GDAŃSK UNIVERSITY OF TECHNOLOGY

LOTOS Asfalt Seminar
12th February 2019, Ryga LATVIA

Use of polymer modified bitumens in road and special pavements

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Outline

- Introduction
- Three research projects
  - Bitumens for Polish climate
  - Poroelastic pavement
  - Typical pavement structures with HiMA
- Summary

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Introduction

Gdańsk Univeristy of Technology (1 from 14)

- Faculty of Civil and Environmental Engineering (1 from 9)
  - Department of Highway and Transportation Engineering (1 from 12)
    - Road Construction Division (1 from 2)
      - » 13 employees; main fields of insteresting:

Bitumen and Asphalt Mixture Properties; Overloaded Vehicles; Flexible and Rigid Pavement Design; Crumb Rubber in Asphalt Mixture Cold, Warm and Hot Recycling of Pavement; WMA Geotextiles; Subgrade and Subbase; Climate

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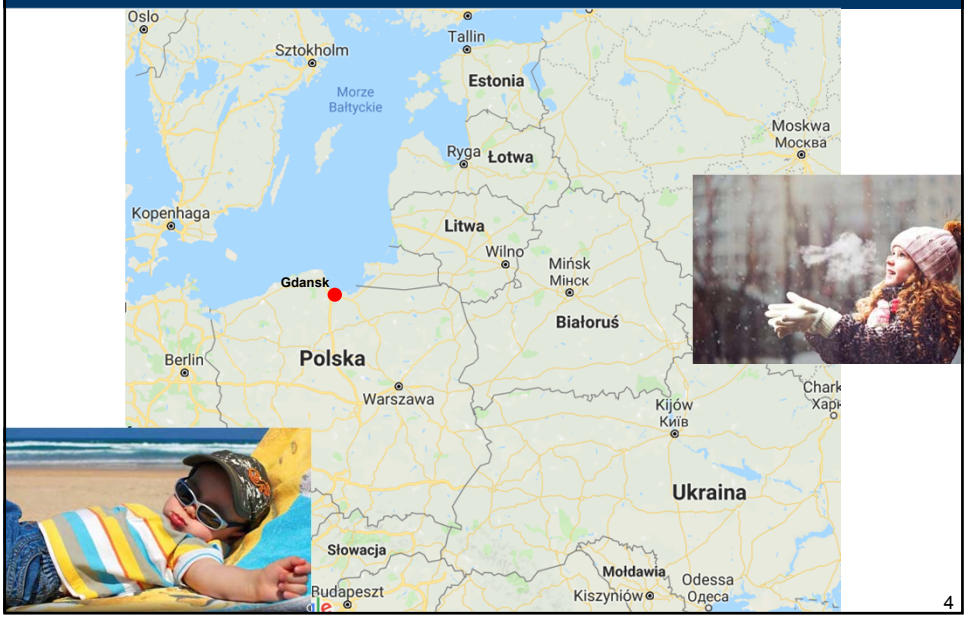
Introduction (2)



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1. Research program

The National Centre for Research and Development

GDDKiA

DEVELOPMENT OF ROAD INNOVATIONS (RID) – PROGRAM 2016-2018

„Bitumen in Polish climate conditions”

Research Group:
Warsaw University of Technology
Gdańsk University of Technology
Road and Bridges Research Institute, Warsaw

