18-00841 Predicting Friction with Improved Texture Characterization

CENTER FOR TRANSPORTATION RESEARCH

Natalia Zuniga-Garcia, M.Sc. *(nzuniga@utexas.edu)*, Andre d.F. Smit, Ph.D., and Jorge A. Prozzi, Ph.D.

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Introduction

Objective

Study the effect of different texture components and their parametric description on the skid resistance of a pavement surface.

- Highway surface skid resistance has a significant influence on the number of wet weather accidents.
- Current methodologies to measure road friction are impractical for field data collection over large highway networks.

Friction and Texture

Friction

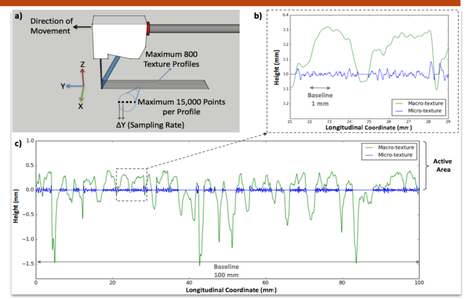
1. British Pendulum Test (BPT)
2. Dynamic Friction Test (DFT)
3. GripTester
4. Micro-GripTester

Texture

1. Sand Patch Text
2. Circular Track Meter (CTM)
3. Laser Texture Scanner (LTS)
4. Line Laser Scanner (LLS)

Line Laser Scanner (LLS)

- Implemented at the University of Texas at Austin
- Captures height information of up to 800 profiles in 15 seconds
- Each profile consists of up to 15,000 data points
- Covers the whole macro-texture wavelength range and the first decade of micro-texture



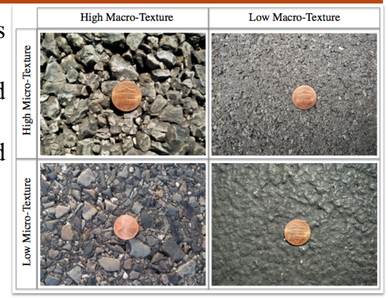
(a) LLS captured information, (b) profiles 1-mm baseline, and c) profiles 100-mm baseline

Texture parameters used for pavement texture characterization

Amplitude	
Mean Profile Depth (MPD)	$MPD = \frac{1}{2}\left[\max(h_1,..,h_{N/2}) + \max(h_{N/2+1},..,h_N)\right]$
Height Average (R_a)	$R_a = \frac{1}{N}\sum_{i=1}^{N}\lvert h_i\rvert$
Maximum Height (R_z)	$R_z = \max(h_i) - \min(h_i),\ \ i = 1..N$
Root Mean Square (RMS)	$RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N} h_i^2}$
Skewness (R_{sk})	$R_{sk} = \frac{1}{RMS^3}\sqrt{\frac{1}{N}\sum_{i=1}^{N} h_i^3}$
Kurtosis (R_{ku})	$R_{ku} = \frac{1}{RMS^4}\sqrt{\frac{1}{N}\sum_{i=1}^{N} h_i^4}$
Hybrid	
Two Points Slope Variance (SV_{2pts})	$SV_{2pts} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{h_{i+1}+h_i}{\Delta x}\right)^2}$
Six Points Slope Variance (SV_{6pts})	$SV_{6pts} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{h_{i+3}-9*h_{i+2}+45*h_{i+1}-45*h_{i-1}+9*h_{i-2}-h_{i-3}}{60*\Delta x}\right)^2}$

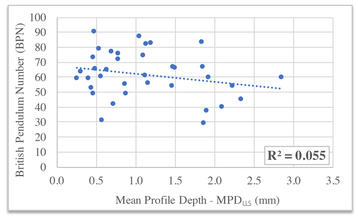
Data Collection

- Nine in-service flexible pavements around Texas
- Thirty-six different surfaces Friction and texture tests
- Broad range of friction coefficients and surface texture

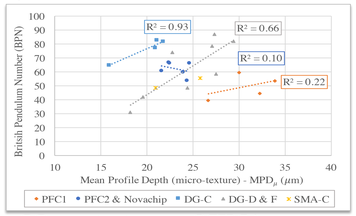


Hot mix asphalt (HMA) groups

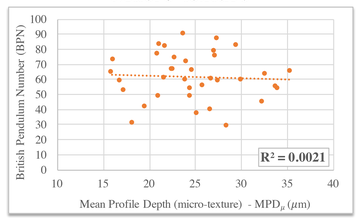
- Type 1: Porous Friction Course 2 (PFC_2) and Novachip
- Type 2: Stone matrix asphalt type C (SMA-C)
- Type 3: Dense-graded type C (DG-C)
- Type 4: Dense-graded types D and F (DG-D&F)
- Type 5: Porous Friction Course 1 (PFC_1)



