PAVEMENT FRICTION SURFACE TREATMENTS

Work being done on County Routes

Somerset County Engineering

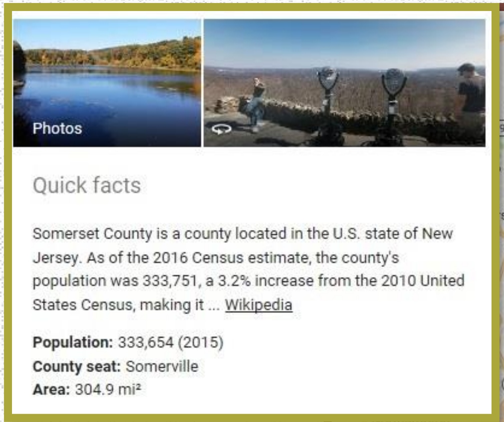
Presented by Patricia Bates Smith

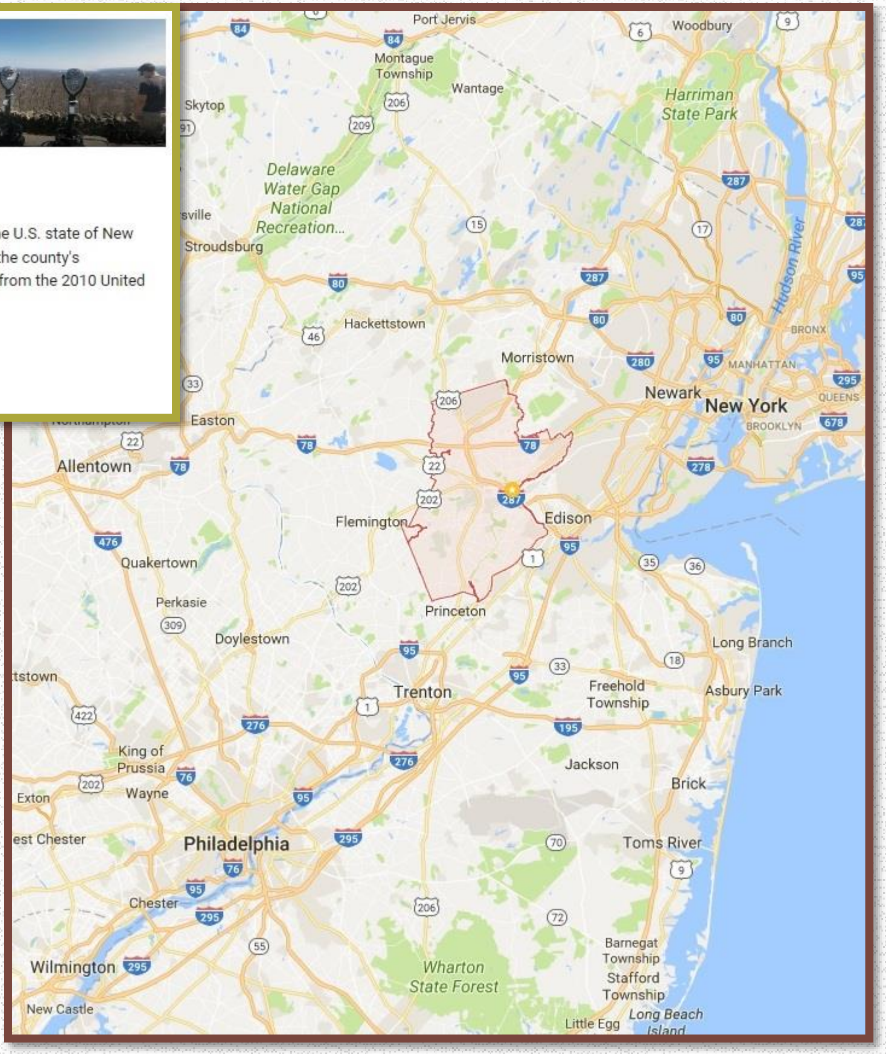
Principal Engineer, Highway

Somerset – who are we?

Engineering office with:

- Staff of 36 people
- In 10 different disciplines
- Managing infrastructure including:
    - 250 miles of County Roads
    - 193 traffic signals
    - 762 bridges
    - As well as county sites, facilities and parks.





Annually, we resurface 15 miles of road, reconstruct 1.5 miles road, replace 7 bridges, install or upgrade 3 traffic signals.

Annual budgets for road and bridges:

$9 - $18 million, County Capital

$4 million, State Aid

$ vary, Federal Aid - based on the project

Somerset County – Local Safety Projects

Program	Project	Town	Description	Grant Amount	Length (miles)	Project Status
2010 LSP	Hamilton St (CR 514) & Franklin Blvd (CR 617)	Franklin	Traffic signal modifications and upgrade, left turn lanes, resurfacing, ADA ramps.	$190,000.00	N/A	completed
2011 LSP	Overheight vehicle detectors	Manville, South Bound Brook	Installation of 2 height detection at approaches to low railroad overpasses, 533 in Manville, 527 in South Bound Brook	$170,000.00	N/A	completed
2012 LSP	North Bridge St & Cliff St intersection	Somerville	Installation of a new traffic signal	$150,000.00	N/A	completed
2012 LSP	Easton Ave (CR 527) & Foxwood Dr.	Franklin	Traffic signal modifications and upgrade: dedicated left turn lanes, pedestrian signals	$220,000.00	N/A	completed
2012 HRRR	New Centre Rd (CR 627)	Hillsborough	Rural road safety measures including, pavement repair, resurfacing, micro-mill friction course, wet weather high visibility traffic stripes	$490,000.00	1	completed
2013 HRRR	River Rd (CR 627)	Hillsborough	Rural road safety measures including, pavement repair, resurfacing, micro-mill friction course, wet weather high visibility traffic stripes	$380,000.00	0.8	completed
2014 LSP	Promenade Blvd (CR 685)	Bridgewater	Safety measures on 4 lane urban drive: Road diet, medians, cross walks, curb ramps, sidewalk extension.	$750,000.00	0.65	completed
2014 HRRR	Bedminster Safety Improvements including Pottersville Rd (CR 512), Lamington Rd (CR 523) and Burnt Mills Rd (CR 620)	Bedminster	Rural road safety measures including pavement repair, resurfacing, High Friction Surface Course on horizontal curves, wet weather high visibility striping, pavement safety edge, driveway aprons, new signage and delineators.	$4,125,000.00	10	completed
2014 LSP	Chimney Rock Rd (CR 525)	Bridgewater	Rural road safety measures including pavement repair, resurfacing, High Friction Surface Course on horizontal curves, wet weather high visibility striping, pavement safety edge, new signage and delineators.	$400,000.00	1	completed
2015 LSP	Mountain Ave (CR 642)	North Plainfield	Local Safety suburban street including: 2 traffic signal modifications and upgrades, ADA ramp compliance, striping.	$960,000.00	1.3	Final docs
2015 LSP	Washington Ave (CR 529) & Greenbrook Rd (CR 634)	Green Brook	Local Safety suburban street including: traffic signal replacement, Road Diet, RCP culvert replacement, ADA curb ramp compliance.	$780,000.00	0.4	completed
2016 LSP	Main St (CR 533)	Manville	Local Safety suburban street including: 5 traffic signal modifications, 1 traffic signal replacement, Road Diet, ADA ramp compliance, resurfacing, striping.	$3,000,000.00	1.1	prelim design
2017 LSP	Easton Ave (CR 527) & Demott Lane	Franklin	Safety measures on 4 lane arterial roadway including: traffic signal modifications, barrier upgrades, ADA ramp compliance, rehabilitation of existing HMA bikepath including ADA compliance.	$1,440,000.00	0.8	await grant award
				$13,055,000.00		
	Projects that applied a pavement surface treatment					

HFST – How did we get started?

… there was a need.

- 2006 police concern for crashes on Warrenville Hill:
- 14% grade at steepest;
- Substandard S-bend horizontal alignment;
- Driveways and side streets;
- Route 22 approach at near 10% gradient.

‘Warrenville Hill’, CR 651 north of Route 22.

Safety became measurable.

The availability of crash data from the Plan4Safety crash database allowed our office, as well as our MPO, to look at crash trends around the region.

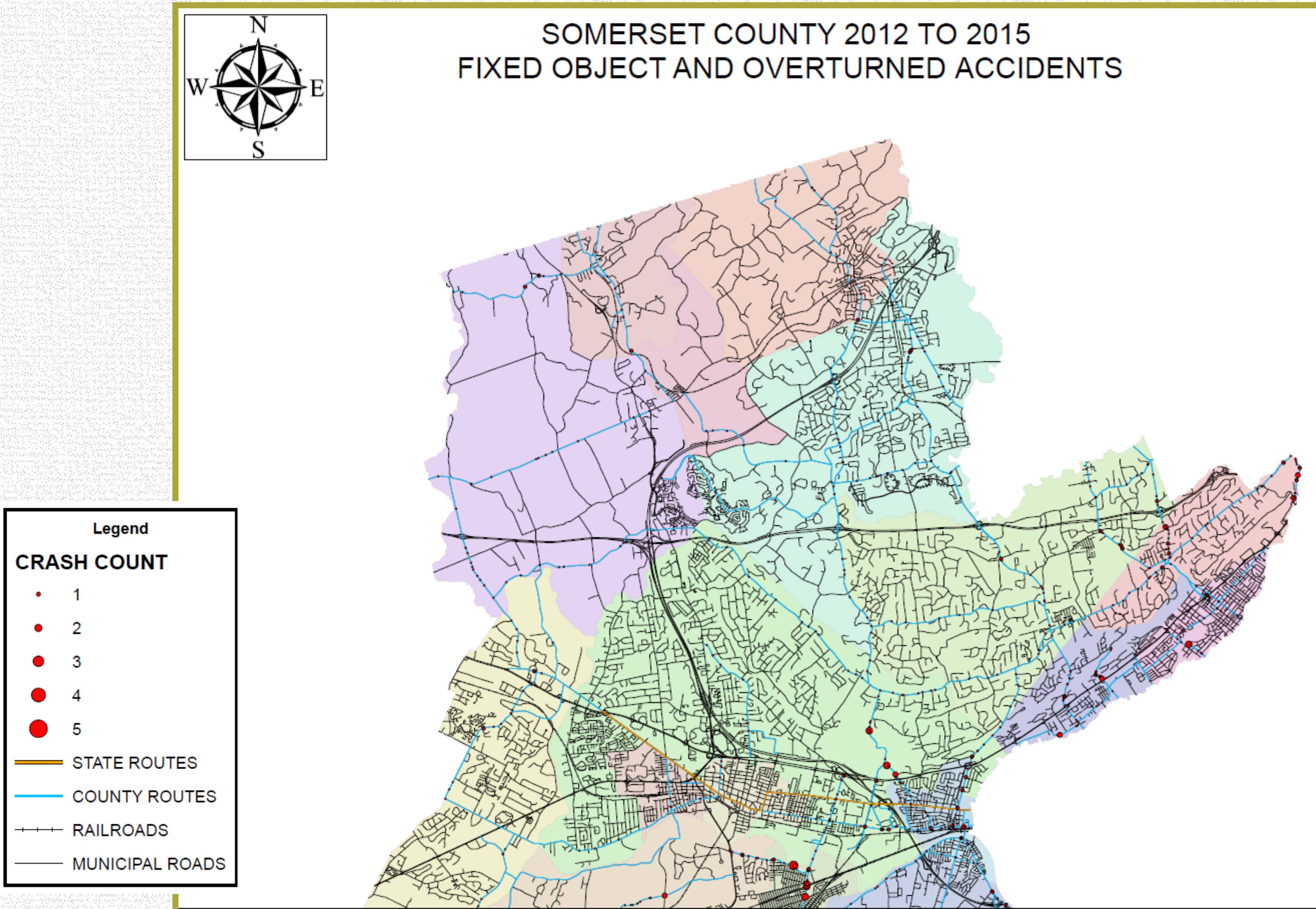
This provided us the data to start planning for infrastructure improvements based on locations of need and type of issues occurring.

