Long-Term Skid Resistance of Asphalt Surfacings

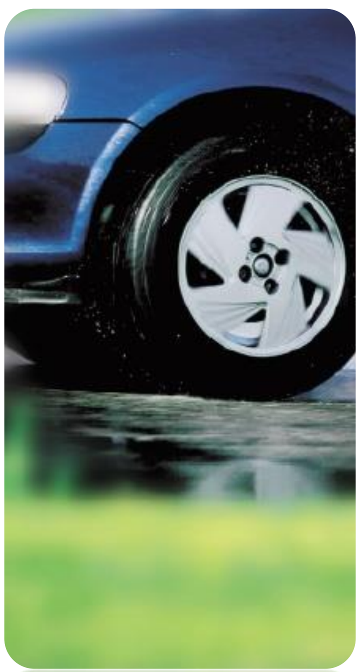
Correlation between Wehner-Schulze friction values and the mineralogical composition of the aggregates

Malal KANE / Minh Tan DO

UGE/AME/EASE
Allée des Ponts et Chaussées
Route de Bouaye - CS4
44344 Bouguenais Cedex

Introduction

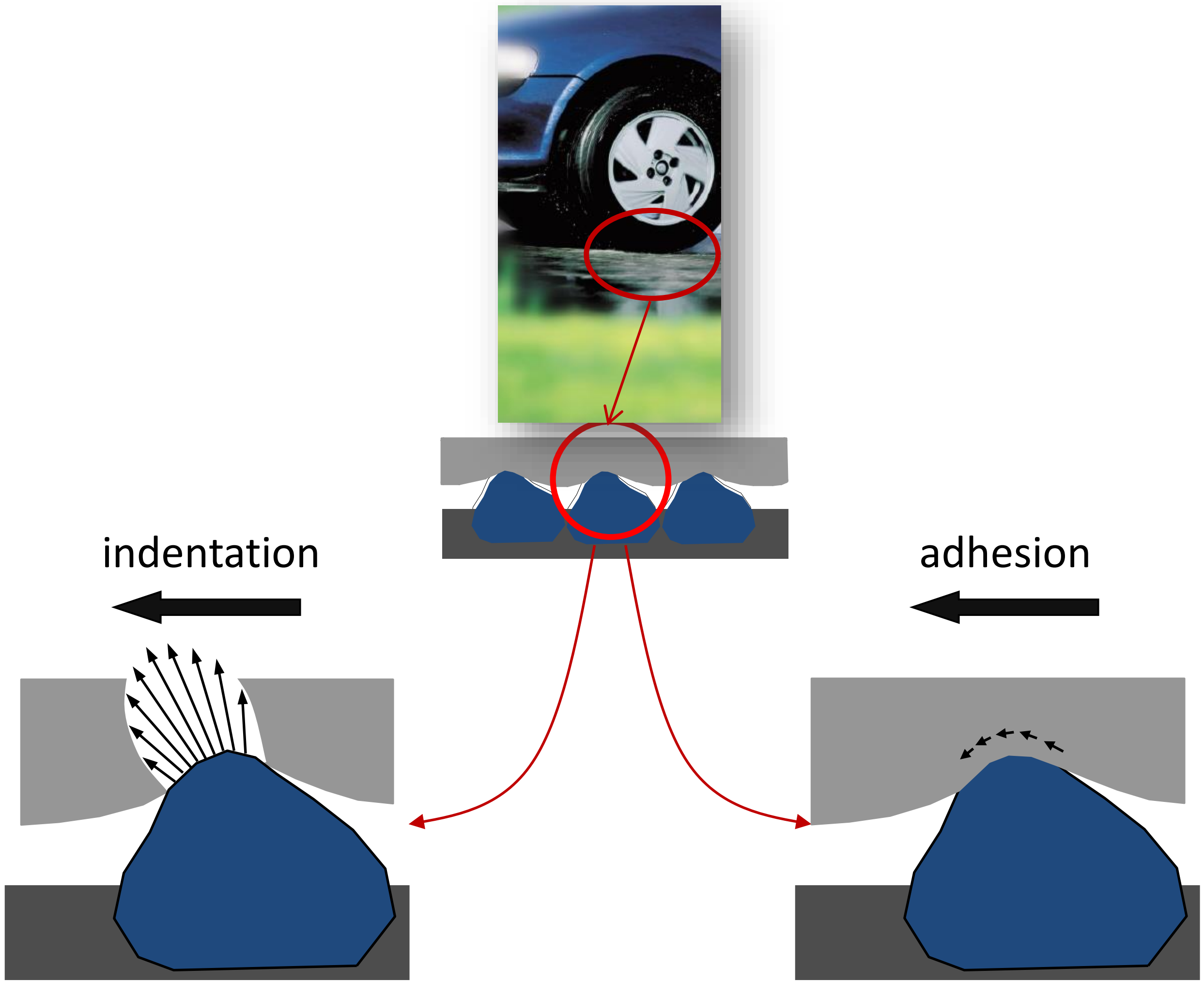
Skid resistance describes the contribution that the **road** makes to tyre/road friction…



