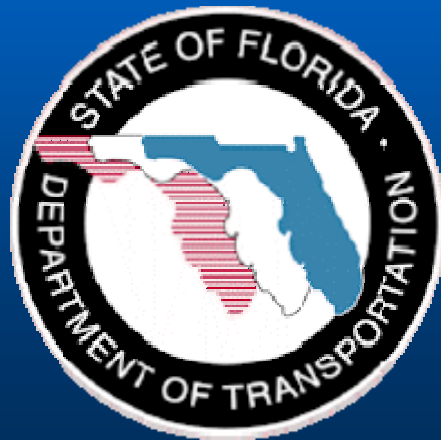


Friction Testing: Florida State of the Practice



Background (*con't*)

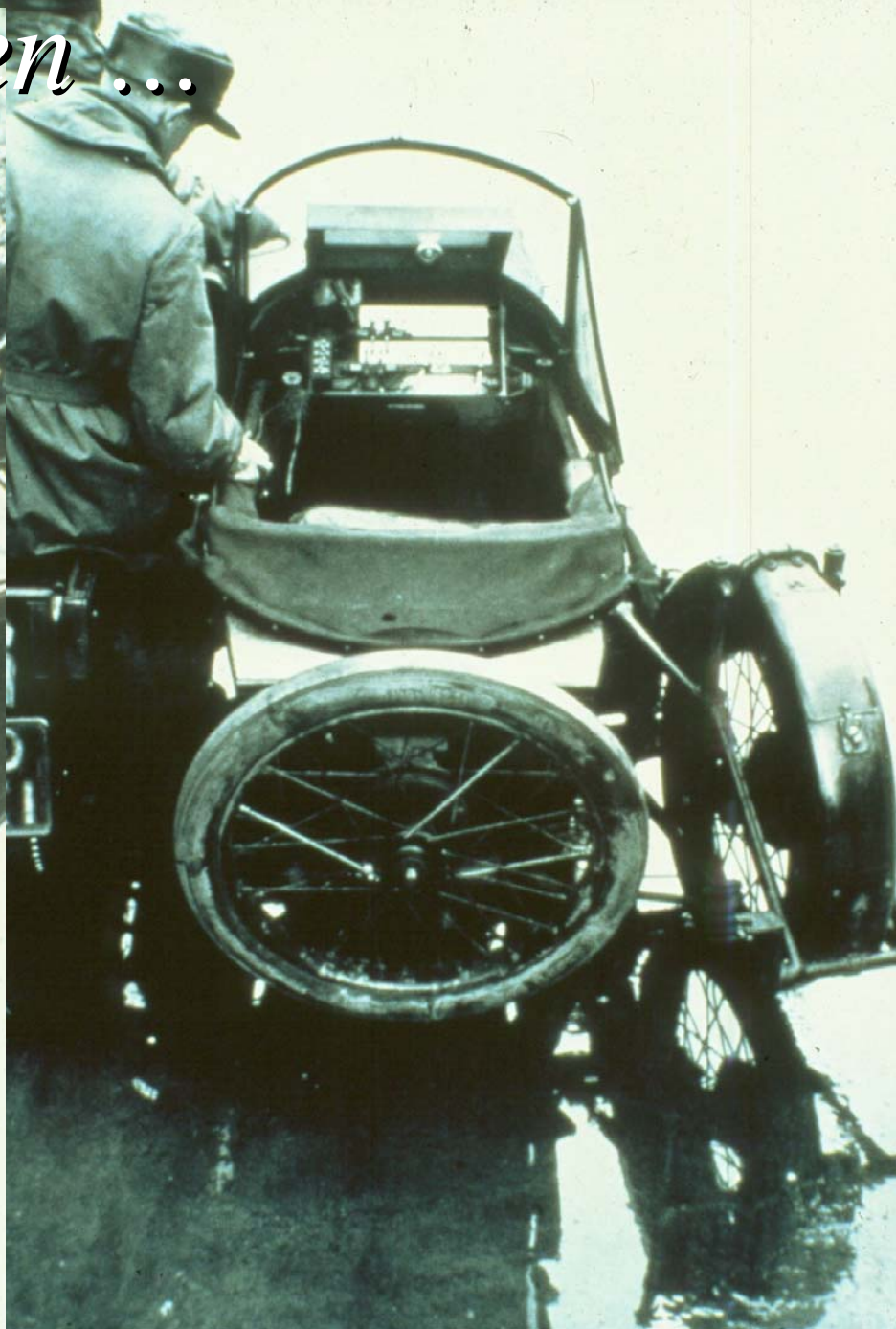
