Performance of High Friction Surfacing Demonstrations in the U.S.

7th Symposium on Pavement Surface Characteristics
19 September 2012

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Overview

• What are High Friction Surfaces?
• Why HFS for Horizontal Curves?
• SEAHC Demonstration Projects
• NCAT Aggregate Durability Study
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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 resin-based products and processes.

• Guidelines 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.”
HFS Materials

• Aggregates
  – Generally calcined bauxite or flint, but slags, granite, and other materials with high PSV have also been used
  – Generally 3-4 mm maximum size

Flint

Granite

Bauxite
HFS Materials

- Binder system (proprietary blends)
  - Bitumen-extended epoxy resins
  - Epoxy-resin
  - Polyester-resin
  - 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: 165-420+ m²/hr (200-500+ 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 1920 m²/hr (2,300 SY/hr.)
HFS Finished Product
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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 is approximately **three times** the crash rate of tangent sections
  – 69% rural
  – 71% on minor arterials (rural and urban)
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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 (and ramps).
  – 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 for each site
• Generally 1-5 sites per State
FHWA SEAHC Demonstrations

• 24 Installations in 10 States
  – Installation, Testing, Monitoring: 19
  – Testing Only: 5
• 5 Different HFS vendors
• 5 Pavement types
  – PCCP
  – Conventional dense-graded HMA
  – Stone Matrix Asphalt
  – Chip Seal
  – Open Grade Friction Course
FHWA SEAHC Demonstrations
FHWA SEAHC Demonstrations

• 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)
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
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 – PRELIMINARY Results

Mean Profile Depth (CTM)

Mean Texture Depth (ASTM E965)

20 kph Friction Value (DFT)

Grip Number (Griptester)

Flint

Bauxite

Site

SB Baldwin

Rochester

I-69/I-75

I-96/US 131

Pre-HFS

Post-HFS

1-Year
Michigan - performance
Wisconsin

- HFS Vendor/Product: Traffic Management USA / Safe-T-Grip
- Aggregate: Calcined Bauxite
- Projects:
  - EB I-94/I-794 to NB I-43 (Marquette Interchange W-N ramp)
  - SMA Pavement
Wisconsin - performance
Preliminary Crash Reduction Results

- **Michigan**
  - **Site 1**
    - 3 yr before: 26 crashes (8 wet)
    - 1 yr after: 4 crashes (1 wet)
  - **Site 2**
    - 3 yr before: 55 crashes (15 wet)
    - 1 yr after: 16 crashes (2 wet, 3 snow/ice)
  - **Site 3**
    - 3 yr before: 22 crashes (7 wet)
    - 1 yr after: 2 crashes (1 icy)
  - **Site 4**
    - 3 yr before: 25 crashes (12 wet)
    - 1 yr after: 3 crashes (1 wet, 1 icy, 1 alcohol)

Overall, 60% crash reduction in first year!
Preliminary Crash Reduction Results

- Wisconsin - Marquette Interchange W-N Ramp
  - “Ramp closed virtually every time it rains”
  - 2008-2010: 81 crashes (59 wet – 73%; 2 icy – 2%)
  - Since Sept. 2011: 2 crashes (dry conditions, driver inattention, truck lost control)
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NCAT Aggregate Durability Study

• Purpose: Test the durability of various aggregate types under the same conditions
  – Installed on similar sections NCAT Test Track on a curve
  – Installed by same HFS supplier using the same resin, crew, and equipment
  – Exposed to the same traffic and climatic conditions
• 2+ Million ESAL applications (April-October 2011)
• Laboratory Testing of smaller samples of each
• Aggregates Tested:
  – Granite, Bauxite, Flint: 30 m (100’) each
  – Basalt, Silica, Steel Slag, Emery, Taconite: 4.5 m (15’) each
NCAT Aggregate Durability Study
NCAT Aggregate Durability Study

HFS Installation Location

- N1 through N11 and S8 through S12 are structural sections
- All other sections have deep perpetual foundations
- Research cycle of construction shown by color

HFS Installation Location
NCAT Aggregate Durability Study

4.5 m (15')
- Taconite
- Emery
- Steel Slag
- Silica
- Basalt

30 m (100')
- Flint
- Bauxite
- Granite
NCAT Aggregate Durability Study

• Laboratory Testing

• Three Wheel Polishing Device
  – Friction and Texture tested at 70k and 140k cycles
  – 2 replicates for each aggregate type
NCAT – PRELIMINARY Test Track Results

Mean Profile Depth (CTM)

Mean Texture Depth (ASTM E965)

20 kph Friction Value (DFT)
NCAT – PRELIMINARY Laboratory Results

**HFS - lab CTM Summary**

- Mean Profile Depth (mm)
- Sample types: granite, bauxite, flint, basalt, silica, slag, emery, taconite
- Comparison between 70K and 140K

**HFS - lab DFT Summary**

- DFT (40 km/h)
- Sample types: granite, bauxite, flint, basalt, silica, slag, emery, taconite
- Comparison between 70K and 140K
SEAHC - General Observations

• Underlying pavement must be in good condition
  – No alligator/block/map cracking
  – Cracks will reflect through regardless of the pavement type

• HFS products used to date have adhered well to all pavement types – HMA/SMA, Chip Seal, OGFC, and PCC
  – PCC pavement must be shotblast and cleaned prior to application

• HFS naturally “sheds” aggregate for the first few weeks/months after installation
  – Friction and texture depth after measure installation artificially high
SEAHC - General Observations

• HFS appears to perform well under snowplow wear, but poorly under studded tires / chains.
  – Double-layer HFS may be necessary for these locations

• Calcined Bauxite is the “premium” aggregate for HFS, but other aggregates have also performed satisfactorily
  – Selection of aggregate should be governed by traffic and environmental conditions
SEAHC - Summary

• 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
• ATSSA has provide an industry “home” for HFS and is currently working on specifications for its use

ATSSA Webinar for HFS on October 10th