

Accelerated Innovation Deployment
(AID) Demonstration Project:
High Friction Surface
Treatment

Final Report
May 29, 2015



US14A West of Sturgis

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INTRODUCTION

ACCELERATED INNOVATION DEPLOYMENT (AID) DEMONSTRATION GRANTS

The Accelerated Innovation Deployment (AID) program is one aspect of the multi-faceted Technology and Innovation Deployment Program (TIDP) approach, which provides funding and other resources to offset the risk of trying an innovation. The AID Demonstration funds are available for any project eligible for assistance under title 23, United States Code. Projects eligible for funding shall include proven innovative practices or technologies such as those included in the EDC initiative. Innovations may include infrastructure and non-infrastructure strategies or activities, which the award recipient intends to implement and adopt as a significant improvement from their conventional practice.

The Federal Highway Administration (FHWA) Accelerated Innovation Deployment (AID) Demonstration grant program, which is administered through the FHWA Center for Accelerating Innovation (CAI), provides incentive funding and other resources for eligible entities to offset the risk of trying an innovation and to accelerate the implementation and adoption of that innovation in highway transportation.

Projects deemed eligible for funding included proven innovative practices or technologies, including infrastructure and non-infrastructure strategies or activities, which the applicant or subrecipient intends to implement and adopt as a significant improvement from their conventional practice. The AID Demonstration funds were available for any project eligible for assistance under title 23, United States Code.

Entities eligible to apply included State departments of transportation (DOT), Federal Land Management Agencies, and tribal governments as well as metropolitan planning organizations (MPOs) and local governments which applied through the State DOT as subrecipients.

REPORT SCOPE AND ORGANIZATION

This report documents the South Dakota Department of Transportation's (SDDOT) demonstration grant award for Interstate I-229 and US highway 14A using High Friction Surface Treatment (HFST). The report presents details relevant to the employed project innovation(s), the overarching TIDP goals, performance metrics measurement and analysis, and the status of activities related to adoption of HFST as conventional practice by SDDOT.

PROJECT OVERVIEW

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This stand-alone safety project was to place and evaluate High Friction Surface Treatment (HFST) on four horizontal curves on the South Dakota State Highway System with higher than average accident rates. The curves—two on US14A near Deadwood and two on I-229 in Sioux Falls—experience crash rates two to four times higher than average, with most incidents occurring during snow-packed or icy road conditions.

LESSONS LEARNED

The process of placing the HFST is very similar to how the SDDOT applies an epoxy deck seal on a bridge deck. Our construction engineers were very prepared to take on a project such as this. As a result, we did not learn anything new on how the product is applied. The real lesson we learned was in the performance of HFST in snow and ice covered road conditions. We had an overall crash reduction rate of 78%. This figure is only based on one winter cycle so we will continue to monitor the crash reduction in winter road conditions.

PROJECT DETAILS

BACKGROUND

This stand-alone safety project was to place and evaluate High Friction Surface Treatment (HFST) on four horizontal curves on the South Dakota State Highway System with higher than average accident rates. The curves—two on US14A near Deadwood and two on I-229 in Sioux Falls—experience crash rates two to four times higher than average, with most incidents occurring during snow-packed or icy road conditions. In the past, the SDDOT would deploy safety improvements such as high cost geometric improvements. The use of HFST was the first of its kind in South Dakota.

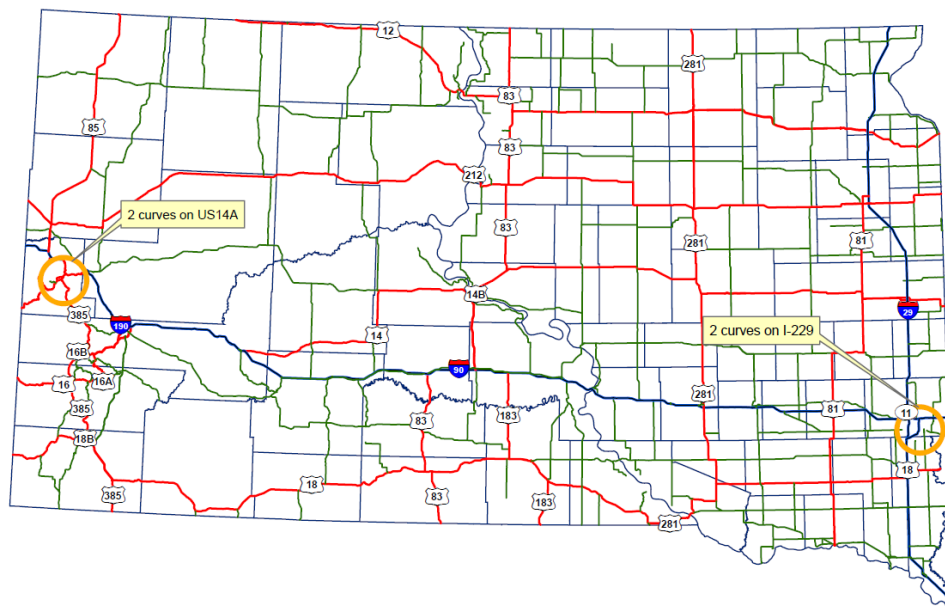


Figure 1. Map. Project location.

PROJECT DESCRIPTION

This stand-alone safety project was to place and evaluate High Friction Surface Treatment (HFST) on four horizontal curves on the South Dakota State Highway System with higher than average accident rates. The curves—two on US14A near Deadwood and two on I-229 in Sioux Falls—experience crash rates two to four times higher than average, with most incidents occurring during snow-packed or icy road conditions. The two curves on I-229 have concrete pavement and the two curves on US14A have asphalt pavement. Selecting these four curves allowed us to work through developing specifications for both PCCP and AC pavements. As described above, the methods used to apply the HFST was very similar in nature to how the SDDOT applies an epoxy deck seal on a bridge. The only element that sets this apart is the type of aggregate used.

