

# High Friction Surface Treatments

## Frequently Asked Questions



## Frequently Asked Questions about High Friction Surface Treatments (HFST)

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### 1. What is a High Friction Surface Treatment (HFST)?

- High Friction Surface Treatments place a thin layer of specially engineered, durable, high friction aggregates as a topping on a thermosetting polymer resin binder - usually epoxy, modified polyester, or urethane. These aggregate systems have long lasting skid resistance, while also making the overlay much more resistant to wear and polishing. The resin or polymer binder combination locks the aggregate firmly in place, creating an extremely rough, hard, durable surface capable of withstanding everyday roadway demands, such as heavy braking and even snowplowing. HFST restores pavement surface friction characteristics where traffic has worn down existing pavement surface aggregates. HFST can also help compensate for inadequate geometric designs such as sharp curves and/or substandard or variable superelevations.
- Aggregates used in an HFST, by definition, have a higher Polished Stone Value (PSV). This is a laboratory test that measures the friction value after wear from an abrasive wheel. This test is used to predict the friction serviceability after it is exposed to traffic. These values have been correlated with successful HFST performance in field installations. Depending on the version of the PSV test used (ASTM or AASHTO), this value may be different, and so the same version of the test must be used to compare aggregate selections. Although several aggregates have been evaluated, only Calcined Bauxite aggregate has met the threshold for performance necessary to be called an HFST.
- An HFST Aggregate Durability Study will be published later this year (2014) in cooperation with FHWA and NCAT.

### 2. What is the purpose of HFST?

- HFST can enhance the ability of a road surface to provide pavement friction to vehicles in critical braking or cornering maneuvers. Maintaining the appropriate amount of pavement friction is critical for safe driving. Compared to vehicles driving on a tangent section of road, vehicles traversing horizontal curves require a greater side force friction; and vehicles at intersections require greater longitudinal force friction. In locations such as sharp horizontal curves where vehicles may brake excessively, the road surface of standard pavements may become prematurely polished, thereby reducing the available pavement friction. This friction

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reduction can contribute to vehicles losing control or skidding when they speed, turn abruptly, or brake excessively. Negotiating a sharper curve demands more friction to keep vehicles on track, and that greater demand causes greater shear forces, thereby leading to even more polishing of the surface aggregate.

### 3. Where are HFSTs likely to be beneficial?

- HFST technology is unique in its ability to address site-specific issues. While the largest numbers of problem locations are likely to be on the local and collector systems, there are also high volume intersections, interchange ramps, and selected segments of interstate alignments where these treatments would also be beneficial. This innovation has application to State DOTs, counties, cities, tribes, and federal lands agencies across the country.

### 4. Are there guidelines for the limits on HFST installations?

- Typically, HFST should be installed at a point where vehicles start to brake. At horizontal curves, brake lights are a good indication of where treatment should start, as the intention is to slow down the drivers as they are going into the curve. Most states will end their treatment at the Point of Tangent (PT).
- The Texas Transportation Institute published a paper titled, "Using High Friction Surface Treatments to Improve Safety at Horizontal Curves," that provides recommendations on how to select start and end points for HFST installation.  
<http://d2dtl5nnlpr0r.cloudfront.net/tti.tamu.edu/documents/TTI-2012-8.pdf>

## SAFETY

### 1. Are there any Crash Modification Factors (CMF) available for HFST?

- There are few CMFs available related to HFST at this time.
- Turner-Fairbank Highway Research Center (TFHRC), as part of the FHWA's Evaluations of Low Cost Safety Improvements Pooled Fund Study, will convert the results of participating states' projects into crash modification factors for these types of treatments. The report will be available in spring 2014.
- The Pennsylvania, Kentucky, and South Carolina DOTs report a before/after total crash reduction of 100%, 90%, and 57%, respectively, for their signature trial projects, for which the after periods equal approximately three to five years. Kentucky went on to install and measure 60 additional HFST applications in 2010-2012: these sites are showing total crash reductions of 78% for the group, with wet-weather crash reductions of 85%.

