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FHWA High Friction Surface Treatments

Frequently Asked Questions – 2022 Update

Non-Binding Contents:
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Update Notice:
This High Friction Surface Treatment (HFST) Frequently Asked Questions (FAQ) 2022 replaces Frequently Asked Questions – High Friction Surface Treatments (HFST) – 2017 (FHWA-SA-18-004). It covers questions related to HFST safety, maintenance and operations, cost, environmental impacts, material specifications, durability, lessons learned, and installation.

U.S. Department of Transportation
Federal Highway Administration

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- Improper embedment depth. Embedment depth should typically be 50 percent of the nominal aggregate size to ensure that the aggregate is held firmly in place by the resin binder while still providing adequate texture for frictional resistance and bulk water drainage. Embedment is affected by resin binder application rate which is dictated by pavement macrotexture depth.

- Application of HFST to newly-constructed pavements. HFST should not be applied to asphalt or concrete pavements that are less than 30 days old. This allows for release of oils, volatile organic compounds, etc. For concrete pavement, all curing compounds should be removed and the surface properly shot-blasted. Shotblasting removes concrete surface contaminants and increases macrotexture to facilitate bonding of the resin binder.

- Application of HFST to pavements in poor condition. Highly distressed pavements exhibiting extensive cracking, raveling, flushing, and subbase pumping will likely fail beneath the HFST under traffic and over time. Failure of the underlying pavement will result in failure of the HFST even when the resin binder and aggregate remain bonded to the failing pavement.

- Environmental requirements were ignored. The pavement surface should be dry at time of installation, and the ambient and surface temperature should be above the manufacturer's minimum recommendation. For most polymer resin binders, a minimum temperature of 50°F and rising is typical, while some recommend even higher minimum temperatures. Other polymer binders are available that can be installed at lower temperatures per the manufacturer's direction. Please see general temperature conditions under INSTALLATION.

2. What pavement conditions caused failures that have been reported?

- Highly distressed pavements. Pavements exhibiting extensive durability-related cracking such as alligator, block, and map cracking. Any pattern cracking that is visible on the pavement likely makes the pavement a poor candidate for an HFST installation.

- Pavements exhibiting rutting, shoving or signs of subgrade failure are likely poor candidates for HFST.

- Poorly draining pavements. Pavements in sag curves with poor drainage and curb and gutter locations where water tends to collect. Pavements exhibiting subsurface moisture issues and the migration of subgrade fines have also led to premature failure of the underlying pavement and HFST and therefore are poor candidates for HFST. Subsurface moisture issues may not be present and obvious at all times and therefore should be checked after rain events.

- Chip seal (seal coat) in poor condition. Chip seal or seal coats exhibiting raveling or flushing in the wheel paths has led to failures. While HFST will adhere to flushed surfaces, the bond will not

be very strong due to a lack of macrotexture. In some cases, shot blasting can be used to enhance macrotexture prior to HFST installation.

- Open graded asphalt surfaces. When applied to an open graded asphalt surface, a very thick and rigid layer of resin binder is created as the resin binder fills the voids in the pavement surface. This thick layer will have different thermal properties from the underlying asphalt layers and can lead to delamination of the open graded surface from underlying layers or substrate failure of the underlying layer. A best practice is to remove existing open graded asphalt surfaces and replace them with a conventional asphalt surface before applying HFST.

- Replace pavement in poor condition prior to installing HFST to increase service life expectancy. Following recommendations, such as a 30-day cure period for new asphalt and concrete pavements prior to installing HFST, will increase the likelihood of a successful installation.

3. Can patches that de-bond be fixed?

- This is not common but can be caused by an isolated spot on the pavement that was not cleaned well or had undetected solvent on the pavement. However, if small localized sections of HFST de-bond from the pavement, this can easily be repaired by milling back to a well-bonded area, cleaning the area well, and applying polymer resin and aggregate by hand to blend the patch in with the existing material.