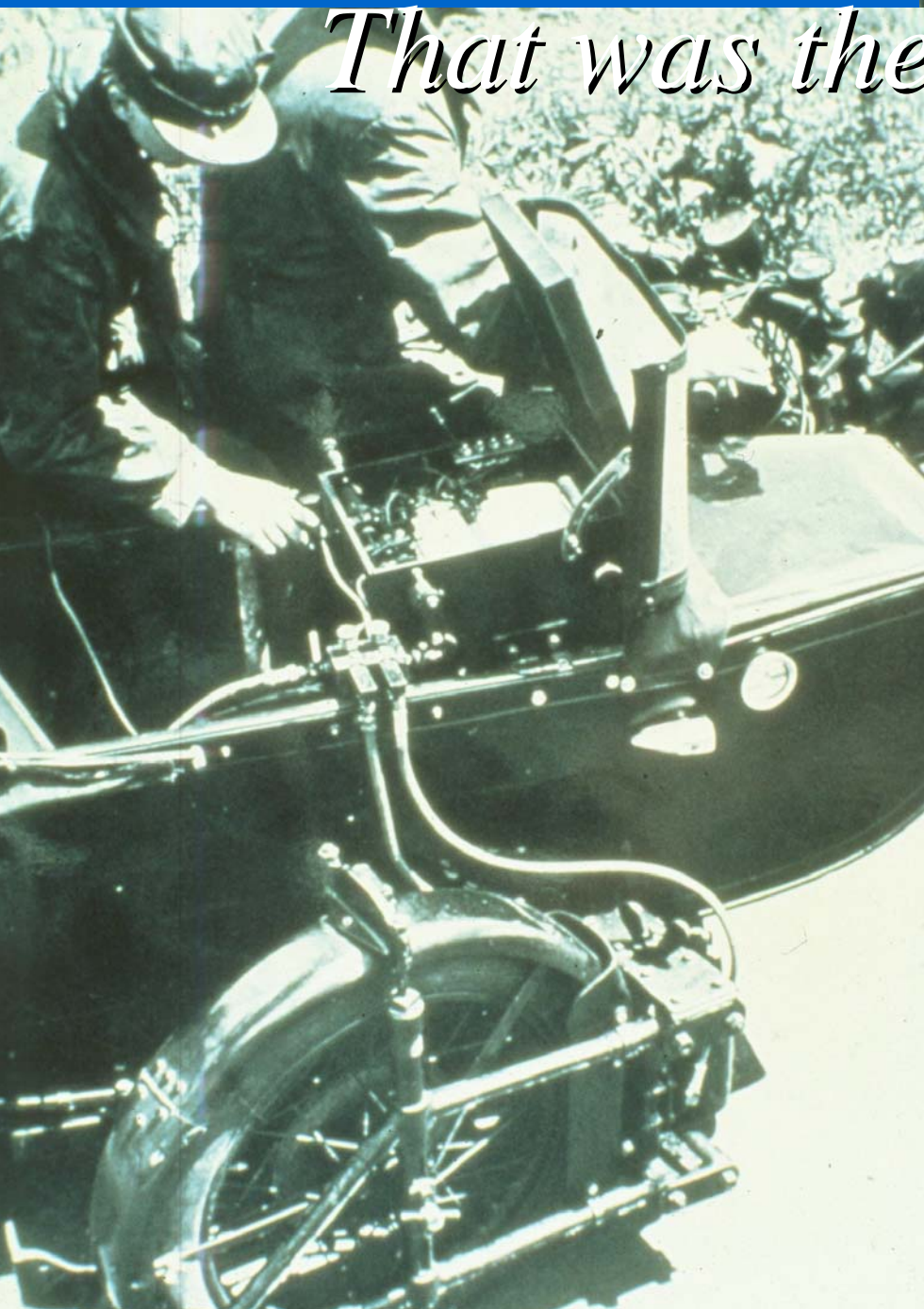
- Identify potential hazardous conditions,
- Determine friction characteristics,
- Assess need for rehabilitation/maintenance.



