Pavement Surfaces and Their Relationship to Safety – Overview in the USA from a Pavement’s Perspective

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Agenda

Friction Testing – History
Road Safety Emphasis – History
Road Safety and Pavement Communities Recent Cooperation
The Road Ahead
Friction Testing - History

US Highway Initial Major Federal Investment
AASHO Road Test – 1950’s
Friction Testing – 1950’s-60’s
National Friction Guidance and Practices up to 1990
U.S. Highway Initial Major Federal Investment

“Federal-Aid Highway Act of 1956” established Interstate (motorway) Road System

- President Eisenhower (WW II General)
- Standards to meet 20 year traffic forecasts
- Also funded Safety and Pavement Research
AASHO Road Test – 1950’s

Major Federal Road Research

• Pavement Design
• Large Vehicle Damage Assessment – Taxes

Source: FHWA
Friction Testing – 1950’s-60’s

- 1st International Skid Prevention Conference held in the USA, 1959
  - Correlation study of locked wheel skid trailers in 1962
- American Society for Testing and Materials (ASTM) committee E-17 on Skid Resistance formed in 1960

Source: Virginia Tech Transportation Institute
National Friction Guidance and Practices

National Cooperative Highway Research Program Report 37, Tentative Skid-Resistance Requirements for Main Rural Highways, 1967

FHWA established 3 calibration centers, 1971
  • One closed in 1975 and two remain open today

1976 American Association of State Highway and Transportation Officials (AASHTO) Guidelines for Skid Resistant Pavement Design

1980 FHWA Technical Advisory, Skid Accident Reduction Program
  • Main purpose is to minimize wet weather skidding accidents
National Friction Guidance and Practices (cont’d)

NCHRP Report 37, 1967:

• Vehicle speeds increased, younger drivers
• “Because the intensity of the polishing process increases markedly with tread element slip, all other factors being equal, the lowest friction levels are found on high-speed roads, curves, and approaches to intersections; in short, in locations at which high friction values are needed most.”
National Friction Guidance and Practices (cont’d)

- Locked-Wheel Skid Trailer
- Wet weather related crashes
- More localized assessment vs. network managed approach

Source: Virginia Tech Transportation Institute
Road Safety Emphasis – History

Emphasis before the Interstate Era (pre-1956)
Interstate Era (1956-2000)
Infrastructure Safety Milestones Over the Years
Major National Advancements and Significant Engineering Countermeasures

1911: First center line is painted
1920: First 3-color traffic signal installed

111

Source: FHWA
Emphasis before the Interstate Era (pre-1956)

Driver Expectations of Road Environment

- Traffic Control
  - Signs
  - Pavement markings
  - Intersections
- Geometric
  - Lane and shoulder widths
  - Curvature
Interstate Era (1956-2000)

Standards and uniformity for the specific class of highways
FHWA Spot Improvement Program, 1964
Roadside Safety
Fatality Rates v. Fatalities

Note: CY2015 fatalities estimated by applying 9M15 YoY growth rate to CY2014 nos.
Source: National Highway Traffic Safety Administration, Morgan Stanley Research

Source: http://www.businessinsider.com/traffic-fatalities-historical-trend-us-2016-4
## Fatality Rates v. Fatalities

Should engineering “fixes” focus on fatality rates per 100 road miles?

### Table:

<table>
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<tr>
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<th>Rural</th>
<th>Urban</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>Fatality Rate</td>
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<tr>
<td>Interstate</td>
<td>9.99</td>
<td>3,297</td>
<td>18.18</td>
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<tr>
<td>Non-Interstate</td>
<td>0.75</td>
<td>22,659</td>
<td>1.63</td>
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<tr>
<td>All roads</td>
<td>0.85</td>
<td>25,956</td>
<td>1.88</td>
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87% of the fatalities occur on roads with the lowest fatality rates

Source: FHWA
Road Safety Emphasis – History

1990’s-2000’s State Highway Agencies establish goals to reduce road related fatalities
Infrastructure improvements to reduce fatalities – low cost/systemic
Road Safety and Pavement Communities
Recent Cooperation

