Pavement Surface Properties Consortium

Speed Adjustment Factors for the Locked-wheel Skid Trailer

VDOT Virginia Department of Transportation

U.S. Department of Transportation Federal Highway Administration

GDOT Keeping Georgia on the Move

SCDOT

PENNDOT

MDOT

VirginiaTech Invent the Future

Connecticut Department of Transportation

VTRC Virginia Transportation Research Council

Center for Sustainable Transportation Infrastructure

VirginiaTech Transportation Institute

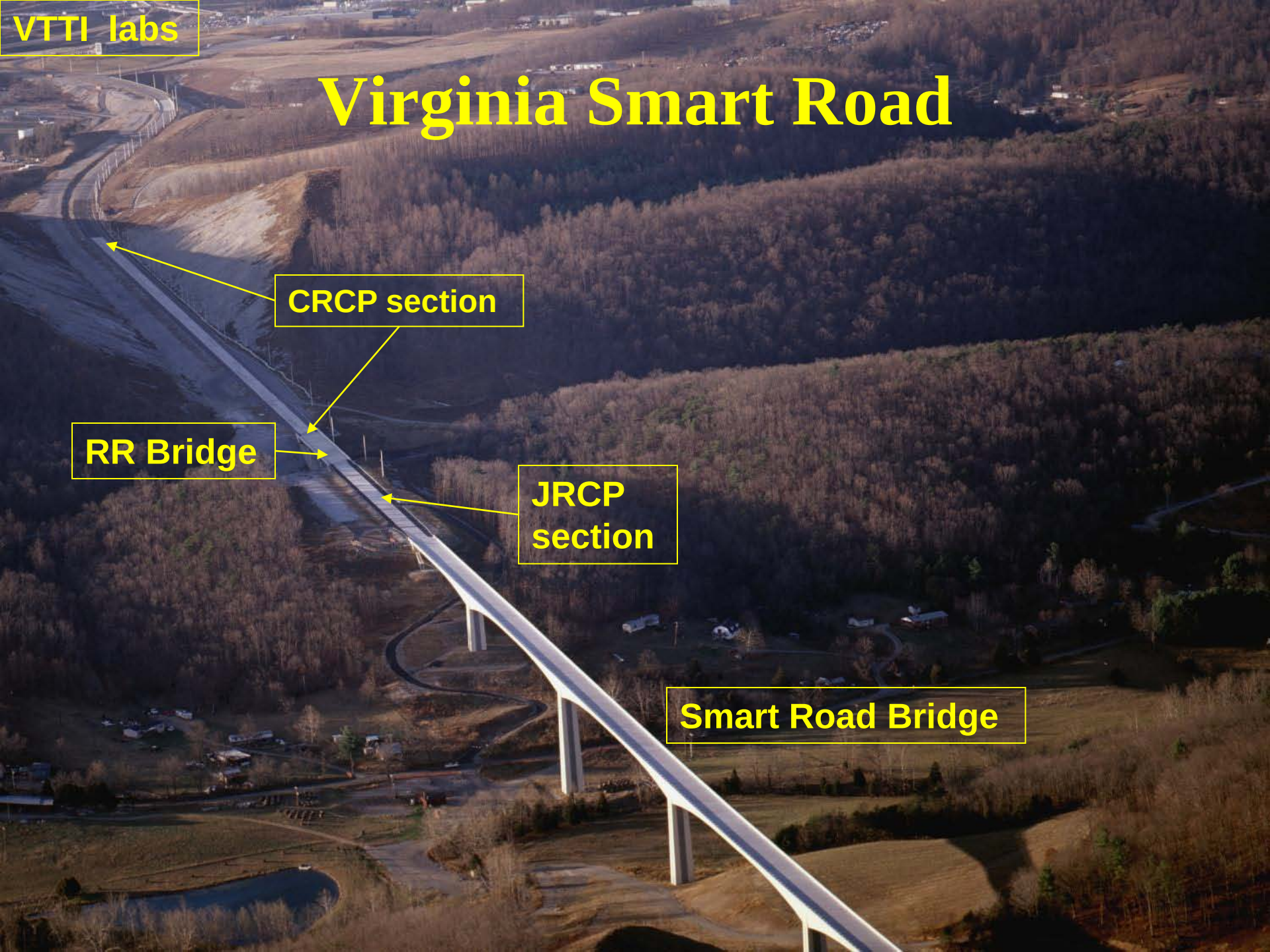
Outline

- Introduction
- Objective
- Data collection
- Analysis
- Results
- Example
- Conclusion

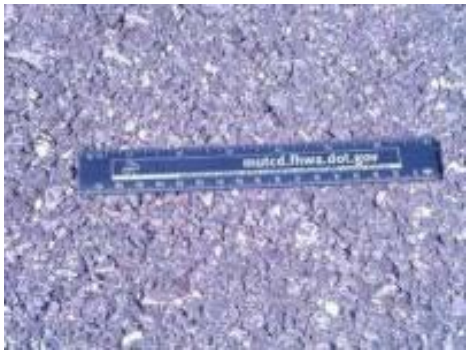
Consortium Objectives

To establish a research program focused on enhancing the level of service provided by the roadway transportation system through optimized pavement surface texture characteristics.


Virginia Smart Road
CRCP, JRCP, and bridges
Sections E-F-G-H-I-J-K-L
Sections Loop-A-B-C-D
VTTI labs


VTTI labs
Virginia Smart Road
CRCP section
RR Bridge
JRCP section
Smart Road Bridge

Available Pavement Surfaces



SM 9.5 D SUPERPAVE

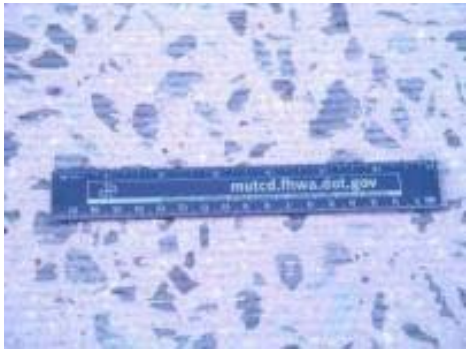
OGFC

SMA 12.5

Cargill SafeLane™

Tined CRCP

JRCP



Ground JRCP

VDOT EP5LV

Current Projects

1. **Annual Equipment Rodeo**
2. **Development of speed adjustment factors for locked-wheel skid trailer measurements**
3. **Evaluation of new "High-Friction Surface" pavement technologies**
4. **GripTester Loan Program**
5. **Stereo Vision Texture Measuring System**