- More common is when a small section of pavement "pops out," but the HFST is still bonded to the fragment of pavement. If this is a limited occurrence, it does not indicate a catastrophic failure of the HFST and generally means the underlying pavement had a weak area and debonded from a lower layer of pavement. The pavement should be repaired and HFST reapplied if the area is large enough to cause roadway issues. If asphalt is used to patch the pavement, HFST should not be placed for at least 30 days. And if concrete is used, any curing compound should be removed and the surface cleaned before applying the HFST, since curing compounds act as bond breakers.

4. Will the polymer have a reaction with magnesium on a bridge deck?

No reactions have been found with magnesium chloride deicers. Some concrete repair materials may contain magnesium phosphate so it is important to consult the HFST resin binder manufacturer prior to the installation of any repair or patching material to confirm compatibility and installation requirements.

INSTALLATION

1. What surface preparation and installation conditions are important for successful installation?

General

- All manufacturer installation instructions and specifications should be followed.

- Surface preparation is key for a successful HFST installation. Shotblasting for concrete and high-pressure air wash for asphalt pavements should be done in advance of HFST application.

- Because HFST resin binders are thermosetting materials, temperature is a very important condition to consider for HFST installation. Temperature limitations for installation depend on the type of polymer resin binder being used as well as the method for applying the aggregate.

    - A general rule of thumb is to not install HFST when the pavement surface temperature is below 50°F (or expected to fall below 50°F during installation) unless the resin binder system is formulated specifically for cooler temperatures. It is important to follow resin binder manufacturer recommendations for temperature restrictions. Also keep in mind that most resin binders cure slower in cooler temperatures, which will impact installation time.

    - As temperatures rise, the resin binder system will reach initial gel faster. Automated methods for aggregate application are often capable of fully covering the resin binder before it begins to gel at these higher temperatures. As ambient temperatures reach 95°F and above, most resin binder systems will begin to thicken and gel within minutes. It is important to verify that the aggregate can be fully applied at the specified coverage rate before the resin binder begins to thicken. If the aggregate is not broadcast to the specified coverage rate while the resin binder is still in its liquid state, the application is at risk of only partial embedment of the aggregate. This can lead to early loss of aggregate in the wheel path and failure of the HFST system to provide the required friction values. Many agencies require a test section to determine that the method of aggregate application will be sufficient to install HFST at the required temperatures. It is important to follow agency specifications and the resin binder manufacturer's instructions for the HFST application.

    - Both surface and ambient temperatures are critical to a successful installation. If the aggregate can be applied to the resin binder immediately, HFST can be installed at temperatures exceeding 100°F (depending on manufacturer recommendations) as long as the resin binder has enough time to penetrate the pavement surface prior to reaching initial gel. Hence, continuous automated installation is the preferred method.

- It is generally not practical or necessary to remove small oil spots, but very large or heavily saturated oil spots may need to be removed by aggressive washing with approved detergents and rinsing with clean water. These deposits are more common at intersection locations where vehicles tend to sit on the pavement at the intersection approach. When washing techniques are used, proper drying time and/or drying techniques should be considered. In some instances, heavily contaminated pavement should be removed and replaced.

- There should be no visible moisture present on the pavement surface at the time of the resin binder application. Compressed air may be used to help dry and remove moisture from pores in the pavement surface. A surface moisture test consisting of a plastic sheet taped in place on the

pavement surface for a minimum of 2 hours, in accordance with ASTM D 4263, may be used to verify if the surface is dry enough for HFST application if there is any question. Use of this testing specification is not required by Federal law or regulation.

- Utilities, drainage structures, curbs, active joints, and any other structure within or adjacent to the treatment location should be protected against the application of the surface treatment materials. Existing pavement markings to be preserved adjacent to the application surface should be masked or care taken that the binder does not cover the markings. High-tack adhesive tape can be used to outline the perimeter of the application area, cover pavement markings, or to protect joints, etc.