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 ...





Background (*con't*)

- Locked-Wheel Testers:
 - instrumented trailer w/locked wheel system.
 - 2-axis transducer:
 - Horizontal friction force
 - Dynamic vertical load.



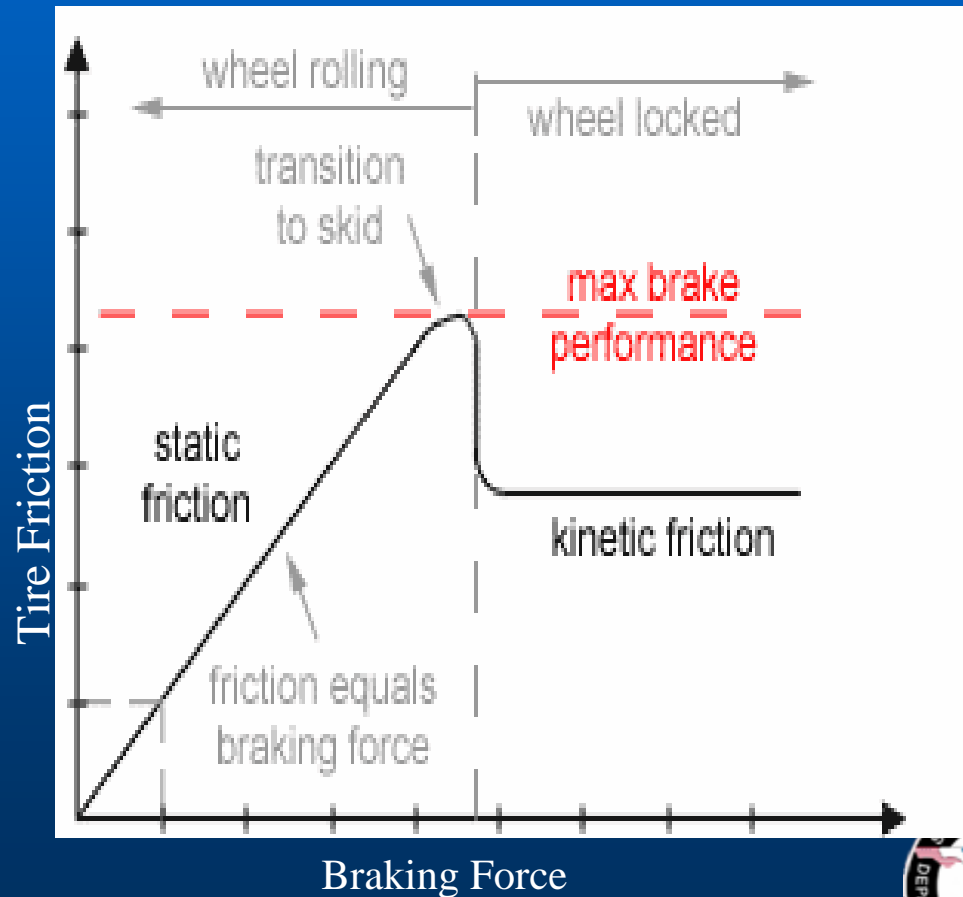
Friction Number

- $FN = (F/W) \times 100$
 - F = Horizontal Force
 - W = Dynamic Vertical Load
- Ex. $FN = (500\text{lb}/1085\text{lb}) \times 100 = 46$