### 2. What are the advantages for HFST as compared to traditional safety treatments at horizontal curves?

- A HFST should be the next treatment when delineation treatments are not reducing crashes. Generally, signs and markings are effective for prudent drivers who are trying to drive carefully, but when vehicles enter a curve too fast it is generally too late for those devices to help the driver. Whether some drivers are willfully speeding or maybe are not focused on the driving task and the curve surprises them, speed is a major contributing factor for crashes in curves. Many studies have shown that a pavement with high friction capability can give drivers a hidden advantage and help them survive their mistakes. Everything has a maximum, but studies have shown in general that doubling the friction reduces the crashes by half. Obviously if the pavement is polished the problem even extends to a greater number of prudent drivers, particularly when the pavement is wet, so placing HFST provides the curve with a pavement that is polish-resistant in addition to having excellent friction. Otherwise, safety improvements may require geometric improvements, which can take a long time, be expensive, and have

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environmental consequences. HFSTs are low cost compared to geometric improvements. The square yard cost of an HFST is not cheap compared to other pavement treatments, but it provides greater durability and safety, making it a good investment since the life-cycle cost is excellent.

- HFSTs have potential, and in many instances are providing, higher crash reduction than is generally expected with lower-cost safety treatments such as chevron and rumble strip application on horizontal curves. As mentioned previously, several states are experiencing large crash reductions of 50-100% after application of an HFST at specific sites. A recent before and after study from the South Carolina DOT for a series of curve installations indicates cost-benefit ratios of about 24 to 1. Kentucky placed HFSTs on 26 curves and to date has seen an average reduction from 6.2 to 1.9 crashes per year at those locations. Additionally, the National Cooperative Highway Research Program (NCHRP) Report 617 indicates a crash reduction of 20% for all intersection crashes.

### **3. What is the safety effect of these surfaces for motorcycles and bicycles?**

- There are no negative safety effects for motorcycles and bicycles. HFST provides a smoother riding surface and improved friction. HFST has been used for treatment of miles of bike lanes in the USA, and it has been applied as a safety countermeasure to specifically address curves and intersections with motorcycle crashes in the United Kingdom. Braking and cornering on a motorcycle demands more friction than passenger vehicles.

### **4. Has there been an increase in rollovers after installation?**

- No increase in rollovers has been reported from any HFST installations, and studies done by FHWA in the past have shown that increases in friction help reduce truck rollover.

### **5. Has accelerated tire wear from HFST been studied?**

- Because HFST is utilized only at spot locations for smaller areas, excessive tire wear should not be a major issue. Getting people home safely far outweighs this as a concern.

## **MAINTENANCE AND OPERATIONS**

### **1. Does HFST promote higher operating speed?**

- HNTB Corporation monitored speeds after an HFST installation for the Florida DOT and found that speeds post-installation were actually lower. The report can be found at: [http://www.dot.state.fl.us/research-center/Completed\\_Proj/Summary\\_SF/BD500/BD500\\_v3\\_rpt.pdf](http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/BD500/BD500_v3_rpt.pdf)
- The installation of HFST at curves does not increase driver comfort. Increasing superelevation does increase driver comfort. Improving driver comfort usually does increase speeds. HFST only satisfies the friction demand to help the vehicle stay on the road.
- It should also be noted that regardless of speed considerations, there has been no reported increase in crashes after HFST application; and in fact, all of the crash evaluations to date have shown remarkable crash reductions, which is the bottom line.

### **2. What is the effect of snow plows on this pavement treatment?**

- The treatment consists of a thin overlay designed to be less than 1/4 - inch in thickness. As such, the effect from snow plows has been minimal, even where bare pavement policies are followed in locations such as Illinois, Vermont, and Michigan.
- The bauxite surface wears very well under heavy snow plowing.
- No deterioration from steel-tipped plows has been observed.