POLITECHNIKA GDAŃSKA
WYDZIAŁ INŻYNIERII LĄDOWEJ I ŚRODOWISKA

Instytut Badawczy Dróg i Mostów

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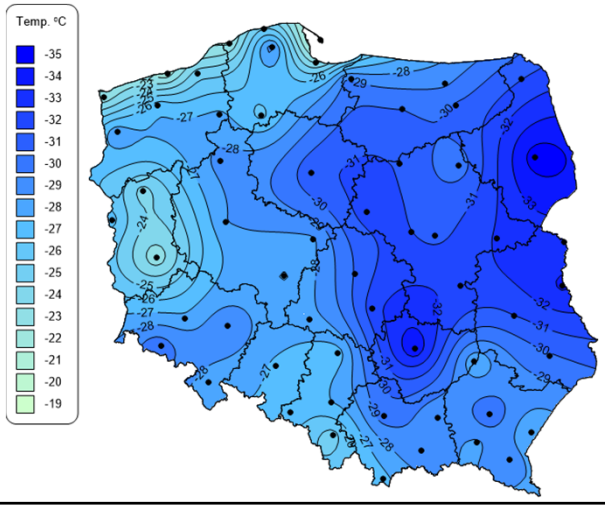
Climate

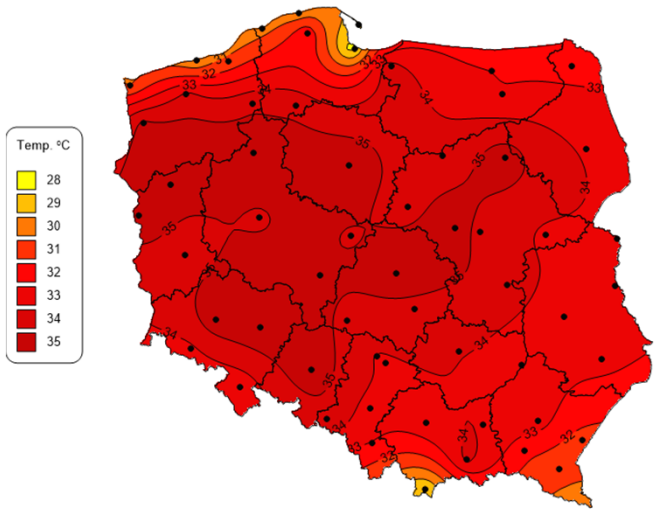
Influence of climate in Poland
– the lowest air temperatures between 1986 - 2015:



6

Climate (2)

Influence of climate in Poland
– the highest air temperatures between 1986 - 2015:



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Support by PG specification

Performance Grade (PG) of bitumen according to Strategic Highway Research Program (SHRP) - USA

The grading system of bitumens

PG 58 -28

Performance Grade

Average 7-day max pavement temperature

Min pavement temperature

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Bitumen PG Specification

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
1-day Min, °C	-34 -40 -46	-10 -16 -22 -28 -34 -40 -46	-16 -22 -28 -34 -40	-10 -16 -22 -28 -34 -40	-10 -16 -22 -28 -34 -40	-10 -16 -22 -28 -34	-10 -16 -22 -28 -34
ORIGINAL							
≥ 230 °C	(Flash Point) FP						
≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV						
≥ 1.00 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ						
	46	52	58	64	70	76	82
(ROLLING THIN FILM OVEN) RTFO Mass Loss ≤ 1.00 %							
≥ 2.20 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ						
	46	52	58	64	70	76	82
PAV Aged	(PRESSURE AGING VESSEL) PAV						
20 Hours, 2.07 MPa	90	90	100	100	100 (110)	100 (110)	110 (110)
≤ 5000 kPa	(Dynamic Shear Rheometer) DSR G* sin δ						
	10 7 4 25 22 19 16 13 10 7 25 22 19 16 13 31 28 25 22 19 16 34 31 28 25 22 19 37 34 31 28 25 40 37 34 31						
S ≤ 300 MPa m ≥ 0.300	(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value						
	-24 -30 -36 0 -6 -12 -18 -24 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 -18 -24						
Report Value	(Bending Beam Rheometer) BBR Physical Hardening						
≥ 1.00 %	(Direct Tension) DT						
	-24 -30 -36 0 -6 -12 -18 -24 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 -18 -24						

