



**ADOT**

Transportation Systems Management and Operations



MCDOT High Friction Surface Treatment  
Before & After Studies  
HSIP Funded Pilot Project

2022 ASU Material Conference  
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# FHWA Every-Day Count-EDC5 Reducing Rural Roadway Departures

Every year, nearly **12,000** people die in crashes when their car leaves its travel lane on a rural road.



In 2015, there were **6.3 million** crashes reported across the nation,

**35,092** Fatalities and  
**2.44 million** Injuries,

More than **one half of the 2015 fatalities** were **roadway departure crashes**.





# FHWA Roadway Departure Safety Program

According to Fatality Analysis Reporting System (FARS):

23% of fatal crashes occurred on Horizontal curves, yet Horizontal curves make up only 5 % of our Nation's roadways.

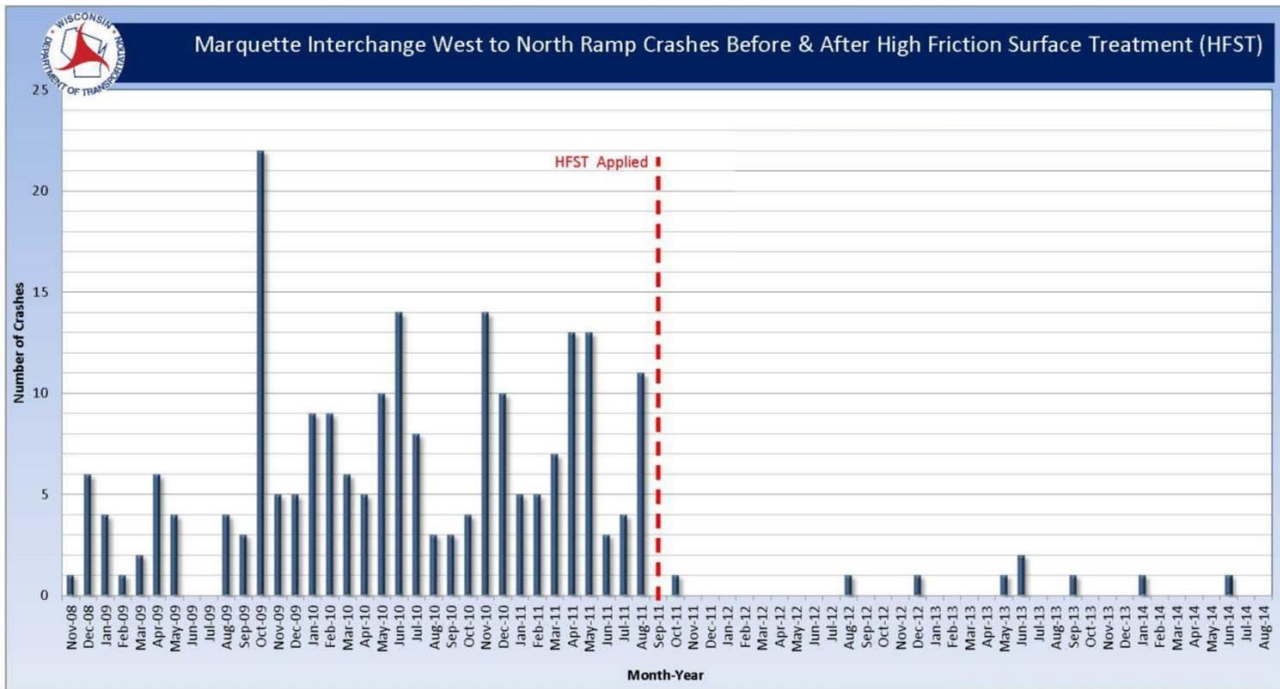


# Losing Control of your vehicle causes ROR crashes



**U.S. Highway 60 – State Route 101**

# Caution When It Rains



**Before HFST (3 year): 219 crashes**

**After HFST (3 year): 9 crashes**

**96% crash reduction**



# Open Graded Asphalt Friction Course vs High Friction surface Treatment

***Open Graded Friction Course OGFC:*** Primarily composed of single size standard coarse aggregate, and high asphalt content with high percentage of air voids. It Provides a higher degree of friction as well as permeability to the surface of the pavement. *Used on urban highways*

***High friction surface treatments (HFST):*** is a pavement treatments application utilizing Calcined bauxite an extremely hard aggregate polish resistant varying in size and angularity sprayed over a thin layer of Binder course. Designed to provide high friction values to help reduce serious crashes, during wet & dry conditions.

