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-Glas/Keramik- GmbH

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Kompetenz für
Ihre Innovation

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Reference Materials

Current problems, the potential of new materials and recommendations

focused on the CEN/TS 16516:16
“Determination of slip resistance of pedestrian surfaces –Methods of evaluation “

M. Engels
08.06.2018
UKSRG Meeting Derbyshire

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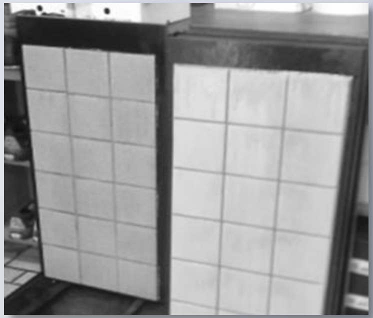
Ihre Innovation

Basis for the presented results

Cooperation Project
“**Development of durable reference systems as basis for capable slip risk measurements using an integrated evaluation of the interactions between sole construction and surface characteristics** (2015 – 2018)“



with the Testing and Research Institute PFI Pirmasens:

- Designed durable reference surfaces with specified slip settings

- A standardised laboratory wear simulation, validated with results from wear in use and including application based gradings of wear (Wear classes)

Topics

- **Introduction**
- **The potential of topography measurements**
- **The durability aspect**
- **Topography and slip resistance measurement**
- **Performance of reference materials**
  - Fit for purpose?
  - Adequate durability and stability?
- **The potential of new and alternative materials**
  - The SlipSTD basis
  - Commercially available materials
  - Surfaces with alternative materials

    Prototype results
- **Summary/Recommendations for CEN/TS 16165**

UKSRG:

special Focus on Pendulum

Introduction

Important aspects regarding reference surfaces[1]

- **Certified references** (CRM, certified value, high confidence level) or **working level reference** (RM, sufficiently homogeneous, specified tolerances)?
- Defined **"fitness for purpose"**, covering the **measurement range of the method**
- Adequate **durability and stability** over time of products and materials
- Specified **reliability and reproducibility,** established by inter-laboratory testing (round robin/proficiency testing)
- Sufficient **availability** of products or materials

[1] The selection and Use of Reference Materials, European Accreditation EA-4/14 Inf: 2003

The potential of topography measurements

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Results on the basis of the SlipSTD Project

- **non-contact, optical 3D-measurement** to measure and objectively evaluate smooth , micro and macro rough, structured and profiled surfaces
- Slip STD and ongoing research: surface parameters to **differentiate between and explain the slip resistance characteristics** of different hard flooring surfaces and their change in use (wear)
- Assessment of the **suitability and comparability of the methods** on topographically different surfaces

SLIP STD standard surfaces for a safer environment

The potential of topography measurements

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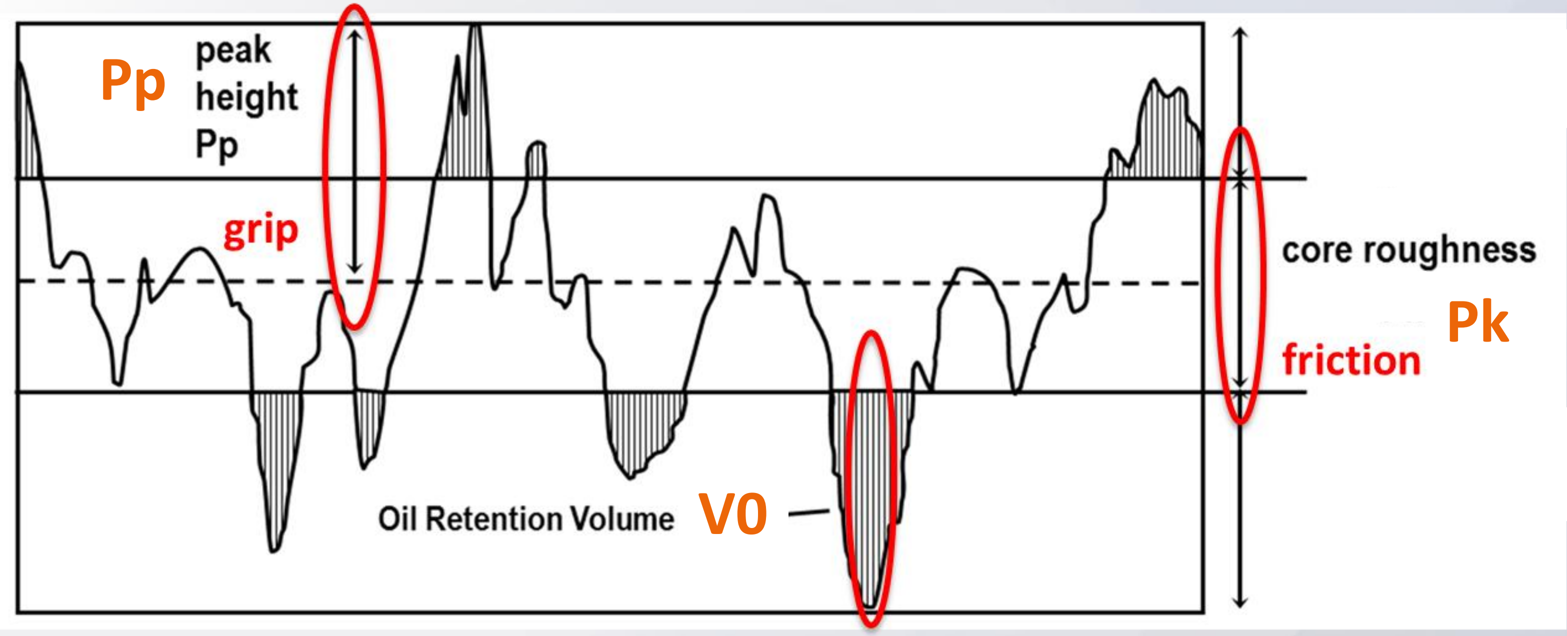

- **Pk** the core roughness of the profile, indicating the friction aspect[2]
- **Pp** height of the highest peak from the mean line, defining the "grip"
- **V0** oil retention volume, "suction" effect on smooth surfaces
- **Psk** skewness/asymmetry of the height distribution,

[2] Primary parameter of the Material Ratio Curve acc. to DIN EN ISO 13565

The potential of topography measurements

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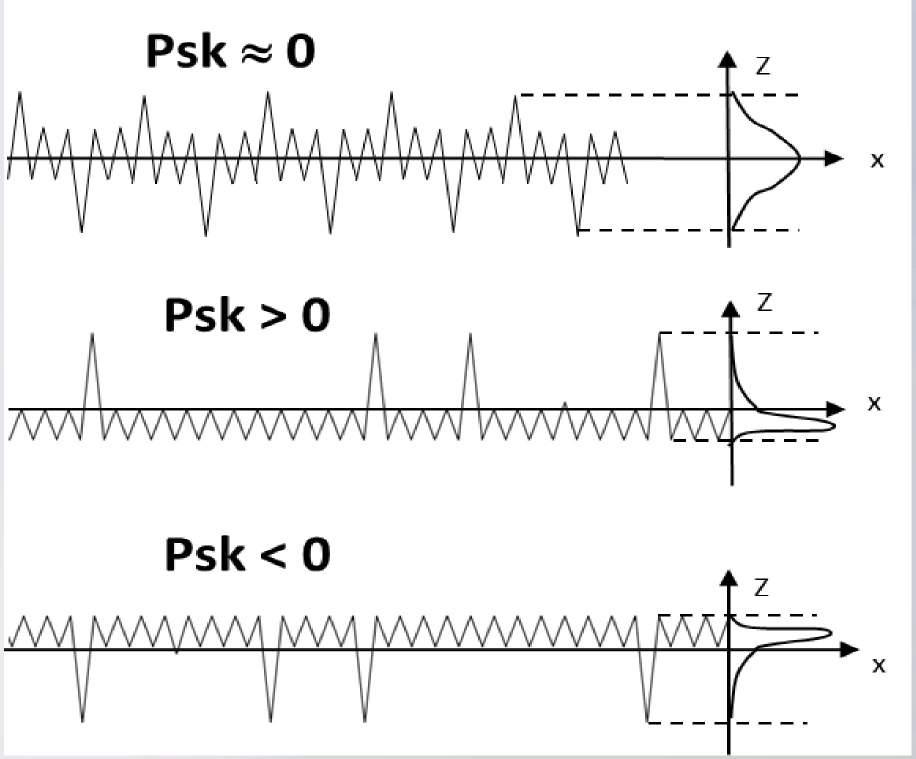
Psk

the skewness/asymmetry of the height distribution

Psk ≈ 0: equally distributed

Psk > 0: mehr peaks (protrusions)

Psk < 0: more valleys (pores, scratches)



