td>
<td>78.63</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.000</td>
<td>2.000</td>
<td>28,486.52</td>
<td>7,121.63</td>
</tr>
<tr>
<td>Minimum</td>
<td>2.000</td>
<td>2.000</td>
<td>27,669.26</td>
<td>6,687.32</td>
</tr>
<tr>
<td>Range</td>
<td>0.000</td>
<td>0.000</td>
<td>617.36</td>
<td>154.31</td>
</tr>
</tbody>
</table>

### By: [Signature]  Date: 5-13-15

---

Martin Testing Laboratories

4724 Arnold Ave, McClelan, CA 95652

TEL (916) 920-4110  FAX (916) 920-4350
Experimental Feature Report

May 7, 2015
MJO: 3766-30

Customer: Kwik Bond Polymers
923 Teal Drive
Benecia, CA 94510
Daniel Tikusis (707) 330-9227

RE: Testing of KBP HFST 32042-11, Batch 912421 for Adhesive Strength
per ASTM C1583

24 hr cure at 77F/25C

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Bond Strength, psi</th>
<th>Mode of Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>469.4</td>
<td>Epoxy/Adh. Failure</td>
</tr>
<tr>
<td>2</td>
<td>533.3</td>
<td>Concrete Failure</td>
</tr>
<tr>
<td>3</td>
<td>478.9</td>
<td>Epoxy/Adh. Failure</td>
</tr>
</tbody>
</table>

24 hr cure at 50F/10C

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Bond Strength, psi</th>
<th>Mode of Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>435.0</td>
<td>Concrete Failure</td>
</tr>
<tr>
<td>2</td>
<td>370.9</td>
<td>Adhesive Failure</td>
</tr>
<tr>
<td>3</td>
<td>427.0</td>
<td>90% Adh Failure/10% Concrete Failure</td>
</tr>
</tbody>
</table>

Samples: Three 2" dia. cored concrete samples with bonded gravel overlay for each set of testing performed.

Please call with any questions.

Debbie Hu

Martin Testing Laboratories
A Division of Materials Technology Laboratories, Inc.
4724 Arnold Ave.
McClellan, CA 95652
Ph: (916) 920-4110; Fx: (916) 920-4390

December 2015
Experimental Feature Report

Report No: 17561-R3
Date: 11/13/2014

Lab No: 143789
Production/Sampled Date: NP
Project No: NP
Received Date: 11/7/2014
Test Performed By: Phillip New, CET

Sample ID: NP
Sampled By: Client
Sample Location: High Friction Surfacing Project-CA
Producer: Great Lakes Minerals
Material Description: Calcined Bauxite Mineral Aggregate

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cumulative Passing %</th>
<th>% Passing Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td>100.0</td>
<td>100</td>
</tr>
<tr>
<td>#6</td>
<td>100.0</td>
<td>&gt;65</td>
</tr>
<tr>
<td>#8</td>
<td>64.5</td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>38.3</td>
<td></td>
</tr>
<tr>
<td>#16</td>
<td>0.9</td>
<td>&lt;5</td>
</tr>
<tr>
<td>#30</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>#60</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Acid Insolubility (%): 99.1 >99%

La Abrasion (D grading) @100rev (%): 3.0 <20%

British Pendulum No...
<table>
<thead>
<tr>
<th>Prior to Polishing</th>
<th>After 10 Hrs Polishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>41</td>
</tr>
</tbody>
</table>

Magnesia Soundness (%): 1.0 <30%

Report Reviewed by:

Dale A. Rand

PaveTex Engineering and Testing
Firm Registration No. F-961

The results shown on this report are for the exclusive use of the client for whom they were obtained and apply only to the samples tested and/or inspected. They are not planned to be indicative of apparently identical products.
Great Lakes Minerals, LLC

CERTIFICATE OF ANALYSIS

<table>
<thead>
<tr>
<th>Date: 05/15/2015</th>
<th>Customer: Kwik Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO. #</td>
<td></td>
</tr>
<tr>
<td>BOL#</td>
<td>RD113861, RD113862, RD11387</td>
</tr>
</tbody>
</table>

Material: RD88
Size: Grip Grain
Lot #: G31115

Chemistry Analysis (%):

<table>
<thead>
<tr>
<th></th>
<th>Al2O3 88% min</th>
<th>Fe2O3 2.0% max</th>
<th>SiO2 7.5% max</th>
<th>TiO2 3.75% max</th>
<th>Na2O + K2O 9.75% max</th>
<th>CaO + MgO 6.0% max</th>
<th>Bulk Density 5.75 g/cc</th>
<th>Moisture 0.5% max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>89.10</td>
<td>1.51</td>
<td>5.07</td>
<td>3.11</td>
<td>0.11</td>
<td>0.42</td>
<td>3.25</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Sieve Analysis:

<table>
<thead>
<tr>
<th>US STD</th>
<th>Sieve/Inch</th>
<th>min / max %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>0.0</td>
<td>0.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Experimentation Report
Great Lakes Minerals, LLC  
1200 Port Road, Suite B  
Wurland, KY 41144

Certificate of Analysis

<table>
<thead>
<tr>
<th>Job:</th>
<th>Submitted Samples - October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product:</td>
<td>Bauxite</td>
</tr>
<tr>
<td>Sample I.D.:</td>
<td>RD-88 6X6 Grip Grain Bauxite</td>
</tr>
<tr>
<td>Terminal:</td>
<td>Submitted</td>
</tr>
<tr>
<td>Job ID:</td>
<td>14-60111-4366</td>
</tr>
<tr>
<td>Lab Ref:</td>
<td>14-601-00194-01-001</td>
</tr>
</tbody>
</table>