# HFST Components

Aggregate: Calcined Bauxite



Binder: Polymer Resin & or Epoxy Resin

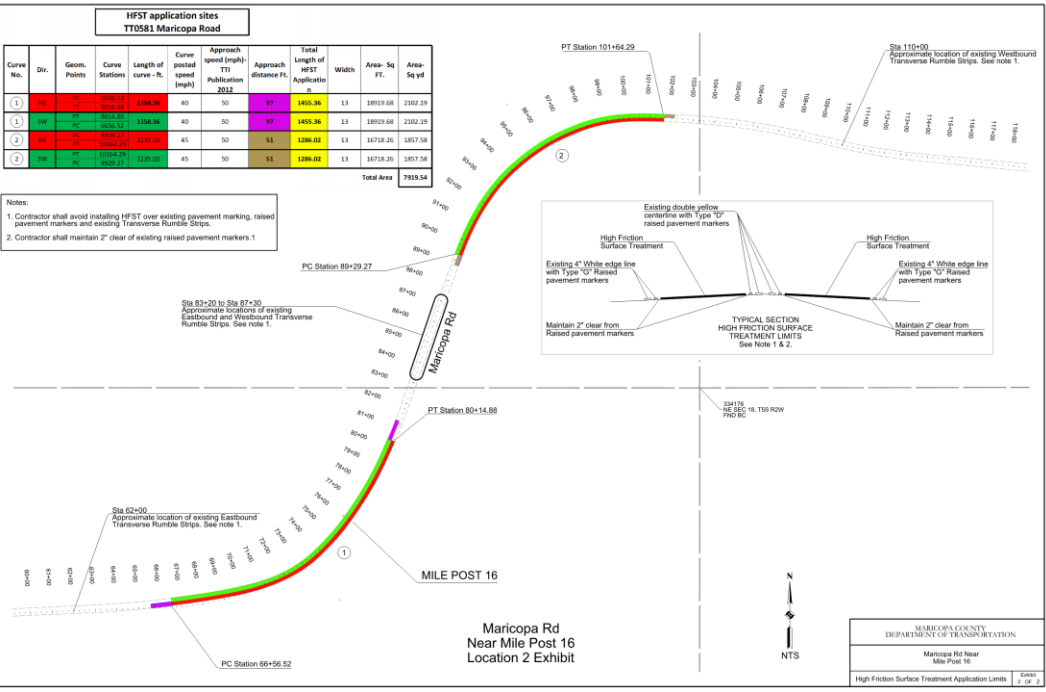




# Where to Install HFST?

- *Horizontal Curves*
- *Intersections*
- *On and Off Ramps— especially with elevation change (loop ramps)*
- *Steep Grades*
- *Line of Sight problem locations*



