Influence of texture properties

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The ROSANNE project was funded in the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n°[illegible]

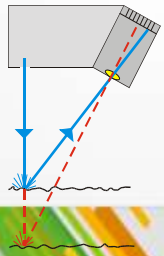
Why talk about texture?

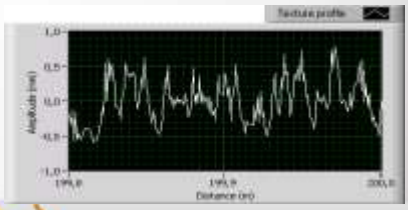
Measuring pavement properties, skid resistance, acoustic quality and rolling resistance:

- Cumbersome measurements
- Constant measurement speed
- Generally: dedicated, expensive, complicated and delicate equipment

Texture measurements

- Texture in macro- and megatexture range can be relatively simply, fastly and reliably measured
- At any speed (up to what the equipment allows)





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WP4 – DoW

Task 4.1: Influence of texture properties and common descriptors

- What is the current "State of the Art" concerning texture influence on skid resistance, noise emission and rolling resistance?
- What is the use of enveloping of texture profile curves? And how can it be improved?
- Do 3D measuring devices yield a significant advantage over traditional 2D devices?
- Which road surface texture descriptors can be used to assess skid resistance, noise and rolling resistance?
- Is it feasible to complement or replace measurement of these performance parameters with texture measurements and suitable models?

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Enveloping

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Enveloping: von Meier et al method (1992)

- Principle: reducing the second derivative (smoothening) the profile with an iterative procedure
- d* = second derivative and is measure for "elasticity" of the tyre rubber
- The authors propose: d* = 0,054 m-1

Der Einfluß von Textur und Schallabsorption auf den Verkehrslärm auf Drainasphalt

A. van Meier, G. J. van Blokland, G. Descornet,
M+P raadgevende ingenieurs B.V., Antwerpse Nederland
Centre des Recherches Routières, Bruxelles, Belgique

Kurzfassung

Der Beitrag berichtet über Verkehrslärmmessungen auf verschiedenen Drainasphaltdecken. Diese Messungen zeigen, dass die Verkehrslärmpegel auf Drainasphalt nicht immer niedriger sind als auf dichten Asphaltdecken. Einige Drainasphalte verursachen sogar mehr Lärm und zwar bei niedrigen Fahrzeuggeschwindigkeiten. Diese Beobachtungen werden durch die Annahme von zwei Mechanismen erklärt:
- ein durch Textur induzierter Effekt, der dazu führt, dass die Lärmpegel zunehmen, wenn die Texturamplitude in einem gewissen Wellenlängenbereich der Textur zunimmt und
- ein durch Schallabsorption induzierter Effekt, der zur Folge hat, dass die Lärmpegel abnehmen, wenn die Schallabsorption in einem für den Verkehrslärm relevanten Frequenzbereich zunimmt.

Der Entwurf von lärmmindernden Straßendecken sollte infolgedessen darauf abzielen, den ersten Effekt zu minimieren und den zweiten zu maximieren. Der Beitrag beschreibt ferner, welche Material- und Naturoberflächenparameter für diese Effekte verantwortlich sind, wie sie gemessen, kontrolliert und optimiert werden können. Auf das Problem der Texturmessung von porösen Straßendecken wird besonders eingegangen.

The influence of texture and sound absorption on the noise of porous road surfaces

A. van Meier, G. J. van Blokland, G. Descornet,
M+P raadgevende ingenieurs B.V., Antwerpse Nederland,
Centre des Recherches Routières, Bruxelles, Belgique

Abstract

The paper reports on measurements on a number of different porous asphalt road surfaces which show that traffic noise levels are not always lower than on dense asphalt surfaces. Some are even noisier, in particular at low vehicle speeds. These observations are explained by assuming two basic mechanisms:

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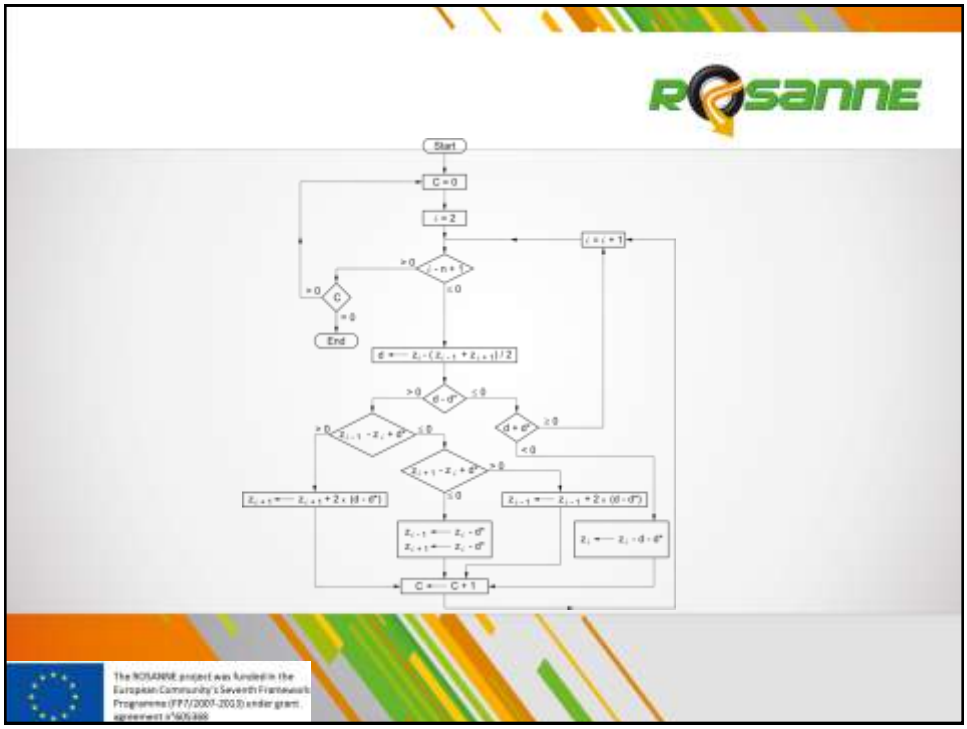

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Research questions

- Is the Von Meier method able to yield a reasonable approximation of the enveloping curve of a texture profile?
- If yes, what would be a good value for d*?