Sample Submitted By: Great Lakes Minerals
Analysis Performed By: IAC New Orleans M&M Operations
Date Received: October 21, 2014
Date Reported: November 6, 2014
Submission ID: 14-601-00194-01

<table>
<thead>
<tr>
<th>Method</th>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C566, AASHTO T-255</td>
<td>Loss on drying (Moisture), %</td>
<td>0.01</td>
</tr>
<tr>
<td>ASTM C25</td>
<td>Alumina, %</td>
<td>88.11</td>
</tr>
</tbody>
</table>

Particle Size Distribution

<table>
<thead>
<tr>
<th>Screen Size</th>
<th>Weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 4 mesh</td>
<td>Nil</td>
</tr>
<tr>
<td>+ 6 mesh</td>
<td>0.3</td>
</tr>
<tr>
<td>+ 16 mesh</td>
<td>99.5</td>
</tr>
<tr>
<td>- 16 mesh</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Analysis performed in an Inspectorate Group or associated laboratory. This document is issued pursuant to a quality and/or quantity control intervention as carried out by the Company within the limits of the agreed scope with its principal(s). When and as applicable, the inspection, weight determination, sampling, sample preparation, physical testing and/or laboratory analysis as carried out by the Company, or its approved subcontractor, and the reported results thereof reflect the findings of the Company at the time and place of intervention only. All services are rendered in accordance with the standard terms and conditions of the Company, available at www.inspectorate.com. This document cannot be reproduced except in its entirety, any unauthorized alteration of contents or appearance is prohibited by the Company.

Renisha Singh, Technical Manager
Appendix C

Work Plan
WORK PLAN
High Friction Surface Treatment

QE9982
Interstate 90
SB 148th Avenue SE on-ramp to I-90 Westbound
I-5
SR 526 Eastbound on-ramp to I-5 Southbound

Keith W. Anderson
Experimental Features Engineer
Washington State Department of Transportation
Introduction

Two ramps, one on I-90 and one on I-5, will have a High Friction Surface (HFS) applied to the ramps to improve the frictional properties of the pavement. The I-90 section is the on-ramp from 148th Avenue SE to westbound I-90 in Eastgate (Figure 1). The I-5 section is the on-ramp from SR 526 eastbound to I-5 southbound south of Everett (Figure 2). Both on-ramps are high accident locations. WSDOT installed warning signs to alert motorists to the hazard but there is still a high occurrence of accidents. The ramp geometry and type of accidents indicate that increasing the pavement friction may reduce the number of accidents.

There are several methods to increase friction on an existing pavement. These include replacing the pavement, placing a surface treatment such as a chip seal over the existing pavement or grooving the pavement by diamond grinding (PCC pavements). These methods are costly and the existing HMA pavement on the subject ramps is not due for rehabilitation. A less costly solution is to install a thin high-friction laminate surface over the existing pavement.

The HFS system selected for this project was provided by Kwik Bond Polymers, Benicia, CA. The system consists of a polyester resin binder and calcined bauxite aggregate. Great Lakes Minerals, Wurtland, KT was the source of the bauxite aggregate. The system can be applied by machine or by hand depending on the size of the project.

Scope

Kwik Bond HFS will be installed on the curved portions of the two ramps. The amount of HFS to be installed is 6,225 square yards, 1520 ft. by 24 ft. on SR 526 and 1055 ft. by 16 ft. on 148th Avenue SE. The contract special provisions require that the method of application be by a mechanical device that mixes, monitors and applies the binder resin system and high friction aggregate in one continuous pass.
Figure 1. HFST installation on SB 148th Avenue SE on-ramp to I-90 WB.

Figure 2. HFST installation on SR 526 eastbound to I-5 SB.
Experimental Feature Report

Staffing

This installation will be constructed as a Northwest Region Traffic Office low cost enhancement project. Representatives from and WSDOT Materials Laboratory (1 – 2 people) will be involved in monitoring the installation to collect data and photos for the post-construction report.

Contacts and Report Author

Mark Russell
State Pavement Design Engineer
Washington State DOT
(360) 709-5479
russelm@wsdot.wa.gov

Keith Anderson
Experimental Features Engineer
Washington State DOT
(360) 584-8648
anderke@wsdot.wa.gov

Testing

Pavement performance will be monitored by the following methods:

- Friction will be measured before and after construction then annually.
- Accident data will be gathered by the Northwest Region Traffic Office
- Visual inspections will be conducted to collect data on cracking, delaminations (potholes) and other pavement distress.

Reporting

A “Post Construction Report” will be written following completion of the ramps. This report will include construction details, cost of the treatment, construction test results, and other details concerning the overall process. Friction testing will be conducted annually and any problems with the friction values or condition of the HFS reported to the NWR. At the end of the five-year period, a final report will be written which summarizes the performance
characteristics, effectiveness at reducing accidents and future recommendations for use of this process.

**Cost Estimate**

**Construction Costs**
No additional construction costs are required. This project will be constructed as a Region HAL enhancement (QE program) project.

**Testing Costs**
Pre and post-construction friction testing will be conducted as part of the Region Q program project (estimated cost $2,500). Annual friction testing will be conducted in conjunction with the annual post-construction testing of HMA preservation projects. Annual inspections will be conducted to assess the condition of the HFS at a cost of approximately $3,000.

**Report Writing Costs**
Initial Report – 16 hours = $2,112
Final Report – 32 hours = $4,224

**Total Cost = $9,336**

**Schedule**

Construction: June – July 2015

<table>
<thead>
<tr>
<th>Date</th>
<th>Friction (Annual)</th>
<th>Post Construction Report</th>
<th>Visual Inspection</th>
<th>Final Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2015</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer 2015</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2016</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fall 2017</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fall 2018</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fall 2019</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Spring 2020</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>