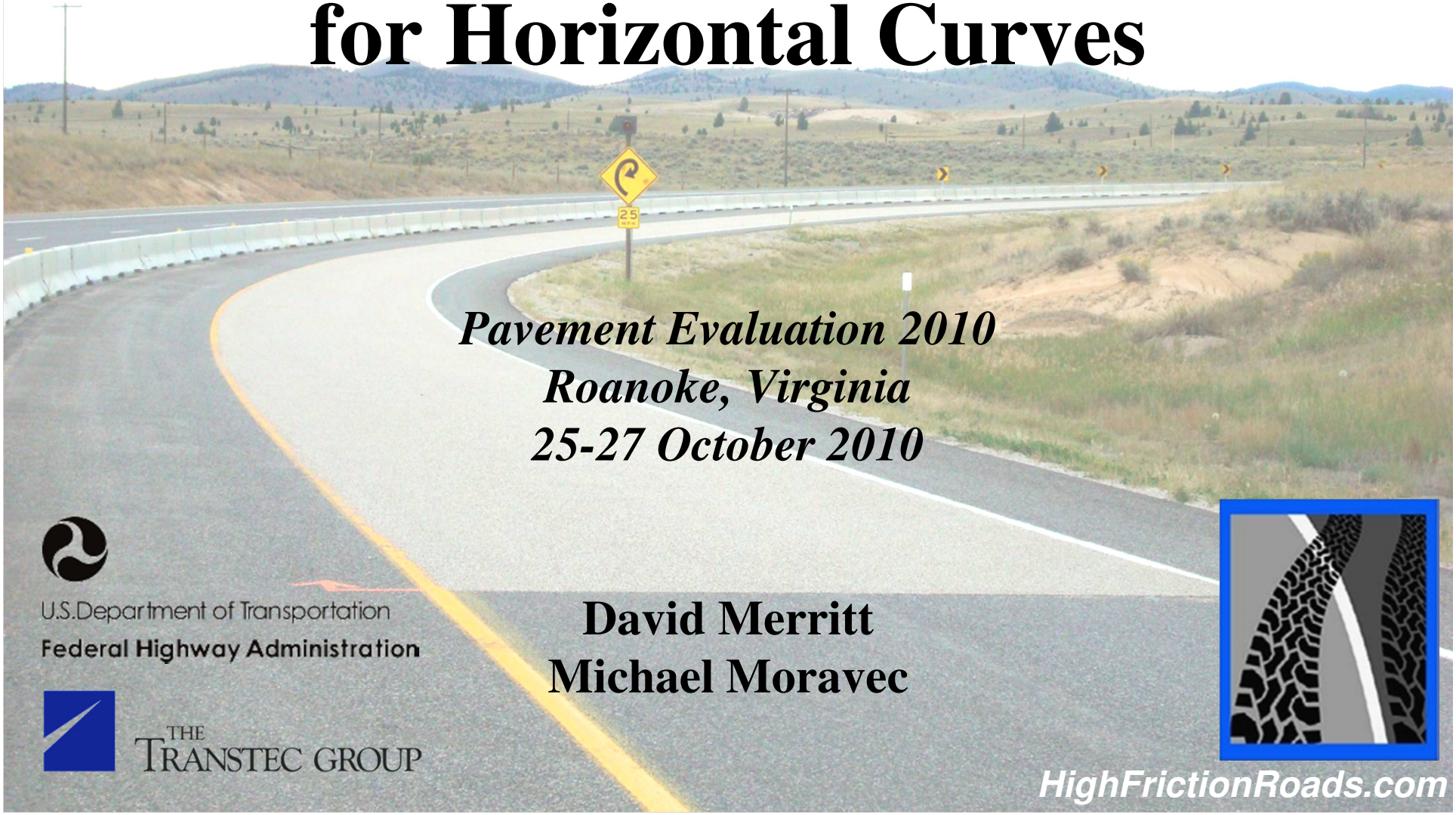
High Friction Surfacing for Horizontal Curves



Pavement Evaluation 2010
Roanoke, Virginia
25-27 October 2010

U.S.Department of Transportation
Federal Highway Administration

THE TRANSTEC GROUP

David Merritt
Michael Moravec

HighFrictionRoads.com

What are High Friction Surfaces?

- High Friction Surfaces (HFS) are pavement surfacing systems with exceptional skid-resistant properties that are not typically acquired by conventional materials
- Generally proprietary epoxy-based products and processes
- Guidelines Document from the British Board Agreement (BBA)

  "…defined as having a minimum skid resistance value (SRV) of 65 measured using the portable Skid-Resistance Tester as defined in TRL Report 176: Appendix E."

What is HFS used for?

- Bridge Decks (most common in U.S. to date)
- Pavements with poor friction or those susceptible to icing
- Intersections/Approaches
- Steep Grades
- Roundabouts
- Bus Stops
- Pedestrian Walkways
- **Non-Tangent Pavement Sections**

HFS Materials

- Aggregates
  - Generally calcined bauxite or flint, but slags, and granite materials with high PSV have also been used
  - Generally 3-4 mm maximum size
- Binder system (proprietary blends)
  - Bitumen-extended epoxy resins
  - Epoxy-resin
  - Rosin-ester
  - Polyurethane-resin
  - Acrylic-resin

HFS Installation

- Manually
  - Manual mixing of epoxy material
  - Manual application of epoxy with squeegee
  - Hand broadcast and distribution of aggregate
  - Production rates: 200-300 SY/hr.

HFS Installation

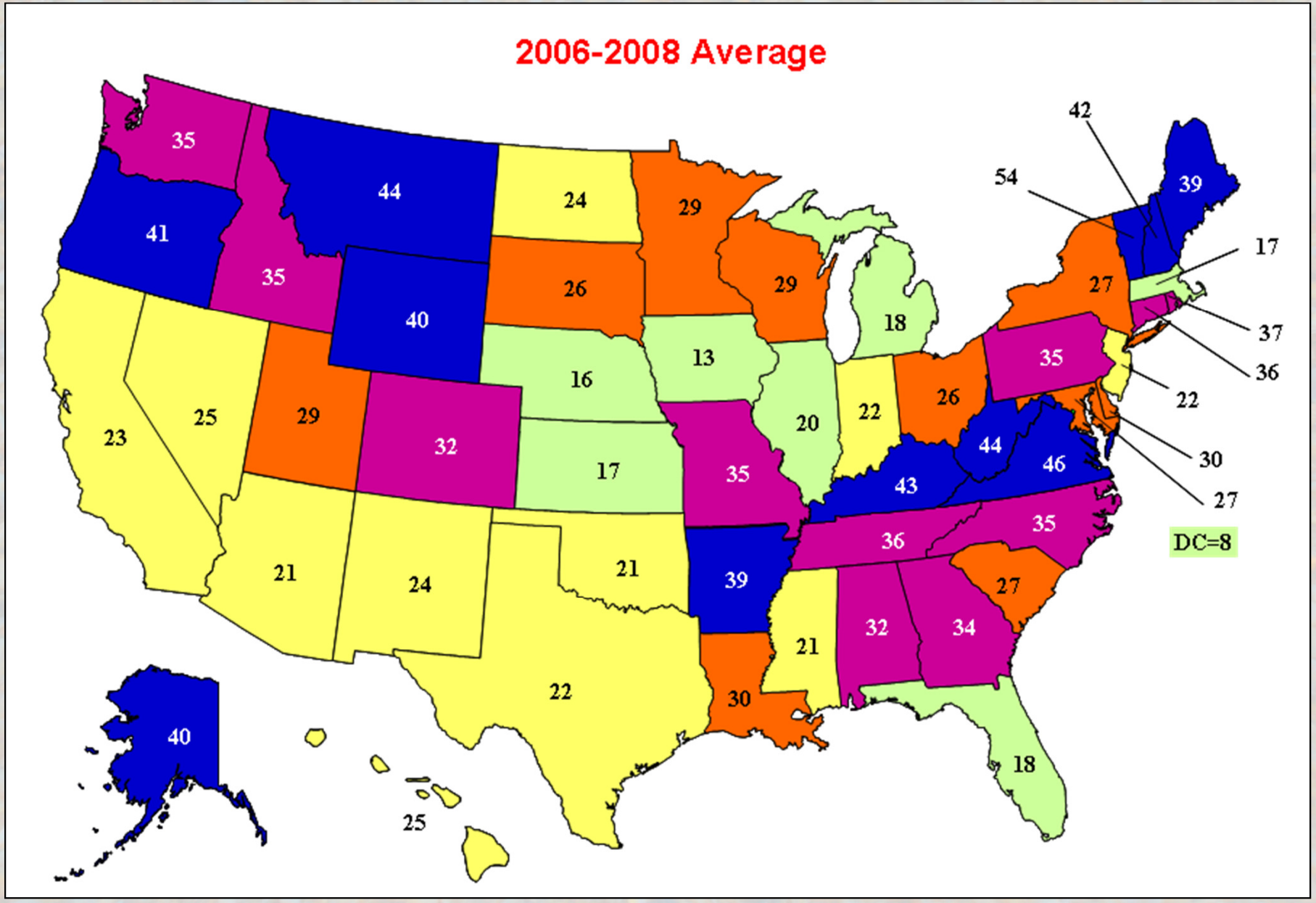
- Automated (machine-aided)
  - Machine mixing and application of epoxy (limited hand/squeegee work)
  - Machine broadcast/application of aggregate
  - Production rates up to 2,300 SY/hr. (1/4 mi. x 12’ in 40 min.)

