PAVEMENT FRICTION SURFACE TREATMENTS
A SYSTEMIC SAFETY APPROACH FOR HORIZONTAL CURVES ON SOMERSET 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 10 traffic signals, and replaced more than 150 ADA curb ramps.

Annual budgets for road and bridges:
- $9 - $18 million, County Capital
- $6 million, State Aid
- $ vary, Federal Aid - based on the project

Quick facts

Somerset County is a county located in the U.S. state of New Jersey. As of the 2016 Census estimate, the county's population was 333,751, a 3.2% increase from the 2010 United States Census, making it ... [Wikipedia]

County seat: Somerville
Area: 304.9 mi²
## Somerset County – Local Safety Projects

<table>
<thead>
<tr>
<th>Program</th>
<th>Project Description</th>
<th>Town</th>
<th>Length (miles)</th>
<th>Grant Amount</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 LSP</td>
<td>Hamilton St (CR 514) &amp; Franklin Blvd (CR 617)</td>
<td>Franklin</td>
<td>N/A</td>
<td>$190,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Traffic signal modifications and upgrade, left turn lanes, resurfacing, ADA ramps.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011 LSP</td>
<td>Overheight vehicle detectors</td>
<td>Manville, South Bound Brook</td>
<td>N/A</td>
<td>$170,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Installation of 2 height detection at approaches to low railroad overpasses, 533 in Manville, 527 in South Bound Brook</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012 LSP</td>
<td>North Bridge St &amp; Cliff St intersection</td>
<td>Somerville</td>
<td>N/A</td>
<td>$150,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Installation of a new traffic signal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012 LSP</td>
<td>Easton Ave (CR 527) &amp; Foxwood Dr.</td>
<td>Franklin</td>
<td>N/A</td>
<td>$220,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Traffic signal modifications and upgrade: dedicated left turn lanes, pedestrian signals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012 HRRR</td>
<td>New Centre Rd (CR 627)</td>
<td>Hillsborough</td>
<td>1</td>
<td>$490,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Rural road safety measures including, pavement repair, resurfacing, micro-mill friction course, wet weather high visibility traffic stripes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 HRRR</td>
<td>River Rd (CR 627)</td>
<td>Hillsborough</td>
<td>0.8</td>
<td>$380,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Rural road safety measures including, pavement repair, resurfacing, micro-mill friction course, wet weather high visibility traffic stripes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014 LSP</td>
<td>Promenade Blvd (CR 685)</td>
<td>Bridgewater</td>
<td>0.65</td>
<td>$750,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Safety measures on 4 lane urban drive: Road diet, medians, cross walks, curb ramps, sidewalk extension.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014 HRRR</td>
<td>Bedminster Safety Improvements including Pottersville Rd (CR 512), Lamington Rd (CR 523) and Burnt Mills Rd (CR 620)</td>
<td>Bedminster</td>
<td>10</td>
<td>$4,125,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014 LSP</td>
<td>Chimney Rock Rd (CR 525)</td>
<td>Bridgewater</td>
<td>1</td>
<td>$400,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015 LSP</td>
<td>Mountain Ave (CR 642)</td>
<td>North Plainfield</td>
<td>1.3</td>
<td>$960,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Local Safety suburban street including: 2 traffic signal modifications and upgrades, ADA ramp compliance, striping.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015 LSP</td>
<td>Washington Ave (CR 529) &amp; Greenbrook Rd (CR 634)</td>
<td>Green Brook</td>
<td>0.4</td>
<td>$780,000.00</td>
<td>completed</td>
</tr>
<tr>
<td></td>
<td>Local Safety suburban street including: traffic signal replacement, Road Diet, RCP culvert replacement, ADA curb ramp compliance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016 LSP</td>
<td>Main St (CR 533)</td>
<td>Manville</td>
<td>1.1</td>
<td>$3,000,000.00</td>
<td>prelim design</td>
</tr>
<tr>
<td></td>
<td>Local Safety suburban street including: 5 traffic signal modifications, 1 traffic signal replacement, Road Diet, ADA ramp compliance, resurfacing, striping.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017 LSP</td>
<td>Easton Ave (CR 527) &amp; Demott Lane</td>
<td>Franklin</td>
<td>0.8</td>
<td>$1,440,000.00</td>
<td>consultant award</td>
</tr>
<tr>
<td></td>
<td>Safety measures on 4 lane arterial roadway including: traffic signal modifications, barrier upgrades, ADA ramp compliance, rehabilitation of existing HMA bikepath including ADA compliance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017 round-about</td>
<td>Allen Road (CR 652) and Somerville Road Roundabout</td>
<td>Bernards</td>
<td>0.2</td>
<td>-</td>
<td>consultant award</td>
</tr>
<tr>
<td></td>
<td>Installation of a modern roundabout at an existing 4-way stop controlled intersection that is seeing high crash rates.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Projects that applied a pavement surface treatment

