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APPLICATION OF POLYMER MODIFIED BITUMEN IN ROAD CONSTRUCTION – EXPERIENCES, TESTS AND CHALLENGES

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Introduction

- **Polymer Modified Bitumen (PmB) has been used from a long time to provide higher performances to bituminous mixes**
- **Reason 1: increase of traffic**
- **Reason 2: better resistance to temperature variation – the highest temperature during hot summer and the lowest temperature during cold winter**

Low temperature cracking of asphalt pavements

Very important issue: stiffness of asphalt mixture at low temperatures!

Deformations of asphalt pavements (rutting)

Very important issue: asphalt mixture composition!

Description of PmB material …

Asphalt binder

+

SBS Polymer Modification

=

Final product – asphalt mixture

Crumb Rubber additive

Example of PmB bitumen properties

Property	Type of bitumen			
	45/80-55 PmB	45/80-55 CR	45/80-65 PmB	45/80-65 CR
Penetration in 25°C, 0,1 mm, acc. PN-EN 1426	43	53	52	45
R&B Temperature, °C, acc. PN-EN 1427	60	55	72	76
Dynamic viscosity, Pa·s, acc. PN-EN 12596				
90°C	35,321	19,058	43,728	81,833
135°C	1,225	0,859	1,813	1,947
160°C	0,373	0,303	0,596	0,563

Advantages of polymer modification

- Improve of temperature sensitivity and resistance to rutting
- Improve of low temperature properties and resistance to cracking
- Better resistance to fatigue cracking
- Better resistance to ageing of bitumen

Lower sensitivity of PmB bitumen means:

- **Higher stiffness in high summer temperatures**
- **Lower stiffness in low winter temperatures**

than conventional bitumens.

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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

