# Making Roads and Bridges Safer with High Friction Surface Treatments

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## Definition and Benefits

Often called "polymer overlays", these surface treatments:

- Provide long-lasting resurfacing and protection to concrete deck and road surfaces from the effects of traffic, de-icing salts, acid rain, and freeze/thaw conditions
- SHRP-S-344: *"Multiple-layer epoxy and epoxy-urethane overlays can provide a skid-resistant wearing and protective surface for 25 years when exposed to moderate salt application rates and light traffic"*
- The overlay also can also increase pavement grip in wet or dry conditions, resulting in fewer accidents
- Reduced dead load: Overlays weigh 4 – 6 lbs/ft$^2$ vs. 18 – 22 lbs/ft$^2$ for an asphalt or concrete topping
- Thin application eliminates the need to raise approach slabs
- Rapid installation and return to service



## Common Applications

Bridge decks

Heavily trafficked roadways, especially curves

Parking garages, especially ramps and turning areas

Warehouse loading/unloading areas

Industrial flooring



## History of Polymer Overlays

1950's: Coal tar epoxy + miscellaneous fine aggregate broadcast in a single layer

1960's: Brittle *(high modulus)* amine-based epoxies in use

Late 1970's: The use of more flexible *(low modulus)* epoxies begins; addressed thermal incompatibility issues between epoxy and concrete

1980's: Increased use of epoxy overlay surface treatments on roads and bridges

1990's to present: Continuous improvement of materials, specifications, and application methods

## American Concrete Institute (ACI) Specifications for Polymer Overlays

Inconsistencies in material properties, construction practices, environmental controls and application methods created unnecessary misunderstandings and premature failures

Standards were prepared by diverse group of manufacturers, contractors, engineers and professors

Significant debate occurred throughout the development of:

- 548.8-07 Specification for Type EM (Epoxy Multi-Layer) Polymer Overlays for Bridge and Parking Garage Decks
- 548.9-08 Specification for Type ES (Epoxy Slurry) Polymer Overlays for Bridges and Parking Garage Decks



## Polymer Overlay Components: Typical Properties - Epoxy

| | |
|---|---|
| Viscosity | 700 – 2000 cP |
| Gel Time | 10 – 45 minutes |
| Compressive Strength | 3,000 psi(21 MPa) in 3 hours<br>5,000 psi (35 MPa) in 24 hours |
| Tensile Strength | 2500 psi (17 MPa) in 7 days |
| Tensile Elongation | 30 – 60 % |
| Water Absorption | less than 0.5% |
| Chloride Permeability | less than 100 coulombs |
| Thermal Compatibility | passes |
| Safety Standards | 100% solids, non-flammable |



## Polymer Overlay Components: Typical Properties - Aggregate

- Gap graded
- Fracture resistant
- Mohs Hardness 6.0 – 6.5
- Flint, Basalt, Bauxite

Typical Gradation

| Mesh | Percent Passing |
|---|---|
| No. 4 | 100 |
| No. 8 | 30-75 |
| No. 16 | 0-5 |
| No. 30 | 0-1 |

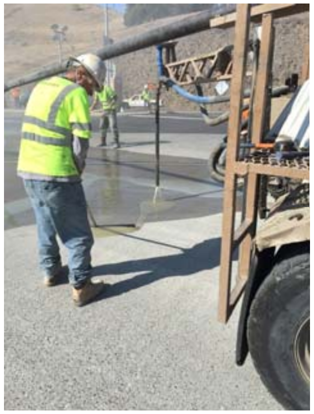


Typical flint aggregate

## Epoxy Polymer Concrete Overlay Application: Broadcast Method

1. Perform concrete surface preparation, check the environment
   - *Ambient and concrete temp must be at least 40°F (4°C)*
2. Apply epoxy, typically with an automatic meter-mix dispensing pump
3. Broadcast aggregate into wet epoxy
4. Remove excess aggregate after epoxy hardens
5. Apply second lift of epoxy resin
6. Broadcast aggregate
7. Allow to cure 3-5 hours
8. Remove excess aggregate and open to traffic





Application of epoxy

Aggregate broadcast

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## Polymer Overlays – Slurry Method

Mix slurry: epoxy (~1 gal) + aggregate (~30 lbs)

Place and screed

Broadcast additional aggregate into slurry

Final thickness: 3/8 inch (9.5 mm)