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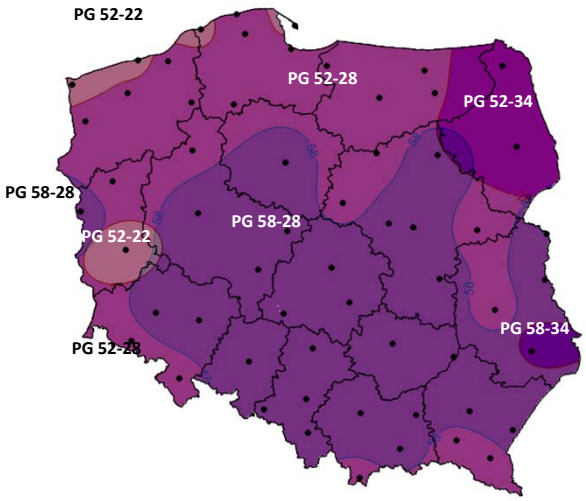
Bitumens for Poland

acc. to PG specification

Wearing course

- PG 52-22
- PG 52-28
- PG 52-34
- PG 58-22
- PG 58-28
- PG 58-34



P=98%

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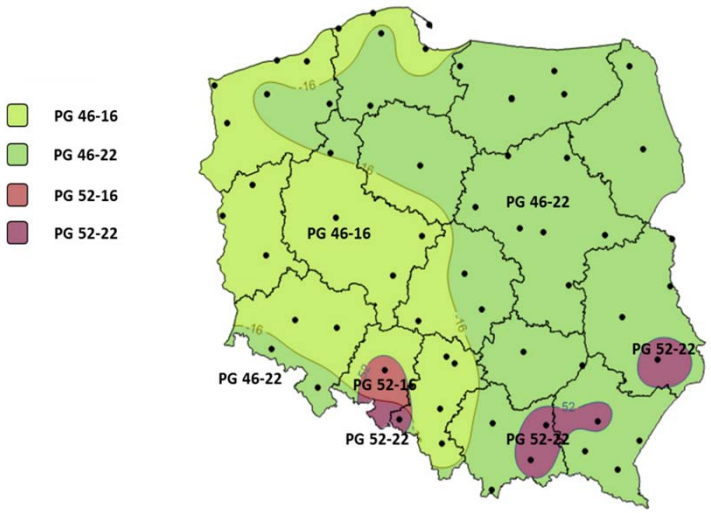
Bitumens for Poland (2)

acc. to PG specification

Wearing course

P=50%



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Bitumens for other countries

acc. to PG specification

Probability level	Belarus			Estonia		Poland			Ukraine		
	Zone 1 N-E	Zone 2 C and W	Zone 3 S-E	Zone 1 E	Zone 2 N-E W and S	Zone 1 E, N-E	Zone 2 C, S, W	Zone 3 Coast	Zone 1 S and S-E	Zone 2 W	Zone 3 E
98%	52-34	52-28	58-28	58-34 58-40	58-28 58-34	52-34 58-34	52-28 58-28	52-22	64-28	58-34	64-34
95%	-	-	-	-	-	**52-28**	**52-28**	**52-22**	-	-	-
80%	-	-	-	-	-	52-28	52-22	46-22 46-16	-	-	-
50%	-	-	-	-	-	46-22	46-22 46-16	46-16	-	-	-

Leonovich I., Melnikova I. 2012 Influence of Temperature on the Formation of Damages in Asphalt Concrete Pavements under Climatic Conditions of the Republic of Belarus, *The Baltic Journal of Road and Bridge Engineering*, Vilnius: Technika, Vol VII, No 1, p. 42-47, DOI: 10.3846/bjrbe.2012.06

Teymourpour P., Bahia H. 2015 Implementation of the Bitumen Performance Grading System in Estonia, Tallinn, 2015 (presentation)

Pszczoła M., Ryś D., Jaskuła P. 2017 Analysis of climatic zones in Poland with regard to asphalt performance grading, *Roads and Bridges - Drogi i Mosty* 16, 4, 245-264, doi: 10.7409/rabdim.017.016