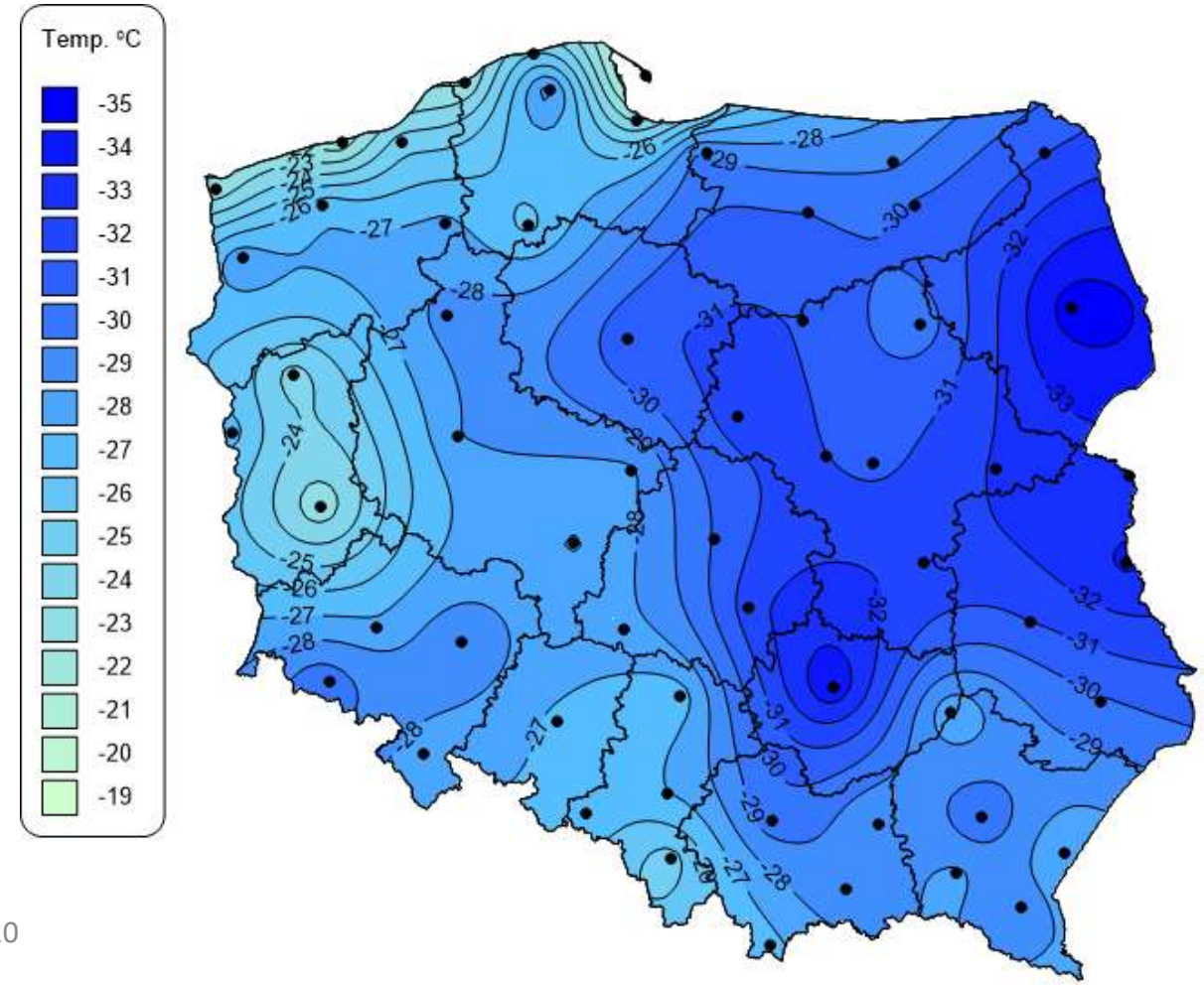
Gdańsk University of Technology

Road and Bridges Research Institute

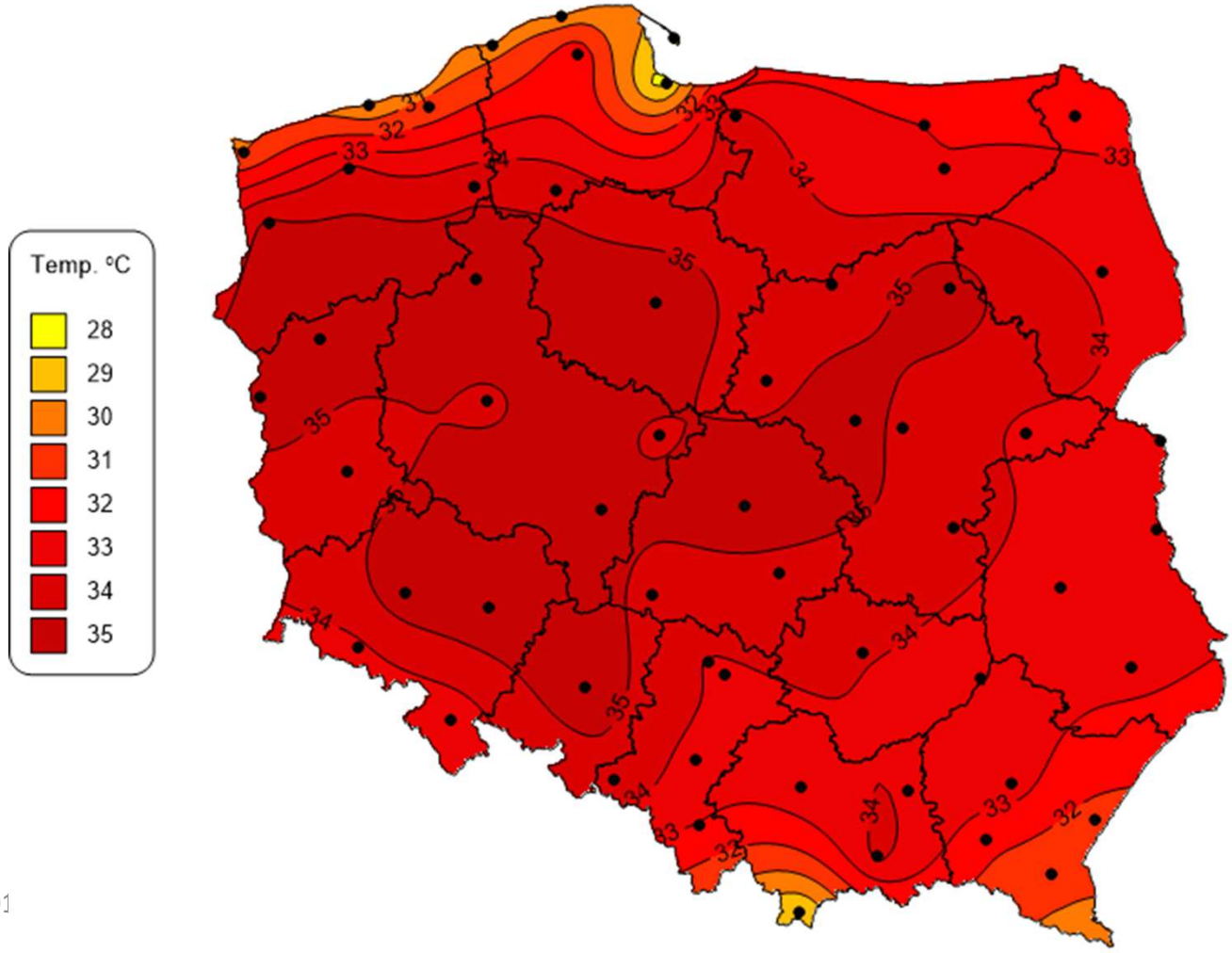
POLITECHNIKA GDAŃSKA
WYDZIAŁ INŻYNIERII LĄDOWEJ I ŚRODOWISKA

Instytut Badawczy Dróg i Mostów

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