The potential of topography measurements

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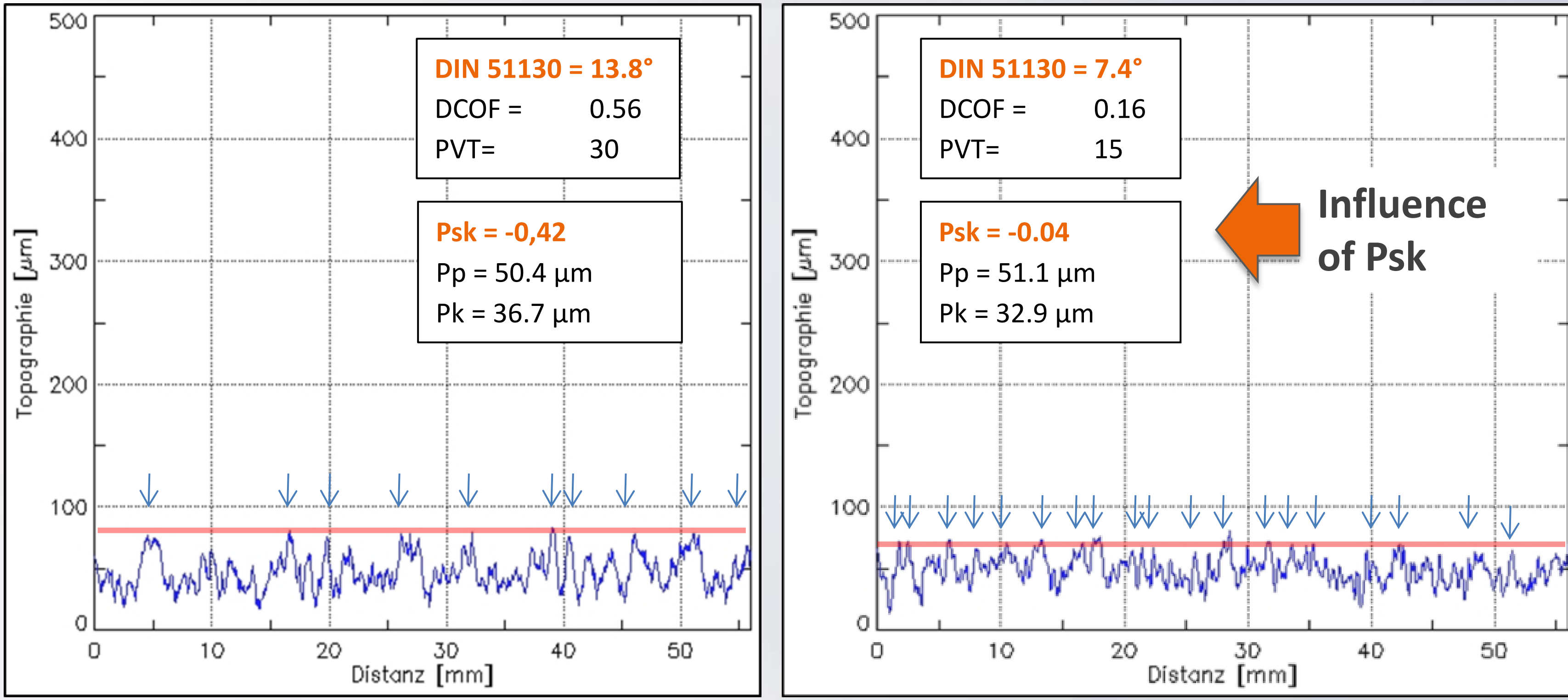

Psk deviation from 0:
irregular peaks, higher grip
(negative: combined with increased displacement volume)

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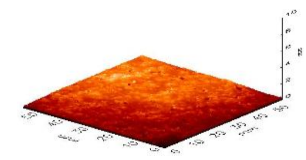
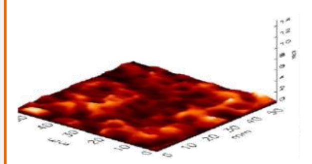
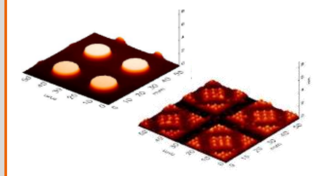
The potential of topography measurements

Surface characterisation based upon SlipSTD development

- Division into **4 surface groups** with different surface characteristics, leading to **different slip resistance behaviour**
- The groups can have **different evaluation of the slip risk** by different methods
- The **topographical description** of each group is **different:** from micro roughness to geometrical and shape parameters

Surface topography groups	Examples
Group 1 **Non profiled, mainly smooth surface, core roughness Pk <50 µm**	
Group 2 **Non profiled, micro rough, „gritty touch“, Pk to 100 µm, Pp up to 200 µm**	
Group 3 **Structured and textured: „macro rough“, Pk above 100, Pp above 200 µm**	
Upper Group 3 **geometrically profiled with Pk above 300, Pp above 700 µm**	

The potential of topography measurements

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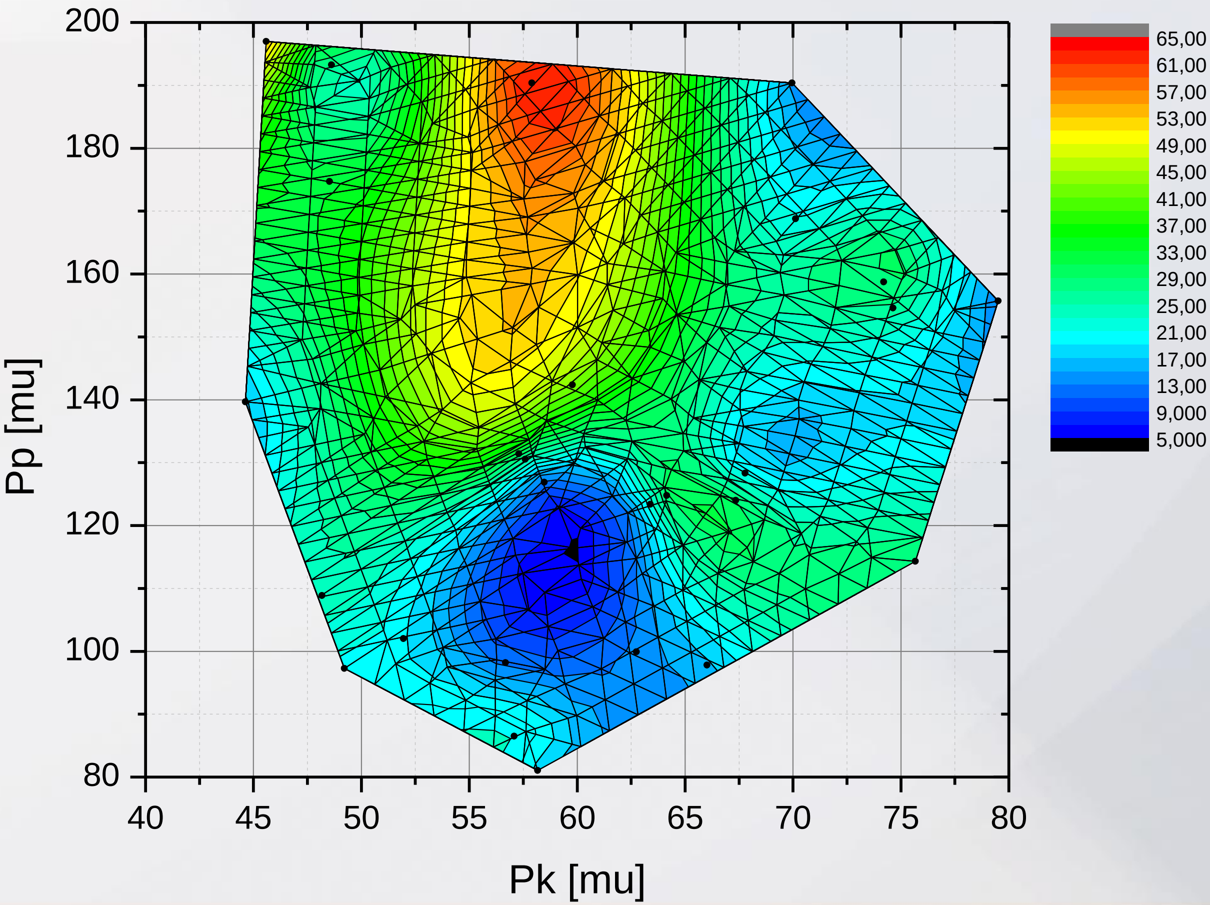
The interpretation of the topography (group 2, Pendulum):



- **Ceramic tile inventory:** 5 suppliers, 4-5 tile types each 4 abrasion stages
- **Slip resistance effects** can be explained
- **Surfaces can be designed**,
- The influence of **shrinkage, sealants, glazes and wear effects** can be investigated

The potential of topography measurements

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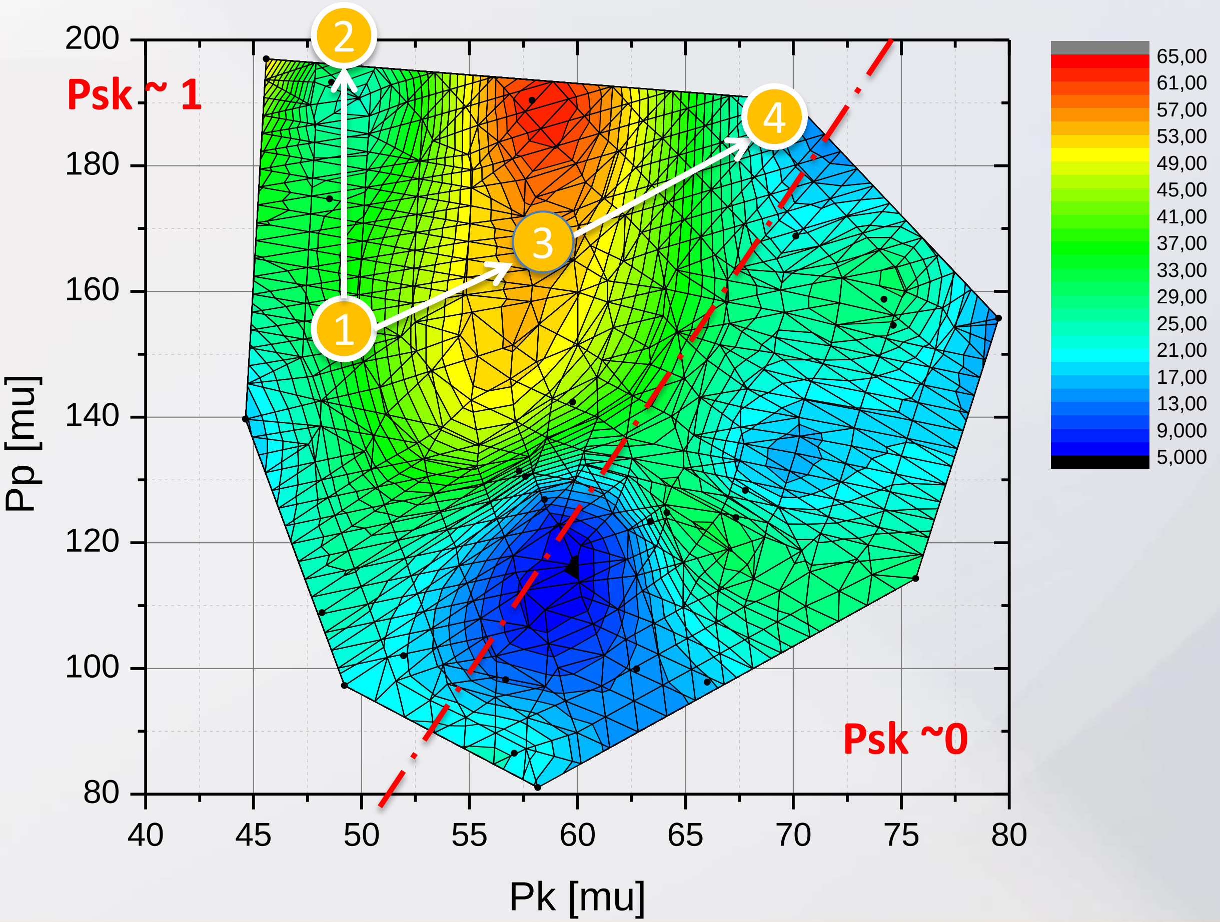

