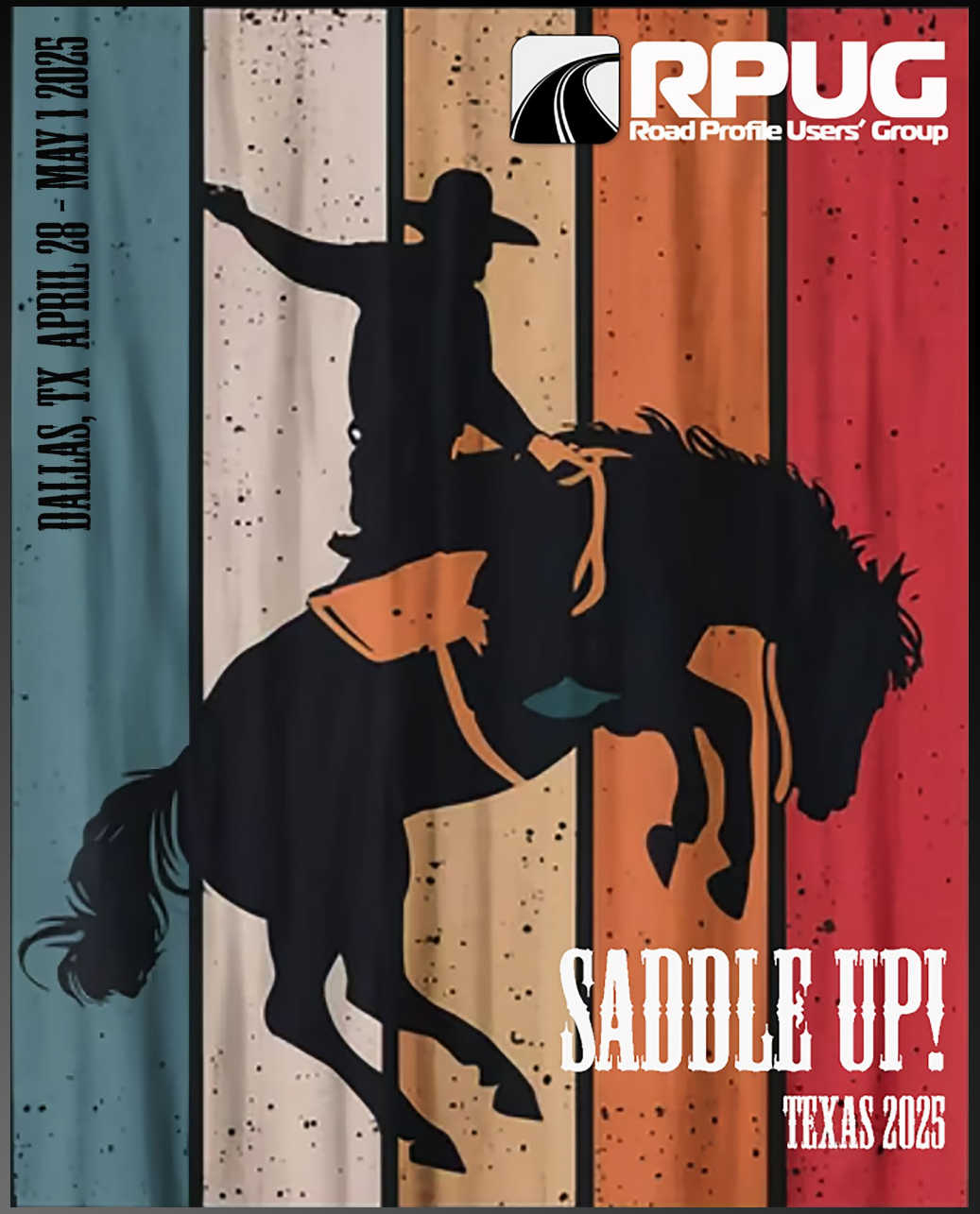


INVESTIGATING THE COMBINED EFFECTS OF FRICTION AND MACROTEXTURE ON CRASHES

GERARDO FLINTSCH, VIRGINIA TECH

DAN PLETTA PROFESSOR AND CSRI DIRECTOR

BEHROKH BAZMARA

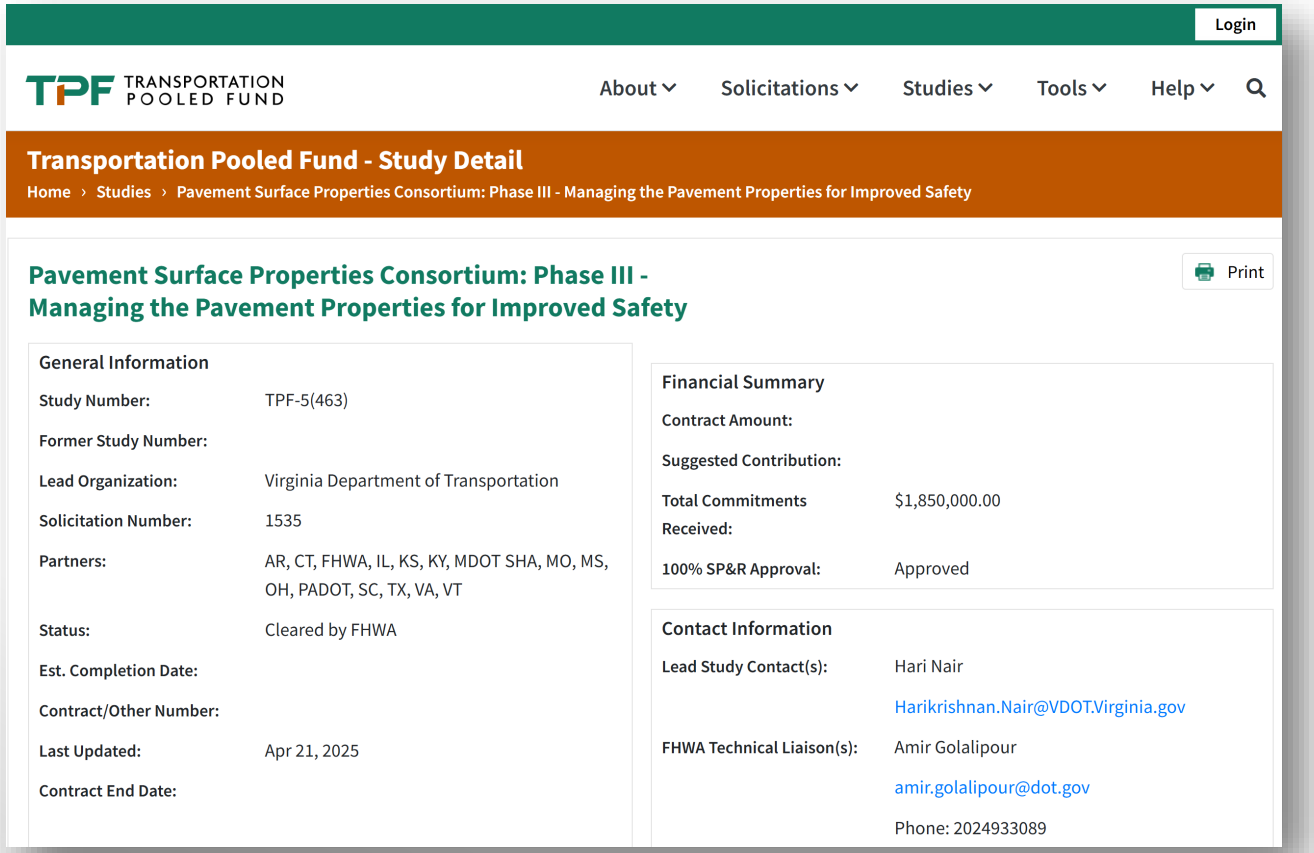
GRADUATE RESEARCH ASSISTANT

RPUG
Road Profile Users' Group

