SCRIM Friction Testing in the USA

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Outline

• Introduction: What is the SCRIM?
• Background and Friction 101
• Pavement Friction Management and Crash Data Analysis
• Case Studies (examples)
• Final Considerations
SCRIM

- Friction
- Macrotexture
- IMU + GPS
  - Grade
  - Cross-slope
  - Curvature
- Video (front)
- 2,400 gallons
- 150 miles of Continuous Data per tank

Sideway-Force Coefficient Routine Investigation Machine

Virginia Tech Transportation Institute
• Electrical Systems: 24 vs 12 V
• EPA/EU diesel rules are not the same???
SCRIM

• Friction
  – Dynamic vertical load system
  – Dynamic water flow control
  – 20° skew angle for 34% slip speed
  – Operating speed of 15 – 55 mph

• Macrotexture
  – 64 kHz laser system
Background

- Federal Rulemaking
- Report:
  - Fatalities and Serious Injuries
  - Rate of Fatalities and Serious Injuries
NHSTA early projection: Deaths jump up 10.6% in first half of 2016
## Background

1. **SAFE**
   - Fatality: 1
2. **DURABLE**
   - Injury: 55
3. **ECONOMIC**
   - PDO: 120
   - Total: 175

### Virginia 2014

**Est:** 656 Fatal, 36,080 Injury, 78,720 PDO, 114,800 Total

**Real:** 656 Fatal, 41,594 Injury, 78,032 PDO, 120,282 Total
NHTSA Report shows traffic deaths were up 7.7% in 2015

Complacency: Satisfied with how things are & Not wanting to make them better

Background

U.S. Traffic Deaths Up In 2015 -- Is There A Solution?

By Cheryl Jensen

It looks like projections earlier this year about an increase in motor vehicle traffic deaths could, unfortunately, become fact.
Introduction

Motor vehicle crash fatalities in the U.S. could drop by half with proven strategies.

Lower death rates in high-income comparison countries suggest that progress is possible.

Road traffic deaths in the US and other high-income countries.

Motor vehicle crash deaths in 10 comparison high-income countries, 2013

- United States: 10.3
- New Zealand: 5.6
- Canada: 5.4
- France: 5.1
- Japan: 4.5
- Germany: 4.0
- Spain: 3.6
- Switzerland: 3.3
- United Kingdom: 2.8
- Sweden: 2.7

Countries with the highest and lowest reductions in crash deaths, 2000-2013

- Spain (highest): 75%
- Average of 19 high-income countries: 56%
- United States (lowest): 31%

Deaths per 100,000 people

High-income countries with the highest percentage of crash deaths involving alcohol or speed

<table>
<thead>
<tr>
<th></th>
<th>Alcohol</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>34%</td>
<td>42%</td>
</tr>
<tr>
<td>United States</td>
<td>31%</td>
<td>40%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>31%</td>
<td>39%</td>
</tr>
<tr>
<td>Australia</td>
<td>30%</td>
<td>35%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>30%</td>
<td>33%</td>
</tr>
<tr>
<td>France</td>
<td>29%</td>
<td>33%</td>
</tr>
<tr>
<td>Belgium</td>
<td>25%</td>
<td>30%</td>
</tr>
<tr>
<td>Finland</td>
<td>22%</td>
<td>29%</td>
</tr>
<tr>
<td>Sweden</td>
<td>19%</td>
<td>28%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>19%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Note: 19 countries reported the percentage of deaths involving alcohol and 15 countries reported the percentage of deaths related to speeding.

### Background

<table>
<thead>
<tr>
<th>Problem</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the US, belt use was lower than in most other countries (9,500 fatalities)</td>
<td>Use a seat belt in every seat, on every trip, no matter how short. Children back seat car seat, booster seat, or seat belt, for appropriate height, age, and weight.</td>
</tr>
</tbody>
</table>
### CDC Conclusions

<table>
<thead>
<tr>
<th>Problems</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not using seat belt</td>
<td>Use seat belts</td>
</tr>
<tr>
<td>Drunk/impaired driving</td>
<td>Don’t drink and drive</td>
</tr>
<tr>
<td>Speeding</td>
<td>Don't drive over the limit</td>
</tr>
<tr>
<td>Distracted driving</td>
<td>Don't text, call, or be distracted when driving</td>
</tr>
</tbody>
</table>
Background: But, what can we do?

1. We can improve the friction of the roads (Maintenance)
2. We can determine where to improve friction with crash data analysis (Safety)
3. We can specify how and when to improve friction (Materials)
Friction 101

Coefficient of Friction

\[ \mu = \frac{F_x}{F_y} = \frac{F_x}{W} \]

- Peak friction
- Intermittent sliding
- Full Sliding friction

Tire influence area
Pavement surface influence area
Critical slip

Tire Slip, %

(after Henry, 2000)
Friction 101: What is texture?

Microtexture

Macrotexture
THREE ZONE CONCEPT

• 1: Macrotexture
• 2: Microtexture
• 3: Dry Contact
Figure 27. Change in highway cross-section as the horizontal alignment transitions from a tangent to a curve.
Figure 28. Lateral forces that act on a vehicle as it travels along a curve.