Zolotareyov V., Pyrig Y. 2018 The application of the method of selecting a brand of bituminous binder, in accordance with the Superpave system, in the conditions of Ukraine, *Вестник ХНАДУ*, вып. 82, DOI: 10.30977/BUL.2219-5548.2018.82.0.119

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Bitumens produced in Poland

Binder classification according to EN	Binder classification according to PG	Penetration at 25°C, 0,1 mm		Softening point by R&B, °C		Fraass breaking point, °C		Elastic recovery at 25°C, %	
		Measured	Required	Measured	Required	Measured	Required	Measured	Required
20/30	**82-10**	26	20-30	62	55 – 63	-7	NR	-	-
35/50	**70-10**	41	35-50	55	50 – 58	-15	≤ -5	-	-
50/70	**64-16**	62	50-70	49	46 – 54	-9	≤ -8	-	-
70/100	**64-22**	82	70-100	46	43 – 51	-14	≤ - 10	-	-
MG 35/50-57/69	**82-***	43	35-50	65	57 – 69	-20	≤ -15	-	-
MG 50/70-54/64	**82-***	52	50-70	63	54 – 64	-20	≤ -17	-	-
PMB 10/40-65	**82-10**	32	10-40	65	≥ 60	-16	≤ - 5	71	≥ 60
PMB 25/55-60	**88-10**	31	25-55	69	≥ 60	-14	≤ - 10	82	≥ 60
PMB 25/55-60 CR	**82-22**	41	25-55	61	≥ 60	-18	≤ - 10	80	≥ 60
PMB 45/80-55	**76-22**	59	45-80	60	≥ 55	-17	≤ - 15	85	≥ 70
PMB 45/80-55 CR	**82-22**	49	45-80	62	≥ 55	-21	≤ - 15	98	≥ 70
PMB 45/80-65	**82-22**	47	45-80	76	≥ 65	-17	≤ - 15	84	≥ 80
PMB 48/80-80	**88-22**	53	45-80	93	≥ 90	-21	≤ - 18	94	≥ 80

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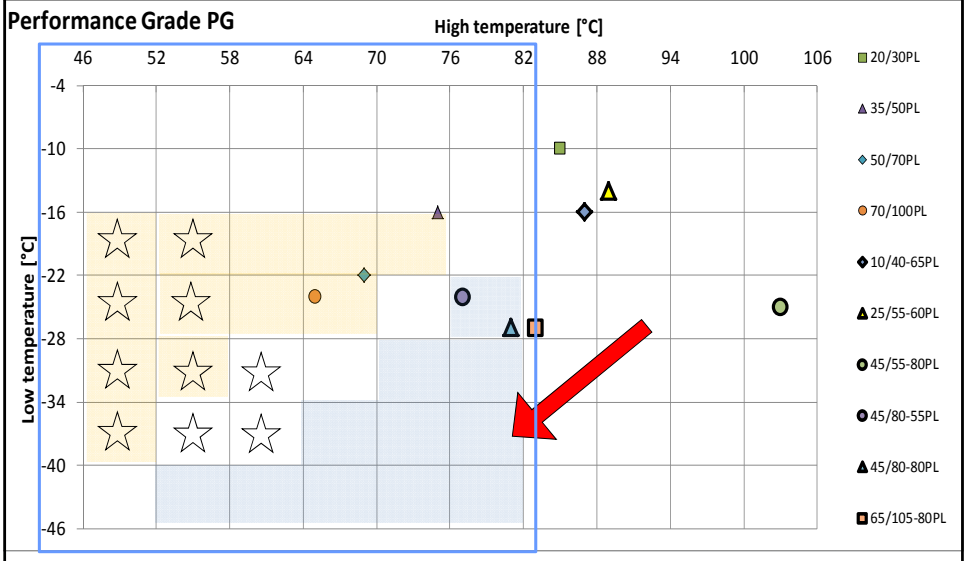
Bitumens produced in Poland