Annual Equipment Rodeo

Organize and provide the facilities and needed support for a pavement surface measurement device comparison and verification roundup at the Virginia Smart Road:

- **Smoothness (high speed, lightweight, etc)**
- **Friction (LWS, CFME (Griptester), DFT, etc)**
- **Texture (CTMeter, SVS, DSRM, Hydro, etc)**


CAUTION
ROAD TEST
MILE 0


20/5/2008


MULE
Lightweight Profiler


Valley
INDUSTRIES
2008 5 15


21/5/2008


22/5/2008

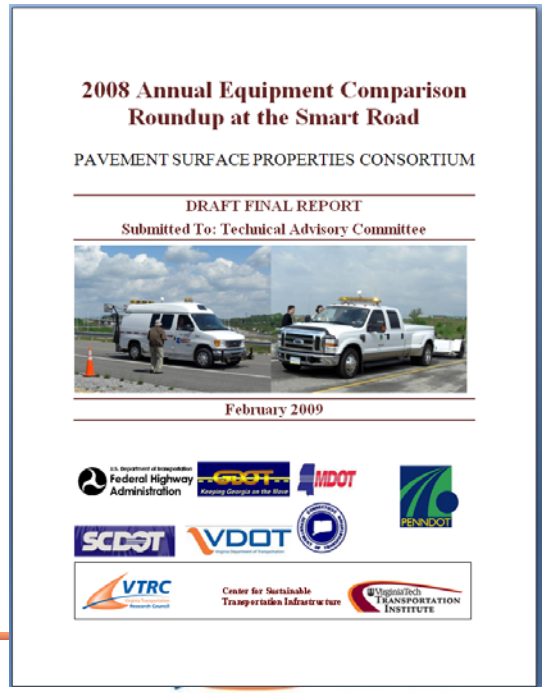
Objectives

- **Road and traffic conditions create problems for operators for skid tests in urban and interstate highways**

- **One solution is to use adjustment factors to convert measurements obtained at different speeds to a standard speed** (40 mph according to ASTM E 274)

Data Collection

- **Smooth Tires: 5 runs for each device at 20, 40 and 50 mph (2007 and 2008)**
- **Ribbed Tires: 5 runs for each device at 40, 50 and 60 mph (2009)**
- **Macrotexture (MPD) with CTMeter**