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



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

The grading system is based on climate

PG 58 -28

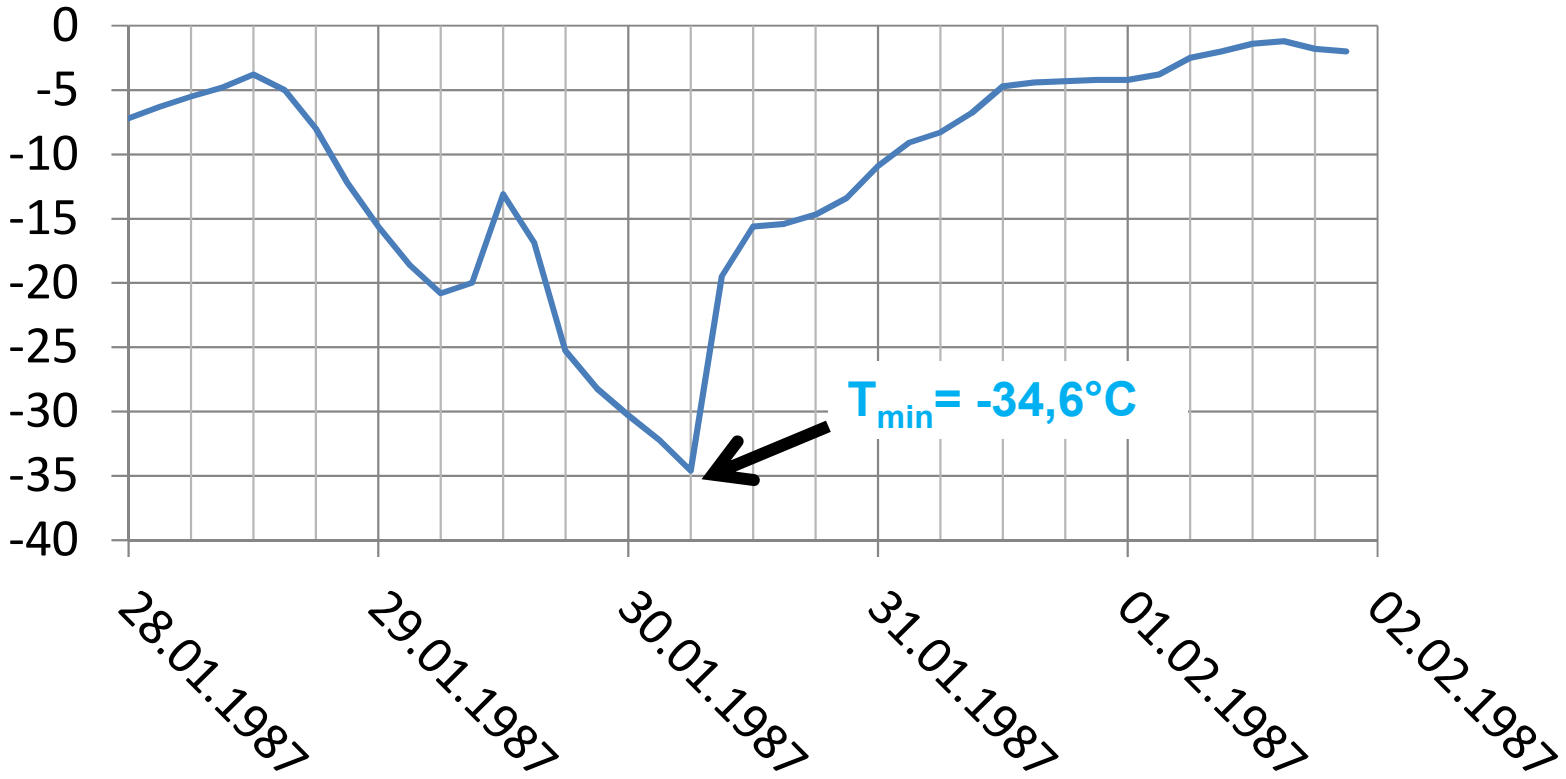
Performance Grade

Average 7-day max pavement temperature

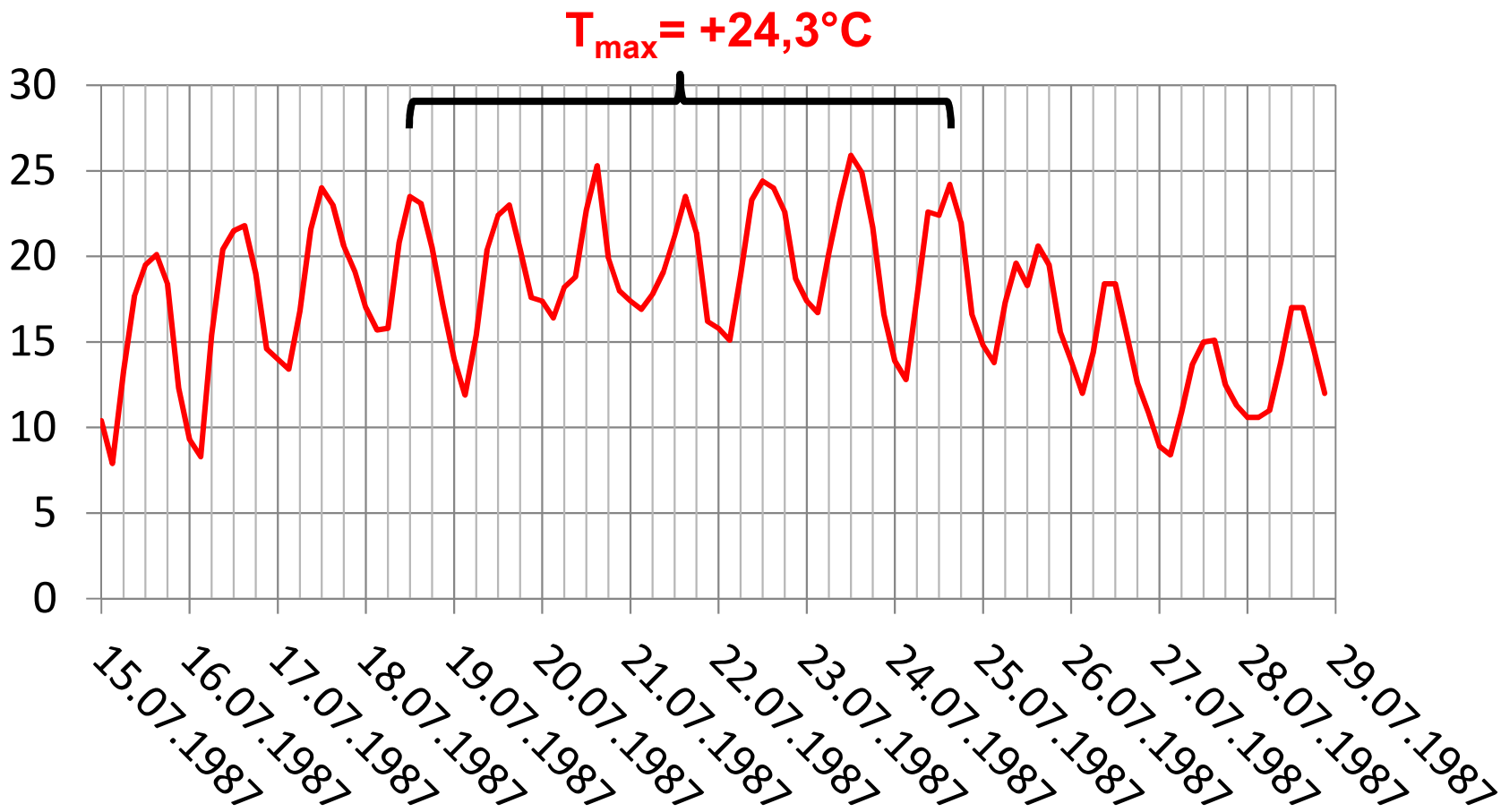
Min pavement temperature