$13,055,000.00
Surface Friction Treatments – 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.
Suddenly, 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.
Then, we could evaluate the whole County for crash trends.
What now to do with this information? Friction treatments!

Because of County wide crash analysis we could now see which areas needed further investigation for possible safety improvements - friction courses gave us a tool to use at horizontal curves. But, we still had questions:

- What was the correct friction treatment method?
- When is it warranted?
- How to determine the length of need on a horizontal curve?

**VARIOUS LOCATIONS - KENTUCKY**
Kentucky Transportation Cabinet. Automated High Friction Surfacing Treatment

BROCHURE www.dbiservices.com
Micro milling – our initial solution.

Pros:
- Provided high friction surface which reduced ‘run-off-road’ type 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.
Next came … 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 (25).

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

NCHRP
Web-Only Document 108:
Guide for Pavement Friction
When is a friction treatment warranted?

After much research … our take away is:

- it is about the difference in the side friction experienced by driver. This is calculated by finding the difference in the travel speeds along the tangent segment of roadway and the horizontal curve.
Our evaluation method.

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

Formula 3.8, AASHTO ‘Green Book’, utilized to provide friction rates based on horz. curve characteristics.

From the result of the evaluation, friction ranges developed giving guidance for the action to take.

<table>
<thead>
<tr>
<th>Side Friction Differential</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - .009</td>
<td>No action</td>
</tr>
<tr>
<td>.01 - .019</td>
<td>Curve warning sign</td>
</tr>
<tr>
<td>.02 - .044</td>
<td>Curve warning with advisory speed</td>
</tr>
<tr>
<td>.045 - .074</td>
<td>Advance curve warnings and chevrons</td>
</tr>
<tr>
<td>.075 and above</td>
<td>High friction surface treatment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACCIDENTS</th>
<th>CURVE</th>
<th>ROAD</th>
<th>TRENDS</th>
<th>DESIGN SLOPE</th>
<th>GROWN</th>
<th>POSTED SPEED</th>
<th>CURVE</th>
<th>TANGENT</th>
<th>FRICTION</th>
<th>CALIBRATION</th>
<th>CRITICAL</th>
<th>FRICTION EVALUATION</th>
<th>ACTION</th>
</tr>
</thead>
</table>
| 1         | 32    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | OK      | 45.09     | NO ACTION    | CURVE WARNING SIGN | ADVA...
| 2         | 35    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | 26.59   | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 3         | 33    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 4         | 36    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 5         | 37    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 6         | 38    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 7         | 39    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 8         | 40    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 9         | 41    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 10        | 42    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 11        | 43    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 12        | 44    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 13        | 45    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 14        | 46    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 15        | 47    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...
| 16        | 48    | 45   | 3     | 45           | 50    | 0.14          | 84.49 | SUBSTD  | 45.09     | NO ACTION    | NO ACTION          | ADVANCE...

Cross slope at curve

Posted speed and curve advisory

Calculated curve design speed

tangent friction, curve friction needed, difference between them.
What is the Length of Need?

