An update on HFST for Horizontal Curves

Pavement Evaluation 2014

Blacksburg, Virginia

17 September 2014

David Merritt - *The Transtec Group, Inc.*

Mike Moravec - *FHWA*

U.S.Department of Transportation

Federal Highway Administration

THE TRANSTEC GROUP

The World's Pavement Engineering Specialists

HighFrictionRoads.com

Overview

- What are High Friction Surfaces?
- HFST for Horizontal Curves
- SEAHC Demonstration Project Program
- General Recommendations
- Summary

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What are High Friction Surface Treatments?

- High Friction Surface Treatments (HFST) are pavement surfacing systems with exceptional skid-resistant properties that are not typically acquired by conventional materials
- Generally proprietary polymeric resin-based products and processes
- Guidelines Document from the British Board of Agrément (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."

HFST Materials

- Binder system (proprietary blends)
  - Bitumen-extended epoxy resins
  - Epoxy-resin
  - Polyester-resin
  - Polyurethane-resin
  - Acrylic-resin
  - MMA

HFST Materials

- Aggregates
  - Generally calcined bauxite, but flint/chert, slags, granite, and other materials with *high abrasion and polish resistance* have also been used
  - Generally 3-4 mm maximum size

HFST Finished Product

HFST Installation

- Manually
  - Manual mixing of binder resin material
  - Manual application of resin with squeegee
  - Hand broadcast and distribution of aggregate
  - Production rates: 200-500+ SY/hr.

HFST Installation

- Semi-Automated
  - Machine mixing with hand application of resin binder
  - Machine-aided broadcast/application of aggregate
  - Production rates up to 2,000+ SY/hr.

HFST Installation

- Fully-Automated
  - Machine mixing and application of binder resin
  - Machine broadcast/application of aggregate
  - Production rates up to 2,300+ SY/hr.

What are HFST used for?

- Bridge Decks
- Pavements with poor friction, particularly in wet conditions
- Intersections/Approaches
- Steep Grades
- Roundabouts
- Bus Stops
- Pedestrian Walkways
- **Non-Tangent Pavement Sections**

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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)

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."

