Introduction

Relationship between Skid Resistance, Crash Risk, and Pavement Funding

- TxDOT Research Project 0-6713 – Quantitative Relationship Between Safety and Reduced Roadway Condition Maintenance
- CTR (UT) performed the research.
- Zhanmin Zhang and Mike Murphy were lead researchers.

Goal: To evaluate the impact of pavement skid resistance on crash risk, so that minimum skid resistance threshold values can be established to ensure that highway safety will not be compromised with reduced maintenance conditions/funding.
Background

- In the past 10 years, the US has had the following wet weather crash averages:
  - 4,789 fatality crashes
  - 384,000 injury crashes
  - 959,760 total crashes

- Wet weather crashes were 17% of total crashes.
- Wet weather fatalities were 13% of total fatalities.
Skid Resistance

- Skid resistance is based on coefficient of friction of roadway surface (aggregate) and tires.

- Skid resistance is based on several factors:
  - Speed
  - Traffic
  - Grades
  - Curves (vertical and horizontal)
  - Intersections
  - Vehicles/tires
Friction / Skid Number

- Engineers can help design to improve skid resistance in many ways:
  - Good design of alignments and superelevations
  - Good design of drainage of pavement
  - Good design of pavement materials:
    - Pavements lose skid resistance over time as traffic “polishes” rocks used in pavement.
    - Variables in skid resistance loss include traffic volume and quality of rock used.
  - Good monitoring of pavement conditions
  - Good monitoring of crash patterns
Research Scope and Objectives

- Since skid resistance is related to surface friction, it should also be an indicator of crash potential:
  - Develop a procedure to determine the relationship between crash rates and pavement skid number (SN) values.
  - Determine guidelines for SN thresholds to assist TxDOT in making critical maintenance decisions.
Research Methodology

The conceptual framework contains four major steps to achieve the objectives:

1. Process data.
2. Quantify statistical relationship between crash risk and skid resistance.
3. Define threshold skid resistance levels.
4. Conduct benefit/cost analysis.
CRR Concept

CRR is being looked at from a network level
CRR is expressed as a function:

\[ CRR = \frac{P_{CR}^{SN}}{P_{LM}^{SN}} \]

Where: 
- \( CRR \) = Crash Rate Ratio
- \( P_{CR}^{SN} \) = Cumulative percentage of total crashes below skid number \( SN \)
- \( P_{LM}^{SN} \) = Cumulative percentage of total lane miles below skid number \( SN \)
Skid Number Data

- Every year, TxDOT measures skid resistance (SN) for:
  - 50% of all IH miles
  - 25% of all US, SH, & FM miles

- Thus:
  - IH skid data is 1-2 years old
  - US, SH, & FM skid data is 1-4 years old
Research

CRR Calculation

Distribution of Total Crashes by SN

<table>
<thead>
<tr>
<th>Skid Number</th>
<th>Cumulative percentage of total crashes</th>
<th>Cumulative percentage of lane miles</th>
<th>CRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>30.4</td>
<td>14.3</td>
<td>2.13</td>
</tr>
</tbody>
</table>

Distribution of Lane Miles by SN
CRR Calculation

Distribution of Total Crashes by SN

<table>
<thead>
<tr>
<th>Skid Number</th>
<th>Cumulative percentage of total crashes</th>
<th>Cumulative percentage of lane miles</th>
<th>CRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>80.0</td>
<td>50.0</td>
<td>1.60</td>
</tr>
</tbody>
</table>
Average Conditions for 2011

CRR Calculation (2011 Data)

Statewide Average SN=38, CRR=1.50
Average Conditions for 2008 thru 2011

CRR vs Skid Number (2008-2011)
Skid Number Thresholds for Action

Determining Skid Number Thresholds

- Crash rate increases significantly when SN declines
- Project-level testing is recommended
- Vigilance is recommended
- Increase in SN results in little reduction in crash rate

Work is needed!
Test and get on future paving plan
Watch for Issues
No Work or watching

(CRR)

(SN₁) (Minimum)
(SN₂) (Vigilant)
(SN₃) (Desirable)

Skid Resistance Number (SN)
Skid Value for Determining Level of Concern

Statewide Skid Number Threshold Values

- Based on the safety level in terms of the crash risks, the EWG recommended that the typical CRR threshold values be set at 3, 2, and 1.

