



COMBINED EFFECTS OF MACROTEXTURE AND FRICTION IN FACILITY-SPECIFIC WET-WEATHER CRASHES

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OUTLINE

- Acknowledgements
- Research Background
- Data Collection
- Safety Performance Function
- Results
- Conclusions



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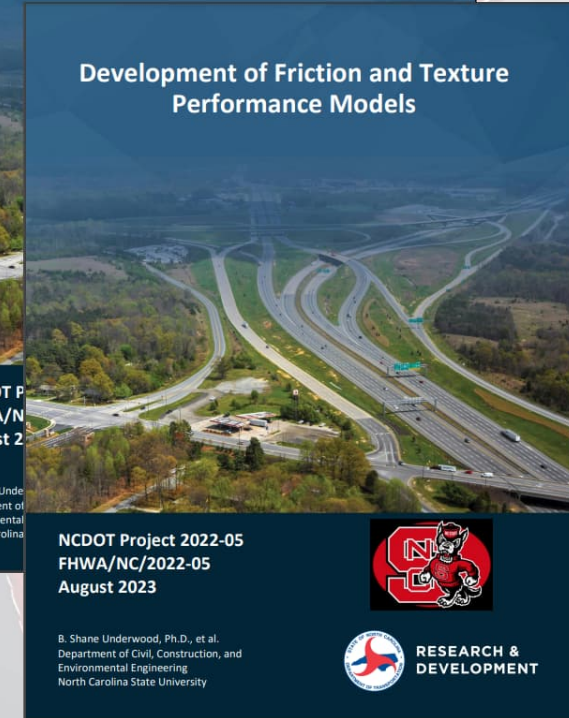
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DISCLAIMER

This presentation represents the opinions of the author and is not meant to represent the position or opinions of the NCDOT or its employees.

RESEARCH BACKGROUND

- ❑ Internal studies on targeted sites (2017-current)
- ❑ RP2017-02 - Evaluation of Methods for Pavement Surface Friction, Testing on Non-tangent Roadways and Segments (**Completed**, VT)
- ❑ RP2020-11 - Evolution of Pavement Friction and Macrotexture after Asphalt Overlay (**Completed**)
- ❑ RP2022-05 - Development of Friction Performance Models (**Completed**)
- ❑ RP2024-12 - Evaluation of Macrotexture and Friction of Alternative Asphalt Surface Course Material (**Completed**)
- ❑ Network Data Collection (**2022, 2023, 2024, 2025**)
- ❑ RP2025-18 - Updating Friction/Texture Demand Categories for Improved Pavement Design Guidance (**Ongoing**)



RESEARCH BACKGROUND



- ❑ Lane-departure crashes are a leading highway safety concern, particularly under wet-weather conditions.
- ❑ Wet weather greatly reduces pavement's available skid resistance.
- ❑ Individual and combined contributions of macrotexture and friction on wet crashes have been explored previously, but how they affect in facility-specific conditions is underexplored.



RESEARCH BACKGROUND

OBJECTIVES

- ❑ Develop a facility-specific safety performance function (SPF) for wet lane departure crashes across the North Carolina primary road network.
- ❑ Quantify the individual influence of friction and macrotexture on wet-weather crash frequency across facility types.
- ❑ Further quantify the combined impact of friction and macrotexture on crash frequency across facility types.



DATA COLLECTION



□ Sideway-Force Coefficient Routine Investigation Machine (SCRIM)

- Macrotexture, Mean Profile Depth (*MPD* in mm)
- SCRIM Coefficient (*SC*)
- Section Length (*L* in miles)

□ NCDOT

- *AADT*
- Wet Lane Departure Crash



6 months before



surface measurement month



6 months after

13-Month Crash Count Window

SAFETY PERFORMANCE ANALYSIS

MODEL DEVELOPMENT



Evaluating Individual and Combined Effects of MPD and SC

Model 1

$$N = \exp(a + b_1 \times \ln(AADT) + b_2 \times \ln(L) + b_3 \times \mathbf{MPD})$$

Model 2

$$N = \exp(a + b_1 \times \ln(AADT) + b_2 \times \ln(L) + b_4 \times \mathbf{SC})$$

Model 3

$$N = \exp(a + b_1 \times \ln(AADT) + b_2 \times \ln(L) + b_3 \times \mathbf{MPD} + b_4 \times \mathbf{SC})$$

Where;

AADT = Annual average daily traffic,

L = Section length (mile),

SC = 10th Percentile SCRIM coefficient divided by 100,

MPD = 50th Percentile mean profile depth (mm), and

a, b₁₋₄ = Fitting coefficients determined through regression.

SAFETY PERFORMANCE ANALYSIS

FACILITY GROUPING STRATEGY



- ❑ The homogeneous sections were grouped based on the following criteria:
 - Facility Type: Divided or undivided.
 - Speed Limit: High Speed (Speed Limit \geq 60 mph) or Low Speed (Speed Limit $<$ 60 mph).