Figure 29. Lateral sliding.

\[ f + e = \frac{V^2_c}{15R} \]
How cross-slope affects hydroplaning

Mraz and Nazef, 2008
Tires used in the US

ASTM E-501, E-524, E-1551, & E1844
Acceptance Testing and Demonstration of CFME:

- Goal: reduce highway crashes and related fatalities
- Evaluate the recommendations 2008 AASHTO: Guide for Pavement Friction

CFME: Continuous Friction Measurement Equipment
Acceptance Testing and Demonstration of CFME:

• Assist 4 states develop Pavement Friction Management Programs (using pavement friction, texture*, crashes, and other data)

• Develop and demonstrate methods
  ➢ Get friction, texture, crash, traffic, other data
  ➢ Define friction demand categories
  ➢ Set investigatory levels of friction/texture

*Texture = macrotexture
Acceptance Testing and Demonstration of CFME:

- Washington 575 miles
- Florida 875 miles
- Indiana 875 miles
- Texas 840 miles
- North Carolina ±500 miles
Bituminous Surface Treatment SC vs SN

SC
SNCalc

SCRIM Coefficient

0.1 mile sections
Statistical Analysis: Regression
SC vs SN

\[ y = 0.4141x + 27.24 \]
\[ R^2 = 0.5529 \]

\[ y = 0.4373x + 23.03 \]
\[ R^2 = 0.5985 \]
Crash analysis

Do we need the same friction everywhere?

• Minimum friction (VA: SN 40S = 20)
• Perera et. al. Skid Crash Reduction Programs – Synthesis (MN SN 40R):
  – Interstate: 28-41
  – Primary: 25-37
  – Secondary: 22-37
<table>
<thead>
<tr>
<th>Site category and definition</th>
<th>Investigatory level 50 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>A Motorway</td>
<td></td>
</tr>
<tr>
<td>B Dual carriageway non-event</td>
<td></td>
</tr>
<tr>
<td>C Single carriageway non-event</td>
<td></td>
</tr>
<tr>
<td>Q Approaches to and across minor and major junctions, approaches to roundabouts</td>
<td></td>
</tr>
<tr>
<td>K Approaches to pedestrian crossings and other high risk situations</td>
<td></td>
</tr>
<tr>
<td>R Roundabout</td>
<td></td>
</tr>
<tr>
<td>G1 Gradient 5-10% longer than 50m</td>
<td></td>
</tr>
<tr>
<td>G2 Gradient &gt;10% longer than 50m</td>
<td></td>
</tr>
<tr>
<td>S1 Bend radius &lt; 500m - dual carriageway</td>
<td></td>
</tr>
<tr>
<td>S2 Bend radius &lt; 500m - single carriageway</td>
<td></td>
</tr>
<tr>
<td>Road classification definitions</td>
<td>Investigatory level 30 mph</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>A Interstate highways</td>
<td></td>
</tr>
<tr>
<td>B Divided highways-no event</td>
<td></td>
</tr>
<tr>
<td>C Two lane road-no event</td>
<td></td>
</tr>
<tr>
<td>Q Approaches to Intersection (&amp; roundabouts)</td>
<td></td>
</tr>
<tr>
<td>K Pedestrian crossings and other high risk areas</td>
<td></td>
</tr>
<tr>
<td>R Roundabout</td>
<td></td>
</tr>
<tr>
<td>G1 Slope 5-10%, longer than 160 feet</td>
<td></td>
</tr>
<tr>
<td>G2 Slope &gt;10% longer than 160 feet</td>
<td></td>
</tr>
<tr>
<td>S1 Curve radius &lt; 1600 feet - divided roads</td>
<td></td>
</tr>
<tr>
<td>S2 Curve radius &lt; 1600 feet - two lane roads</td>
<td></td>
</tr>
</tbody>
</table>
Safety Performance Function (SPF)

Model: \( \lambda_i = e^{\beta_0 + \beta_j X_{ij}} \)

\( \lambda_i = \) crash rate for the \( i^{th} \) segment of roadway

\( X_{ij} = \) the value of variable \( j \) at the \( i^{th} \) road segment

\( \beta_j = \) The estimated parameter coefficient for the \( j^{th} \) variable (where: \( j > 0 \))
Final Model: crash prediction

- Combine results of the SPF with EB, vs.
- Crash Modification Factors: Before/After
- Results in Economic Analysis (B/C) for selected treatments to improve friction and macrotexture at all 0.1 mile sections of network tested
CASE 1

- State Route 3 (MM 59.9)
- 0.1 mile comparison data collection
CASE 2

- Interstate Pavement
- Friction and Texture
CASE 3

- Interstate I-81
- Friction and Texture
- Grade, cross-slope and curvature
I-81 NB Grade
I-81 NB Cross-slope and Curvature
I-81 NB Cross-slope and Curvature

MILE MARKER

CROSS-SLOPE

CURVATURE (1/R) m
CASE 4

- Interstate I-275 Tampa, Florida
- To TOLL 589
- HFST
- Friction and Texture
End of HFST
Exit 39 from I-275 to Memorial Highway (Toll 589)
Exit 39 from I-275 to Memorial Highway (Toll 589)

Average SC 67.5
Average SC 46.6
Average SC 33.1

SCRM Coefficient (SC x 100) vs Macrotexture MPD (mm)
Final Considerations

- 49/50 States use the locked-wheel
- Limitations: Curves, ramps, and cannot do continuous (every 0.3, 0.5, 1.0 miles, +)
- Macrotexture possible, not common
- Crash data analysis needs friction data
Final Considerations

- Water ± 2 gal @40 mph, so every 0.1 mile:
  - 300 gallon tank, 150 tests, 15 miles
  - 1000 gallon tank, 500 tests, 50 miles
- Summary: E-274 SCRIM
- Miles/day: 50 300
- Miles/Year: 6,000 36,000
- Direct Cost/mile $15.82 $8.72
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- WASH DOT: David Luhr and Jianhua Li
- TTI: Don Zimmer and Dusty Arrington
Questions?
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