- Pavement markings that are not covered or consist of material other than paint should be removed. *HFST will not fully adhere to thermoplastic road markings*. The removal method may be grinding, light milling, shotblasting, or water blasting after which the surface should be dried and swept clean prior to HFST application. Pavement marking lines should be considered clean when the pavement has exposed aggregate showing through the existing marking. Care should be taken to not damage or gouge the pavement surface when removing pavement markings. Uneven surfaces should not be repaired with the HFST system.

- Pavement cracks greater than 1/4 inch in width and depth should be sealed 30 days prior to HFST installation if rubberized asphalt or similar products are used. Several manufacturers offer crack sealing materials that are compatible with HFST resin binder and may eliminate the 30-day cure period. When sealing cracks, it is important to ensure the sealant is recessed slightly below the pavement surface and not overbanded onto the pavement. Most agencies specify that joints and cracks less than 1/4 inch be pre-treated with the mixed polymer resin just prior to HFST placement. Once the polymer in the pre-treated areas has gelled, the HFST binder and aggregate topping installation may proceed.

    - Repair all pavement defects such as spalls, potholes, raveling, and rutting prior to placing HFST. Consult the binder resin manufacturer to ensure compatibility of repair materials with the HFST system. Clean and fill all inadequately sealed joints, including shoulder areas within the treatment area. HFST may be applied over pavements exhibiting minor rutting or heaving; however, it should not be used as a repair for these conditions (e.g., to fill ruts). Proper evaluation of pavement condition during the project selection and design stage is important before considering HFST.

Concrete Surfaces

- HFST should not be applied to portland cement concrete that has been in place less than 30 days. Concrete surfaces should be abrasively cleaned by shot blasting to remove oils, dirt, rubber deposits, curing compounds, paint carbonation, laitance, weak surface mortar, and other potentially detrimental contaminants that may interfere with the bonding or curing of the HFST. Shotblasting should achieve an International Concrete Repair Institute concrete surface profile

(CSP) of 5. Shotblasting should always be followed with a high-pressure compressed air wash to remove any latent dust from the shotblasting process.

- When using rapid strength concrete to shorten the 30-day waiting period prior to HFST installation, it is critical to qualify compatibility of the patching materials/rapid strength mortars with the HFST polymer resin binder as some patching materials may not provide a good bonding surface. No matter what material goes on top, installers should always refer to the manufacturer's installation instructions to determine if it qualifies as compatible with the repair material.

Asphalt Surfaces

- Before placement of HFST on an asphalt surface, the entire surface should be cleaned using a high-pressure air washing or other approved washing methods to remove oils, dirt, rubber deposits, paint, laitance, and other potentially detrimental contaminants that may interfere with the bonding or curing of the HFST. Acceptable cleaning should result in a surface with no oil spots, dirt, or other debris. Asphalt deposits larger than one inch in diameter and smaller areas spaced less than six inches apart should be removed.

- For applications on new asphalt pavements, it is recommended to wait a minimum of 30 days after paving before installing HFST. Asphalt pavements that still appear to be "tacky" or look wet on the surface should be evaluated for possible extension to the waiting period prior to installing the HFST. On open-graded friction course asphalt surfaces, stone mastic asphalt, or pavement that has been treated with prior surface treatments (e.g., microsurfacing, slurry seal, etc.), contact the resin binder manufacturer for more information.

- Several agencies have experimented with pressure washing or lightly shotblasting new asphalt surfaces to shorten the 30-day waiting period. This practice is not recommended since the potential for trapping moisture or volatile oils can still be a risk and can contribute to the failure of the HFST installation.

2. Can you apply HFST over existing striping?

- In general, HFST can be applied over painted lines, but thermoplastic lines should be removed prior to HFST installation. If the existing pavement markings are in good condition, it is recommended that the markings be retained by masking them off prior to HFST placement. Refer to resin binder manufacturer recommendations before applying over any surface treatment like paint lines.