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### 3. Can you apply HFST over existing striping?

- In general, HFST can be applied over painted lines, but thermoplastic lines should be removed by grinding. If the existing pavement markings are in good condition, it is recommended that the markings be retained by covering with tape prior to HFST placement.

## COST

### 1. What is the average unit cost for HFST?

- Installed costs vary widely, depending on the size of the project, the prevailing labor costs in the jurisdiction, and the various components of the projects such as traffic control, treatment of pavement markings, etc. Projects accordingly have ranged from \$25/SY to \$35/SY as of a couple years ago. However the per SY price has been steadily going down for larger projects and where small installations have been bundled. In addition, only including work pertinent to the HFST project, and therefore increasing the chance of contracting directly with an installer instead of general contractors (GC), can give a better price.
- In comparing installation costs, there are several factors to consider. For example, the Kentucky Transportation Cabinet (KYTC), which has the most HFST projects (well over 100), had a significant number of projects on two-lane roads. On two-lane roads they averaged 750 SY each with an average installation price between \$14,000 and \$16,000 per project.
- A recent project in another state with multiple locations that totaled about 77,000 SY cost about \$19 per SY. Multiple projects in California and New York recently were priced about the same. All of these projects included the total project cost in the unit prices, which included mobilization, traffic control, striping, remedial crack sealing, and patching in some cases. Also, they exclusively used Calcined Bauxite as aggregate.
- Most of the aggregates generally used for HFST (flint, granite, bauxite) are fairly expensive (\$350 - \$500 per ton). However, the aggregate is not the largest part of the HFST cost. The binder and the installation is the larger cost.

### 2. Is there a certification process for contractors who want to perform this type of work?

- Not at this time. It would be beneficial to have a certification process since, during installation, we have experienced some good contractors but also a few who were not quite as knowledgeable. The best way to address this is to develop a good specification that requires several quality checks and holds the bidders accountable to meet the specifications for a proper installation. We are working diligently to try to help State DOTs write a better specification to cover some of these concerns.
- FHWA participated, along with the ATSSA High Friction Council, in developing a guide specification for HFSTs. The document has recently been approved for inclusion in the AASHTO Guide Specifications.

### 3. Is there a list of approved contractors?

- No. It is against FHWA policy to recommend contractors. However, ATSSA is compiling a list of members that install HFST, and it will be made available on their website in the near future.

### 4. What is the cost-benefit ratio for HFST?

- A recent before and after study from the South Carolina DOT for a series of curve installations indicates cost-benefit ratios of about 24 to 1. Kentucky placed HFST on 26 curves and to date has seen an average reduction from 6.2 to 1.9 crashes per year at those locations. Additionally, the National Cooperative Highway Research Program (NCHRP) Report 617 indicates a crash reduction of 20% for all intersection crashes.

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## ENVIRONMENTAL IMPACTS

### 1. What effect does HFST have on road noise?

- Increases or decreases in road noise will depend on the original surface. In general, it will be less noisy than transversely tined concrete pavement, chip seals, and possibly dense-graded asphalt, but may be noisier than open graded surfaces. There is no established “rule of thumb” for what effect it will have on noise. While the HFST does increase the mean texture depth (MTD) and mean profile depth (MPD), the relationship (for all types of pavement surfaces) between MPD and noise level is extremely weak, and it is even worse for MTD. Therefore, it is not a valid conclusion that higher texture depth will always lead to more noise.
- Some noise reductions and/or pavement color changes may be perceived and/or observed by drivers, especially on curves, which may tend to cause a reduction in average speeds. Additional research in this area is needed to substantiate or refute this.
- Overall, since most high friction installations only span from PC to PT of the curve section, the difference in audible level over the HFST will only be for a few seconds, and then the vehicle will be back on the regular pavement surface.
- Tire-pavement noise was measured by the Transtec Group, the contractor for the projects on two HFST sections (one in Kansas and one in Montana) approximately one year after they were installed. Kansas was a dense graded asphalt pavement and Montana a chip seal.