2008 Annual Equipment Comparison Roundup at the Smart Road

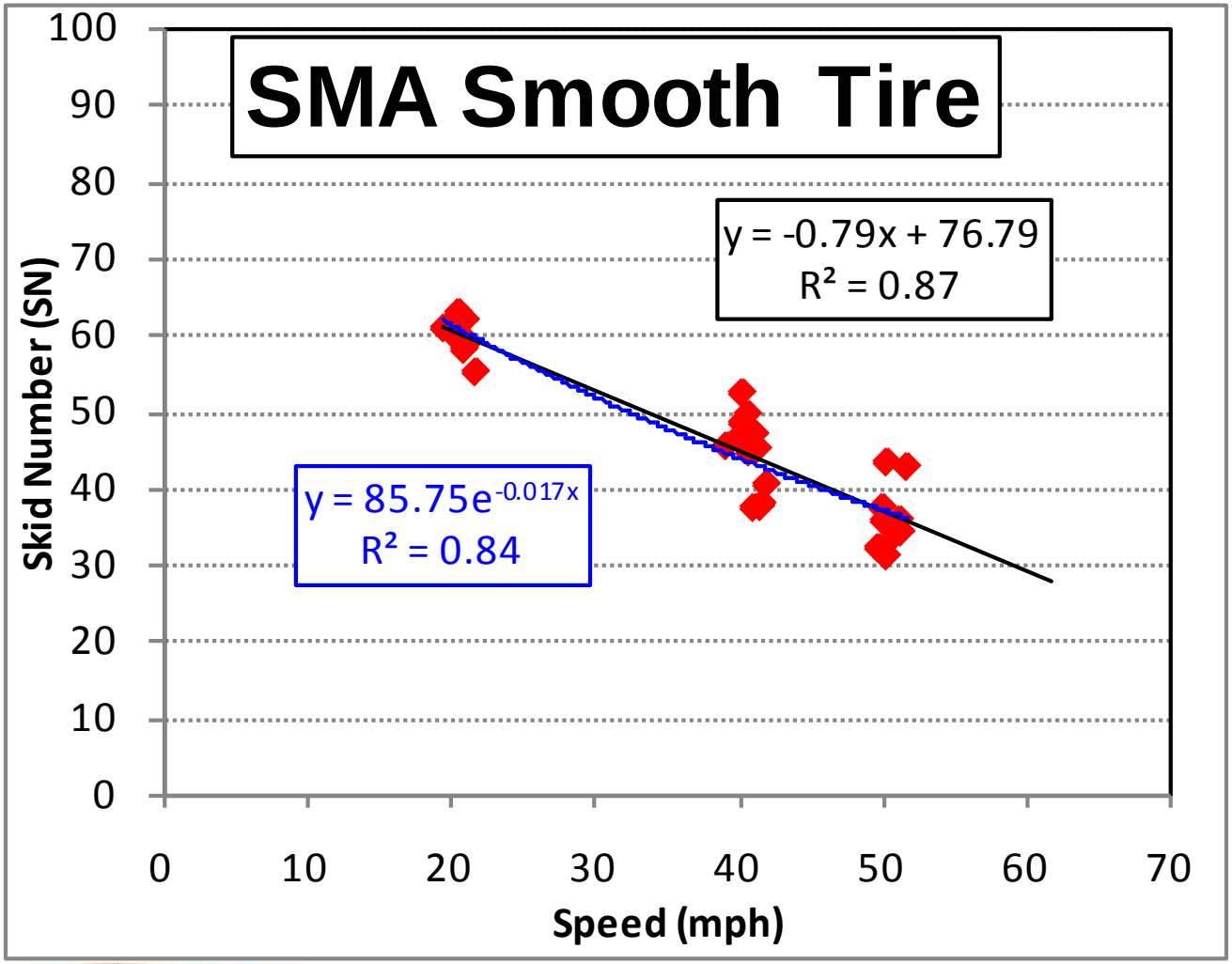
PAVEMENT SURFACE PROPERTIES CONSORTIUM

DRAFT FINAL REPORT

Submitted To: Technical Advisory Committee

February 2009

Data Analysis

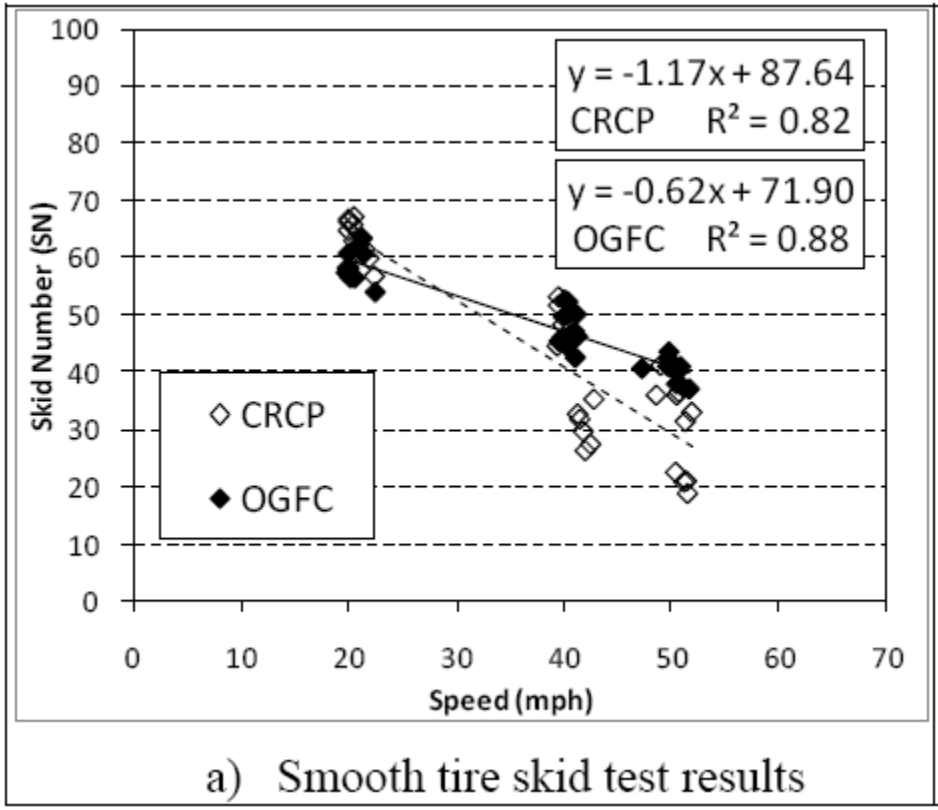


Linear model:
$R^2 = 0.87$

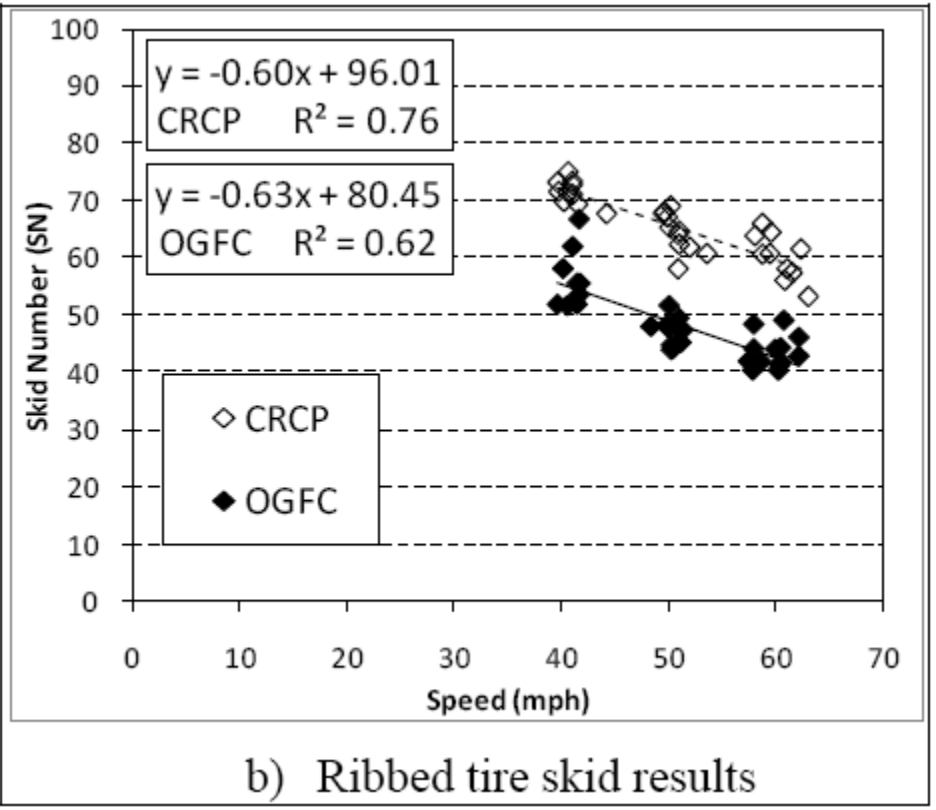
