Subject: HIGH FRICTION SURFACE TREATMENT

Date: September 12, 2018	**Author**: Manoj Jogi
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Contacts	**Standards Affected**
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Background

High Friction Surface Treatment (HFST) is a pavement surfacing system with exceptional skid-resistance properties not typically provided by conventional materials. The local application of a thin layer of durable, high friction aggregates as a topping on specially engineered epoxy resin binder (or other accepted binder products) affords long-lasting traction, while making the overlay much more resistant to wear and polishing. Average expected life of HFST is 5-7 years under heavy traffic. HFST are to be used on small sections in key areas and not for large stretches of road.

HFST aim at increasing the friction between vehicle tires and pavement surface, leading to better grip at horizontal curves and shorter stopping distance at intersections. Improving surface treatments will reduce collisions associated with friction demand issues, such as the reduction in pavement friction during wet conditions, and/or a high friction demand due to vehicle speed and/or roadway geometrics.

HFST Usage

HFST can be used at locations where higher friction and skid resistance is required. HFST may be considered as a treatment option to address rear-ends and off-road collisions if it proves more economically feasible than other countermeasures. The following locations may be considered for HFST installation:

- Intersection approaches
- Interchange ramps
- Bridges
- Highway horizontal curve segments
- Highway sections at or near steep grades

The length of the HFST installation at intersections should be determined based on local traffic conditions. Typically, HFST is installed from the stop bar to the end of traffic queue, which tends to be around 200 – 300m. Longer length may be required at some locations. At highway curves and interchange ramps, HFST should be installed at a point where vehicles start to brake and end at the point of tangency.

From a materials and pavement perspective, HFST is not recommended for the following situations.

- Pavements to be rehabilitated within five years or less
- Locations where preventive maintenance is required
- Open graded asphalt surface
- Pavement with more than 7 mm deep rutting
- Pavement with cracking type distress
- Pavement with raveling type of distress
- Pavement with bleeding type of distress
- Pavement experiencing structural damage or needing extensive rehabilitation or structural improvement
- Pavement sections where debonding with underlying asphalt layers can be an issue

Materials

Aggregate

The HFST aggregate consist of clean aggregates that have a very high polishing and wear resistance with extremely low moisture content. This requirement is met by calcined (heated) bauxite. It is understood that other aggregates such as basalt, granite etc. have been evaluated for the HFST application but these have not performed as well as calcined bauxite.

Binder

The binder used for HFST holds the aggregates in place. Typically these are epoxy resin binders and consist of multicomponent systems that react chemically and harden when mixed. Some agencies have used Polyurethane- resin, MMA and Polyester- resin binders. These binders need to be very hard to withstand extreme shear forces from vehicle movement especially during summer months when asphalt binders can get softer. Further the binders need to withstand the damage caused by the winter maintenance activities. This is not achievable by the traditional asphalt binders.

Binder properties that are critical for performance are as follows.

- Viscosity – allows for proper spreading without binder flowing off the pavement
- Gel time – allows adequate time to mix and apply
- Cure rate – allows curing so that section can be opened to traffic

- Strength – allows repeated traffic loading without failure
- Hardness –resists displacement under traffic
- Elongation – allows flexibility to resist cracking
- Low water absorption – resist moisture-induced damage
- Adhesive strength – bond with aggregate and the ground

It should be noted that some binder products can cause caustic fumes and result in issues during application if not handled correctly.

Materials Storage

The materials used for HFST need to be stored in a clean, dry environment and in accordance with the manufacturer's recommendations.

The binder components should be packaged in well-sealed containers with labels showing brand name, manufacturer name, type of material, mixing ratio by volume, temperature range for storage, and total quantity in the container and expiration date.

The aggregate should be in suitable packaging that protects them from contaminants on the job site as well as exposure to rain or moisture.

Construction

Application conditions

Appropriate conditions are critical for the successful application of HFST. The best practice is to apply HFST when the surface is clean and dry with temperatures in 15°C - 35°C range. No rain should be in the forecast during application and curing of HFST. Do not apply binders when the ambient temperature is below manufacturer's recommendation for binder application.