1 → 2

Pp increases, contact with Pk is lost:
loss of slip resistance

1 → 3

Increasing Pk and Pp :
increased friction and grip

3 → 4

Pk increase a d so reduced Psk value (more equal distribution):
lower slip resistance

The durability aspect

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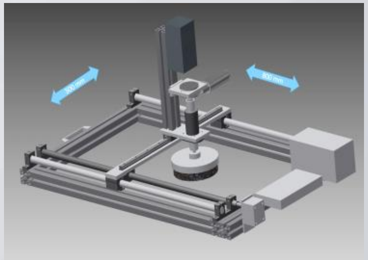
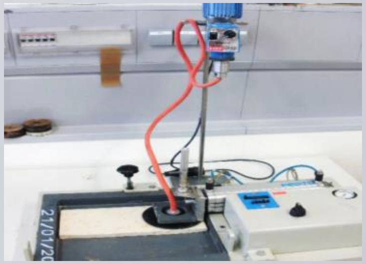
- Wear becomes **increasingly important** (CPR, declaration of Performance)
- Wear simulation methods address **worst case scenarios**, on **small surface areas**
- Wear simulation needs to be validated by **objective surface change measurements** on site (duplication and topography)





FGK Approach:

- Radial wear on 50 x 50 cm, using **abrasive pads, validated with on site topography measurements (laboratory prototype in development)**

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The durability aspect

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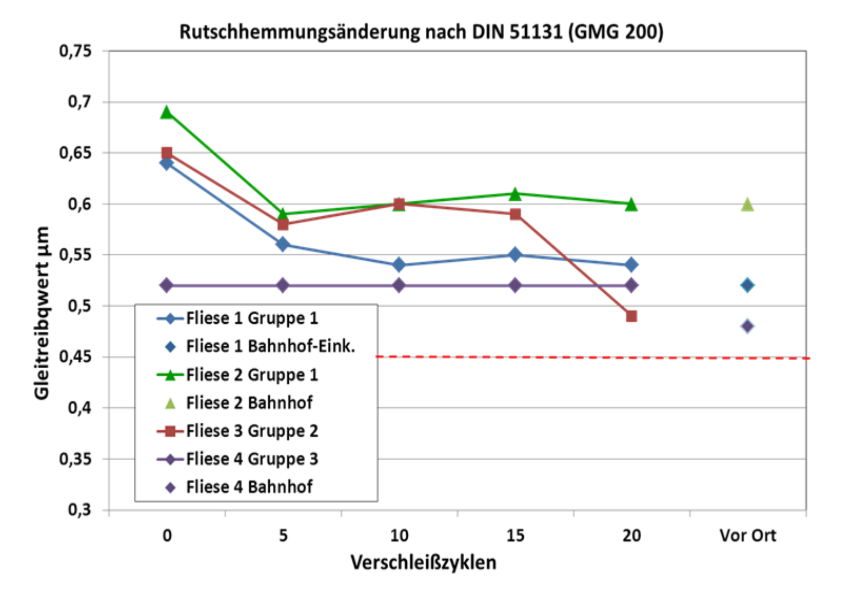
FGK wear simulation:

- **20 cycles** correspond to actual wear in highly trafficked areas (malls, train station halls) **after 1,5 years of use**

- For "high slip resistant surfaces": **reductions of between 30 and 50 %** are no exceptions!



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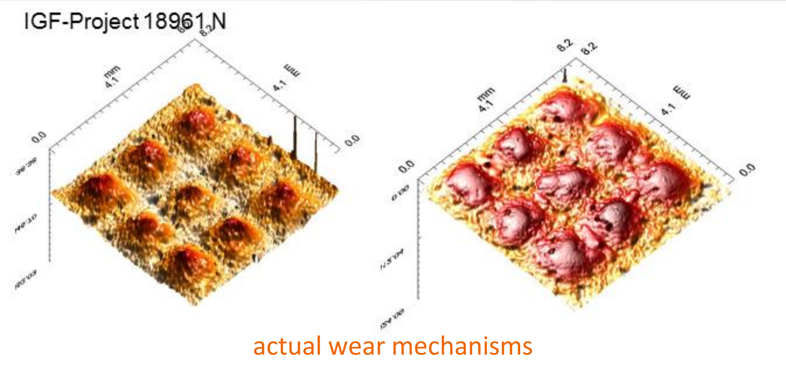
ca


Large scale, radial abrasion



actual wear mechanisms

Compared with effects on site

Topography and slip resistance measurements

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Reference materials in DIN/CEN TS 16165

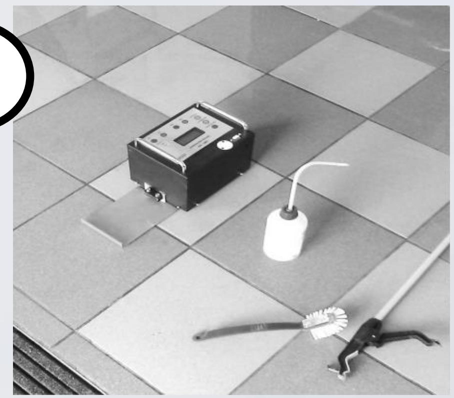
DIN CEN/TS 16165 – 8/2016 (E)

Determination of slip resistance of pedestrian surfaces – Methods of evaluation

3 main methods

1

2



3

Ramp walking method	Friction measurement pull- /propulsiontest	Pendelum impact brake
Stat. /dyn. friction	friction measurement	loss of energy
gait velocity (ca. 140/min)	low velocity (0,2 – 0,3 m/sec)	high velocity (ca. 3 m/sec)

Topography and slip resistance measurements

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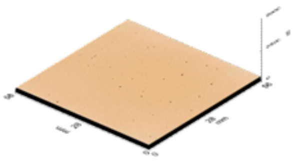
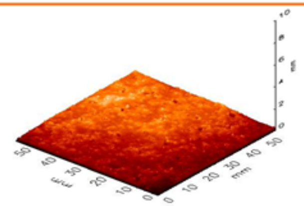
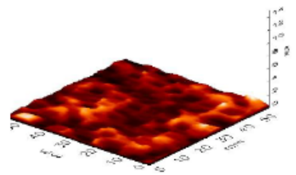
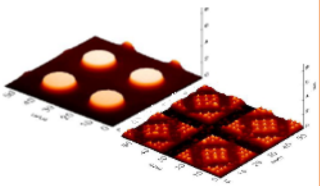
Surface topography groups	Examples
Group 1 Non profiled, mainly smooth surface, Pk <50 µm	
Group 2 micro rough, „gritty touch“, Pk to 100 µm, Pp up to 200 µm	
Group 3 Structured and textured: „macro rough“, Pk above 100, Pp above 200 µm	
Upper Group 3 geometrically profiled with Pk above 300, Pp above 700 µm	

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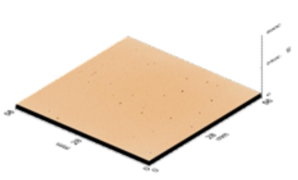
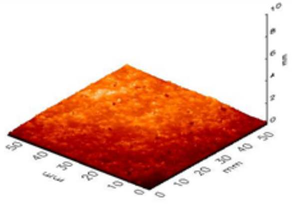
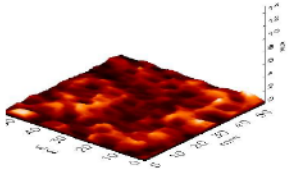
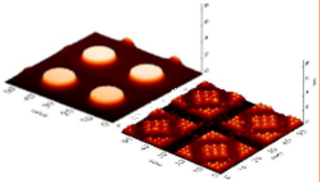
Topography and slip resistance measurements

Surface topography groups	Examples	Surface influences	
Group 1 Non profiled, mainly smooth surface, Pk <50 µm		hydrodynamic film effects, different measurement methods and settings influence results	
Group 2 micro rough, „gritty touch“, Pk to 100 µm, Pp up to 200 µm		topography is significant: correlations between surface and slip and different methods	
Group 3 Structured and textured: „macro rough“, Pk above 100, Pp above 200 µm		topography and geometry (shape) are significant. Loss of contact area	
Upper Group 3 geometrically profiled with Pk above 300, Pp above 700 µm		geometry (shape) is significant, different for each surface. Loss of contact area	