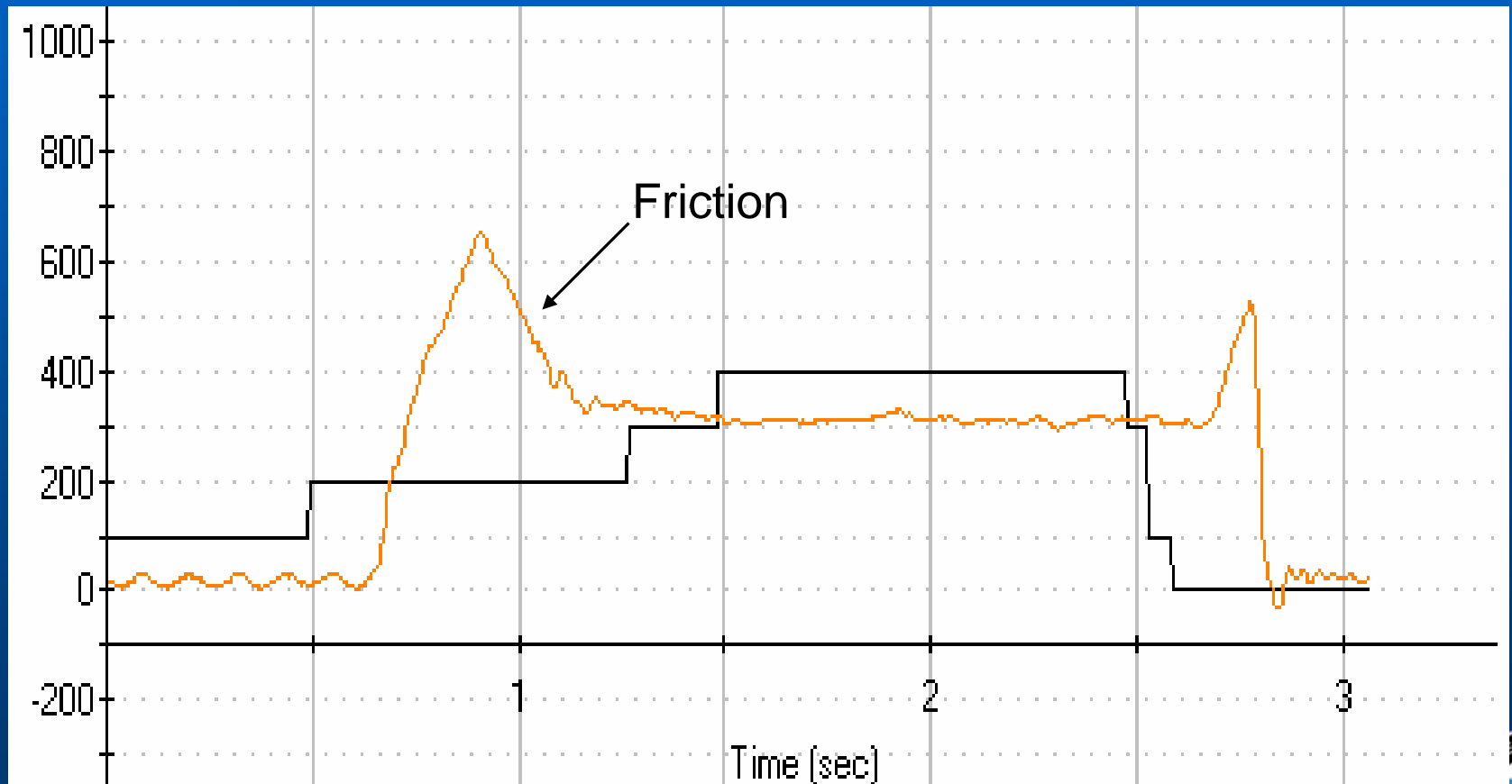


Tire Friction Vs. Braking

- 2 Controlling Factors
 - Static Friction
 - Kinetic Friction



Friction Lockup



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

Posted Speed Limit	ALL HIGHWAY SECTION SURFACES		
	Questionable	Review ²	Desired ³
	FN ¹ 40	FN 40	FN 40
<= 45 MPH	25	26-28	30
> 45 MPH	27	28-30	35

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 GUIDE



CALIBRATION

- 30 to 45 Days
 - Transducer, Speed, Distance
 - Conduct Test on Local Sections
- 6 Months
 - Water Flow