CONTENTS

Acknowledgements

- ✓ **Behrokh Bazmara, VTTI**
- ✓ Edgar de Leon, VTTI
- ✓ Samer Katicha, VTTI
- ✓ Ross McCarthy, VTTI
- ✓ Hari Nair, VTRC



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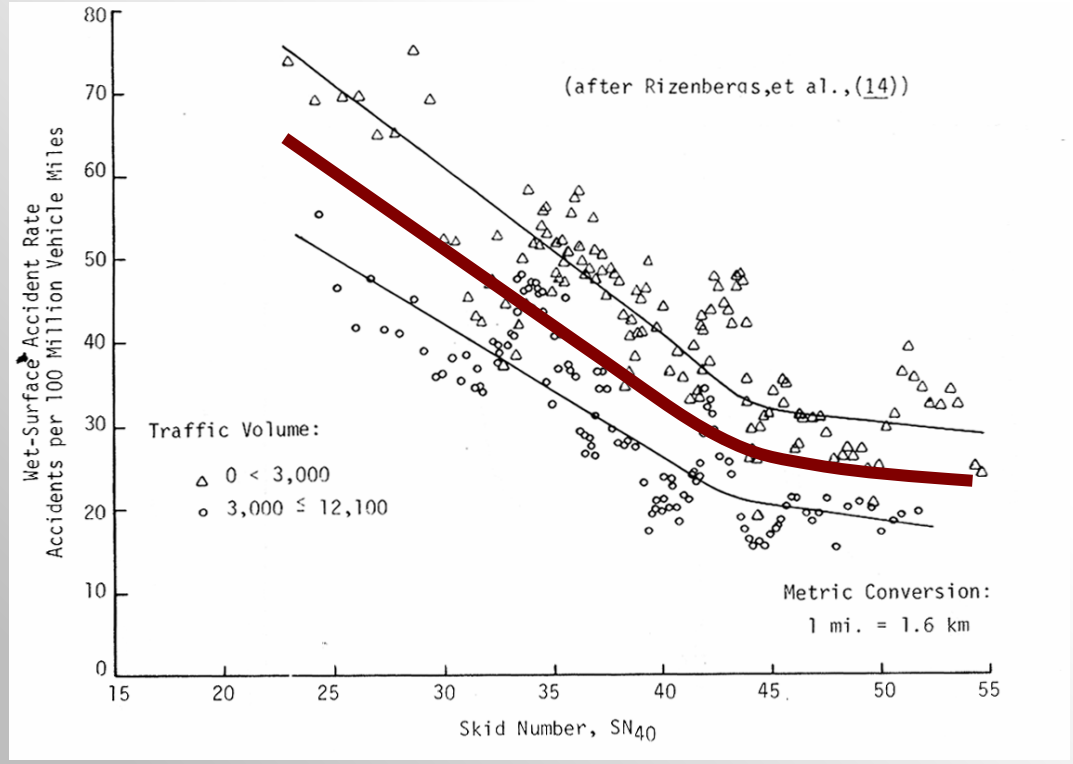
VTRC Virginia Transportation Research Council