Low Speed	✓	✓
High Speed	✓	✗
	Divided	Undivided

This facility was not evaluated because of the limited sample size.

SAFETY PERFORMANCE ANALYSIS

MODEL CALIBRATION AND EVALUATION METRICS



R²

Coefficient of determination

- Variance explained by the model
- Higher = better fit.

MAD

Mean absolute deviation

- Difference: observed vs predicted
- Lower = better accuracy.

MACD

Moving average convergence divergence

- Detect over/under-prediction
- Indicates model bias.

Statistical significance level: $p < 0.05$. Coefficients with $p \geq 0.05$ are highlighted as not significant.

RESULT

UNDIVIDED – LOW SPEED FACILITIES



Model Coefficients	Name	Model 1		Model 2		Model 3	
		Value	P-value	Value	P-value	Value	P-value
a	<i>Intercept</i>	-4.986	<0.05	-5.144	<0.05	-4.677	<0.05
b1	<i>AADT</i>	0.471	<0.05	0.459	<0.05	0.466	<0.05
b2	<i>L</i>	0.944	<0.05	0.948	<0.05	0.948	<0.05
b3	<i>MPD</i>	-0.582	<0.05	-	-	-0.592	<0.05
b4	<i>SC</i>	-	-	-0.316	0.676	-0.421	0.581
R²		0.648		0.642		0.658	
MAD		0.795		0.798		0.794	
MACD		28.231		28.739		28.265	

Results are physically consistent: *MPD* significantly reduces crashes, while *SC* shows the expected direction but is not statistically significant.

RESULT

DIVIDED – LOW SPEED FACILITIES



Model Coefficients	Name	Model 1		Model 2		Model 3	
		Value	P-value	Value	P-value	Value	P-value
a	<i>Intercept</i>	-8.691	<0.05	-8.202	<0.05	-8.154	<0.05
b1	<i>AADT</i>	0.840	<0.05	0.811	<0.05	0.822	<0.05
b2	<i>L</i>	1.033	<0.05	1.033	<0.05	1.035	<0.05
b3	<i>MPD</i>	-0.138	0.592	-	-	-0.152	0.556
b4	<i>SC</i>	-	-	-0.543	0.561	-0.586	0.531
R²		0.504		0.507		0.507	
MAD		1.847		1.841		1.845	
MACD		108.585		107.032		107.390	

MPD and *SC* follow the expected physical direction, but are not statistically significant.