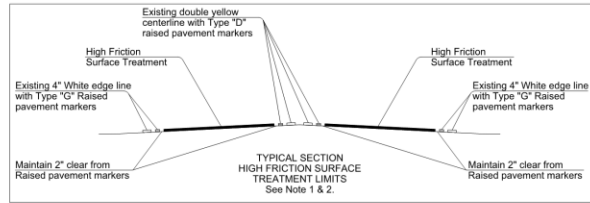


# Maricopa Road(SR238 MP 16)

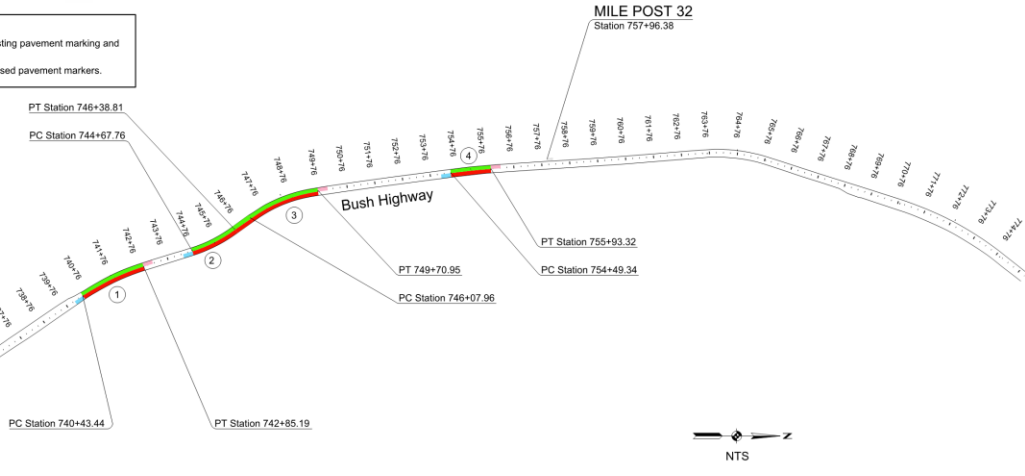


# Bush Highway MP 32

HFST application sites TT0581 Bush Highway											
Curve No.	Dir.	Geom. Poles	Station	Length- Ft.	Curve posted speed (mph)	Approach speed (mph) TTI Publication 2012	Approach distance Ft.	Total Length of HFST Application	Width	Area- Sq Ft.	Area- Sq yd
1	R	PC	7170+12	143.96	35	35	35	170.98	12	2147.76	238.64
2	L	PT	7126+82	124.99	35	35	35	170.98	12	2147.76	238.64
3	R	PC	7150+12	342.39	35	35	35	337.39	12	4775.88	530.65
4	L	PT	7200+00	342.39	35	35	35	337.39	12	4775.88	530.65
5	R	PC	7220+12	171.60	35	35	35	206.00	12	2472.6	274.73
6	L	PT	7240+12	171.60	35	35	35	206.00	12	2472.6	274.73
7	R	PC	7260+12	276.71	35	35	35	276.71	12	3321	369.00
8	L	PT	7280+12	276.71	35	35	35	276.71	12	3321	369.00
Total Area										2826.05	



- Notes:
- Contractor shall avoid installing HFST over existing pavement marking and raised pavement markers.
  - Contractor shall maintain 2" clear of existing raised pavement markers.



Bush Hwy  
Mile Post 31 To Saguaro Lake  
Location 1 Exhibit

MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION	
Bush Hwy Mile Post 31 To Saguaro Lake	
High Friction Surface Treatment Application Limits	Exhibit 1 of 2





# HFST Properties & Installation parameters



HFST paving operation  
A fully automated Surface  
Treatment

- The polymer resin binder spread rate- .32 gal/sq yd
- Calcined bauxite application rate 15lbs/sy.
- HFST thickness. Generally, less than 1/4-inch
- Customized to the intended lane width 12ft. Standard
- Only short-term TC-Traffic Control.
- HFST typically cures in 1-2 hours.
- After cure, surface is swept with a **mechanical broom**



Bush Highway  
HFST paving  
operation



## HSIP(Highway Safety Improvement Program) Funding

HSIP : is a Federal-aid funding program designed to reduce traffic fatalities and serious injuries on all public roads. The object of this program is to identify, implement and evaluate cost effective construction safety projects.

The application require that **B/C ratio** be over **1.5%** for it to be a candidate for qualification

