INSTALLING AND INSPECTING HIGH FRICTION SURFACE TREATMENTS
ARE YOU TRAINED?

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WORKSHOP OVERVIEW

- Why HFST?
- What is HFST?
- Why HFST Training?
- Overview of Training Course
- Overview of Installation Module
- Overview of Inspection Module

WHY HFST?

- 18,257 people were killed in roadway departure crashes in the U.S. in 2013.
  - 56% of all traffic fatalities.
  - 28% of fatal crashes occurred at horizontal curves (only 5% of the Nation's highway are horizontal curves).
- 13% of fatal crashes (77% of weather-related crashes) occur on wet pavement.
- FHWA estimates that up to 70% of wet pavement crashes can be prevented or minimized by improved pavement friction.
**Why HFST?**

- Kentucky HFST Program Crash Reduction

<table>
<thead>
<tr>
<th>Annual Reduction</th>
<th>RAMPS</th>
<th>CURVES</th>
</tr>
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<tbody>
<tr>
<td>Wet Avg.</td>
<td>90%</td>
<td>84%</td>
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<tr>
<td>Dry Avg.</td>
<td>77%</td>
<td>79%</td>
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<tr>
<td>Total Avg.</td>
<td>89%</td>
<td>83%</td>
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Crash data from 3 years of before/after data on 70 curves

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**What is HFST?**

- Layer of polish and abrasion-resistant aggregate bonded to the pavement surface with resin binder.

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**What is HFST?**

- SAFETY treatment
- NOT a pavement preservation treatment
- Used to enhance or restore pavement surface friction in areas with high friction demand.
- Generally a spot treatment
- Provides a level of friction not generally achievable with conventional paving materials.
Inspection and Installation of HFST

**What is HFST?**

- **Benefits of HFST**
  - Restores/enhances friction of virtually any surface.
  - Topical treatment of existing pavement (i.e., not re-paving).
  - Thin layer - does not reduce overhead clearance or require raising of guardrails, does not change cross-slope/superelevation.
  - Install and open to traffic quickly.
  - Exceptional friction levels, sustained over time.

- **Precautions for HFST**
  - Not suitable for highly distressed pavements.
  - Not guaranteed to reduce crashes.
  - Cannot be installed in all weather conditions.
  - Not all materials (aggregates) will provide the same friction benefit.
  - Installation utilizes non-conventional materials and installation processes.

**HFST and Other Treatments**

- HFST is used specifically to enhance pavement surface friction.
- Other surface treatments serve to preserve the underlying pavement (sealing and rejuvenating existing surfaces) while also restoring friction.
HFST Specifications

- AASHTO PP 79-14, “Provisional Standard Practice for High Friction Surface Treatment for Asphalt and Concrete Pavements”
  - Material specifications
  - Test procedures
  - Packaging, materials certification and installer qualifications.
  - Surface preparation
  - Material installation
  - Does not address QC/QA procedures
  - Does not cover best practices in depth

HFST Specifications

- State DOT Specifications
  - Generally follow AASHTO PP 79-14
  - Additional state-specific requirements for material testing
  - Additional QC/QA requirements
  - Additional best or preferred practices based on state-specific experience

Why HFST Training?

State DOT HFST Status
(circa 2005)
Why HFST Training?

State DOT HFST Status
(as of 7/30/2015)

- No curves
- At least one curve
- 2 – 10 curves
- 10 – 50 curves
- More than 50 curves
- Active project implementation progress
- Over 100 curves in place

Training Course Objectives

- To provide an overview of the current state-of-the-practice for HFST installation.
- To highlight key considerations for HFST installation.
- To educate HFST installers on best practices for installation of HFST materials.
- To educate inspectors on key items of inspection during HFST installation.
**Training Course Development**

- Development funded by ATSSA.
- Developed by The Transtec Group, Inc.
- Oversight and review of materials provided by ATSSA HFS Council

**Training Course Outline**

- Installation Module
- Inspection Module
- Final Exam

**Training Course Schedule**

- Pilot Training Course (Tentative)
  - Week of March 7, 2016
  - Hosted by Tennessee DOT in Nashville
- Future Training Courses TBD
Installation Module

- Session 1: Introduction to High Friction Surface Treatments
- Session 2: HFST Materials Considerations
- Session 3: Installation Methods and Equipment
- Session 4: Surface Preparation
- Session 5: Manual Installation
- Session 6: Semi- and Fully- Automated Installation
- Session 7: Residual Aggregate Removal and Reclamation
- Session 8: Post-Installation Procedures

Session 2: HFST Materials Considerations

- Two Components:
  - Resin Binder
  - Aggregate

Resin Binder

- Purpose is to bond the aggregate to the substrate (underlying pavement).
- Must be compatible with the underlying pavement type.
- Must be appropriate for installation conditions.
  - Ambient temperature
- Must be appropriate for installation methods.
  - Manual vs. automated installation
Resin Binder

- Binder Types Currently Used in the U.S.
  - Epoxy Resin
  - Polyester Resin
  - Methyl Methacrylate (MMA)

Aggregate

- Purpose is to provide frictional properties for the HFST.
- Combination of macrotexture and microtexture.
- Must “wear” well under repeated wheel passes.

