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SURF 2012

CHARACTERIZING PAVEMENT SURFACE MACROTEXTURE USING FRACTALS

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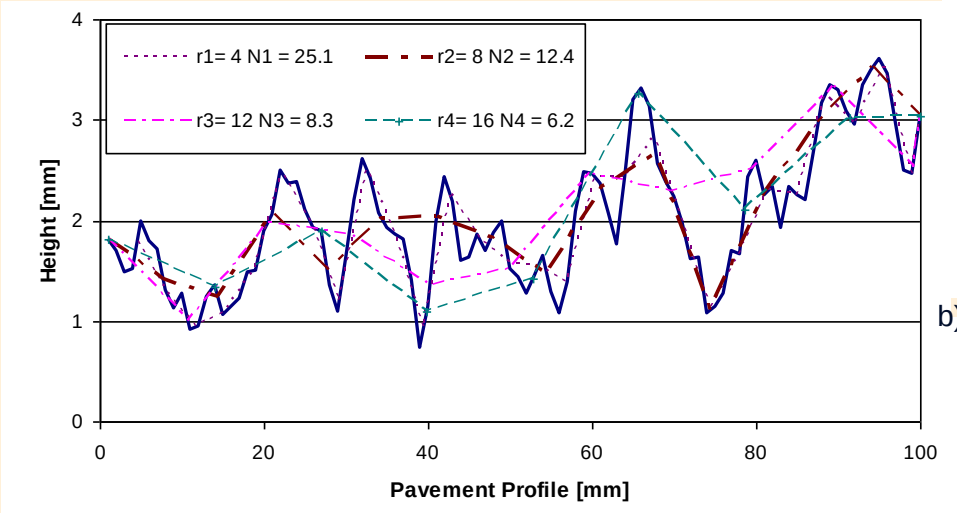
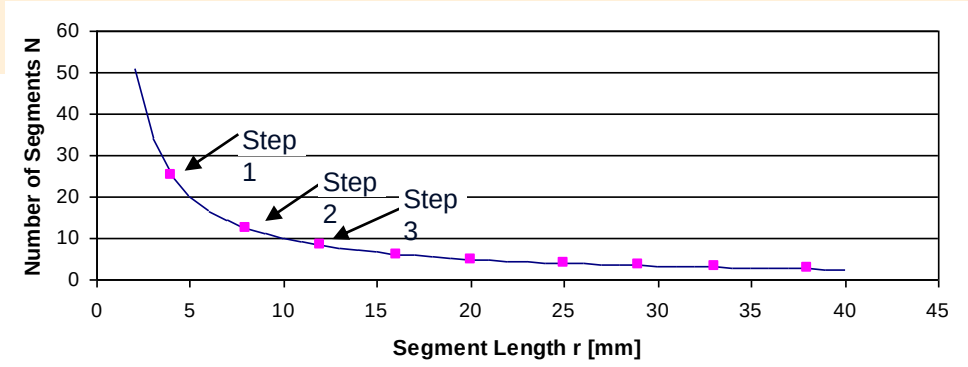
3D Pavement Surface Macrotexture: Measurements and Friction Relationships

- **Methods for computing the fractal dimension**
- **2D/ 3D Fractal**
- **Using fractal analysis to examine texture properties**
- **Field Application**
  - **Fractal Analysis of 2D Profiles**
  - **Fractal Analysis of 3D Surfaces**
- **Estimating Mean Profile Depth**
- **Results and conclusions**

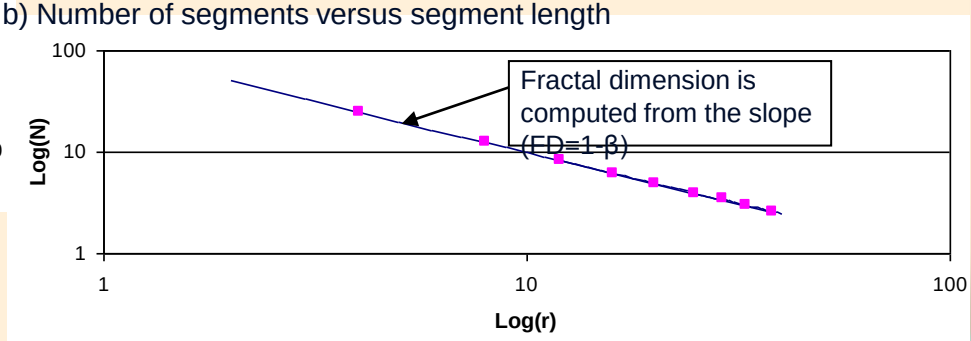
The divider method for computing the fractal dimension



a) Pavement profile measured by different segment lengths (r=4, 8, 12, and 16)