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BRRC experiment

- Two “easy” surfaces: one with a pronounced positive and one with a negative texture
- Measurement of original profile with profilometer
- Filling voids with suitable plastic, non sticking material
- Drive over with real car tyre and fixing enveloping surface
- Measuring enveloping curve with profilometer




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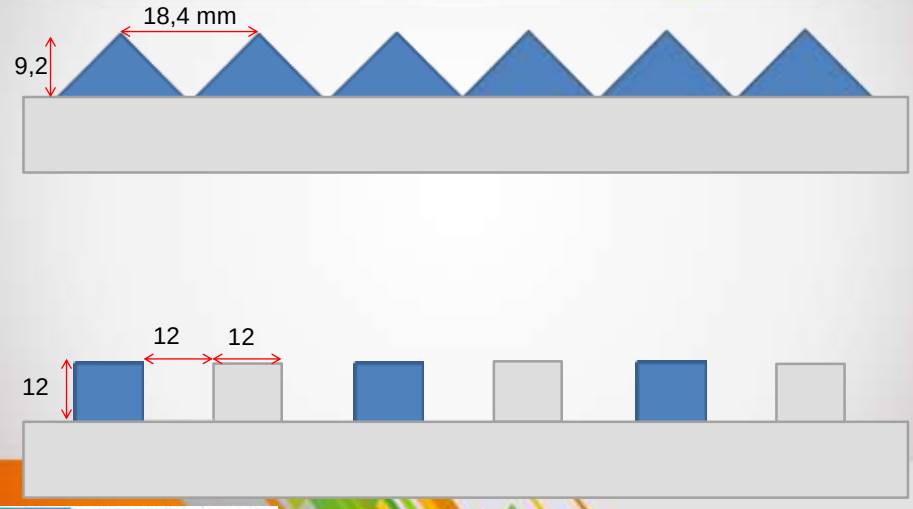
Used profiles



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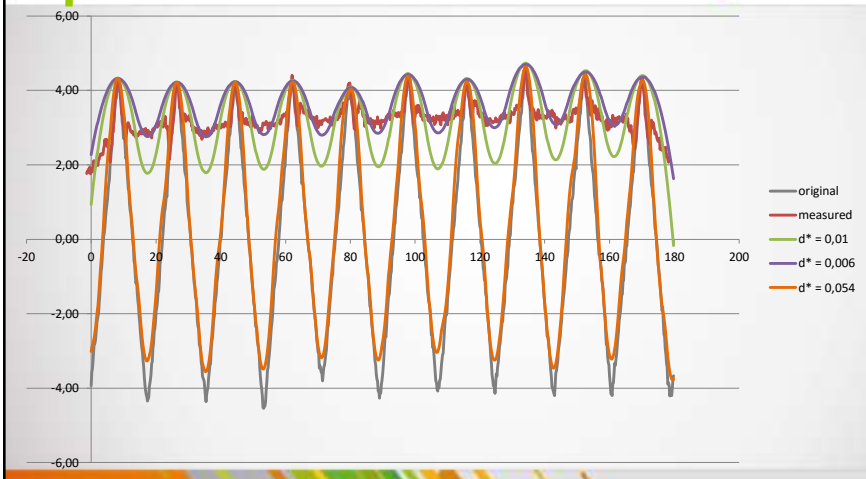
Measured and calculated profiles



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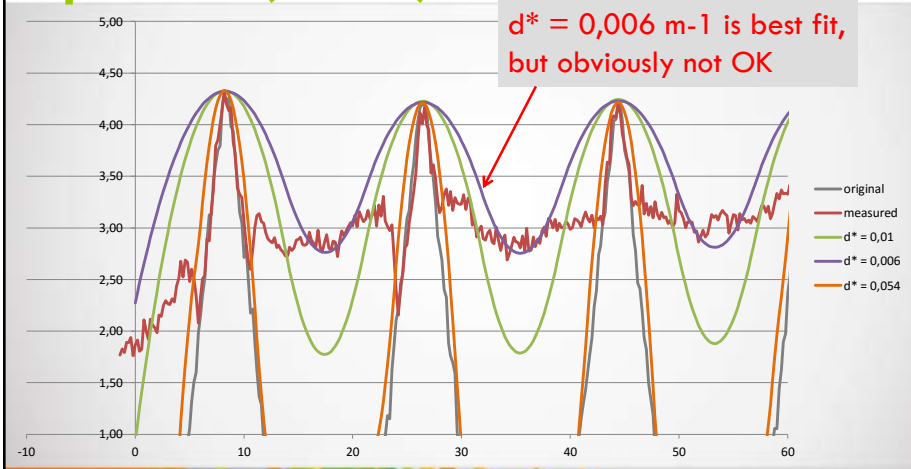
Measured and calculated profiles (detail)



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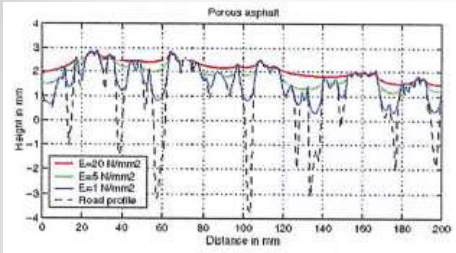
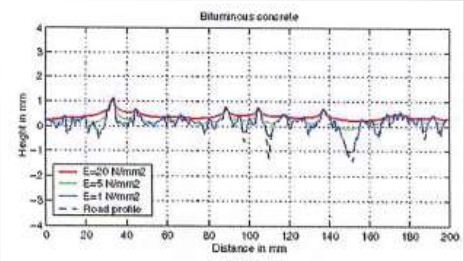
Enveloping procedure Hamet & Klein





J.-F. Hamet & P. Klein, "Road texture and tire noise", INTERNOISE 2000, Nice, August 2000

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Enveloping procedure Hamet & Klein

- the tire itself (vibration behaviour),
- the tire road mechanical interaction,.
- the acoustic radiation of the tire including the horn effect.