MCDOT HFST Project showed **12.9 B/C ratio**





# MCDOT HFST Pilot Project After studies

## AZDPS Vehicular Crimes Unit



Test Vehicle

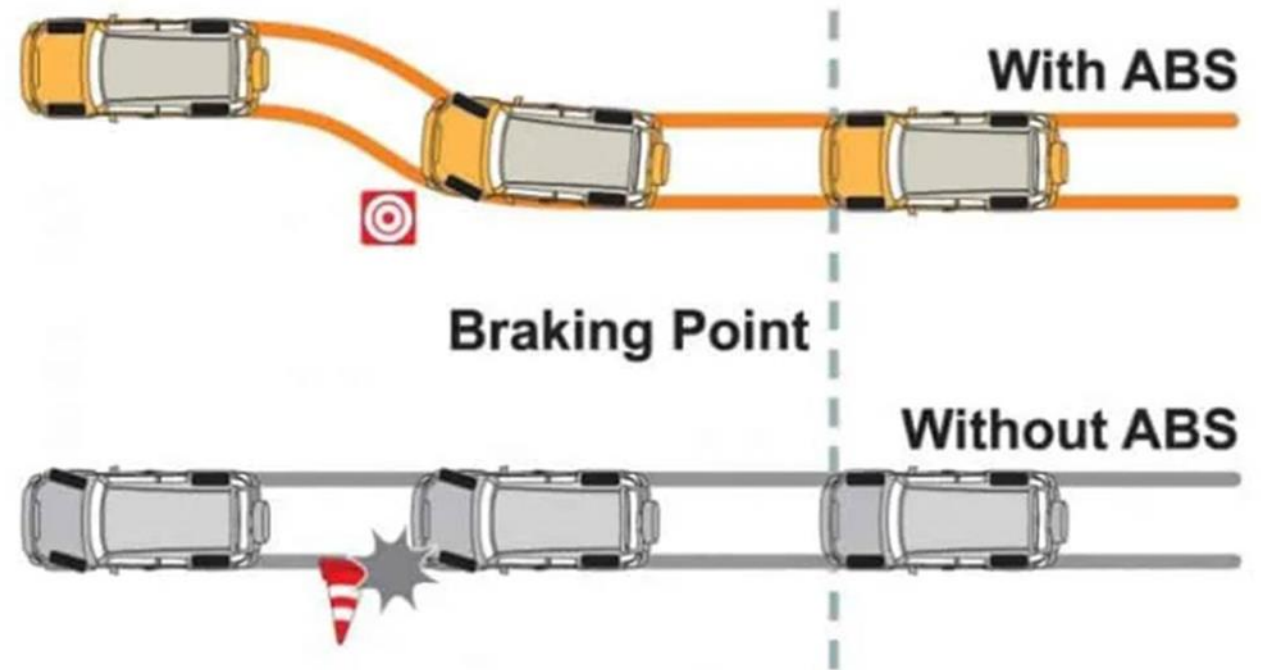


Vericom VC4000  
Brake Meter



# Anti-lock brake system (ABS)

Anti-lock brake system is a Safety feature helps drivers maintain control of their vehicles.



**Arizona Department of Public Safety- (Vehicular Crimes Unit)****Friction test values****Location: Maricopa Rd. (SR238)- MP 16-16.5**

<b>Test Location</b>	<b>Surface</b>	<b>Condition</b>	<b>Avg coefficient of Friction "f"</b>				
			<b>May 24<sup>th</sup>, 2019</b>	<b>February 3, 2020</b>	<b>April 28, 2021</b>	<b>July 19th, 2022</b>	
<b>Curve 1</b>	<b>HFST</b>	<b>ABS- (Dry)</b>		<b>0.96 - 1.02</b>	<b>0.96 – 0.998</b>	<b>0.92- 0.99</b>	
<b>Curve 1</b>	<b>HFST</b>	<b>ABS-(Wet)</b>		<b>0.92 – 0.98</b>	<b>0.92 - 0.98</b>	<b>0.90- 0.91</b>	
<b>Curve 1</b>	<b>HFST</b>	<b>Non-ABS (Dry)</b>		<b>0.94 - 0.97</b>	<b>0.966</b>	<b>0.93- 0.91</b>	
<b>Curve 1</b>	<b>HFST</b>	<b>Non-ABS (Wet)</b>		<b>0.97-0.99</b>	<b>0.943</b>	<b>0.95- 0.91</b>	
<b>Curve 2</b>	<b>HFST</b>	<b>ABS- (Dry)</b>		<b>0.94-0.99</b>	<b>0.97-0.99</b>	<b>0.98- 0.97</b>	
<b>Curve 2</b>	<b>HFST</b>	<b>ABS-(Wet)</b>		<b>0.70-0.72</b>	<b>0.94 – 0.97</b>	<b>0.94- 0.96</b>	
<b>Curve 2</b>	<b>HFST</b>	<b>Non-ABS (Dry)</b>		<b>0.94-0.95</b>	<b>0.95</b>	<b>0.93-0.97</b>	
<b>Curve 2</b>	<b>HFST</b>	<b>Non-ABS (Wet)</b>		<b>0.70-0.73</b>	<b>0.96</b>	<b>0.93- 0.95</b>	