DATE TEXT	CRAS	C(	CRASH_TIME	CRASH_TYPE	CRASH_'	CROSS_STREET	DIRECTION_FR	DISTANCE_I	ENVIRONM	I	H	INTERSECTION	I	LIGHT_CONDIT
1/17/08	Thurs	Ja	5:50 PM	Opposite Direct	2008	LISK HILL RD	NULL		Snow	I	N	At Intersection	I	Dark (No Street
2/8/08	Frida	Fe	6:56 AM	Animal	2008	LARGER CROSS	East	500	Clear	I	N	Not At Intersec	I	Daylight
2/13/08	Wed	Fe	8:11 AM	Fixed Object	2008	LARGER CROSS	West	1584	Rain	I	N	Not At Intersec	I	Daylight
3/8/08	Satur	M	3:00 PM	Fixed Object	2008	SOUTHFIELD D	East	1000	Rain	I	N	Not At Intersec	I	Daylight
5/20/08	Tues	M	5:30 PM	Fixed Object	2008	RT 206	East	528	Rain	I	N	Not At Intersec	I	Daylight
9/26/08	Frida	Se	6:25 PM	Fixed Object	2008	LISK HILL ROAD	East	100	Rain	I	N	Not At Intersec	I	Daylight
10/6/08	Mon	Oc	6:14 PM	Fixed Object	2008	SOUTHFIELD D	East	2112	Clear	I	N	Not At Intersec	I	Daylight
10/25/08	Satur	Oc	8:35 AM	Other	2008	LISK								
12/15/08	Mon	De	4:21 PM	Right Angle	2008	OLD								
12/22/08	Mon	De	5:11 PM	Animal	2008	LARG								
12/23/08	Tues	De	6:00 PM	Animal	2008	LARG								
12/23/08	Tues	De	2:37 PM	Fixed Object	2008	SOU								
1/17/09	Satur	Ja	10:24 AM	Animal	2009	FOW								
1/19/09	Mon	Ja	5:02 PM	Fixed Object	2009	LISK								
9/13/09	Sund	Se	1:48 AM	Fixed Object	2009	LISK								
[illegible]	Mon	Se	[illegible]	Right Angle	[illegible]	SOU								

SOMERSET COUNTY
LOCAL SAFETY PROGRAM
CORRIDOR RANKINGS BY WEIGHTED SEVERITY
CRASH DATA: 2010-2012

County Rank	NJTPA Region Rank	County	Municipality	SRI	Milepost Start	Milepost End	Total Crashes	Fatal	Incap
1	17	SOMERSET	Franklin Twp (Somerset Co)	527	48.08	49.08	269	0	0
2	45	SOMERSET	Franklin Twp (Somerset Co)	514	22.35	23.35	191	1	0
3	46	SOMERSET	Franklin Twp (Somerset Co)	527	49.25	50.25	220	0	2
4	77	SOMERSET	Franklin Twp (Somerset Co)	527	50.95	51.95	287	0	0
5	97	SOMERSET	Manville borough	533	27.87	28.87	228	0	2
6	113	SOMERSET	Bridgewater township	533	29.64	30.64	127	1	0
7	141	SOMERSET	Franklin Twp (Somerset Co)	18000617	0.87	1.87	112	0	1
8	212	SOMERSET	Franklin Twp (Somerset Co)	514	19.11	20.11	168	0	0
9	237	SOMERSET	Franklin Twp (Somerset Co)	514	20.46	21.46	115	0	0
10	301	SOMERSET	Franklin Twp (Somerset Co)	18000619	1.69	2.69	100	0	1
11	304	SOMERSET	North Plainfield borough	18000636	0.92	1.92	77	0	0
12	318	SOMERSET	Watchung borough	531	10.76	11.76	104	0	0
13	353	SOMERSET	Branchburg township	18000614	0	1	136	0	0
14	399	SOMERSET	Franklin Twp (Somerset Co)	18000623	2.33	3.33	73	0	0
15	408	SOMERSET	Watchung borough	18000655	0	1	114	1	0

We could evaluate the whole County …



How, what, where, and when of friction courses …

Because of County wide crash analysis we could now see which areas needed further investigation for possible safety improvements including friction courses at horizontal curves.