Surface preparation

The existing pavement surface needs to be cleaned using a mechanical sweeper or vacuum sweeper followed by a high-pressure air wash. Application of a test strip prior to full scale application is recommended. Pavement surfaces contaminated with oils, greases or other materials not removable by sweeping should be washed with a mild detergent solution, rinsed with clean water and dried using compressed air to ensure the surface is free of any such contaminants. Bridge decks should also be dried with compressed air to ensure a dry surface prior to HFST application.

Pavement markings that are not covered or consist of material other than paint should be removed. The removal method should be grinding, water blasting or other acceptable treatments; the surface should then be dried and swept clean prior to the binder application. Pavement marking lines can 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 6mm (1/4 inch) in width and depth should be sealed a minimum of 30 days prior to HFST installation if rubberized asphalt or similar products are used. Otherwise the joints and cracks can be pre-treated with the mixed binder. Once the epoxy in the pre-treated areas has gelled, the HFST binder and aggregate topping installation may proceed.

Utilities, deck joints, drains and curbs should be covered to protect them from HFST treatment. Tape or plastic sheeting can be used for this purpose. Pavement marking that needs to be protected can be protected using duct tape or other suitable methods.

Pavement defects such as rutting, raveling, potholes and spalling need to be repaired prior to installing HFST.

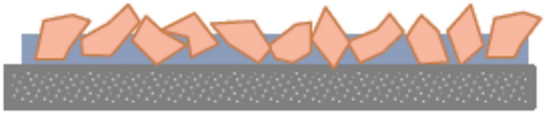
Binder Proportioning and Mixing

The manufacturer's specification should be followed for mixing the binder components. The binder must be proportioned correctly and mixed thoroughly. Inadequate mixing can occur if the automated systems are not properly maintained and monitored.

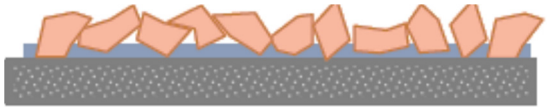
The material readiness can be verified by placing a small amount of mixture in a bucket or a cup. The mixture should set up within 15-20 minutes.

Poor mixing can result in soft spots of uncured binder in the final HFST. These HFST sections must be removed and replaced.

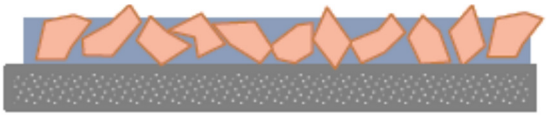
HFST Application



(A) Appropriate amount of binder: 50-60% Aggregate embedment – Good for retention and friction



(B) Insufficient binder: Inadequate aggregate embedment – Poor for retention and aggregates will be lost over time leaving only binder on the pavement surface



(C) Excessive amount of binder: Excessive aggregate embedment – insufficient aggregate exposure , Low texture depth, poor friction and waste of expensive aggregates material

Figure1: Binder and aggregate application (Source: AASHTO TC3)

Figure 1 shows different combinations of aggregate and binder applications. The resin binder can typically be applied to achieve a film thickness of 50-55 mils. The goal is to achieve about 50% embedment depth of aggregate. Too little binder can result in the inability of the binder to hold aggregate resulting in fast raveling of the applied aggregate. Too much binder can result in poor surface texture defeating the purpose of the HFST treatment to provide adequate friction.

The binder application rate may need to be adjusted if the surface texture of the pavement shows changes. The application rate for binder can be verified by a wet film thickness gauge or similar tool used to measure the binder thickness on the pavement.

The aggregate needs to be spread immediately after application of binder, ideally within 30 seconds of binder application for automatic systems. The aggregate should completely cover the binder with no exposed binder spots.

Curing and sweeping

HFST needs to cure adequately prior to opening of traffic. The time to cure depends on the type of resin binder, atmospheric temperature and surface temperature. The HFST must be protected from all traffic until cured.

Once the HFST has cured, excess aggregate must be removed by sweeping. If the recovered aggregate is intended to be reused, a vacuum sweeper must be used. The aggregate recovery system should be clean, dry and should not contaminate the aggregate. Dust-free recovered aggregate from sweeping can be reused if blended with new aggregate at a rate of two parts of virgin aggregate to one part recovered aggregate. The containers for the recovered aggregate should be clearly labelled.