Exponential model:
$R^2 = 0.84$

Skid Unit Comparison

- **Sample skid testing results for two sections of the Smart Road**



a) Smooth tire skid test results

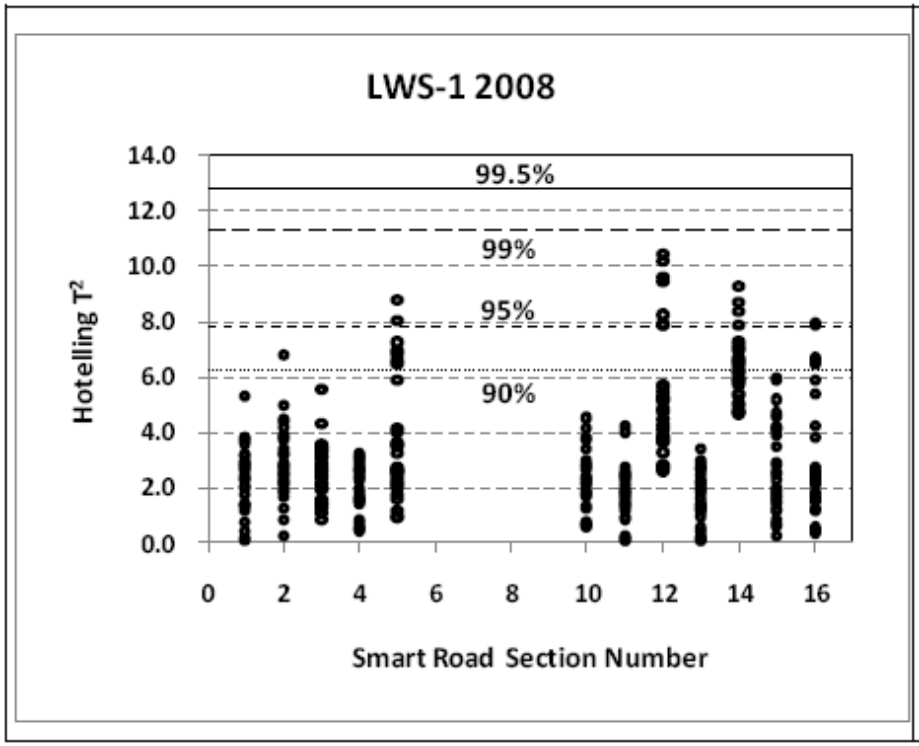


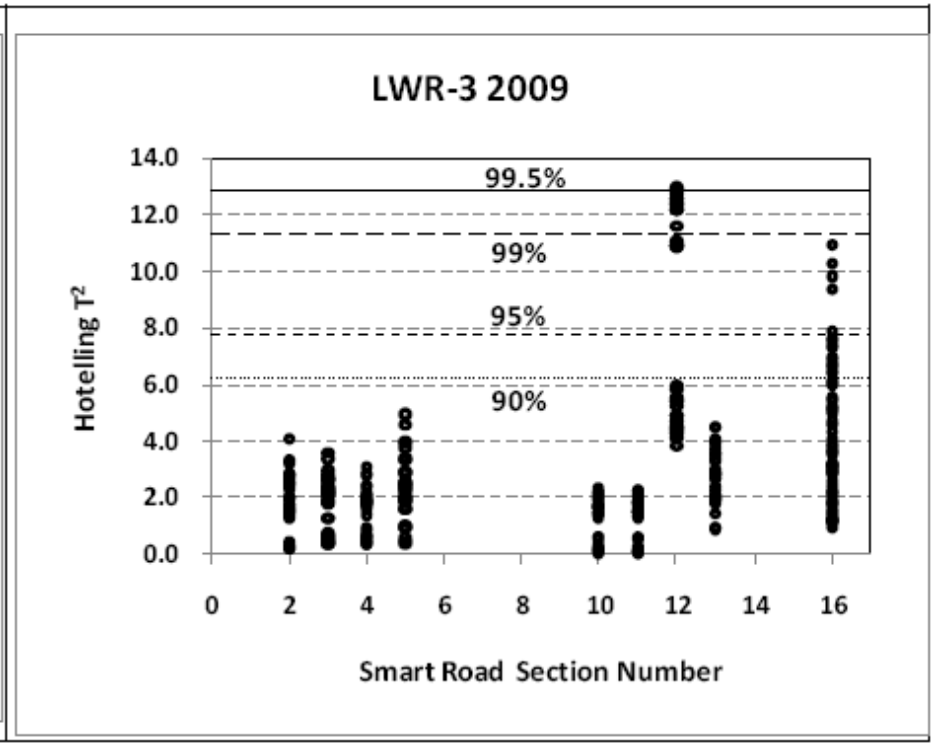
b) Ribbed tire skid results

Principal Component Analysis

