Standard Practice for
High Friction Surface Treatment for Asphalt and Concrete Pavements

AASHTO Designation: PP XX-13
Standard Practice for

High Friction Surface Treatment for Asphalt and Concrete Pavements

AASHTO Designation: PP XX-13

1. SCOPE

1.1. This practice describes furnishing and applying a High Friction Surface Treatment (HFST) for asphalt and concrete pavements. The HFST is comprised of a minimum of a single layer using a Binder Resin System and surface applied aggregate. Binder Resin Systems include Polymeric and Methyl methacrylate Resins.

1.2. This standard may involve hazardous materials, operations and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:

- AASHTO M 235 Standard Specification Epoxy Resin Adhesives
- AASHTO T 27 Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
- AASHTO T 96 Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- AASHTO T 242 Standard Method of Test for Frictional Properties of Paved Surfaces using a full scale tire
- AASHTO T 278 Standard Method of Test for Surface Properties Using the British Pendulum Tester
- AASHTO T 279 Standard Method of Test for Accelerated Polishing of Aggregates Using the British Wheel
- AASHTO T 255 Standard Method of Test for Total Evaporable Moisture Content of Aggregate by Drying

2.2. ASTM Standards:

- ASTM C 25 Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
- ASTM C 566 Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
- ASTM C 579 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing’s, and Polymer Concretes
ASTM C 1583 Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)

ASTM D 570 Standard Test Method for Water Absorption of Plastics


ASTM D 1640 Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature

ASTM D 2196 Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer

ASTM D 2240 Standard Test Method for Rubber Property—Durometer Hardness

ASTM D 2556 Standard Test Method for Apparent Viscosity of Adhesives Having Shear-Rate-Dependent Flow Properties

ASTM D 4285 Standard Test Method for Indicating Oil or Water in Compressed Air


3. **TERMINOLOGY**

3.1. High Friction Surface Treatment (HFST)—a Binder Resin System and surface applied aggregate utilized to increase the coefficient of friction of an asphalt or concrete pavement.

3.2. Binder Resin System—a polymeric resin used to bond a surface applied aggregate to an asphalt or concrete pavement.

3.3. Prime Coat—a polymeric resin that is used to fill cracks and voids in existing pavement surface that is compatible with the binder resin system.

3.4. Skid Resistance (SR)—the ability of the traveled surface to prevent the loss of tire traction.

3.5. Skid Number (SN)—a value representing the friction of a surface obtained from using the locked-wheel trailer.

3.6. Skid Resistance Value (SRV)—a measure of friction from the actual road surface, usually determined by using the Portable Friction Resistance Tester. This value is dependent on the Polish Stone Value (PSV) of the aggregate and the macro texture of the surface.

3.7. Polish Stone Value (PSV)—a measure of resistance to the polishing action of vehicle tires under conditions similar to those occurring on the surface of a road.

3.8. Macro Texture—a family of wave-shaped road surface characteristics that have wavelengths from 0.5 mm up to 50 mm and affect the interaction between the road surface and the tire footprint.

3.9. Open Graded Friction Course (OGFC)—a special type of hot mix asphalt surface mixture used for reducing hydroplaning and potential for skidding, where the function of the mixture is to provide a free-draining layer that permits surface water to migrate laterally through the mixture to the edge of the pavement.
4. SUMMARY OF PRACTICE

4.1. This practice describes furnishing and applying a HFST for asphalt and concrete pavements. The HFST is comprised of a minimum of a single layer using a Binder Resin System which holds a surface applied aggregate firmly in place. The HFST may be applied by either mechanical or manual techniques. These systems may be applied to both asphalt and concrete pavements.

5. SIGNIFICANCE AND USE

5.1. The HFST is used primarily for restoring or enhancing the friction properties of a pavement surface where high friction or anti-skidding properties are desired.

5.2. Typically recommended locations for High Friction Surface Treatment installations include horizontal curves, intersections, exit-entrance ramps, steep grades, bridges, and other identified areas where increased friction demand requires an effective counter measure.

5.2.1. A HFST will provide improved friction for bridge decks. This specification is not intended to address bridge deck preservation sealing projects.

6. MATERIALS

6.1. Binder Resin Systems:

6.1.1. Binder Resin System: Binder resin systems shall be recommended by the manufacturer as suitable for use on the intended pavement surface and for the potential range of atmospheric exposure.

6.1.2. Prime Coat: a primer shall be used before application of the binder resin system when recommended by the manufacturer.