For example: Białystok, the lowest air temperature during 1986 – 2015

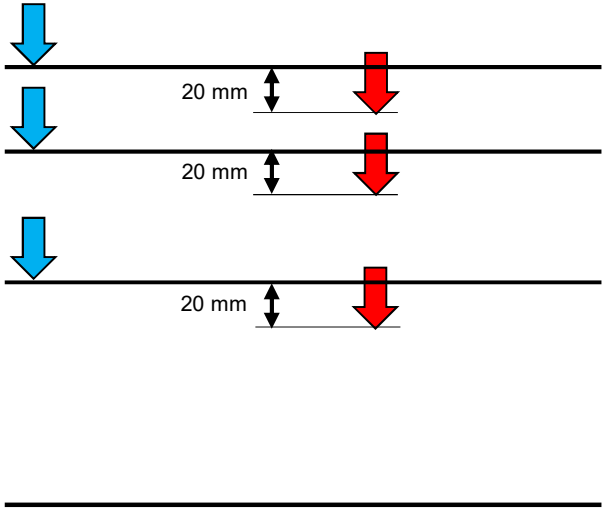
T_{min}= -34,6°C, 30.01.1987



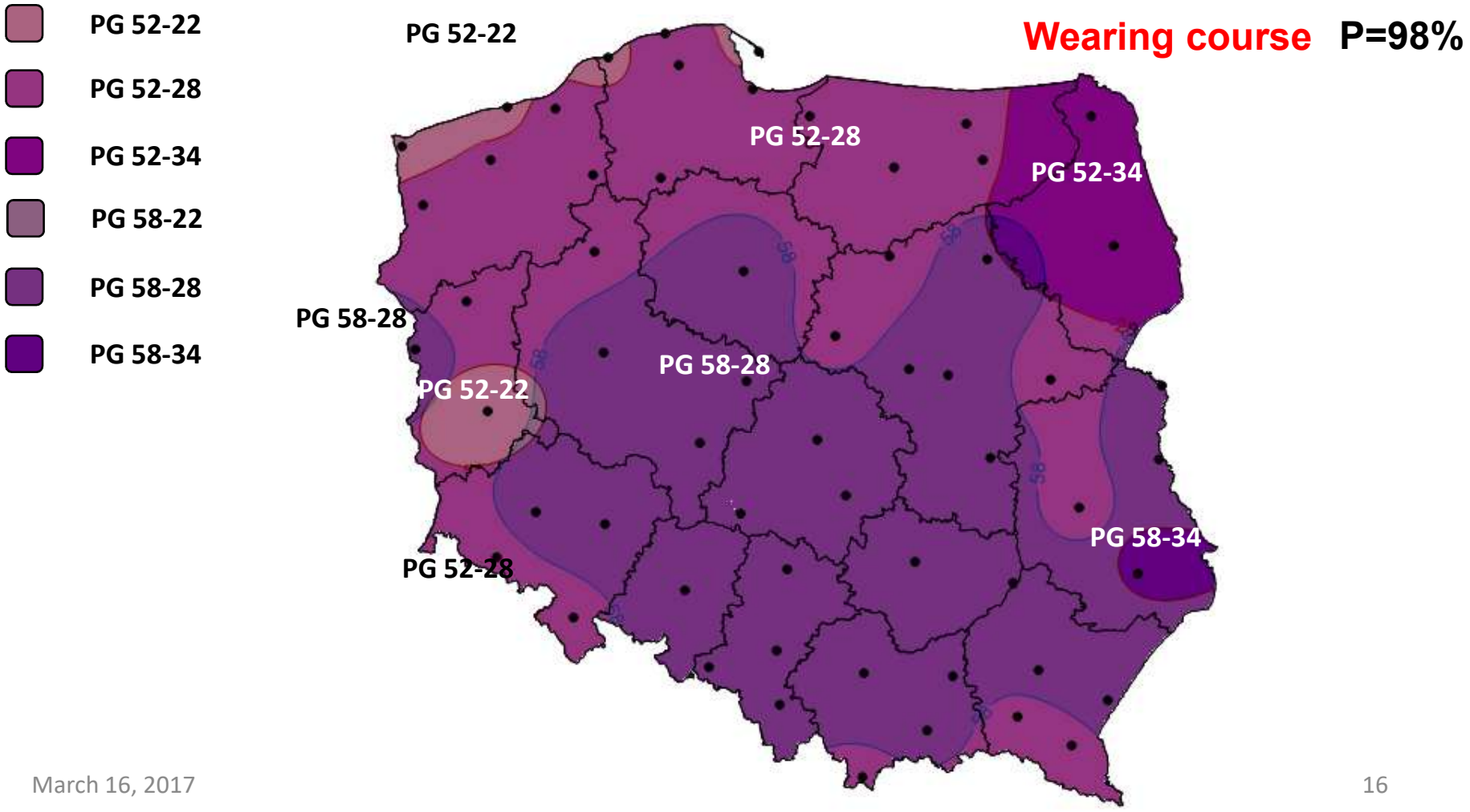
For example: Białystok, the average 7-day max air temperature in 1987



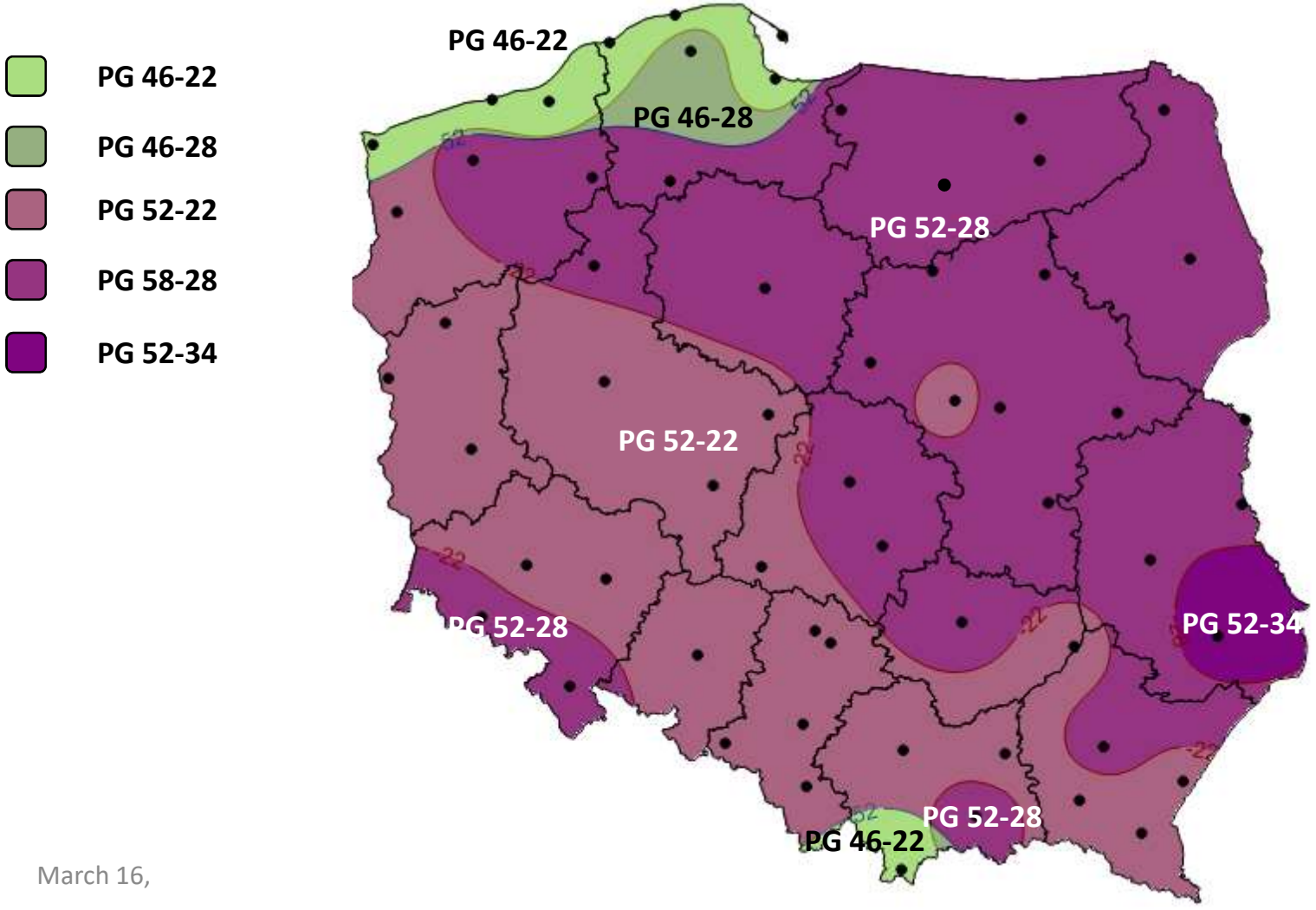
Influence of climate in Poland – pavement temperature:



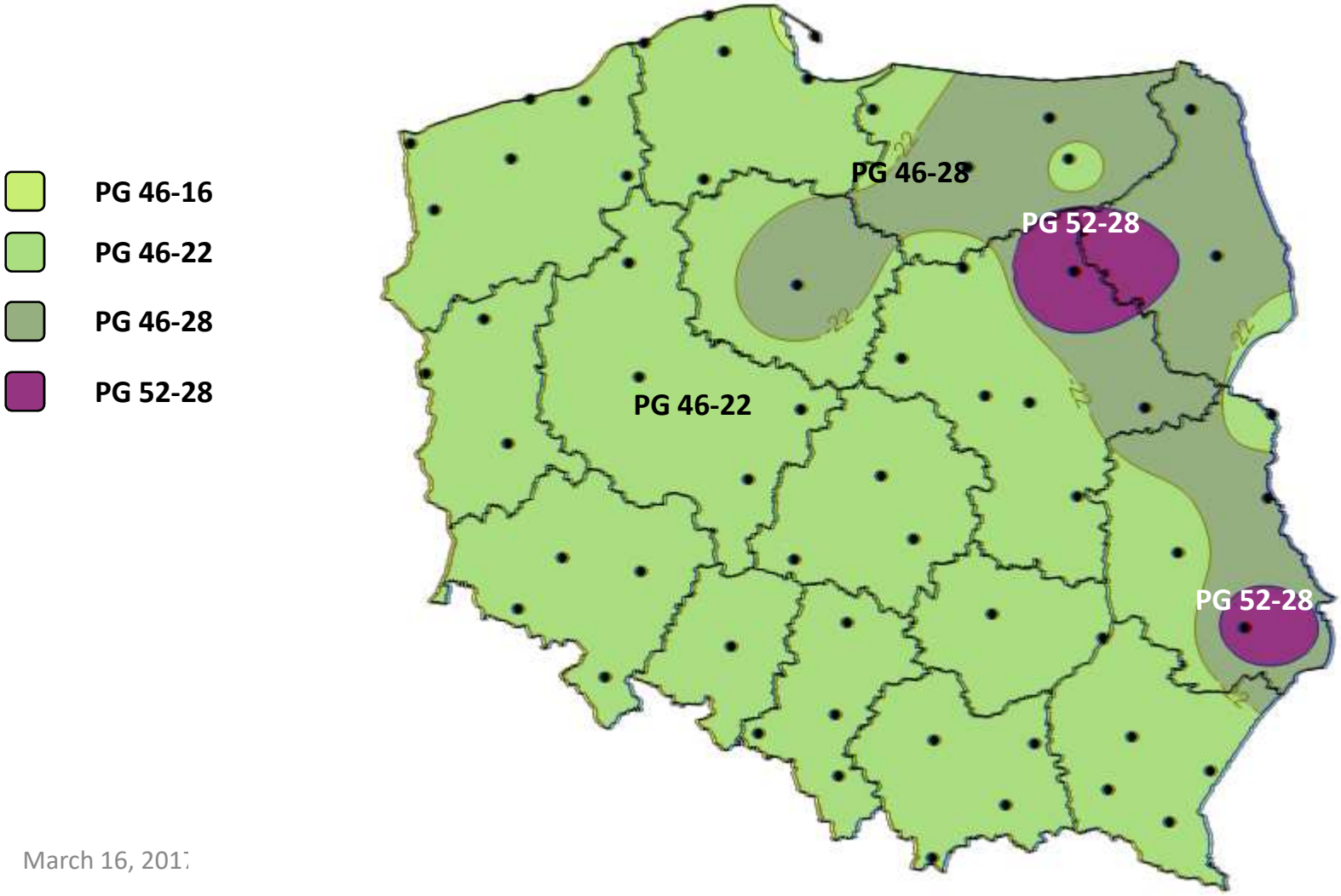
Influence of climate in Poland – Performance Grade (PG) of bitumen:



Binder course P=98%



Base course **P=98%**



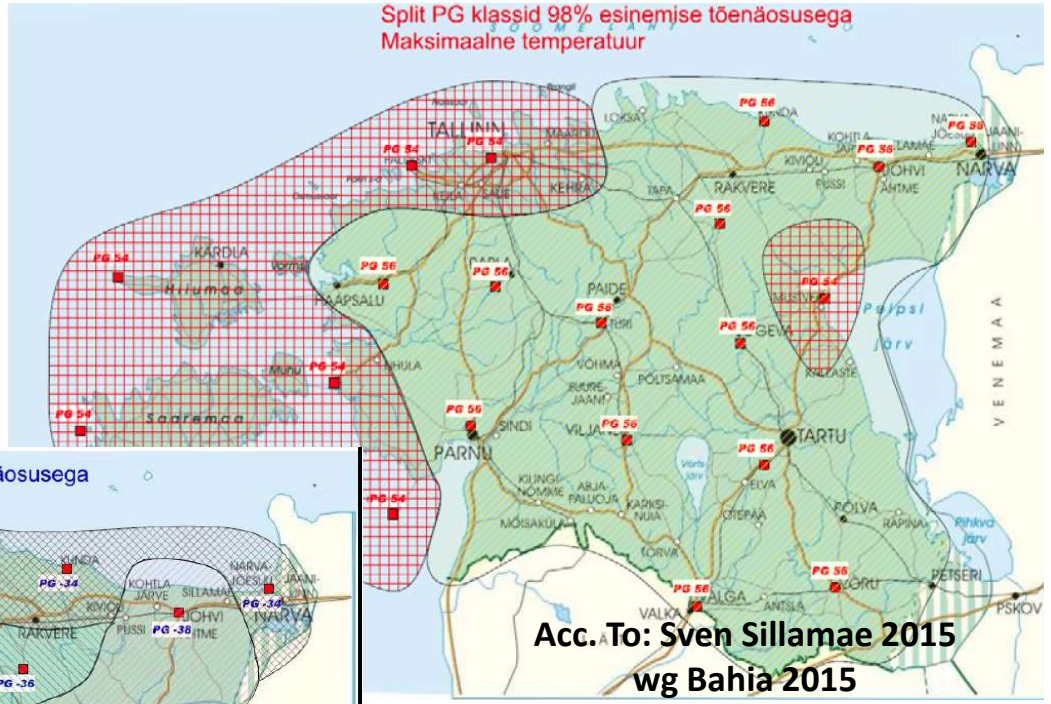
Estonia

PG 58-28

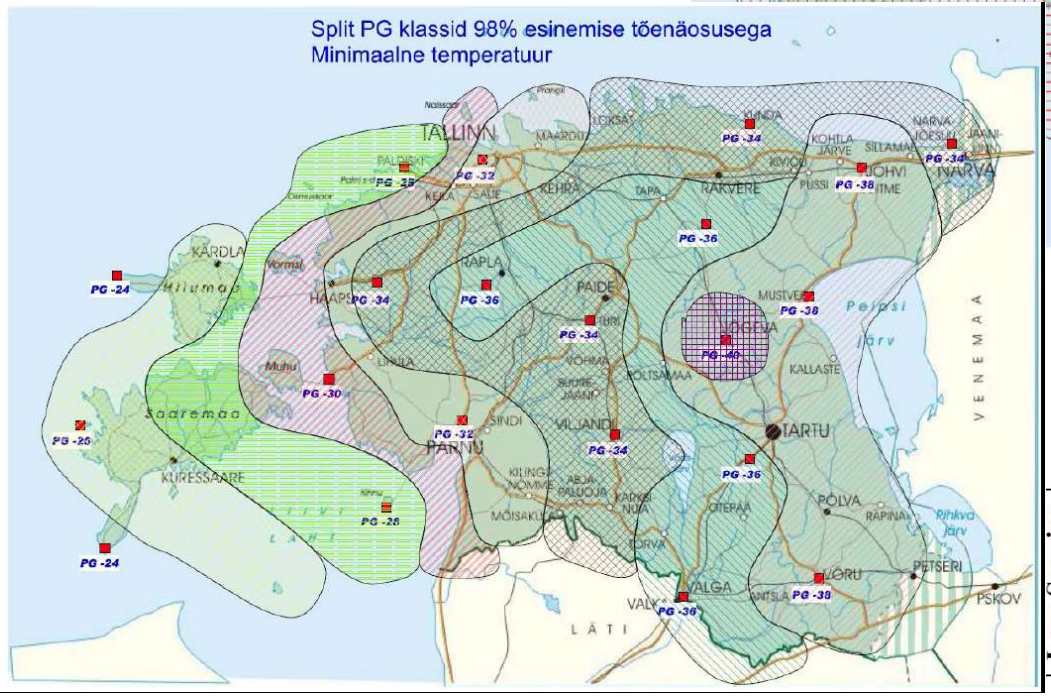
PG 58-34

PG 58-40

PG HT split
+52
+54
+56



PG LT split
-24
-28
-30
-32
-34
-36
-38
-40



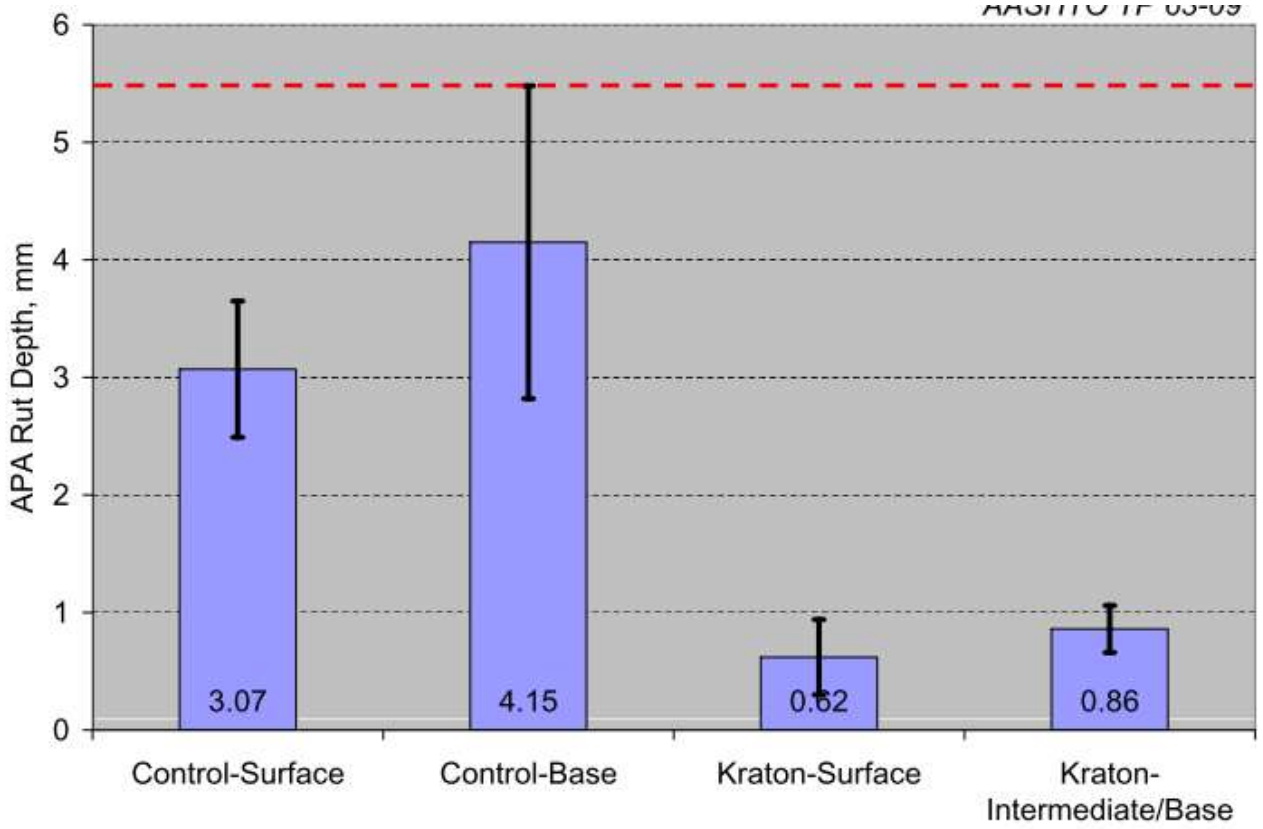
Acc. To: Sven Sillamae 2015
wg Bahia 2015

●	Available PG
○	Needed, Unavailable PG

Low Service temperature	High Service Temperature 52	58	64	70
-22	●	●	●	
-28		●		●
-34		○		
-40		○		