U.S. Department of Transportation
Federal Highway Administration

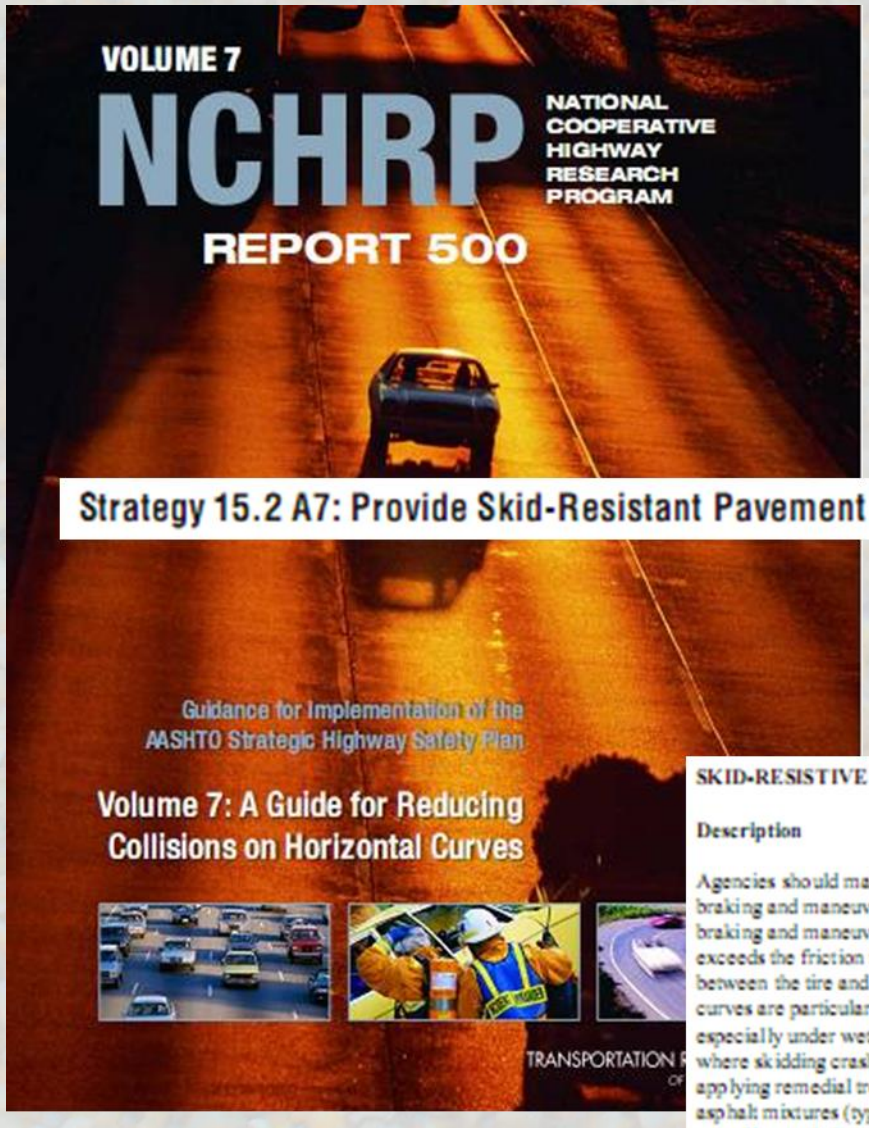
Technical Advisory

Subject
Pavement Friction Management

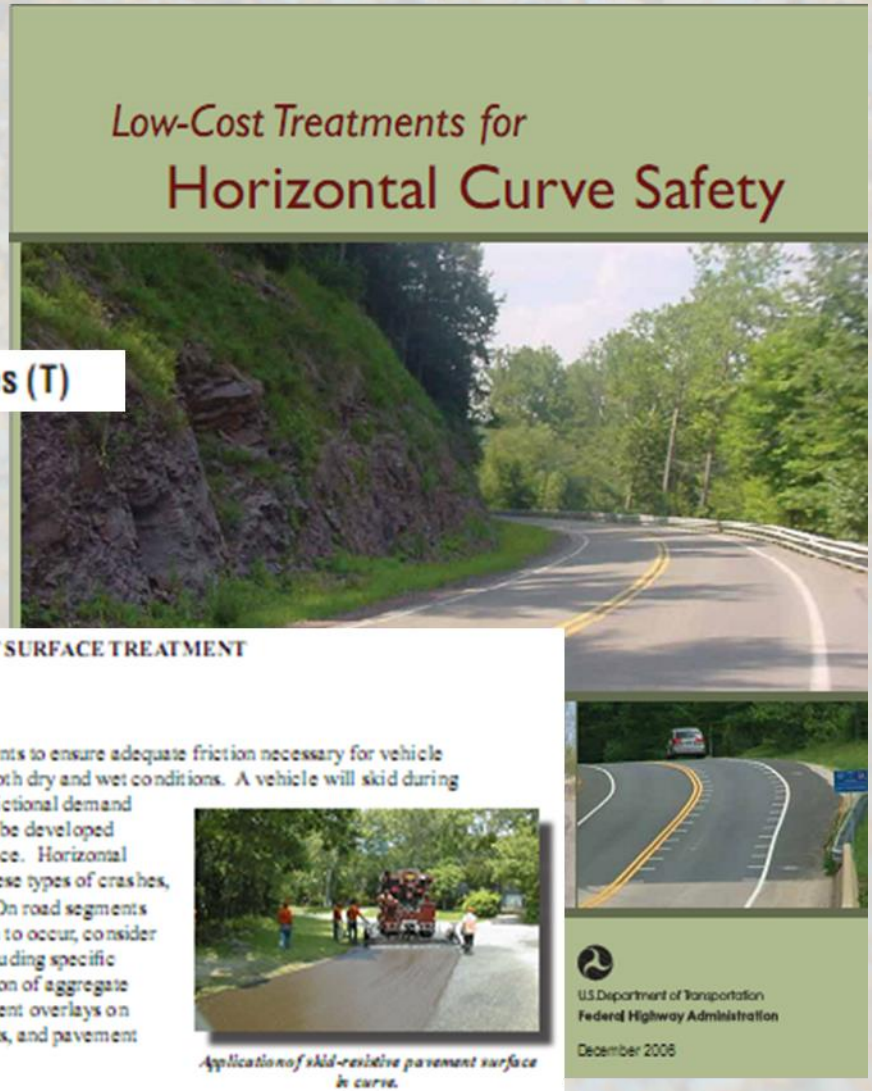
Classification Code	Date	Office of Primary Interest
T 5040.38	June 17, 2010	HIPT-20

"Research has shown that curves and intersections tend to lose friction at a faster rate than other roadway locations and thus justify a higher friction demand."