- The overall crash reduction performance anticipated was at least 25%. This was conservative based on the performance of HFST on wet road conditions but the performance of HFST in winter road conditions was not known.
- The SDDOT was not notified of the grant award until after the project was complete so there was not any time available for public outreach.
- The South Dakota division of FHWA was in full support of the HFST projects.



Figure 2 - US14A – South of Lead



Figure 3 – I-229 Southbound

DATA COLLECTION AND ANALYSIS

Performance measures consistent with the project goals were jointly established for this project by SDDOT and FHWA to qualify, not to quantify, the effectiveness of the innovation to inform the AID Demonstration program in working toward best practices, programmatic performance measures, and future decision making guidelines

Data was collected to determine the impact of using HFST on safety and demonstrate the ability to:

- Achieve a safer environment for the traveling public and workers

This section discusses how the SDDOT established baseline criteria, monitored and recorded data during the implementation of the innovation, and analyzed and assessed the results for each of the performance measures related to these focus areas.

SAFETY

The SDDOT is always concerned with the safety of both the workers delivering the project and the users of our infrastructure during construction. The 2009 to 2013 crash history for these locations revealed a high rate of run-off-road crashes as seen in Table 1 below.

Historically, a comparable roadway, with similar traffic would be expected to experience two to four times lower rate of run-off-road crashes during five year time period. A typical five year time period would have one or two extreme winters with multiple snow events creating winter road conditions. These figures establish the baseline for our comparison of the innovative and traditional project delivery methods.

There were a total of 45 run-off-road crashes between 2009 and 2013 on all four horizontal curves. This averaged out to 9 run-off-road crashes per year. During the 2014-2015 winter season these four horizontal curves experienced only two run-off-road crashes. This was a total crash reduction of 78%, well over the anticipated 25% crash reduction.

Location	2009 - 2013 ROR Crashes	Crashes/Year	Oct 2014 - April 2015 Crashes	2015 ROR Crashes	% Crash Reduction	2016 ROR Crashes	% Crash Reduction	2017 ROR Crashes	% Crash Reduction	2015 – 2017 ROR Crashes	% Crash Reduction
I-229 NB	11	2.2	0	0	100%	1	55%				
I-229 SB	18	3.6	1	1	83%	0	100%				
14A Deadwood	13	2.6	1	1	62%	0	100%				
14A Lead	5	0.6	0	0	100%	0	100%				

Table 1 – Crash Counts

RECOMMENDATIONS AND IMPLEMENTATION

RECOMMENDATIONS

The SDDOT determined from the results of our data analysis that the experienced crash reduction of 78% was well above the overall goal of a 25% crash reduction. We propose adopting HFST into our standard operating procedures.

STATUS OF IMPLEMENTATION AND ADOPTION

Since the completion of HFST the SDDOT has undertaken the following activities to implement HFST into our standard operating procedures as a significant improvement from our traditional practice for similar type projects:

Horizontal curves with a higher than average run-off-road crash rate during winter conditions will be identified. A benefit cost analysis for HFST improvement will be done to prioritize projects.

Our plan for full adoption of HFST is as follows:

Standard specifications have been developed (see Appendix A) and are in place to allow for an immediate adoption of HFST. The performance of HFST on the four curves identified in the report will be monitored for an additional two years to better define the anticipated crash reduction. As additional HFST projects are complete, a three year crash analysis will be done so the anticipated crash reduction of HFST in winter road conditions can be better defined.

TECHNOLOGY TRANSFER

Since the completion of the HFST project, there have been two presentations done which share information on the project.

The first presentation was done at the biannual South Dakota Transportation Conference and covered many horizontal curve safety improvements. The HFST was a small part of this presentation (see Appendix B for agenda). The safety conference catered to a wide range of attendees including engineers and technicians from state, city, county, and consultants.

The second presentation was held at the annual South Dakota Engineering Society Central Chapter Conference. This presentation gave an in-depth look at the I-229 HFST project (see Appendix C for agenda). The attendees at this conference included engineers from the state, city, county, and consultants.

APPENDIX A

SDDOT Template HFST Specifications

**STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION
FOR
HIGH FRICTION SURFACE TREATMENT**

**PROJECT NUMBER, PCN NUMBER
NAME COUNTY**

MONTH DAY, YEAR

I. DESCRIPTION

This work consists of construction of a High Friction Surface Treatment (HFST) using calcined bauxite aggregate bound with a polymeric resin binder.

II. MATERIALS

A. Polymeric Resin Binder: The polymeric resin binder shall be either a polymer resin binder or an epoxy resin binder. The polymeric resin binder shall consist of a two-part resin binder/compound which holds the calcined bauxite aggregate firmly in position and conforms to the requirements of Table 1. The polymeric resin binder shall be certified to meet the requirements of Table 1. The certification shall contain test results from an accredited laboratory for the properties listed in Table 1.meeting the following requirements.

Table 1

Polymeric Resin Binder Requirements		
Property	Requirements	Test Method
Viscosity (Class C), poises	7-30	ASTM D2556
Gel Time (Class C), minutes	10 Minimum	AASHTO M 235
Ultimate Tensile Strength, psi	2,500 Minimum	AASHTO M 235
Elongation at Break Point	30-70%	AASHTO M 235
Durometer Hardness (Shore D)	60-80	ASTM D2240
Compressive Strength, psi	1,600 Minimum	AASHTO M 235
Cure Rate (Dry through time), hours	3 Maximum	ASTM D1640 5 mil thickness @ 75 Deg F
Water Absorption	1% Maximum	AASHTO M 235

Adhesion Strength, psi @ 24 hrs.	250 Minimum or 100% Substrate Failure	ASTM C1583
Mixing Ratio	Per Manufacturer	Provide manufacturer's recommendations a minimum of 15 days prior to construction.
Permeability to Chloride Ion @ 28	Less than 100	AASHTO T 277

B. Calcined Bauxite Aggregate: The material shall be clean, dry, free from foreign matter, and conform to the requirements in Table 3. The Contractor shall deliver the calcined bauxite aggregate to the construction site in clearly labeled containers. The calcined bauxite aggregate shall be certified to meet the requirements of Table 2. The certification shall contain the test results from an accredited laboratory for the properties listed in Table 3.