For the chip seal, HFST was slightly quieter (Overall OBSI levels, dBA):

- ▶ Chip seal: ~104.4
- ▶ HFST: ~101.95

For the HMA, HFST was slightly louder (Overall OBSI levels, dBA):

- ▶ HMA: ~98.75
- ▶ HFST: ~100.05

*Note:* 3 dBA is essentially the minimum threshold for human-perceived change in noise level.

### 2. There has been some discussion of placing HFST in a double layer. Why is this done?

- Double layers are most commonly applied to bridge decks. The common treatment is to apply a double layer of polymer/resin and aggregate for insurance against water penetration of the deck, and to provide added durability to the installation. This is common for bridge deck preservation after a bridge deck is sealed and the treatment is used to restore friction, so the aggregate friction is generally not as important as aggregate hardness, so the aggregates used may not all meet the PSV qualification for HFST, but the concept is the same. If this same bridge was in a curve and also identified to have a crash problem, the bridge deck could substitute Calcined Bauxite and accomplish both purposes. This has been done in many locations across the country.
- Double layers may also be used on roads where snow chains or studded tires are common or as a treatment for pavement with an existing open grade friction course.
- A double layer should not affect noise any more than a single layer, as the surface texture generally remains the same.

### 3. Is there any data on the effectiveness of colored aggregates?

- This is a specialized area that uses the same application process as HFST but uses colored binder with either a dyed aggregate or an artificial aggregate made from reformulated recycled glass. The dyed aggregate does show color wear on the aggregate eventually,

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which can cause a faded appearance, but the recycled glass addresses the wear issue since the aggregate is translucent and the color from the back side of the aggregate can be seen through the aggregate since it does not receive tire wear and it retains the color rather well. Both are much more durable than a surface coating such as paint, because the HFST aggregates retain their color throughout the aggregate. These will not have the friction of an HFST, but the PSV of the glass is higher than most conventional aggregates. These good friction characteristics are beneficial where traffic either crosses a bike lane or in bus lanes or crosswalks.

- The question of whether a colored lane is effective at separating and encouraging specific vehicle paths is not related to colored aggregates, but to the general strategy of coloring the paths. Regarding that measure of effectiveness, there are some published studies that report colored bike lanes and on entrances to small towns as traffic calming.

#### **4. Bike groups have expressed concerns about the abrasiveness of HFST. How is this being addressed across the country?**

- To date there has not been any identified problems regarding bicycle use on HFST. This product has been used widely for many years in Europe and in many other countries that have large bicycle populations and this has not been an issue. In fact the HFST process is being used to install colored aggregate that serves as delineation. This product has been requested by bicycle groups for bike lane surfaces. The texture provides a superior smoothness and should help reduce the problem of tires sliding when wet that is common on some demarcation treatments.

### **SITE CONDITIONS**

#### **1. What pavement conditions caused failures that have been reported?**

- In North Carolina and in Colorado, two different problems combined to cause the underlying asphalt pavement to be delaminated: poorly draining pavement that trapped water underneath the HFST and cracking of the underlying asphalt pavement that reflected through the HFST. However, the HFST remained intact on the asphalt material.
- It should be noted that other sites in Colorado where the same overlay material was applied have maintained their integrity, despite being installed at altitudes of over 8,000 feet and being subjected to repetitive snow plowing.