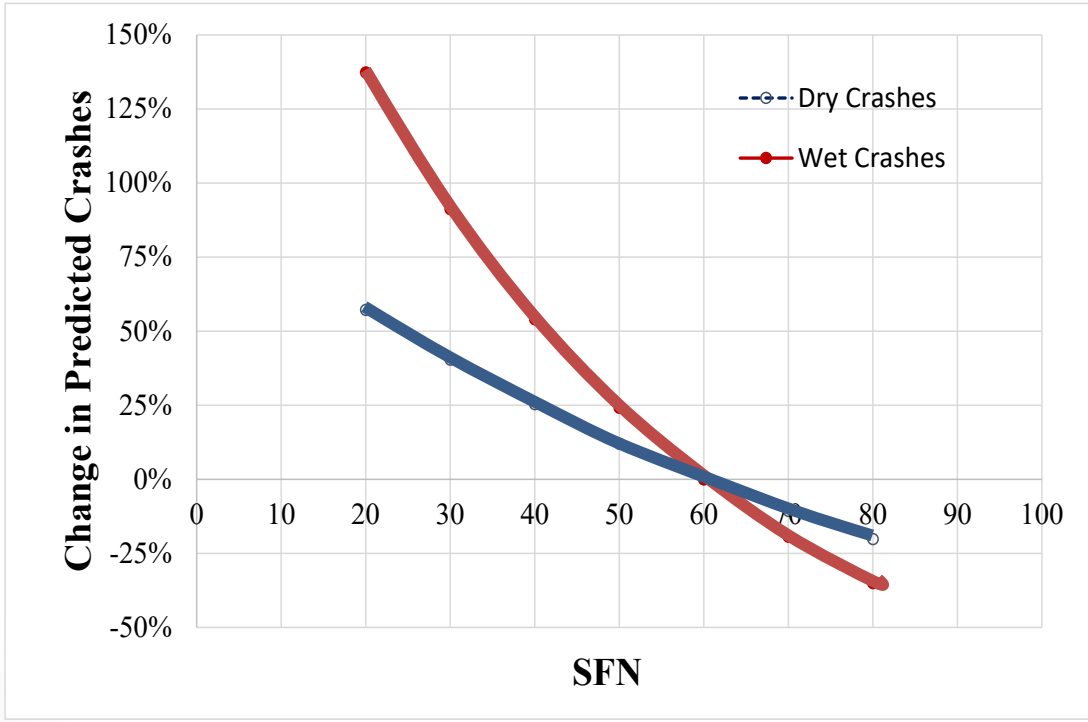
VIRGINIA TECH

Motivation

Relationship between Crashes and Friction



Example Illustration of the Relationship between Wet-Weather Crash Rates and Pavement Friction for Kentucky Highways (after Rizenbergs et al. 1973)



Illustrative example of estimated changes of Average Wet- and Dry-crash Rates vs. Friction (SFN) (after McCarthy et al., 2021)

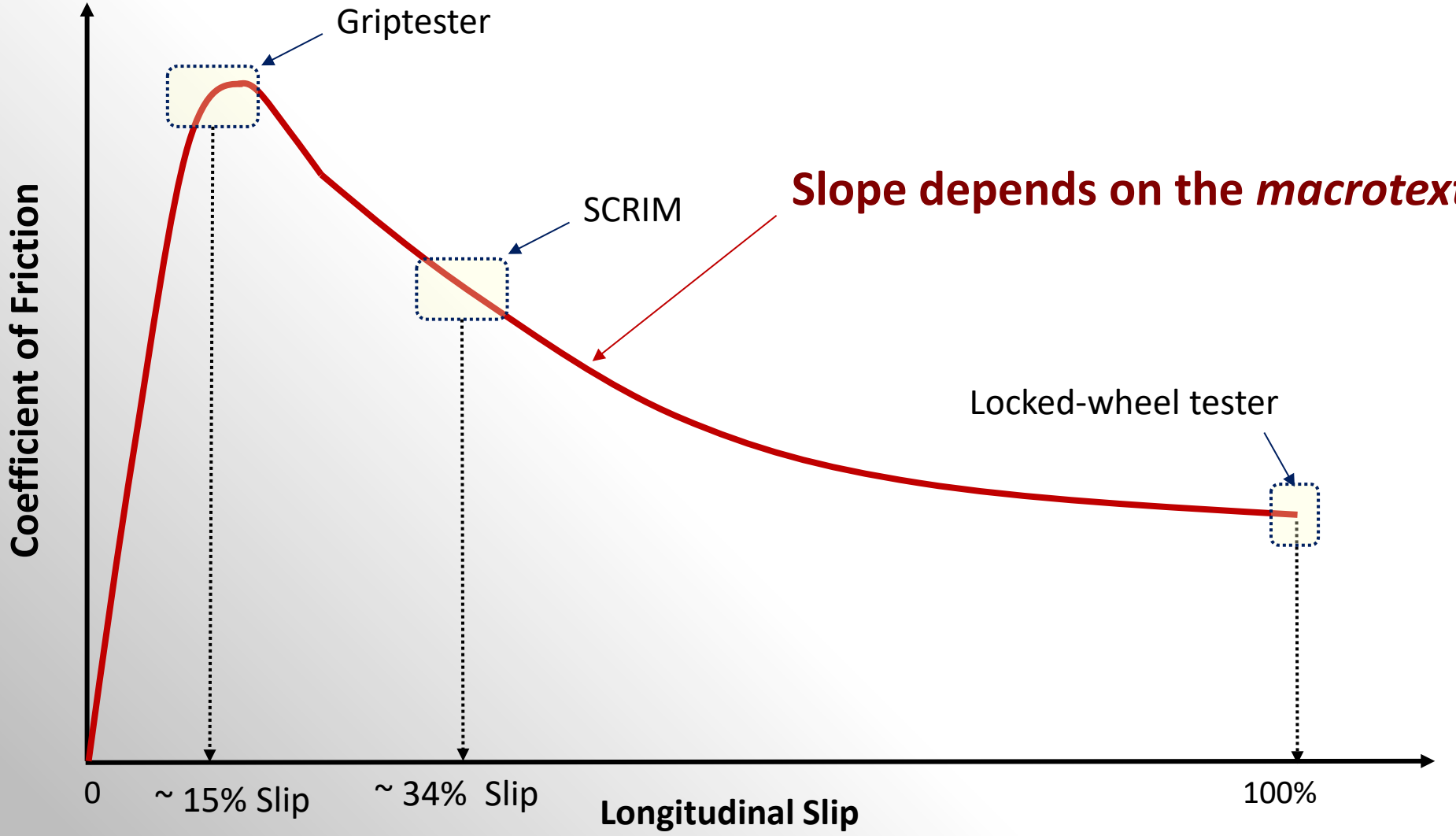


Illustration of the Slip Operational Ranges for Different Friction Measuring Equipment (not to scale)