# Friction Test Values

Location: Bush Hwy- MP 31

<b>Test Location</b>	<b>Avg coefficient of Friction "f"</b>		
	<b>5/22/2019 (Pre- HFST) 1.5" AR</b>	<b>1/26/2022 (Pre- HFST) 1.5" AR</b>	<b>1-26-2022 (After HFST)</b>
<b>Test Section 1- Dry with ABS</b>	<b>0.754</b>	<b>0.754</b>	<b>0.891</b>
<b>Test Section 1- Dry-Non-ABS</b>	<b>0.682</b>	<b>0.646</b>	<b>0.734</b>
<b>Test Section 2- Wet with ABS</b>		<b>0.673</b>	<b>0.849</b>
<b>Test Section 2- Wet-Non-ABS</b>		<b>0.574</b>	<b>0.773</b>

# Maricopa Road Crash Data

## Maricopa Rd crash data Before HFST-MP 16.0 to 16.5

2016,2018 & 2019

PD	7
inj 2	4
Inj3	2
Inj4	1
FAT	2
Total	16

## Maricopa Rd crash data After HFST-MP 16.0 to 16.5

Dec 2019 to July 2021

One year and 7 Months

PD	1
inj 2	2
Inj3	1

# Bush Highway Crash Data

## Bush Hwy crash data before HFST-South of MP32

2012	4
2013	6
2014	3
2015	1
2016	2
2017	3
2018	1
2019	0
Total	20

PD	8
inj 2	4
Inj3	2
Inj4	4
FAT	2
Total	20

## Bush Hwy crash data After HFST-South of MP32

Dec 2019 to July 2021 (One year and 7 Months)

No Crashes @ HFST sites



# Pavement Condition and Rideability



Pavement Condition: In terms of distress types, severity & Density (amount of distress)

Rideability characteristics: in terms of Roughness and rut depth

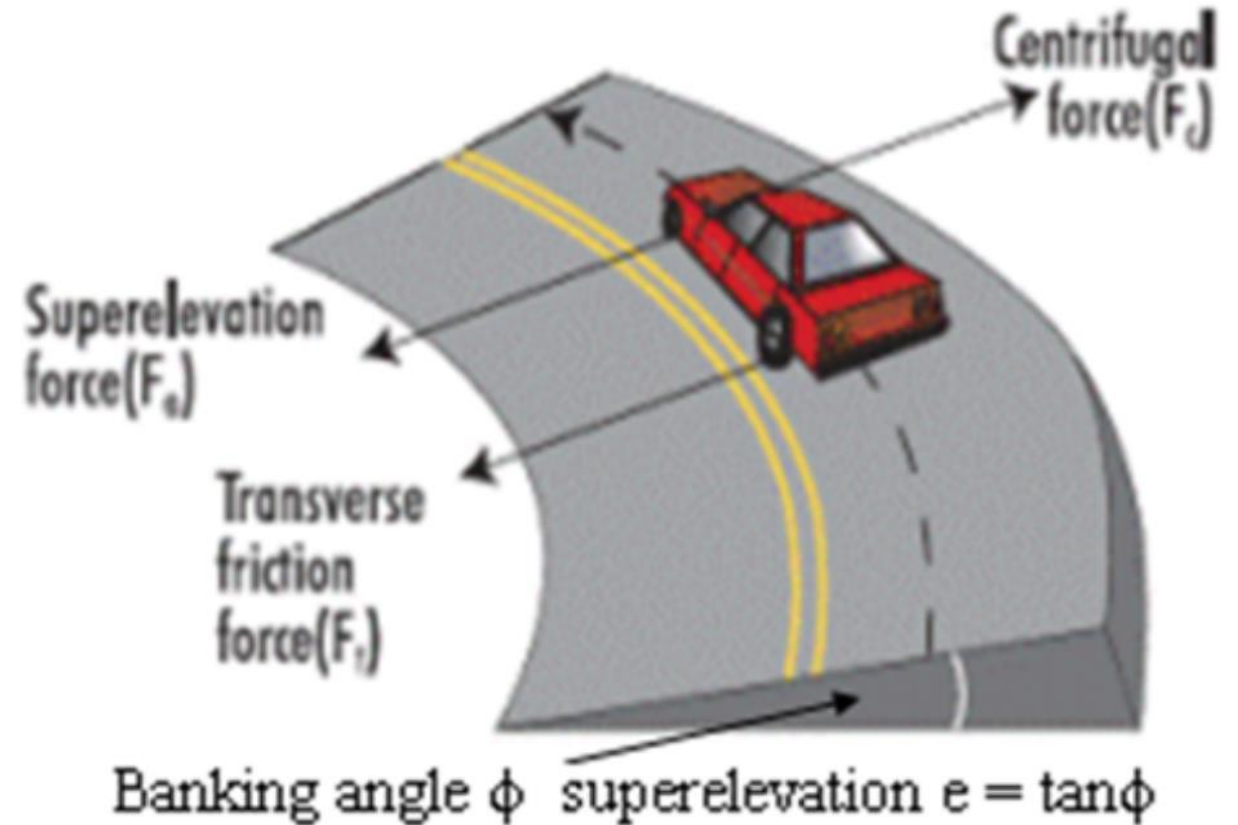
Based on the equation derived from the laws of mechanics **Centrifugal force** is balanced by both **Transverse friction & Super elevation**, but if friction surface can provide enough resistance to keep the vehicle on the road super elevation will not be a factor