Topography and slip resistance measurements

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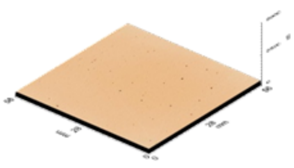
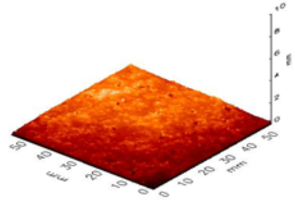
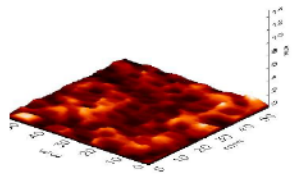
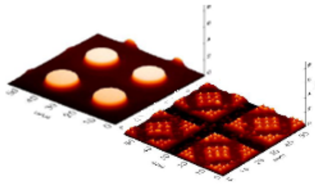
Surface topography groups	Examples	Surface influences		Measurement suitability
Group 1 Non profiled, mainly smooth surface, Pk <50 µm		hydrodynamic film effects, different measurement methods and settings influence results		tribometer and pendulum can overestimate actual slip resistance due to stiction effects
Group 2 micro rough, „gritty touch", Pk to 100 µm, Pp up to 200 µm		topography is significant: correlations between surface and slip and different methods		ramp, tribometer and pendulum can be applied
Group 3 Structured and textured: „macro rough", Pk above 100, Pp above 200 µm		topography and geometry (shape) are significant. Loss of contact area		Ramp and pendulum applicable, tribometer impaired by loss of contact surface (low) or irregular traction (high)
Upper Group 3 geometrically profiled with Pk above 300, Pp above 700 µm		geometry (shape) is significant, different for each surface. Loss of contact area		Ramp and Pendulum applicable, impact variation on profile with Pendulum needs attention

Topography and slip resistance measurements

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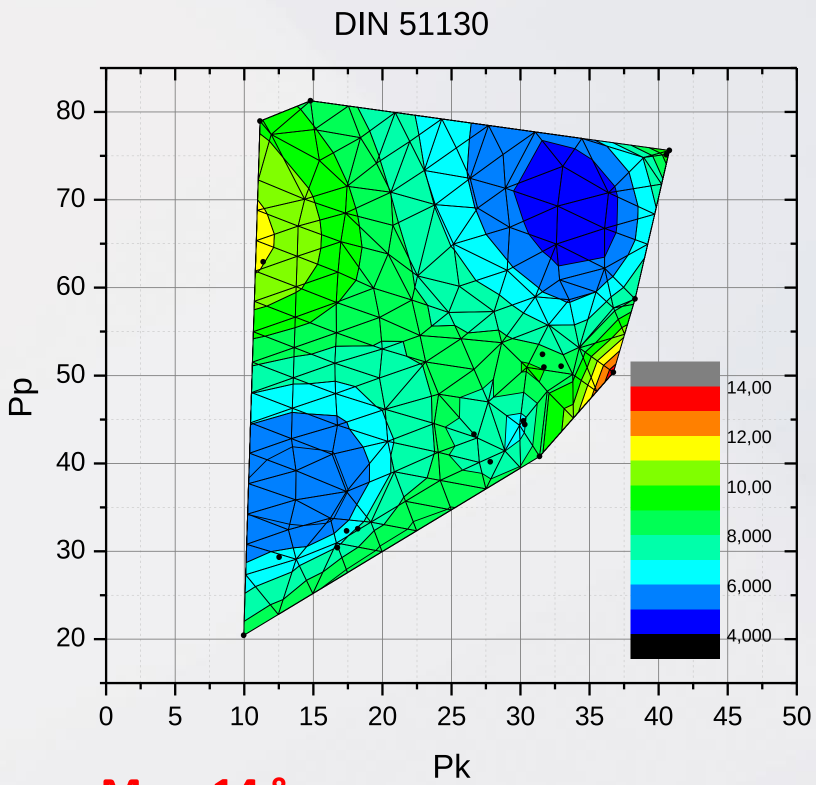
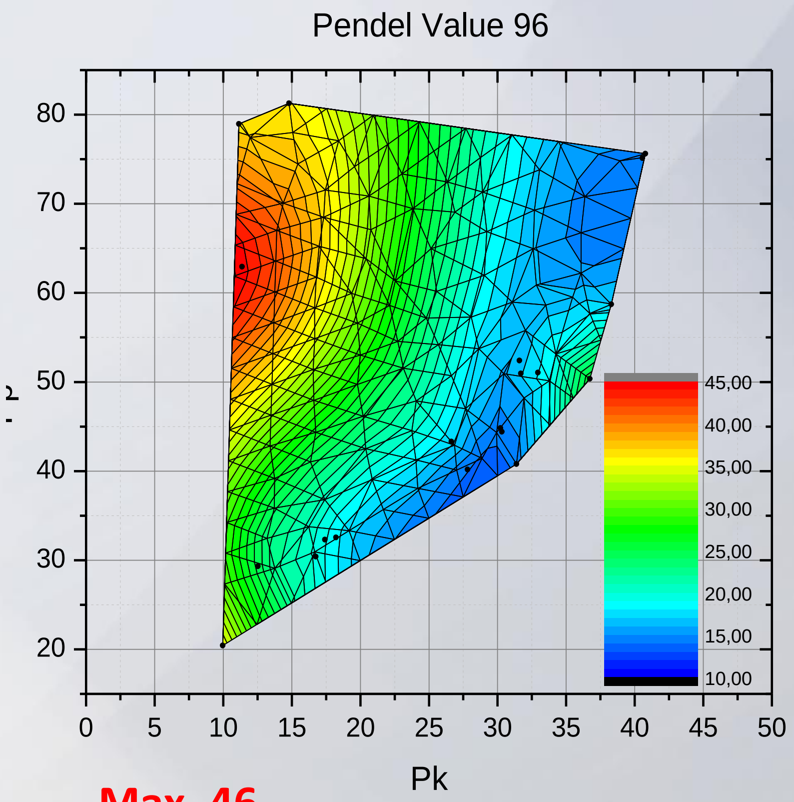
The influence of the measurement method in group 1





Max. 14 °

Max. 46

Comparison of Pendulum to DIN 51130
tested group 2 tiles status june 2918

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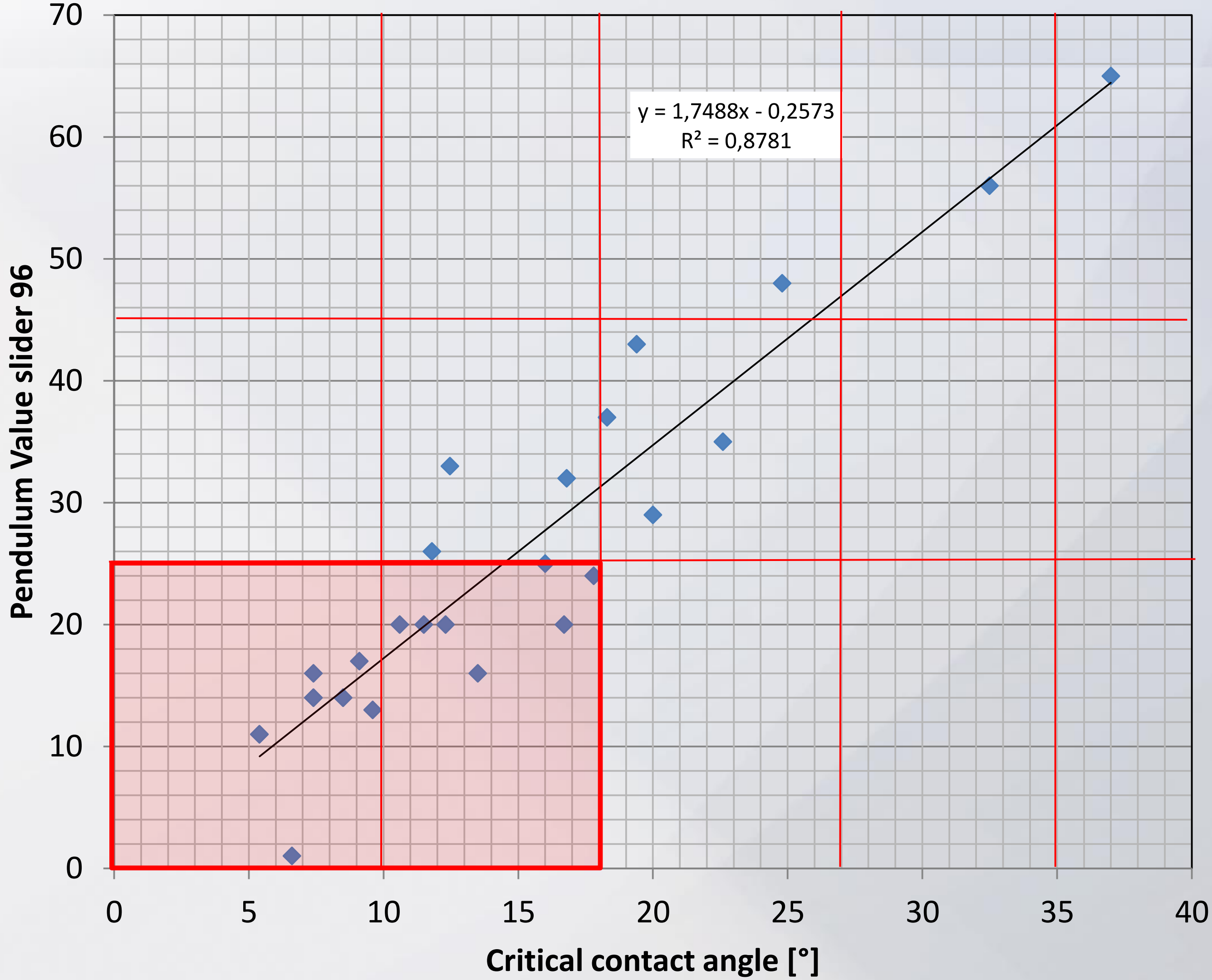