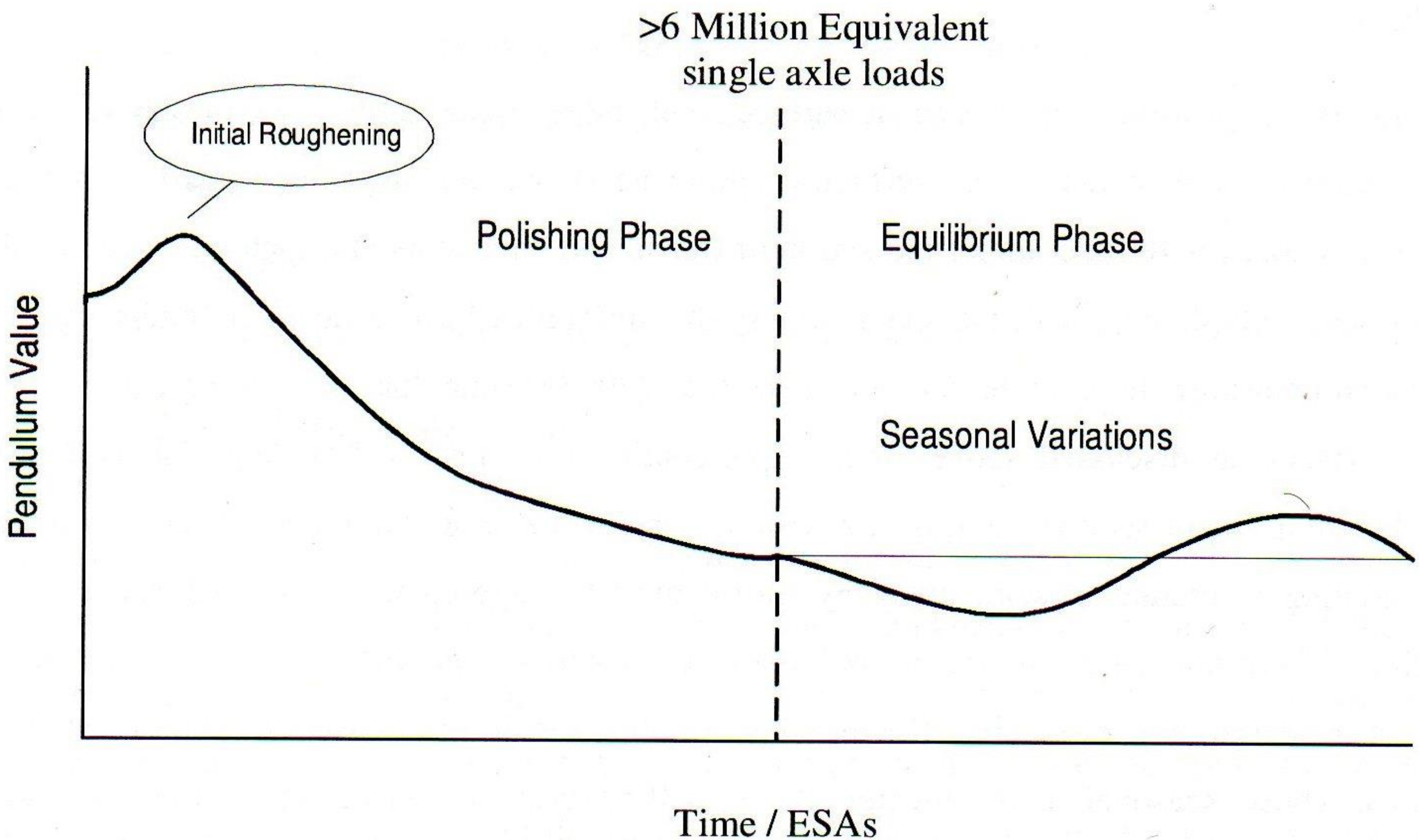
Braking

Turning

Introduction



Introduction

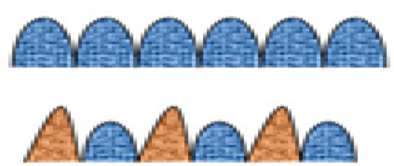


Introduction

Analysis after polishing showed two mechanisms regarding polishing of aggregates :

- “General” polishing that tends to smooth off the coarse aggregate edges, and

- “Differential” polishing that tends to create additional roughness on the aggregate faces.



Introduction

- So, while the texture evolves continuously due to the polishing effect of traffic, analyzing the mineralogical composition can give a quantitative evaluation of an aggregate's ability to retain its texture.

The objective is to correlate the long term skid resistance of road surfacings to the mineralogical properties of aggregates.

Aggregates

- Different types of aggregates commonly used in asphalt surfacings were used in the study. The selection of aggregates was based on the mineralogy and their PSVs.
  - **Greywacke** is a type of sedimentary rock belonging to the sandstone group.
  - **Granites** are intrusive igneous rocks composed of interlocking crystals. They are usually coarse grained, often with similar sized individual crystals, which are generally randomly arranged.
  - **Limestone** is also a sedimentary rock formed in a marine environment from the precipitation of calcium carbonate and compressed to form a solid rock.

Aggregate type

Type of Aggregates	Name of the Aggregates	Origin
Sedimentary rock	Dolomite	Luxembourg
	Limestone (1)	France
	Limestone (2)	France
	Silico-Limestone	France
	Greywacke (1)	France
	Greywacke (2)	England
Igneous rock	Basalt	France
	Granite	France
Metamorphic rock	Quartzite (1)	Luxembourg
	Quartzite (2)	France
	Quartzite (3)	France
	Rhyolite / Dacite	Portugal
Slag	Blast Furnace (HF)	Luxembourg
	Slag from Electrical oven (EAF)	Luxembourg

Petrographic examination

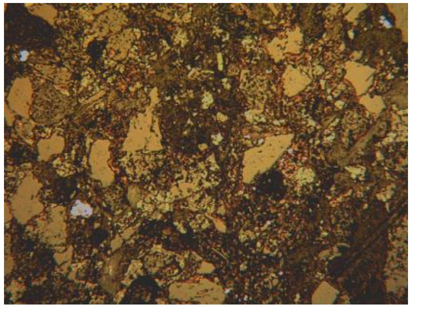
- Petrographic examination of aggregate samples was carried out in accordance.
- The main rock types were then identified and the relative proportions of the constituents were estimated using a light microscope.