RESULT

DIVIDED – HIGH SPEED FACILITIES



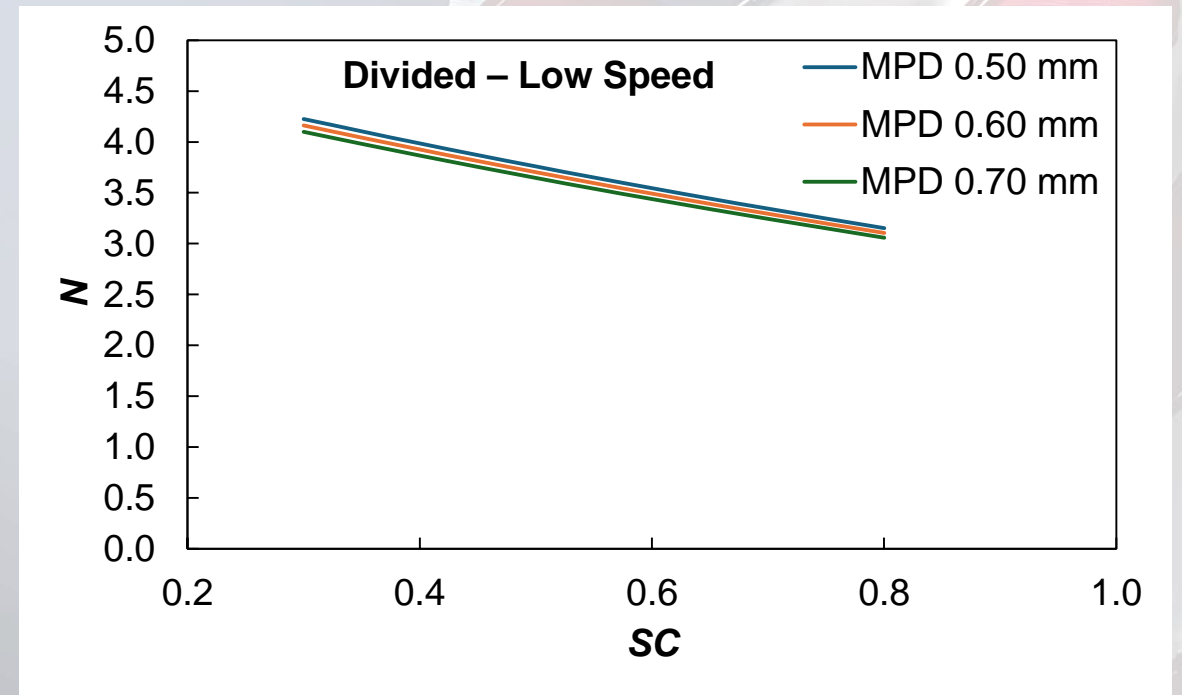
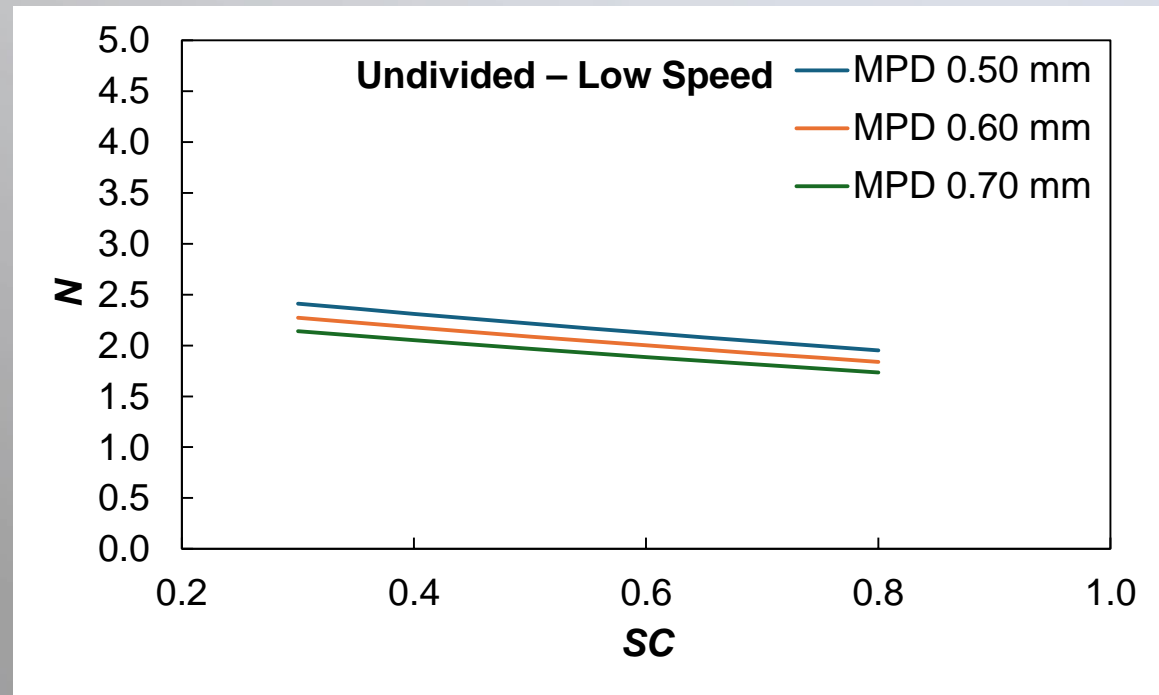
Model Coefficients	Name	Model 1		Model 2		Model 3	
		Value	P-value	Value	P-value	Value	P-value
a	<i>Intercept</i>	-6.715	<0.05	-8.288	<0.05	-6.955	<0.05
b1	<i>AADT</i>	0.734	<0.05	0.823	<0.05	0.742	<0.05
b2	<i>L</i>	0.982	<0.05	0.983	<0.05	0.982	<0.05
b3	<i>MPD</i>	-0.562	<0.05	-	-	-0.545	<0.05
b4	<i>SC</i>	-	-	1.403	<0.05	0.228	0.762
R²		0.621		0.583		0.621	
MAD		4.735		4.887		4.736	
MACD		112.724		114.054		108.970	

MPD is statistically significant, while *SC* is physically counterintuitive.

RESULT

SENSITIVITY ANALYSIS FOR MODEL 3

Crash frequency (N) decreases with increasing SC and MPD across both facility types (at constant $AADT$ and L).



CONCLUSIONS



- ❑ Macrotexture shows a consistent negative coefficient with wet lane departure crashes across all facility groups.
 - *MPD* is statistically significant for Undivided - Low Speed and Divided - High Speed facilities
 - Even where *MPD* is not statistically significant (Divided - Low Speed, $p = 0.556$), the coefficient remains negative, physically consistent with the improved drainage and reduced crash risk.
- ❑ Friction demonstrates variable effects across facility types.
 - For low-speed facilities, *SC* generally follows the expected negative direction but is often not statistically significant.
 - The positive *SC* coefficient at Divide - High Speed facilities results suggest that *MPD* has a stronger influence than *SC*.
- ❑ Sensitivity analysis supports the combined role of *MPD* and *SC* in reducing wet crash risk at low speed facilities.

THANK YOU