3. Is installation over an open-graded friction courses (OGFC) an issue?

- While there have been many successful applications of HFST on OGFC, it is not recommended practice. OGFCs are relatively thin and the bond with underlying asphalt layers can be a highly variable. This has led to a few problematic installations since it is often difficult to detect

underlying pavement issues. Recommended practice is to remove OGFC within the limits to be treated with HFST and place conventional asphalt pavement prior to HFST.

- Successful installations over OGFC have used a double layer treatment to seal the voids with the first layer and use the top course to maintain the proper binder depth, which is necessary for the aggregate embedment into the HFST riding surface. However, the following precautions should be considered for placing a double layer HFST:
    - Since a double layer is less flexible than a single layer, a sound pavement is most important. A double layer creates a thick layer of resin binder which is much less flexible than a single layer system and the underlying pavement (asphalt in particular). This thicker layer can increase shear forces at the bond interface due to differing thermal properties, leading to delamination (of the HFST or OGFC) or substrate failure.
    - Resin binder demand, or the application rate required to achieve proper aggregate embedment will likely be different for the second layer than the first, depending on the texture of the existing pavement surface.
    - A double-layer HFST is also less permeable than a single layer system, which increases vapor pressure between the HFST and underlying pavement, increasing the potential for stripping of underlying bituminous pavement surfaces.
- Additionally, if placing HFST over OGFC, the shoulder on the high side of the superelevation may need to be sealed to keep water from running through the OGFC and under the HFST, which can cause failure. It may also be necessary to extend the HFST further when the curve is on a grade in order to seal the OGFC to prevent water from running down the grade and under the HFST as well. Be aware that this adds to the quantity of HFST required.

4. What are some of the key factors that can affect the placement of HFST?

- Current methods of installing HFST vary based on recent advancements and the automation of mixing and placement equipment. Although some agencies still allow hand mixing and placement for HFST, the opportunities for human error with these methods are significant and warrant stringent quality control procedures within a specification to ensure consistent and proper application. The selection of different methodologies depends on the size of the installation, site-specific conditions like storage and ready access, and the availability of acceptable detour routes or traffic restrictions.

- Because the HFST system will have a greater coefficient of thermal expansion than the pavement substrate, applying an even and consistent wet mil thickness for the resin binder is critical to the longevity of the system. Variable thickness within the HFST installation can increase the potential for cracking and spalling, especially when installed on pavements that show signs of degradation.

- Consistent mil thickness of the HFST is also important for maintaining even contact with vehicle tires. Any high spots that are created because of un-even installation practices can create "point loading" under traffic over the HFST system. These high spots can potentially transfer very high dynamic impact to the underlying pavement potentially leading to early age spalling and delamination of the HFST.

- Prompt application of aggregate onto the resin binder is important to ensure proper embedment of the aggregate within the resin binder. At higher temperatures, resin binder systems tend to reach initial gel within minutes. When the binder gels, the viscosity increases which can inhibit aggregate penetration and proper embedment. This can result in premature loss of surface aggregates.

5. What is the difference between manual and fully automated HFST installation?

- There are two main methods for installing HFST: manual and fully automated. The preferred application method depends on the size of the project, the number of installations within the contract, and specific project needs. For example, manual installation may be used for small spot-treatments or irregular areas where a fully automated process is not practical, while a fully automated process might be used for larger contracts consisting of numerous sites. Most agencies contract out their HFST installations to avoid purchasing HFST-specific equipment. Regardless of the method used for installation, robust specifications and good inspection practices are essential for a proper installation, but particularly for manual installation where there are more opportunities for human error.