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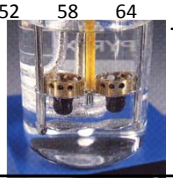
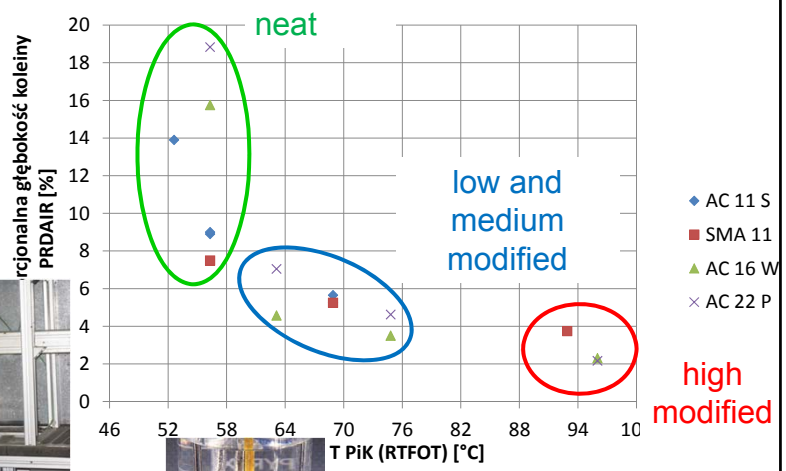
High temperature properties (2)





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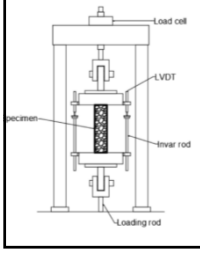
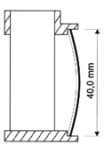
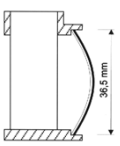
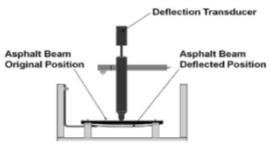
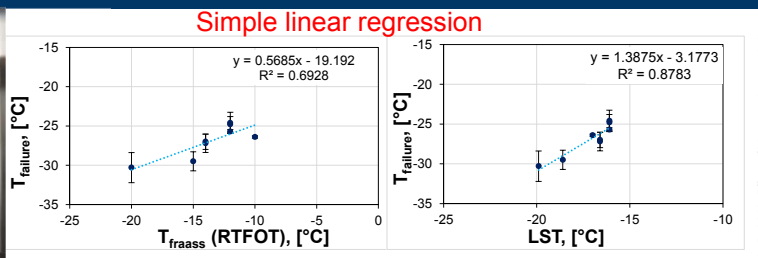
Low temperature properties











Rys D., Pszczola M., Jaczewski M., Jaskula P. 2019 Effect of bitumen characteristics obtained according to EN and Superpave specifications on asphalt mixture performance in low-temperature laboratory tests. EATA 2019

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Low temperature properties (2)

Multiple linear regression - bitumen properties and the TSRST results of asphalt mixtures

Multiple regression model	Regression adjusted R^2	Standard error of the regression
$T_{failure} = 0.55 \cdot T_{Fraass} + 0.23 \cdot LST + 0.78 \cdot LmT - 4.7$	0.930	0.563
$\sigma_{cry} = 0.0037 \cdot S_{bin\,60s} - 5.216 \cdot m_{bin\,60s} + 5.261$	0.968	0.180

Rys D., Jaczewski M., Pszczola M., Jaskula P. 2019 Effect of bitumen characteristics obtained according to EN and Superpave specifications on asphalt mixture performance in low-temperature laboratory tests, EATA 2019, in press