Pavement Requirements and Guidance
Safety Requirements and Guidance
Safety/Pavement Cooperation
FHWA Pavement Friction Requirements

Current Requirements

Current Guidance/Policies
Present National REQUIREMENTS
For Friction Measurement

THERE ARE NONE
Pavement Policies

Federal Regulation - Policy

• “Pavement shall be designed to accommodate current and predicted traffic needs in a safe, durable, and cost effective manner.”
Pavement Guidance

Technical Advisory – Surface Texture for Asphalt and Concrete Pavements TA 5040.36, 2005

• Provides information on state-of-the-practice for providing surface texture/friction on pavements
  • Does not establish texture/friction thresholds
• Guidance for selecting techniques that will provide adequate wet pavement friction

www.fhwa.dot.gov/pavement/t504036.cfm?prnt=yes
Pavement Guidance

Technical Advisory - Pavement Friction Management
TA 5040.38, 2010

• Guidance to highway agencies in the management of pavement surface friction on roadways.
• Supersedes TA 5040.17 Skid Accident Reduction Program (1980) - impetus to many agency friction testing programs (reactive, localized hazards)

www.fhwa.dot.gov/pavement/t504038.cfm?prnt=yes
Pavement Guidance – Pavement Friction Management (cont’d)

- Issued to support Safety regulation requiring:
  - “Data-driven" and shall incorporate "A process for collecting and maintaining a record of . . . Roadway . . . data on all public roads."
  - To provide roadway data that will establish the relative severity of locations identified for highway safety improvement projects, a State highway agency should implement a program to manage pavement friction on its public roads.
2008
AASHTO: Guide for Pavement Friction
Safety Requirements and Guidance

Federal Regulation - Highway Safety Improvement Program (HSIP) - Policy

• (a) Each State shall develop, implement, and evaluate on an annual basis a HSIP that has the overall objective of significantly reducing the occurrence of and the potential for fatalities and serious injuries resulting from crashes on all public roads.
FHWA Safety Program identified focus areas with the greatest potential to reduce fatalities using infrastructure-oriented improvements. These areas include the following:

- Roadway departure crashes (vehicle leaves lane), involved in 50% of fatalities.
- Intersection-related crashes, account for 16% of fatalities.
- Pedestrian/bicycle crashes, account for 12% of fatalities.
- Combination of the above three crash types, account for 11% of fatalities.

These three focus areas encompass almost 90% of USA traffic fatalities.

2011-2013 data
SOURCE: NHTSA FARS
Safety/Pavement Cooperation (cont’d)

National and State Efforts to Reduce Fatalities/Severe Injuries

FHWA Pavement Surface Characteristics

- Friction – equipment demonstration
- Noise
- Splash/Spray
- Smoothness, cracking, rutting
Safety/Pavement Cooperation (cont’d)

FHWA Internal Cooperation: Systemic, Preventive

- Crash Analysis Research focusing on Pavement Surface Type
- Safety Edge
- High Friction Surface Treatment
- Rumble Strip
- Pavement Friction Management Study
Safety/Pavement Cooperation (cont’d)

FHWA Every Day Counts Program - 2009

• Accelerate the implementation of innovations and enhanced business processes
  ✓ Safety Edge
  ✓ High Friction Surface Treatments
What Is the Safety Edge?

30 degree beveled pavement edge shaped during the paving process. Asphalt or Concrete located where the pavement interfaces with a graded material. It allows a vehicle to re-enter the pavement with greater stability and less loss of control resulting in reduced crashes. When used on asphalt pavement the extruded shape can improve pavement edge durability.

Source: FHWA
High Friction Surface Treatment

• High Friction Surface Treatments (HFST) are pavement surfacing overlay systems with:
  - Exceptional skid-resistant properties that are not typically acquired by conventional materials.
  - Retains the higher friction property for a much longer time.

