IMPROVING HIGHWAY SAFETY THROUGH PAVEMENT FRICTION MANAGEMENT (PFM) PROGRAMS

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Other Acknowledgements

- Andy Mergenmeier (FHWA liaison)
- Jim Wambold (CDRM, Penn State)
- Helen Viner (TRL)
- Tony Parry (University of Nottingham)
- Peter Roe (TRL)
- Edgar de León Izeppi (VTTI)
- Kevin McGhee (VDOT)
- Kurt Smith (APTech)
Presentation Overview

- Background on pavement-related safety.
- “Development and Demonstration of PFM Programs.”
  - Examinations of past studies investigating the relationship between pavement friction/texture and crashes.
  - Examinations of PFM-related practices.
- Key findings/conclusions.
Background

- U.S. Highway Safety
  - Historical crash trends
  - Performance goals
- Crash Factor Categories
U.S. Highway Safety


New Goal: Cut fatalities in half by 2030
Crash Factor Categories

- Driver/road user behavior
- Vehicle conditions
- Roadway conditions
Development and Demonstration of PFM Programs

• Objectives

1. Determine criteria and develop methods for establishing investigatory and intervention levels of friction and texture for different friction demand categories on highway facilities.

2. Identify state-of-the-art friction and texture measurement equipment.

3. Work with selected states to develop and demonstrate PFM programs using results from first two objectives.
T1. Lit Review & Theoretical Analysis Report

T2. Equipment Recommendation Report

T3. Task 1 & 2 Deliverables and Phase II Work Plan

T4. Purchase Equipment

T5. Establish SHA Participation in PFM Program Development/Demonstration

T6. Data Collection & Preliminary Analysis

T7. Data Analysis of Friction Thresholds

T8. Develop Suggested PFM Programs for Participating SHAs


T10. Develop Promotional & Implementation Products
Task Focus

- Activity 1—Examination of past studies investigating the relationship between vehicle-tire-pavement interactions and crashes.
- Activity 2—Examination of PFM-related practices.
Relationships Between Pavement Friction/Texture and Crashes

- Literature Search/Review
  - Studies in last 10 years
  - State DOTs, other countries

- Evaluate studies in terms of:
  - Physical scope of the study and the timeframe
  - Area of safety interest and crash types examined
  - Types of friction/texture and crash data evaluated
  - Analysis techniques used
  - Findings/results of the study
## Synopsis of Studies

| Physical Scope (highway segments analyzed) | Projects–interstates, trunk highways  
Corridors–interstates, US routes, state routes  
Networks–interstates, freeways, 2-lane roads, multi-lane divided and undivided roads, strategic routes, principal roads |
| Spans of Years for Data Analyzed | Various–anywhere from 1 to 8 years |
| Type of Friction/Texture Data | **Locked-wheel FN** (various speeds, ribbed or smooth)–primarily states  
**SCRIM SFC and MSSC**–other countries  
**Mu-Meter FN**  
**High-Speed profiler EMTD or SMTD**  
**Sand patch MTD**  
Generic surface texture type or material type (e.g., tined PCC, HMA of various gradations, microsurfacing, high-friction surfacing) |
## Synopsis of Studies (cont.)

<table>
<thead>
<tr>
<th>Areas of Safety Interest</th>
<th>Hot-spot locations</th>
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<tbody>
<tr>
<td></td>
<td>Intersections</td>
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<tr>
<td></td>
<td>Congested freeways</td>
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<tr>
<td></td>
<td><strong>Curves</strong> (horizontal and vertical)</td>
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<td>Roundabouts</td>
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<td>Interchange ramps</td>
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<table>
<thead>
<tr>
<th>Crash Types Analyzed</th>
<th>All</th>
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<tbody>
<tr>
<td>Intersection</td>
<td></td>
</tr>
<tr>
<td>Rear-end</td>
<td></td>
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<tr>
<td>Run-off-road</td>
<td></td>
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<tr>
<td>Combination rear-end and side-swipe</td>
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<tr>
<td>Rollover</td>
<td></td>
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<tr>
<td>Jackknife</td>
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<tr>
<td>Object-in-road</td>
<td></td>
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<td>Fixed-object</td>
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## Synopsis of Studies (cont.)