The tire is characterised by its Green's function $G(\underline{x}\backslash\underline{\xi},t\backslash\tau)$ giving at time t the tread displacement $z_{tread}(\underline{x},t)$ produced at point $\underline{x}$ by the pressure $F'(\underline{\xi},\tau)$ which was applied at time τ at point $\underline{\xi}$

$$z_{tread}(\underline{x},t) = \int\int\int F'(\underline{\xi},\tau)\, G(\underline{x}\backslash\underline{\xi},t\backslash\tau)\, d\underline{\xi}d\tau$$

The model is linear and three dimensional.
Due to the non linearity of the contact, the interaction must be worked out in the time domain, not in the frequency domain as it is usual in acoustics. The mechanical interaction between the tire and the road is performed through the tread gum, modelled here by a local stiffness s_e. A contact pressure is generated when the gum is compressed:

$$F'(\underline{x},t) = s_e \Delta h(\underline{x},t)\, H(\Delta h < 0)$$

where

$$\Delta h(\underline{x},t) = h_{tread}(\underline{x},t) - h_{road}(\underline{x},t)$$

J.-F. Hamet & P. Klein, "Road texture and tire noise", INTERNOISE 2000, Nice, August 2000

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New enveloping algorithm

- Proposal: "indentor" algorithm:
  - we let a defined area of the 2D profile "indent" into the rubber of the tyre
  - For the points which are indented in the rubber (the peak areas of the profile):

    y(enveloped profile) = y(original profile)
  - For the points which are not indented in the rubber (the valley areas of the profile):

    y(enveloped profile) = y(interpolated between the nearest remaining points of the original profile)

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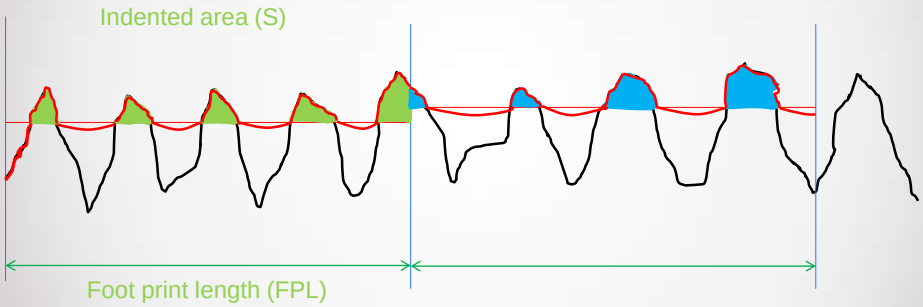
New enveloping algorithm: principle



(before the calculation of the area S for each footprint, the slope is suppressed by subtraction of the regression line (not shown here))

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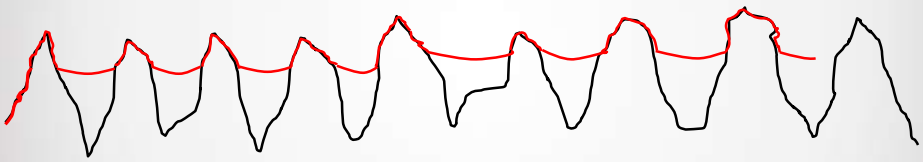
New enveloping algorithm:principle



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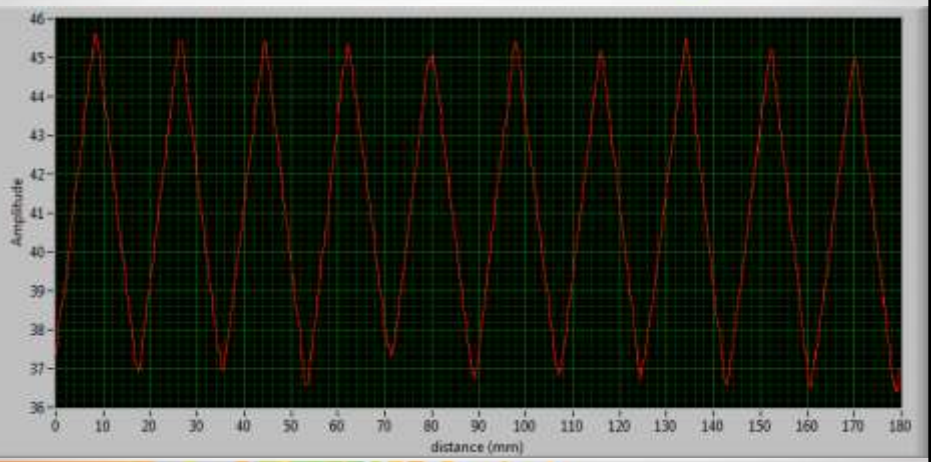
Triangular profile



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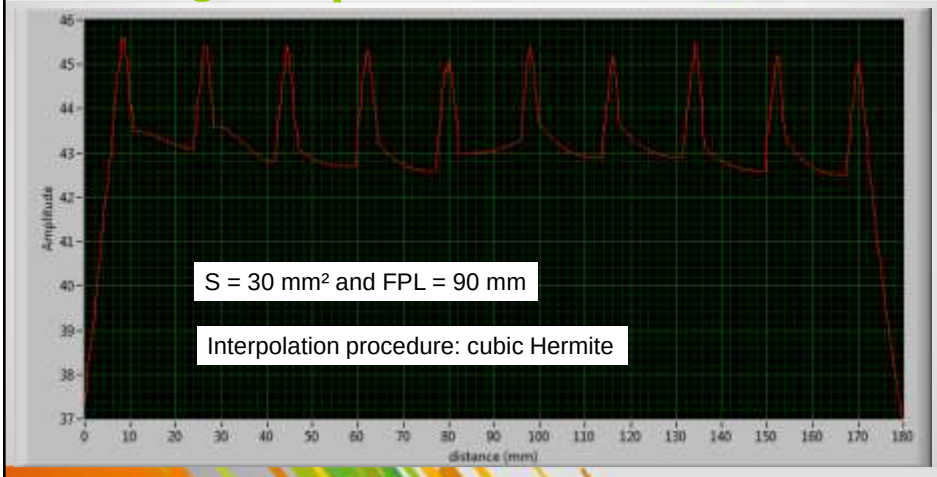
New algorithm on triangular profile