Friction treatment length of need determination: approach length + length of curve (PC to PT)

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

<table>
<thead>
<tr>
<th>Approach Speed (mph)</th>
<th>Curve Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>40</td>
<td>76</td>
</tr>
<tr>
<td>45</td>
<td>122</td>
</tr>
<tr>
<td>50</td>
<td>173</td>
</tr>
<tr>
<td>55</td>
<td>230</td>
</tr>
<tr>
<td>60</td>
<td>292</td>
</tr>
<tr>
<td>65</td>
<td>359</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>County Roads</th>
<th>Road Segments</th>
<th>Year applied</th>
<th>Corridor - Annual avg crashes before</th>
<th>Corridor - crashes year after</th>
<th>Reduction</th>
<th>Treatment type</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Center Road (CR 627)</td>
<td>From Auten Road to Roycefield Road</td>
<td>2013</td>
<td>19</td>
<td>10</td>
<td>47%</td>
<td>Micro surfacing full project length</td>
</tr>
<tr>
<td>River Road (CR 625)</td>
<td>From Lyman Street Bridge to Roycefield Road</td>
<td>2014</td>
<td>25</td>
<td>5</td>
<td>80%</td>
<td>Micro surfacing full project length</td>
</tr>
<tr>
<td>Chimney Rock Road (CR 525)</td>
<td>From Thompson Avenue to Gilbride Road</td>
<td>2015</td>
<td>73</td>
<td>12</td>
<td>84%</td>
<td>HFST applied to 5 curves on 1 mile road segment (steep vertical)</td>
</tr>
<tr>
<td>Burnt Mills Road (CR 620)</td>
<td>From Rattlesnake Bridge Road to Country Club Road</td>
<td>2015</td>
<td>20</td>
<td>9</td>
<td>55%</td>
<td>HFST applied to 5 curves on 3 mile road segment</td>
</tr>
<tr>
<td>Pottersville Road (CR 512)</td>
<td>From Hacklebarney Road to Route 206</td>
<td>2015</td>
<td>8</td>
<td>7</td>
<td>13%</td>
<td>HFST applied to 4 curves on 2.4 mile road segment</td>
</tr>
<tr>
<td>Lamington Road (CR 523)</td>
<td>From County Line to Route 206</td>
<td>2015</td>
<td>23</td>
<td>17</td>
<td>26%</td>
<td>HFST applied to 2 curves on 5 mile road segment</td>
</tr>
<tr>
<td>Dukes Parkway East (CR 618)</td>
<td>From 6th Ave to 7th Ave, Manville</td>
<td>2016</td>
<td>4.4</td>
<td>1</td>
<td>77%</td>
<td>HFST applied to both travel lanes at one horz. curve</td>
</tr>
</tbody>
</table>
Where are we now?

2016 and 2017, as part of our annual resurfacing program, we installed HFST treatments to locations in need. Locations to evaluate were determined from:

- Concerns expressed by Municipalities or residents
- Recent severe crashes

2019 performing restoration to micro-milled areas and repairs to HFST areas.

Future: prioritize high crash locations for evaluation to implement additional signage or friction surface treatments. Data sources to prioritize coming from:

- In-house GIS crash mapping
- NJ Regional Curve Inventory and Safety Assessment for the North Jersey Transportation Planning Authority (NJTPA) Region
Our HFST Installations

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

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 LINES HOLD 4" GAP FROM YELLOW LINE OR WHITE INSIDE LEFT-LANE LINE. HOLD 10" WIDE HFST WIDTH OR AS DIRECTED BY RE.
New HFST Resources

Federal Highway Administration webpage has a page of FAQs, Links, and Other Resources, General Pavement Friction Resources which includes documents of:

- May 2016 HFST Curve Selection and Installation Guide
- Guidance documents
- Fact Sheet
- Aggregate Studies
- Technical specifications
- Videos
- Other resources
Thank You!

References:

- 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.
- [https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/faqs_links_other/](https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/faqs_links_other/) Federal Highway HFST FAQ webpage

For more information contact:
Patricia Bates Smith | Principal Engineer, Highway | Somerset County Engineering Division
908-231-7175 (direct) | 908-231-7024 (main) | 908-231-7170 (fax)
County Administration Building | 20 Grove Street | PO Box 3000 | Somerville, NJ 08876-1262
Email smithT@co.somerset.nj.us