Long Term Performance Monitoring of High Friction Surfacing Treatments (HFST) Sites

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Introduction

- Roadway departure crashes on horizontal curves
  - 52% of the total traffic fatalities in the U.S. (FHWA, 2017).
  - Significantly related with friction and texture.
- High Friction Surface Treatments (HFST)
  - Proved to be an efficient countermeasure to reduce roadway departure crashes
  - Lacks long term performance evaluation nationwide.
- Research goals
  - Monitor the long-term performance of HFST sites
  - Analyze HFST benefits and costs at a national scale

Field Data Collection

- 36 HFST sites in 12 states
- 65 collection events each cycle
- October 2016 to October 2019
- Data collection devices
  - Grip Tester
  - AMES® high speed profiler
  - PaveVision3D laser imaging system

Grip Tester

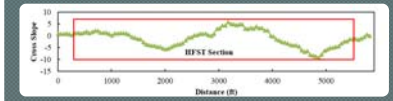
Pavision3D System

AMES® profiler

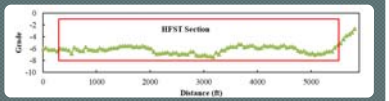
Map of HFST Sites

HFST Surface Characteristics

- Geometric information



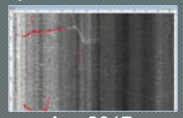
Cross Slope



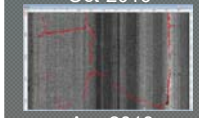
Grade

- Texture, roughness & friction
- Cracking development

Oct-2016

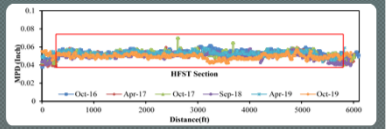


Apr-2017

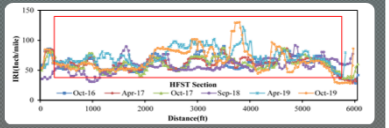


Apr-2019

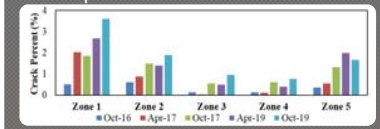
Oct-2019



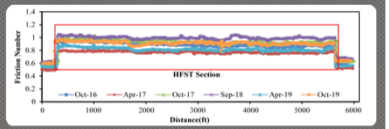
MPD



IRI



Crack development on OK-I-40-C-Site 2



Friction

HFST Surface Characteristics of SC-US-25-C

- Delamination development

Oct-2016

Oct-2017

Oct-2019

Delamination development on OK-I-40-C-Site 2

Indicators	Data Collections				
	Oct-16	Apr-17	Oct-17	Apr-19	Oct-19
Delamination Area (ft²)	83	138	140	279	303
Ratio of Delamination Area (%)	0.70	1.17	1.19	2.37	2.57

Friction Model

Variable Category	Symbol	Mean	Range	Estimate Coefficient	Std. Error	t value	P-value	Sig. Level
	(Intercept)	/	/	3.127	0.249	12.565	< 2e-16	***
Pavement	Treatment Age (Years)	3.50	[0.10, 10.20]	-0.052	0.014	-3.632	8.7e-9	***
	MPD (inch)	0.10	[0, 0.40]	1.84	1.069	1.716	0.087	.
Traffic	AADT (1000 vehicles)	7.29	[0.50, 39.69]	0.024	3.4e-3	5.916	0.000	***
	Curve Radius (1000 ft)	0.870	[0.20, 3.300]	-0.063	4.1e-2	-1.532	0.127	
Geometry	Cross Slope (°)	3.70	[-7.7, 12.4]	-0.007	0.005	-1.541	0.124	
	Longitudinal Grade (°)	1.90	[-5.3, 7.7]	0.014	0.008	1.633	0.103	
Environment	Precipitation (inch)	44.40	[30, 60]	-0.020	0.004	-4.667	4.6e-6	***
	Air Freezing Index (°F Days)	978.6	[400, 2000]	-3.0e-4	7.0e-5	-4.250	2.8e-5	***

Notes: (1) Significance codes: 0 - '***', 0.001 - '**', 0.01 - '*', 0.05 - '.', 0.1 - ' '; (2) Multiple R-squared: 0.2597, Adjusted R-squared: 0.2405; (3) F-statistic: 13.55 on 8 and 309 DF, p-value: <2.2e-16.

Crash Model

Variable Category	Symbol	Estimate Coefficient	Std. Error	t value	P-value	Sig. Level
	(Intercept)	1.148	2.307	0.498	0.618	
Pavement	Shoulder Existence	1.67	0.7086	2.357	0.018	*
	Median Existence	-5.79	1.3	-4.455	8.39e-6	***
	No. of Lanes	2.548	0.6627	3.845	1.2e-4	***
	MPD (in.)	-50.41	21.16	-2.382	0.017	*
	Friction	-2.636	0.8648	-3.048	0.002	**
Traffic	log(AADT)	1.508	0.2571	5.864	4.51e-9	***
	Pattern (Urban)	-3.858	0.8405	-4.59	4.44e-6	***
	Speed Limit (mph)	-0.1218	0.03487	-3.492	4.79e-4	***
Geometry	Curve Radius (ft)	0.001186	0.0005189	2.286	0.022	*
	Longitudinal Grade (%)	0.1202	0.06392	1.88	0.060	.
Environment	Precipitation (in.)	-0.1025	0.02755	-3.72	1.99e-4	***

Notes: Significance codes: 0 - '***', 0.001 - '**', 0.01 - '*', 0.05 - '.', 0.1 - ' '; (2) 2 x log-likelihood: -431.711

Crash Reduction and Benefit-Cost Analysis

- The HFST systems could achieve crash reductions of 37% to 100% by comparing crash numbers before and after the installation.
- By comparing benefits, which are estimated based on crash reductions that avoided possible injury and property damage, with the cost of HFST construction, 91.6% of the sites achieve the benefit-cost ratios equal to or greater than 1.

Conclusions

- HFST sites continue functioning with much higher friction numbers and slightly higher MPD values compared to non-treated surfaces.
- The life expectancy of HFST can last at least up to 11 years if the installation was properly applied.
- Cracks on the existing pavement surfaces gradually propagated to the HFST layers over time.
- Treatment age, MPD, AADT, precipitation, and air freezing index are significant factors in friction model.
- The presence of median, higher MPD, higher pavement friction, and urban traffic pattern has a positive contribution to reducing the crash number, while the increase in the number of pavement lanes may result in a higher crash number.
- The application of HFST is a cost-effective measure to reduce the crash probability, especially on tight crash-prone curves.

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