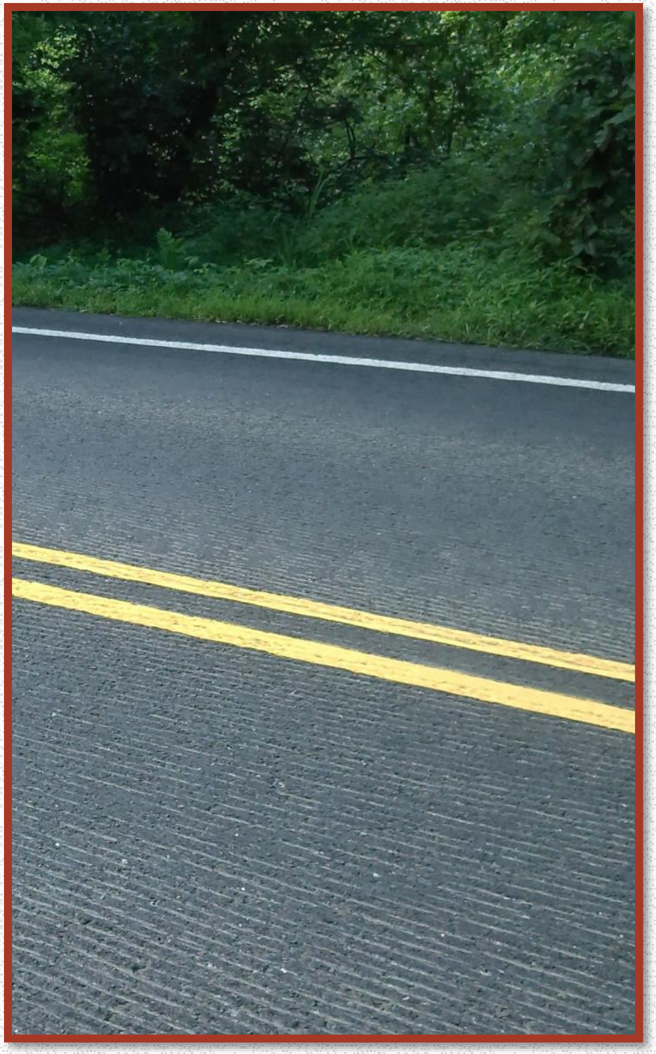
- What was the correct method?
- When is it warranted?
- How to determine the limits of need on a curve?

BROCHURE www.dbiservices.com

Micro milling – our early solution

Pros:
- Provided high friction surface which reduced ‘run off road’ crashes
- Low cost of installation
- Installation by local pavement contractors

Cons:
- Short life expectancy with surface due to moisture penetration, oxidation, and friction loss.
- Complaints from motorcyclists and bicyclists
- Poor image portrayed to the public of milling off new pavement surface.



High Friction Surface Treatment

PROS:
- Promoted by FHWA as proven safety measure (NCHRP Document 108)
- Safe for all vehicle types
- Longer life expectancy than micro-milling (due to microtexture of aggregate used).

CONS:
- High cost
- Specialize trade needing sub-contracting work added to paving contracts.

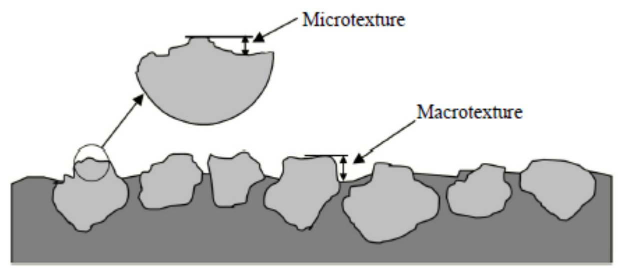
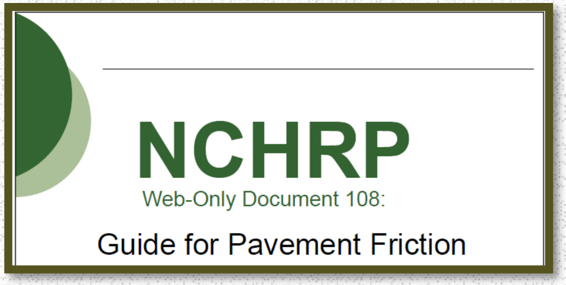


Figure 3: The relationship between different textures in pavement aggregate (*23*).

Texas Transportation Institute, July 2012, Using High Friction Surface Treatments to Improve Safety at Horizontal Curves.



When is HFST warranted?

Assessing Curve Severity and Design Consistency Using Energy- and Friction-Based Measures

Michael P. Pratt and James A. Bonneson

Numerous published models can be used to predict curve speed based on geometric and operational characteristics like radius, superelevation rate, and approach tangent speed. Speed-based design consistency measures have also been developed to help identify which curves on a roadway are the most severe. However, the use of speed reduction alone can result in improper assessment of curve severity because drivers are more reluctant to reduce speed on roadways with higher speeds and thus accept speeds associated with higher crash risk. New measures of curve severity are suggested, based on considerations of side friction demand and kinetic energy. The increase in side friction demand above drivers' comfort thresholds is shown to be roughly proportional to the kinetic energy reduction associated with speed reduction. Agencies can use these curve severity measures to assist in identifying curves in their jurisdictions that would most likely benefit from safety improvements.

Horizontal curves are an essential part of any highway system, but they can present safety hazards to drivers. Research has consistently shown that crash rates on horizontal curves are significantly higher than are crash rates on tangent roadway segments of similar geometric design, even for curves that may appear to be relatively mild.

