3D PAVEMENT SURFACE MACROTEXTURE: MEASUREMENTS AND FRICTION RELATIONSHIPS

Presented by
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3D Pavement Surface Macrotexture: Measurements and Friction Relationships

- Pavement Texture
- Influence of Surface Texture
- How to Measure Texture
- Image-Based Macrotexture
- Macrotexture Indicators and Tire/Pavement Friction
- Field Application
- Results and conclusions
Pavement Texture Classification

Macrotexture \((0.5 \text{ mm} \leq \lambda \leq 50 \text{ mm})\)

Microtexture \((\lambda \leq 0.5 \text{ mm})\)

Megatexture \((50 \text{ mm} \leq \lambda \leq 500 \text{ mm})\)

Roughness \((0.5 \text{ m} \leq \lambda \leq 50 \text{ m})\)
Is measuring road surface texture important?
Influence of Road Surface Texture

Texture Wavelength (m)

<table>
<thead>
<tr>
<th>$10^{-6}$</th>
<th>$10^{-5}$</th>
<th>$10^{-4}$</th>
<th>$10^{-3}$</th>
<th>$10^{-2}$</th>
<th>$10^{-1}$</th>
<th>$10^{0}$</th>
<th>$10^{1}$</th>
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<tbody>
<tr>
<td>Microtexture</td>
<td>Macrotecture</td>
<td>Megatecture</td>
<td>Roughness</td>
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<td>Pavement Friction</td>
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<td>Exterior Noise</td>
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<td>In Vehicle Noise</td>
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<td>Splash and Spray</td>
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<td>Tire wear</td>
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- Adhesion component
- Rapid air comp
- Hysteresis component
- Block impact
- Dry road surface
- Water Depth
- Wheel
- Direction of travel
- Wet road surface
- Stage 1
- Stage 2
- Stage 3
Mean Profile Depth (MPD) and Root Mean Square Roughness

Root mean square roughness

\[ \delta = \sqrt{\frac{1}{n} \sum_{i=1}^{n} z_i^2} \]

\( z_i \) = height of surface profile from the mean profile level at position \( i \),
\( n \) = number of discrete measured points along the profile length.
Power Spectrum Indicator

- The sum of power spectrum (energy) provides information about the frequency content and a better indication of the quality of the texture.

- The image-based surface is recovered in the frequency domain.

- If image specifications are standardized (dimensions of images and condition of lighting) the energy can be used as texture indicator.
Smooth versus Rough Surfaces

Recovered surface in time and frequency domains for sample A1

Recovered surface in time and frequency domains for sample E1
Measuring surface three-dimensional heights using PhotoTexture

Four images of pavement surface illuminated from tilt angles of 90°, 90°, 180°, and 270°

Digital camera: 5.1 mega pixels
12X optical zoom

System with fixed four light sources

4D recovery of the texture

Photometric stereo software used for recovering the texture information
Three-dimensional surface recovery of pavement surface

a) Pavement surface  
b) Map of heights
Relating Image-Based Macrotexture Indicators to Tire/Pavement Friction

With the support of Department of National Defence (DND), an airport runway was tested to examine the relationship between image-based macrotexture indicators and friction measurement.
### Statistical Properties

<table>
<thead>
<tr>
<th>GripTester</th>
<th>Image-Based Macrotexture</th>
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</thead>
<tbody>
<tr>
<td>Friction</td>
<td>MPD (mm)</td>
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<tr>
<td>Mean</td>
<td>0.65</td>
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<tr>
<td>Standard Deviation</td>
<td>0.02</td>
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<tr>
<td>Minimum</td>
<td>0.61</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.69</td>
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(Sample size n= 52)
Friction and texture measurements at 3m left from the centerline of the runway
Segmenting friction profile

Using CDA approach for segmenting C.L. friction profile
Segmenting friction profile

Using CDA approach for segmenting friction profiles (3m and 15m left and right)
Relationship between Surface Texture Indicator and Skid Resistance

Calculating international friction index from macrotexture according to the ASTM Standard (E1960-98)

1- Use the macrotexture measurement (TX in mm) to calculate the speed constant \( S_p \) which is used to adjust friction measurement to a common speed of 60 km/h.

\[
S_p = a + b \times TX
\]

\( a, b \) are constants depending upon the method of computing the macrotexture.

2- Adjust the friction measurement (FRS) at given speed \( S \) to the speed of 60 km/h

\[
FR_{60} = FRS \times e^{[(S-60)/S_p]}
\]

3 - Determine the calibration constants \( (A, B \text{ and } C) \)

\[
F_{60} = A + B \times FR_{60} + C \times TX
\]

For calibrating new equipments that has never been calibrated and when Griptester is used, the estimated target \( F_{60} \) and \( S_p \) could be determined by the Griptester and the texture measurements.

TX is replaced by MPD, RMSR, and MPD= a1.PSEb1
Relationship between MPD and Skid Resistance

Correlation between GripTester friction and friction estimated from MPD

\[ R^2 = 0.5211 \]

- The centreline profile data were not included in the analysis
- The probabilistic models are examined for 95% confidence interval.
Relationship between RMSR and Skid Resistance

\[ R^2 = 0.5267 \]

Correlation between GripTester friction and friction estimated from RMSR
Relationship between PSE and Skid Resistance

Correlation between GripTester friction and friction estimated from PSE

\[ R^2 = 0.5506 \]

95% prediction band

C.L. Profile

3L, 15L, 3R, and 15R Profiles
Relationship between Surface Texture Indicator and Skid Resistance

- Test of hypothesis of the constant parameters support that there is a correlation between Grip Tester friction and image-based macrotexture.
- Texture-skid resistance relationship required a wider range of textures and surface types.
Thank You