Table 2

Calcined Bauxite Aggregate Requirements		
Property	Requirements	Test Method
Mohs Hardness	7.0 Minimum	Mohs
Polish Stone Value	65 Minimum	ASTM E660
Gradation	100.0% Passing No. 4 95.0% - 100.0% Passing No. 6 0.0% - 5.0% Passing No. 16	AASHTO T 27
Moisture Content	0.2% Maximum	AASHTO T 255
Aluminum Oxide	87% Minimum	ASTM C25
Apparent Specific Gravity	3.1 Minimum	AASHTO T 84
Sodium Sulfate Soundness	12% Maximum	AASHTO T 104
LA Abrasion Test	30% Maximum. Test sample gradation differs from gradation requirements.	AASHTO T 96 (C grading)

III. CONSTRUCTION REQUIREMENTS

A. General:

- 1. Qualifications:** The Contractor shall provide documentation of experience for the Contractor's superintendent placing the HFST. The Contractor's superintendent shall have a minimum of 2 years and 10,000 yd² HFST experience on projects with other state highway agencies.
- 2. Quality Control (QC) Plan:** The Contractor shall submit a QC plan to the Engineer for approval at least 15 days prior to the placement of the HFST. The QC plan shall show proposed methods to control the equipment,

materials, mixing, and placement operations to ensure conformance with these specifications. The Contractor shall discuss the QC plan at the preconstruction meeting and as requested by the Engineer.

At a minimum, the QC plan shall contain the following:

- a. Key Personnel and Contact Information.**
 - 1)** The QC plan shall designate a plan administrator, who shall have full authority to institute any action necessary for the successful operation of the plan. The plan administrator shall be available on the jobsite within one hour after being notified of a concern.
 - 2)** A field technician shall be present at the job site unless otherwise approved in the QC plan. The technician shall be responsible for the required field quality control sampling and testing in conformance with the approved QC plan and contract documents. The Contractor shall maintain and make available upon request complete records of sampling, testing, actions taken to correct problems, and quality control inspection results. Any deviation from the approved QC plan, without Engineer approval, shall be cause for immediate suspension of operations.
- b.** Polymeric resin binder production plants, locations of plant, personnel qualifications, inspection and record keeping methods, equipment calibration records, accreditation certificates, and minimum frequencies of sampling and testing per Table 1.
- c.** Calcined Bauxite aggregate production plant locations, personnel qualifications, inspection and record keeping methods, equipment calibration records, accreditation certificates, and minimum frequencies of sampling and testing per Table 2.
- d.** Calcined Bauxite aggregate storage and moisture control methods.
- e.** Cleaning and maintenance procedures and schedule for mixing and application equipment. The cleaning and maintenance procedures and schedule shall contain the equipment manufacturer's recommendations for maximum allowable time the polymeric resin binder may remain in the application equipment before cleaning of the mixer and application system is required.
- f.** Corrective actions that will be taken for unsatisfactory construction practices.

- 3. Weather Limitations:** The Contractor shall not apply the polymeric resin binder material on wet surfaces (including condensation moisture from construction vehicles in front binder application), when the ambient temperature is less than 55°F or above 105°F, or when the anticipated weather conditions or pavement surface temperature would prevent the proper application of the surface treatment in accordance with the manufacturer's recommendations.
- 4. Seasonal Limitations:** HFST shall only be applied within the seasonal limitation of May 1 to October 15 (inclusive).
- 5. Manufacturer's Representative:** A manufacturer's representative must be present on the jobsite for a minimum of the first two full production days of HFST application.

The manufacturer's representative shall provide the Engineer and the Contractor with a copy of the written recommendations, technical data sheet, and product safety data sheet. In addition, the Contractor shall make a product safety data sheet available to anyone who will be exposed to the polymeric resin binder materials.

- 6. Application Equipment:** The Contractor shall use an approved application machine capable of continuously and thoroughly mixing the polymeric resin binder components to the ratio recommended by the polymeric resin binder manufacturer. The application machine must continuously mix, meter, monitor, and apply the polymeric resin binder. The Contractor shall mechanically spray or squeegee the polymeric resin binder over the application surface area. The Contractor shall use spiked shoes for all walking, standing, or any other form of foot contact with the polymeric resin binder prior to the application of the calcined bauxite aggregate. Construction and public vehicle traffic will not be allowed on the HFST until the HFST has completely cured. The Contractor shall replace contaminated sections of polymeric resin binder at no additional cost to the Department.

The application machine must have continuous pumping and proportioning devices which blend the polymeric resin binder within a controlled system. The polymeric resin binder must be blended and mixed to the ratio under the manufacturer's recommendations (+/- 2 percent by volume). The polymeric resin binder must be continuously applied once blended.

Broadcasting of the calcined bauxite aggregate material shall be by equipment capable of variable width dispensing of the calcined bauxite aggregate material on the roadway in a uniform manner as approved by the manufacturer of the polymeric resin binder. Calcined bauxite

aggregate must be broadcast in a manner which will not disturb the leveling of the polymeric resin binder.

Exposed uncured mixed polymeric resin binder must not be visible after the calcined bauxite aggregate is applied. If exposed uncured mixed polymeric resin binder is visible after applying the calcined bauxite aggregate, the Contractor shall apply calcined bauxite aggregate to the exposed areas using an approved application method.

The Contractor shall not allow the mixed polymeric resin binder to separate, cure, dry, be exposed, or harden which may impair retention and bonding of the calcined bauxite aggregate.

7. **Test Section:** The Contractor shall construct a test section (minimum of 200 SY) at a self-determined location to demonstrate equipment has been properly calibrated a minimum of 24 hours prior to beginning the project. If the project site is used for the test section, the Contractor shall open the test section to traffic after curing has completed, and no uncovered polymeric resin binder remains exposed. The Contractor shall correct deficient areas before opening to traffic as directed by the Engineer at no additional cost. At the completion of the test section, the Contractor shall demonstrate the application equipment cleaning procedures.