### **MATERIAL SPECIFICATIONS / DURABILITY**

#### **1. What is the life expectancy of HFST?**

- Life expectancy will vary with type of roadway, geometry of roadway, volume of and mix of traffic types, and nature of traffic movements. Accordingly, it is difficult to generalize. International experience indicates at least 7-12 years of service can be expected with correctly applied installations. Some USA data indicates a service life of over 15 years in bridge deck applications.
- Vendors have reported from 5-8 years for 15,000 vehicles per day, and up to 5 years with 50,000 vehicles per day.
- Just like pavement performance, HFST wear is dependent on many things such as initial construction quality, friction demand, and traffic volume as well as the severity of the climate and the weight and number of heavy truck axles.
- Michigan reports 12-15 years of durability for bridge deck sites, including interstate highways with 48,000-62,000 ADT.

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## 2. Are these materials resistant to fuels and common de-icing agents?

- The polymer binder is unaffected unless it is flooded with diesel fuel or solvents. They are resistant to common de-icing agents.

## 3. How does microsurfacing compare to HFST?

- As a pavement preservation technique, microsurfacing is far superior to HFST, and can actually extend the life of a poor pavement. In contrast, HFST is not a pavement preservation technique and is not recommended for application on poor pavement.
- As a friction-providing technique, HFST is far superior to microsurfacing. HFST aggregate by definition begins with PSV that rate much higher than the aggregates used for microsurfacing. The installed HFST supplies friction numbers (skid-testing) over 70 and many times in the high 80s or low 90s, which is well above those found with microsurfacing. Calcined Bauxite in particular can be expected to maintain a very high friction reading for many years into the future. Microsurfacing, by contrast, generally produces good initial friction readings in the low 60s or high 50s but then deteriorates within two years to the high 40s or low 50s (Michigan data).

## 4. Are HFSTs proprietary? Are there any good examples of generic specification?

- Virtually all HFST products are non-proprietary. However a product similar to HFST is Cargill's SafeLane, and it is patented and proprietary. The binder materials such as epoxy materials/blends are generally trade secrets of the manufacturer, and certain application machines are patented.
- Currently, numerous states such as Florida DOT, South Carolina DOT, Maryland DOT, California DOT, and Texas DOT have developed specifications or special provisions for high friction surfacing.

## 5. What is the difference between this treatment and a typical chip seal?

- Chip seals are a pavement treatment that can have some safety benefits but generally it is placed in large quantities to extend the life of the pavement, while HFST is a safety treatment that happens to be a pavement application, and it is placed in relatively small spots that are critical for safety.
- HFST is made for locations with high friction demand (shear forces) such as severe curves and braking areas, while chip seals don't perform well in those locations.
- The primary difference is the types of materials used. The HFST "binder" material is a polymer-based material as opposed to emulsions used for chip seals.
- The aggregate in HFST is much smaller (1-3 mm nominal size) than typical chip seal aggregate, and is specifically a very polish- and abrasion-resistant material.
- In terms of service,
  - ▶ Chip seal is a 5-7 year pavement preservation technique that can actually extend the life of a poor pavement. In contrast, HFST is not recommended for application on poor pavement.
  - ▶ HFST is an 8-12 year friction enhancing technique that supplies friction numbers (skid-testing) beyond conventional aggregates. Bauxite in particular can be expected to maintain this high friction reading for many years after installation. Chip seal, by contrast, produces initial friction readings lower than HFST, and the less polish-resistant aggregate typically used in chip seals generally loses its friction properties much more quickly than bauxite.

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## 6. Is it always worth the investment to use HFST compared to other friction treatments?

- The answer to this question likely depends on (1) the condition of the existing pavement since HFST only lasts as long as the pavement it is placed on and (2) the severity and type of crashes. If you have a deteriorating pavement with substandard friction characteristics and minimal pavement life, you may solve that problem with more conventional pavement treatments by just restoring standard friction characteristics, at least for a short term. However, HFST may still be a good idea if the location has severe geometric features and high speeds, since this tends to escalate pavement polishing, so the problem may return even if you placed new pavement.
- It is understood that many pavement preservation treatments (microsurfacing, chip seal, etc.) can improve available friction, especially on a polished pavement, and we are currently working to establish and quantify the beneficial impacts of improved and enhanced friction as a result of the installation of selected pavement preservation treatments.
- It may not always be necessary to apply the treatment that provides the highest, most sustained friction at a particular site; that would depend on the nature and severity of existing traction problems, life expectancy desired for the installation, and the friction demand produced by the traffic at the location.