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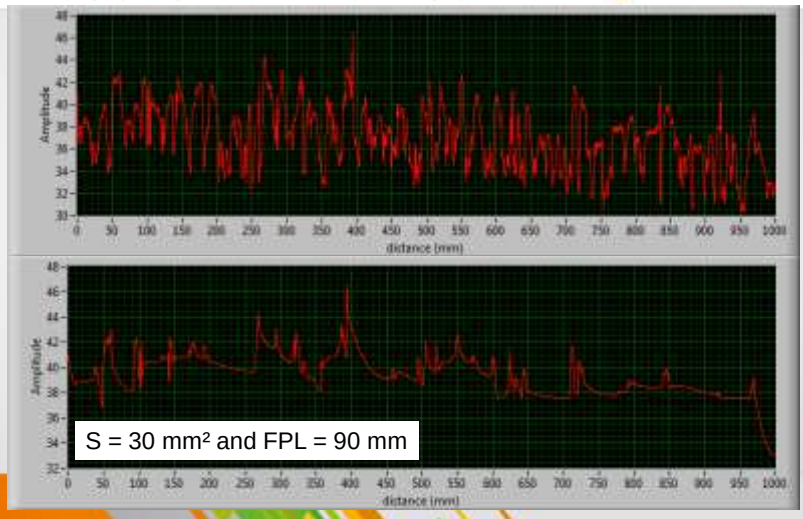
Real road surface: C2-section in Nantes



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Calibration of the indentor enveloping

Overriding with SRTT, mounted in CPX

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Calibration of the indentor enveloping

OK, but unwanted traces of sipes

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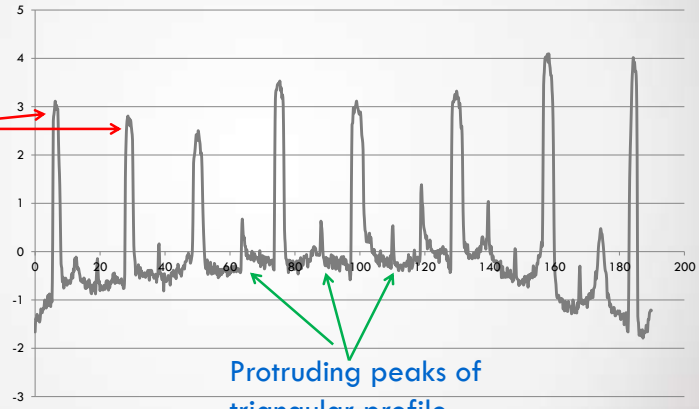
Calibration of the indentor enveloping

OK, but unwanted traces of sipes



Protruding peaks of triangular profile

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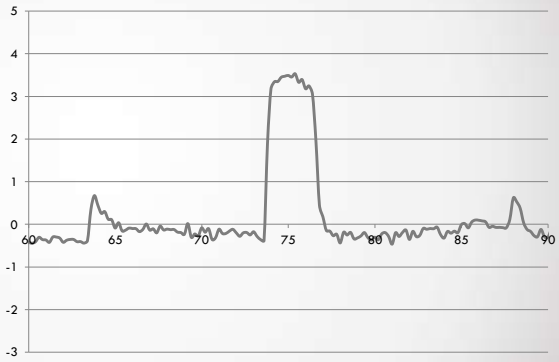
Calibration of the indentor enveloping

For P1 tyre:

$S \approx 6\ mm^2$



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Enveloping and rolling resistance

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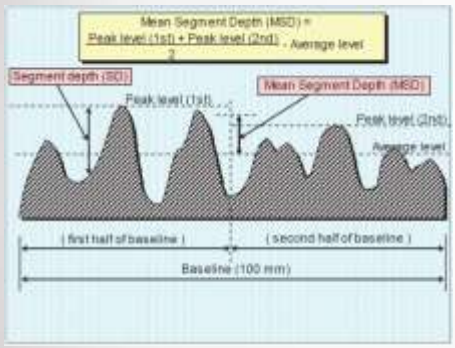
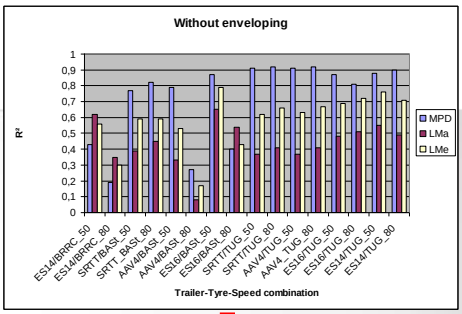
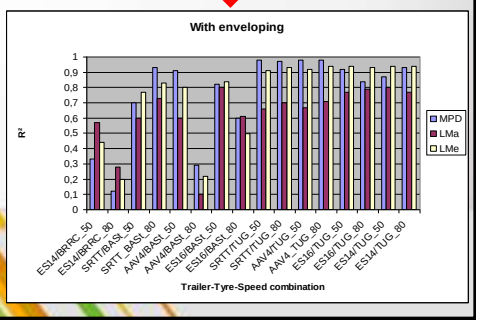
RRC and Lme, Lma and MPD



(source: MIRIAM 2011)