Aggregate mineralogical ID

Greywacke

- Petrographic examination showed that greywacke aggregate comprised of several mineral grains namely: quartz, feldspars, chlorite and biotite.

Phase	% by weight	Moh's scale
Quartz	52	7
Feldspar	16	6
Chlorite	22	2.5
Biotite	10	3

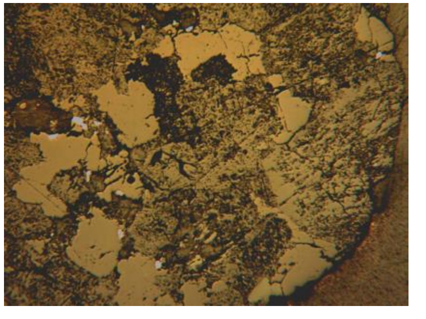


Aggregate mineralogical ID

Granite

- Petrographic examination of the granite showed that the rock comprised mainly of quartz, feldspars (orthoclase), amphibole and biotite.

Phase	% by weight	Moh’s scale
Quartz	27	7
Orthoclase felspar	49	6
Amphibole	19	6
Biotite	5	3

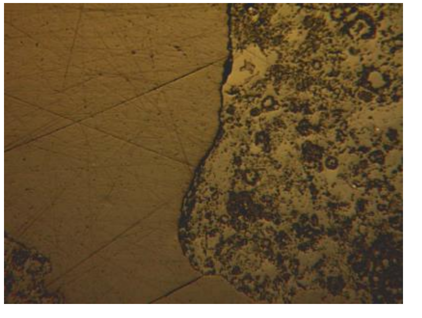


Aggregate mineralogical ID

Limestone

- Petrographic examination of the limestone showed an almost single mineral phase nature of the aggregate.

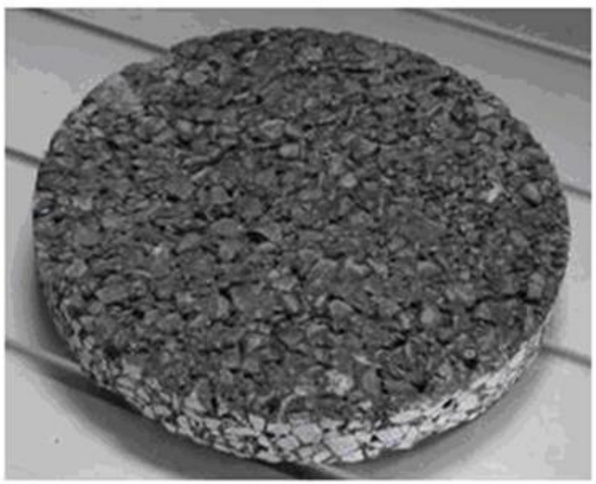
Phase	% by weight	Moh's scale
Calcite	100	3



Aggregate mineralogical ID

	Dolomite	Limestone (1)	Limestone (2)	Silico-Limestone	Greywacke (1)	Greywacke (2)	Granite	Basalt	Quartzite (1)	Quartzite (2)	Quartzite (3)	Rhyolite / Dacite	Blast Furnace (HF)	Slag Electrical oven (EAF)	Moh's Scale Average
Illite	2			2	5				2	5	4				1,5
Gypsum								1					8		1,8
Chlorite					4	22			3	5		2			2,3
Ettringite													10		2,5
Muscovite	5	2		3	8				7	6		9			2,5
Biotite						10	5								3,0
Calcite		95	100	6					1		2		1		3,0
Nordstrandite															3,0
Dolomite	85				1						1	2			3,8
Brownmillerite													13	14	5,0
Wuestite														5	5,3
Gehlenite													62	35	5,5
Augite								18							5,8
Nepheline								11							5,8
Aegirine								8							6,0
Amphibole							19								6,0
Feldspar						16	49								6,0
Diopside								5					4	10	6,0
Hematite					1				1					2	6,0
Magnetite														6	6,0
Merwinite														1	6,0
Sanidine												4			6,0
Albite					12			5	2	15	4	6			6,3
Anorthite								22							6,3
Orthoclase								1				14			6,3
Microcline	3			5	5			11	3	4		18			6,3
Jadeite								2						26	6,8
Forsterite iron								17							7,0
Quartz	4	3		81	64	52	27		82	61	90	45	2		7,0
Miscellaneous				3						5					6,0