6.1.3. The properly proportioned and mixed binder shall conform to the requirements of Table 1. See Section 7: Method of Testing, for sample preparation and testing procedures.
Table 1—Physical Requirements of the Binder Resin System

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>ASTM D-2556</td>
<td>Class C: 7 - 30 poises</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class C: 12-20 poises</td>
</tr>
<tr>
<td>Gel Time</td>
<td>AASHTO M-235</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</td>
<td>2500 - 5000 psi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1500 - 5000 psi</td>
</tr>
<tr>
<td>Elongation at break point</td>
<td>AASHTO M-235</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 D-2240</td>
<td>60-80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40-75</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>ASTM C-579</td>
<td>1,000 psi min at 3 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,000 psi min at 3 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,000 psi min at 7 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,000 psi min at 7 days</td>
</tr>
<tr>
<td>Cure Rate (Dry through time)</td>
<td>ASTM D-1640</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</td>
<td>1% max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1% max</td>
</tr>
<tr>
<td>Adhesive Strength @ 24 hours</td>
<td>ASTM C-1583</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>

6.1.4. Independent laboratory reports per formulation shall be provided, documenting that the resin binder meets the requirements of this section.

6.1.5. A sample of the resin binder or components lot/batch shall be supplied upon request.

6.1.5.1. Failure to comply with the specified material properties shall result in rejection of the material lot/batch provided.

6.2. Aggregates:

6.2.1. Calcined Bauxite

6.2.2. The surface applied aggregate shall be calcined bauxite that is clean, dry, and free from foreign matter.

6.2.3. The Calcined Bauxite aggregate shall conform to the physical and chemical requirements of Table 2. See Section 7: Method of Testing, for sample preparation and testing procedures.
Table 2 — Physical and Chemical Requirements of the Aggregate

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polish Stone Value</td>
<td>AASHTO T-279</td>
<td>38 min</td>
</tr>
<tr>
<td>Resistance to Degradation</td>
<td>AASHTO T-96</td>
<td>20% max</td>
</tr>
<tr>
<td>Aggregate Grading</td>
<td>AASHTO T-27</td>
<td></td>
</tr>
<tr>
<td>Sieve Designation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 4 Sieve Size</td>
<td></td>
<td>100% min Passing</td>
</tr>
<tr>
<td>No. 6 Sieve Size</td>
<td></td>
<td>95% min Passing</td>
</tr>
<tr>
<td>No. 16 Sieve Size</td>
<td></td>
<td>5% max Passing</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>AASHTO T-255</td>
<td>0.2% max</td>
</tr>
<tr>
<td>Aluminum Oxide</td>
<td>ASTM C-25</td>
<td>87% min</td>
</tr>
</tbody>
</table>

6.2.4. A sample of the aggregate lot/batch shall be supplied upon request.

7. METHOD OF TESTING

7.1. Test shall be conducted in accordance with the following


7.1.2. Viscosity---ASTM D 2556 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].

7.1.3. Gel time---AASHTO M 235. Prepare a 60g sample per manufacturer's recommendation. Perform testing at a temperature of 73 ± 2°F [23 ± 1°C].

7.1.4. Ultimate Tensile Strength---AASHTO M 235, 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.

7.1.5. Elongation at break point---AASHTO M 235, 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.

7.1.6. Durometer Hardness---ASTM D 2240, prepare sample as per manufacturer's recommendation. Use the Type 1 Precision—Type D Durometer Method. 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.

7.1.7. Compressive Strength---ASTM C 579, prepare sample as per manufacturer's recommendation. Prepare specimen according to Method "B", 2" x 2" cube, using 2.75 parts of sand to one part of

7.1.8.  
_Cure Rate (Dry Through Time) ---_ ASTM D 1640, prepare sample as per manufacturer's recommendation. Prepare a specimen of 50-55 wet mil thickness. Cure specimens for 3 hours max 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.

7.1.9.  
_Water Absorption ---_ AASHTO M 235, 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.

7.1.10.  
_Adhesive Strength @ 24hours ---_ ASTM C 1583, Withdrawn in 2013 still available, prepare sample as per manufacturer's recommendation. 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.

7.2.  
Aggregates

7.2.1.  
_Polishing of Aggregates ---_ AASHTO T-279, use AASHTO T-278 to measure friction values.

7.2.2.  
_Resistance to Small Size Coarse Aggregate Degradation ---_ AASHTO T 96, use Grading D from Table 1.