<table>
<thead>
<tr>
<th>Crash Data Parameter Types</th>
<th>Total crashes or total crash rate (all components or just severe [fatal/serious])</th>
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<tbody>
<tr>
<td></td>
<td>Wet crashes or wet crash rate</td>
</tr>
<tr>
<td></td>
<td>Dry crashes or dry crash rate</td>
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<tr>
<td></td>
<td>Wet-to-dry crash ratio</td>
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<td></td>
<td>Wet-to-total crash ratio</td>
</tr>
<tr>
<td></td>
<td>LPSR or WSF (normalize for differences in wet pavement time)</td>
</tr>
<tr>
<td></td>
<td>Time of day crashes, seasonal crashes</td>
</tr>
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<thead>
<tr>
<th>Analysis Techniques Used</th>
<th>Direct comparison</th>
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<tr>
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<td>Before-and-after comparison</td>
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<tr>
<td></td>
<td>Comparison to the norm</td>
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<tr>
<td></td>
<td>Regression analysis</td>
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</tbody>
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## Before-and-After Comparison—Example

<table>
<thead>
<tr>
<th>Year</th>
<th>Prior to App AR PFC</th>
<th>After AR PFC</th>
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<tbody>
<tr>
<td></td>
<td>2001</td>
<td>2002</td>
</tr>
<tr>
<td>Total No. of Accidents</td>
<td>25</td>
<td>48</td>
</tr>
<tr>
<td>Dry Weather Accidents</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Wet Weather Accidents</td>
<td>15</td>
<td>26</td>
</tr>
<tr>
<td>Fatalities</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total Injuries</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Incapacitating Injuries</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Non-incapacitating Injuries</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Annual Rainfall (in)</td>
<td>42.9</td>
<td>36.0</td>
</tr>
<tr>
<td>Total Rain Days (&gt;0.1 in)</td>
<td>57</td>
<td>58</td>
</tr>
</tbody>
</table>

Rubber Pavements Association (RPA). 2008. “Safety on Friction Courses-Update.” Volume 11, Number 1, Rubber Pavements
Regression Analysis—Example

Wet/Total Crash Ratio vs. FN40 (Avg and Min) for All Sections (Ribbed and Smooth Tires)

- FN40R Avg: $y = -0.2597 \ln(x) + 1.1916$, $R^2 = 0.1712$
- FN40R Min: $y = -0.2566 \ln(x) + 1.1644$, $R^2 = 0.181$
- FN40S Avg: $y = -0.1578 \ln(x) + 0.7693$, $R^2 = 0.0697$
- FN40S Min: $y = -0.1422 \ln(x) + 0.7038$, $R^2 = 0.0673$

PFM-Related Practices
(Pavement Safety Approaches)

- Traditional approach
  - Based on FHWA Technical Advisory T 5040.17 (*Skid Accident Reduction Program*).
  - Basic steps
    1. Collect and review crash data to identify high wet-weather crash locations.
    2. Analyze wet pavement crash rates to identify locations with potentially inadequate levels of friction and/or texture.
    3. Conduct detailed site investigation of hot-spot locations, including testing for friction and possibly texture.
    4. Develop, prioritize, and program pavement countermeasures, as necessary.
PFM-Related Practices (Pavement Safety Approaches) (cont.)

• Pro-active approach
  • Based on AASHTO *Guide for Pavement Friction* and FHWA Technical Advisory T 5040.38 (*Pavement Friction Management*).
  • For agencies where friction is recurring problem.
  • Basic steps
    1. Perform routine friction testing and collect crash data.
    2. Identify locations with friction below investigatory level
    3. Of these locations, identify which have friction below intervention level and/or have high wet-weather crash rates.
    4. Develop, prioritize, and program treatments, as necessary.
Pavement Safety Approaches

- Literature Search/Review
  - Sampling of US states and international agencies
- Evaluate programs/practices in terms of:
  - Basic approach (traditional or proactive)
  - Components/features
  - Noteworthy ideas, procedures, and technical information
Key Findings/Conclusions

- **Strong Friction/Texture—Crash Relationships Elusive**
  - crashes largely *caused* by human error, frequently involve one or more contributing factors—confounds analysis.
  - inadequate matching of friction/texture test locations and crash locations also confounding.

- **Concept of Investigatory and Intervention Levels Important**
  - Recognizes inaccuracies in friction/texture—crash relationships; logical and reasonable approach to determining if friction/texture is contributing to crashes (or severity of crashes).
  - Establish for individual site categories (friction demand)
Key Findings/Conclusions (cont.)

- PFM-Related Practices Vary According to Need
  - Traditional safety-driven approach practical in some locations.
  - Proactive approach necessary or more practical in other locations.
  - Successful application of a specific practice in one place, does not guarantee success elsewhere; customization needed.
Key Findings/Conclusions (cont.)

- Continue Assessing Role of Equipment in Friction/Texture–Crash Relationships
  - No direct comparisons of effectiveness of different friction and texture measuring devices.
  - Strong relationships not available from any device (locked-wheel, continuous side-force equipment).
  - Potential advantages/disadvantages.
Closing Thought

- “Skid resistance (friction) is likely to remain a key element in the provision of a safe road system in the future, although priorities for the detailed manner in which they are provided may change.”

--- Peter Cairney
Thank You!!

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