HFS Finished Product

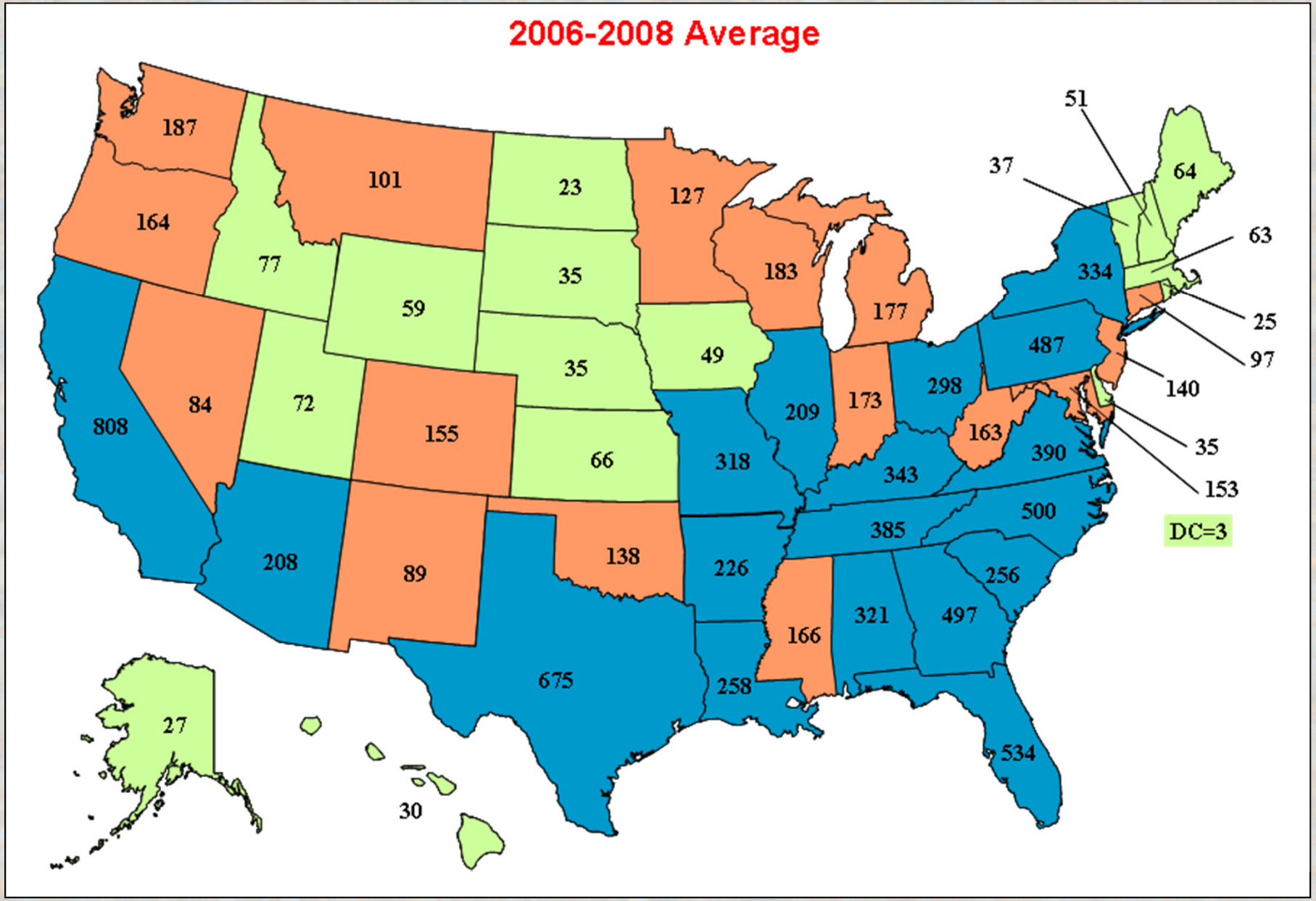
Crashes at Horizontal Curves

- Roughly 28% of all fatal crashes occurred at horizontal curves (source: 2007 NHTSA FARS)
- The average crash rate for horizontal curves it approximately **three times** the crash rate of tangent sections
  - 69% were rural
  - 71% on minor arterials (rural and urban)

Percent Curve Crashes



Horizontal Curve Fatal Crashes



Crashes at Horizontal Curves

U.S. Department of Transportation
Federal Highway Administration

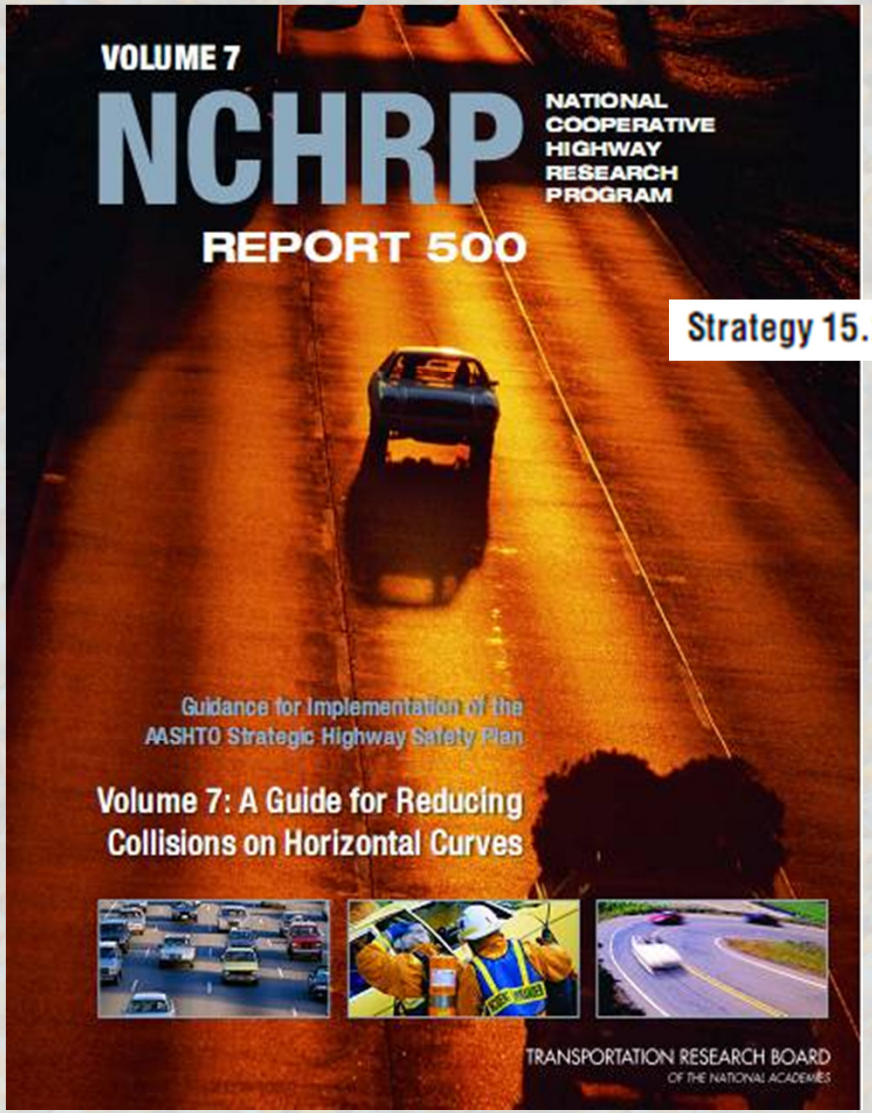
Technical Advisory

Subject
Surface Texture for Asphalt and Concrete Pavements

Classification Code	Date	Office of Primary Interest
T 5040.36	**June 17, 2005**	**HIPT-20**