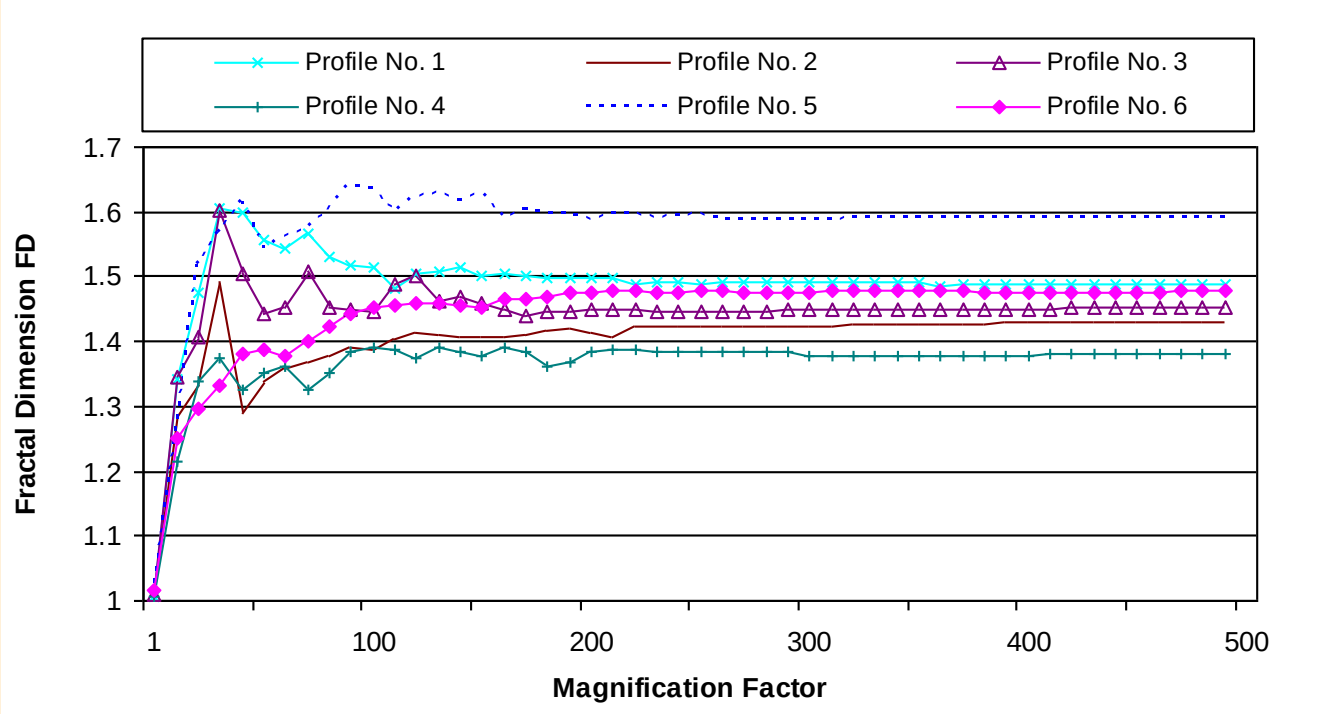


b) Number of segments versus segment length



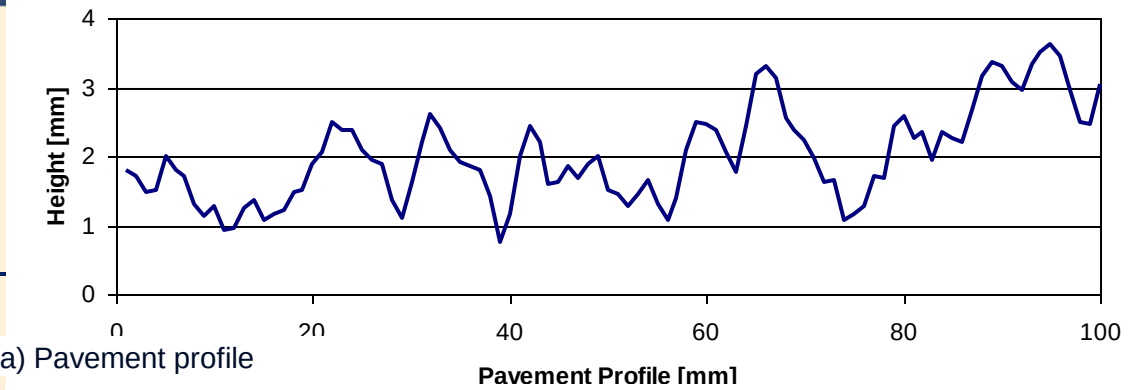
c) Number of segments versus segment length on a log-log scale