Numerous models published in the literature can be used to predict curve speed based on geometric factors like radius and superelevation rate, and operational factors like approach tangent speed. Models accounting for the influence of tangent speed have shown that drivers choose curve speeds that minimize their speed reduction (and travel time) while avoiding excessive amounts of side friction demand. Speed reduction is used to assess the design consistency of curves, and it is also a measure of curve severity. Larger speed reduction levels indicate that a curve is more severe, and also more inconsistent with drivers' expectations and the design of the roadway, compared with other curves. Curve severity is a measure that reflects crash risk and the effort drivers expend to avoid risk while minimizing travel time.

In this paper, curve severity measures based on side friction demand levels and kinetic energy reduction are explored. The friction-based measure is side friction differential, measured as the difference between side friction demand at the curve speed that drivers choose and their friction comfort threshold for that speed. The energy-based measure is the amount of energy reduction that must occur for drivers to decelerate from tangent speed to their chosen curve speed. It is proposed that side friction differential and energy reduction are more closely related to driver behavior and safety, and thus better suited to assess curve severity, than speed reduction is. These measures can be used by agencies to determine which curves in their jurisdictions would most likely benefit from safety improvements.

HORIZONTAL CURVE OPERATIONS

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Transportation Research Record: Journal of the Transportation Research Board, No. 2075, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 8–15.
DOI: 10.3141/2075-02

Friction-Based Curve Risk Components

Given the importance of side friction demand in drivers' curve speed choice and perception of risk, and the fact that skidding or truck rollover will occur at excessive side friction demands, it can be rationalized that curve risk can be quantified in regard to side friction comfort levels and the friction demands experienced at curve speed.

TABLE 2 Candidate Guidance for Curve Signing

Side Friction Demand, g	Suggested Signing Treatments	Side Friction Differential, g
0.19 or less	None	0.00
0.20–0.23	Curve warning sign	0.01–0.04
0.24–0.27	Curve warning sign, advisory speed plaque	0.05–0.08
0.27–0.30	Redundant curve warning signs and advisory speed plaques	0.08–0.11
0.30–0.34	Redundant curve warning signs and advisory speed plaques, chevrons	0.11–0.15
0.35 or more	Other measures to reduce speed limit, rebuild curve, etc.	0.16 or more

My take away … it is about the difference in the side friction experienced by driver, calculated from the speeds along the tangent segment of roadway and the horizontal curve.

The evaluation …

CURVE #	RADIUS	PC STA	ACCIDENTS: ROAD	ACCIDENTS: TRENDS	CURVE: DIRECTION	CROWN: %(+SE)	L: > 5%	POSTED SPEEDS: SEGMENT	POSTED SPEEDS: CURVE	DESIGN SPEED EVALUATION: TANGENT	DESIGN SPEED EVALUATION: FRICTION	DESIGN SPEED EVALUATION: CALC V-CURVE	DESIGN SPEED EVALUATION: CONDITION	CRITICAL: CURVE SPEED	FRICTION EVALUATION: F-TANGENT	FRICTION EVALUATION: F-CURVE	FRICTION EVALUATION: F-CHANGE	ACTION
C2	3964.81	0+95.15			LEFT	-2		45	45	50	0.14	84.48	OK	45.00	[illegible]	[illegible]	[illegible]	NO ACTION
C4	1323.18	6+70.98			LEFT	-2		45	45	50	0.14	48.80	SUBSTNDRD	45.00	[illegible]	[illegible]	[illegible]	NO ACTION
C7	2660.42	14+64.57			LEFT	-2		45	45	50	0.14	69.20	OK	45.00	[illegible]	[illegible]	[illegible]	NO ACTION
C9	3827.8	17+21.84			RIGHT	-2		45	45	50	0.14	83.01	OK	45.00	[illegible]	[illegible]	[illegible]	NO ACTION
C11	1231.6	20+80.9	4	3-ROR-DAY	RIGHT	-4		45	45	50	0.14	42.98	SUBSTNDRD	42.98	[illegible]	[illegible]	[illegible]	CURVE WARNING SIGN
C13	906.1	28+56.03			LEFT	3		45	30	50	0.14	48.07	SUBSTNDRD	30.00	0.14	0.2	0.06	ADVANCE CURVE WARNINGS AND CHEVRONS
C15	352.97	30+96.3	1	ROR-ICE	RIGHT	2		45	30	50	0.14	29.11	SUBSTNDRD	29.11	0.14	0.23	0.09	HIGH FRICTION SURFACING
C17	691.62	35+43.65	4	3-ROR	RIGHT	-1	Y	45	35	50	0.14	36.72	SUBSTNDRD	35.00	0.12	0.18	0.06	ADVANCE CURVE WARNINGS AND CHEVRONS
C19	1577.67	38+64.16			RIGHT	-2		45	35	50	0.14	53.29	OK	35.00	0.14	0.18	0.04	CURVE WARNING WITH ADVISORY SPEED
C21	723.72	40+65.35	1	ANML	LEFT	-3		45	35	50	0.14	34.56	SUBSTNDRD	34.56	0.14	0.2	0.06	ADVANCE CURVE WARNINGS AND CHEVRONS
C24	477.18	58+63.73	1	ROR-ICE	RIGHT	-2		45	30	50	0.14	29.31	SUBSTNDRD	29.31	0.14	0.23	0.09	HIGH FRICTION SURFACING
C26	738.45	67+31.01	1		RIGHT	-2		45	35	50	0.14	36.48	SUBSTNDRD	35.00	0.14	0.18	0.04	CURVE WARNING WITH ADVISORY SPEED
C28	573.46	79+94.9	5	4-ROR 1-SS	LEFT	-3.6		45	30	50	0.14	29.91	SUBSTNDRD	29.91	0.14	0.23	0.09	HIGH FRICTION SURFACING
C30	2235.89	102+77.81			RIGHT	-2		45	45	50	0.14	63.44	OK	45.00	0.14	0.15	0.01	NO ACTION

CURVES | LOOKUP | Sheet3

tangent friction, curve friction needed, difference between them.