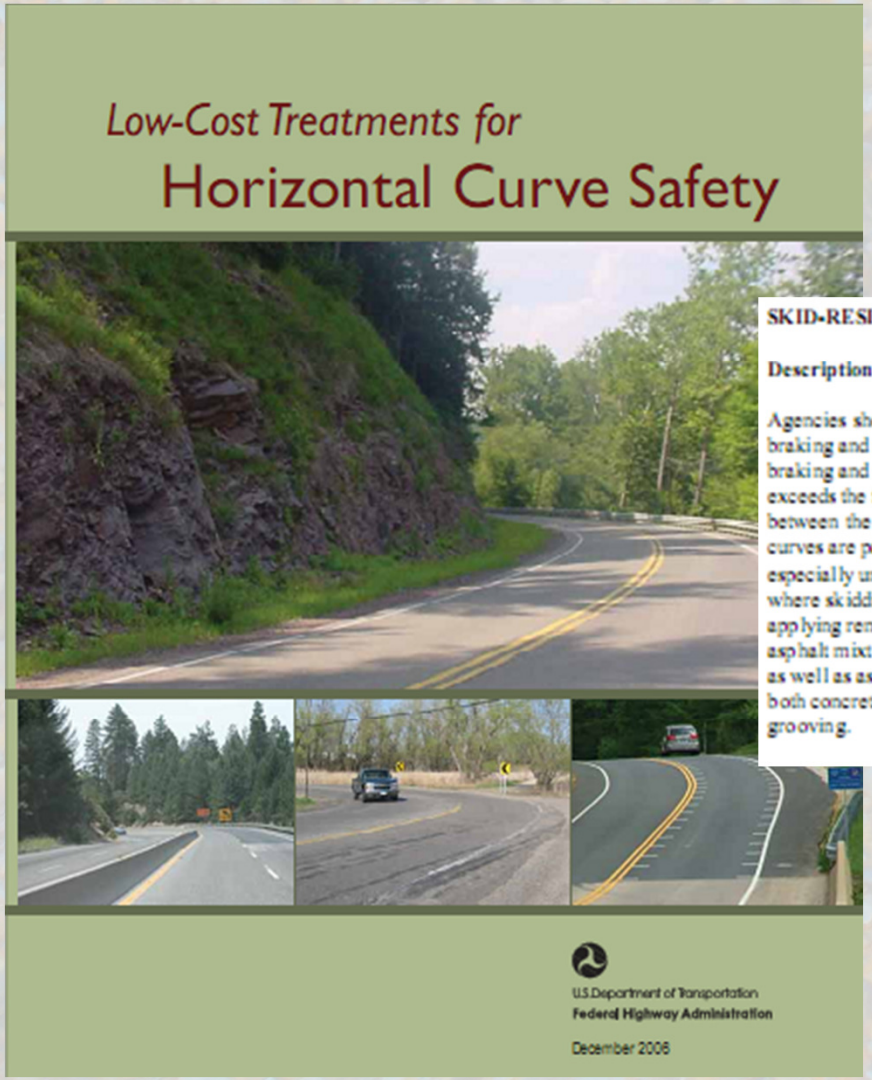
"Curves may justify a higher level of texture or higher threshold value for a friction-related parameter."

Crashes at Horizontal Curves



Strategy 15.2 A7: Provide Skid-Resistant Pavement Surfaces (T)

Crashes at Horizontal Curves



SKID-RESISTIVE PAVEMENT SURFACE TREATMENT

Description

Agencies should maintain pavements to ensure adequate friction necessary for vehicle braking and maneuvering under both dry and wet conditions. A vehicle will skid during braking and maneuvering when frictional demand exceeds the friction force that can be developed between the tire and the road surface. Horizontal curves are particularly prone to these types of crashes, especially under wet conditions. On road segments where skidding crashes are known to occur, consider applying remedial treatments, including specific asphalt mixtures (type and gradation of aggregate as well as asphalt content), pavement overlays on both concrete or asphalt pavements, and pavement grooving.

Application of skid-resistive pavement surface in curve.

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- Goals of SEAHC:
  - Demonstrate the effectiveness of High Friction Surfaces (HFS) in enhancing/restoring friction to reduce lane departure crashes at horizontal curves.
  - Measure the properties of HFS and monitor changes and performance over first year
  - Monitor crashes before and after HFS application
- Utilize currently available HFS products
- 3+ year study
- Initial Demonstration States: NC, KS, MT, CO, MI, TX
- Generally 2-5 sites per State (budget dependent)

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- Site Selection Criteria
  - Non-tangent roadway sections with high rates of lane departure/run-off-road accidents (per AADT)
  - Sections where poor friction is suspected (not geometry or driver behavior)
  - Sections where no major maintenance and rehabilitation is planned for at least 3 years
  - Sections where no other mitigative techniques will be used

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- Data Collection
  - Crash Data:
    - Historical: min. 3 years prior to installation
    - Post-Installation: 3 years following installation
  - Friction
  - Texture
  - Tire-Pavement Noise – OBSI (select sites only)

Friction

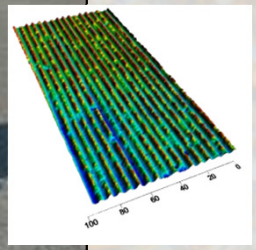
Dynamic Friction Tester (DFT)

Griptester

DOT-provided Locked Wheel Skid Trailer (ribbed and/or smooth tire)