Wet Friction and Impact of Macrotexture

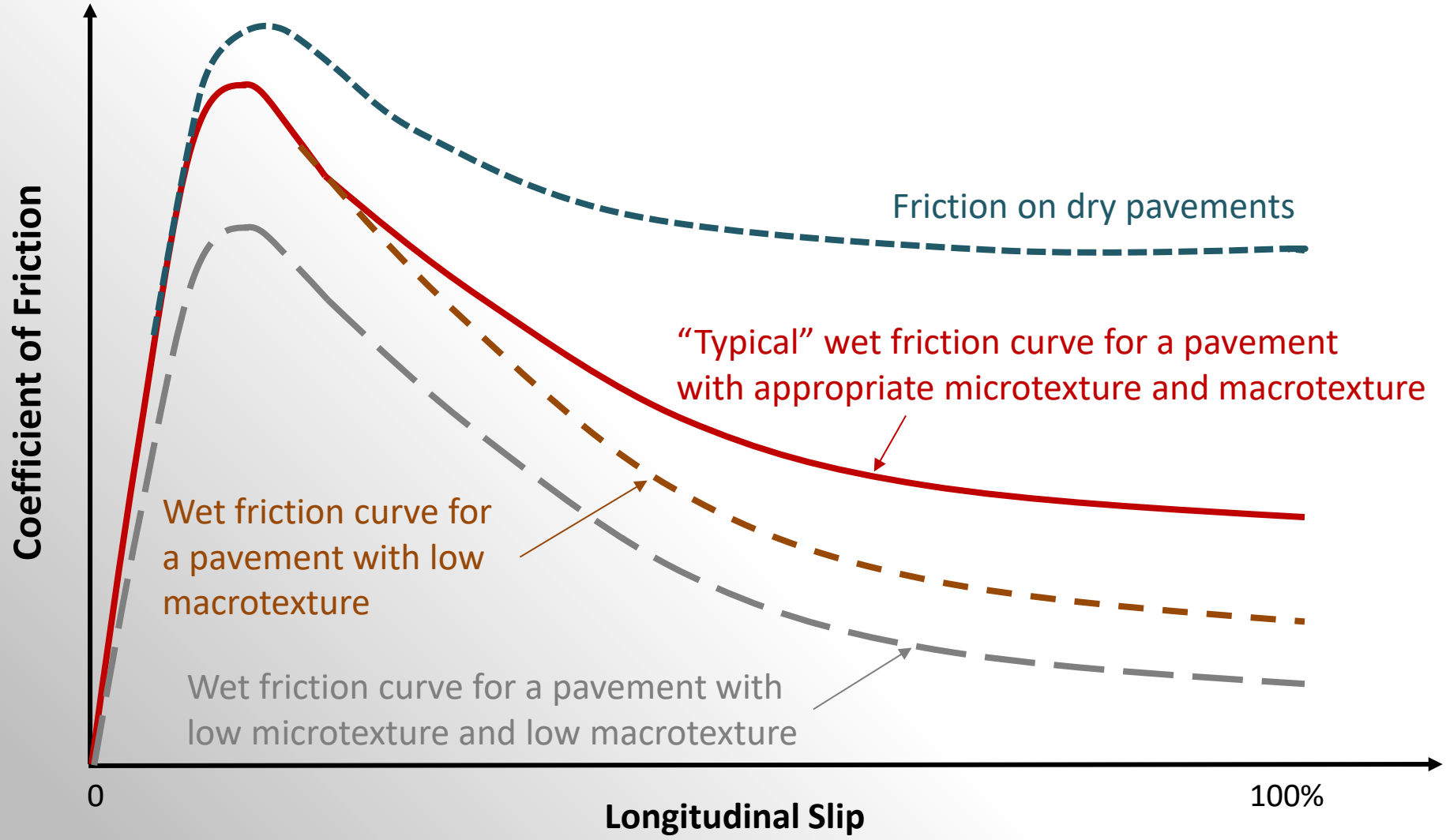
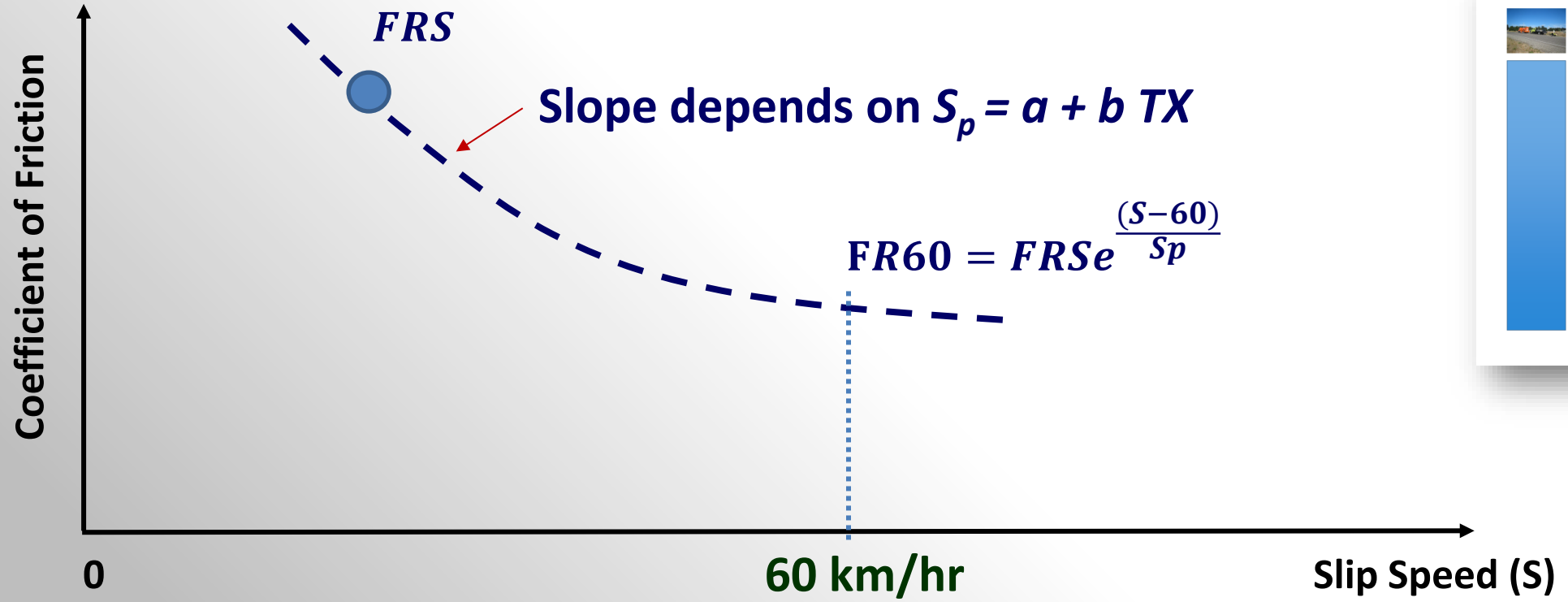
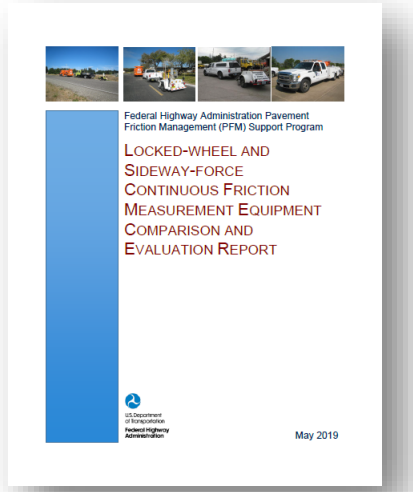


Figure 4.