B. Bridge Deck Preparation and HFST Application:

1. **Bridge Deck Preparation:** Surfaces must be clean, dry, and free of all dust, oil, debris and any other material that might interfere with the bond between the polymeric resin binder material and existing surfaces. Adequate cleaning of all surfaces will be determined by the Engineer. The Contractor shall remove pavement markers and delineation within the area to receive HFST prior to placing polymeric resin binder.

The Contractor shall prepare the bridge deck receiving a HFST in accordance with the following.

- a. **Bridge Deck Grinding:** The bridge deck surface shall be ground prior to placement of a HFST.

The grinding shall remove the existing surface conditions as defined by the bridge plan notes including, but not limited to; rubberized asphalt chip seal, epoxy chip seal, pavement markings, and tining and shall be to the satisfaction of the Engineer.

The grinding shall be performed in the longitudinal direction. The grinding shall result in a parallel corduroy texture consisting of grooves between 0.090 and 0.130 inches (2 and 3 mm) wide. The distance

between the grooves shall be between 0.060 and 0.125 inches (1.5 and 3 mm). The peaks of the ridges shall not be greater than 1/16 inch (1.5 mm) higher than the bottom of the grooves. The grinding shall be uniform and shall follow the existing profile of the bridge deck. The grinding process shall not introduce dips and bumps that did not previously exist on the bridge deck surface or in any way decrease the existing riding quality of the bridge deck.

Grinding of the bridge deck shall be accomplished utilizing diamond blades mounted on a self-propelled machine designed for grinding and texturing pavement. The equipment shall be operated in such a manner that it will not damage the underlying deck surface. Grinding equipment that causes ravels, aggregate fractures, or spalls shall not be permitted. Residue or excess water generated by the grinding operations shall be removed with vacuum equipment from the deck surface before the residue has time to set up. Vacuumed residue or excess water shall not be expelled on the approach roadway or shoulder surfaces.

- b. Abrasive Blasting of Bridge Deck:** After grinding and removal and replacement of loose and delaminated concrete, the entire bridge deck surface shall be thoroughly shot blasted to approximately an International Concrete Repair Institute (ICRI) concrete surface profile CSP-5 (medium shot blast) to remove all foreign materials which may interfere with the bonding or curing of the HFST. The shot blasting shall remove all surface laitance and shall expose the coarse aggregate to the satisfaction of the Engineer. Small areas where shot blasting is unable to be performed (curb lines, etc.) shall be cleaned by abrasive blast cleaning to the satisfaction of the Engineer.

Upon completion of the shot blasting and abrasive blasting, the entire bridge deck shall be blown clean with dry compressed air to remove all dust and debris.

Cleaning by shot blasting, abrasive blasting, and compressed air shall be done no more than 24 hours prior to the placement of the HFST. In the event the HFST is not placed within 24 hours of shot blasting and abrasive blast cleaning or in the event of rain or other inclement weather contaminating the surface, the surface shall be re-cleaned by abrasive blast cleaning and dry compressed air.

Only equipment required for the application of the HFST will be allowed on any portion of the bridge deck which has been cleaned and prepared for application of the HFST. If equipment is used on the cleaned and prepared bridge deck, the area shall be protected from contamination with plastic.

2. Bridge Deck HFST Application: The Contractor shall apply the HFST on the bridge deck in accordance with the following.

a. Polymeric Resin Binder Application Requirements:

- 1) The openings of any bridge deck drains shall be temporarily sealed during polymeric resin binder placement as approved by the Engineer.
- 2) When phased construction of the two coat HFST is required, the Contractor shall maintain a straight line between the phases of polymeric resin binder placement for both layers by masking the line between phases with duct tape, or other material approved by the Engineer. The masking shall be completely removed before the polymeric resin binder achieves initial set and shall be removed in a manner that will not damage the adjacent polymeric resin binder. Overlapping the new HFST onto existing HFST shall not be done.
- 3) A prime coat, if required by manufacturer, shall be applied according to manufacturer's recommendations and will be applied in addition to the two coats of HFST.
- 4) The Contractor shall mix the polymeric resin binder components proportionally in accordance with the manufacturer's recommended ratio. The Contractor shall apply the two part modified polymeric resin binder onto the bridge deck section to be treated within the temperature range specified at the manufacturer's recommended application rate. The application rate shall be a minimum of 1 gallon per 40 square feet (1 liter per 1 square meter). The Contractor shall not allow the polymeric resin binder to separate in the mixing lines, cure, dry, chill, set up, or otherwise impair retention bonding of the HFST calcined bauxite aggregate. The Contractor shall ensure no seams are visible in the middle of the traffic lanes of the finished work after application of the HFST calcined bauxite aggregate.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall mix the polymeric resin binder components to the correct proportion within 4% by weight using a low speed high torque drill fitted with a helical stirrer.

b. Calcined Bauxite Aggregate Application Requirements:

- 1) After the polymeric resin binder is distributed on the application area of the bridge deck surface, a broadcast of calcined bauxite aggregate shall be made to refusal such that:

- 2) A uniform layer of calcined bauxite aggregate is attained. (*A non-uniform broadcast will result in an inconsistent HFST thickness and a poor riding bridge deck*).
- 3) There are no visible shiny wet spots after application.
- 4) The Contractor shall apply the calcined bauxite aggregate at a uniform minimum rate of 13 lbs/yd². The Contractor shall completely cover the “wet” polymeric resin binder with calcined bauxite aggregate to achieve a uniform surface with no exposed polymeric resin binder remaining visible on the surface before the polymeric resin binder begins to gel. The Contractor must vertically drop the calcined bauxite aggregate material in a manner which will not disturb the level of the polymeric resin binder liquid.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall sprinkle or vertically drop the calcined bauxite aggregate resulting in a minimum coverage rate of 13lbs/yd² without splashing or disrupting the leveling of the “wet” polymeric resin binder during placement, whether by mechanical or manual means.