Texture

Circular Track Meter (CTM) – MPD



RoboTex – MPD

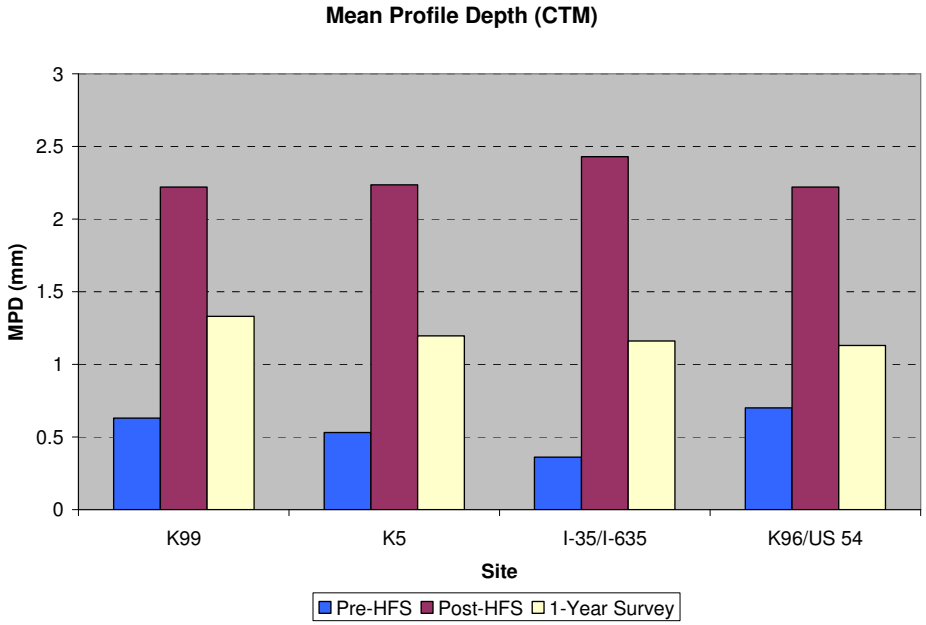
ASTM E965 (“Sand Patch”) – MTD

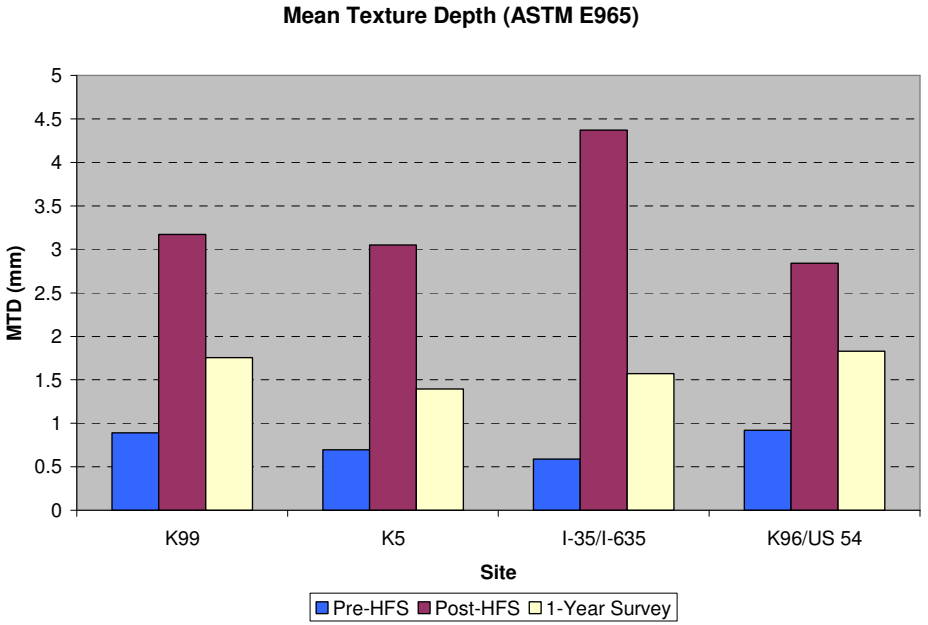
Kansas

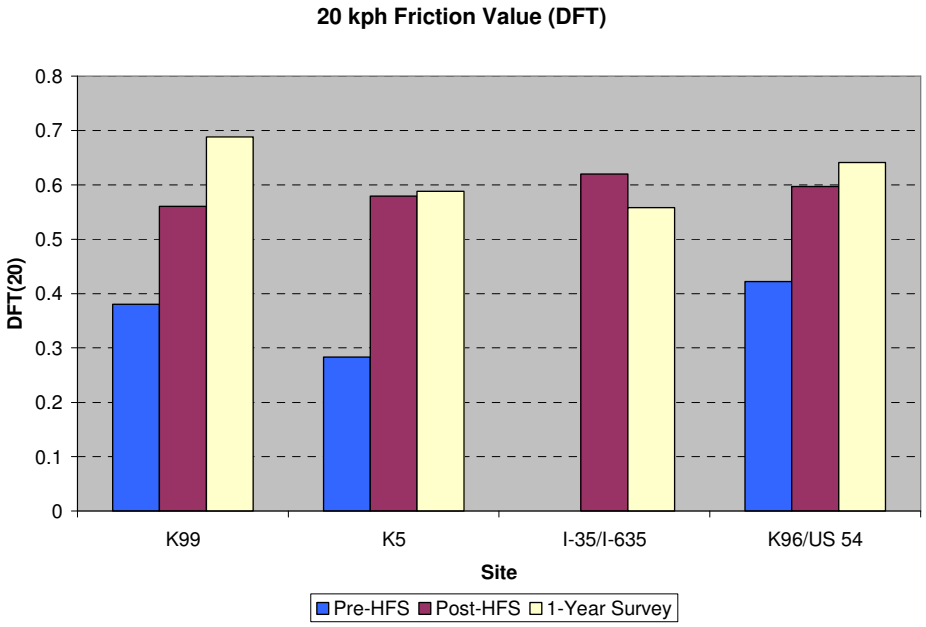
- HFS Vendor/Product: POLYCARB/SAFETYGRID
- Aggregate: Crushed Flint
- Projects:
  - K5, Leavenworth (HMA)
  - I35-I635 ramp, Kansas City (PCC)
  - K96-US54 ramp, Wichita (PCC)
  - K99, Wamego (HMA)

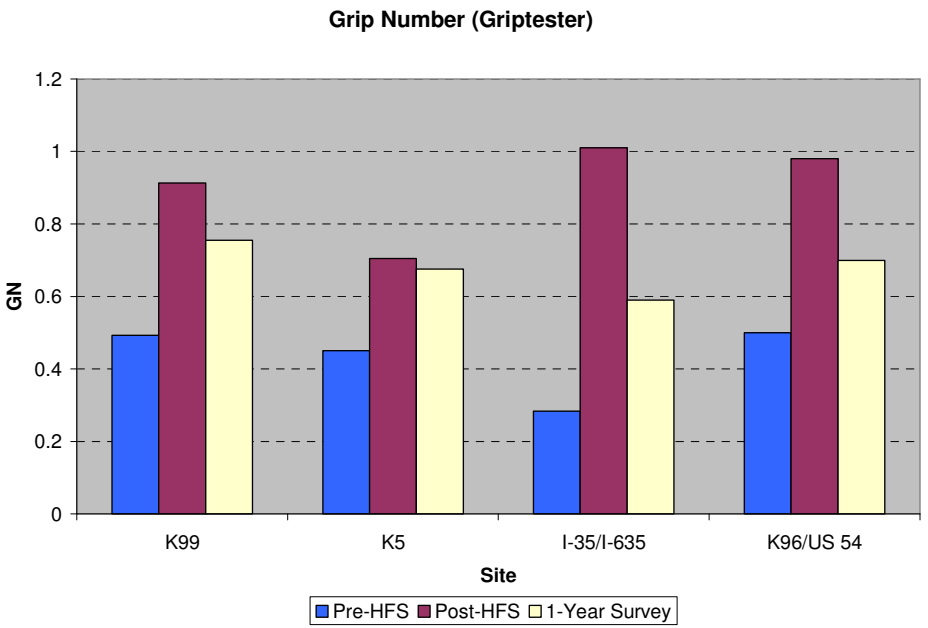
Kansas

Kansas

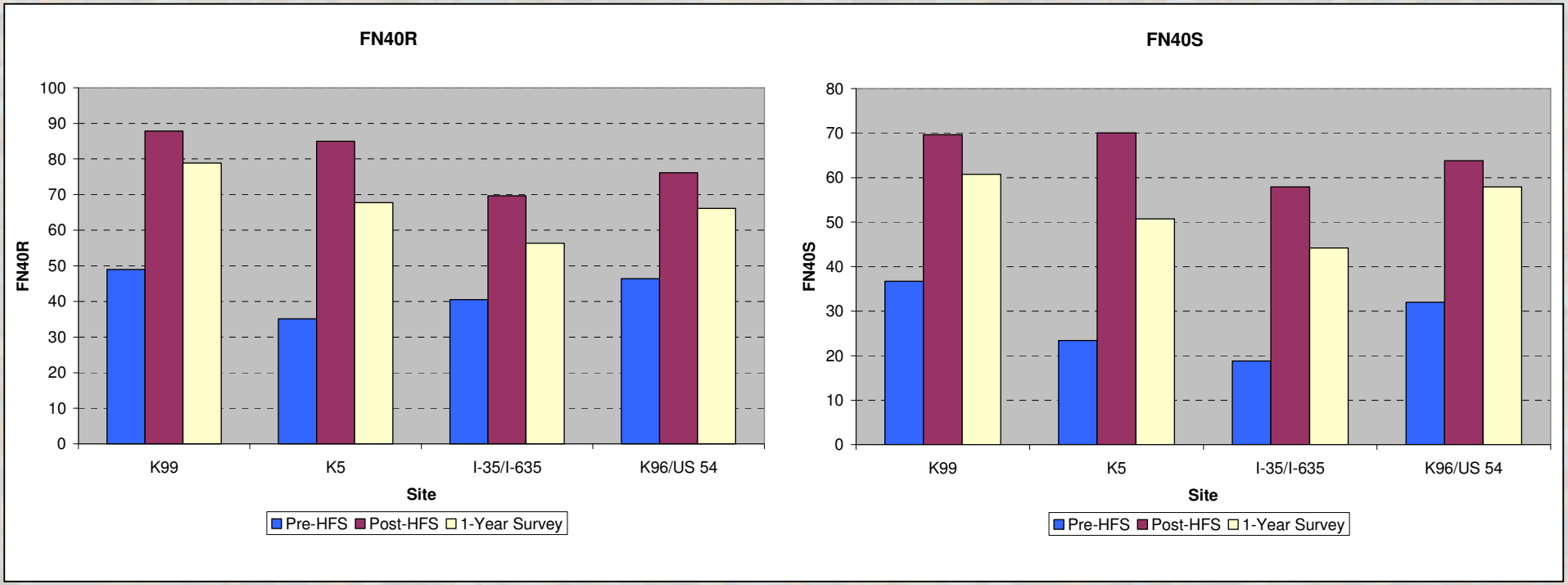

Mean Profile Depth (CTM)
MPD (mm)
3
2.5
2
1.5
1
0.5
0
K99
K5
I-35/I-635
K96/US 54
Site
Pre-HFS
Post-HFS
1-Year Survey