Frictional Properties

- ✓ Many Studies over the years show that you need both friction and macrotexture
- ✓ Example: International Friction Index





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Objectives

→ Investigate the feasibility of combining macrotexture and low-speed friction into a single indicator

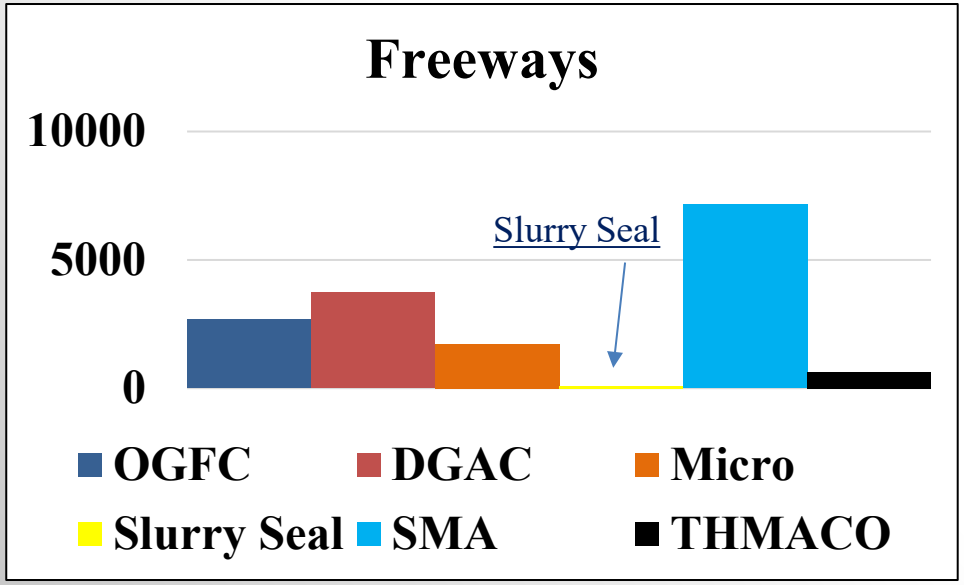
→ that supports a more comprehensive assessment of pavement safety using safety performance function (SPF)

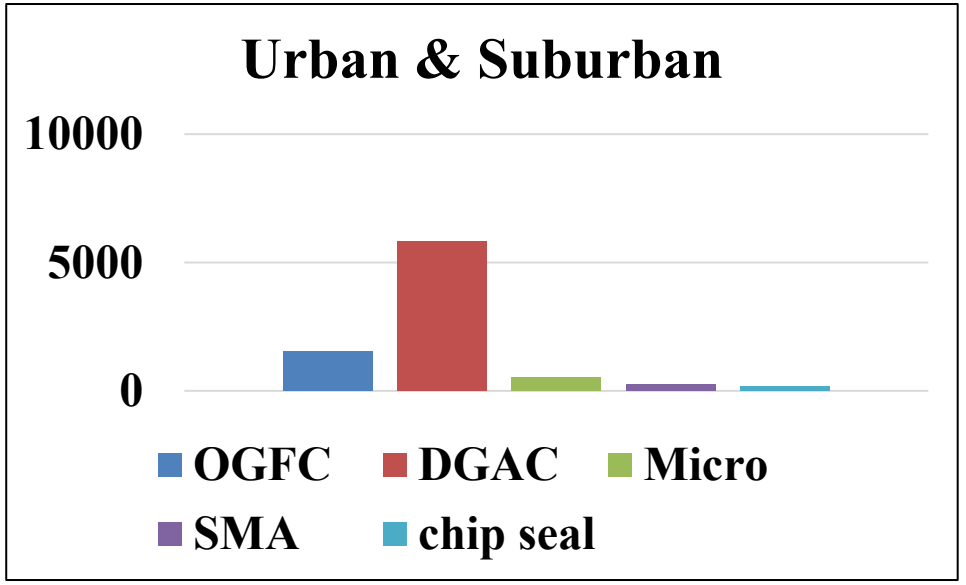
Data Collection

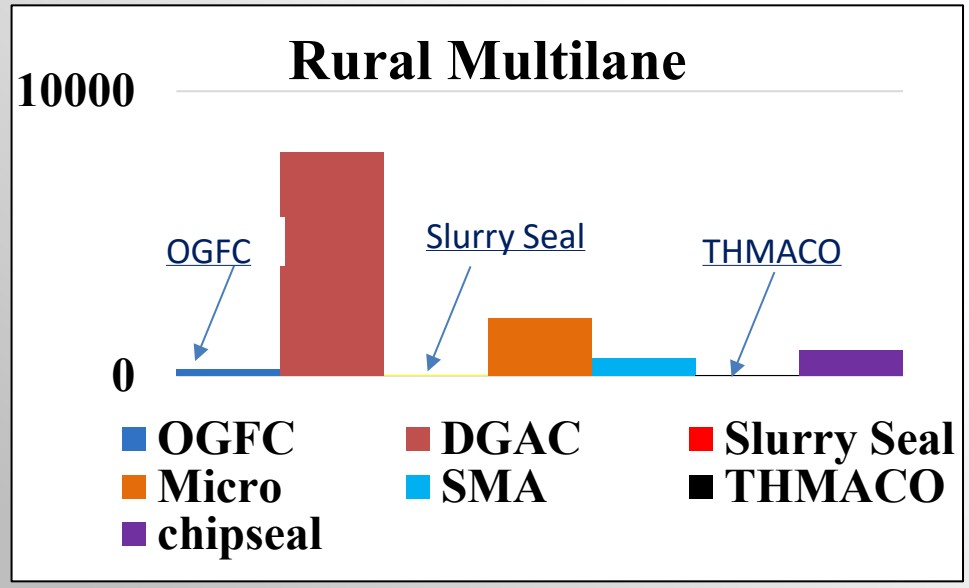
- ✓ ***Sideway-Force Coefficient Routine Investigation Machine (SCRIM)***
  - →Sideway-force Friction (SFN(40)) ***AASHTO - TP143***
  - →Macrotexture [Mean Profile Depth (MPD in mm)
  - →Vertical Grade (%)
  - →Cross-slope (%)
  - →Horizontal Curvature (1/m)