Crashes at Horizontal Curves



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



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.

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FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- Goals of SEAHC:
  - Demonstrate the effectiveness of HFST in enhancing/restoring friction to reduce lane departure crashes at horizontal curves (and ramps).
  - Measure the properties of HFST and monitor changes and performance over first year
  - Monitor crashes before and after HFST application
- Utilize currently available HFST products
- 3+ year study for each site
- Generally 1-5 sites per State
- **Recent demonstrations funded by EDC2**

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- 32 Installations in 14 States
  - Installation, Testing, Monitoring: 25
  - Testing Only: 7
- Site Type
  - Curves on Grade: 19
  - Ramps/Connectors: 13
- Location Type:
  - Rural: 15
  - Urban: 17
- Traffic (AADT): 2,230 to 72,000

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- 6 Different HFST products (resin binders)
  - Calcined Bauxite aggregate (4 sources)
  - Flint aggregate (1 source)
- 5 Pavement types
  - PCCP
  - Conventional dense-graded HMA
  - Stone Matrix Asphalt
  - Chip Seal
  - Open Grade Friction Course

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

Site Locations – The ~~Good~~, Bad, Ugly

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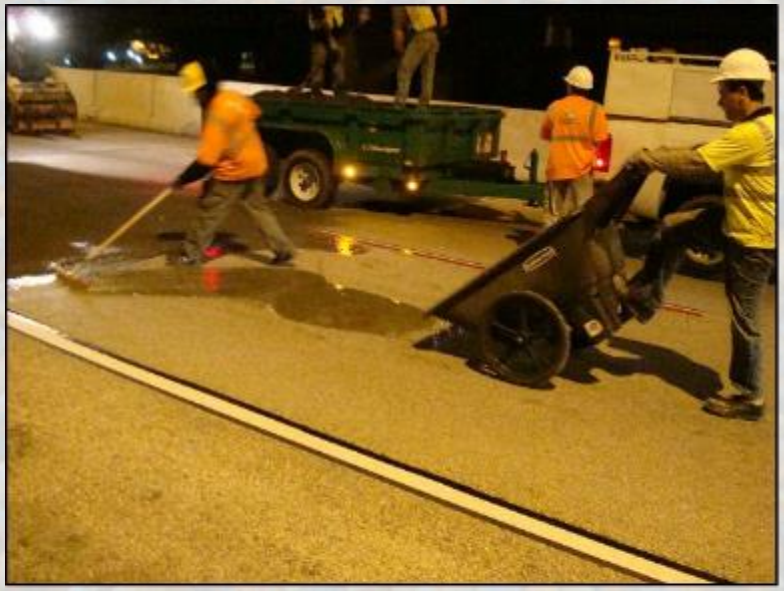
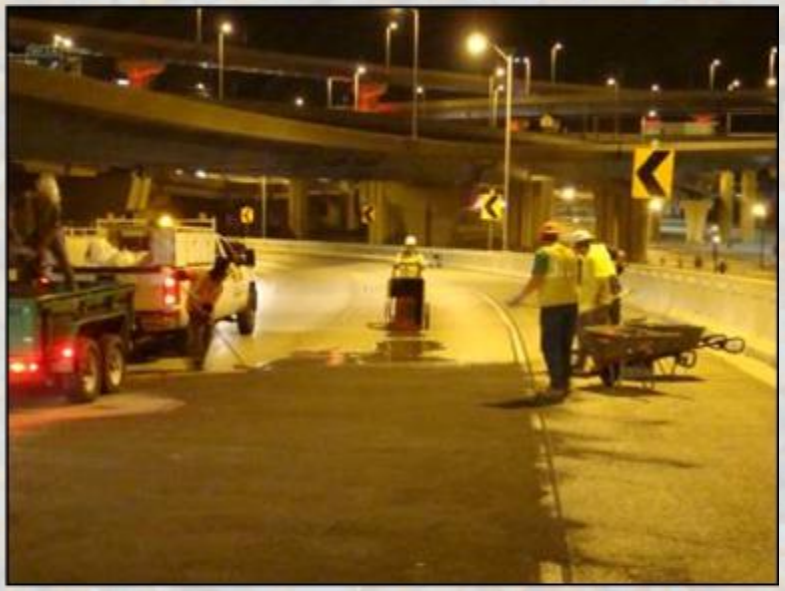
Site Locations – The ~~Good~~, Bad, Ugly