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IFSTTAR test tracks

Test track	Length (m)	MPD (mm)
A	214.40	1.27
A'	47.00	3.40
C1	139.00	0.36
C2	96.40	4.19
E1	245.00	0.94
E2	240.00	1.16
F	238.00	1.56
L1	124.00	0.14
L2	112.00	0.81
M1	223.00	1.44
M2	144.40	1.27
N	184.00	0.41

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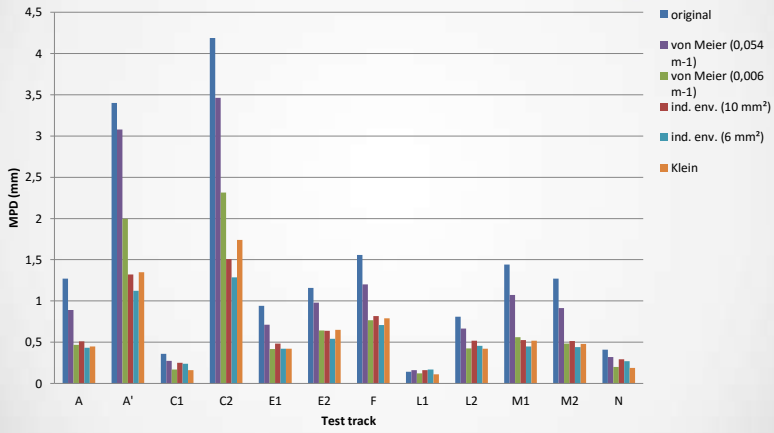
MPD versus different enveloping procedures



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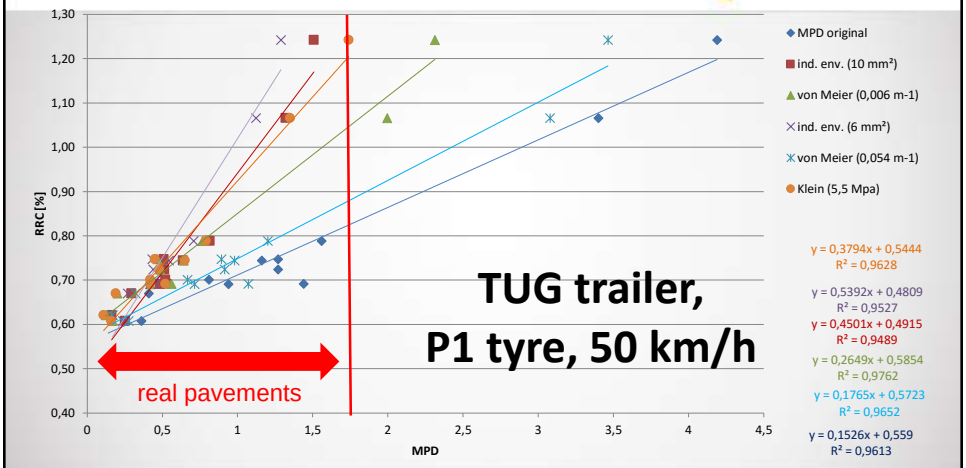
RRC versus MPD



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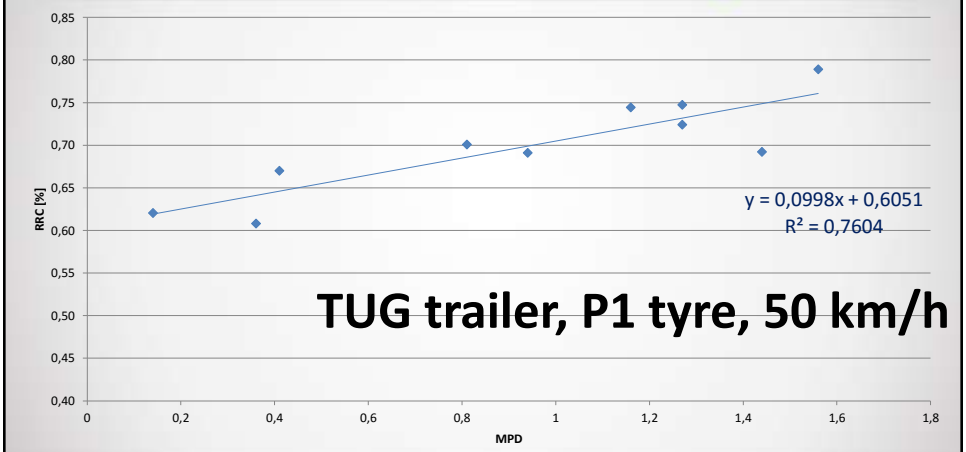
RRC versus MPD (original)



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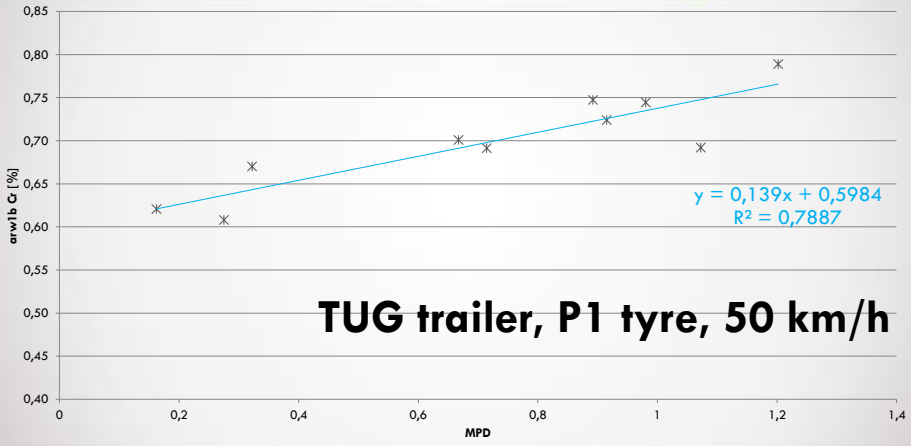
30