7.2.3.  
_Aggregate Grading ---_ AASHTO T 27

7.2.4.  
_Moisture Content ---_ AASHTO T 255

7.2.5.  
_Aluminum Oxide Content ---_ ASTM C 25, as per section 15.

8.  
PACKAGING

8.1.  
Binder Resin System Packaging:

8.1.1.  
Binder Resin System components shall be packaged in suitable, well-sealed containers clearly labeled as to the type material and the ratio of the components to be mixed by volume. Any special instructions regarding mixing shall be included.

8.1.1.1.  
The label shall show resin or hardener components, brand name, name of manufacturer, lot or batch number, temperature range for storage, expiration date and the quantity contained therein.

8.1.1.2.  
Caution warnings regarding contact of the binder with skin and eyes shall be included on the labels.

8.2.  
Aggregate Packaging:

8.2.1.  
All aggregates shall be furnished in appropriate packaging that is clearly labeled and protects the aggregate from any contaminates on the jobsite and from exposure to rain or other moisture.

8.2.1.1.  
The label shall show the name of the manufacturer and location of processing.
9. **MATERIALS CERTIFICATION**

9.1. At the request of the purchaser, the manufacturer of the Binder Resin System shall certify that the Binder Resin System meets the requirements of this specification. Such certification shall consist of either a copy of the manufacturer's test report or a statement by the manufacturer, accompanied by a copy of the current test results, that the Binder Resin System has been sampled and tested. Such certification shall indicate the date of testing and shall be signed by the manufacturer.

9.2. At the request of the purchaser, the manufacturer of the aggregate shall certify that the aggregate meets the requirements of this specification. Such certification shall consist of either a copy of the manufacturer's test report or a statement by the manufacturer, accompanied by a copy of the current test results, that the aggregate has been sampled and tested. Such certification shall indicate the date of testing and shall be signed by the manufacturer.

9.3. The manufacturer shall maintain and make available upon request complete records of sampling, testing, actions taken to correct problems and quality control inspection results.

10. **QUALIFICATION OF INSTALLER**

10.1. The installer shall submit a minimum of 3 projects with the owner’s contact information on which a cumulative minimum of 10,000 square yards of HFST have been placed within the past three years demonstrating a friction reading of 65 FN40R when tested in accordance to AASHTO T 242. 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.

10.2. Quality Control (QC) Plan: The QC Plan shall be project specific detailing installer's key personnel, equipment, materials, proposed methods of installation, materials blending procedures, and proposed methods of curing.

10.2.1. Key Personnel

10.2.1.1. Provide contact information for key personnel.

10.2.1.2. Designate a Project Superintendent: who shall have full authority to institute any action necessary for the successful operation of the QC plan.

10.2.1.3. Designate a Lead technician who shall be present at the job site and be responsible for the required field quality control sampling and testing in conformance with the approved QC plan and contract documents.

10.2.2. Equipment

10.2.2.1. Equipment calibration records of metering devices and application monitoring devices.

10.2.2.2. Cleaning and maintenance schedule for application equipment.

10.2.3. Materials

10.2.3.1. Provide certification showing all materials meet the requirements of this specification.

10.2.3.2. Provide procedures for storage of materials both stockpiled and onsite.

10.2.4. Installation of HFST:
10.2.4.1. Provide procedures for blending of materials and placement of HFST.

10.2.4.2. Monitoring and recording of ambient conditions (air temperature, surface temperature, relative humidity).

10.2.4.3. Recording of quantities of materials installed.

10.2.4.4. Provide procedures for curing of HFST.

10.2.5. Corrective Action: The manufacturer shall address corrective actions to address unsatisfactory installation.

10.3. Submit a QC Plan to the Engineer for approval at least 30 days prior to the placement.

10.4. Any deviation from the approved QC Plan shall be cause for immediate suspension of operations.

11. RECOMMENDED CONSTRUCTION PRACTICES

11.1. Storage of Materials

11.1.1. Materials shall be stored in a clean, dry environment and in accordance to the manufacturer’s recommendations.

11.1.2. At no time shall the aggregate be exposed to rain, or moisture.

11.1.3. Material Safety Data Sheet (MSDS), Product Data Sheet, and other information pertaining to the safe practices for the storage, handling, and disposal of the materials, and to their health hazards shall be obtained from the manufacturer and posted at storage areas. A copy of such information shall be provided to the Engineer.

11.2. Application Conditions

11.2.1. Do not apply Binder Resin System on a wet surface or when the ambient temperature is below manufacturer’s recommendation.