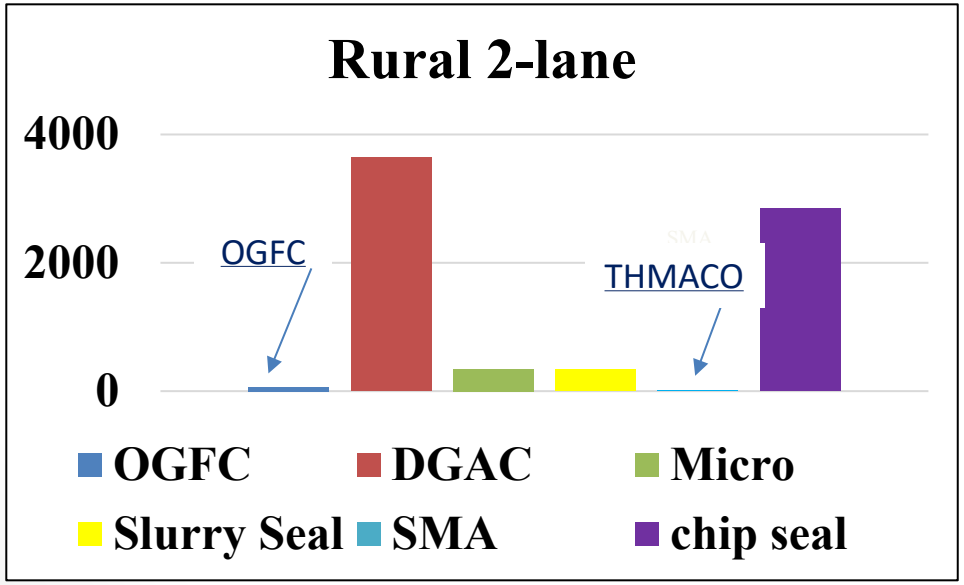
Variables	Unit	Minimum	Mean	Maximum
Grade	Percentage	-8.81	0.39	10.97
Cross Slope	Percentage	0.13	2.8	13.82
Horizontal Curvature	1/meter	0.000009	0.0005	0.02
AADT	Count	72	9083.4	56,000
Friction	Dimensionless	6.21	53.67	91.1
Macrotexture	Millimeter	0.21	0.79	4.15

Available Data



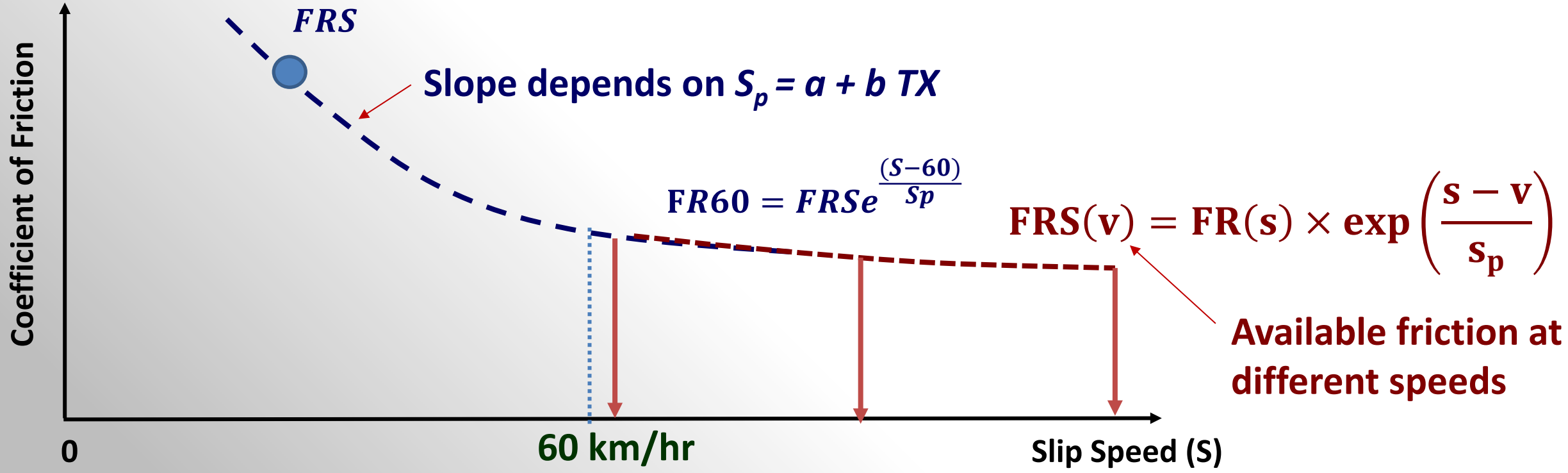






Methodology

- ✓ Applying the speed correction equation in ASTM E1960-07 to estimate available friction at speeds between 40 mph and 70 mph.



Average Expected Number of Crashes

$$\lambda_i = SPF_i = exp\left(\beta_0 + \beta_1 \times ln(AADT_i) + \sum_{j=2}^{k} \beta_j X_{ij}\right)$$