RRC versus MPD (von Meier d* = 0,054 m-1)



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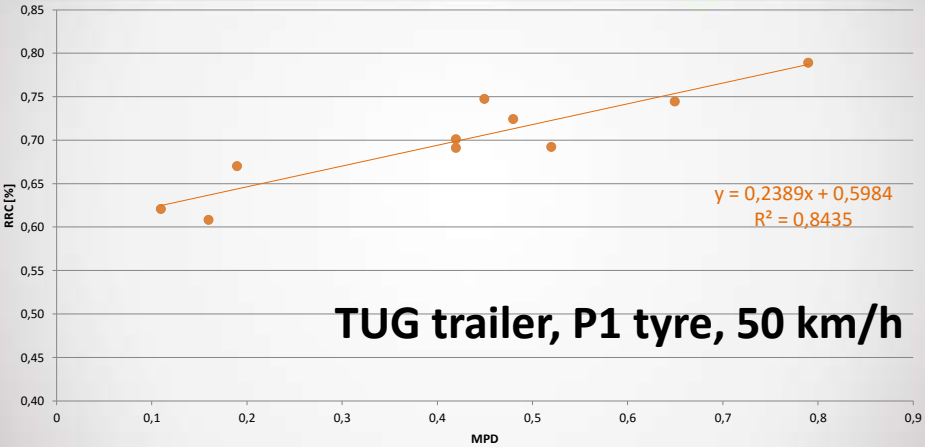
RRC versus MPD (Hamet & Klein)



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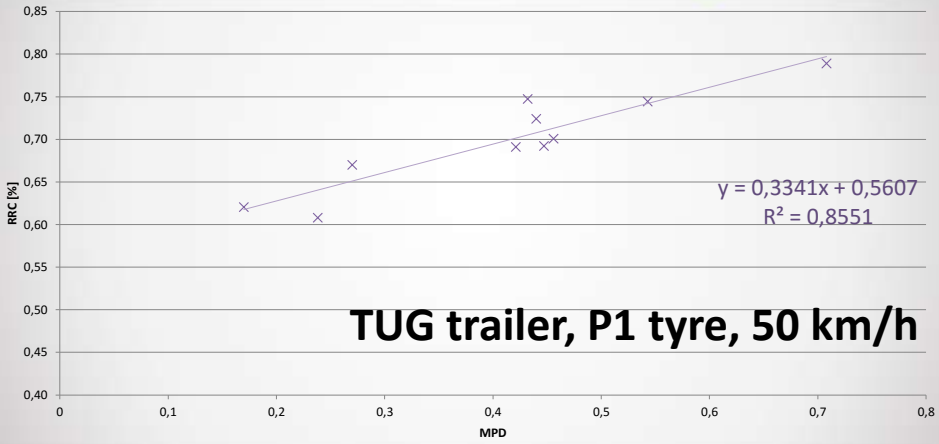
32

RRC versus MPD (indentor with S = 6 mm²)



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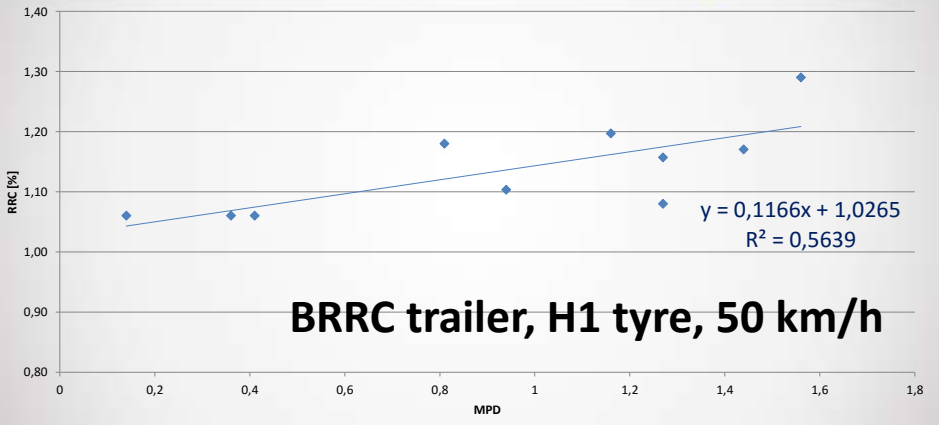
33

RRC versus MPD (original)



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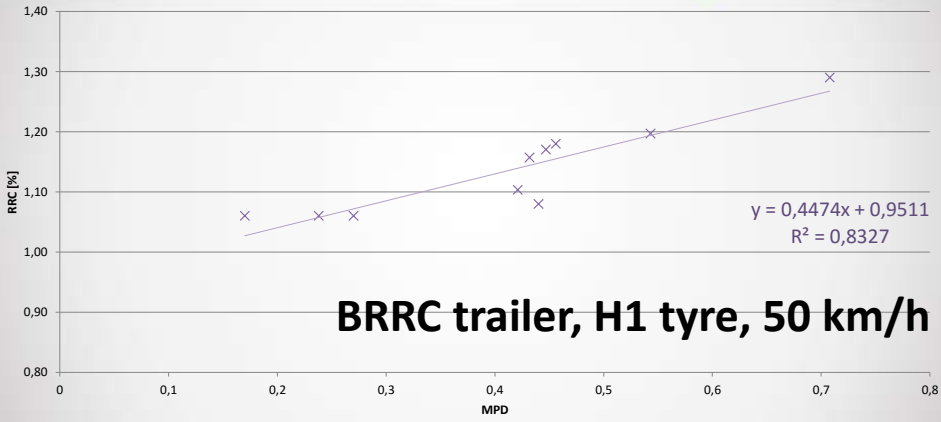
34

RRC versus MPD (indentor with S = 6 mm²)



