Where Does Safety Fit In Pavement Evaluation?

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Three Objectives:

1. Review challenges/pitfalls of traditional assessments
2. Share changes in technology
   (making more comprehensive assessments now possible)
3. Review potential implications
History

• 1st International Skid Prevention Conference held in the USA, 1959
• American Society for Testing and Materials, ASTM committee E-17 on Skid Resistance, formed in 1960
Traditional Safety Measurements

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Standard Safety Analysis Methods

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

\[ X_1, X_2, ..., X_n \]

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 Assessment

Rubber Element

- **Adhesion**
  - Depends mostly on micro-level surface roughness
  - \( F_a = \tau \cdot A \)

- **Hysteresis**
  - Depends mostly on macro-level surface roughness
  - \( F_h = C \cdot (E_e - E_s) \)
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Friction & Texture

Microtexture
Friction & Texture
Transverse Profile Analysis

1. Calculate Cross-slope

Roadway $C_L$

Center of Lane

Shoulder

Average elevation of left $\frac{1}{2}$ lane

Average elevation of right $\frac{1}{2}$ lane
Transverse Profile Analysis

2. Calculate Percent Deformation:

Road

\[ C_L \]

1 2 3

Shoulder
Transverse Profile Analysis

3. Calculate Rut Depths

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“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.”

NCHRP Report 37, 1967
Friction Demand – Investigatory Levels (UK)

<table>
<thead>
<tr>
<th>Site category and definition</th>
<th>Investigatory level (50 or 80 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>
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</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>
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</tr>
</tbody>
</table>
Continuous vs. Sampled

Standard friction testing in the USA is:
• "Sample" based
• Locked Wheel Skid Testing (LWST)

Pavement conditions however, vary along roadways
• Density (Intelligent Compaction, Infrared Technology, GPR)
• Structural Integrity (TSD, GPR)
• Segregation (Texture)
• Ride
Road inspection technology

- Digital Cameras (asset and pavement)
- Data Acquisition System
- Automatic Crack Detection
- LiDAR Asset Detection
- GPS or DGPS
- GIPSI-Trac Geometry
- Digital Laser Profiler
- Side Projection Lasers
- Mobile Line Reflectivity
- Rotorpulser
Hawkeye 2000 system integration

- high resolution and calibrated images
- geo-referenced
- Gipsitrac (IMU)
  - For objective measure of horizontal curvature
- fully integrated outputs
- customised safety rating software
- collection of roughness, rutting and texture data
Calibrated images

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Continuous Friction Measurement

- Continuous friction measurement
- 15 to 55 mph
- Typically 150 lane miles per day
Continuous Friction Measurement

- Skewed tire (20°- 34% slip)
- Dynamic vertical load system
- Continuous tire pressure monitoring
- Dynamic speed controlled water system
- Ambient air temperature monitoring
- Tire temperature monitoring

Full compliance with BS 7941-1:2006.
Continuous Friction Measurement

Rubber Tire Slip
- measuring **micro**-texture continuously
Laser based texture measurement system
- measuring **macro**-texture continuously

Both Wheel Paths Simultaneously
Additional Assessment Capabilities

- Digital imaging system
- GNNS DGPS geospatial location
- Geometry – Cross fall, Grade, Horizontal and Vertical curvature
- Rutting over full lane width
- Texture in Center and Both wheel paths
- Continuous Friction Response

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Network level data, project level detail

Pavement Conditions Vary
  • Continuous properties needed

Averages over network level segments
  • Lose something in the summation.
Spatial Data Representation

- Direct spatial exports
- Imbedded data detail
- URL links
All data in one place...for all time

9 years ago in 2009

4 years ago in 2014

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Preliminary Conclusions

Measuring friction continuously, especially when complemented by:

+ road geometry
+ texture
+ traffic
+ imagery
+ rutting
+ crash data

✓ Provides a more effective method for identifying the most critical sections

✓ Allow for focused safety improvement efforts on higher risk locations, such as:
  - intersections and
  - curves.
Comprehensive Assessment

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Questions

• How can network level pavement evaluation better support safety assessments decisions?
• What are the perceived limitations and/or potential approaches for mitigation?
• What additional applications for these new tools merit consideration?

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