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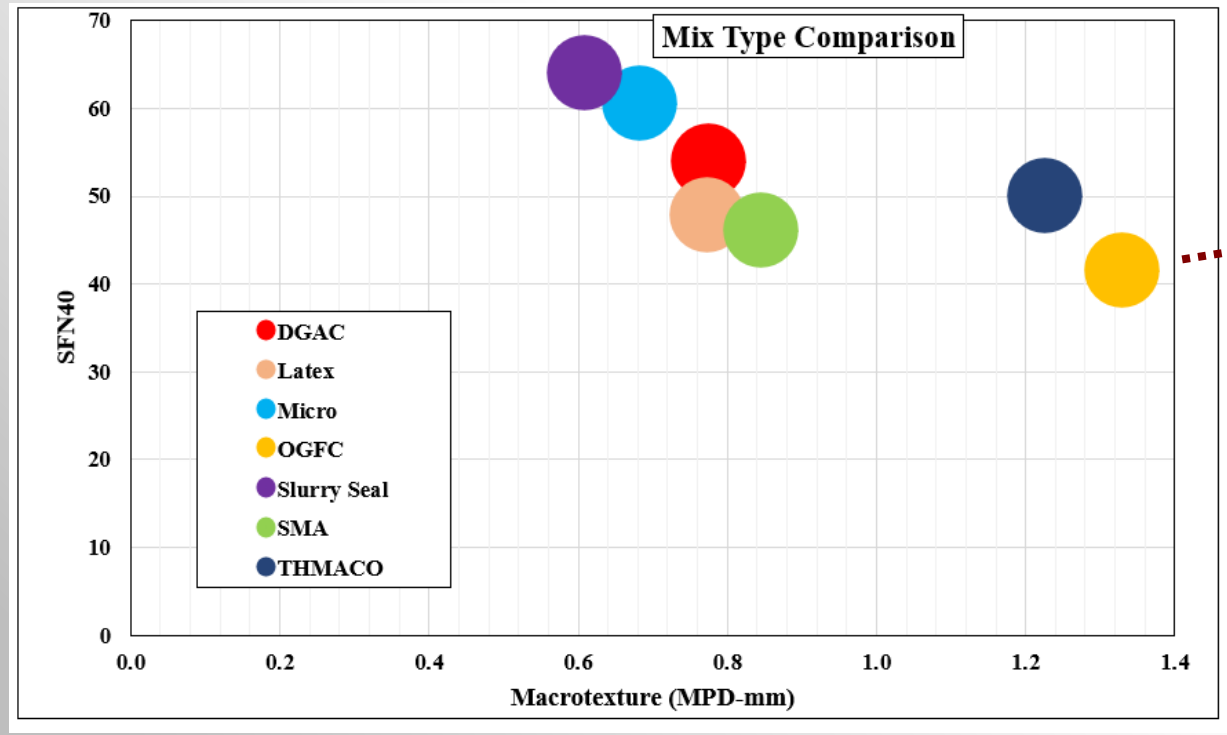
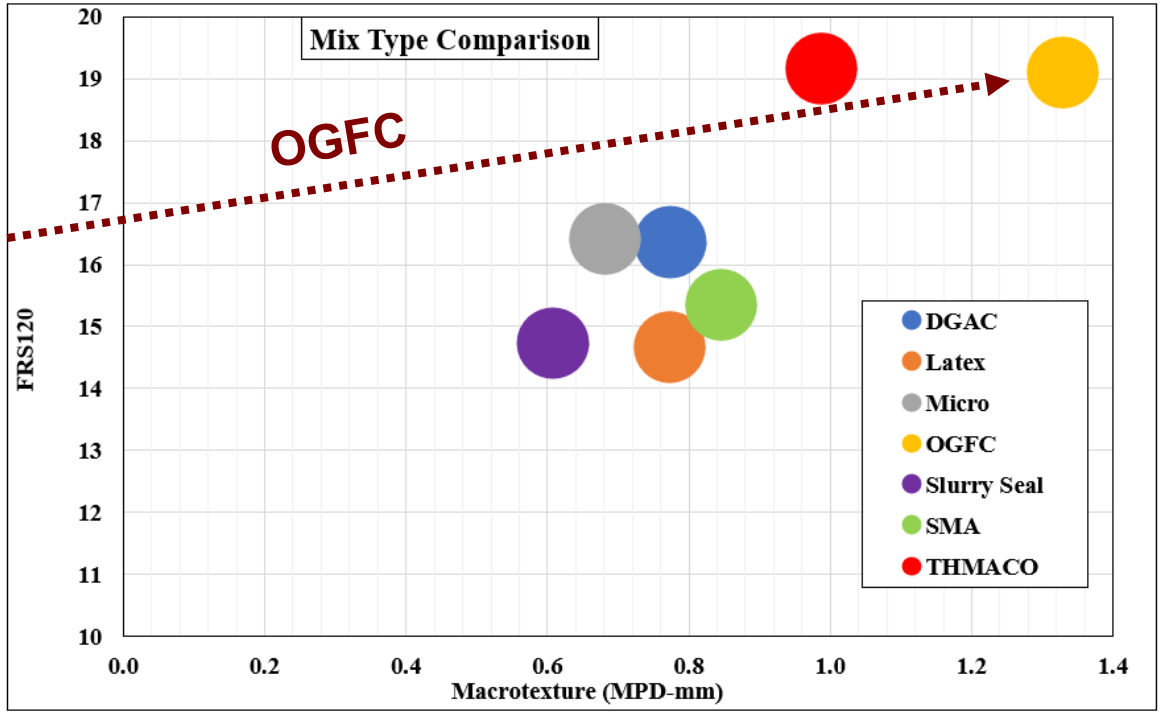
Qualitative Assessment





Results

Freeways		
Term	SFN(40) & MPD (Mph)	
	β	P-value
Intercept	-13.921	<.0001
# of Intersection	0.475	<.0001
Lane-Count	-0.084	<.0001
lnAADT	1.454	<.0001
Macrotexture (MPD)	-0.335	<.0001
Grade	0.051	<.0001
Cross-slope	-0.048	<.0001
Curvature	508.73	<.0001
Friction	0.0003	0.83
R^2	0.4	
AIC	63424.03	
Overdispersion	1.01	
NLL	-31702.008	

Results

Freeways								
Term	SFN(40) & MPD (Mph)		FRS 65 (km/h)		FRS 89 (km/h)		FRS 113 (km/h)	
	β	P-value	β	P-value	β	P-value	β	P-value
Intercept	-13.921	<.0001	-13.784	<.0001	-13.727	<.0001	-13.739	<.0001
# of Intersection	0.475	<.0001	0.472	<.0001	0.473	<.0001	0.473	<.0001
Lane-Count	-0.084	<.0001	-0.086	<.0001	-0.084	<.0001	-0.084	<.0001
lnAADT	1.454	<.0001	1.429	<.0001	1.426	<.0001	1.427	<.0001
Macrotexture (MPD)	-0.335	<.0001						
Grade	0.051	<.0001	0.046	<.0001	0.047	<.0001	0.047	<.0001
Cross-slope	-0.048	<.0001	-0.06	<.0001	-0.059	<.0001	-0.057	<.0001
Curvature	508.73	<.0001	534.411	<.0001	531.685	<.0001	528.995	<.0001
Friction	0.0003	0.83	-0.005	0.0073	-0.008	<.0001	-0.01	<.0001
R^2	0.4		0.4		0.4		0.4	
AIC	63424.03		63515.01		63505.56		63496.76	
Overdispersion	1.01		1.02		1.02		1.02	
NLL	-31702.008		-31748.5		-31743.78		-31739.37	