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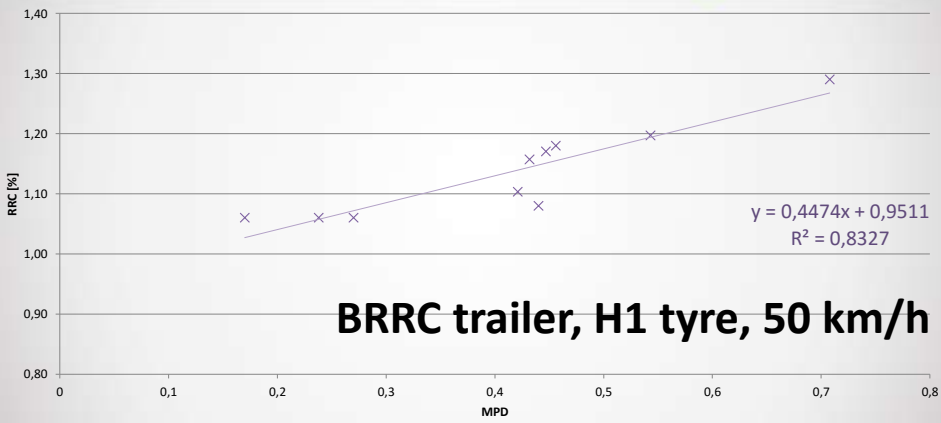
35

RRC versus MPD (indentor with S = 6 mm²)



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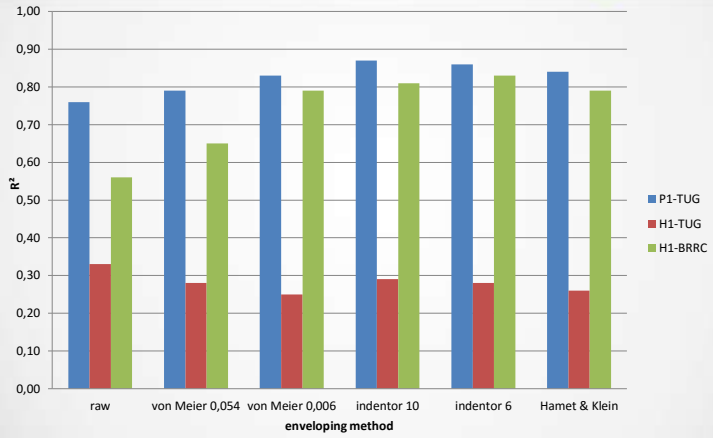
36

R² for RRC versus MPD (50 km/h)



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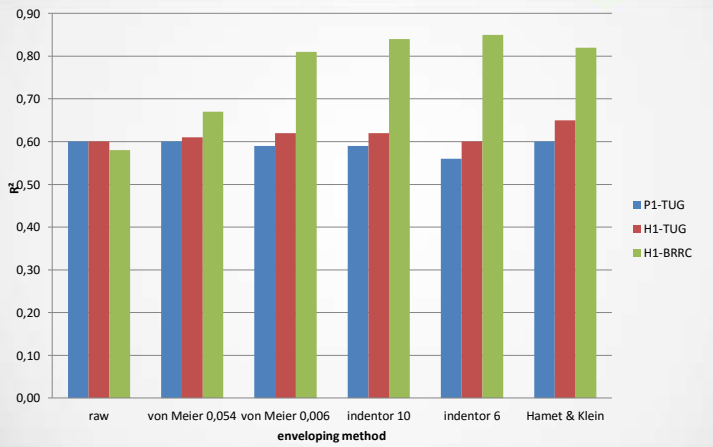
37

R² for RRC versus MPD (80 km/h)



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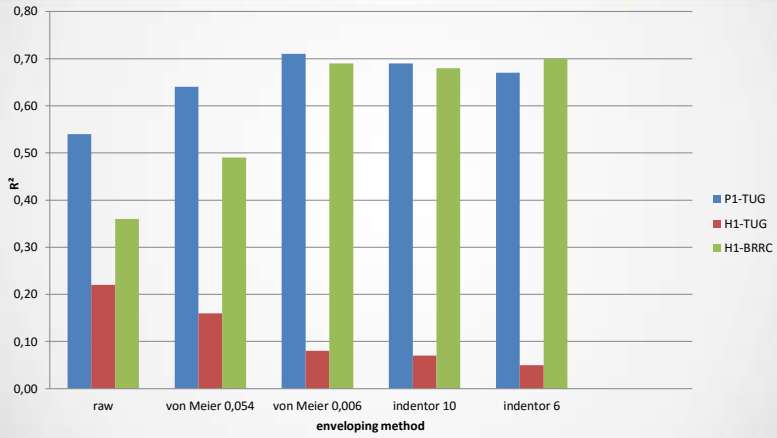
R² for RRC versus LMe (50 km/h)



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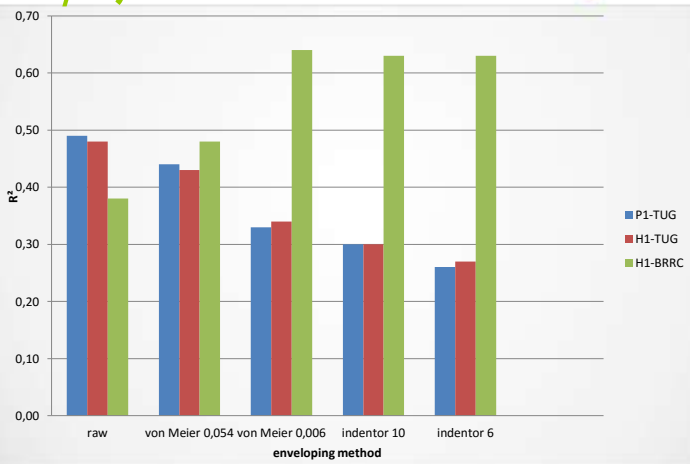
39

R² for RRC versus LMe (80 km/h)



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2D/3D devices

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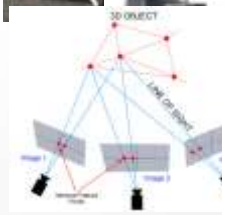
2D/3D Devices