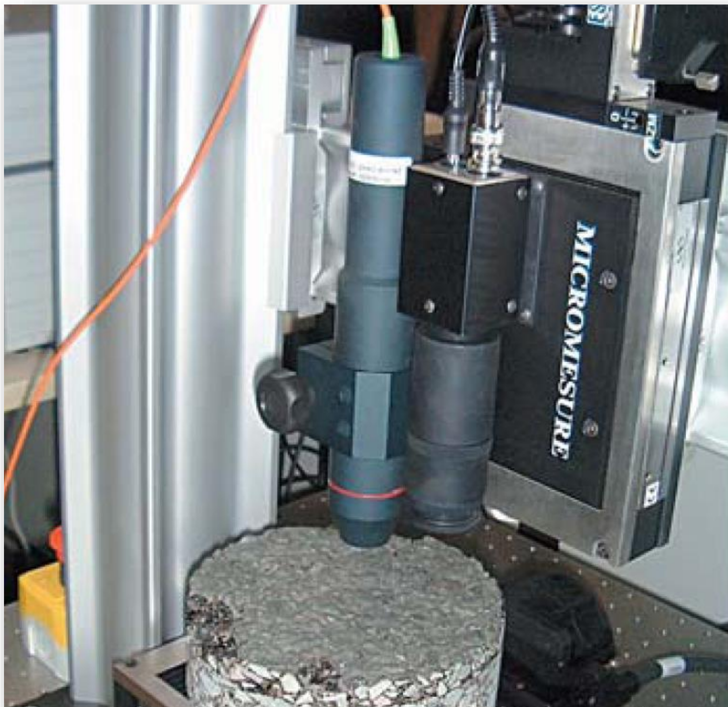
Specimens

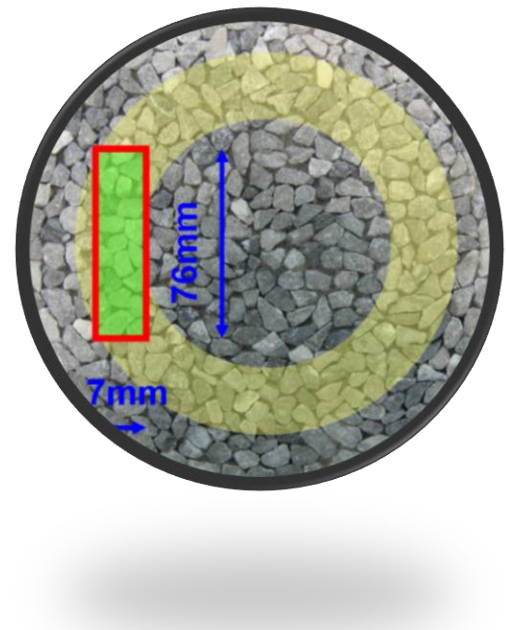


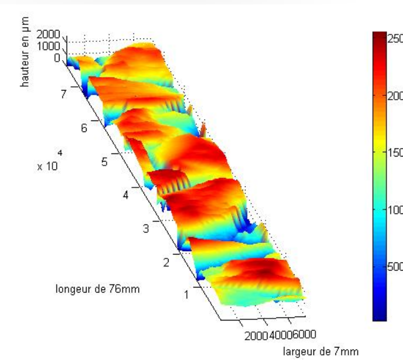
Asphalt

Mosaic

Texture measurements

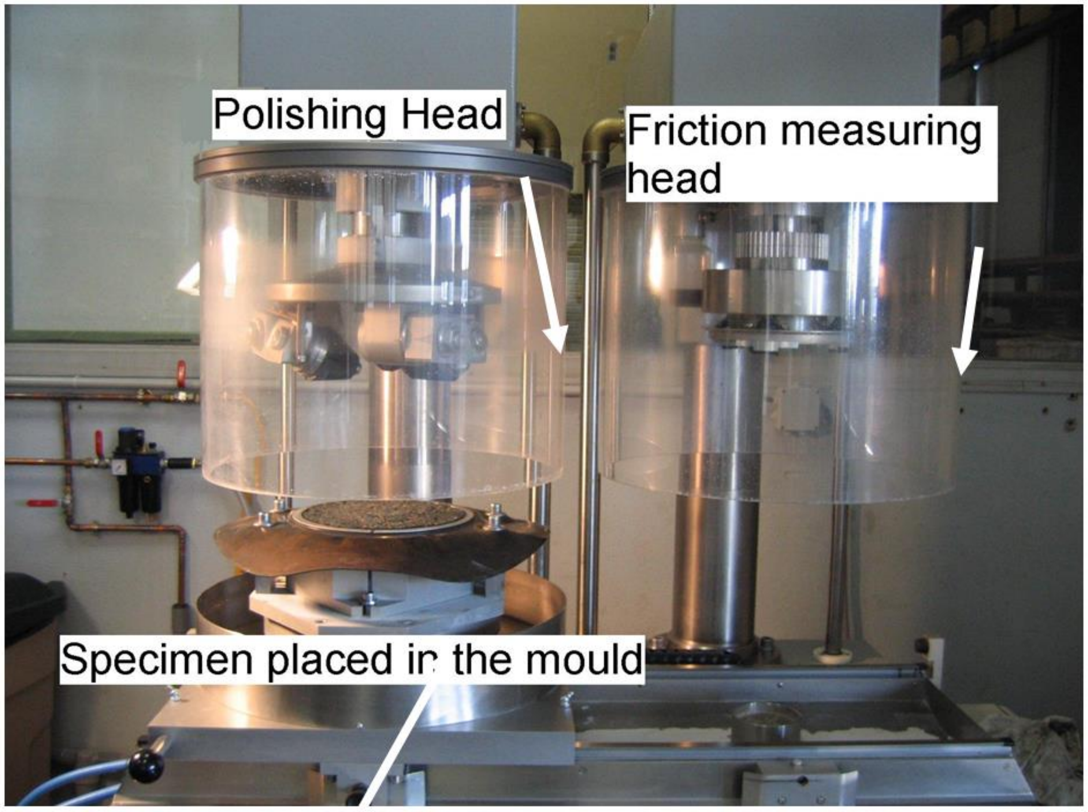


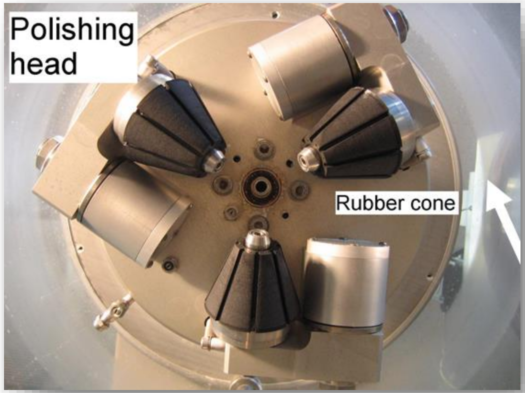


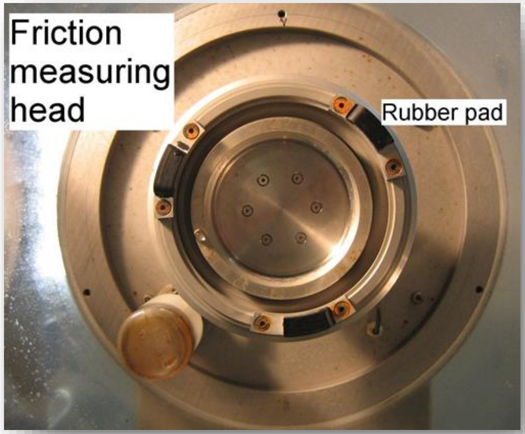


- measuring range in the direction "x": 10 microns
- number of measuring points per profile: 7601
- profile measured by length: 76 mm