Mean Texture Depth (ASTM E965)
MTD (mm)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
K99
K5
I-35/I-635
K96/US 54
Site
Pre-HFS
Post-HFS
1-Year Survey


20 kph Friction Value (DFT)
DFT(20)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
K99
K5
I-35/I-635
K96/US 54
Site
Pre-HFS
Post-HFS
1-Year Survey


Grip Number (Griptester)
GN
1.2
1
0.8
0.6
0.4
0.2
0
K99
K5
I-35/I-635
K96/US 54
Site
Pre-HFS
Post-HFS
1-Year Survey

Kansas – Skid Trailer



Kansas – OBSI (~8 months old)

Site	Overall OBSI Levels (dBA)	
	Abutting HMA	HFS
K99 NB	**98.8**	**100.1**
K99 SB	**98.7**	**100**

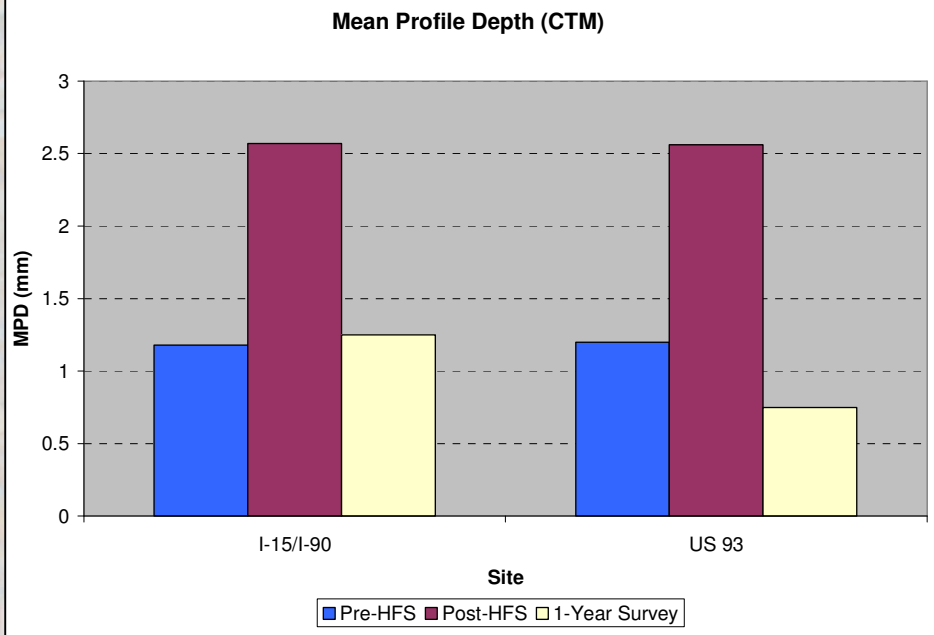
Kansas - performance

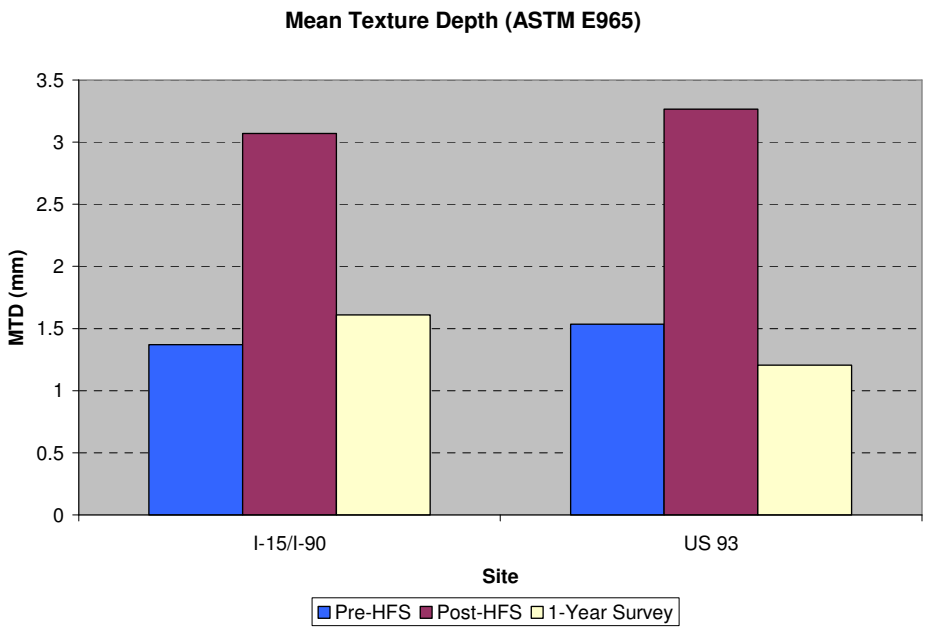
Montana

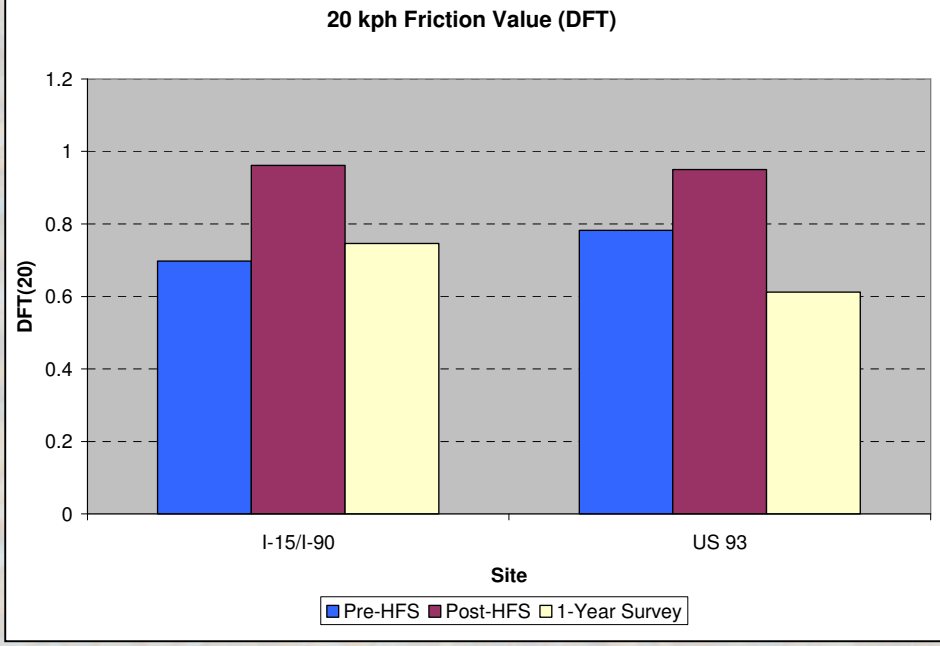
- HFS Vendor/Product: POLYCARB/SAFETYGRID
- Aggregate: Crushed Flint
- Projects:
  - I-15/I-90 ramp, Butte (Chip Seal)
  - US 93 SB, Missoula (Chip Seal)