Properties at high temperatures: resistance to rutting

- Temperature: +60°C
- Measured parameter: rut depth

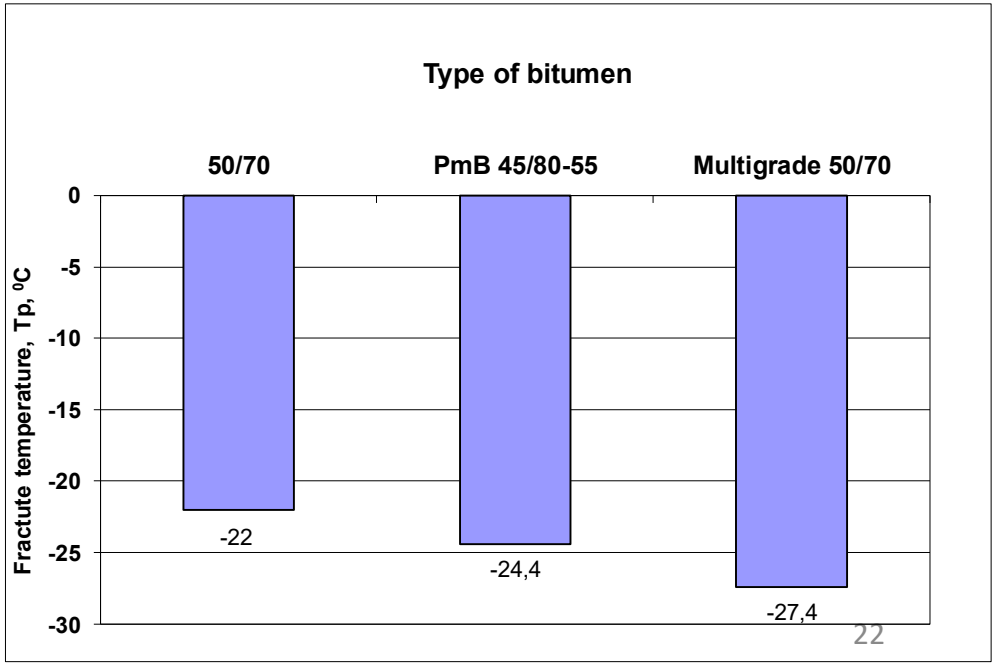


Properties at low temperatures: TSRST according to PN-EN 12697-46

- Temperature decreasing from +20°C by 10°C per hour
- Thermal stress inducted into asphaltic beam is measured
- As results: critical temperature at which the specimen was cracked and maximum induced thermal stress

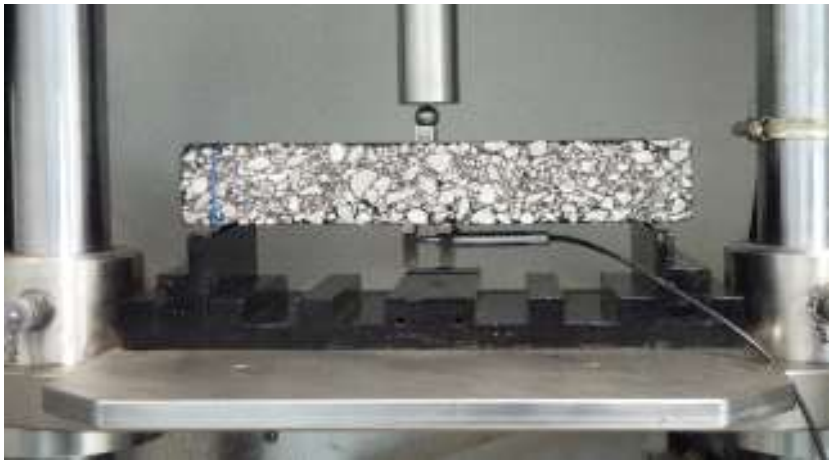
Test results - TSRST

Mix type	Fracture temperature		Maximum thermal stress at the moment of fracture	
	Mean [°C]	St.dev. [°C]	Mean [MPa]	St.dev. [MPa]
SMA8 45/80-55 CR	-27,8	1,29	3,890	0,240
SMA8 45/80-55	-25,8	1,36	3,917	0,565
PA8 45/80-65 CR	-29,1	0,79	1,205	0,040
PA8 45/80-65	-31,4	0,50	1,165	0,062



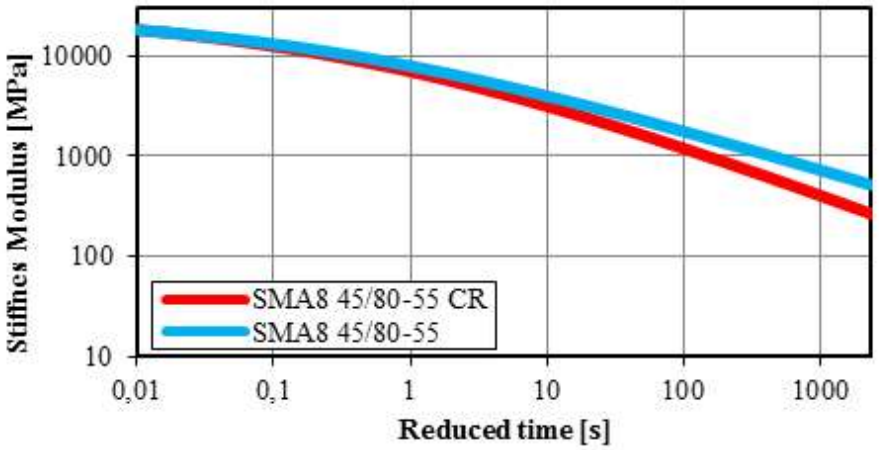
Properties at low temperatures: Three-Point Bending Creep Test

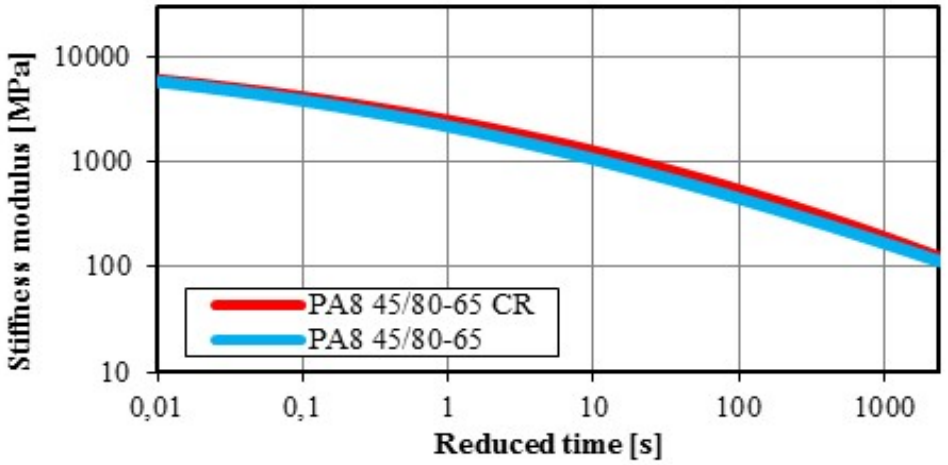
- 2 phases: in the first phase beams were subjected to constant static load for a time of 2400 seconds; in the second phase beams were left unloaded for a time of 1200 seconds
- The test temperatures were -20°C, -10°C and 0°C
- The strain at the bottom of the specimen was measured with a LVDT sensor