$$V^2 = 15(0.01e + f)R$$

V = advisory speed, mph;  
e = superelevation, percent;  
f = side friction factor; and  
R = radius of curvature, ft.

$$0.01e + f = V^2/15R$$

# Curve Advisory Speed



# Non HFST Pavement Chip seal Curve approach Non-ABS-Wet





# HFST Pavement-Maricopa Road 2020 (ABS-Wet )





# HFST Segment – Non-ABS Wet





# HFST Segment - ABS Wet





# Critical Speed

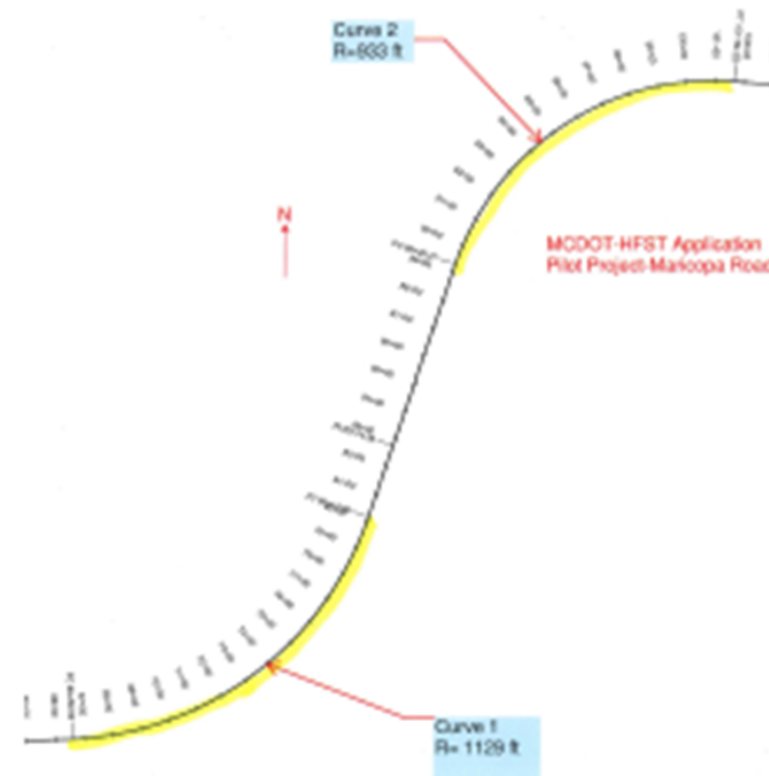
## Critical Curve Speed Calculations

$$S=3.86\sqrt{R \times (f+e)}$$

East Curve, R=933 ft, e = .01

- Old surface Dry (non ABS)
  - S=94 to 96 mph
- Old surface wet (non ABS)
  - S=79 to 81 mph
- New HFST wet (non ABS)
  - S=116 to 117 mph

Critical Curve Speed gained by adding High Friction Surface Treatment is **36 to 37 mph** on the East curve during wet conditions.



**Critical speed is the max speed at which a vehicle can reach before losing control**





# What is the average unit cost for HFST?



HFSTs are relatively low in cost compared to geometric improvements. State DOTs report HFST costs ranging from **\$25 to \$50 per square yard**. While this is not cheap, HFST's durability makes up for the initial high cost since the treatments have at least a 10-year life-cycle.

*Thank You*

*Questions?*