- c. **Curing and Clean Up:** The Contractor shall allow the HFST to cure in accordance with the polymeric resin binder manufacturer’s recommendations (3 hours maximum at an ambient air temperature of at least 75°F). The Contractor shall clean up the HFST by removing the excess calcined bauxite aggregate on the treated area and adjacent areas with raveled calcined bauxite aggregate. The Contractor shall perform the clean-up prior to applying the second coat of HFST. The Contractor may reuse excess HFST calcined bauxite aggregate. In order to reuse the reclaimed excess HFST calcined bauxite aggregate, the Contractor must reclaim the excess HFST calcined bauxite aggregate with a mechanical sweeper. The recovered calcined bauxite aggregate must be clean, uncontaminated, and dry.
- d. **Second Coat HFST Application:** A second coat of HFST shall be distributed at the manufacturer’s recommended application rate. The application rate shall be a minimum of 1 gallon per 20 square feet (2 liters per 1 square meter). The Contractor shall apply the calcined bauxite aggregate as per section III.B.2.b of this special provision. In the event of rain before second coat is applied, the surface shall be dried for 24 hours prior to application. If second coat is not applied within 24 hours or traffic is allowed on the first coat, the bridge deck must be abrasive blasted prior to application. The Contractor shall perform street sweeping before placing pavement markings.

Temporary or permanent pavement markings must be in place prior to opening lanes to traffic.

C. Bridge Approach Slab Preparation and HFST Application:

- 1. Bridge Approach Slabs Preparation:** Surfaces must be clean, dry, and free of all dust, oil, debris and any other material that might interfere with the bond between the polymeric resin binder material and existing surfaces. Adequate cleaning of all surfaces will be determined by the Engineer. The Contractor shall remove pavement markers and delineation within the area to receive HFST prior to placing polymeric resin binder.

The Contractor shall prepare the bridge approach slab receiving a HFST in accordance with the following.

The entire concrete surface shall be thoroughly shot blasted to approximately an International Concrete Repair Institute (ICRI) concrete surface profile CSP-5 (medium shot blast) to remove all foreign materials which may interfere with the bonding or curing of the HFST. The shot blasting shall remove all surface laitance and shall expose the coarse aggregate to the satisfaction of the Engineer. Small areas where shot blasting is unable to be performed (curb lines, etc.) shall be cleaned by abrasive blast cleaning to the satisfaction of the Engineer.

Upon completion of the shot blasting and abrasive blasting, the entire surface shall be blown clean with dry compressed air to remove all dust and debris.

Cleaning by shot blasting, abrasive blasting, and compressed air shall be done no more than 24 hours prior to the placement of the HFST. In the event the HFST is not placed within 24 hours of shot blasting and abrasive blast cleaning or in the event of rain or other inclement weather contaminating the surface, the surface shall be re-cleaned by abrasive blast cleaning and dry compressed air.

Only equipment required for the application of the HFST will be allowed on any portion of the surface which has been cleaned and prepared for application of the HFST. If equipment is used on the cleaned and prepared surface, the area shall be protected from contamination with plastic.

Surfaces may need to be washed with a mild detergent, rinsed, and dried using a hot compressed air lance.

- 2. Bridge Approach Slab HFST Application:** The Contractor shall apply the HFST on the bridge approach slab in accordance with the following.

- a. **Polymeric Resin Binder Application Requirements:** The Contractor shall mix the polymeric resin binder components proportionally in accordance with the manufacturer's recommended ratio. The Contractor shall apply the two part modified polymeric resin binder onto the surface to be treated within the temperature range specified. The number of layers (minimum of one) and the application rates of the polymeric resin binder in the various layers shall be as recommended by the manufacturer in order to achieve an average thickness of 60 mils (cured) on the surface. The Contractor shall not allow the polymeric resin binder to separate in the mixing lines, cure, dry, chill, set up, or otherwise impair retention bonding of the HFST calcined bauxite aggregate. The Contractor shall ensure no seams are visible in the middle of the traffic lanes of the finished work after application of the HFST calcined bauxite aggregate.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall mix the polymeric resin binder components to the correct proportion within 4% by weight using a low speed high torque drill fitted with a helical stirrer.

- b. **Calcined Bauxite Aggregate Application Requirements:** The Contractor shall apply the calcined bauxite aggregate immediately after placing the polymeric resin binder at a uniform minimum rate of 13 lbs/yd². The Contractor shall completely cover the "wet" polymeric resin binder with calcined bauxite aggregate to achieve a uniform surface with no exposed polymeric resin binder remaining visible on the surface before the polymeric resin binder begins to gel. The Contractor must vertically drop the calcined bauxite aggregate material in a manner which will not disturb the level of the polymeric resin binder liquid.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall sprinkle or vertically drop the calcined bauxite aggregate resulting in a minimum coverage rate of 13lbs/yd² without splashing or disrupting the leveling of the "wet" polymeric resin binder during placement, whether by mechanical or manual means.

- c. **Curing and Clean Up:** The Contractor shall allow the HFST to cure in accordance with the polymeric resin binder manufacturer's recommendations (3 hours maximum at an ambient air temperature of at least 75°F). The Contractor shall clean up the HFST by removing the excess calcined bauxite aggregate on the treated area and adjacent areas with raveled calcined bauxite aggregate. The Contractor shall perform the clean-up prior to opening the section to traffic. The Contractor may reuse excess HFST calcined bauxite aggregate. In

order to reuse the reclaimed excess HFST calcined bauxite aggregate, the Contractor must reclaim the excess HFST calcined bauxite aggregate with a mechanical sweeper. The recovered calcined bauxite aggregate must be clean, uncontaminated, and dry. The Contractor shall perform street sweeping before placing pavement markings. Temporary or permanent pavement markings must be in place prior to opening lanes to traffic.