CAUTION
WATER SPRAY

LOCAL REFERENCE SECTIONS

June 2004

Section Number	Unit #6	Unit #7	Unit #8	Unit #9	Section Mean FN _{40R}
1(FC-3)	32.1	31.5	33.5	32.6	32.4
2(FC-2)	35.7	33.0	34.9	36.6	35.1
3(FC-5,O)	33.7	32.3	34.1	33.6	33.4
4(FC-5,G)	38.6	39.4	40.0	38.7	39.2
5(FC-4)	47.0	45.6	46.0	46.3	46.3

- 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

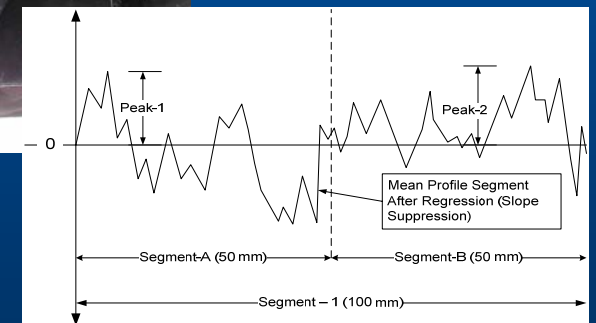


Retractable 5th Wheel for Continuous Slip Friction



Laser Based Technology

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



ASTM E 1845-01: Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth

$$\text{Mean Segment Depth}_{\text{Segment-1}} = (\text{Peak-1} + \text{Peak-2})/2$$

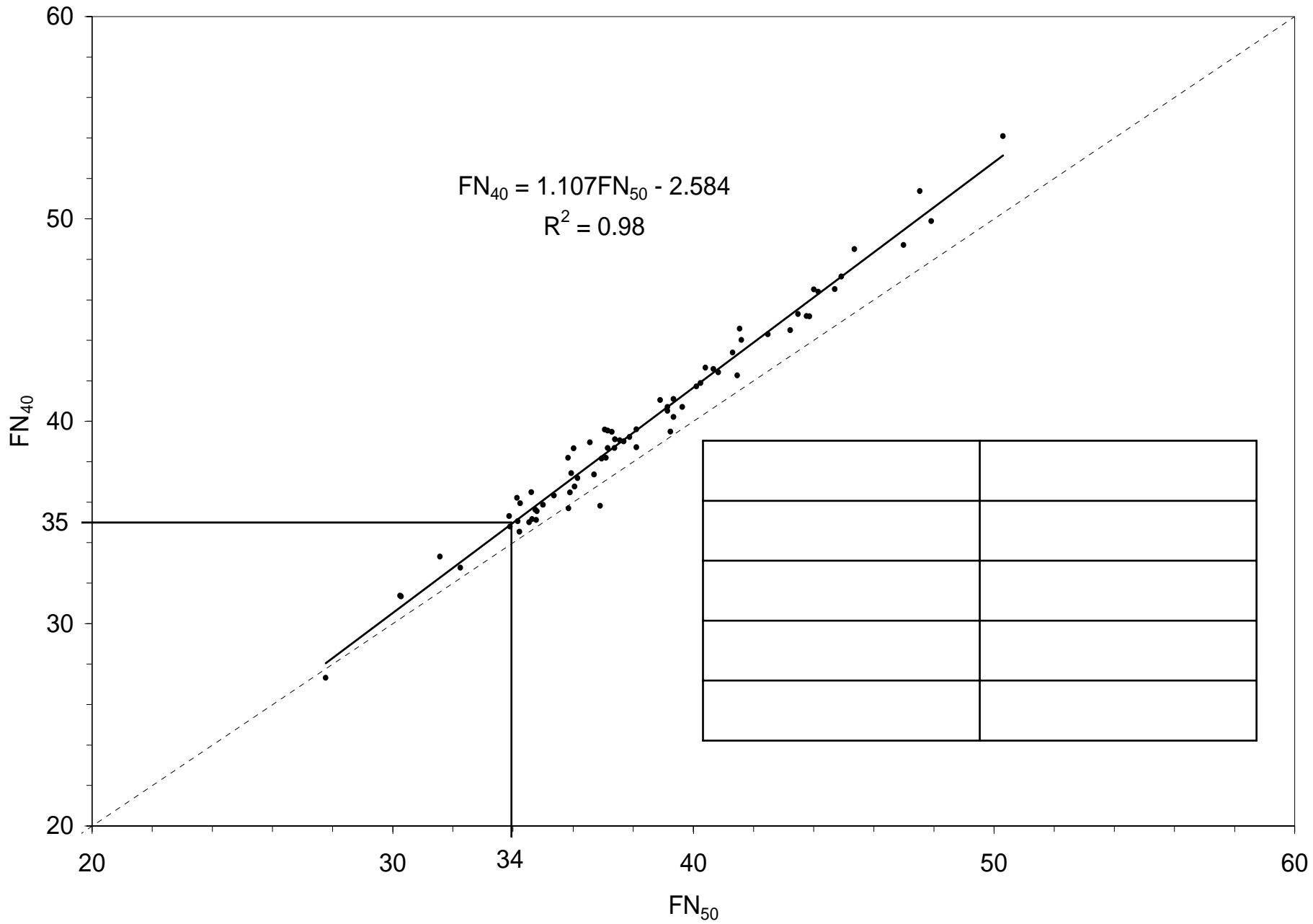
$$\text{MeanSegmentDepth}_{\text{Section}} = \frac{\sum_{i=1}^n \text{MeanSegmentDepth}_{\text{Segment-1}}}{n}$$