## 7. Do these materials crack? If so, how do they resist crack erosion?

- The materials typically do not crack on their own, but any cracks in the underlying pavement will generally reflect through.
- The polymer overlay can be repaired, using the same materials as used originally. The de-bonded area must be cleaned until both the area to be patched and all overlay areas surrounding the area to be patched are solidly bonded to the road surface. If the repair is to be made manually, or with mixing apparatus designed to be used with a hand-held or mounted wand and/or notched squeegee, then a suitable quantity of epoxy should be mixed and applied to the patch area. In order to avoid a ridge around the patched area, care should be taken that the polymer only be applied within the area to be patched. Once the resin is applied, it should be spread as necessary using a notched squeegee so that the correct thickness is achieved. Aggregate should then be broadcast at the specified rate and the area allowed to fully cure. Once cured, the repaired area should be swept or vacuumed to remove loose aggregate before the roadway is reopened to traffic. If repair is to be made using mechanical equipment designed for full lane width dispensing and application of the polymer, then the area to be patched should be identified, and the equipment then operated over the area with a length of approximately 1 - 2 feet of roadway before and after the patch area.

## 8. Are there any issues with thermoplastic on HFST?

- None – thermoplastic bonds extremely well and will in fact last longer when applied to the textured surface of HFST. Other marking materials also bond well but pavement marking tape should be avoided since it does not adhere well due the texture.

## 9. What aggregates are appropriate for HFST and what sources are available?

- The HFST surface texture is formed from a crushed clean aggregate with an extremely low moisture content that is adhered to the roadway by a high quality, durable polymer resin. The aggregate undergoes a rigorous washing, drying, and grading before being bagged to assure it is clean and can be shipped and stored with low moisture content. Generally, the vendors that sell the HFST system procure the aggregate from mineral companies that specialize in this crushing and preparation process for such specialized aggregates.



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- The aggregate must be a polish- and wear-resistant aggregate such as Calcined Bauxite.
  - Other aggregates such as flint, basalt and granite have been evaluated but have not performed as well as Calcined Bauxite. The other aggregate can be placed in a similar manner and may perform adequately in a less demanding environment, but in critical locations they have not provided the duration of friction service to be classified as an HFST. Other aggregates are being evaluated for performance, but at this time only Calcined Bauxite is recommended to provide the expected safety performance and durability.
  - Although bauxite is a natural resource mined in three states in the USA, most of the bauxite used for HFST originates in either China or India. Bauxite is abundant in many countries around the world, with Australia producing the most bauxite of any country. Four of the largest international mineral companies (or subsidiaries) in the world are wholesale bauxite distributors in the USA. They typically import in large quantities and stockpile for distribution. The product is also resold at regional businesses. These are generally not the local quarry that paving contractors typically deal with, but the professional HFST installers have contacts that can supply any project need. The U.S. Geological Survey report states that a world bauxite shortage is not foreseen for the next century. <http://minerals.usgs.gov/minerals/>

#### **10. If a large amount of bauxite comes from international sources, does the Buy America provision apply when using federal funds for HFST?**

- No, Buy America applies only to steel products.

#### **11. How do these products compare to Verglimit?**

- Based on our knowledge, Verglimit is a de-icing additive added to a paving mix and is not a surface treatment like HFST. Cargill's SafeLane product uses a similar process in that the HFST aggregate is infused with de-icing chemicals.

#### **12. Is a performance-based specification for HFST available?**

- A draft performance-based specification is available but more refinement is needed and can be provided to any user upon request to the EDC2 HFST Team.
- The performance-based specification will require the contracting agency to own or obtain services for a friction-measurement device to be applied to the installed product to ensure the performance standard will be achieved.