D. Portland Cement Concrete Pavement Preparation and HFST Application:

- 1. Portland Cement Concrete Pavement Preparation:** Surfaces must be clean, dry, and free of all dust, oil, debris and any other material that might interfere with the bond between the polymeric resin binder material and existing surfaces. Adequate cleaning of all surfaces will be determined by the Engineer. The Contractor shall remove pavement markers and delineation within the area to receive HFST prior to placing polymeric resin binder.

The Contractor shall prepare the Portland cement concrete pavement receiving a HFST in accordance with the following.

The entire surface shall be thoroughly shot blasted to approximately an International Concrete Repair Institute (ICRI) concrete surface profile CSP-5 (medium shot blast) to remove all foreign materials which may interfere with the bonding or curing of the HFST. The shot blasting shall remove all surface laitance and shall expose the coarse aggregate to the satisfaction of the Engineer. Small areas where shot blasting is unable to be performed (curb lines, etc.) shall be cleaned by abrasive blast cleaning to the satisfaction of the Engineer.

Upon completion of the shot blasting and abrasive blasting, the entire surface shall be blown clean with dry compressed air to remove all dust and debris.

Cleaning by shot blasting, abrasive blasting, and compressed air shall be done no more than 24 hours prior to the placement of the HFST. In the event the HFST is not placed within 24 hours of shot blasting and abrasive blast cleaning or in the event of rain or other inclement weather contaminating the surface, the surface shall be re-cleaned by abrasive blast cleaning and dry compressed air.

Only equipment required for the application of the HFST will be allowed on any portion of the surface which has been cleaned and prepared for application of the HFST. If equipment is used on the cleaned and prepared surface, the area shall be protected from contamination with plastic.

Surfaces may need to be washed with a mild detergent, rinsed, and dried using a hot compressed air lance.

2. Portland Cement Concrete Pavement HFST Application: The Contractor shall apply the HFST on Portland cement concrete pavements in accordance with the following.

a. Polymeric Resin Binder Application Requirements: The Contractor shall mix the polymeric resin binder components proportionally in accordance with the manufacturer's recommended ratio. The Contractor shall apply the two part modified polymeric resin binder onto the surface to be treated within the temperature range specified. The number of layers (minimum of one) and the application rates of the polymeric resin binder in the various layers shall be as recommended by the manufacturer in order to achieve an average thickness of 60 mils (cured) on the surface. The Contractor shall not allow the polymeric resin binder to separate in the mixing lines, cure, dry, chill, set up, or otherwise impair retention bonding of the HFST calcined bauxite aggregate. The Contractor shall ensure no seams are visible in the middle of the traffic lanes of the finished work after application of the HFST calcined bauxite aggregate.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall mix the polymeric resin binder components to the correct proportion within 4% by weight using a low speed high torque drill fitted with a helical stirrer.

b. Calcined Bauxite Aggregate Application Requirements: The Contractor shall apply the calcined bauxite aggregate immediately after placing the polymeric resin binder at a uniform minimum rate of 13 lbs/yd². The Contractor shall completely cover the "wet" polymeric resin binder with calcined bauxite aggregate to achieve a uniform surface with no exposed polymeric resin binder remaining visible on the surface before the polymeric resin binder begins to gel. The Contractor must vertically drop the calcined bauxite aggregate material in a manner which will not disturb the level of the polymeric resin binder liquid.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall sprinkle or vertically drop the calcined bauxite aggregate resulting in a minimum coverage rate of 13lbs/yd² without splashing or disrupting the leveling of the "wet" polymeric resin binder during placement, whether by mechanical or manual means.

- c. Curing and Clean Up:** The Contractor shall allow the HFST to cure in accordance with the polymeric resin binder manufacturer's recommendations (3 hours maximum at an ambient air temperature of at least 75°F). The Contractor shall clean up the HFST by removing the excess calcined bauxite aggregate on the treated area and adjacent areas with raveled calcined bauxite aggregate. The Contractor shall perform the clean-up prior to opening the section to traffic. The Contractor may reuse excess HFST calcined bauxite aggregate. In order to reuse the reclaimed excess HFST calcined bauxite aggregate, the Contractor must reclaim the excess HFST calcined bauxite aggregate with a mechanical sweeper. The recovered calcined bauxite aggregate must be clean, uncontaminated, and dry. The Contractor shall perform street sweeping before placing pavement markings. Temporary or permanent pavement markings must be in place prior to opening lanes to traffic.

E. Asphalt Concrete Pavement Preparation and HFST Application:

- 1. Asphalt Concrete Pavements Preparation:** Surfaces must be clean, dry, and free of all dust, oil, debris and any other material that might interfere with the bond between the polymeric resin binder material and existing surfaces. Adequate cleaning of all surfaces will be determined by the Engineer. The Contractor shall remove pavement markers and delineation within the area to receive HFST prior to placing polymeric resin binder.

The Contractor shall clean existing surfaces without the use of dust suppression water, or by other methods approved by the manufacturer and the Engineer. When recommended by the manufacturer and approved by the Engineer, surfaces may be washed with a mild detergent, rinsed, and dried using a hot compressed air lance.

The entire asphalt concrete surface shall be thoroughly shot blasted to approximately an International Concrete Repair Institute (ICRI) concrete surface profile CSP-5 (medium shot blast) to remove all foreign materials which may interfere with the bonding or curing of the HFST. The shot blasting shall remove all surface laitance and shall expose the coarse aggregate to the satisfaction of the Engineer. Small areas where shot blasting is unable to be performed (curb lines, etc.) shall be cleaned by abrasive blast cleaning to the satisfaction of the Engineer.

Upon completion of the shot blasting and abrasive blasting, the entire surface shall be blown clean with dry compressed air to remove all dust and debris.

Cleaning by shot blasting, abrasive blasting, and compressed air shall be done no more than 24 hours prior to the placement of the HFST. In the

event the HFST is not placed within 24 hours of shot blasting and abrasive blast cleaning or in the event of rain or other inclement weather contaminating the surface, the surface shall be re-cleaned by abrasive blast cleaning and dry compressed air.