Once sweeping is completed, the existing line, utilities and deck joint protection can be removed as applicable. HFST can continue shedding loose aggregate for several days/weeks. The sweeping operations need to be managed accordingly.

Quality control

Quality control activities can include following.

1. Ensuring qualified personnel are available for the project.
2. Ensuring proper equipment that is well calibrated is available.
3. Ensuring that materials that meet the Ministry's specifications / special provisions are available for the project.
4. Ensuring proper material storage and handling
5. Ensuring application conditions are suitable for HFST installation
6. Ensuring proper application rate for binder and aggregate.
7. Verifying set up time for binder (mix and setting up process can be observed after placing the mix in a cup)
8. Conducting trial applications prior to full placement of HFST.

9. Verifying application quantities
10. Verifying binder film thickness (wet film gauge can be used)
11. Testing gel time to check binder mixing and proportion
12. Verifying proper curing of binder.
13. Ensuring adequate sweeping of the HFST after placement.
14. Conducting in situ pull off testing to check bonding strength
15. Removing poor HFST locations (e.g. soft, uncured spots) and replacing with new HFST

Required qualification for HFST installation Contractor

- Project experience – Minimum 4200 square meters HFST installed in last 3 years
- Quality Control Plan – Project specific quality control plan
- Key personnel experience - Project Superintendent, lead technician
- Equipment – Calibration records, cleaning and maintenance schedule
- Materials – Certification for material compliance to specifications, procedures for storage and handling in stockpiles / onsite
- Installation – Plans and documented procedures required for blending of materials, placement, monitoring and recording of air/pavement temperature, recording quantities of materials, curing.
- Training - Project personnel with materials and installation is important.
- Corrective action – Plan should be in place to address corrective actions for poor installation.
- Vendor certification – If applicable

Communication Practices for HFST projects

Proper communication is very important for the success of a HFST project. Some of the things to consider are:

- establishing an internal communication process
- establishing a project team with designated authority and assigned duties
- pre-construction meeting
- holding regular team meetings
- assigning designated project and agency staff to address issues as they arise

Typical warranty defects / failures

The following defects for HFST can be considered from a warranty perspective.

- Surface cracking (independent of cracking from underlying pavement)
- Raveling / aggregate loss – Caused by
  - Insufficient embedment of aggregate in the binder, low or inadequate binder application to hold the aggregate.
  - Poor bond between aggregate and binder.
  - Non-uniform surface texture of pavement.
  - Binder draindown for pavement with high air voids, low viscosity of binder making it easy to flow.
  - Dirty, contaminated or wet aggregate.
  - Aggregate application too late – after binder gel time.
- Delamination (poor bond between HFST and the underlying pavement) – Caused by
  - Contaminated surface prior to HFST application, poor sweeping or surface preparation,
  - Moisture present on the surface or surface voids.
  - Thermal incompatibility between HFST and the surface (different expansion/contraction of HFST and asphalt surface).
- Uncured binder – Uncured binder can result in aggregate loss and tracking. This can be caused by
  - Incorrect binder proportioning.
  - Poor binder mixing, inadequate mixing time etc.
  - Poor quality binder, formulation.
- Substrate failure – This type of failure can be top-down tearing or shallow horizontal tearing and is caused by
  - HFST application on weak subgrade
  - Excess stopping and turning movements
  - Thermally induced stresses
  - Excessive thickness of HFST
- Reflective cracking- Existing cracks can easily reflect through HFST. Ideally cracks should be treated prior to HFST installation.

References:

- FHWA-CAI-14-019 FAQs About High Friction Surface Treatment (HFST)
- Minnesota DoT, 2018 - Transportation Synthesis TRS 1802, High Friction Surface Treatments
- AASHTO TC3 Training, Best Practices for High Friction Surface Treatment
- Wilson B., Mukhopadhyay A., 2016. Alternative Aggregates and Materials Research for HFSTs. Final Report Texas A & M Transportation Institute BDR74-977-05