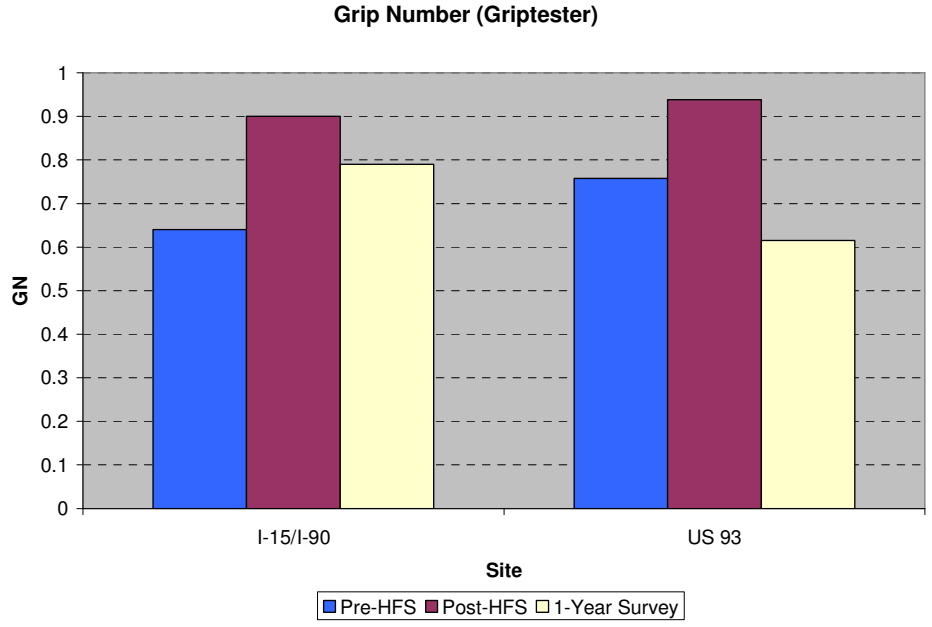
Montana

Montana

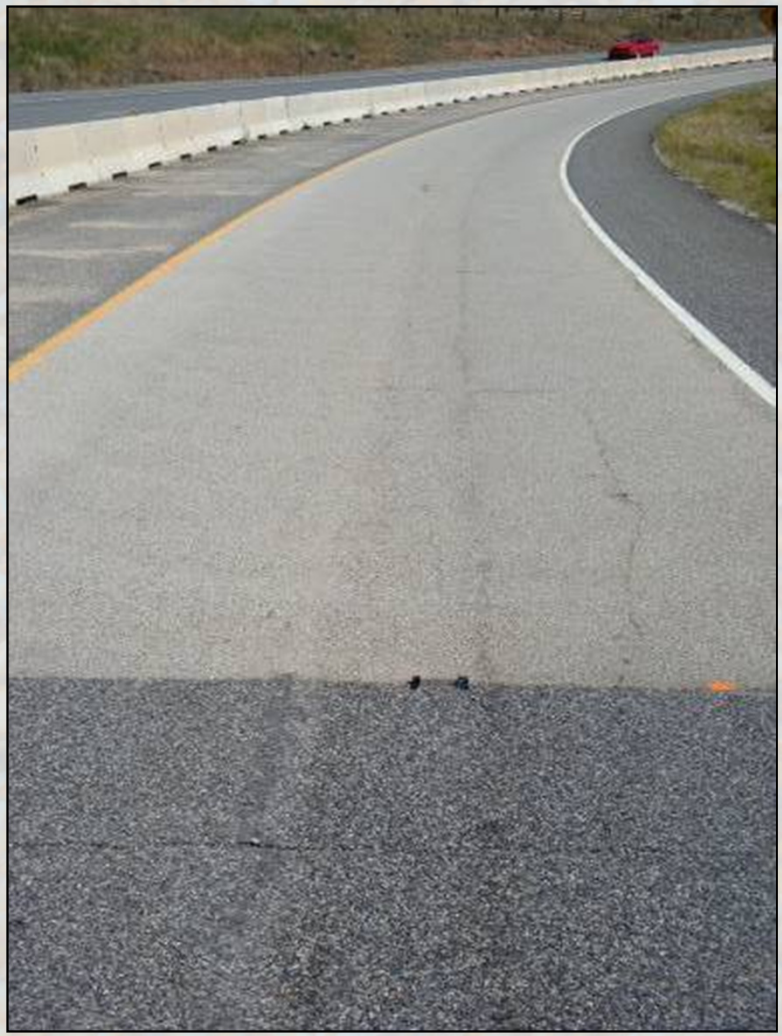

Mean Profile Depth (CTM)
MPD (mm)
3
2.5
2
1.5
1
0.5
0
I-15/I-90
US 93
Site
Pre-HFS
Post-HFS
1-Year Survey


Mean Texture Depth (ASTM E965)
MTD (mm)
3.5
3
2.5
2
1.5
1
0.5
0
I-15/I-90
US 93
Site
Pre-HFS
Post-HFS
1-Year Survey


20 kph Friction Value (DFT)
DFT(20)
1.2
1
0.8
0.6
0.4
0.2
0
I-15/I-90
US 93
Site
Pre-HFS
Post-HFS
1-Year Survey


Grip Number (Griptester)
GN
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
I-15/I-90
US 93
Site
Pre-HFS
Post-HFS
1-Year Survey