Installation – Manual





Installation – Semi-Automated

Installation – Fully Automated

Installation – County Forces

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)

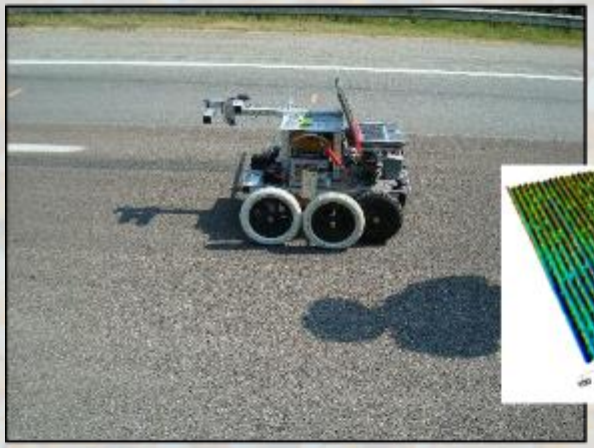
Griptester

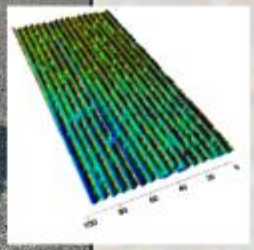
Highway Friction Tester (HFT)

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

Texture

Circular Track Meter (CTM) – MPD





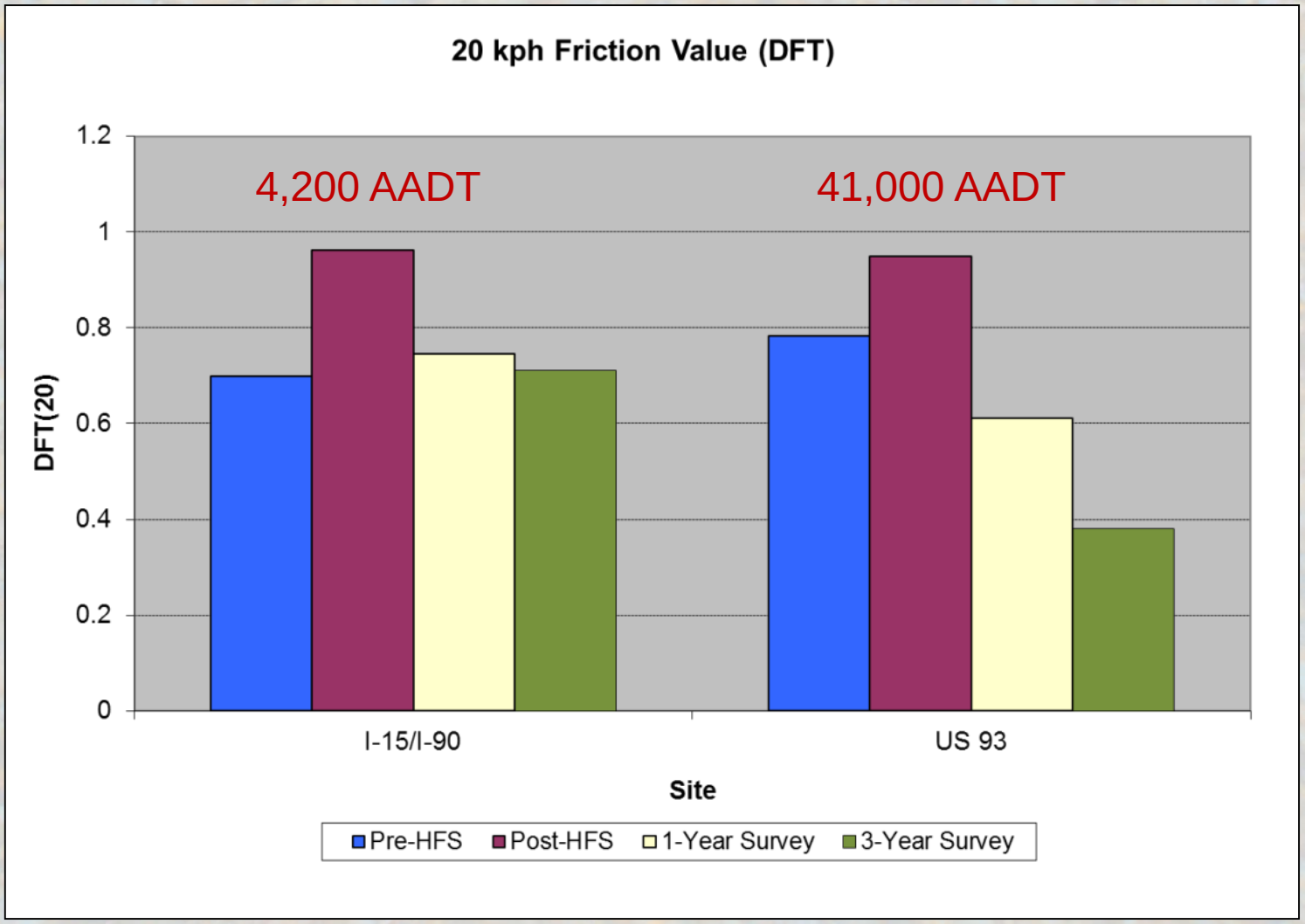
RoboTex – MPD

ASTM E965 (“Sand Patch”) – MTD

Performance

- No issues with delamination of HFST
- No extraordinary damage from snowplow wear
- 4 sites removed prior to 3 years in service due to failure of the underlying HMA pavement
- Wearing off of HFST under high traffic volumes