Performance of the reference materials

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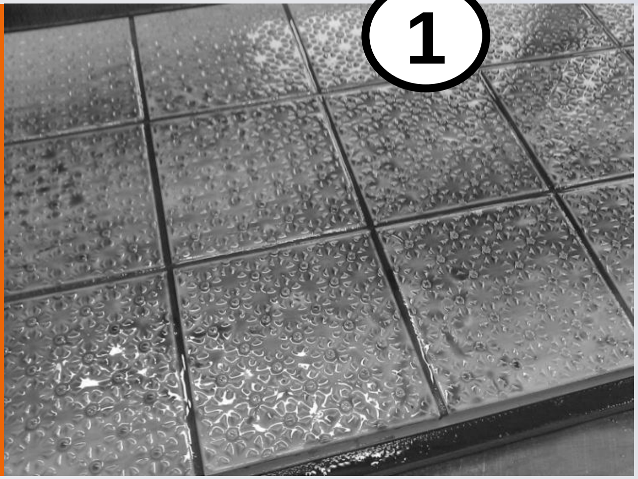
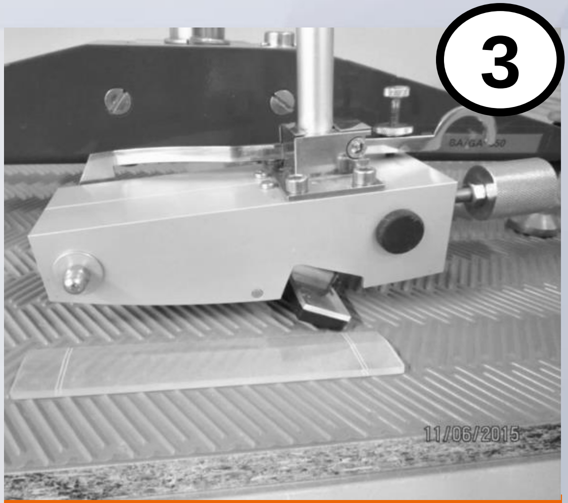
Reference materials in DIN/CEN TS 16165

Calibration Boards

Shod:		Barefoot:	
St-I	8.7 ° ± 3.0°	St-A	11.5° ± 2.1°
St-II	17.3° ± 3.0°	St-B	18.5° ± 2.1°
St-III	27.3° ± 3.0°	St-c	23.9° ± 2.1°

Testing Shoes:
LeipzigV73-SP
Safety Shoe
Sole: Nitril-Cautchuc, Shore-A-Hardness 73 ± 5 acc. to EN ISO 868





Wet conditions with SBR slider:

Floatglass	μ = 0.14 ± 0.02
HPL-plate acc to EN 438-4	μ = 0.30 ± 0.03
Portugese tile	μ = 0.42 ± 0.04

Slider:	57
3M 261X Imperial Foil:	53 – 63
Floatglassplate:	5 – 10
Reference tile:	13 – 19
Slider:	96
3M 261X Imperial Foil:	X ± 3
Floatglassplate:	5 - 10
Reference tile:	29 - 39

Status 2016

Different reference materials for different measurement methods!

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Performance of the reference materials

Fit for purpose?

Reference Comparison

Reference materials for:	surface parameters		DIN CEN/TS 16165 – 06/2012							SlipSTD PAS surface group
	Pk	Pp	Ramp	R-Class	Standard Requirements	DCOF	Standard Requirements	PVT	Standard Requirements	
1 DIN CEN/TS 16165 (Ramp Oil/Shoe)										
ST-I new	11 µm	80 µm	9.8°	R9	8.7 ° ± 3,0°	0.43		38		1
ST-II new	75 µm	120 µm	20.0°	R11	17.3° ± 3,0°	0.58		29		2
	79 µm	112 µm	17,8°	R10	17,3 ± 3,0°	0,58		34		2
ST-III new	not relevant		28.4°	R12	27.3° ± 3,0°	-		-		3
2 DIN CEN/TS 16165 (DCOF GMG 2000)										
UGL Tile	17 µm	47 µm	-	-	-	0.50	0,45 ± 0,04	30		1
HPL tile	22 µm	75 µm	-	-	-	0.24	0,28 ± 0,03	13		1
Floatglas	1 µm	1 µm	-	-	-	0.11	0,12 ± 0,03	9		1
3 DIN CEN/TS 16165 (PVT Pendulum)										
Eurotile 2	9 µm	20 µm	8.5°	-	29 - 39	0.53		35	29 - 39	1
Verification foil	4 µm	7 µm	-	-	58 - 64	-		62	58 - 64	1

- References for tribometer and pendulum are **all in group 1,** not covering the application areas (use on site) with **differences in evaluation!**

Performance of the reference materials

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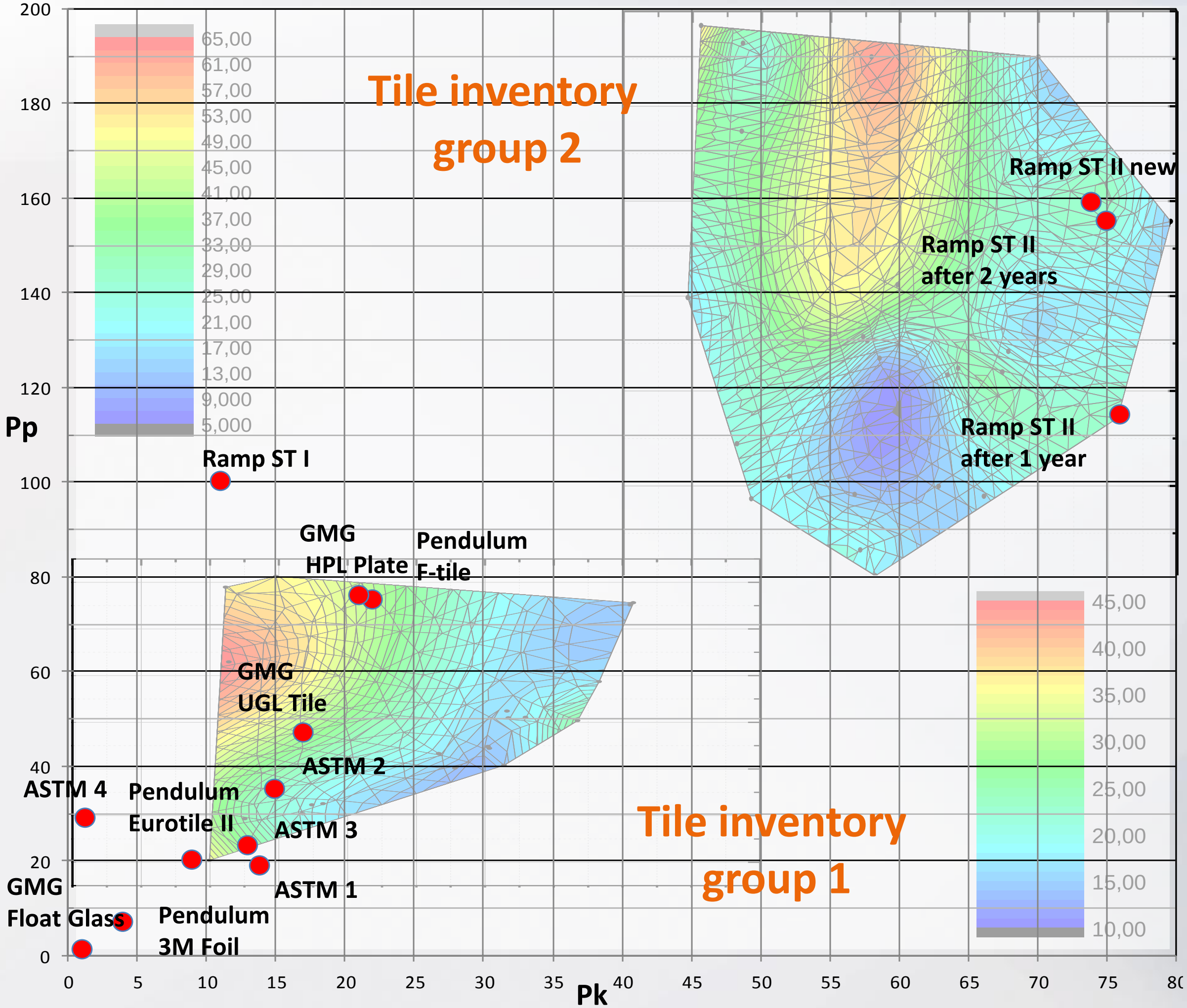
Fit for purpose?

