Friction Testing: Florida
State of the Practice
Background (con’t)

- Identify potential hazardous conditions,
- Determine friction characteristics,
- Assess need for rehabilitation/maintenance.
That was then ...
That was then ...
Background (con’t)

- FDOT testing since late 1950s.
- Initially used stopping distance method,
- Modified to include a decelerometer
That was then … 50s
Background (con’t)

- Trailer concept introduced in mid-1960s
- FDOT built its first trailer (E-274-65T).
- E-274 for Skid Resistance of Paved Surfaces Using a Full-Scale Tire adopted:
  - Locked wheel dragged over a wetted surface under constant load and speed
That was then ... 60s
That was then ... 70s
That was then ... 80s
This is now ...
Locked-Wheel Testers:
- instrumented trailer w/locked wheel system.
- 2-axis transducer:
  - Horizontal friction force
  - Dynamic vertical load.
Friction Number

- \[ FN = \left( \frac{F}{W} \right) \times 100 \]
  - \( F \) = Horizontal Force
  - \( W \) = Dynamic Vertical Load

- Example: \[ FN = \left( \frac{500\text{lb}}{1085\text{lb}} \right)\times100 = 46 \]
Tire Friction Vs. Braking

- 2 Controlling Factors
  - Static Friction
  - Kinetic Friction
Friction Lockup

![Graph showing friction over time](image-url)
CATEGORIES OF TESTING

- Inventory
- Spot hazard
- Special request
- Overlay/New construction
- Re-test
INVENTORY

- FHWA skid accident reduction program (1980)
- 1/3 of system annually
- Interstate/toll system every 2 years
- Database to monitor state roadway system
SPOT HAZARD

- High number of wet-weather accidents
  - Request by District Safety Engineers
  - Law enforcement agencies, city, county, or concerned motorists
Others

- District Request
- Test Sections
- Product evaluations
- Off-system locations (city, county)
Overlay/New Construction

- State roadways which have been resurfaced
- All resurfacing projects with federal aid participation
- Safety Improvements
RE-TEST

- Friction Test and Action Program (FTAP)
  - Resurfaced Section with FN < 35
Field Test Procedures

- Two-lane roadways
- Four-lane roadways – both traffic lanes tested
- Multi-lane roadways - lane #1 or lane #2 (middle) tested both directions
- Overlay/new construction – all lanes tested
- Testing frequency – normally 3 tests per mile or section
# Friction Number Guidelines

<table>
<thead>
<tr>
<th>Posted Speed Limit</th>
<th>ALL HIGHWAY SECTION SURFACES</th>
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<tbody>
<tr>
<td></td>
<td>Questionable</td>
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<tr>
<td>&lt;= 45 MPH</td>
<td>FN$^1$ 40</td>
</tr>
<tr>
<td>&gt; 45 MPH</td>
<td>25</td>
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</table>

1. **EXISTING PAVEMENTS** - WARRANTS INVESTIGATION TO DETERMINE IF CORRECTIVE ACTION IS NECESSARY. REVIEW PERCENT OF WET WEATHER ACCIDENTS, SURFACE CONDITIONS, TRAFFIC DENSITY, DRAINAGE, ETC.

2. **EXISTING PAVEMENTS** – WARRANTS REVIEW TO DETERMINE IF SECTION APPEARS ON 25% OR 50% WET WEATHER CRASH LIST. IF ON LIST, INVESTIGATE AS OUTLINED IN NOTE 1.

3. **DESIRED VALUE FOR NEW PAVEMENT SURFACES**

**Table 1, Appendix E-1, Highway Safety Improvement Program Guidelines**
CALIBRATION

- 30 to 45 Days
  - Transducer, Speed, Distance
  - Conduct Test on Local Sections

- 6 Months
  - Water Flow
### Local Reference Sections

**June 2004**

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Unit #6</th>
<th>Unit #7</th>
<th>Unit #8</th>
<th>Unit #9</th>
<th>Section Mean $\text{FN}_{40R}$</th>
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<tbody>
<tr>
<td>1(FC-3)</td>
<td>32.1</td>
<td>31.5</td>
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<td>2(FC-2)</td>
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<tr>
<td>4(FC-5,G)</td>
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<td>39.4</td>
<td>40.0</td>
<td>38.7</td>
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<tr>
<td>5(FC-4)</td>
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<td>45.6</td>
<td>46.0</td>
<td>46.3</td>
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</table>

- **Unit Mean** based on five (5) tests per section
- **Section Mean** based on twenty (20) tests per section
Reference Calibration

- Texas Transportation Institute
- 2 units calibrated annually
- In-house calibration equipment (force plate/flow meter) calibrated annually
- Calibration Report
Additional Friction Services
Airport Friction Tester
Airport Maintenance of Runways
Retractable 5th Wheel for Continuous Slip Friction
Laser Based Technology

- Implement IFI for Pavement Management
- Friction and Texture
- Establish Friction Speed Gradient
50 MPH Study

- High Speed Facilities (Open Grade Mixtures Only) Minimum Speed Increased to 50
- 7 Districts evaluated
- 1,500 miles (FN) tested at 40 and 50 mph
- Macrotexture information collected also
$$FN_{40} = 1.107FN_{50} - 2.584$$

$$R^2 = 0.98$$
Crosswalk Specification 523
Patterned/Textured Pavements

- Prequalification (min 35 FN40R)
- QPL Field Test Section (3 year)
  - Minimum 8K – 12K ADT
  - Minimum of FN 35
  - Maintain 50% texture
- Evaluating site specific tools to enhance product evaluation
  - Dynamic Friction Tester
  - Circular Texture Meter
Site Specific Friction Equipment

- Replace Older Test Equipment (Sand Patch, Pendulum)
- Dynamic Friction Tester
  ASTM E-1911
- Circular Texture Meter
  ASTM E-2157
Precision

“In this world nothing is certain but death & taxes”

B. Franklin (1789)

- Assess precision of locked-wheel testers for friction measurements (ASTM E-274)
Data Collection

- 4 locked-wheel testers
- Ribbed (E-501) & Smooth (E-524) tires
- 5 sections to include different surface textures & serviceability levels
- 5 sites w-each section
Data Collection (cont.)

- Measurements along predefined paths
- Minimum of 5 mn between repeat lockups
- Start of test identified by 6-in x 4 ft strip
- Four replicate per site per tester
- Testing in accordance with ASTM E-274
Data Analysis
Precision

- Data analyzed as factorial experiments
- Repeatability & reproducibility assessed in terms of:
  - Range: measure of data dispersion;
  - Std. Dev.: measure of deviation around mean;
  - COV: normalized way of expressing variability.
<table>
<thead>
<tr>
<th>Section</th>
<th>Avg. FN&lt;sub&gt;40R&lt;/sub&gt;</th>
<th>Range</th>
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## Smooth Tire Data

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“D2S” as index of precision (ASTM C-670)

95% confidence level

Testing per ASTM E-274:

- Repeatability
  - Results should not differ by more than 3.7 (Ribbed) and 4.5 (Smooth)

- Reproducibility
  - Results should not differ by more than 4.0 (Ribbed) and 5.1 (Smooth)
Finding Summary

- Comparison of 800 measurements showed good correlation between testers.
- High level of precision regardless of texture or serviceability level. Pooled Std. Dev. for repeatability below value in E-274.
- Effect of surface textures/serviceability levels on testers’ precision negligible.
QUESTIONS???