- **Principal Component Analysis (PCA) was used to identify multivariable homogeneity (SN, texture, and speed)**
- **To simplify adjustment factors, grouping was done for similar types of pavements with similar behavior**
- **Results were divided into 3 groups: SM 9.5D, OGFC and CRCP**

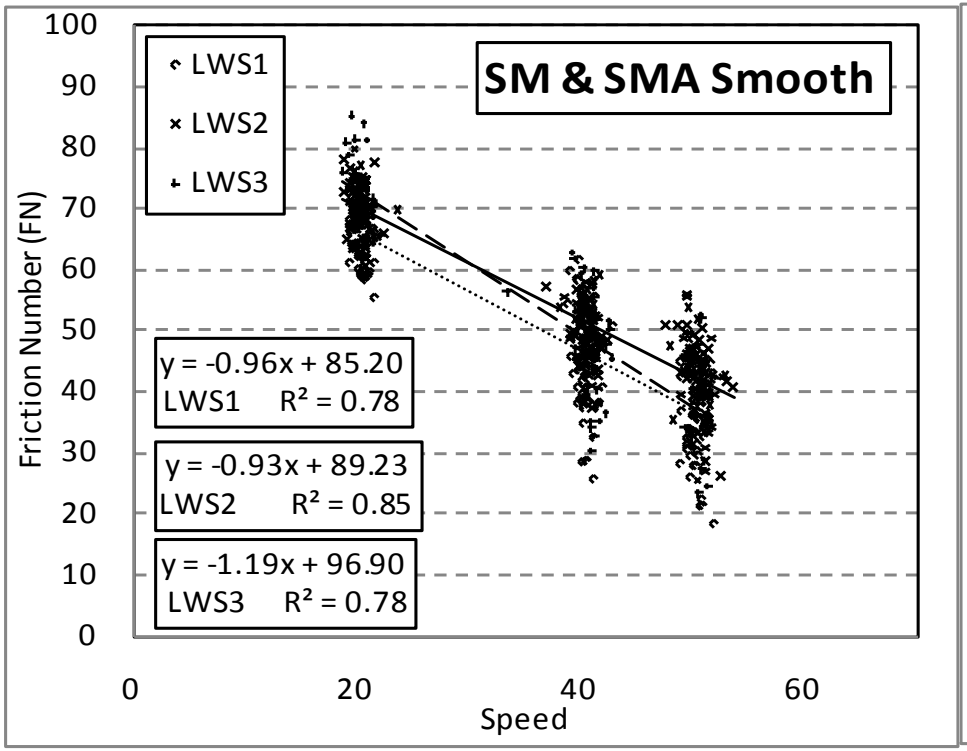
Principal Component Analysis (cont.)