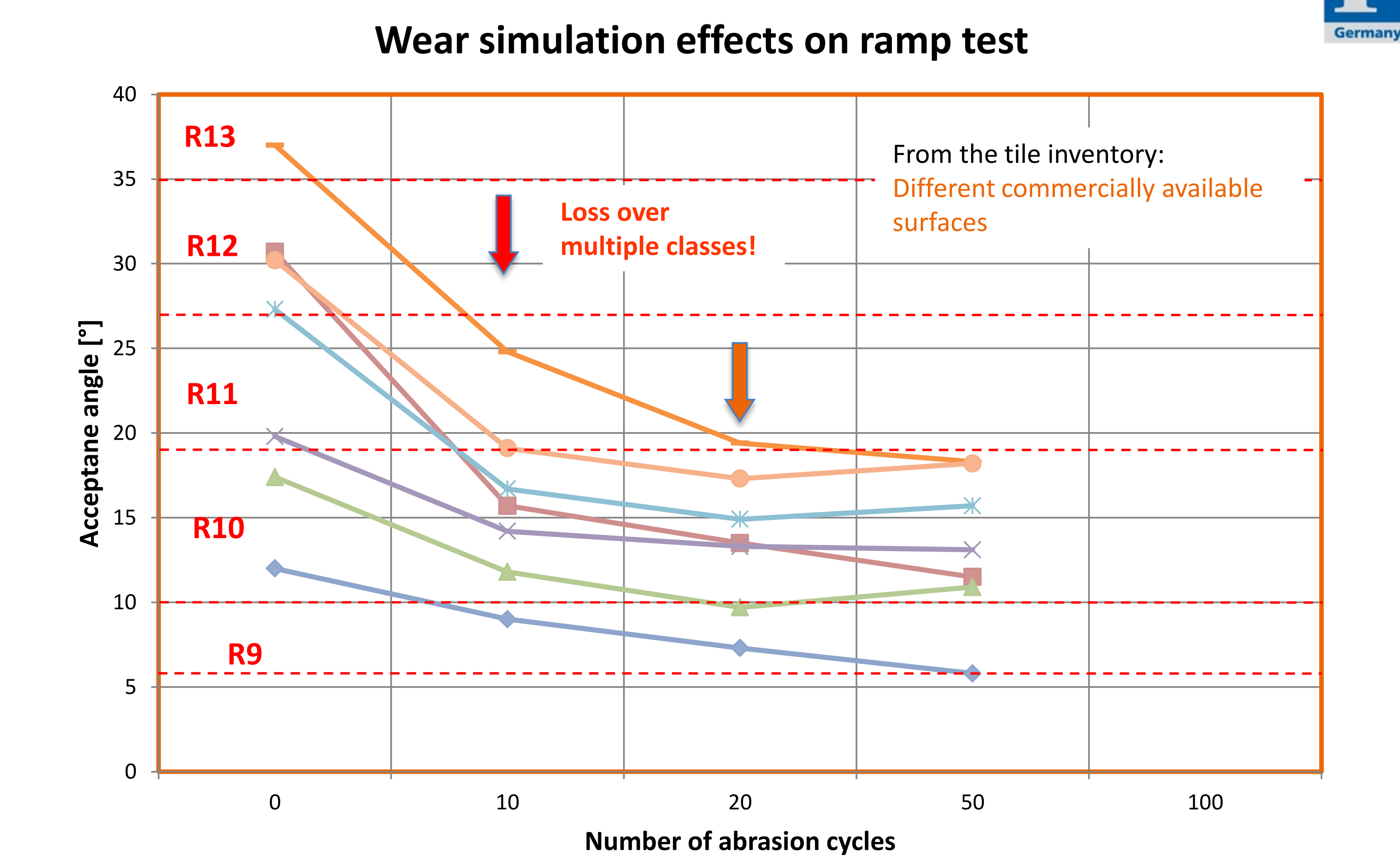


- None of the reference materials for tribometer and pendulum **cover the group 2 tile range!**
- The pendulum and GMG reference materials are **partially below the group 1 range!**

The reference materials for tribometer and pendulum do not cover the application range!

Performance of the reference materials

Adequate durability and stability?



Performance of the reference materials

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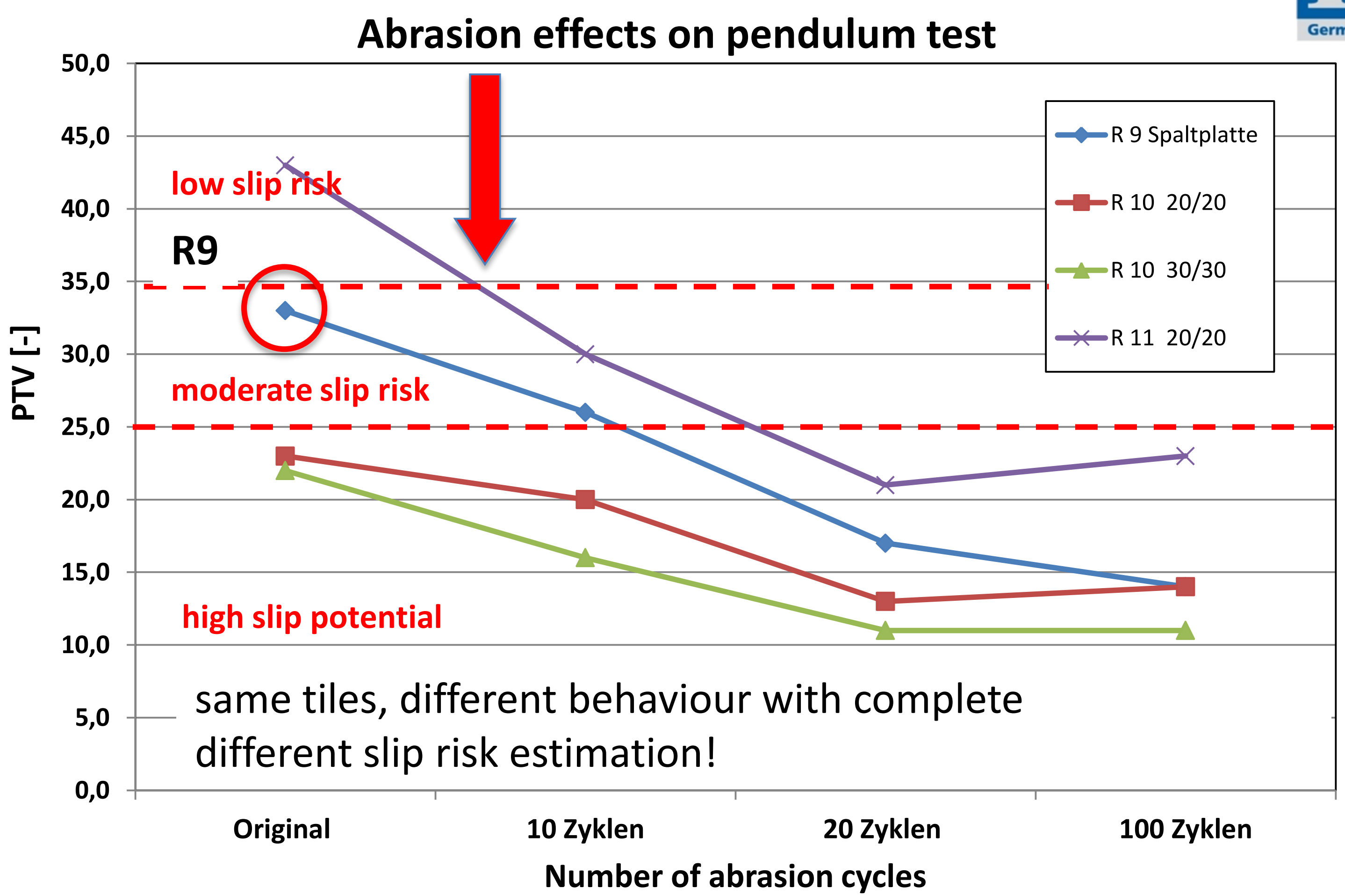
Adequate durability and stability?



same tiles, different behaviour with complete different slip risk estimation!