Effect of magnifying the vertical axis of pavement profiles

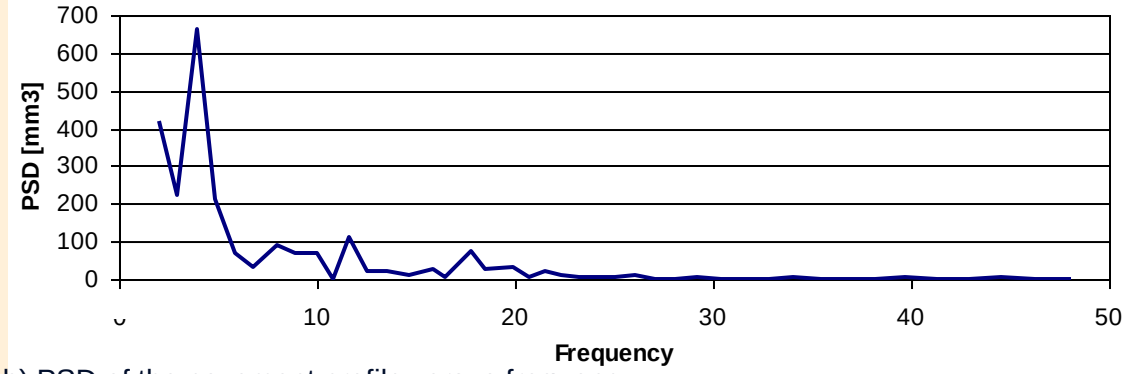


2D Fractal

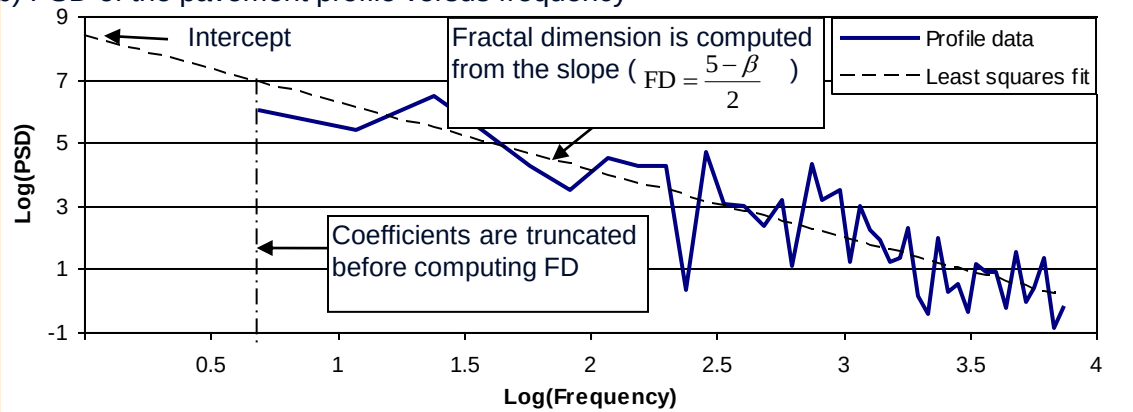
Fractal dimension of 2D profile by the power spectral density method