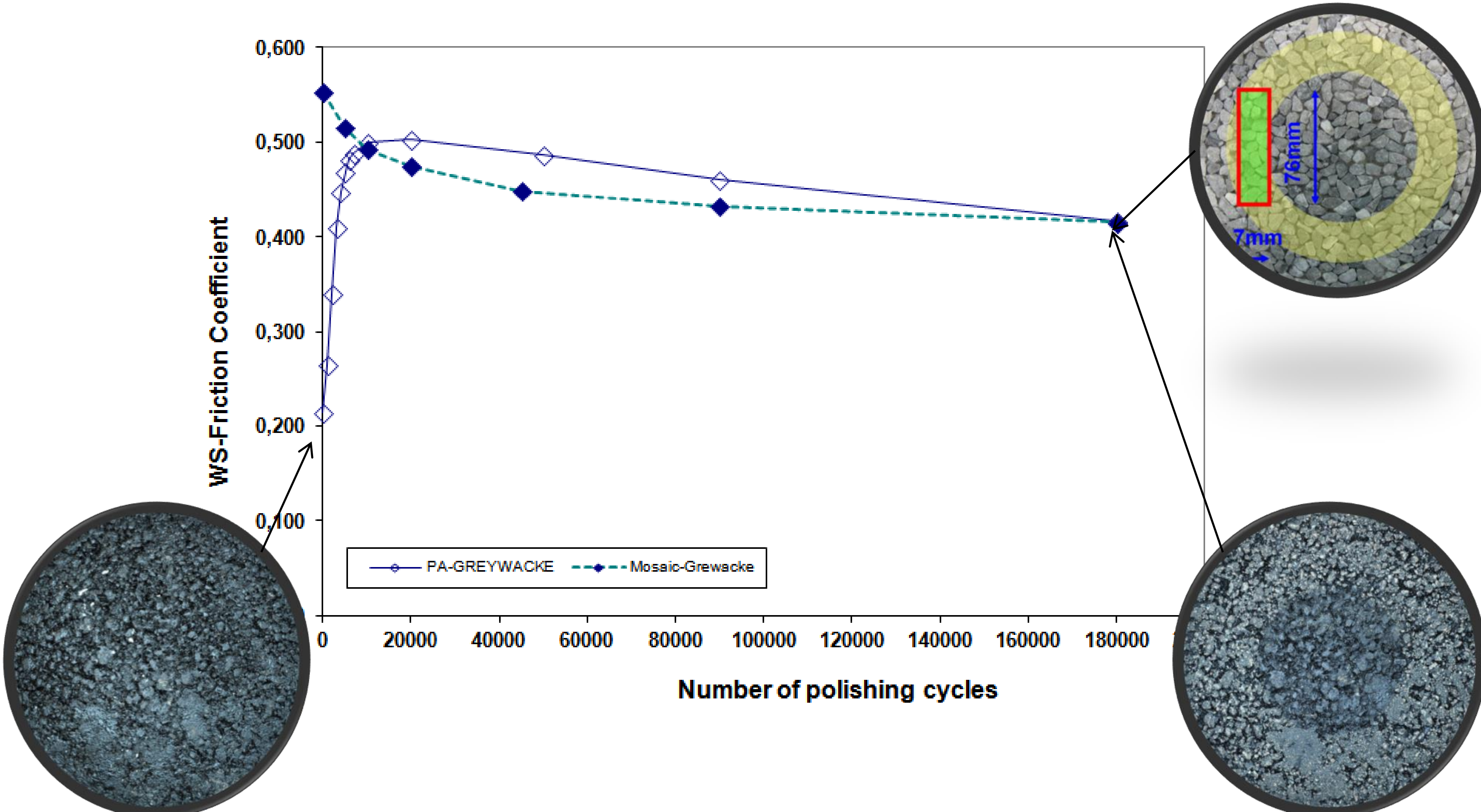
Polishing tests



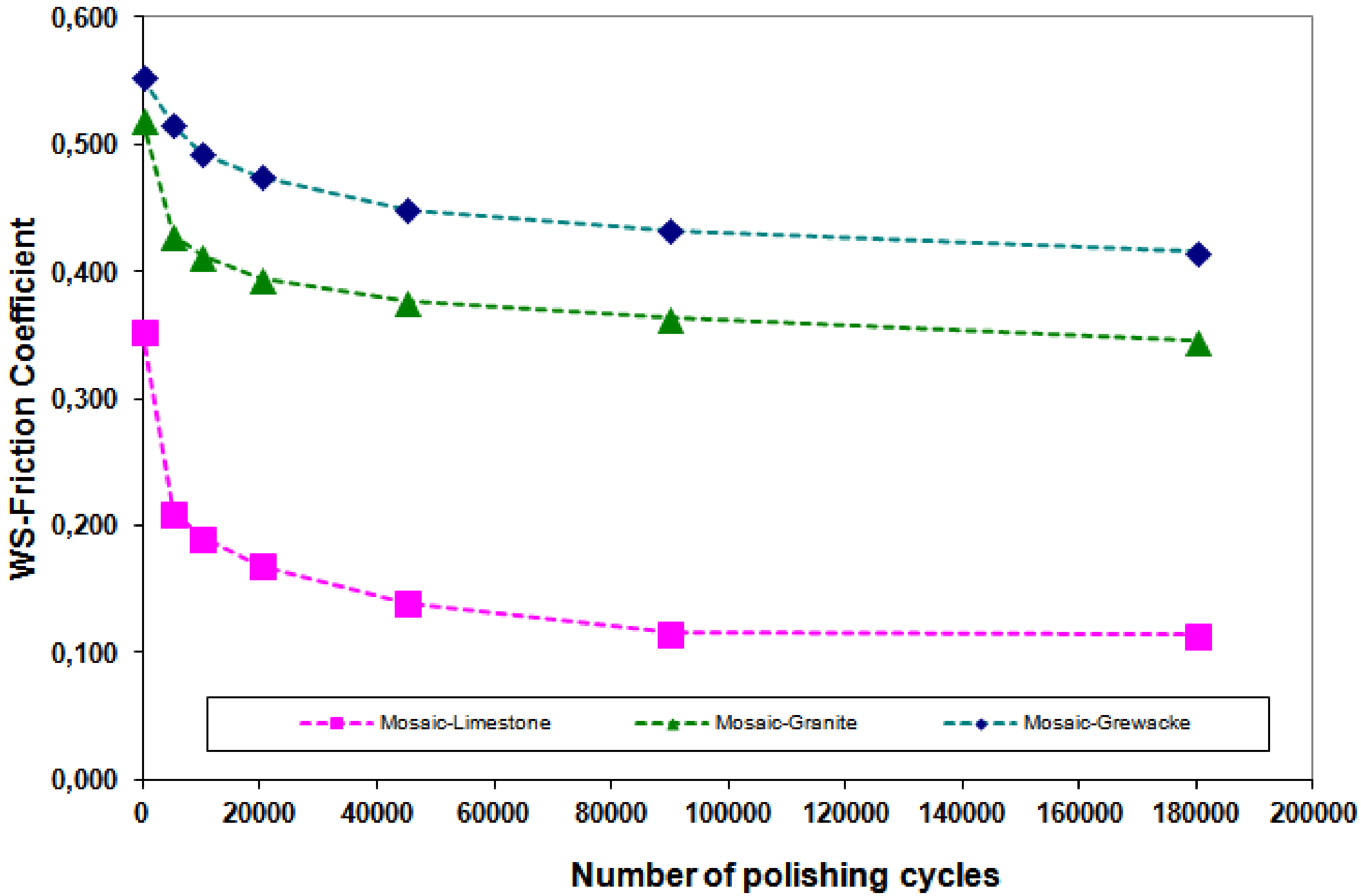




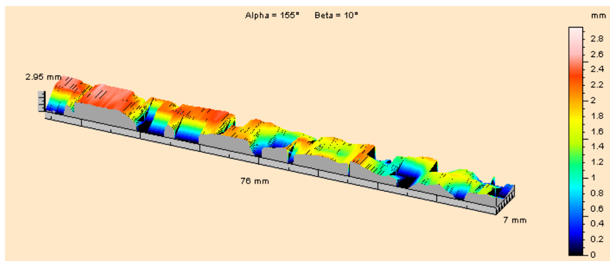
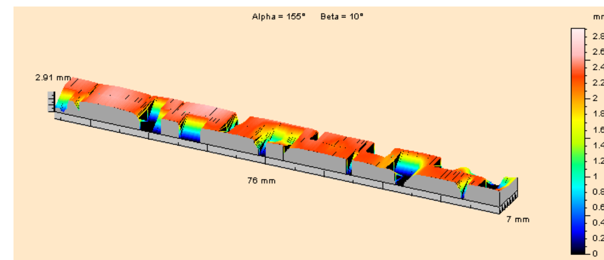