Performance - Effect of Traffic Volume



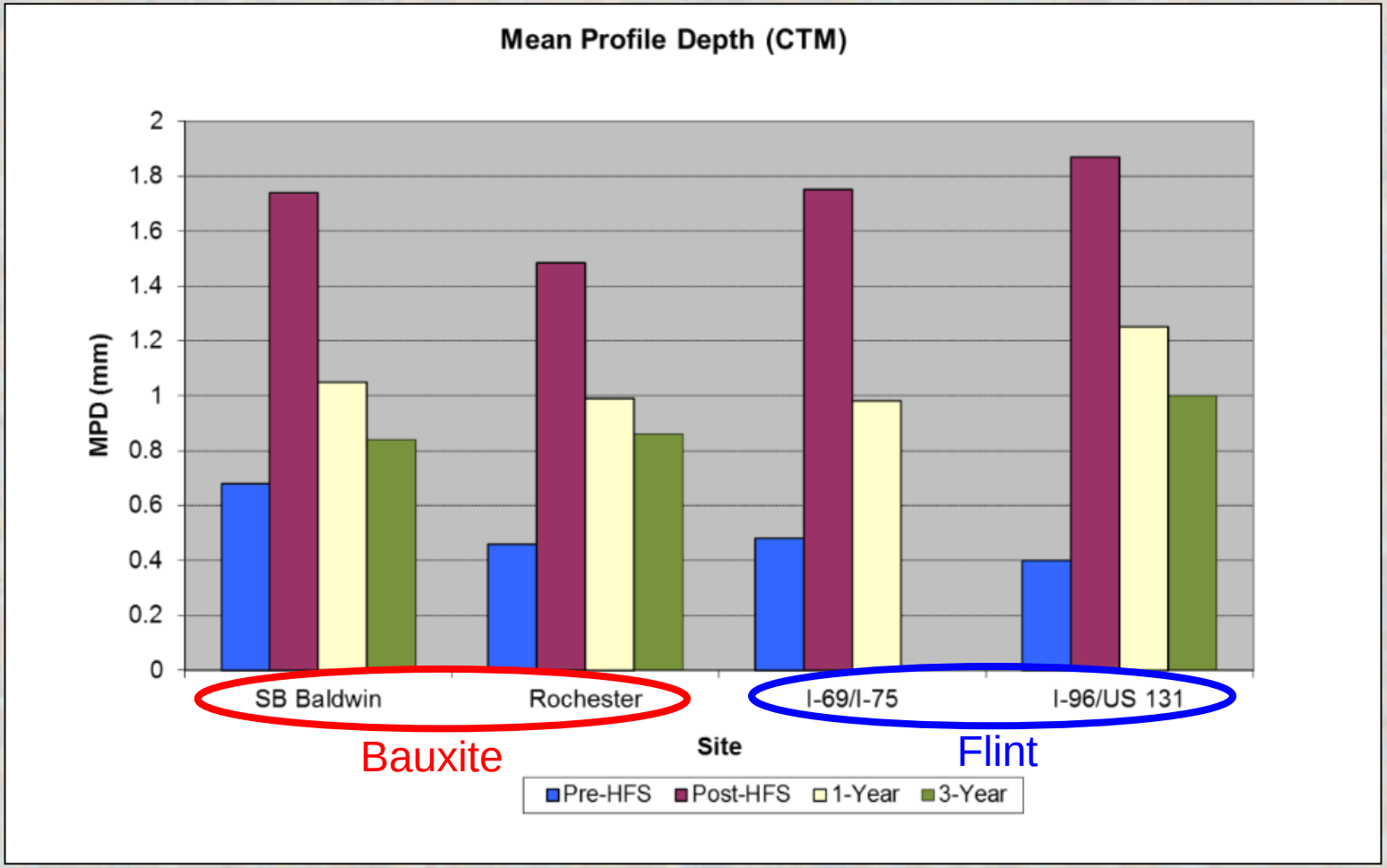
Performance - Effect of Traffic Volume

I-15/I-90:
HFS showing minimal wear
AADT: 4,200

US 93:
HFS worn off in wheelpaths
AADT: 41,000

Performance

- Calcined Bauxite tended to maintain higher friction numbers the best over time.