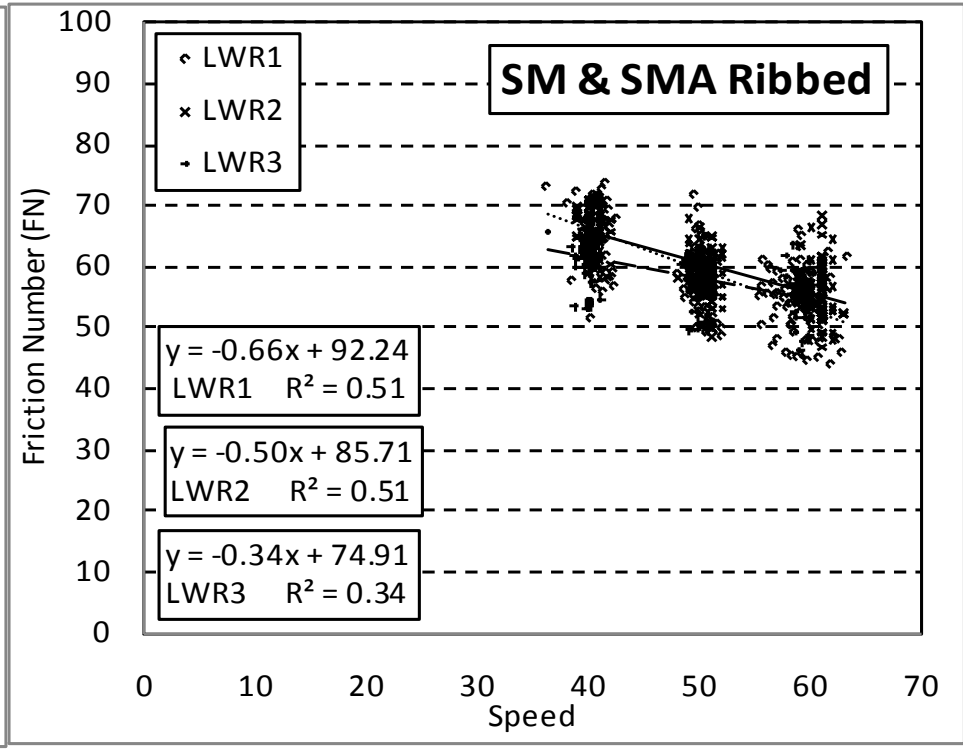




Results by Surface Mix

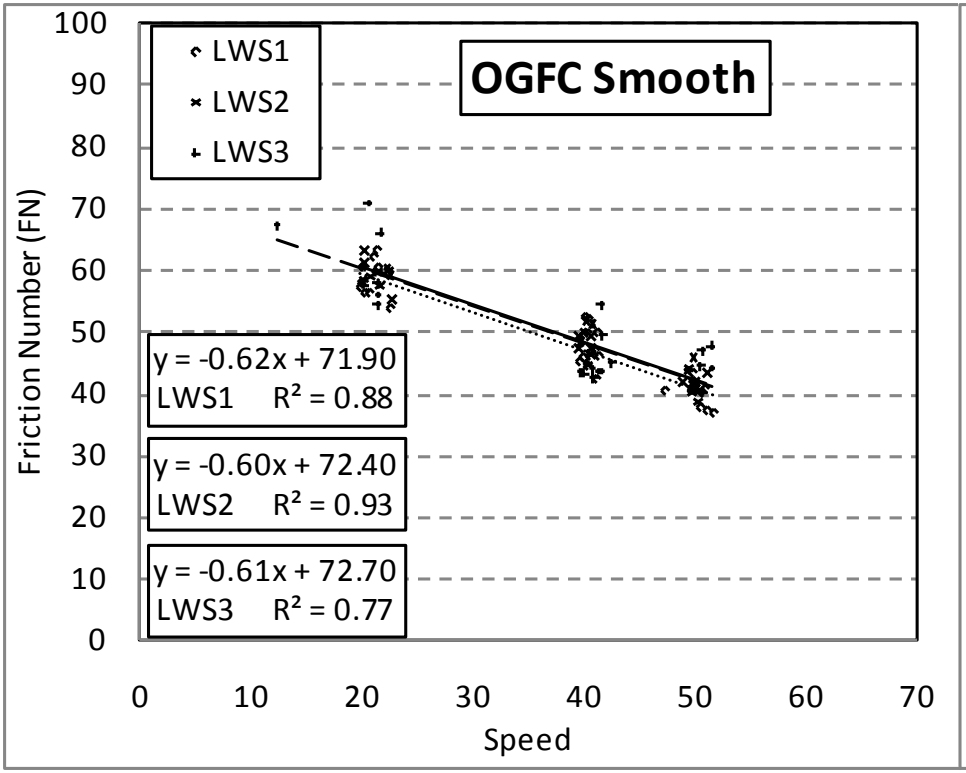
SUPERPAVE and SMA mixes

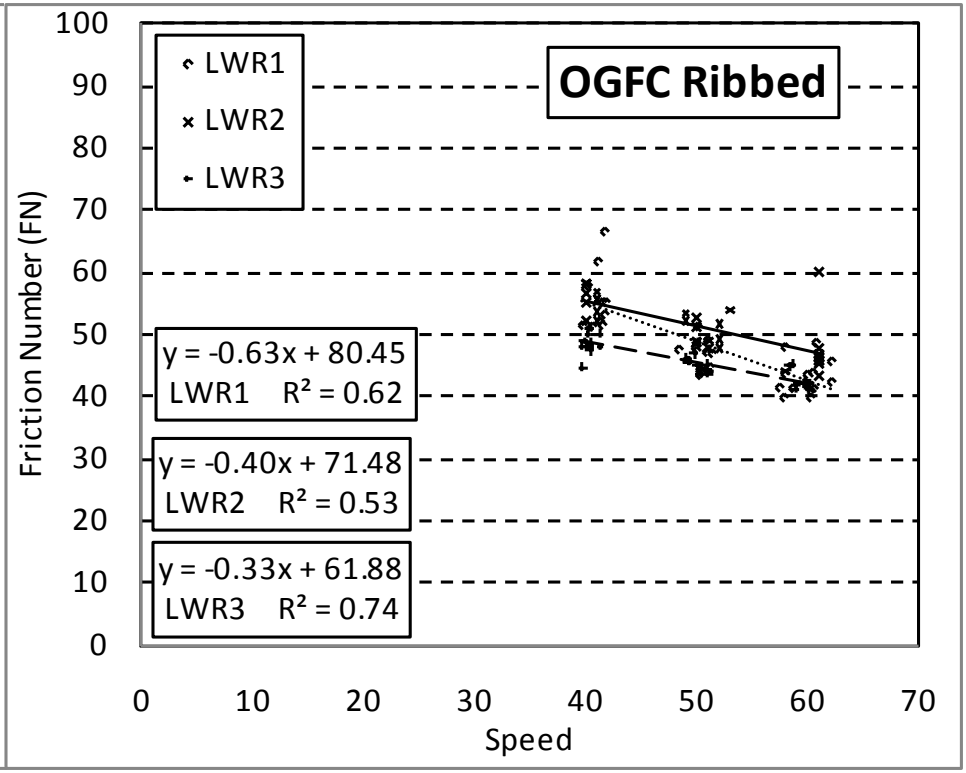




Results by Surface Mix

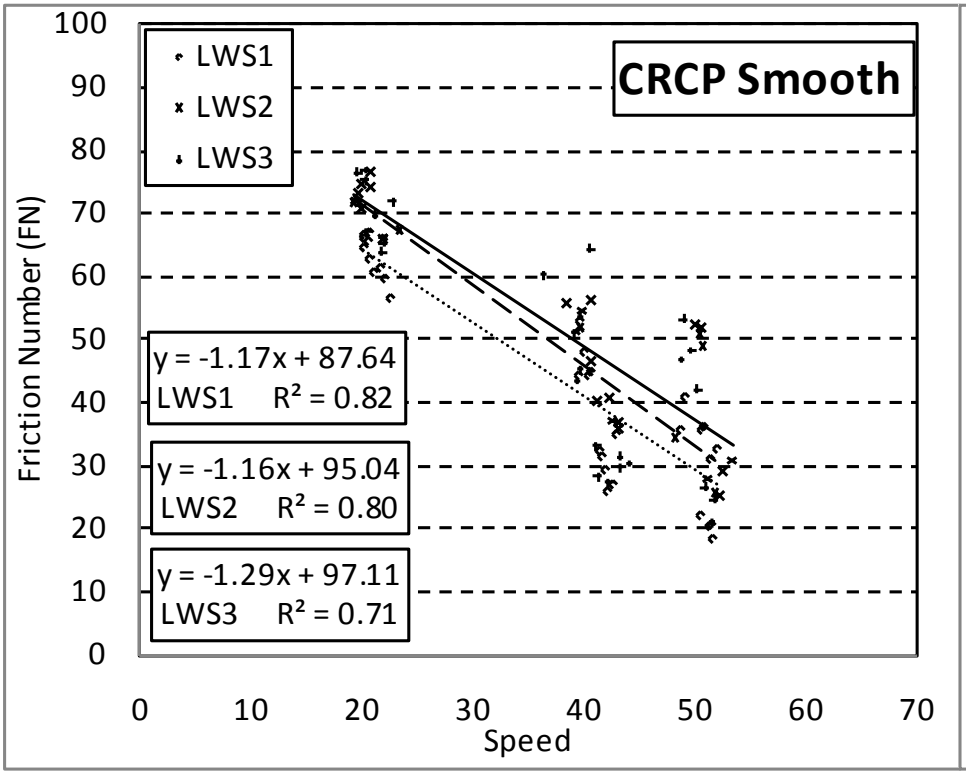
Open Graded Friction Course (OGFC)

