NON – LOCK
FRICITION TESTING
CURRENT METHOD
LOCKED WHEEL

• ASTM - E-274 Skid Truck
  – Measure Drag Force during Sliding Friction
  – Primary Sensor – Tire (grooved/ribbed)
  – Collect Average force values over 59 ft.* (1 sec.)
  – Total Test Sequence ~ 225 ft.*
  – Water consumed - ~ 2 gal.

* = at standard test speed (40 mph)
E – 274 ISSUES

• Long averaging distance – lost detail

• Large sample spacing (typically 1056 ft.):
  – CAUSES:
    • Water consumption per test
    • Total test sequence time
  – RESULTS:
    • Lost tests at intersections etc.
    • Sections shorter that ¼ mile very difficult to test
    • Miss key pavement sections of concern:
      – Ramps, Sharp curves, Traffic control areas

• Measuring “locked” sliding friction
PLAN

• Apply the limited testing resources more effectively
• Collect a more representative sample
• Increase the size of the sample
• Functional test that more closely resembles the typical vehicle response (anti-lock brakes)
• Minimize the impact of tire structure properties
• Maintain focus on microtexture (ribbed tire)

• Measure macro-texture separately (laser)
RESULT – NL TEST

• Data averaging time of 0.1 to 0.2 sec (6-12ft.)
• Averaging between 33% and 67% “lock-up”
• Reduce total test time to under 1 sec
• Reduce water consumption to ~ 0.5 gal
• Routine sample spacing - 0.04 mi (211ft)
• Short routes - 0.02 mi. (106 ft)
• Projects ~ 0.01 mi. (53ft)
TEST SEQUENCE

Start NL Data Average
33% Slip

End NL Data Average
67% Slip

ASTM E274 Average
ADVANTAGES

• More tests per mile (higher resolution data)
• Tests in critical areas (curves, intersections)
• Less water and tire wear per test
• Less impact from tire structure than other slip type tests
• Test is more representative of current vehicles with anti-lock brakes
TESTING @ 0.2 Miles
TESTING @ 0.04 MILES
KEY IMPROVEMENTS

• Heavy duty brake calipers
• High output air compressor
• High output generator
• 1kHz data sampling rate
• Automatic load leveling
• Texture laser & GPS
SAMPLE DATA

• Montgomery & Prince Georges Counties (widest range of friction values)
• Maryland state maintained roads
• Typical sample interval - 0.2 miles
• > 4000 test locations
• Vast majority asphalt pavement
DATA FILTERING

• Removed first:
  – Speed less than 20 mph
  – Water (gal/min) less than 60% speed (mph)

• Removed outliers: (highway discontinuities)
  – Expansion joints
  – Pavement markings
  – Railroad tracks
  – Patches
  – Bridges
AN OUTLIER LOCATION

• PAVEMENT DISCONTINUITY
DATA FILTERING SUMMARY

- Total tests – 4563
- Bad tests – (s,w) 412
- Acceptable tests - 4151
- Deemed outliers - 191
- Remaining tests - 3960
### DATA DISTRIBUTION

<table>
<thead>
<tr>
<th></th>
<th>N - L</th>
<th>Lock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>62.24435</td>
<td>47.74793</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.135867</td>
<td>0.117658</td>
</tr>
<tr>
<td>Median</td>
<td>62.7</td>
<td>48</td>
</tr>
<tr>
<td>Mode</td>
<td>64.5</td>
<td>48.7</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>7.671346</td>
<td>6.643228</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>58.84955</td>
<td>44.13247</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.0997</td>
<td>-0.15843</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.30811</td>
<td>-0.25061</td>
</tr>
<tr>
<td>Range</td>
<td>44.4</td>
<td>36.4</td>
</tr>
<tr>
<td>Minimum</td>
<td>36.9</td>
<td>28.1</td>
</tr>
<tr>
<td>Maximum</td>
<td>81.3</td>
<td>64.5</td>
</tr>
</tbody>
</table>
LOCK vs. NON-LOCK (- outliers)

\[ Y = 0.7673 \times X \]

\[ R^2 = 0.996 \]

Removed 5% outliers
NEXT STEPS

• INTEGRATION OF TEXTURE DATA
  – More complete traction picture
  – May get appropriate factor for speed compensation

• INTEGRATION OF SPEED DATA
  – Data collection at 25-55 mph is a goal
QUESTIONS?