#### **13. What are some typical polish stone values (PSV) for HFST aggregates using ASTM E 303 British Portable Pendulum and ASTM D 3319, Accelerated Polishing Machine?**

- PSV is a value applicable to a particular aggregate, not the road surface. Aggregate that has a PSV value over 60 is regarded as a High Friction Aggregate. The higher the PSV figure, the greater the resistance the aggregate has to polishing and the greater the ability the aggregate has to retain its own natural very fine texture (roughness). Typical values for a high quality, durable aggregate such as Calcined Bauxite generally exceed 70.

## **LESSONS LEARNED**

### **1. Can patches that de-bond be fixed?**

- This is not extremely common. However if small localized sections of HFST de-bond from the pavement, it can easily be repaired by cutting back to a well-bonded area and using hand application of polymer resin and stone to blend the patch in with the existing material. This can be caused by an isolated spot on the pavement that was not cleaned well, or maybe an undetected solvent on the pavement.

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- This may not appear immediately, but it is possible that the binder does not adhere well initially and the resin cannot transfer the tensile load to the structural pavement as traffic loads are transferred from the material and the force is pulling the material loose, or this could appear as the weather changed and thermal stress caused a release due to a poor bond. This is usually due to poor preparation like dust on the pavement, undetected solvents, or, specifically in the case of concrete, a lack of shot blasting as part of the preparation.
  - More common is a small section pops out but the HFST is perfectly attached to a fragment of pavement. If this is a limited occurrence, this is not a catastrophic event. Generally this means the underlying pavement had a weak spot and lost its bond. Again, the pavement can be fixed and HFST reapplied. If asphalt is used to patch the pavement, HFST should not be placed for at least 30 days, and if concrete is used then any curing compound must be removed and the surface cleaned before applying the HFST, since curing compounds act as bond breakers.

## **2. Will the polymer have a reaction with magnesium on a bridge deck?**

- The issue is possible reaction with magnesium phosphate based patching like Set 45, not with magnesium chloride deicer.

## **3. What negative issues have occurred with HFST installation?**

- There have been a few projects across the country where there have been failures. For a short time, one major epoxy manufacturer had a flaw in their formulation and this led to some failed projects. In most of the installations the manufacturer corrected the problem and this issue has been corrected. More often the issues have stemmed from poor installation practices. A good, rigorously enforced, specification and a skilled installation crew will help prevent installation-related issues from occurring.
- Common contributing issues for installation problems appear to be due to a combination of four primary issues.
  - ▶ Improper mixing of the 2-part epoxy, either manually or by the automated equipment that did not have fail safes or monitoring devices.
  - ▶ The roadway may have had significant cracking, so that over time the asphalt or concrete gave way – in these instances the epoxy and aggregate have remained completely bonded but the underlying pavement failed so it was a poor candidate for HFST.
  - ▶ Many polymers such as epoxy resins will not reach their fully designed strengths when cured at lower temperatures. This can result in early loss of aggregates and premature wear in the wheel path.
  - ▶ Third, ambient requirements were ignored – the roadway must be dry at time of installation, and the ambient temperature must be above the manufacturer's recommendations. For most epoxies this is a minimum of 50 degrees F and rising while some recommend even higher minimum temperatures. Other polymer binders are available that can be installed at lower temperatures per the manufacturer's direction.
  - ▶ The HFST should not be applied to asphalt that is less than 30 days old, and in the case of concrete, all curing compounds must be removed prior to overlay application. Also, it is just better to have all concrete shot blasted.