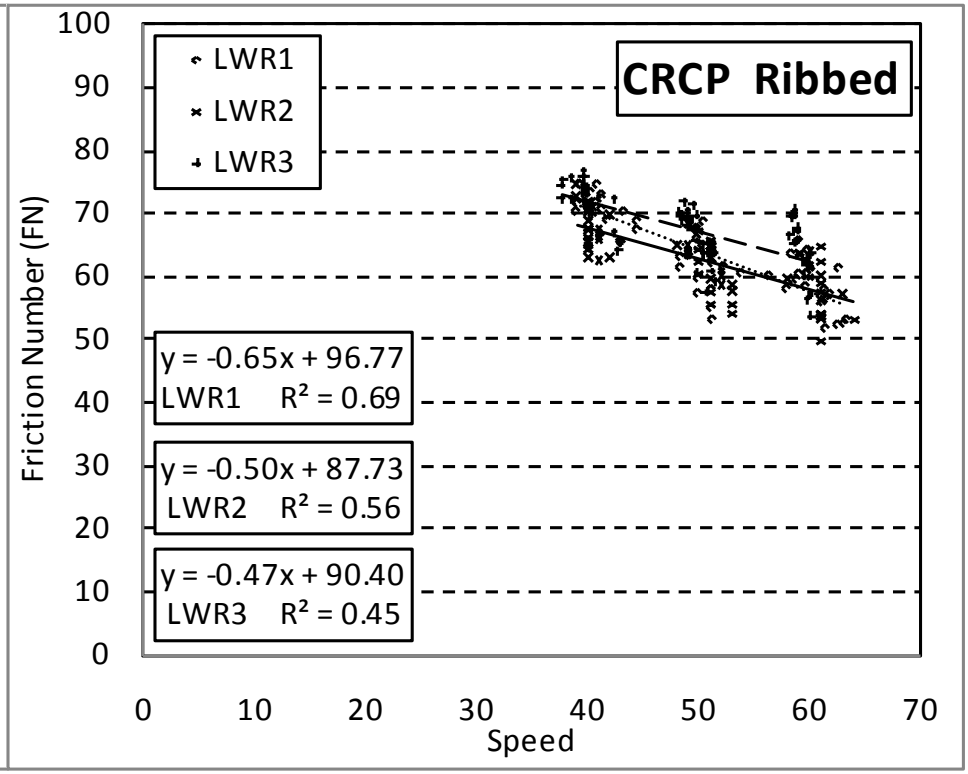




Results by Surface Mix

Continuously Reinforced Concrete Pavement





Results

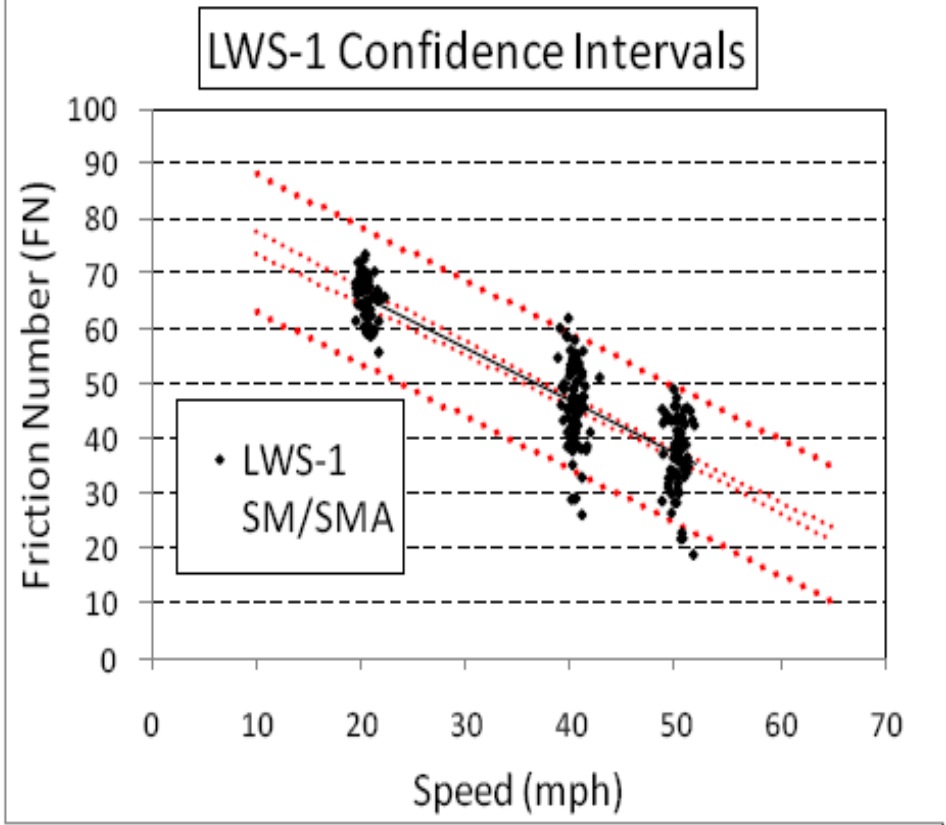
ADJUSTMENT FACTORS: change of skid number for one mph change in speed

Surface	SM and SMA			OGFC			CRCP		
Smooth tire	LWS-1	LWS-2	LWS-3	LWS-1	LWS-2	LWS-3	LWS-1	LWS-2	LWS-3
	-0.96	-0.94	-1.19	-0.62	-0.60	-0.61	-1.17	-1.16	-1.29
Ribbed tire	LWR-1	LWR-2	LWR-3	LWR-1	LWR-2	LWR-3	LWR-1	LWR-2	LWR-3
	-0.66	-0.50	-0.34	-0.63	-0.40	-0.33	-0.65	-0.50	-0.47

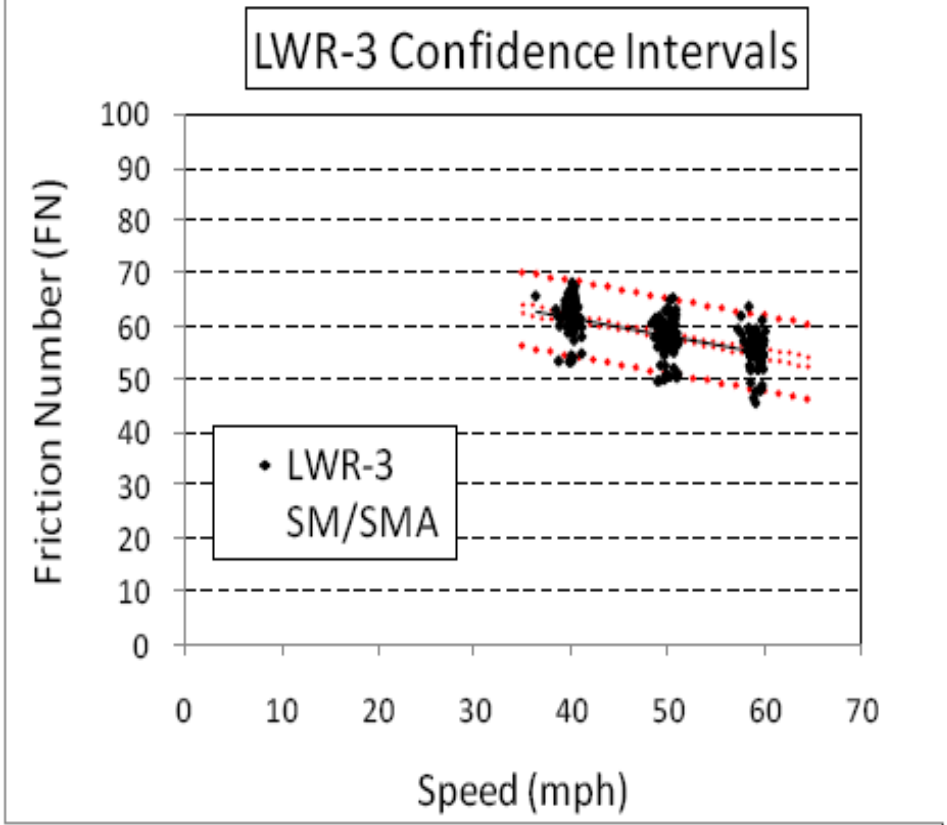
Confidence Intervals

- Confidence intervals were determined for the mean and predicted observations for both tires
- For smooth tire tester around SN ± 12 and for ribbed tire testers were SN ± 8
- Range of the adjustment factors can be used for each group of mixes from confidence intervals
- Confidence intervals for the smooth tire appear wider (more sensitive to road and testing conditions)

Confidence Intervals (cont.)