11.2.2. Do not apply when anticipated weather conditions would prevent proper application and curing of the HFST.

11.3. Preparation of surfaces

11.3.1. Utilities, drainage structures, curbs and any other structure within or adjacent to treatment location shall be protected from the surface preparation and installation of the HFST.

11.3.2. Cover and protect all existing pavement markings that are adjacent to the treatment location as directed by the Engineer prior to performing surface preparation. Pavement markings that conflict with the HFST installation shall be removed by methods acceptable to the Engineer.

11.3.3. Prepare all pavement surfaces immediately prior to the installation of HFST. Pavement 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.
11.3.3.1. 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 air lance perpendicular to the surface and the tip of the air lance within 12 inches of the surface.

11.3.3.1.1. For applications on new asphalt pavements a mandatory 30 day cure period shall take place prior to the installation of the HFST.

11.3.3.2. Clean concrete pavement 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.

12. APPLICATION

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


12.2.1. If a Prime Coat is required consult manufacturer for the recommended application procedures.

12.3. Mixing and Application of Binder Resin system and Aggregate

12.3.1. Utilize one of the following methods to apply the binder resin and aggregate wearing course, in accordance with manufacturer’s recommendations.

12.4. Mechanical Application

12.4.1. Mechanical application shall be performed by an applicator vehicle.

12.4.2. The Binder Resin System manufacturer shall approve the use of said automated continuous application device with their material.

12.4.3. An open-graded pavement surface shall likely require 2 applications to achieve this requirement.

12.4.4. The applicator shall mechanically mix, meter, monitor and apply the Binder Resin System and high friction aggregate in one continuous pass.

12.4.5. The application vehicle shall feature volumetric metering pumps that continuously mix, meter, and monitor and apply the resin binder. If recommended by the manufacturer, metering pumps shall be heated.

12.4.6. The application vehicle shall have continuous pumping and portioning devices that blend the Binder Resin System within a controlled system.

12.4.7. The Binder Resin System shall be blended and mixed in the ratio per the manufacturer’s specification (+/- 2% by volume) and shall be continuously applied once blended.
12.4.8. The application vehicle shall 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 pavement.

12.4.9. The operation should proceed in such 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.

12.4.10. The high friction aggregate shall be applied within 5 minutes (+/- 1 min) of the base resin binder application onto the pavement section

12.4.11. Mechanically apply the high friction surface aggregate at a rate of 12 -15 lbs./sqyd. (Achieving saturation) in such a manner there is no disruption to the leveled binder.

12.4.12. It is the responsibility of the HFST installer to ensure full embedment of the calcined bauxite aggregate.

12.4.13. Wet spots must be covered with the aggregate prior to the gelling of the Binder Resin System.

12.4.14. Excess aggregate that can be reused shall be reclaimed by a Vacuum sweeper. The recovered aggregate must be clean, uncontaminated and dry.

12.4.15. Applications on high speed highways such as interstate ramps and bridge decks will require additional sweeping three days after the initial installation is completed.

12.4.16. Walking, standing or any form of contact or contamination with the wet uncured Binder Resin System 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 System being removed and replaced at the installer’s expense.

12.4.17. Contractor equipment and traffic is not permitted on the HFST during curing period.

12.5. Hand Mixing and Application

12.5.1. For areas where mechanical forms of application are not conducive or economical, hand-mixed Binder Resin System in accordance to the manufacturer’s recommendations shall be used.

12.5.2. Uniformly spread the Binder Resin System 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 pavement.

12.5.3. An open-graded pavement surface shall likely require 2 applications to achieve this requirement.

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

12.5.5. It is the responsibility of the HFST installer to ensure full embedment of the calcined bauxite aggregate.

12.5.6. Wet spots must be covered with the aggregate prior to the gelling of the Binder Resin System.

12.5.7. Excess aggregate that can be reused shall be reclaimed by a Vacuum sweeper. The recovered aggregate must be clean, uncontaminated and dry.
12.5.8. Applications on high speed highways such as interstate ramps and bridge decks will require additional sweeping three days after the initial installation is completed.

12.5.9. Walking, standing or any form of contact or contamination with the wet uncured Binder Resin System 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 System being removed and replaced at the installer's expense.

12.5.10. Contractor equipment and traffic is not permitted on the HFST during curing period.

13. FIELD TESTING

13.1. In-place friction characteristics must meet a minimum requirement of 65 FN40R when tested in accordance to AASHTO T 242 upon completion of the installation.