• Resin-based binder with calcined bauxite aggregate

• Generally applied in short sections to improve spot locations where friction demand is critical
HFST Installation

Manually - Manual mixing of binder material and application with squeegee

Automated - (machine-aided) Machine mixing and application of binder (limited hand/squeegee work)

Source: FHWA
HFST Finished Product

Source: FHWA
Edge Line or Shoulder Rumble Strips

Crash Reduction: 36% of fatal and injury SVRORs

(for rural 2-lane roads)

Standard Practice on Access Controlled Motorways – First installations mid-1980’s

Recent Initiative is to increase use on rural 2-lane roads

Source: FHWA
Center Line Rumble Strips – Rural 2-lane Roads

Crash Reduction: 44% of fatal and injury head-ons (for rural 2-lane roads)

Few countermeasures address cross-center crashes

Source: FHWA
Pavement Friction Management Study

• Assist 4 States in developing Pavement Friction Management Programs (using continuous pavement friction and texture* measurements, crashes, and other data)

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

• Demonstrate continuous friction, texture and other data measurement equipment

* Texture = macrotexture
Data – 700 Lane Miles Tested Per State

1. Friction/Texture Data
   • Continuous Friction Testing.
   • Locked Wheel Skid Tester (standard).
   • Continuous Macrotexture Measurement.
   • Historical Locked Wheel Skid Tests and frequency.

2. Crash Data
   • Section lengths, locations (0.1 mile units).
   • Types of crashes (fatalities, injuries, property damage).
   • Road Conditions: Wet/dry, night/day, others.

3. Road Management System Data
   • Road classification, AADT, geometry, etc.
   • Pavement type, condition.
Alternative Analysis Approaches

Safety Performance Functions, relate crashes to several factors FHWA General (SPF)

- $X_1, X_2, \ldots, X_n$
  - Explanatory variables
    - $P$: Number of crashes on segment L
    - $AADT$: Traffic count
    - $X_i$: Friction, Texture, Curvature, cross-slope, grade, etc.

$$P = L \times e^{\beta_0 + \ln(AADT) \beta_1 + X_{1+i} \beta_{1+j}}$$
Friction Measurement Equipment Selection Criteria

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<tr>
<td>1</td>
<td>Effectiveness in the prediction of (fatal) crash potential</td>
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<tr>
<td>2</td>
<td>Continuous friction measurement capability and operating principle; slip ratio</td>
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<tr>
<td>3</td>
<td>Macrotexture measurement</td>
</tr>
<tr>
<td>4</td>
<td>Stage of development of the device (experimental vs commercially available)</td>
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<tr>
<td>5</td>
<td>Proven robustness and readiness for deployment for network data collection</td>
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<tr>
<td>6</td>
<td>Data collection productivity</td>
</tr>
<tr>
<td>7</td>
<td>Measurement speed</td>
</tr>
<tr>
<td>8</td>
<td>Precision (Repeatability and Reproducibility)</td>
</tr>
<tr>
<td>9</td>
<td>Global Positioning System (GPS)</td>
</tr>
<tr>
<td>10</td>
<td>Software</td>
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</table>
Data Collection System - SCRIM

Water tank: 2200 gallon = 8400 liters

Source: Virginia Tech Transportation Institute
• Skewed tire (20°- 34% slip)
• Macrotecture 62.5 kHz laser
• Air, surface & tire temperature
• Grade, cross-slope, & curves radius (3-axis inertial GPS)
• Dynamic vertical load system
• Dynamic water flow control
Pavement Friction Management Study - status

Field Data Collection completed in all 4 States
Data Analysis ongoing
Draft Reports to States underdevelopment

Crash Data:
• Roadway Characteristics: horizontal curve, vertical curve, super-elevation.
• Develop Friction Demand Categories.
• Pavement Surface Type.
• Current Safety Analysis Methodologies.
The Road Ahead


Five performance measures as the 5-year rolling averages for:

- Number of Fatalities.
- Rate of Fatalities per 100 Million Vehicle Miles Traveled (VMT).
- Number of Serious Injuries.
- Rate of Serious Injuries per 100 Million VMT.
- Number of Non-motorized Fatalities and Non-motorized Serious Injuries.
Thank You

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U.S. Department of Transportation
Federal Highway Administration
FHWA Resource Center