Montana - performance

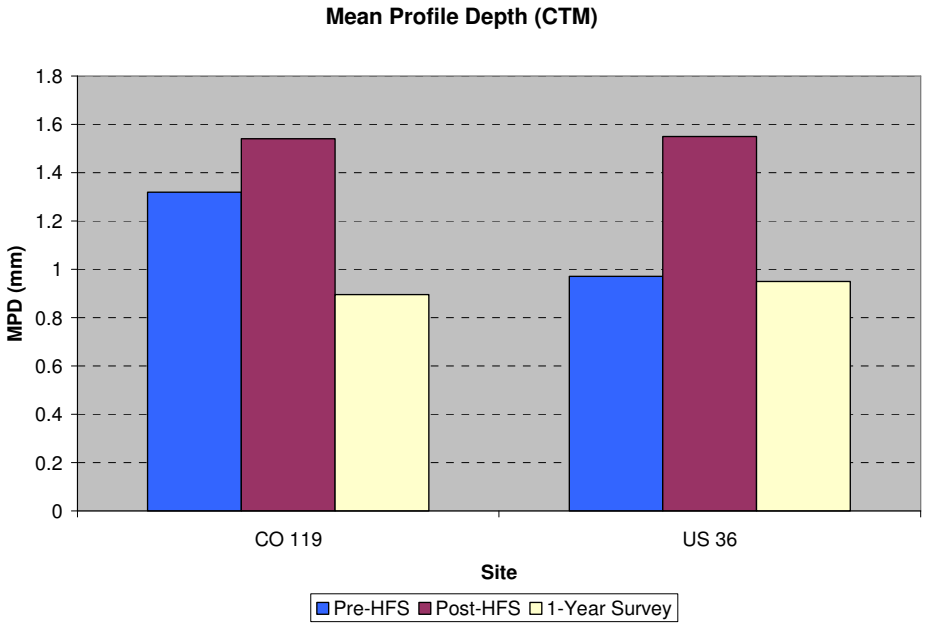


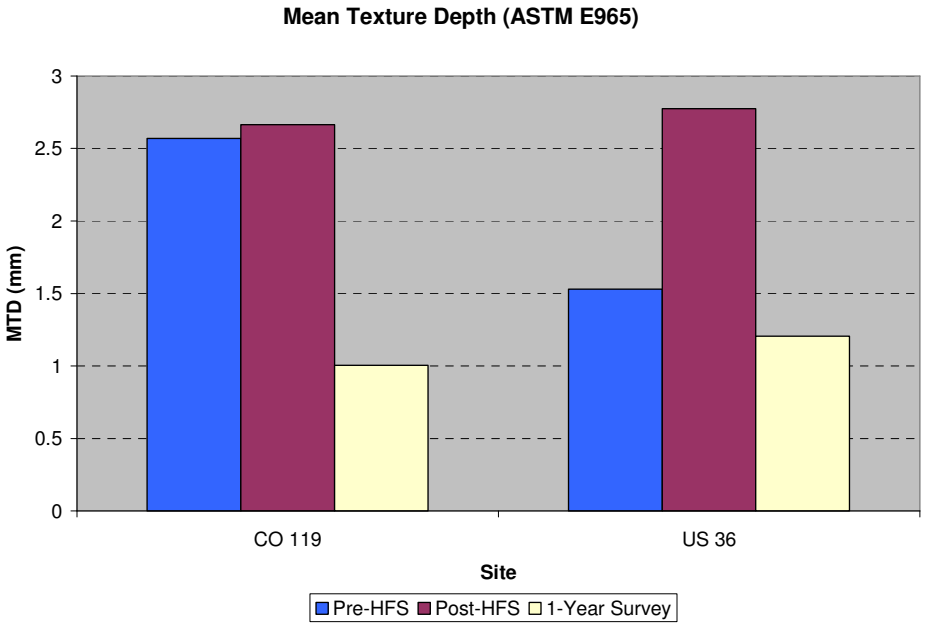
Colorado

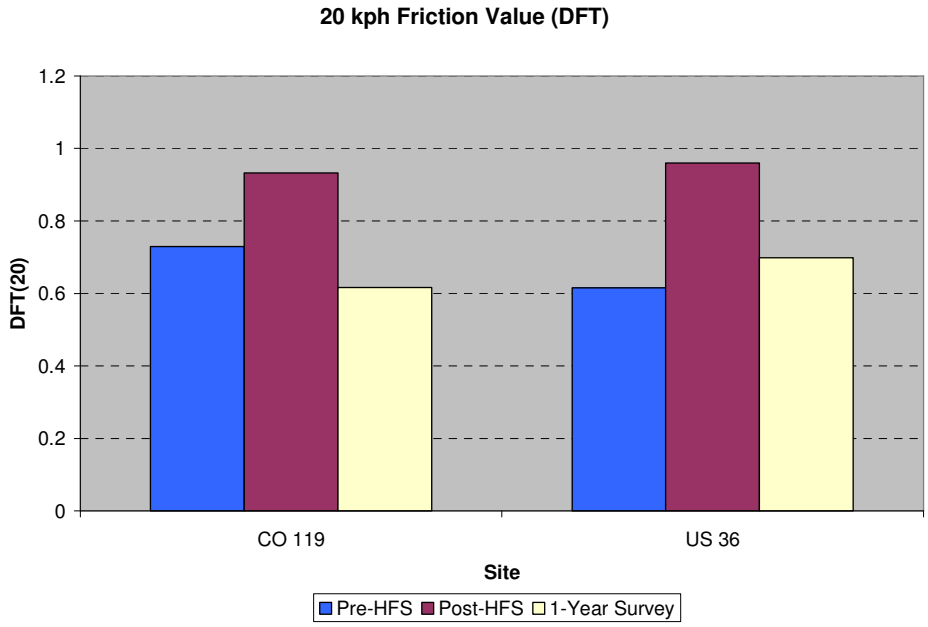
- HFS Vendor/Product: Crafco/Crafco HFS
- Aggregate: Crushed Flint
- Projects:
  - US 36, Lyons (HMA)
  - SR 119, Boulder Canyon (HMA)
  - I-25 NB, Pueblo (HMA)
  - I-25 SB, Pueblo (HMA)
  - HFS installations on I-25 were removed during a mill and overlay of I-25 due to deterioration of the underlying pavement.

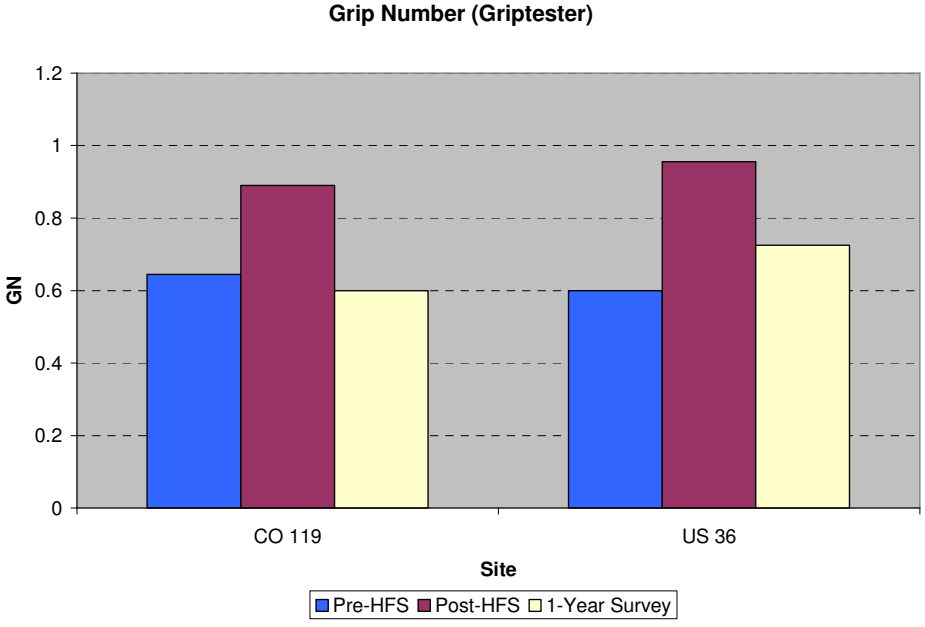
Colorado

Colorado


Mean Profile Depth (CTM)
MPD (mm)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
CO 119
US 36
Site
Pre-HFS
Post-HFS
1-Year Survey


Mean Texture Depth (ASTM E965)
MTD (mm)
3
2.5
2
1.5
1
0.5
0
CO 119
US 36
Site
Pre-HFS
Post-HFS
1-Year Survey


20 kph Friction Value (DFT)
DFT(20)
1.2
1
0.8
0.6
0.4
0.2
0
CO 119
US 36
Site
Pre-HFS
Post-HFS
1-Year Survey


Grip Number (Griptester)
GN
1.2
1
0.8
0.6
0.4
0.2
0
CO 119
US 36
Site
Pre-HFS
Post-HFS
1-Year Survey