Posted speed and curve advisory

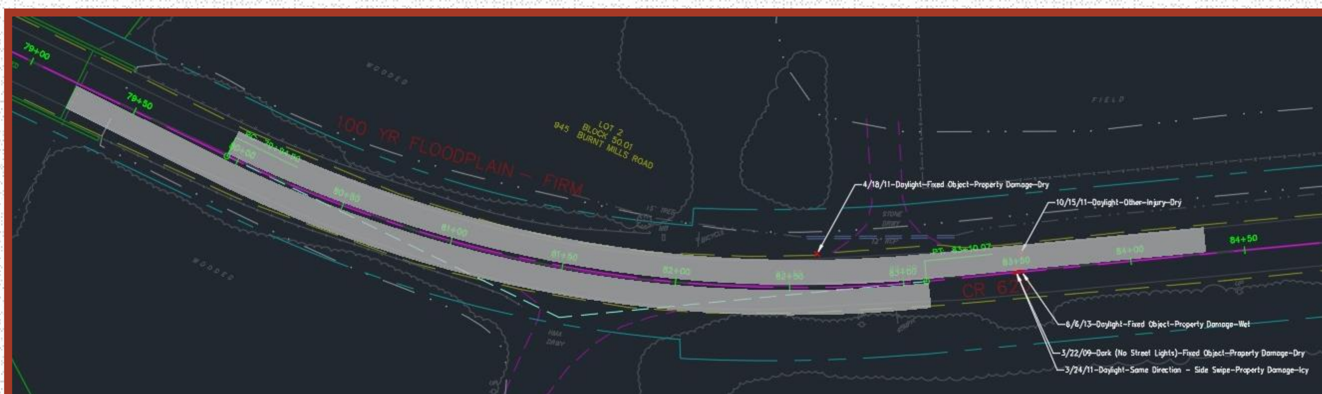
Calculated curve design speed

cross slope at curve

AASHTO "A Policy on Geometric Design of Highways and Streets 2011" Chapter 3, p3-31, equation 3.8 for minimum radius.

Data needed:

- Centerline alignment geometry
- Roadway cross slope
- Road profile slope
- Posted speed limit
- Posted curve advisory plate speed



The Details

U.S. Customary

$$R_{min} = \frac{V^2}{15(0.01e_{max} + f_{max})} \quad (3\text{-}8)$$

Result of evaluation – action to take

Side Friction Differential	Action
0 - .009	No action
.01 - .019	Curve warning sign
.02 - .044	Curve warning with advisory speed
.045 - .074	Advance curve warnings and chevrons
.075 and above	High friction surface treatment

HFST limits: approach length + length of curve (PC to PT)

Table 5: Recommended Distance Upstream of the PC to Begin HFST Application

Approach Speed (mph)	Curve Speed (mph)						
	30	35	40	45	50	55	60
35	35	-	-	-	-	-	-
40	76	41	-	-	-	-	-
45	122	86	46	-	-	-	-
50	173	138	97	51	-	-	-
55	230	194	154	108	57	-	-
60	292	257	216	170	119	62	-
65	359	324	284	238	186	130	68

Texas Transportation Institute, July 2012, Using High Friction Surface Treatments to Improve Safety at Horizontal Curves.

HIGH FRICTION SURFACE TREATMENT

1. DESCRIPTION

Work for placing high friction surface treatment (HFST) on HMA pavement. The HFST consists of a resin binder with a aggregate topping.

2. MATERIALS

2.1 Epoxy Resin Binder

A two-part exothermic epoxy resin binder which holds the aggregate topping firmly in place, and meets the requirements shown in the following table:

Epoxy Resin Binder Requirements

Property	Requirement	Test Method
Ultimate Tensile Strength	2650 psi min	ASTM D638
Elongation at break point	30% min	ASTM D638
Compressive Strength	1600 psi min	ASTM D695
Water Absorption	1.0% max	ASTM D570
Shore D Hardness, min 77°F	65-75	ASTM D2240
Gel Time, minutes	15-45 min	ASTM C881
Flexural Yield Strength, min psi	2000	ASTM D790
Cure Rate	3 hrs. max	ASTM D1640, 0.2" thickness
Mixing Ratio	As recommended by the manufacturer	N/A

Two part epoxy materials that are not exothermic in curing will not be allowed. Material to arrive on-site in clearly marked pails for hand applications and in larger plastic containers for mechanical application-operations. The volumes of the pails or containers must be labeled in US gallons to assist in proper mixing dosage and application rates.

2.2 Aggregate Topping

Furnish a blend of calcined bauxite aggregate consisting of a 1-3mm gradation. Ensure the aggregate is delivered to the construction site in clearly labeled 55 lb bags or 2200 lb super sacks. The aggregate topping is to be clean, dry, and free from deleterious matter. The aggregate topping must meet the requirements shown in the following table:

Aggregate Topping Requirements

Property	Test Method	Requirement
Aggregate Grading	AASHTO T27	No. 6 Percentage Passing 95% min No.16 Percentage Passing 5% max
Aggregate Abrasion Value.	AASHTO T96	20% max.
Aggregate Acid Insolubility	ASTM D3042	Greater than 90%
Aggregate Magnesium Soundness	ASTM C88	30% max

2.3 Material Certifications

Provide an independent laboratory report showing that the epoxy binder meets the requirements of this section.