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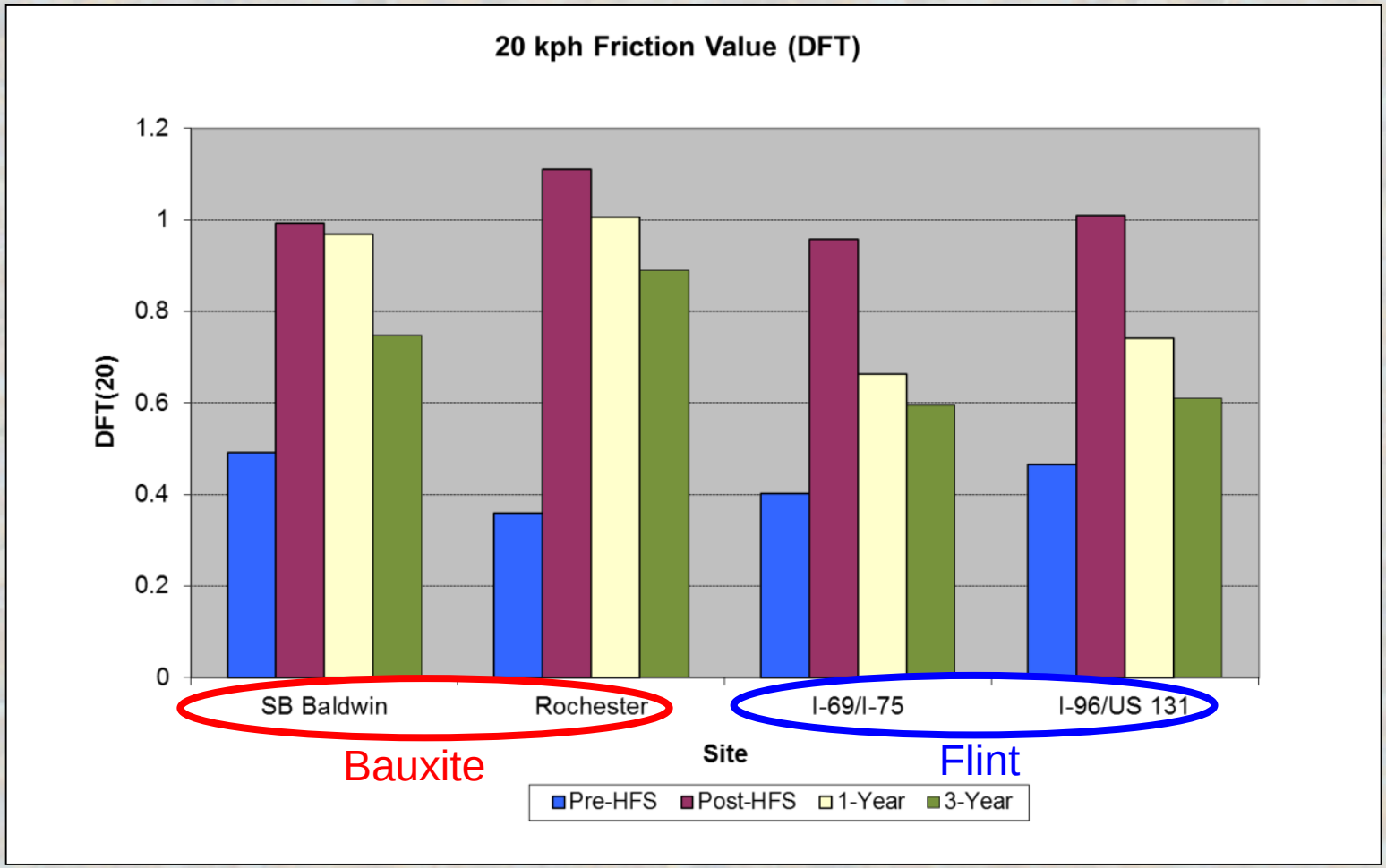
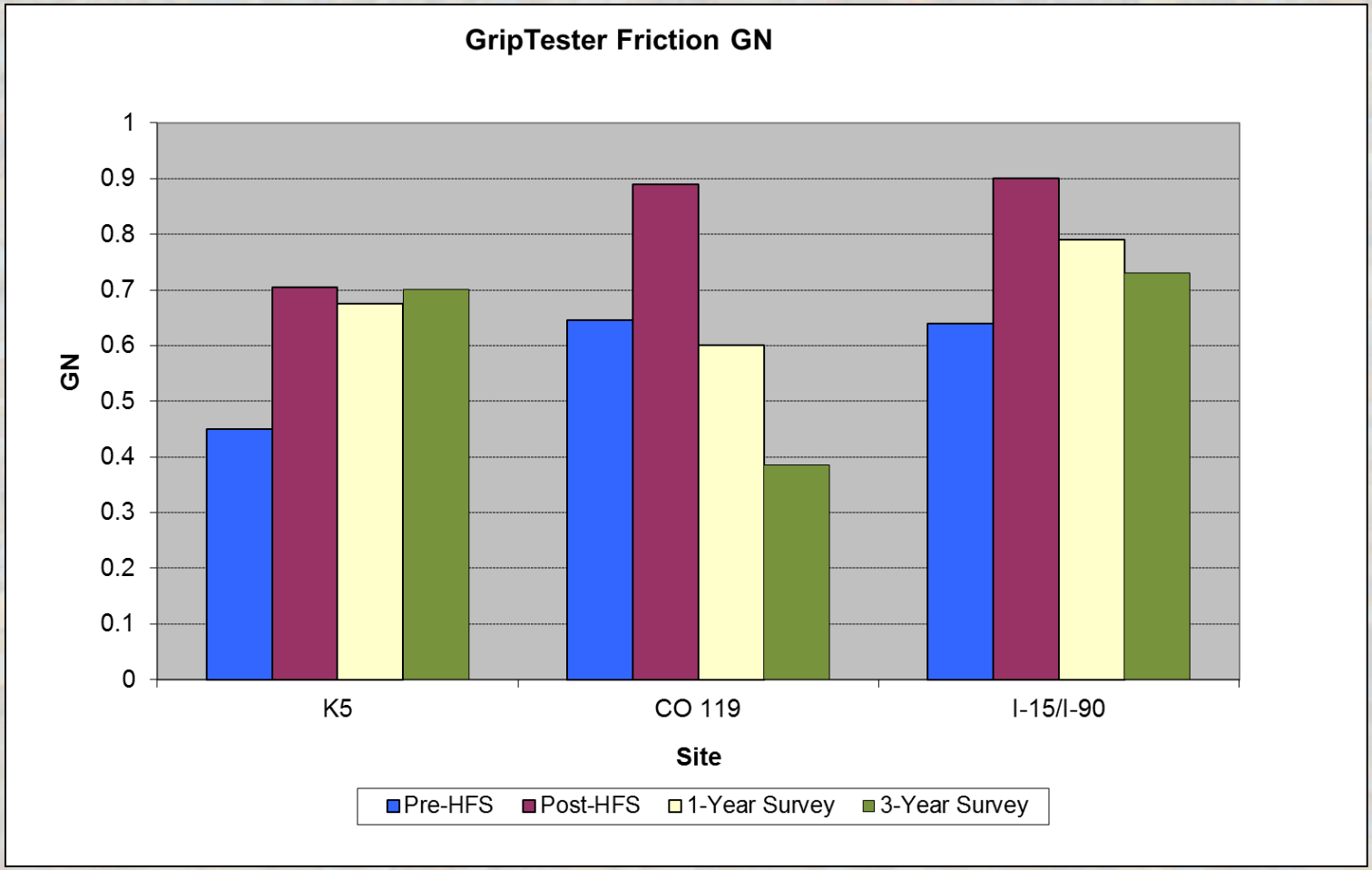