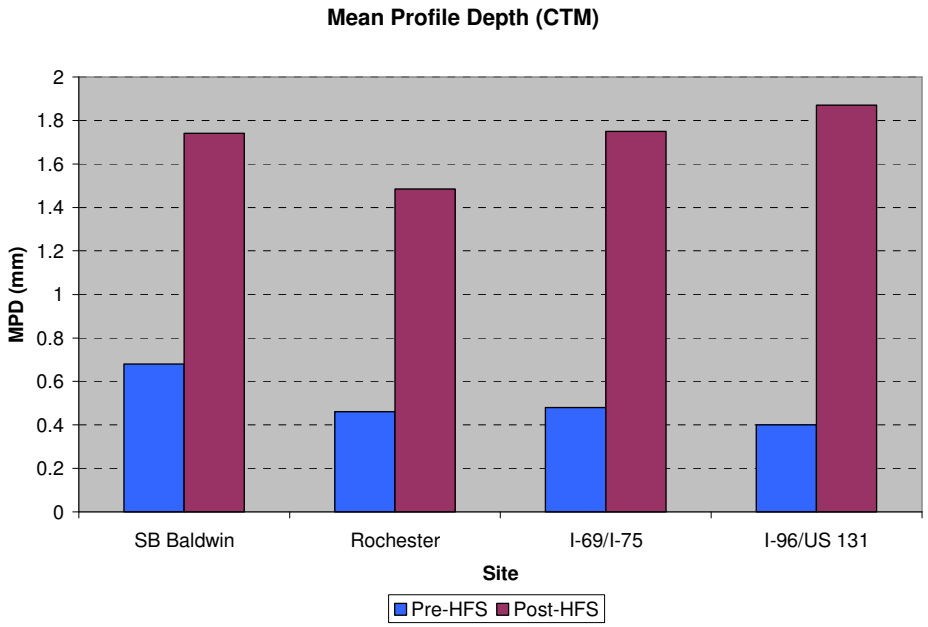
Colorado - performance

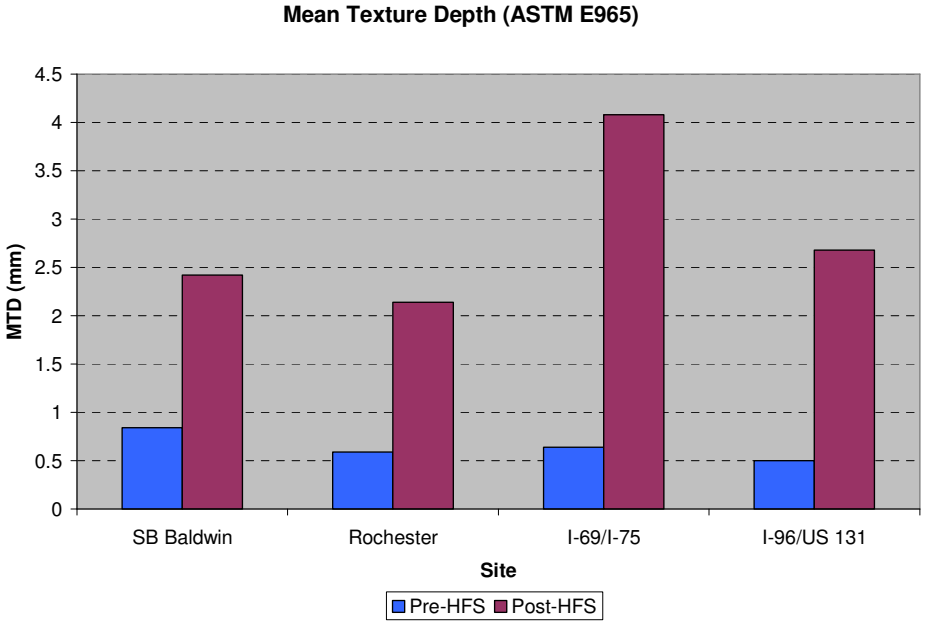
Michigan

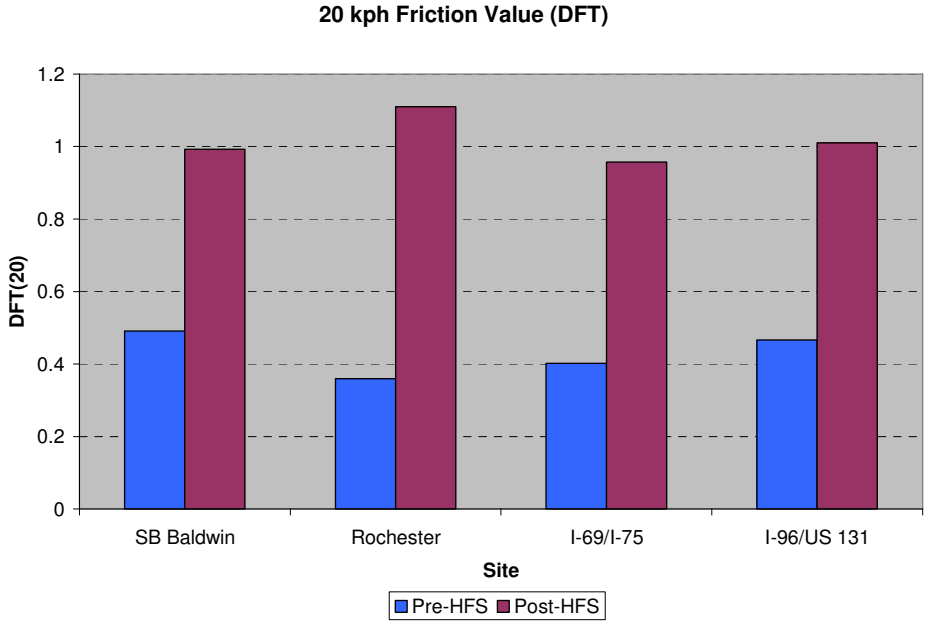
- HFS Vendor/Product: POLYCARB/SAFETYGRID
- Aggregate: Calcined Bauxite and Crushed Flint
- Projects:
  - NB I-75 to NB Baldwin Rd. ramp, Auburn Hills (PCC)
  - NB I-75 to Rochester Rd. ramp, Auburn Hills (HMA)
  - WB I-69 to SB I-75 ramp, Flint (PCC)
  - WB I-96 to NB US 131 ramp, Grand Rapids (PCC)

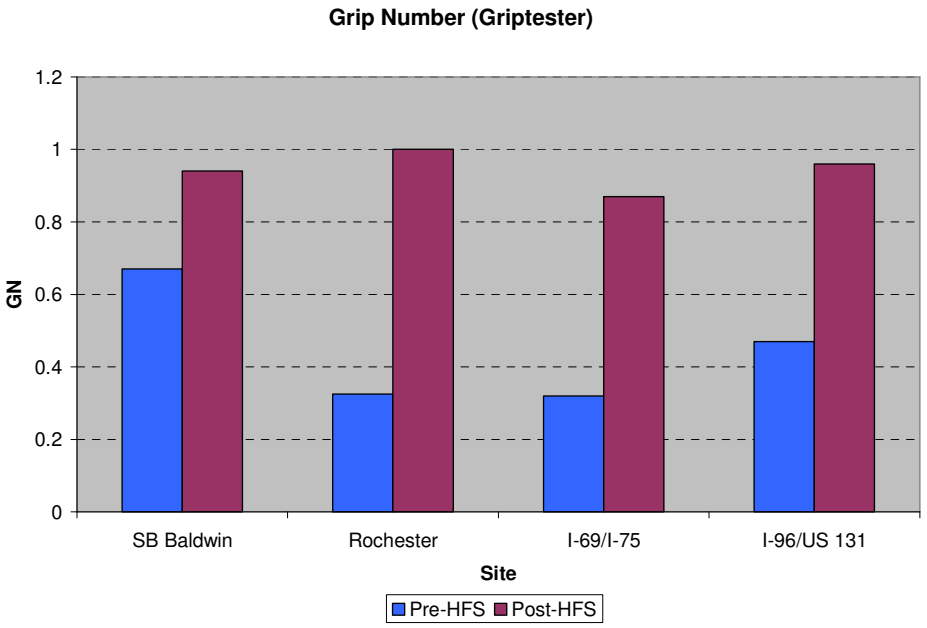
Michigan

Michigan


Mean Profile Depth (CTM)
MPD (mm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
SB Baldwin
Rochester
I-69/I-75
I-96/US 131
Site
Pre-HFS
Post-HFS


Mean Texture Depth (ASTM E965)
MTD (mm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
SB Baldwin
Rochester
I-69/I-75
I-96/US 131
Site
Pre-HFS
Post-HFS


20 kph Friction Value (DFT)
DFT(20)
1.2
1
0.8
0.6
0.4
0.2
0
SB Baldwin
Rochester
I-69/I-75
I-96/US 131
Site
Pre-HFS
Post-HFS


Grip Number (Griptester)
GN
1.2
1
0.8
0.6
0.4
0.2
0
SB Baldwin
Rochester
I-69/I-75
I-96/US 131
Site
Pre-HFS
Post-HFS

North Carolina

- HFS Vendor/Product: Ennis Paint/Tyregrip
- Aggregate: Calcined Bauxite
- Projects:
  - US 311 to I-40 ramp, Winston-Salem (HMA)
  - HFS installation was removed during the milling an overlay of the existing pavement due to deterioration of the underlying pavement.

North Carolina

General Observations

- Underlying pavement must be in good condition – no alligator/block/map cracking
- HFS products used to date have adhered well to all pavement types – HMA, Chip Seal, and PCC
  - PCC pavement must be shotblast prior to application
  - Cracks will reflect through regardless of the pavement type
- HFS naturally "sheds" aggregate for the first few weeks/months after installation
- HFS performs well under snowplow wear, but not studded tires

Surface Enhancements At Horizontal Curves (SEAHC) - Project Status

- Monitoring and Testing of Completed Installations
  - Most evidence of crash reduction is antidotal at this point
  - Continuously monitor performance (via local DOT feedback)
  - Re-test sites after 1 year (Michigan in 2011) for friction and texture
  - DOT to monitor crash rates over 3 year period (ending in 2012-2013)
- Pavement Performance Issues
  - Underlying pavement performance issues in NC and CO led to removal of the HFS
  - Will affect site selection criteria for future installations

Surface Enhancements At Horizontal Curves (SEAHC) - Summary

- To Date: 18 installations in 6 states using 3 different HFS vendors
- Participating State DOTs have enthusiastically embraced HFS as a cost-effective method for enhancing safety at horizontal curves
- HFS vendors are continually seeking to improve application equipment and installation practices
- HFS vendors have been extremely supportive and are the key element to the successful projects to date
- FHWA continues to support HFS as a solution for enhancing safety on pavement surfaces


THANK
YOU!