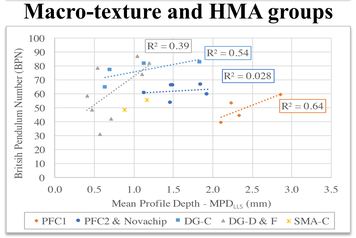
Macro-texture



Macro-texture and HMA groups



Micro-texture



Micro-texture and HMA groups

Results and Discussion

Model 1

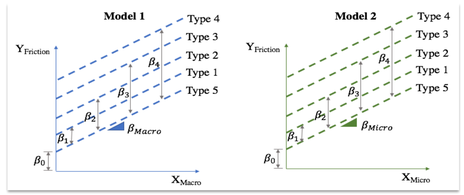
$$Y_{Fr} = \beta_0 + \beta_{Macro}X_{Macro} + \beta_1 X_{Type\,1} + \beta_2 X_{Type\,2} + \beta_3 X_{Type\,3} + \beta_4 X_{Type\,4}$$

Model 2

$$Y_{Fr} = \beta_0 + \beta_{Micro}X_{Micro} + \beta_1 X_{Type\,1} + \beta_2 X_{Type\,2} + \beta_3 X_{Type\,3} + \beta_4 X_{Type\,4}$$

Model 3

$$Y_{Fr} = \beta_0 + \beta_{Macro}X_{Macro} + \beta_{Micro}X_{Micro} + \beta_1 X_{Type\,1} + \beta_2 X_{Type\,2} + \beta_3 X_{Type\,3} + \beta_4 X_{Type\,4}$$



- The BPT measures can be modeled using the Model 3 (R_{adj}^2=0.649)
- The micro-GripTester measure can be modeled using Model 2 (R_{adj}^2=0.549)
- The DFT can be modeled using Model 3 for DFT40 (R_{adj}^2=0.830)

$Y_{Friction}$	Model		MPD β_{Macro}	MPD β_{Micro}	RMS β_{Macro}	RMS β_{Micro}
BPN	1	t-stat	2.53		1.56	
		p-value	0.021		0.136	
		R_{adj}^2	**0.357**		**0.232**	
	2	t-stat		4.40		4.54
		p-value		0.000		0.000
		R_{adj}^2	**0.579**		**0.593**	
	3	t-stat	2.14	4.00	1.26	4.26
		p-value	0.047	0.001	0.223	0.001
		R_{adj}^2	**0.649**		**0.606**	
GN	1	t-stat	1.68		0.69	
		p-value	0.111		0.498	
		R_{adj}^2	**0.339**		**0.250**	
	2	t-stat		3.47		3.64
		p-value		0.003		0.002
		R_{adj}^2	**0.549**		**0.567**	
	3	t-stat	1.01	2.99	0.09	3.42
		p-value	0.326	0.009	0.933	0.004
		R_{adj}^2	**0.549**		**0.540**	
DFT20	1	t-stat	2.61		1.61	
		p-value	0.018		0.126	
		R_{adj}^2	**0.728**		**0.672**	
	2	t-stat		3.48		3.50
		p-value		0.003		0.003
		R_{adj}^2	**0.776**		**0.777**	
	3	t-stat	3.03	2.14	1.28	3.23
		p-value	0.008	0.047	0.218	0.005
		R_{adj}^2	**0.813**		**0.785**	
DFT40	1	t-stat	2.89		1.78	
		p-value	0.010		0.092	
		R_{adj}^2	**0.682**		**0.604**	
	2	t-stat		4.40		4.52
		p-value		0.000		0.000
		R_{adj}^2	**0.775**		**0.782**	
	3	t-stat	2.62	4.10	1.57	4.28
		p-value	0.018	0.001	0.135	0.001
		R_{adj}^2	**0.830**		**0.798**	
DFT60	1	t-stat	2.80		1.71	
		p-value	0.012		0.104	
		R_{adj}^2	**0.613**		**0.523**	
	2	t-stat		4.35		4.50
		p-value		0.000		0.000
		R_{adj}^2	**0.729**		**0.739**	
	3	t-stat	2.48	4.01	1.47	4.25
		p-value	0.024	0.001	0.159	0.001
		R_{adj}^2	**0.790**		**0.755**	
Note:			|t-stat| < 1.96		p-value > 0.05	

Conclusions

- There is not a unique relationship between texture and friction
- It is important to include the surface type information when modeling friction
- The mean profile depth (MPD) was the most significant parameter for macro- and for micro-texture to explain the distinct friction measures
- A measure of micro-texture should be included into friction models based on texture