Aggregate

- AASHTO PP 79-14 Specification and most state DOT specifications require calcined bauxite.
Session 3: Installation Methods and Equipment

- Common Installation Methods
- Key Components of Installation
- Resin Binder Installation
- Aggregate Application
- Coordination of Installation
- Other Installation Considerations

Manual Installation

- Manual mixing of resin binder
  - Resin mixed in large buckets

Manual Installation

- Manual application of binder resin
  - Binder resin is poured onto pavement surface
  - Squeegees used to spread binder to proper thickness
Manual Installation

- Manual broadcasting of aggregate
  - Aggregate is broadcast from buckets or wheelbarrows by hand or with shovels

Semi-Automated Installation

- Partial automation of binder resin mixing, application, or aggregate placement.
  - Binder resin
    - Machine mixed or manually mixed
    - Manually applied with squeegees
  - Aggregate
    - Machine applied behind binder resin
    - Manually applied behind binder resin

Semi-Automated Installation

Automated Resin Mixing and Manual Application
Semi-Automated Installation

Automated Aggregate Application

Fully Automated Installation

- Machine mixing and application of resin
- Machine application of aggregate

Key Properties for Installation

- Resin Binder:
  - Viscosity
  - Gel Time
  - Thickness
  - Cure Rate
  - Adhesion
- Aggregate:
  - Must be clean and dry.
  - Must be uniform in size, within specification requirements.
  - Must be properly embedded in the resin binder.
Session 4: Surface Preparation

- Key Surface Preparation Items
- Pavement Distresses
- Surface Preparation Options
- Treatment of Pavement Markings and Drainage Structures

Key Surface Preparation Items

- Addressing pavement distresses
- Cleaning and roughening of pavement surface
- Treatment of pavement markings
- Treatment of pavement joints, drainage inlets
- Maintaining edge lines and begin/end locations
- Double layer HFST

Session 5: Manual Installation

- Installation Personnel Roles
- Equipment and Tools
- Coordination of Installation
- Resin Application
- Aggregate Application
Inspection and Installation of HFST

**Equipment and Tools**

- **Timer**
- **Tarp**
- **Resin component containers**
- **"Jiffy" style mixer**
- **Variable speed drill**
- **Clean mixing container**
- **Nozzles for resin containers**

**Resin Application**

*Pour a bead of resin binder across the pavement width.*

*Maintain a wet line of resin ahead of the aggregate broadcasting operation.*

**Resin Application**

*Pulling the squeegee*

*Pushing the squeegee*
**Aggregate Application**

- Aggregate broadcast from an adjacent lane
- Aggregate broadcast from the shoulder

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**Session 6: Semi-Automated and Fully-Automated Installation**

- Semi- and Fully-Automated Techniques
- Personnel Roles
- Equipment and Tools
- Resin Application
- Aggregate Application

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**Semi- and Fully-Automated Techniques**

- Semi-Automated Techniques
  - Either resin mixing, resin application, or aggregate placement is automated.
- Fully-Automated Techniques
  - Resin binder mixing and application and aggregate placement are fully automated.
Semi-Automated Examples

- Automated resin binder proportioning and mixing with manual resin placement with manual or automated aggregate placement.

Automated resin binder proportioning and mixing

Automated aggregate placement with a "venturi" blower

Fully Automated Examples

- Automated resin binder proportioning, mixing, application, and aggregate placement
**Aggregate Application**

Example of resin binder left exposed too long (for the ambient conditions and resin viscosity) before aggregate application.

- Resin "sheeting" across the lane
- Resin running across the lane and over edge stripe

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**Aggregate Application**

Example of non-uniform coverage due to aggregate application issues

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**Session 7: Residual Aggregate Removal and Reclamation**

- Overview of Aggregate Removal
- Techniques for Aggregate Removal
- Aggregate Disposal
- Reclamation of Aggregate
- Other Considerations
Residual Aggregate Removal

- Primary purpose is to remove excess (loose) aggregate from the HFST after resin has cured.
  - Loose aggregate will degrade the frictional properties of the surface.
- Secondary purpose is to loosen and remove lightly-bonded aggregate.
  - Helps to minimize shedding of aggregate under traffic over time.