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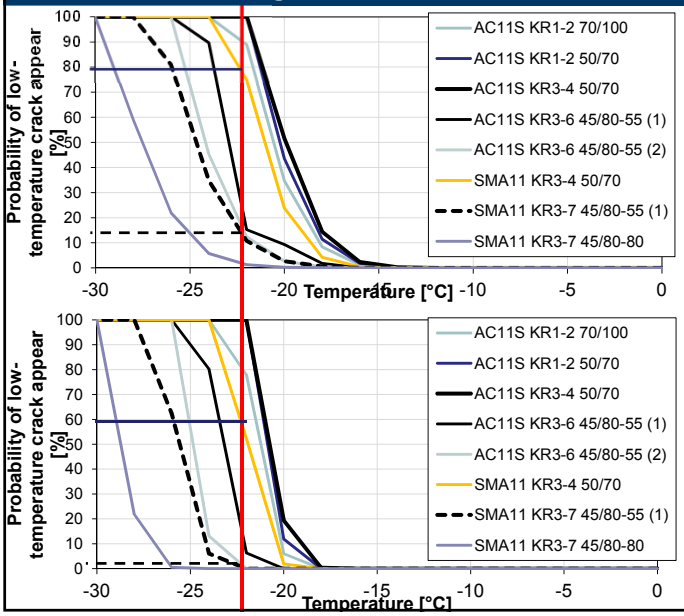
Probability of low-temperature crack



Variability +/-20% „standard quality of works”

Variability +/-10% „high quality of works”

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2. Research program

Safe, eco-friendly poroelastic road surface (SEPOR)

Finansed by NCRD
TECHMATSTRATEG 1/347040/17/NCBR/2018

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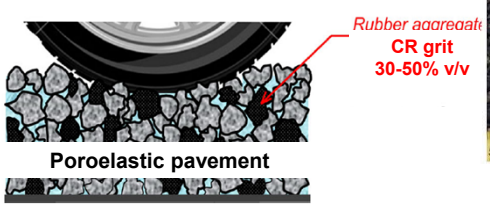
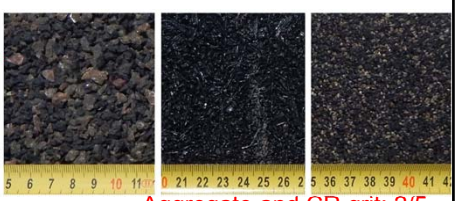
SEPOR - Aim

Development of innovative poroelastic pavement, where is used crumb rubber grit instead of aggregate which:

- extremly decrease traffic noise (10-12 dB)
- increase safety by high waterpermeability and high skid reisistance
- improve properties of fire suppression from spills of liquid fuels





Aggregate and CR grit: 2/5,

Air voids: 30% Binders: HiMA, epoxy

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State of the art

- World
  - 1985 – PEAC (3-5 dB): von Meier and Heerkens
  - 1993 – PERS (10 dB): Meiarashi
  - 2004 – PERS (10 dB): Sandberg & Ejsmont
  - 2005 – PERS QCITY (7 dB): Ulmgren & Nilson
  - 2009 – PERSUADE (11 dB): Sandberg & Goubert
    - 2015 – finished PERSUADE (lack of durrability)
- Poland
  - 2004 – QCITY i PERSUADE: Ejsmont
  - 2018-2021 – SEPOR

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State of the art (2)

Problems

- Production of mixture because of epoxy resin
- Raveling and low cohesion of mixture – finer mineral-rubber mixture
- Durability of layer – finer mixture, binder
- Lack of interlayer bonding (3 days – 1.5 y) – gradient of stiffness and special tack coat
- Weakening of bitumen over time (chemical diffusion) – pre-treat of crumb rubber