a) Pavement profile



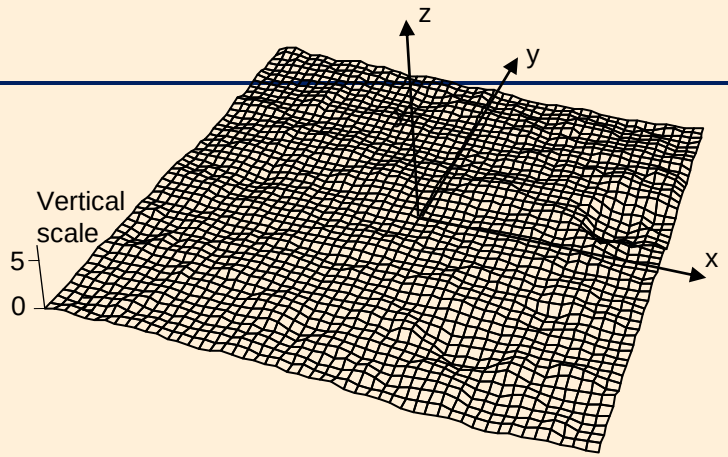
b) PSD of the pavement profile versus frequency



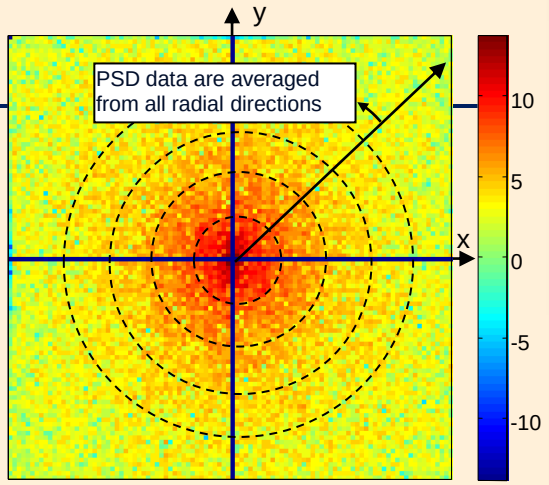
c) Log-log plot of the PSD of the pavement profile versus frequency

Fractal Dimension of 3D Surface

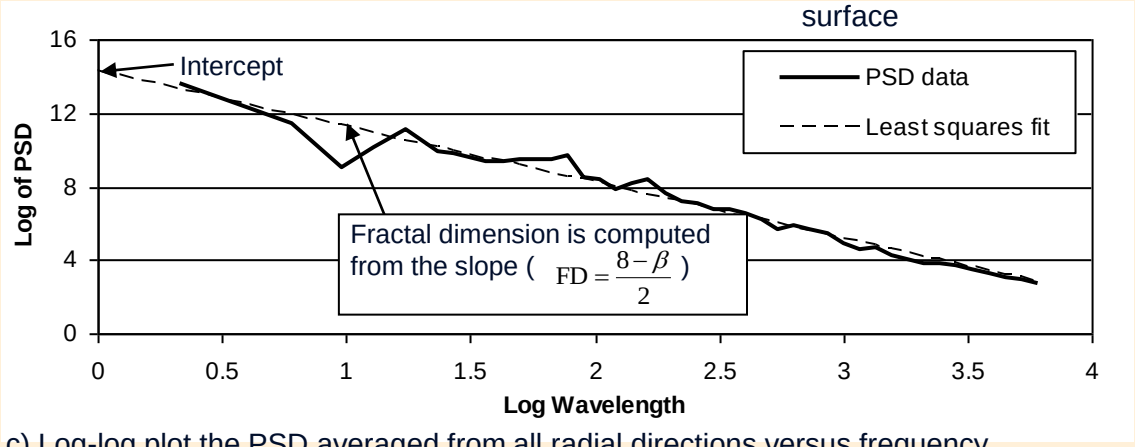
Fractal dimension of 3D surface by the power spectral density method



a) 3D recovery of pavement surface (100 mm×100 mm)