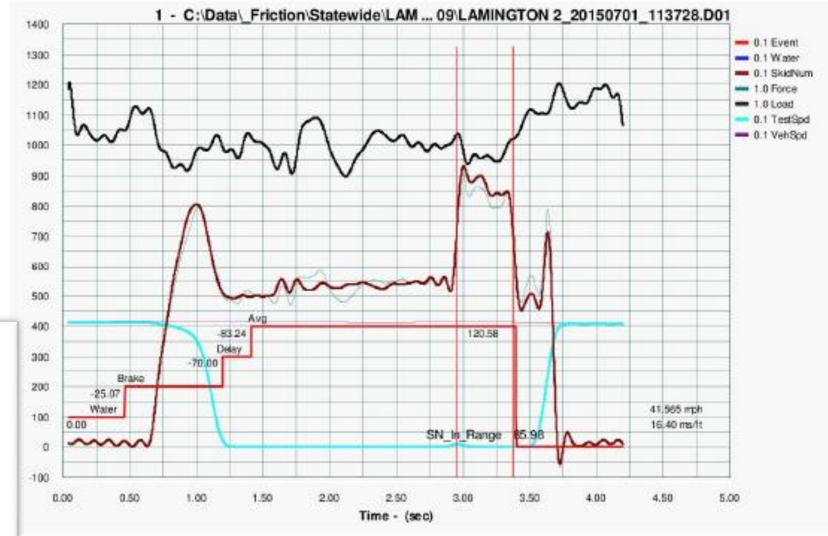
Submit certification from the manufacturer of the aggregate that it meets the requirements of this section.

Submit documentation of the in-place friction characteristics (minimum 55 FN40R in accordance with ASTM E274) of aggregate bonded to a vehicular bearing surface using the modified epoxy binder.

Submit a list of project with the installer's contact information on which a minimum of 3000 SY of high friction aggregate and epoxy binder was placed within the past three years.

HFST – first installation 2015

Federal Aid project Bedminster Safety
Performing test strip for friction number evaluation before installation.



ICC performed 16 tests on the road around the Test Patch of Safe-T-Grip on Lamington Rd, Bedminster NJ. The average FN40R value for the asphalt road was 55. The Test Patch numbers jumped up to a FN40R value of 86. The graphs provided show what the jump in friction looks like. It is our professional opinion that the material we tested on the Test Patch is extremely safe for roadway surface application and has a significantly higher friction value then the road it was placed on.

Statewide Striping Test Patch, Lamington Rd Bedminster Township, NJ Friction Report
7/17/2015 International Cybernetics, Largo, FL

Some results …

An in-office evaluation of crashes in the years prior to applying friction treatment and the year following. The data utilized was distributed along the entire project corridors so the reductions shown are not solely attributed to the horizontal curve crash reductions.

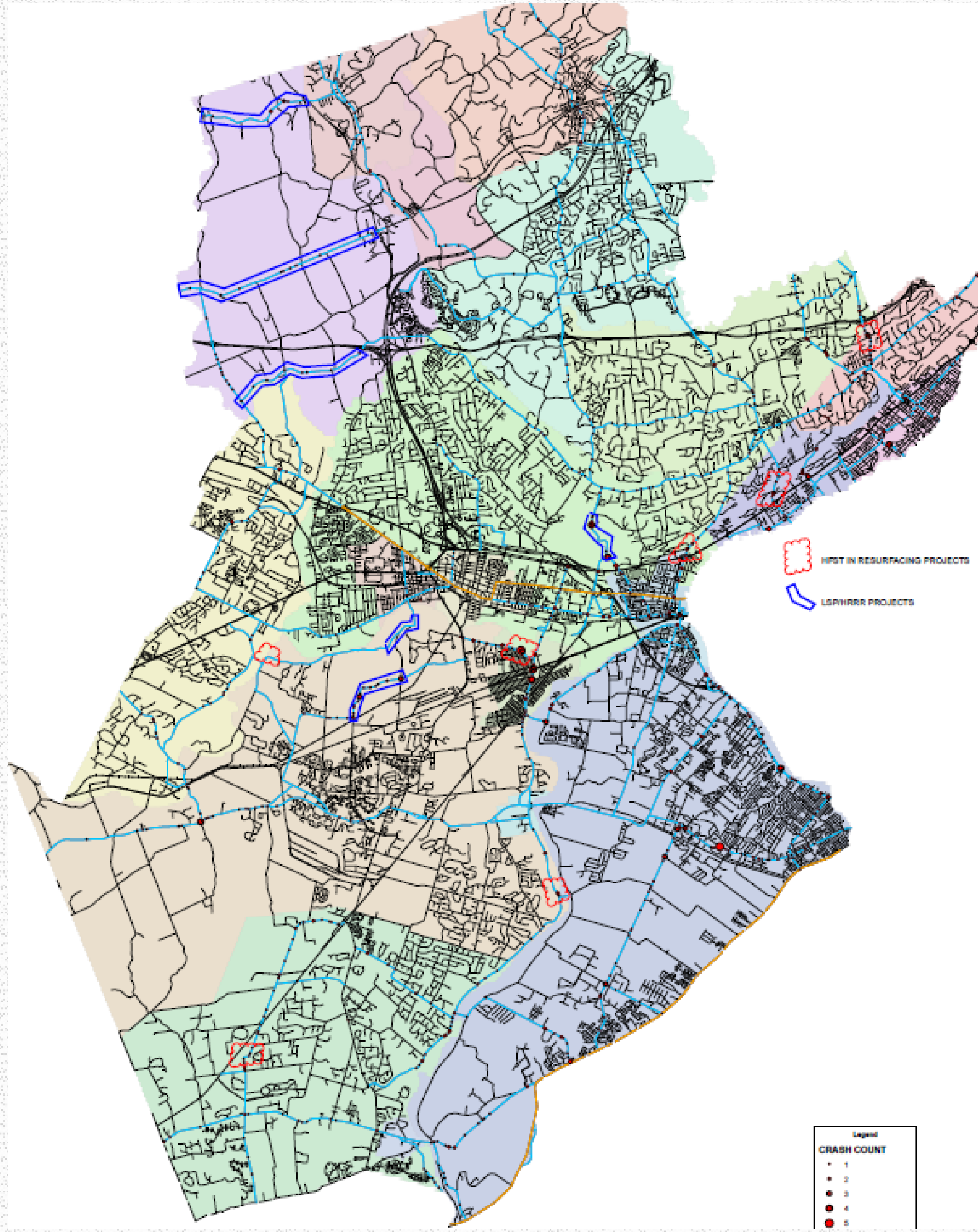
County Roads	Road Segments	Year applied	Corridor - Annual avg crashes before	Corridor - crashes year after	Reduction	Treatment type
New Center Road (CR 627)	From Auten Road to Roycefield Road	2013	19	10	47%	Micro surfacing along full segment
River Road (CR 625)	From Lyman Street Bridge to Roycefield Road	2014	25	5	80%	Micro surfacing along full segment
Chimney Rock Road (CR 525)	From Thompson Avenue to Gilbride Road	2015	73	12	84%	HFST applied to 5 curves on 1 mile road segment (steep vertical)
Burnt Mills Road (CR 620)	From Rattlesnake Bridge Road to Country Club Road	2015	20	9	55%	HFST applied to 5 curves on 3 mile road segment
Pottersville Road (CR 512)	From Hacklebarney Road to Route 206	2015	8	7	13%	HFST applied to 4 curves on 2.4 mile road segment
Lamington Road (CR 523)	From County Line to Route 206	2015	23	17	26%	HFST applied to 2 curves on 5 mile road segment