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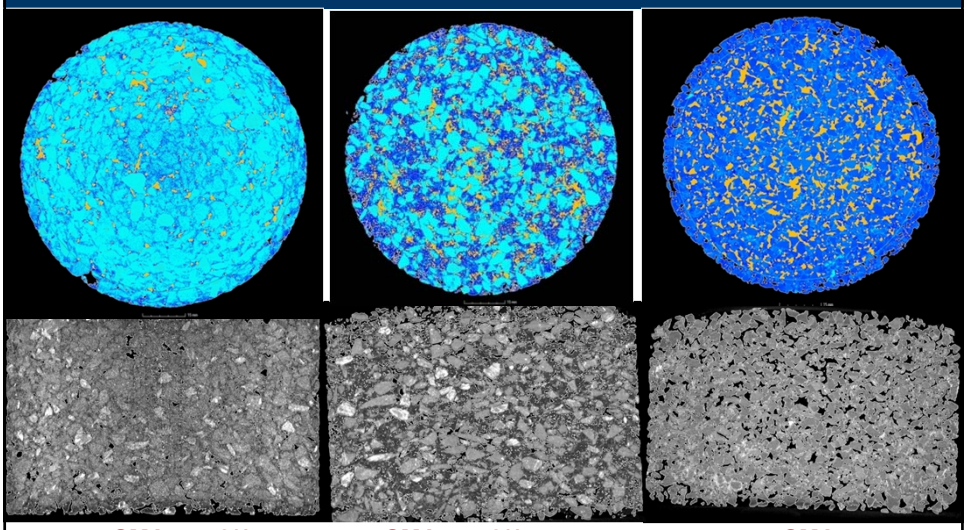
Laboratory tests

1. Resilient Modulus IT-CY, 25°C
2. Indirect Tensile Strength ITS, 25°C
3. Axial Compression Strength, 25°C
4. Cantabro Test, 25°C
5. In-layer Shear Strength (Leutner), 20°C
6. Wheel Tracking Test, small device, 60°C
7. Plate polisher (PB)

Politechnika Białostocka

Laboratory tests (2)



SMA 5 w 2/1	SMA 5 w 2/1	SMA 4
CR=0%	CR=15%m/m (33%v/v)	CR=85%m/m (93%v/v)
v=3,7%, b=7,1%m/m	v=16,6%, b=10%m/m	v=31,3%, b=22%m/m

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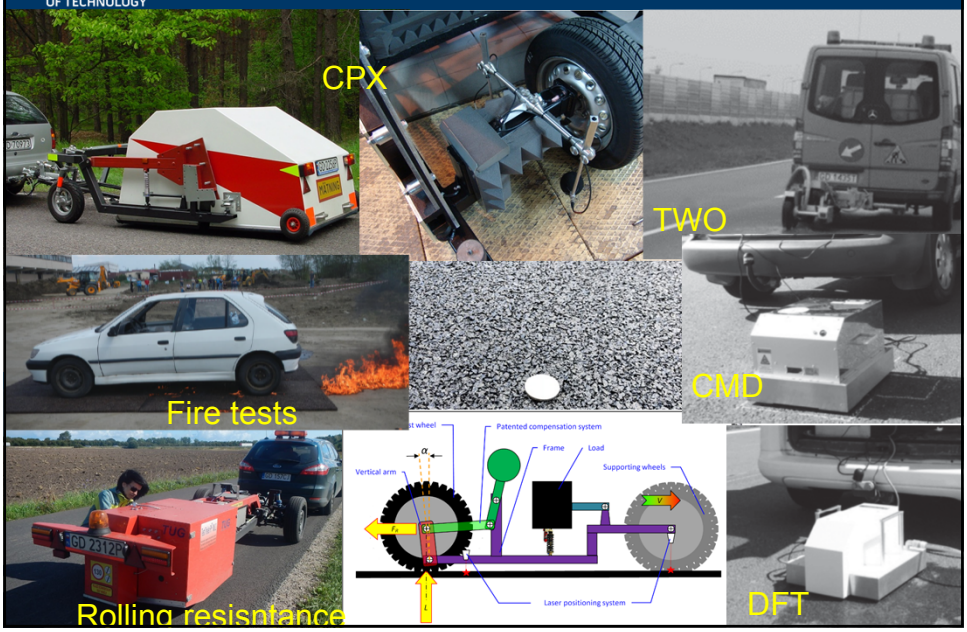
Trial section…