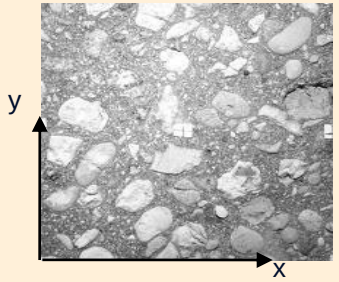


b) Fourier Transform of the pavement surface



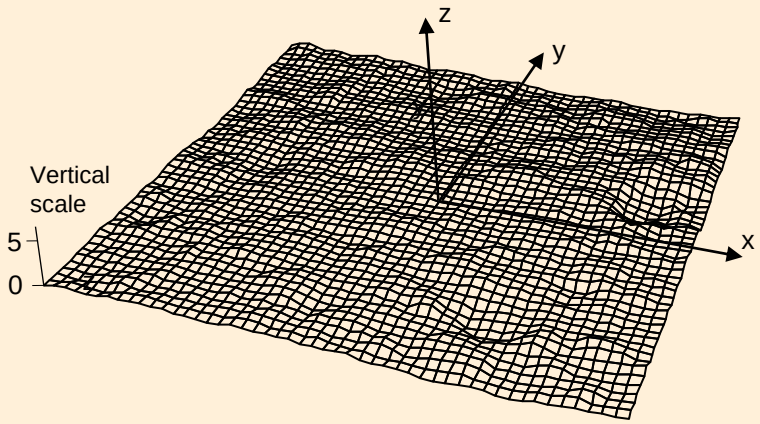
c) Log-log plot the PSD averaged from all radial directions versus frequency

Using fractal analysis to examine surface isotropy: Asphalt surface

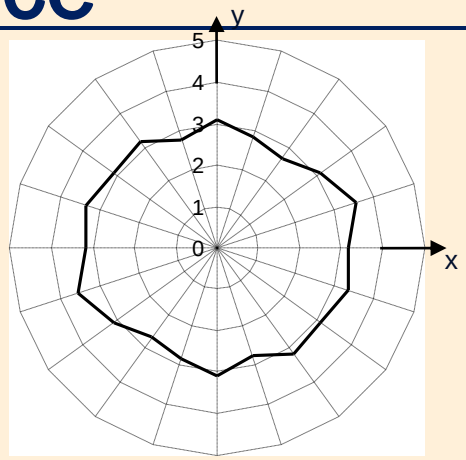


Asphalt surface

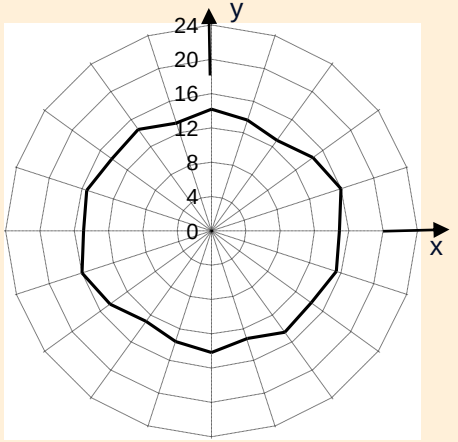
a) Surface type



b) 3D recovery (100 mm×100 mm)