Only equipment required for the application of the HFST will be allowed on any portion of the surface which has been cleaned and prepared for application of the HFST. If equipment is used on the cleaned and prepared surface, the area shall be protected from contamination with plastic.

Surfaces may need to be washed with a mild detergent, rinsed, and dried using a hot compressed air lance.

2. Asphalt Concrete Pavements HFST Application: HFST installation will not be permitted within the first 30 days following any new asphalt concrete paving. The Contractor shall apply the HFST on asphalt pavements in accordance with the following.

a. Polymeric Resin Binder Application Requirements: The Contractor shall mix the polymeric resin binder components proportionally in accordance with the manufacturer's recommended ratio. The Contractor shall apply the two part modified polymeric resin binder onto the surface to be treated within the temperature range specified. The number of layers (minimum of one) and the application rates of the polymeric resin binder in the various layers shall be as recommended by the manufacturer in order to achieve an average thickness of 60 mils (cured) on the surface. The Contractor shall not allow the polymeric resin binder to separate in the mixing lines, cure, dry, chill, set up, or otherwise impair retention bonding of the HFST calcined bauxite aggregate. The Contractor shall ensure no seams are visible in the middle of the traffic lanes of the finished work after application of the HFST calcined bauxite aggregate.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall mix the polymeric resin binder components to the correct proportion within 4% by weight using a low speed high torque drill fitted with a helical stirrer.

b. Calcined Bauxite Aggregate Application Requirements: The Contractor shall apply the calcined bauxite aggregate immediately after placing the polymeric resin binder at a uniform minimum rate of 13 lbs/yd². The Contractor shall completely cover the "wet" polymeric resin binder with calcined bauxite aggregate to achieve a uniform surface with no exposed polymeric resin binder remaining visible on the surface before the polymeric resin binder begins to gel. The Contractor

must vertically drop the calcined bauxite aggregate material in a manner which will not disturb the level of the polymeric resin binder liquid.

Hand application may be used for areas less than 300 yd². For hand applications, the Contractor shall sprinkle or vertically drop the calcined bauxite aggregate resulting in a minimum coverage rate of 13lbs/yd² without splashing or disrupting the leveling of the “wet” polymeric resin binder during placement, whether by mechanical or manual means.

- c. Curing and Clean Up:** The Contractor shall allow the HFST to cure in accordance with the polymeric resin binder manufacturer’s recommendations (3 hours maximum at an ambient air temperature of at least 75°F). The Contractor shall clean up the HFST by removing the excess calcined bauxite aggregate on the treated area and adjacent areas with raveled calcined bauxite aggregate. The Contractor shall perform the clean-up prior to opening the section to traffic. The Contractor may reuse excess HFST calcined bauxite aggregate. In order to reuse the reclaimed excess HFST calcined bauxite aggregate, the Contractor must reclaim the excess HFST calcined bauxite aggregate with a mechanical sweeper. The recovered calcined bauxite aggregate must be clean, uncontaminated, and dry. The Contractor shall perform street sweeping before placing pavement markings. Temporary or permanent pavement markings must be in place prior to opening lanes to traffic.

- F. Field Acceptance Testing:** The Contractor shall ensure the coverage rate of the retained calcined bauxite aggregate is a minimum of 13 lbs/yd². The Contractor shall remove and reapply HFST where any patches of exposed polymeric resin binder exist, at no additional cost. The Contractor shall perform testing in accordance with Table 3.

Table 3

Field Acceptance Testing Requirements			
Property	Requirements	Frequency	Test Method
FN40R (Corrected field FN by adding the correction in Table 4)	72 Minimum	Every 0.1 mile in each lane. Location determined by SDDOT	ASTM E274 using a ribbed tire
Field Dynamic Friction Value	0.90 Minimum	1 per each location or 1 per every 1,500 lane feet, whichever is shorter. Location determined by SDDOT	ASTM E1911
Mean Profile Depth (mm)	1.0 Minimum	1 per each location or 1 per every 1,500 lane feet, whichever is shorter. Location determined by SDDOT	ASTM E2157

Table 4

HFST Speed Correction Factors for ASTM E274 Testing					
Test Speed (mph)	FN Correction	Test Speed (mph)	FN Correction	Test Speed (mph)	FN Correction
20	-9.3	30	-4.8	40	0.0
21	-8.9	31	-4.4	41	0.5
22	-8.4	32	-3.9	42	1.0
23	-8.0	33	-3.4	43	1.5
24	-7.6	34	-2.9	44	2.0
25	-7.1	35	-2.5	45	2.5
26	-6.7	36	-2.0	46	3.1
27	-6.2	37	-1.5	47	3.6
28	-5.8	38	-1.0	48	4.1
29	-5.3	39	-0.5	49	4.6

IV. METHOD OF MEASUREMENT

- A. Bridge Deck Grinding:** Measurement will not be made for bridge deck grinding. The plan quantity will be the basis of payment
- B. Abrasive Blasting of Bridge Deck:** Measurement will not be made for abrasive blasting of bridge deck. The plan quantity will be the basis of payment.
- C. Two Coat High Friction Surface Treatment:** Measurement will not be made for two coat high friction surface treatment. The plan quantity will be the basis of payment unless additional applications areas are ordered by the Engineer. No deductions will be made for the areas occupied by manholes, inlets, drainage structures, pavement markings, or by any public utility appurtenances within the area.
- D. Abrasive Blasting of PCC Pavement:** Measurement will not be made for abrasive blasting of PCC Pavement. The plan quantity will be the basis of payment.
- E. Abrasive Blasting of AC Pavement:** Measurement will not be made for abrasive blasting of AC Pavement. The plan quantity will be the basis of payment.
- F. High Friction Surface Treatment:** Measurement will not be made for high friction surface treatment. The plan quantity will be the basis of payment unless additional application areas are ordered by the Engineer. No deductions will be made for the areas occupied by manholes, inlets, drainage

structures, pavement markings, or by any public utility appurtenances within the area.