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More Preliminary Results

Rural 2-lane								
Term	SFN(40) & MPD		FRS 65 (km/h)		FRS 89 (km/h)		FRS 113 (km/h)	
	β	P-value	β	p-value	β	p-value	β	p-value
Intercept	-7.398	<.0001	-7.612	<.0001	-7.91	<.0001	-8.093	<.0001
# of Intersection	0.989	<.0001	1.015	<.0001	1.025	<.0001	1.031	<.0001
Lane-Count	-0.61	0.304	-0.637	<.0001	-0.62	<.0001	-0.607	<.0001
lnAADT	0.918	<.0001	0.929	<.0001	0.945	<.0001	0.956	<.0001
Macrotexture (MPD)	~~0.344~~	<.0001						
Grade	0.009	0.511	0.02	0.15	0.02	0.153	0.019	0.167
Cross-slope	0.0105	0.579	0.01	0.598	0.01	0.595	0.01	0.591
Curvature	95.5	0.0001	122.098	<.0001	124.603	<.0001	125.127	<.0001
Friction	-0.012	<.0001	-0.007	0.0216	-0.004	0.2739	-0.001	0.8
R^2	0.15		0.15		0.14		0.14	
AIC	10602.26		10639.89		10643.97		10645.11	
Overdispersion	1.58		1.61		1.61		1.61	
NLL	-5291.2		-5310.93		-5312.97		-5313.54	

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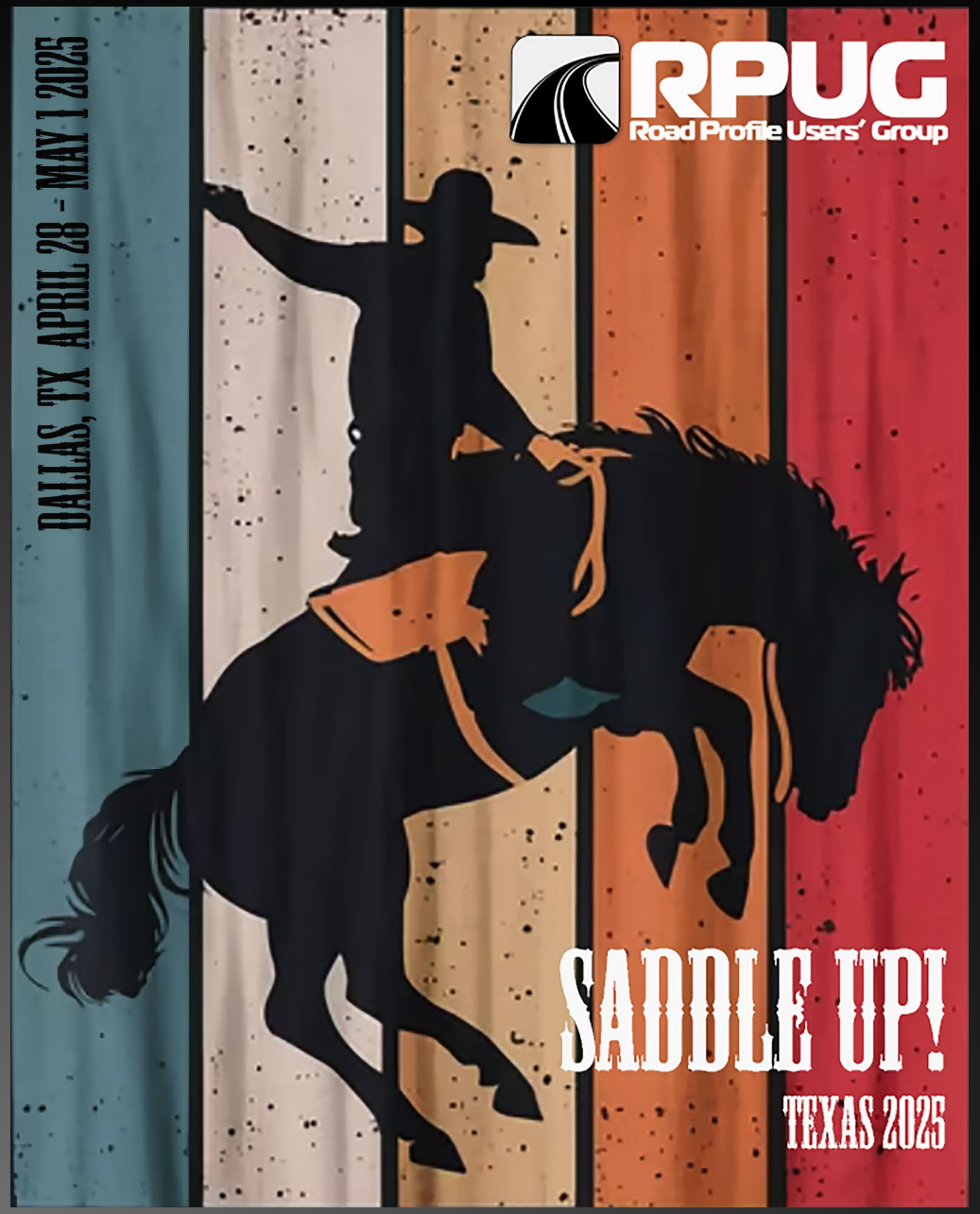
Conclusions

- ✓ Both microtexture and macrotexture measurements are needed to get the available friction under different conditions (e.g., OGFC)
  - → SFN40 predominantly reflects microtexture
- ✓ Crash analysis
  - → The model incorporating the estimated available friction at 113 km/h (FRS113) resulted in better SPFs for freeways
  - → For 2-way rural roads (with generally lower posted speeds) the FRS65 seems to work better
- ✓ **Should we use FRS at the posted speed for safety analysis?**



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