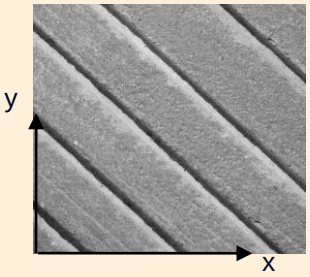


c) Slope by orientation



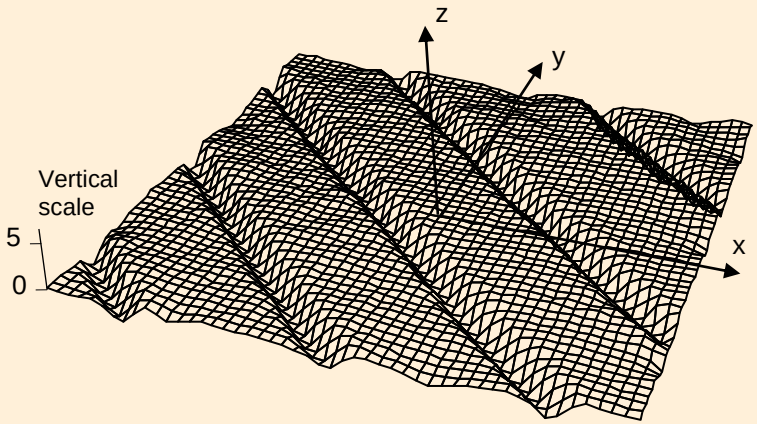
d) Log of PSD intercept by orientation

Using fractal analysis to examine surface isotropy: Tined concrete

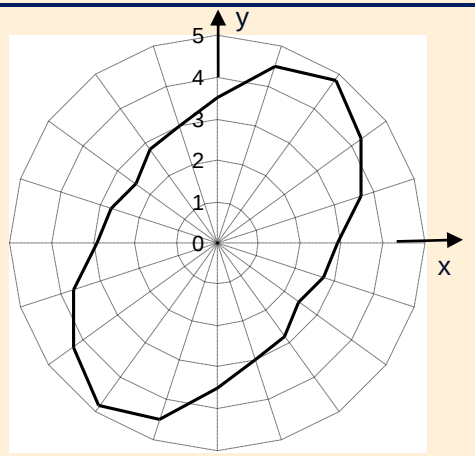


Tined concrete surface

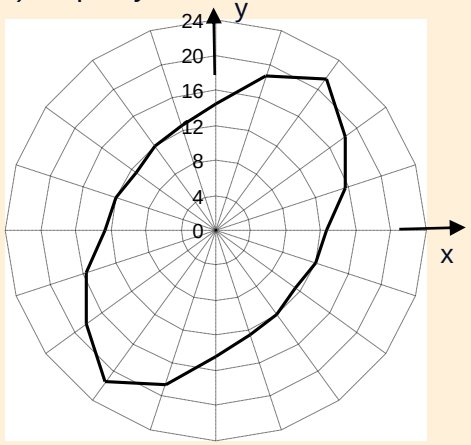
a) Surface type



b) 3D recovery (100 mm×100 mm)



c) Slope by orientation



d) Log of PSD intercept by orientation

Fractal Analysis of 2D Profiles

Descriptive Statistics (48 Profiles)

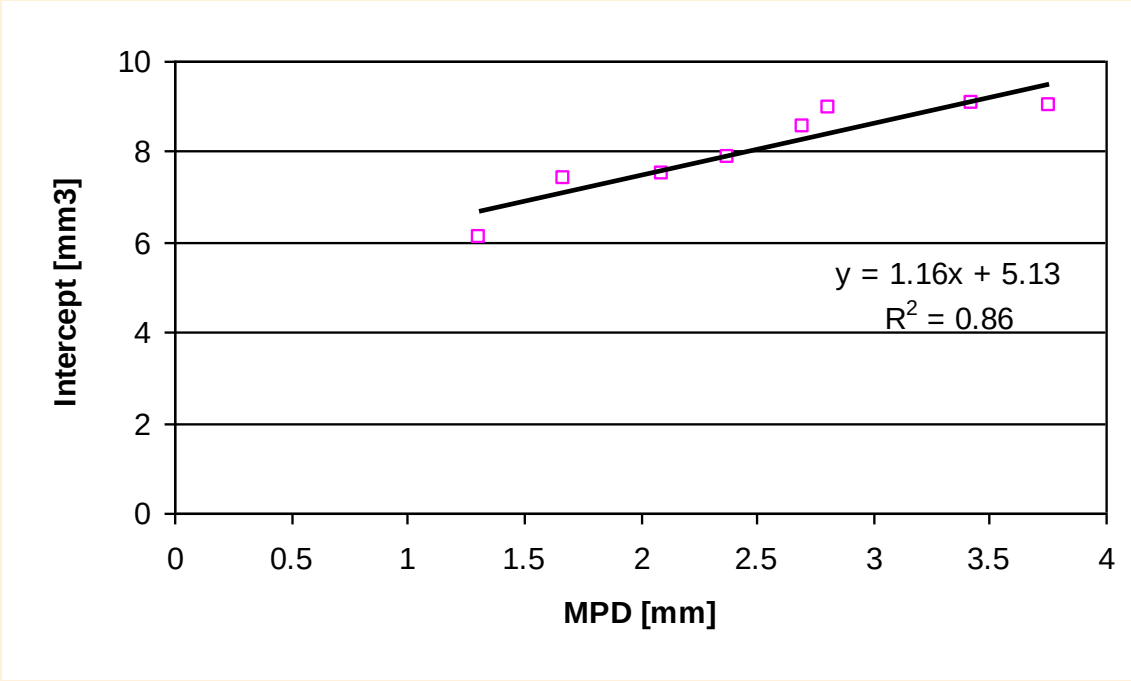
	MPD	FD_{dv}	FD_{psd}	Intercept
Mean	2.52	1.5	1.5	8.05
Standard Error	0.15	0.01	0.03	0.22
Standard Deviation	1.05	0.1	0.2	1.55
Sample Variance	1.09	0.01	0.03	2.41
Minimum value	0.58	1.3	1.0	4.21
Maximum value	5.11	1.8	1.9	11.56