Performance of the reference materials

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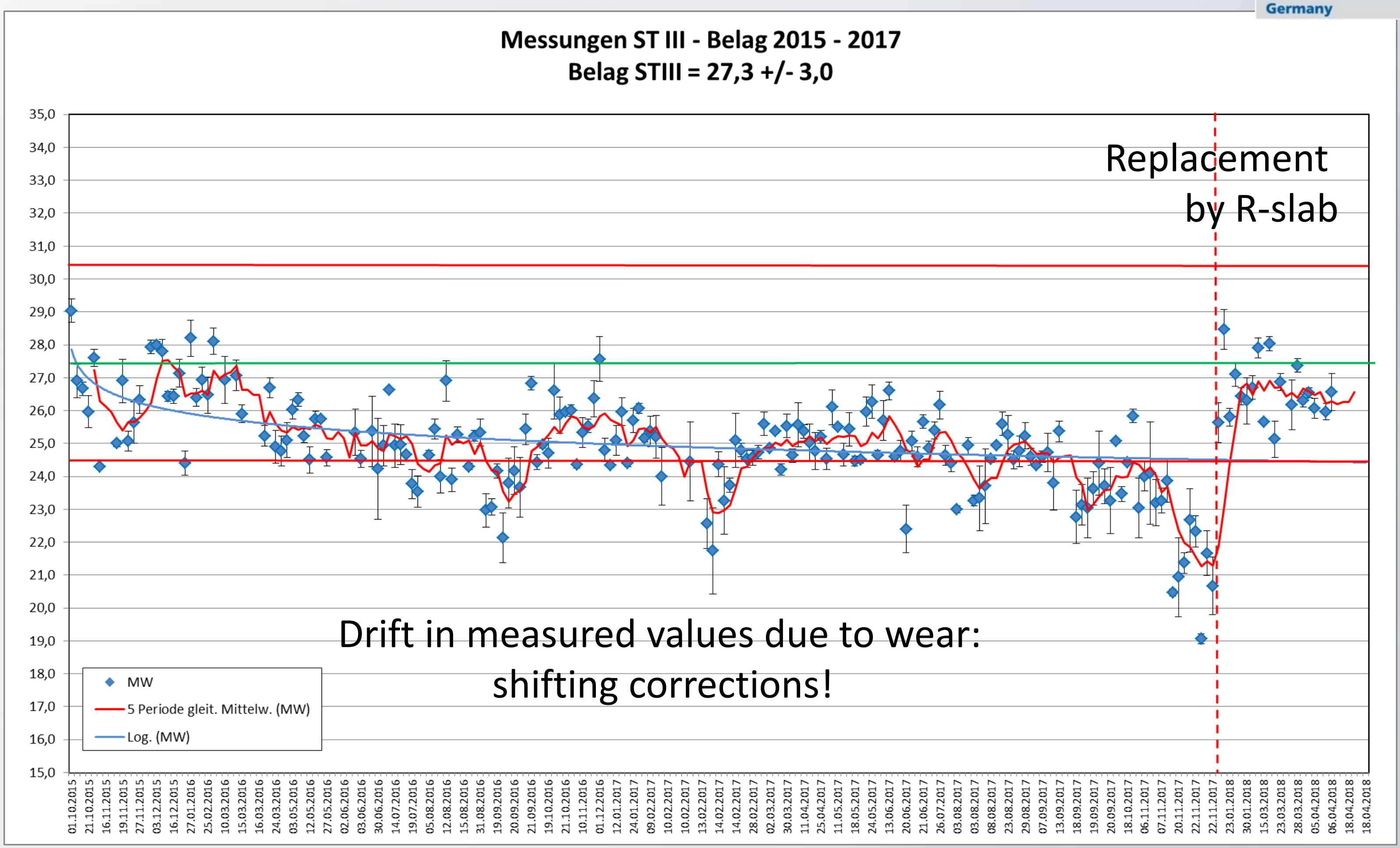
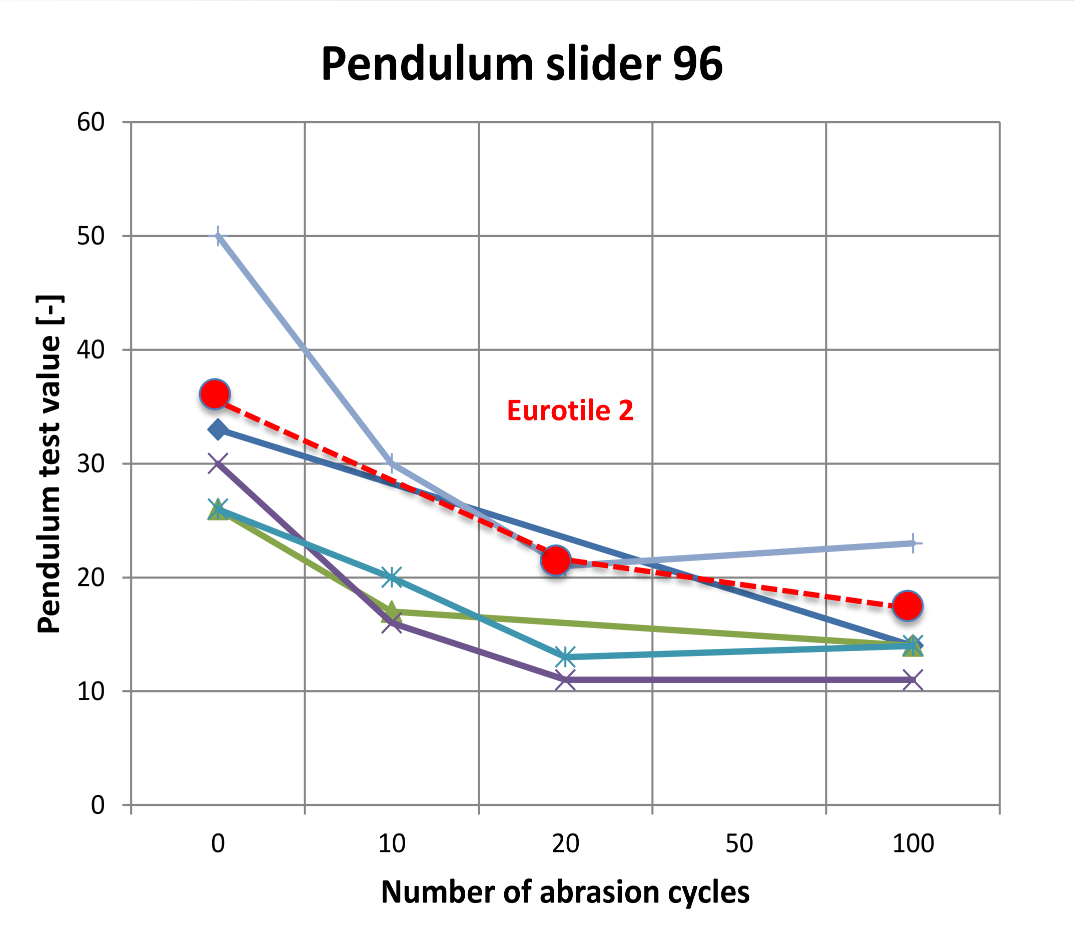
Adequate durability and stability?



Performance of the reference materials

Adequate durability and stability?



- Eurotile 2 has been tested (ramp, tribometer, pendulum)
- The Eurotile 2 also shows a **decrease in slip resistance** due to wear.
- The effects is **less than experienced using the pendulum**

The potential of new and alternative materials

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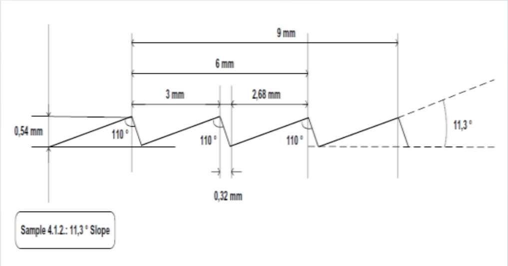
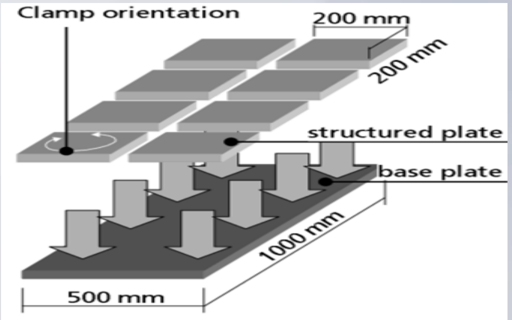
The Slip STD Basis of modular systems:

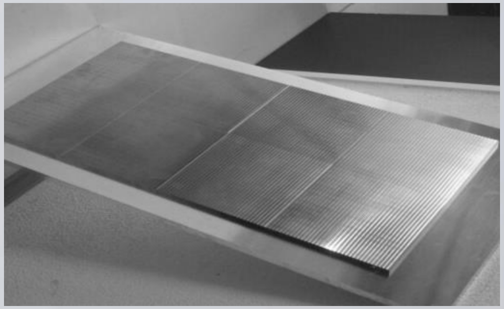
- **Reproducible designed** and **objectively specified** surfaces
- Durable **wear resistant** surfaces
- **Targeted slip resistance values** by topographical or geometrical design
- **covering the application range**





Model based design by the University of Uppsala, Sweden ():

- Single Slope Concept, load-independent friction
- Targeted slip resistance values by “slope design”
- Transferred to steel and ceramic glazed and unglazed precursors

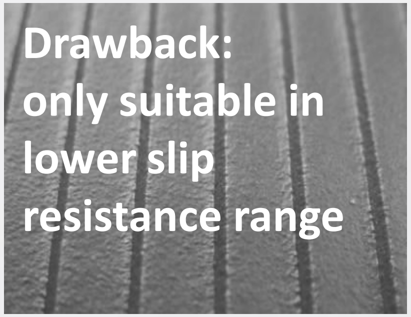


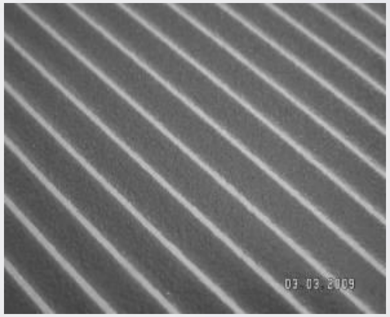
Drawback: no working level reference

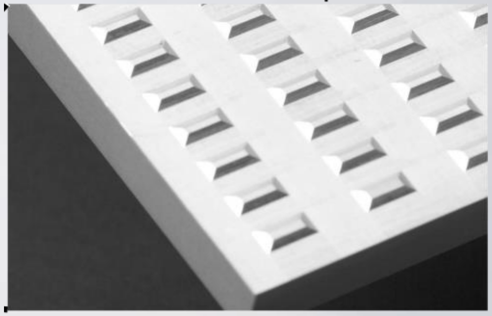
The potential of new and alternative materials

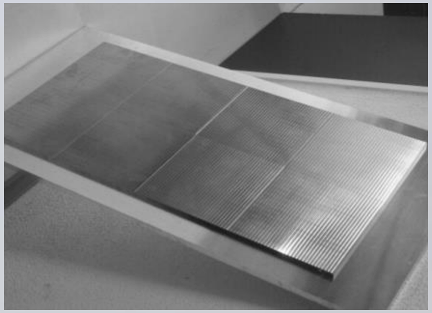
First prototypes:

		mean	std.dev
Package for DIN 51097	ceramic single slope angle „I-GL-A"	12,4°	1,8°
	ceramic single slope angle „I-GL-B/R10“	19,8°	1,6°
	ceramic single slope angle „I-GL-C“	22,2°	0,8°
Package for DIN 51130:	ceramic single slope angle „I-GL-B/R10“	8,9°	1,6 °
	ceramic single slope angle „C-UGL /R11“	19,1°	3,1°
	alumina bidirectional sample „F-TP-R10“	10,3°	0,6°
		14,5°	0,5°
BS 7679 Pendulum	ceramic single slope angle „I-GL-A" (MSP),	25,1	2,3
	ceramic single slope angle „I-GL-B“ (LSP)	33,6	3,4
	steel single slope angle „F-LSP“	33,9	1,4