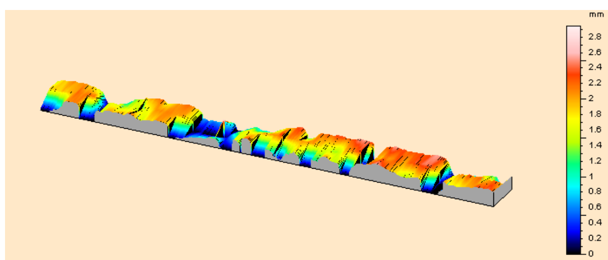
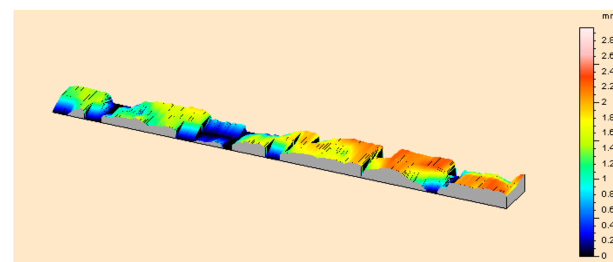
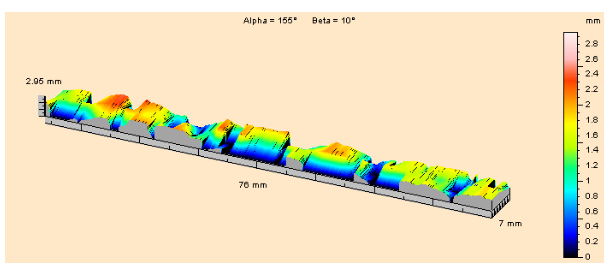
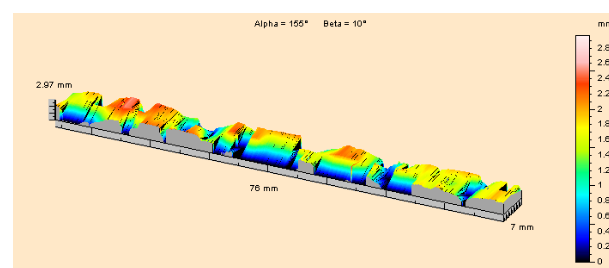
Friction/Polishing