V. BASIS OF PAYMENT

- A. Bridge Deck Grinding:** Bridge deck grinding, when specified in the plans, will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to grind the bridge deck surface to the required profile and to remove and dispose of the grinding residue and water.
- B. Abrasive Blasting of Bridge Deck:** Abrasive blasting of bridge deck will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to shot blast and abrasive blast clean the bridge deck surface of all foreign materials and to remove and dispose of all residue.
- C. Two Coat High Friction Surface Treatment:** Two Coat high friction surface treatment will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to furnish and install the two coat high friction surface treatment including all testing and to remove and dispose of existing pavement markings and excess calcined bauxite aggregate.
- D. Abrasive Blasting of PCC Pavement:** Abrasive blasting of PCC pavement will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to shot blast and abrasive blast clean the PCC pavement surface of all foreign materials and to remove and dispose of all residue.
- E. Abrasive Blasting of AC Pavement:** Abrasive blasting of AC pavement will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to shot blast and abrasive blast clean the AC pavement surface of all foreign materials and to remove and dispose of all residue.
- F. High Friction Surface Treatment:** High friction surface treatment will be paid for at the contract unit price per square yard. Payment will be full compensation for all labor, equipment, materials, and all incidental work required to furnish and install the high friction surface treatment including all testing and to remove and dispose of existing pavement markings and excess calcined bauxite aggregate.

* * * * *

APPENDIX B

**SOUTH DAKOTA TRANSPORTATION CONFERENCE
AGENDA**

Every Life Counts – Partnering to Save Lives

**2015 SOUTH DAKOTA TRANSPORTATION
SAFETY CONFERENCE**

**MARCH 11TH & 12TH, 2015
BEST WESTERN RAMKOTA HOTEL
PIERRE, SD**

WEDNESDAY – MARCH 11TH

**8:00-9:00 AM - Registration & Continental Breakfast in Vendor Area
Sponsored by Vendors, Please Visit Their Booths**

9:00-9:30 AM - Opening Comments – Gallery B/C

Darin Bergquist, Secretary, South Dakota Dept. of Transportation
Trevor Jones, Secretary, South Dakota Dept. of Public Safety
Virginia Tsu, Division Administrator, Federal Highway Administration

9:30-10:00 AM – Gallery B/C

Strategic Highway Safety Plan
Andy Vandell, Highway Safety Engineer, SDDOT

10:00-10:30 AM - BREAK

Sponsored by Vendors- Please Visit Their Booths

10:30-11:15 AM – Gallery B/C

BREAKOUT SESSIONS – Roadway Departures

1. **Gallery D** - Roadway Delineation
Doug Kinniburgh, Local Government Assistance, SDDOT
2. **Gallery E** – Horizontal Curves Improvements
Andy Vandell, Highway Safety Engineer, SDDOT
3. **Gallery F** – Intersection Improvements - Using ITS
Jon Jackels, SRF Consulting Group, Inc.

11:15-Noon – Gallery B/C

BREAKOUT SESSIONS – Intersections

1. **Gallery D** - Signal Timing, Use of Cameras
Heath Hoftiezer, City of Sioux Falls
2. **Gallery E** – Roundabouts, 4-lane Divided
Mark Malone, Project Development, SDDOT

3. **Gallery F** – Intersection Improvements – Using ITS
Jon Jackels, SRF Consulting Group, Inc.

Noon-1:00 PM – LUNCH – Gallery A

1:00-2:00 – Gallery B/C

Keynote Speaker – Vehicle Safety Technology
Thomas Artushin, Ford Motor Company

2:00-2:45

BREAKOUT SESSIONS – Speeding Related Crashes

1. **Gallery D** - Setting a Speed Limit and Speed Limit Compliance
Monica Heller, Rapid City Region Traffic Engineer, SDDOT
2. **Gallery E** - Work Zone Safety
Christina Bennett, Operations Traffic Engineer, SDDOT
3. **Gallery F** – Road Diet, other innovative techniques
Heath Hoftiezer, City of Sioux Falls

2:45-3:15 PM - BREAK

Sponsored by Vendors- Please Visit Their Booths

3:15-4:00 PM

BREAKOUT SESSIONS – Motorcycle Crashes, Unbelted Vehicle Occupants

1. **Gallery D** - Sturgis Motorcycle Rally
Stacy Bartlett, RC/Pierre Access Management Engineer, SDDOT
2. **Gallery E** – Awareness and Education
Developing current seatbelt campaign
Lawrence and Schiller

4:00-4:45 – Gallery B/C

Drug and Alcohol Related
SD DRE Program – Rick Olauson

4:45 PM – Adjourn

Dinner on your own

Every Life Counts – Partnering to Save Lives

**2015 SOUTH DAKOTA TRANSPORTATION
SAFETY CONFERENCE**

**MARCH 11TH & 12TH, 2015
BEST WESTERN RAMKOTA HOTEL
PIERRE, SD**

THURSDAY, MARCH 12TH

**7:30-8:00 AM - Continental Breakfast in Area of Vendors
Sponsored by Vendors, Please Visit Their Booths**

8:00-8:45 AM – Gallery B/C
Legislative Update
Bill Nevin, Legal Office, SDDOT

8:45-9:30 AM
BREAKOUT SESSIONS – Young Drivers

1. **Gallery D** – Drivers' Education Across South Dakota
Chris Grant, SD Office of Highway Safety
2. **Gallery E** – Traffic Incident Response Training
Dave Huft, Research Program Manager, SDDOT
3. **Gallery F** – Horizontal Curve Improvements
Andy Vandell, Highway Safety Engineer, SDDOT

9:30-10:00 AM BREAK
Sponsored by Vendors, Please Visit Their Booths

10:00-10:45 AM – Gallery B/C
Live Well – Pedestrian Safety
Mary Michaels

10:45-11:45 AM – Gallery B/C
Summarize Breakout Sessions and Conference Wrap-up

11:45 PM – Adjourn

Thank you for coming and have a safe trip home!

APPENDIX C

SOUTH DAKOTA ENGINEERING SOCIETY CONFERENCE AGENDA