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





Crosswalk Specification 523

Patterned/Textured Pavements

- Prequalification (min 35 FN40R)
- QPL Field Test Section (3 years)
 - 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.



Ribbed Tire Data

Section		Avg. FN _{40R}	Range		Std Dev	
			W/U	B/U	W/U	B/U
Open Graded	1	36	3.8	3.9	1.1	1.2
	2	35	4.4	4.4	1.3	1.3
	3	45	4.0	5.4	1.2	1.5
Pooled Statistics					1.2	1.4
Dense Graded	4	36	4.3	4.7	1.5	1.5
	5	46	5.4	6.0	1.3	1.6
Pooled Statistics					1.4	1.6
Overall Pooled Statistics					1.3	1.4

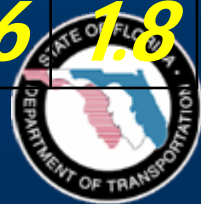


Smooth Tire Data

Section	Avg. FN _{40R}	Range		Std Dev		
		W/U	B/U	W/U	B/U	
Open Graded	1	35	4.9	6.3	1.6	1.9
	2	34	4.9	5.6	1.5	1.5
	3	42	4.6	5.8	1.3	1.6
Pooled Statistics				1.5	1.7	
Dense Graded	4	19	5.3	6.1	1.9	2.0
	5	23	6.5	7.1	1.5	1.7
Pooled Statistics				1.7	1.9	
Overall Pooled Statistics				1.6	1.8	



Section		Ribbed Tire					Smooth Tire				
		Avg. FN _{40R}	Range		Std Dev		Avg. FN _{40S}	Range		Std Dev	
			W/U	B/U	W/U	B/U		W/U	B/U	W/U	B/U
Open Graded	1	36	3.8	3.9	1.1	1.2	35	4.9	6.3	1.6	1.9
	2	35	4.4	4.4	1.3	1.3	34	4.9	5.6	1.5	1.5
	3	45	4.0	5.4	1.2	1.5	42	4.6	5.8	1.3	1.6
Pooled Statistics					1.2	1.4	--	--	--	1.5	1.7
Dense Graded	4	36	4.3	4.7	1.5	1.5	19	5.3	6.1	1.9	2.0
	5	46	5.4	6.0	1.3	1.6	23	6.5	7.1	1.5	1.7
Pooled Statistics					1.4	1.6	--	--	--	1.7	1.9
Overall Pooled Statistics					1.3	1.4	--	--	--	1.6	1.8



Precision Estimates

- “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???