Fractal analysis of 2D Profiles

Fractal analysis of 2D Profiles grouped by samples

Sample	MPD			FD_{dv}			FD_{psd}		
	Average	Min	Max	Average	Min.	Max.	Average	Min	Max
A1	1.3	0.6	3.0	1.5	1.4	1.6	1.7	1.4	1.9
A2	1.7	0.7	2.8	1.6	1.4	1.8	1.5	1.3	1.8
B1	2.1	1.6	2.5	1.5	1.3	1.7	1.5	1.3	1.8
B2	2.4	1.8	3.5	1.5	1.4	1.6	1.5	1.0	1.8
C1	2.7	2.3	3.3	1.5	1.3	1.6	1.5	1.3	1.5
C2	2.8	1.9	4.1	1.4	1.3	1.6	1.3	1.2	1.5
D1	3.4	2.5	4.0	1.5	1.4	1.5	1.4	1.1	1.7
D2	3.8	2.5	5.1	1.5	1.5	1.5	1.5	1.4	1.6

Fractal analysis of 2D Profiles



Fractal analysis of 2D Profiles grouped by samples (PSD method): Mean profile depth versus *Intercept*

Fractal Analysis of 3D Surfaces

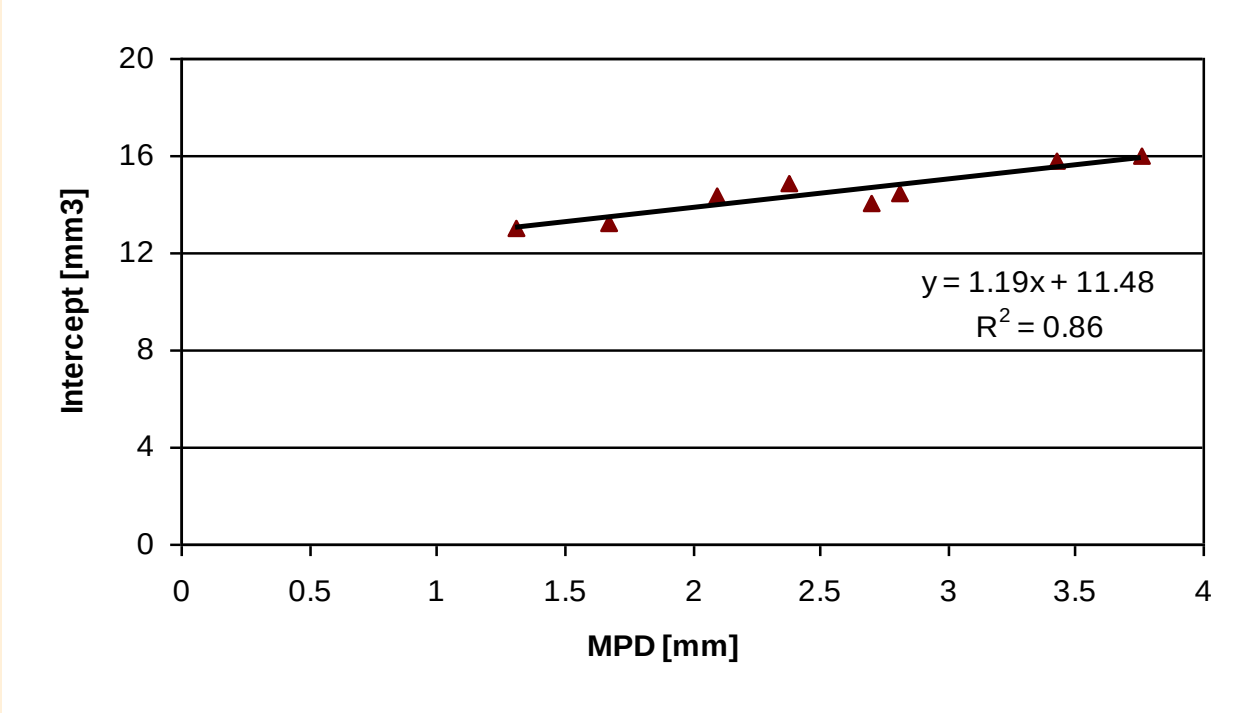
Descriptive Statistics (8 Samples)