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## INSTALLATION

### 1. What surface preparation and installation conditions are required?

#### General

- Surface preparation is the key for all successful HFST installations. Best practice is a clean and dry surface above 50 degrees F (and rising), preferably 60F - 95F. Temperatures outside this range may affect working time for installing the material and/or material curing time as well as strength of the final product. However, some manufacturers have developed polymer resin binders that perform well at lower temperatures.
- Placement of the polymer resin can be installed by machine at a similar rate to other paving surface treatments, or can also be applied by hand or by tools. The selection of different methodologies is dependent on size of the installation, site specific conditions like storage and ready access, and availability of acceptable detour route or traffic restriction.
- It is generally not practical to remove small oil spots, but very large or heavily saturated oil spots may need to be removed by removing and replacing the surface layer.
- For bridge decks there should be no visible moisture present on the surface at the time of the binder application. Compressed air may be used to dry the deck surface. A plastic sheet left taped in place for a minimum of two hours, according to ASTM D 4263, should be used to identify moisture in the deck.
- Utilities, drainage structures, curbs, 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 that are adjacent to the application surfaces to be preserved should be covered 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. The method should be grinding, water blasting or other treatments; the surface should then be dried and swept clean prior to the polymer binder application. Pavement marking lines should be considered clean when the pavement has exposed aggregate showing through the existing marking. HFST will not fully adhere to thermoplastic road markings.
- 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. Otherwise pre-treat joints and cracks with the mixed polymer resin. Once the epoxy in the pre-treated areas has gelled, the HFST binder and aggregate topping installation may proceed.
- Repair all pavement defects such as spalls, pot holes, raveling and rutting prior to placing an HFST. Contact the manufacturer's Technical Service Department to review which materials will permit proper adhesion of HFST system. Clean and fill all inadequately sealed joints, including shoulder areas. HFST may be applied over pavements exhibiting minor rutting or heaving; however, the product is not intended as a repair for these conditions and will not level pavements.

#### Concrete Surface

- The polymer resin overlay should not be placed on Portland cement concrete that is less than 28 days in place. Patching and cleaning operations should be inspected and approved prior to placing each layer of the overlay. Any contamination of the deck or intermediate courses, after initial cleaning, should be removed. Both courses should be applied within 24 hours following the final cleaning and prior to opening the area to traffic.

- Concrete surface should be abrasively cleaned by shot blasting or other means to remove oils, dirt, rubber, curing compounds, paint carbonation, laitance, weak surface mortar and other potentially detrimental contaminants, which may interfere with the bonding or curing of the overlay.

### Asphalt Surface

- Before placement of HFS on an asphalt concrete deck surface the entire deck surface should be cleaned to remove oils, dirt, rubber, curing compounds, paint carbonation, laitance, and other potentially detrimental contaminants which may interfere with the bonding or curing of the overlay. Acceptable cleaning is recognized as a surface with no oil spots, dirt or debris and the beginning exposure of coarse aggregate particles in the asphalt concrete.
- Areas of asphalt larger than one inch in diameter, or smaller areas spaced less than six inches apart, should be removed. High pressure air or a vacuum should be used to remove all dust and other loose material. Brooms should not be used.
- For applications on new asphalt pavements, it is recommended to wait a minimum of 30 days after paving before placement of HFST. On open graded friction course asphalt surfaces, stone mastic asphalt or pavement that has been treated with prior surface treatments, contact the manufacturer's Technical Service department for guidance.

## 2. Is installation over an open graded pavement an issue?

- Many HFST applications have been successfully installed on OGFC. However OGFC are relatively thin and vary in strength based on the aggregate used and the condition of the pavement. This has led to a few problematic installations since it often difficult to detect existing pavement issues. Successful installations over OGFC have used a double layer treatment in order to seal the voids with the first layer and maintain the proper binder depth of the top course with the second layer which is necessary for the aggregate embedment of the HFST riding surface.
- A new method to seal the pores promises many advantages and is being investigated. Although this new technique shows promise it is premature to say that it is proven at this time.
- If you are placing HFST over OGFC, it may require the shoulder on the high side of the superelevation 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. This adds to the quantity of HFST so be aware.

For additional information, please contact:

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