And now …
a systematic approach

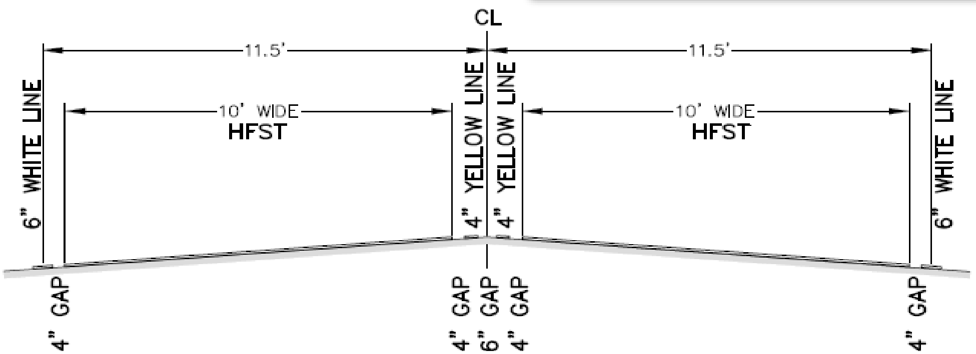
As part of our annual resurfacing program we are including HFST treatments to locations in need. Locations to evaluate are determined from:

- County wide crash mapping
- Concerns expressed by Municipalities or residents
- Recent severe crashes

HFST is bid as square yard (SY) pay item. Bids have come in between $35 -$65/ SY (bid within large resurfacing contracts).



Photos



NOTES:

1. THIS DETAIL SHOWS THE MINIMUM LANE WIDTH AND GAP SPACING BETWEEN HFST AND THERMOPLASTIC LANE STRIPES.
2. MASK OFF GAPS AND THERMOPLASTIC STRIPING DURING PLACEMENT OF HFST TO MAINTAIN CLEAN EVEN GAPS TO THE THERMOPLASTIC STRIPING.
3. FOR INTERSECTIONS WITH TURNING LANES HOLD 4" GAP FROM YELLOW LINE OR WHITE INSIDE LEFT–LANE LINE. HOLD 10' WIDE HFST WIDTH OR AS DIRECTED BY RE.

HIGH FRICTION SURFACE TREATMENT LAYOUT WITH LANE STRIPING

Questions?

Thank You!

References:

- http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w108.pdf NCHRP Web Only Document 108, “Guide for Pavement Friction”, Transportation Research Board
- http://trb.metapress.com/content/7717239k62781311/ Pratt, Michael P. and James A. Bonneson “Assessing Curve Severity and Design Consistency Using Energy and Friction Based Measures”, Transportation Research Record No. 2075, 2008, pp 8-15.
- AASHTO “A Policy on Geometric Design of Highways and Streets 2011” Chapter 3, p3-25, Figure 3.6 Side Friction Factors Assumed for Design, and p3-31, equation 3.8 for minimum radius.
- http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/TTI-2012-8.pdf Brimley, Brad & Paul Carlson, “Using High Friction Surface Treatments to Improve Safety at Horizontal Curves”, Texas Transportation Institute, July 2012, p 13.

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