Trial section (2)



3. Research program

Optimization of asphalt pavement structure with polymer modified bitumen – Stage I and II

Research Group:
Gdańsk University of Technology
Warsaw University of Technology
Road and Bridges Research Institute, Warsaw

Finansed by LOTOS (Stage II some others also)

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Aim

Development of pavement structures using high polymer modified bitumen (HiMA):

- with extended fatigue life or
- optimized (reduced thickness) pavement with the same fatigue life as typical catalogue solutions

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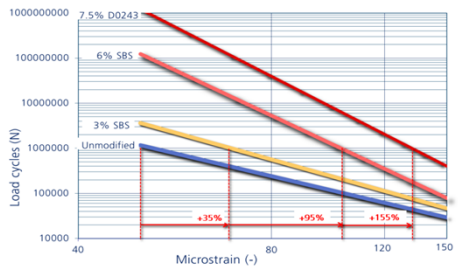
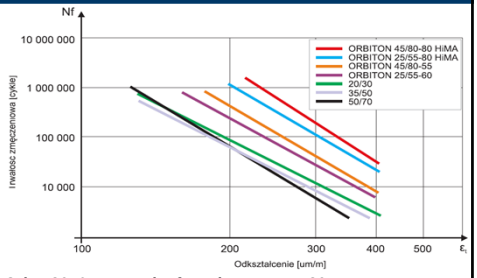
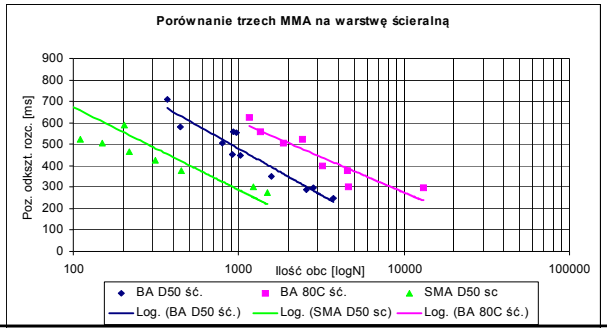
State of the art



Kraton, 2011; research of TU Delft, 2009



Orlen 2016, research of IBDiM Warsaw, 2015



Lotos 2001, research of Gdansk UT, 2000

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Conception of pavement structure

Possible thickness reduction of asphalt layers

- Typical structure acc. to KTKNPiP 2014
  - 20% - 5 cm (binder/base course PmB),
  - 30% - 8 cm (binder/base course H-PmB)
- Pavement structure with HMAC
  - 10% - 3 cm (binder PmB),
  - 30% - 8 cm (binder PmB, base H-PmB)
- Perpetual pavements
  - 10% - 3 cm and 66% increase in fatigue life to 50 y (binder PmB, base H-PmB)

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Stage II

- Advanced tests of bitumen
- Advanced tests of asphalt mixture (long time consuming)
- Results analysis – **proof of thesis** – PmB extend fatigue life of mixture and pavement
- Calculation analysis and pavement structures **(catalogue of special pavements)**
- Required properties of bitumen and mixture to verified design assumptions in the field:
  - Fatigue life and stiffness modulus,
  - Permanent deformation and low-temperature cracking.

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Summary

- **PmB would be good solution in the region with the influence of cold climate**
- **PmB increase resistance of asphalt mixture to permanent deformation**
- **PmB extend fatigue life of asphalt mixture and pavement**
- **HiMA can be proper binder for durable poroelastic surface (SEPOR)**
- **Use of HiMA will reduce the thickness of asphalt layers or much extend the fatigue life**

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Paldies par uzmanību!

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LOTOS Asfalt Seminar
12th February 2019, Ryga LATVIA

Use of polymer modified bitumens in road and special pavements

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