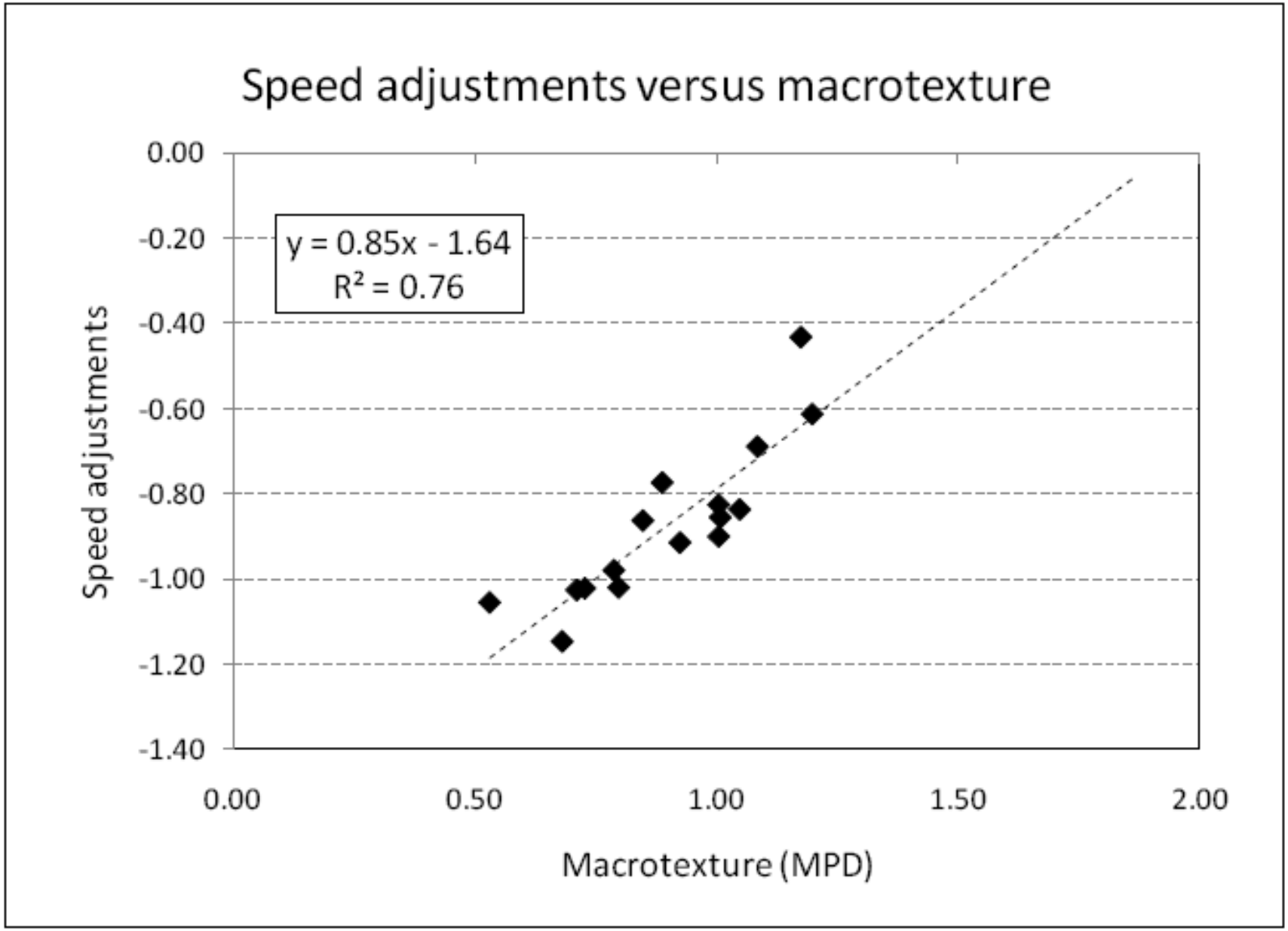
Smooth tire confidence intervals for SM/SMA



Ribbed tire confidence intervals for SM/SMA

Alternative Method

- **Adjustment Factors are a function of macrotexture (For Smooth Tire only)**
  - **Based on correlation between adjustment factors and texture**
  - **Allows using adjustment factors on other sites**


Speed adjustments versus macrotexture
y = 0.85x - 1.64
R² = 0.76
Speed adjustments
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
0.00
0.50
1.00
1.50
2.00
Macrotexture (MPD)

Revised Adjustment Factors

$$F_{V2} = F_{V1} + \Delta F$$

$$\Delta F = (0.85 * TX - 1.64) * \Delta V$$

F_{V2} = skid number at desired speed (V_2)

F_{V1} = skid number at measured speed (V_1)

$\Delta V = V_2 - V_1$

$$C = 0.85TX - 1.64$$

Example

- Section L (SMA)
- LWS-2 (Adj. Fact.) → -0.94
- TX (MPD) → 1.08
  - V_{20} → 19.4 V_{40} → 41.7 V_{50} → 47.5
  - F_{20} → 67 F_{40} → 47.5 F_{50} → 44.7

Example (cont.)

Using proposed factors

- From 20 to 40
- $SN_{40} = 67 - 0.94*(41.7 – 19.4) = 46.0$

- From 50 to 40
- $SN_{40} = 44.7 - 0.94*(41.7 – 47.5) = 50.1$

$SN_{40} \rightarrow 47.5$ @ 41.7 mph

Example (cont.)

Alternative Method (using texture)

- From 20 to 40
- $SN_{40} = 67 + (0.85*1.08 – 1.64)*(41.7 – 19.4) = 50.9$

- From 50 to 40
- $SN_{40} = 44.7 + (0.85*1.08 – 1.64)*(41.7 – 47.5) = 48.8$

$SN_{40} \rightarrow 47.5$ @ 41.7 mph

Summary & Conclusions

- **Linear relationships between skid and speed work well in 30-65 mph range**
- **Skid-speed Adjustment Factors were computed for both tire skid-testers**
- **Two methods developed for smooth-tires** (simple and with texture correction)

Acknowledgements

- **Co-authors: Kevin McGhee, Edgar de León, Gerardo Flintsch**
- ***Pavement Surface Properties Consortium*** **members: FHWA, CT, GA, SC, MS, PA, VA**
- **VA-SPRC team**

Question?