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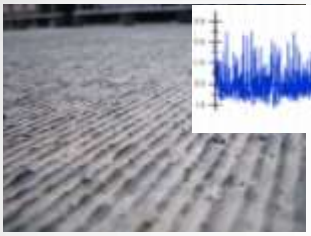
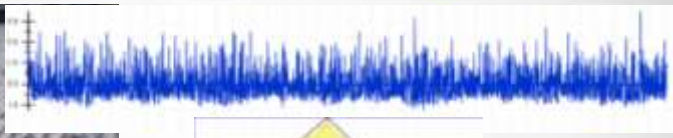
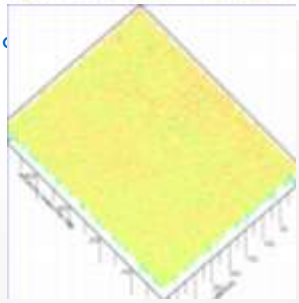
Benefits of 3D





The high amount of data acquired with one measurement leads to a higly statistical significance



amount of data (measured in a few seconds)
40120 (2D) / 1310720 (3D)

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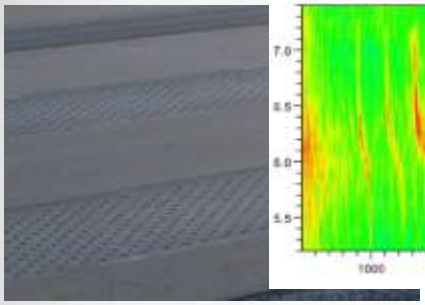
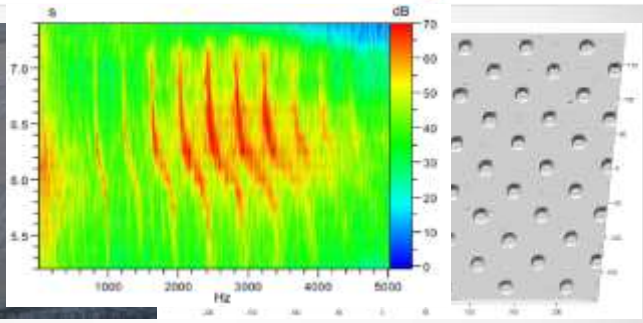
Benefits of 3D





Polished mastic asphalt with drilled holes to isolate the flow-induced noise effects

Resulting noise

Texture measurement

Nearly impossible to calculate from single „texture line“ values, but a 3D representation allows a (time consuming) computational calculation

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Texture and skid resistance

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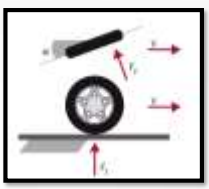
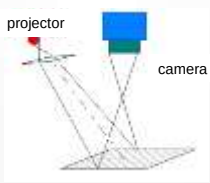
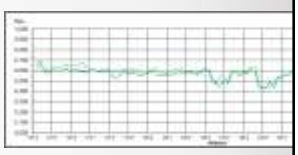
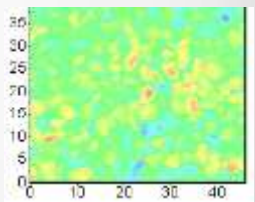
device





measuring principle





measuring result

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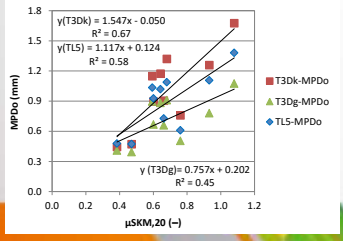
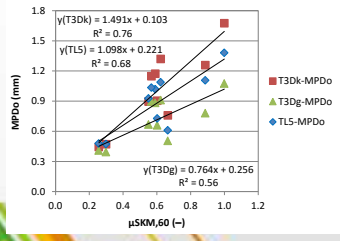
T3Dg
3D-device with a big measuring field, but a relative low resolution (~ 0,04 mm)

TL 5
only 2-D device but medium resolution (~0,001 mm, Spot size ~0,1 mm)





T3Dk
small 3D-device with a high resolution (~ 0,001 mm)

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Skid resistance and MPD

	texture measuring device					
	T3Dg		T3Dk		TL5	
	y = x	R^2	y = x	R^2	y = x	R^2
	(2) Correlation MPD = μSKM,v					
v = 20km/h	0.757x+0.202	0.45	1.547x-0.050	0.67	1.117x+0.124	0.58
v = 40km/h	0.724x+0.249	0.52	1.429x+0.079	0.73	1.048x+0.207	0.64
v = 50km/h	0.749x+0.261	0.56	1.453x+0.119	0.76	1.070x+0.233	0.68
v = 60km/h	0.764x+0.256	0.56	1.491x+0.103	0.76	1.098x+0.221	0.68
v = 80km/h	0.855x+0.231	0.62	1.633x+0.073	0.81	1.214x+0.192	0.74

higher speed (SKM)

lowest resolution

highest resolution

medium resolution

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Conclusions (enveloping)

- The existing "simple" enveloping method of von Meier e.a. does not yield a realistic enveloping profile
- The d* parameter proposed by the authors is not representative for the P1 tyre (a realistic value has been determined in ROSANNE)
- A simple and suitable for standardization enveloping "indentor" enveloping method has been proposed, yielding realistic enveloped profiles (close to result very sophisticated Hamet & Klein method)
- Correlation of RRC for P1 and H1 tyres with MPD improves in some cases significantly with the new enveloping procedure, up to excellent R^2
- "performance" of indentor enveloping appears comparable with sophisticated Hamet & Klein method
- But in some cases enveloping doesn't work

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Conclusions (3D and skid resistance)

- 3D measurements are necessary for assessing the texture influence on noise in the case of anisotropic pavements
- Regarding the correlation skid resistance and MPD: it gets better with a higher resolution (regardless 2D or 3D)

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ROSANNE

Thanks for your attention!

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