Residual Aggregate Removal

- Timing of aggregate removal is critical.
  - Sweeping/vacuuming before resin has fully cured will potentially diminish the frictional properties of the finished surface.
  - There is no way to replace aggregate that are removed – HFST must be re-applied.

Aggregate Removal Techniques

- Power Broom
- Vacuum
- Broom-Vacuum
- Compressed Air
- Hand Broom
Aggregate Removal Techniques

Power broom
Non-metallic bristles

Aggregate Reclamation

- Follow agency-specific requirements for use of reclaimed aggregate.
  - Some agencies allow remixture of reclaimed aggregate with new aggregate at a ratio of 1:2.
- Check cleanliness of vacuum/broom-vacuum holding tank.
- Re-package or store reclaimed aggregate to protect from rain.

Aggregate Reclamation

- Special attention must be paid to cleanliness of reclaimed aggregate before reuse.
  - Dust content
  - Foreign matter/deleterious material
- Off-site reprocessing may be necessary before reuse
  - Sieve aggregate to remove deleterious materials and larger (non-HFST) stone that may have been picked up.
  - Wash and thoroughly dry aggregate if necessary to reduce dust content.
Other Considerations

- Sweep paved shoulders and adjacent lanes after completion of HFST sweeping to remove loose aggregate.
- Monitor aggregate shedding over time.

Session 8: Post-Installation Procedures

- Removal of Masking
- Replacement of Striping and Pavement Markers
- Aggregate Shedding
- Patching of Missed Areas
- Removal of Unacceptable HFST
- Items to Monitor Over Time

Aggregate Shedding

- Virtually all HFSTs will shed aggregate over the first few weeks after installation.
- Shedding is caused by traffic dislodging aggregate that are only lightly bonded to the resin binder.
- Shedding will generally be heaviest during the first 24-72 hours, tapering off over time, depending on traffic volume.
Aggregates Shedding

- Aggregate shedding can leave loose aggregate on paved shoulders, adjacent lanes, or within the lane itself.
- Material generally accumulates along the lane edges and, to a certain extent, down the center of the lane.
- If not removed, loose aggregate can create a safety hazard.

Aggregate Shedding

Examples of aggregate shedding in the first 24 hours

- Aggregate accumulation on a paved shoulder
- Aggregate accumulation along the wheelpath

Patching Missed Areas

Areas missed during installation and exposed after sweeping
Items to Monitor Over Time

- Delaminations of HFST from underlying surface
- Raveling/aggregate loss
- Discoloration of HFST
- Aggregate polishing
- Complete wearing off of HFST
- Failure of underlying pavement

Inspection Module

- Session 9A: Introduction of Key Inspection Items
- Session 9B: Inspection of Surface Preparation
- Session 9C: Inspection of Materials
- Session 9D: Inspection of Installation Practices
- Session 9E: Inspection of Post-Installation Surface
- Session 9F: Early-Age and Long-Term Monitoring

Session 9A: Key Inspection Items and Quality Control Plan

1. Materials
2. Equipment
3. Surface preparation
4. Resin proportioning and mixing
5. Resin application
6. Aggregate application
7. Residual aggregate removal and reclamation
8. Removal of masking
9. Replacement of pavement markings and opening to traffic
10. Post-installation monitoring
**Test Strip**
- If required by project specifications, monitor the construction of a test strip prior to full-scale installation.
- Allows for verification of installation processes.
- Allows for verification of resin binder coverage rate for the actual pavement surface texture.
- Allows for determination of resin binder cure rate.

**Quality Control Plan**
- Requirement of a quality control (QC) plan from the installation contractor will help ensure items for inspection covered in detail.
- QC plan should be submitted to owner-agency for approval at least 30 days prior to installation.
- Owner-agency inspector should be on site at all times during installation and ensure QC plan is followed.
- Any deviation from approved QC plan shall be cause for immediate suspension of operations.

**Session 9B: Inspection of Surface Preparation**
- Treatment of Pavement Distresses
- Removal and Masking of Pavement Markers
- Masking of Pavement and Roadway Features
- Cleaning/Roughening of Pavement Surface
- Surface Dryness
Pavement Distresses

- Overbanded crack sealant
- Recessed crack sealant

Cleaning and Roughening

- Ensure pavement cleaning and roughening has been completed in accordance with project plans.
  - Compressed air lance is typically the minimum requirement for asphalt pavement and shotblasting the minimum requirement for concrete pavement.
- For shotblasting or waterblasting
  - Ensure a minimum ICRI CSP of 5 (or as specified).
  - Ensure all residual dust/laitance has been removed with compressed air.
  - Ensure there are no “holidays” (missed areas) in the prepared surface.