Performance

- Aggregate Size is important



Performance - Aggregate Size

Colorado Flint

Kansas/Montana Flint

Performance – Crash Reduction

- Aggregated Crash Data

State	Program	No. HFST Sites Installed	Crashes BEFORE	Crashes AFTER
KS	SEAHC	4	23	42
CO	SEAHC	2	6	5
MT	SEAHC	2	41	31
MI	SEAHC	5	49	31
WI*	SEAHC	1	231	3
CA*	SEAHC	1	181	10
OK	EDC2	2	22	TBD
AL	EDC2	2	30	TBD
WA	EDC2	2	17	TBD
	Total	**21**	**531****	**141****

**AFTER data is for ~15 month period following installation*
***Excludes OK, AL, WA; 3-year data extrapolated for CA, WI*

Performance – Crash Reduction

From ELCSI PFS Phase VI Study

- Two methodologies used for analysis:
  - Naïve Approach: simple before and after analysis
  - Comparison Group Approach: uses comparison sites to estimate crash reduction at treated sites
- Results*:

Methodology	Total Crashes		Wet Road Crashes	
	Curves	Ramps	Curves	Ramps
Naïve	0.628	0.484	0.373	0.211
Comparison Group	0.759	0.653	0.481	0.139

*Includes CMF correction factor of 1.25 from HSM

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General Recommendations

- HFST is NOT a pavement preservation treatment… It is a **SAFETY** treatment.
- HFST is most effective in reducing wet-weather crashes.
- HFST should be used where poor friction is suspected (not geometry or driver behavior).

NOTE: Conduct friction testing to confirm friction levels whenever possible.

General Recommendations

- Can be installed on virtually any pavement surface type, including chip seals and open-graded surfaces.
- Underlying pavement must be in good condition for long-term performance of HFST.
  - Asphalt Pavement: no fatigue-related distresses (alligator or block cracking, preferably no rutting.
  - Concrete Pavement: No map cracking or scaling; Deep spalls should (preferably) be repaired.

General Recommendations

- Treatment Limits
  - Treatment Length – ideally treat curves between points of tangency
  - Confirm extent of treatment limits with friction testing.
- Materials
  - Specify a binder resin that is appropriate for installation conditions.
  - Calcined Bauxite is the known high-performing aggregate recommended for most projects (other aggregates may be appropriate for lower traffic volume projects).

General Recommendations

- Double layer may be necessary for high traffic volume roadways and OGFC pavements.
- Performance will be largely dictated by installation.
  - Proper surface preparation based on type and condition of pavement
  - Proper mixing and application of resin
  - Proper application of aggregate
  - Experience of installation contractor

Summary

- HFST vendors are continually seeking to improve application equipment and installation practices.
- HFST vendors have been extremely supportive and are the key element to the successful SEAHC and EDC2 projects to date.
- FHWA continues to support HFST as a solution for enhancing safety on pavement surfaces.
- ATSSA has provided an industry “home” for HFST
  - Developed an AASHTO Provisional Specification for its use.
  - Through FHWA EDC2, two videos on HFST are now available.

    YouTube: “FHWA/ATSSA – High Friction Surface Treatments”

HighFrictionRoads.com

FHWA.dot.gov/everydaycounts

www.atssa.com/resources/highfrictionsurfacing