Friction/Polishing



Texture/Polishing

	Initial	After polishing
Limestone		
Granite		
Graywacke		

Texture/Polishing

- Aggregates composed of single minerals of relatively low hardness have a very low resistance to polishing.

- On the other hand, sandstones, composed primarily of hard quartz mineral particles cemented together with a softer mineral matrix, have good frictional properties because of the differential wear and debonding of individual particles.

Aggregate Hardness Parameter (AHP)

$$\mathbf{AHP = dmp_M + cd_M}$$

Where,

- **AHP** is defined as the Aggregate Hardness Parameter of the aggregate.
- **cd**$_M$ and **dmp**$_M$ are respectively the "**Contrast of Hardness**" and the "**Average Hardness**" defined as following:

$$\mathbf{dmp_M = \sum_i p_i\, dv_i}$$

$$\mathbf{cd_M = \textstyle\sum_i |dv_i - dv_b|}$$

***dv**$_i$* is the "Moh's scale hardness value" of each mineral constituting the aggregate and **p**$_i$ is the percentage by mass of each mineral constituting the aggregate. ***dv**$_p$* is the "Moh's scale hardness value" of the most abundant mineral constituting the aggregate.

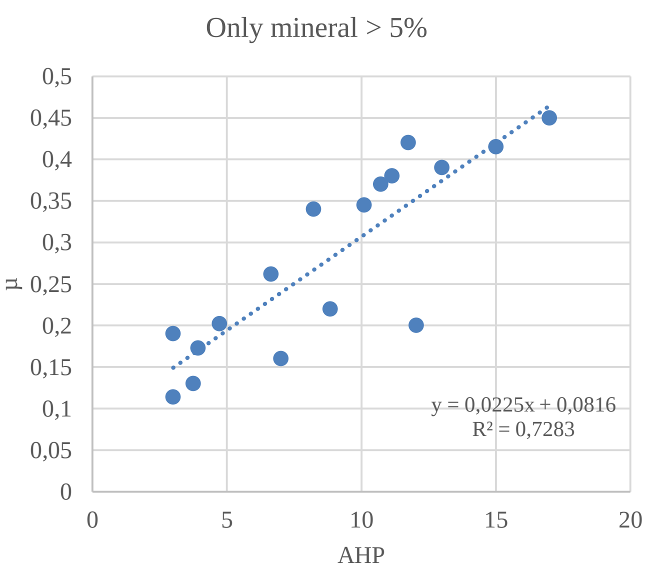
AHP Generalisation

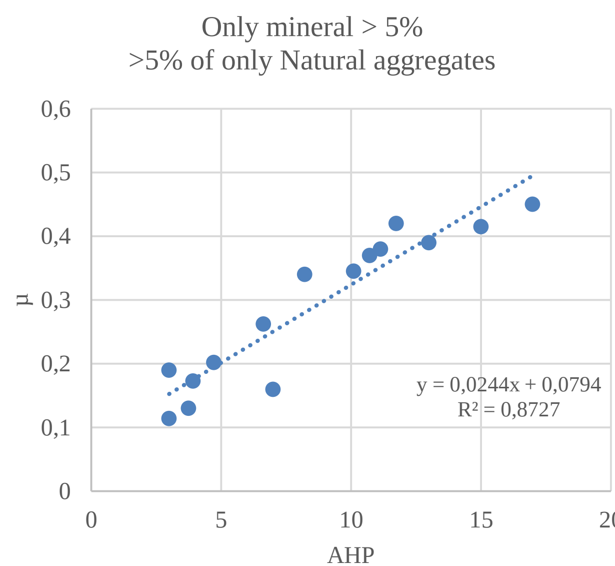
$$\mathrm{AHP_M} = \frac{1}{\sum_{\mathrm{i}}^{\mathrm{N}} \alpha_{\mathrm{i}}} \sum_{\mathrm{i}}^{\mathrm{N}} \alpha_{\mathrm{i}} \times \mathrm{AHP_i}$$

Where N represents the number of aggregates in the mixture.