    - **Manual** – Manual HFST application is ideal for small spot locations of 200 SY or less where it may be difficult or not economical to bring in automated installation equipment. For a completely manual application, the resin binder components and any additives are manually proportioned and mixed on site in a large mixing vessel. The

mixed resin binder is poured onto the prepared surface and spread to the proper mil thickness using notched squeegees. Next, the aggregate is broadcast on top of the resin binder. There is no preferred method to broadcast the aggregate, but the binder should be completely covered (i.e., until refusal). While the manual application method is ideal for keeping costs low on small projects, this method has a few drawbacks. Given the opportunity for human error and inconsistency in all aspects of application (proportioning, mixing, and placing resin binder and application of aggregate), quality and uniformity of manually applied treatments are a concern. Manual application is a much slower process and working under live traffic conditions increases safety risks by prolonging workers' exposure to traffic. In addition, the prolonged presence of a work zone can potentially cause secondary crashes. While there are several mechanically-assisted methods for resin binder proportioning and mixing and aggregate application which may help reduce human error, these devices generally do not improve resin binder application and may only marginally decrease application time.

- **Fully Automated** – A fully automated HFST application typically involves a truck that is customized to condition, meter, and mechanically blend the resin binder components in accordance with manufacturer guidelines based on the current ambient or surface temperature. These machines are capable of applying a consistent and uniform wet mil thickness of the resin binder to the proper application rate, followed immediately by a uniform layer of aggregate, without any manual squeegeeing or spreading. The truck contains the binder and aggregate in large bulk containers on its chassis. The application can be customized to the intended lane width of the treatment. The fully automated method minimizes lane closures due to quick installation time and reduces the number of workers on the roadway. The installation speed and the uniformity of application of binder and aggregate reduces the risk of premature failure and improves the likelihood of a higher quality application. This method may reduce overall cost on large projects or projects bundled from numerous small installations.

6. Can agency personnel install HFST?

Yes, but agency personnel should receive proper training before attempting an installation, and a trial project or test strip is highly recommended if the installation crew does not have prior experience. Due to the cost of investment in automated application equipment, agency personnel will typically use manual installation methods. As such, this should be limited to small or isolated applications only.

7. What are items to look for in terms of early-age performance that may indicate materials and workmanship issues?

- Uncured resin binder. This will normally appear as a discolored area where the HFST is soft and is typically caused by improper or incomplete blending of the resin binder components. These areas will not retain aggregate under traffic wear and should be removed and patched.
- Aggregate loss. HFST will normally shed aggregate over the first 24-72 hours after opening to traffic. This aggregate will accumulate along the edge of the lane or out in the shoulder or adjacent lane and should be removed through re-sweeping. If significant aggregate loss continues, the cause should be further investigated.
- Delamination. This generally manifests as "sheets" of HFST peeling away from the underlying pavement and may be caused by improper surface preparation. Sounding techniques can be used to identify the extent of delamination. These areas should be patched.
- Aggregate polishing. Polishing will cause the surface to have a smooth or glassy appearance under traffic wear. Calcined bauxite aggregate should not polish and therefore any polishing should be investigated further.
- Discoloration. This will appear as a visible difference in color of localized areas, and may be an indicator of moisture trapped beneath the HFST. It does not necessarily indicate a problem with the HFST but should be monitored over time.
- Surface wear loss of HFST. This is a condition when the HFST wears off, exposing the underlying pavement. It generally begins with loss of aggregate, which exposes the resin binder which is quickly worn off by traffic. It is an indicator that the HFST resin binder was placed too thin, aggregate was applied after gelling occurred, or the resin binder was not strong enough to retain the aggregate, and will call for the reapplication of HFST.
- Friction loss. Friction loss is identified through routine measurement of HFST friction. A sustained decrease in friction indicates a problem with the aggregates (e.g., polishing) or the HFST system.
- Failure of underlying pavement. This generally manifests as potholes in the HFST surface where both the HFST and underlying pavement break away under traffic and is more common with asphalt pavement. It generally indicates a cohesive failure within a weak asphalt layer or stripping of the asphalt due to moisture. Isolated areas can be patched but if deterioration progresses, removal and replacement should be undertaken.

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