- Based on the recommended CRR values, the threshold values in terms of SN were determined as follows:

<table>
<thead>
<tr>
<th>Total Crashes</th>
<th>Wet Weather Crashes</th>
<th>Rule of Thumb (old)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$SN_1=14$</td>
<td>$SN_1=17$</td>
<td>$SN_1=15$</td>
</tr>
<tr>
<td>$SN_2=28$</td>
<td>$SN_2=29$</td>
<td>$SN_1=30$</td>
</tr>
<tr>
<td>$SN_3=74$</td>
<td>$SN_3=74$</td>
<td>$SN_1=??$</td>
</tr>
</tbody>
</table>
Benefit/Cost Analysis

- Benefit: savings in crash costs, estimated by the expected reduction in the number of crashes and the average cost per crash based on NSC values

<table>
<thead>
<tr>
<th>Crash Severity</th>
<th>Willingness to pay ($per person)</th>
<th>Count of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>4,459,000</td>
<td>8,708</td>
</tr>
<tr>
<td>Incapacitating Injury</td>
<td>225,100</td>
<td>30,863</td>
</tr>
<tr>
<td>Non-incapacitating Injury</td>
<td>57,400</td>
<td>125,560</td>
</tr>
<tr>
<td>Possible Injury</td>
<td>27,200</td>
<td>253,211</td>
</tr>
<tr>
<td>Property Damage Only</td>
<td>2,400</td>
<td>208,023*</td>
</tr>
</tbody>
</table>

* Property damage only counts for number of crashes

- Cost: the corresponding costs for improving pavement skid resistance, taken as the average cost for improving pavement skid resistance per lane-mile
Benefit-Cost Ratios for Statewide Total Crashes

<table>
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<tr>
<th>Skid number thresholds</th>
<th>Benefit cost ratio</th>
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<tr>
<td>14</td>
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</tr>
<tr>
<td>28</td>
<td>19.70</td>
</tr>
<tr>
<td>74</td>
<td>0.98</td>
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</tbody>
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Benefit-Cost Ratios for Statewide Wet Weather Related Crashes

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<th>Benefit cost ratio</th>
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Skid Threshold Values

Threshold Value Uses

- The threshold will provide TxDOT pavement managers a method to correlate future funding levels to changes in safety.
  - Less funding will result in lower values of skid numbers for TxDOT system.
  - Can predict how crash numbers will increase due to lower funding/lower skid numbers.

- Educate pavement managers on real threshold values for skid number
  - Research verified that the old “Rule of Thumb” values were actually accurate.
  - Provide a benefit/cost ratio to justify distribution of funds for skids improvement.

- Bring pavement manager and safety engineers together.
  - Shows the correlation between pavement surfacing funding and safety.
  - Can justify sending additional funds to areas with lower skid numbers.
Paving Solutions to Skid Issues

- Signing – Watch for Water on Road; advisory speeds on curves
- Texturing/milling – removes polished surface $5k/LM
- Seal coat – places asphalt and new rock on surface $20k/LM
- Microsurfacing – places new surface mixture $35k/LM
- HMA paving – places new surface mixture (COST) $65k/LM
- High Friction Surface Treatment – place new surface, spots only $155k/LM
Law Enforcement Roles

- During accident investigation involving possible skid type issues, please review and document the tire tread condition.

- Communicate with local TxDOT crews on locations of high wet weather accidents with loss of control type issues.
  - Many locations have minor runoff road incidents during wet weather and no accident reports are filed, thus TxDOT does not get the ability to study accident history to find these locations.
  - TxDOT needs assistance in finding these locations from law enforcement.
Public Education Roles

- Educate drivers on slowing down in inclement weather
  - Especially when the weather affects the pavement surface.

Example: This billboard is on IH 45 going to Dallas
Public Education

Public Education Roles

- Educate drivers on slowing down in inclement weather
  - Especially when the weather affects the pavement surface.

- Educate drivers on the importance of maintaining good tires
  - Proper Pressure
  - Adequate tire tread depth

- Educate to Eliminate Distracted Driving of all kinds
  - Pay attention to roadway conditions, to be able to react

- Educate the Public on Defensive Driving
  - Safe following distances
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