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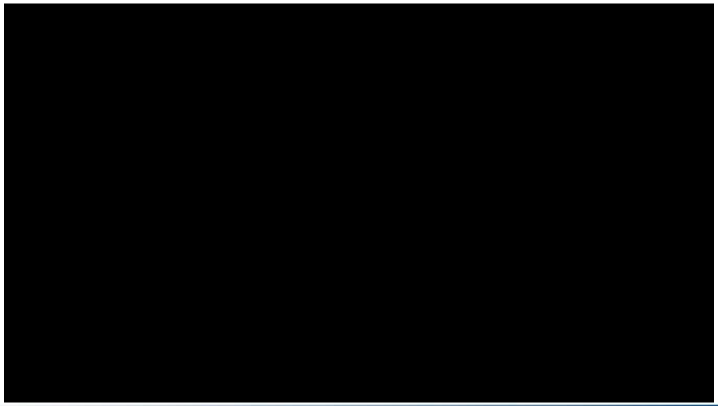
## High Friction Surface Treatments (HFST)

*FHWA/ATSSA video*





## HFST History

The concept of applying high friction surface treatments was first evaluated in the United Kingdom in 1967

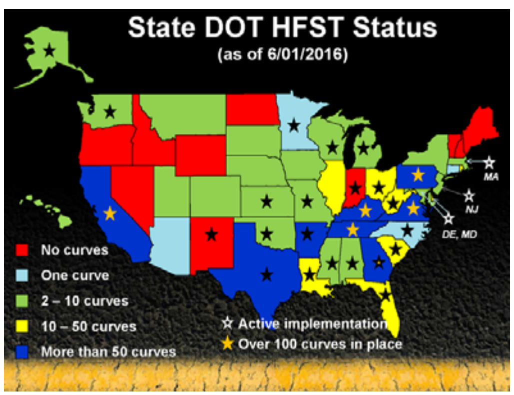
After installing HFST, a 31 percent reduction in automobile accidents was realized at over 800 locations in London

The technology arrived in the United States a few decades later, but was used mainly for sealing bridge decks

In the early 2000s, various polymer overlay suppliers began to market HFST as a safety countermeasure, to provide:

- An increase in pavement friction during wet conditions
- Increased friction on special roadway geometrics (tight curves)
- Pennsylvania, Kentucky and South Carolina DOTs report a before/after total crash reduction of 100 percent, 90 percent, and 57 percent, respectively, for their signature HFST trial projects






Source: FHWA



## HFST – What's Special About It?

The calcined bauxite aggregate

- An aluminum ore with high $AlO_2$ content
- Harder and more stable than flint and basalt
- Less likely to become smooth and "polished" due to abrasion/traffic

HFST consists of <u>only one</u> layer of epoxy and aggregate

## HFST has been applied to:

Concrete

…and asphalt!



## HFST Benefits

One layer of epoxy/aggregate means the project is completed in just a few hours – low impact on traffic

Once applied, surface friction is significantly enhanced

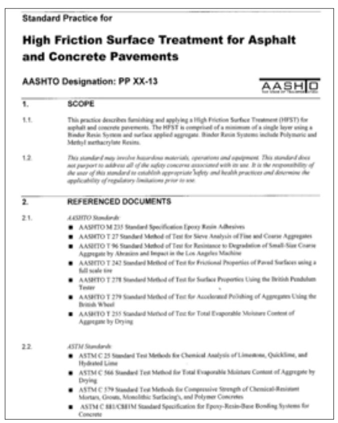
Measurable results: dramatic reduction in the number of crashes

HFST considered a low cost, valuable safety tool for state DOT's to address site-specific safety issues such as:

- High volume intersection approaches
- Interchange ramps
- Bridges
- Selected segments of interstates



## HFST Provisional Standard



Standard Practice for

**High Friction Surface Treatment for Asphalt and Concrete Pavements**

**AASHTO Designation: PP XX-13** AASHTO

1. SCOPE

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

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

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*

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

2.2. *ASTM Standards*

- ASTM C 25 Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
- ASTM C 566 Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
- ASTM C 579 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing's, and Polymer Concretes
- ASTM C 881/C881M Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete



## HFST Case Study

HFST was applied in May-June 2012 on a dangerous S curve of Interstate 380 in Cedar Rapids, IA

From June 13, 2012, to June 12, 2013, there were four crashes and one injury on the .3-mile stretch of I-380

Compared to an average 10.8 crashes and 5.6 injuries in each of the previous five years

The project cost $494,000 for 1.8 miles of roadway

## Recent HFST Project in Alaska

1.3 million sq. ft. of HFST installed in 48 counties

Locations included sections of heavily traveled highway that include a series of sweeping curves

- *Have a history of roadway departure crashes especially during wet or icy conditions*

50,000 gallons epoxy used

May 2016 start → August 2016 finish



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