Test results – Three-Point Bending Creep Test

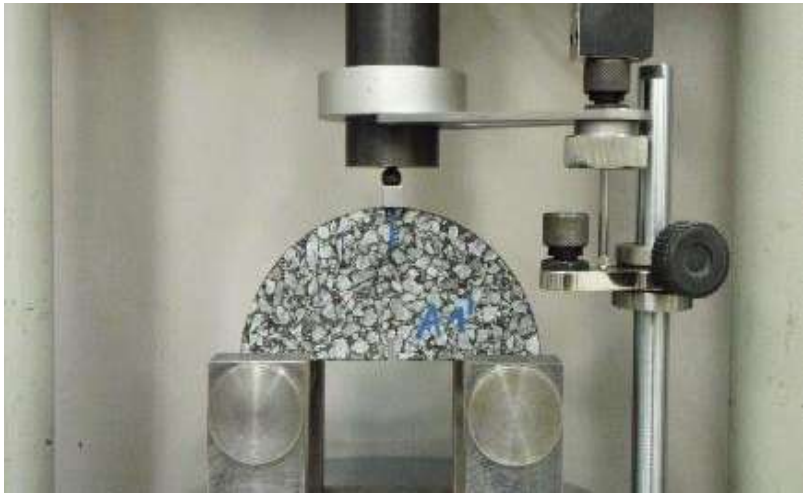
Master curves of tested asphalt mixtures
reference temperature T=0°C



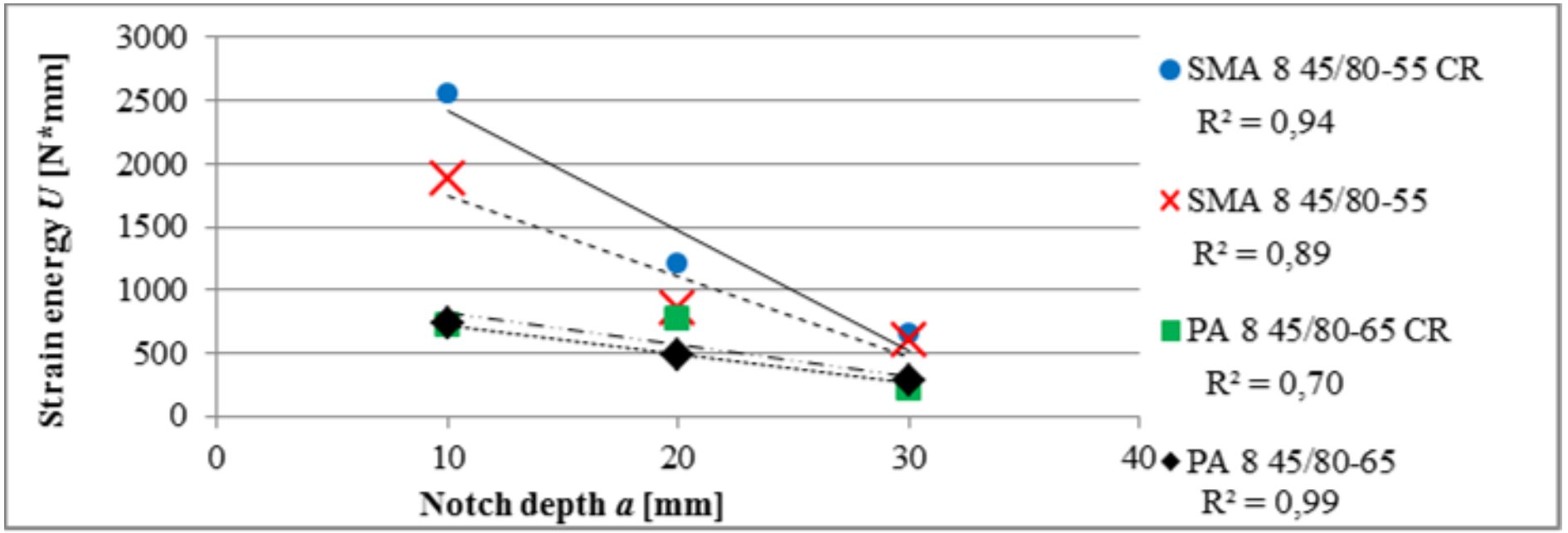


Methods of research: Fracture Toughness Test – according to PN-EN 12697-44

- Use of semi-circular bending test
- During the test, load and vertical displacement were continuously recorded
- The displacement rate 1 mm/min
- Temperature of -20°C
- Calculating factors: critical stress intensity factor, K_{IC} and strain energy to failure



Test results - Fracture Toughness Test



Experiences – A1 Motorway

– 3,5 cm wearing course – SMA 0/8, Modbit 80B
– 8 cm binder course – AC 0/20, Modbit 30B
– 15,5 cm base course – AC 0/25, 35/50
• 20 cm crushed aggregate 0/25
• 15-20 cm cement treated subbase
• 20 cm drainage layer

Experiences – A1 Motorway

- **Application of SBS modified bitumen increased of fatigue life of about 32%**
- **At the beginning: 12,7 mln osi 115 kN**
- **Final: 16,9 mln osi 115 kN!**

Conclusions:

- **Polymer SBS modification of bitumen increses of:**
  - **resistance to fatigue cracking**
  - **resistance to low temperature cracking**
  - **resistance to permanent deformations (rutting)**
  - **resistance to reflective cracking**
  - **resistance to water and frost action**
  - **resistance to ageing of bitumen**

Conclusions:

- **Polymer SBS modification of bitumen can extend of fatigue live of asphalt pavement**

- **But application of PmB modified bitumen do not guarantee of premature failures – the reason of some type of failures can be for example in mixture design, quality of works and so on…**

Thank you
for your attention!