Sample	FD_{psd}		
	Average	Min.	Max.
A1	2.7	2.6	2.9
A2	2.7	2.5	2.8
B1	2.5	2.3	2.7
B2	2.5	2.2	2.7
C1	2.8	2.6	2.9
C2	2.8	2.5	3.0
D1	2.5	2.2	2.7
D2	2.5	2.3	2.7

Fractal dimension of the 3D surface

	FD_{psd}	Intercept
Mean	2.6	14.47
Standard Error	0.04	0.38
Standard Deviation	0.12	1.07
Sample Variance	0.01	1.14
Minimum	2.5	12.99
Maximum	2.8	15.95

Fractal Analysis of 3D Surfaces



Fractal analysis of the 3D surfaces: Mean profile depth versus *Intercept*

Estimating Mean Profile Depth

$$MPD = 0.73 Intercept_T + 1.32 - 4.69 D_T$$

$$SSE = \sum (MPD_e - MPD)^2$$

The sum of squared errors (SSE) for estimating MPD from 2D profiles is 0.68 [mm] while for estimating MPD from 3D surface is 0.71 [mm].

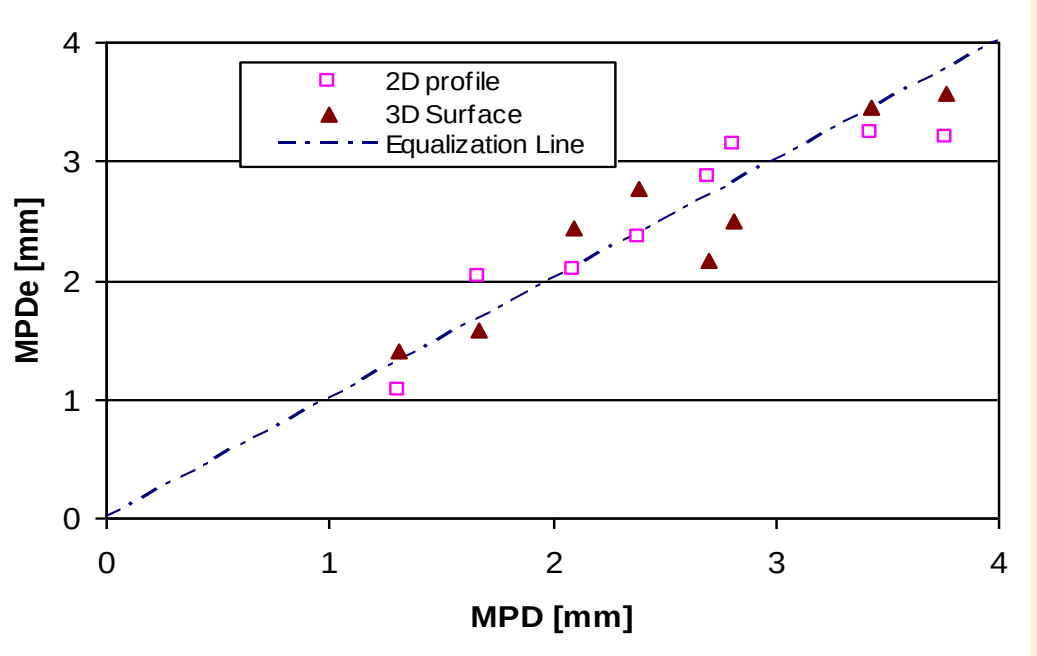


FIGURE 8 Estimating Mean Profile Depth using *Intercept*

Summary and Conclusions

- Two methods for computing fractal dimension of pavement surface texture have been presented; the divider method (DV) and the power spectral density method (PSD
- The concept of utilizing the fractal analysis as a measure of pavement surface texture has been presented.
- *Intercept* is found to be a scale parameter independent of fractal dimension that can be used to characterize pavement macrotexture.
- *Intercept* yields a reasonable estimation of the mean profile depth.

Summary and Conclusions

- **The PSD method could reveal information about directionality, roughness, and friction properties of pavement surface.**
- **The fractal analysis should not be seen as a replacement of the current methods.**
- **The fractal analysis can potentially describe the complexities of pavement surface texture.**
- **It contributes to a higher understanding of the texture roughness and provides both crosscheck and a basis for further applications.**

Thank You