Analysis and Discussion

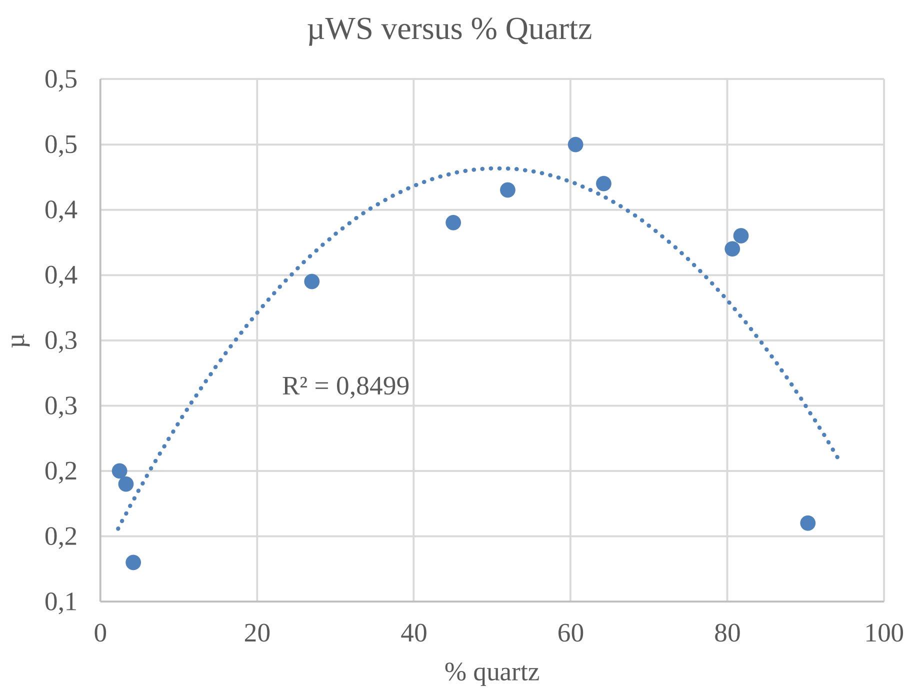
		Dolomite	Limestone (1)	Limestone (2)	Silico-Limestone	Greywacke (1)	Greywacke (2)	Granite	Basalt	Quartzite (1)	Quartzite (2)	Quartzite (3)	Rhyolite / Dacite	Blast Furnace (HF)	Slag Electrical oven (EAF)	(Mixe 1 = 52% Limestone (2) + 40% Basalt	(Mixe 2 = 8% Limestone (2) + 29% Basalt + 54 Quarzitz (3)	Mixe 3 = 70% Limestone (2) + 21% Quarzitz (3)
% Quartz		4	3		81	64	52	27		82	61	90	45	2				
All minerals	AH	3,9	3,1	3	6,4	6,0	5,5	6,1	6,2	6,3	5,7	6,7	6,1	4,9	5,8			
	CH	15,0	6,0	0,0	22,8	21,3	9,5	4,0	7,5	22,0	21,0	13,5	15,8	11,8	6,5			
	AHP	18,9	9,1	3,0	29,2	27,3	15,0	10,1	13,7	28,3	26,7	20,2	21,9	16,6	12,3	4,7	6,6	3,9
Only minrerals > 5 %	AH	3,8	3,0	3	6,7	6,5	5,5	6,1	6,2	6,6	6,2	7,0	6,2	4,8	5,8			
	CH	0,0	0,0	0,0	4,0	5,3	9,5	4,0	2,0	4,5	10,8	0,0	6,8	7,3	3,0			
	AHP	3,8	3,0	3,0	10,7	11,7	15,0	10,1	8,2	11,1	17,0	7,0	13,0	12,0	8,8	4,7	6,6	3,9
μ_{ws} (after polishing)		0,1	0,2	0,1	0,4	0,4	0,4	0,3	0,3	0,4	0,5	0,2	0,4	0,2	0,2	0,2	0,3	0,2





Analysis and Discussion

		Dolomite	Limestone (1)	Limestone (2)	Silico-Limestone	Greywacke (1)	Greywacke (2)	Granite	Basalt	Quartzite (1)	Quartzite (2)	Quartzite (3)	Rhyolite / Dacite	Blast Furnace (HF)	Slag Electrical oven (EAF)	(Mixe 1 = 52% Limestone (2) + 40% Basalt	(Mixe 2 = 8% Limestone (2) + 29% Basalt + 54 Quarzitz (3)	Mixe 3 = 70% Limestone (2) + 21% Quarzitz (3)
% Quartz		4	3		81	64	52	27		82	61	90	45	2				
All minerals	AH	3,9	3,1	3	6,4	6,0	5,5	6,1	6,2	6,3	5,7	6,7	6,1	4,9	5,8			
	CH	15,0	6,0	0,0	22,8	21,3	9,5	4,0	7,5	22,0	21,0	13,5	15,8	11,8	6,5			
	AHP	18,9	9,1	3,0	29,2	27,3	15,0	10,1	13,7	28,3	26,7	20,2	21,9	16,6	12,3	4,7	6,6	3,9
Only minrerals > 5 %	AH	3,8	3,0	3	6,7	6,5	5,5	6,1	6,2	6,6	6,2	7,0	6,2	4,8	5,8			
	CH	0,0	0,0	0,0	4,0	5,3	9,5	4,0	2,0	4,5	10,8	0,0	6,8	7,3	3,0			
	AHP	3,8	3,0	3,0	10,7	11,7	15,0	10,1	8,2	11,1	17,0	7,0	13,0	12,0	8,8	4,7	6,6	3,9
μ_{WS} (after polishing)		0,1	0,2	0,1	0,4	0,4	0,4	0,3	0,3	0,4	0,5	0,2	0,4	0,2	0,2	0,2	0,3	0,2



Conclusion

- An aggregate hardness parameter was defined based on the mineralogical composition of the aggregates and the hardness of the individual mineral grains.
- This parameter was then correlated to the WS-friction coefficient values.
- It was found that the aggregate hardness parameter gives a good indication of the ability of an aggregate to retain its microtexture and consequently its friction properties.

Conclusion

- Aggregates composed of single minerals of relatively low hardness, such as limestones, have a very low resistance to polishing.

- On the other hand, sandstones, composed primarily of hard quartz mineral particles cemented together with a softer mineral matrix, have good frictional properties because of the differential wear and debonding of individual particles under traffic.

Conclusion

Of significance to practitioners are the following observations:

- When choosing the aggregate, the mere knowledge of the mineralogical composition of aggregates is enough to estimate the final skid resistance that will be offered the road.

- This information may be sufficient to predict the lifetime of the wearing course, duration beyond which the layer must be renewed.

Thanks! Questions?