The potential of new and alternative materials

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-Glas/Keramik- GmbH

Choosing alternative, commercially available materials

- Development of tiles with **proven high wear resistance**:
  STD-P tile developed by ITC, produced by Porcelanosa , Spain –
  tested for Pendulum (!), surface development (FGK)
- Commercial tile surfaces with **proven wear resistance**:
  (Benchmark study by FGK)
- Defined **pre-treatment of tile surfaces** (abrasion)

Wear =
material- and surface
design-dependent

Drawbacks:

- **Availability**
- **Durability of high profiled slip resistant surfaces: unpredictable wear results vs. targeted slip values**

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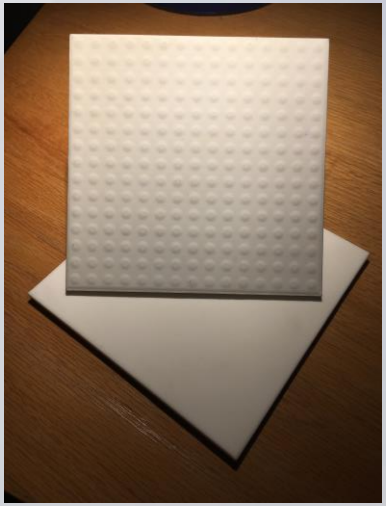
Developing surfaces with alternative materials

- alternative (technical) ceramic materials with superior **wear and chemical resistance**
- Covering the range of **profiled ab non-profiled surfaces**
- produced under controlled **production pilot scale** conditions to ensure constant and reproducible (specified!) quality as a prerequisite for the use as reference surface.

Prototypes are being produced and checked, first results available



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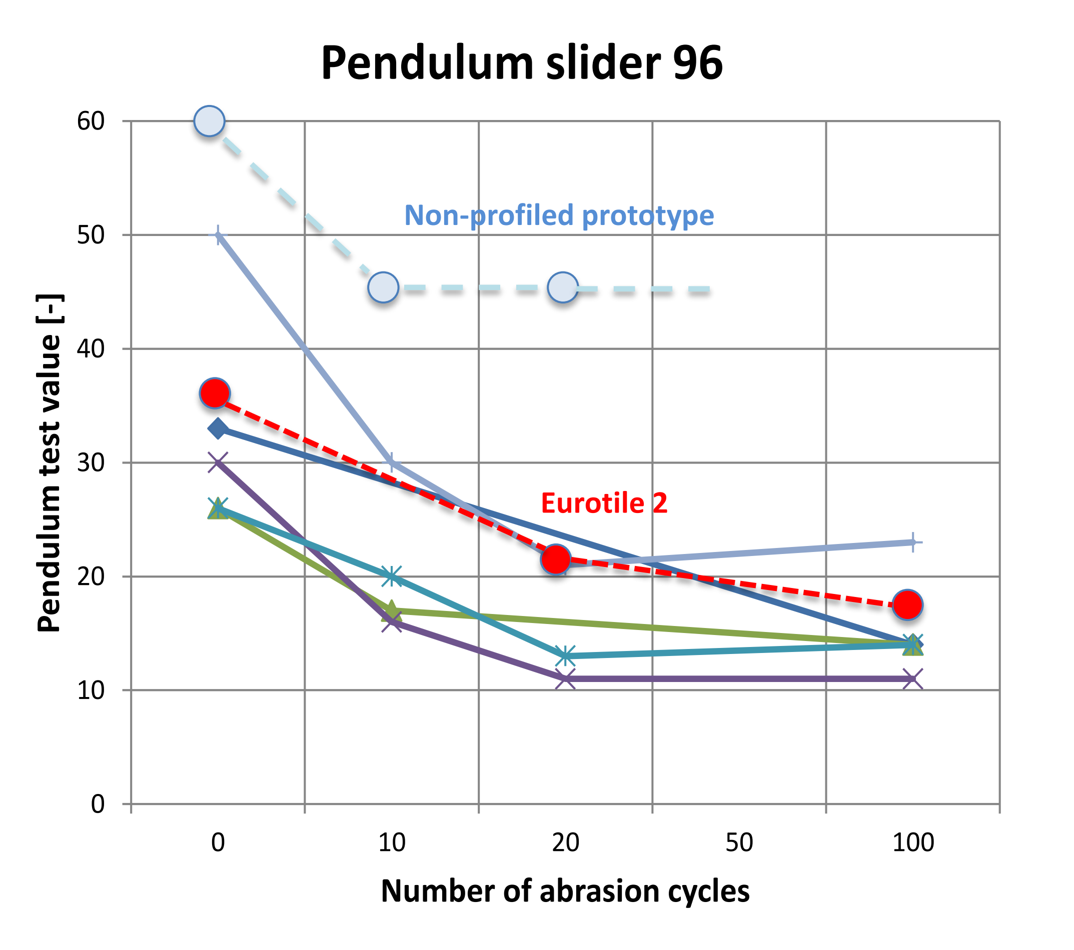
Prototype results



- The slip resistance decreases initially, but stabilizes at a high level
- The material is extremely hard (fired at 1600 °C) and durable. Water absorption is below 0,1.
- The tile can easily be cleaned (chemically resistant)
- Planarity needs optimizing

The potential of new and alternative materials

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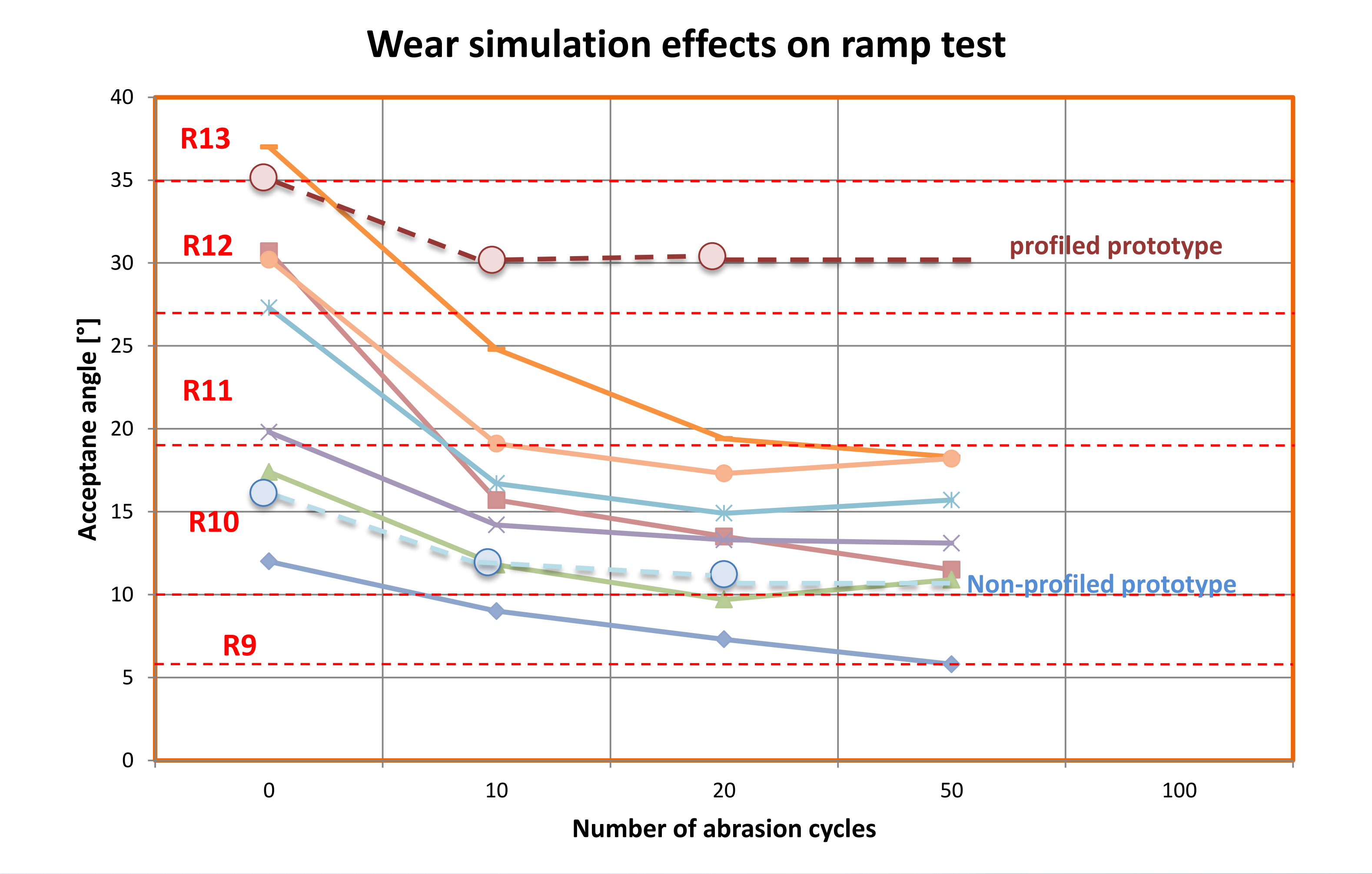
Prototype results



Summary/recommendations

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- Current reference systems in the DIN CEN/TS 16165
  - do not cover the **test method application range**
  - Are **not comparable/transferable** between methods
  - lack **reproducibility, reliability and durability**
- For **commercially available surf**aces the use of **pre-treatment/estimation of the actual relevant wear effects** for new references is recommended
- The **performance of the methods** mentioned in DIN CEN/TS 16165 on different surfaces should be validated and used to develop **basic guidance for their use as informative part of the TS.**
- The use of **alternative materials** as a basis for **designed, reproducible, controlled and durable surfaces**, produced under **controlled and specified conditions** is highly recommended. These can also include specified surface types from practice (FGK development).

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Thank you for your attention!

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