Cleaning and Roughening

- Shotblasting of concrete surfaces
- CSP 5

Ensure no missed areas and adequate overlap between passes
Surface Dryness

- Damp pavement surface (not suitable for HFST installation)
- Moisture in pavement cracks (not suitable for HFST installation)

Session 9C: Inspection of HFST Materials

- Verify specification requirements for field sampling and testing of materials prior to HFST installation.
- Ensure necessary sampling containers and testing equipment are on site prior to installation.
- Review requirements for documentation, sampling, and testing from QC Plan.

Inspection of HFST Materials

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- Ensure necessary sampling containers and testing equipment are on site prior to installation.
- Review requirements for documentation, sampling, and testing from QC Plan.
**Binder Resin**

*Resin container labeling information*

**Aggregate**

*Verify storage of materials to ensure protection from rain*

**Aggregate**

*Inspect for moisture in the aggregate stockpile*
Session 9D: Inspection of Installation Practices

- Four Key Inspection Items
  - Binder resin proportioning/mixing
  - Binder resin placement
  - Aggregate placement
  - Aggregate removal
- Consider a requirement for placement of a test strip to verify installation processes and coverage rate.

Binder Resin Placement

- Request periodic samples to verify mix ratios and curing times.
  - Typical requirement: 2 oz. sample for each 100 gallons of resin placed.
  - Sample resin after each stop/start operation.
- Conduct routine checks of mil thickness with thickness gage.
- Verify thickness based on material usage and coverage rate using process outlined in QC plan.

Binder Resin Placement

*Resin wet mil film thickness gauge*
Binder Resin Placement

Monitor uniformity of resin layer

Non-uniform resin placement will affect uniformity of the finished surface

Binder Resin Placement

Monitor edge lines for flow of resin across striping

Aggregate Placement

- Monitor timeliness of aggregate placement onto binder for conformance with QC plan.
- Monitor uniformity of thickness of aggregate layer.
- Monitor any potential segregation of aggregate in the hopper (e.g., dust settling to the bottom).
- Note any "patterns" that could be caused by non-uniformity of placement.
Aggregate Removal

- Monitor aggregate removal and disposal requirements for conformance with QC plan.
  - Sweeping aggregate off pavement.
  - Collection for disposal or reuse.
- Monitor protection/masking of drainage inlets until sweeping is complete.
- Monitor accidental sweeping of aggregate into live traffic in adjacent lanes.

Session 9E: Inspection of Post-Installation Surface

- Surface Uniformity
- Edge Lines
- Loose Aggregate
- Repaired Areas
- Acceptance Testing for Friction
- Opening to Traffic

Surface Uniformity

Non-uniform finished surface appearance
Surface Uniformity

Inspect for aggregate embedment. Resin should not be clearly visible.

Loose Aggregate

- Inspect finished surface for loose aggregate.
  - Look for any small piles or "windrows" of loose aggregate that were missed by sweeping.
- Inspect adjacent lanes, paved shoulders, and downstream/upstream from HFST section for loose aggregate.
- Aggregate should not move when walked on or pressed with fingers.

Repaired Areas

Patches should match the surrounding surface.
Inspection and Installation of HFST

Acceptance Testing for Friction

- AASHTO T 242 (ASTM E 274) Locked-wheel friction tester
- ASTM E 1911 Dynamic Friction Tester (DFT)

Session 9F: Early-Age and Long-Term Monitoring

- Early-Age Monitoring
  - Most materials and workmanship related issues typically develop within the first 30-60 days of installation.
- Long-Term Monitoring
  - Long-term performance is generally related to how the HFST responds to traffic and climate over time.

Performance Issues

- Aggregate Loss
- Delamination
- Aggregate Polishing
- Surface Wear/Loss of HFST
- Friction Loss
- Underlying Pavement Failure
**Aggregate Loss**

Aggregate loss over time (resin binder matrix remains in place)

**Delamination**

Underlying pavement is exposed by delamination of HFST.

**Aggregate Polishing**

Polished surfaces will have a smooth texture. Aggregate particles polish flush with the binder resin.
Underlying Pavement Failure

Delamination of open graded friction course and HFST from underlying asphalt

Fatigue cracking and resulting potholes

Installing and Inspecting High Friction Surface Treatments
Are You Trained?

QUESTIONS?