

SPENS Final seminar
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Practical mix design model for asphalt mixtures

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Participants:

Project SPENS, WP3, Task 3.3 "Optimisation of asphalt mixture design to ensure favourable behaviour at low and high air temperatures"

Participants involved in research:

IP (Institut za puteve -The Highway Institute), Serbia

ZAG (Zavod za gradbeništvo - Slovenian National Building and Civil Engineering), Slovenia

IGH (Institut građevinarstva Hrvatske – The Civil Engineering Institute of Croatia), Croatia

TUZA (Zilina University), Slovakia

IBDiM (Road and Bridge Institute), Poland

VTI (The Swedish National Road and Transport Research Institute), Sweden

Objective

The objective of this task was to find a practical model for the optimisation of asphalt mixture design to ensure satisfactory behaviour at low and high air temperatures which will be related to the target functional properties of asphalt pavement such us:

- Resistance to permanent deformation,
- Resistance to fatigue cracks and
- Resistance to thermal cracks.

Optimisation

Optimisation procedure are consists of following steps:

- Selection of mineral materials (aggregate, sand, filler),
- Selection of binder (B or PmB),
- Design of mineral mixture,
- Estimation the volumetric characteristics of asphalt mixture (Vm, VMA and VFB),
- Verification composition of asphalt mixture - mechanical tests (S, D, WTT, ITSM, 2PBT, TSRST) and
- Assessment with criteria (Specifications)

In essence the optimisation of asphalt mix properties are compromise between different and conflicting criteria, such a resistance to fatigue and resistance to rutting.

Materials:

- 4 binders
 - B 70/100 (INA-Rijeka, Croatia)
 - B 50/70 (INA-Rijeka, Croatia)
 - PmB 50/90s (MODIBIT, Croatia)
 - PmB 25/55-55 STARFALT (OMV, Austria)
- 1 silicate sand and aggregates HRUŠKOVEC (Croatia),
- 1 limestone filler OČURA (Croatia)
- 1 grading of mineral mixture 0-11 mm and
- 1 type of asphalt (asphalt concrete AC-11)

PRADO and Marshall

Two methods of asphalt mix design were used in WP 3.3:

- Marshall method (ZAG) and
- Program for Asphalt Mix Design Optimization (PRADO - developed by BRRC) (IP)

Using PRADO by variation of mineral grading of AC-11 and binder content the optimal volumetric composition of AM was established in a way that ensured favourable functional properties of asphalt mixture: stiffness modulus, permanent deformation and fatigue.

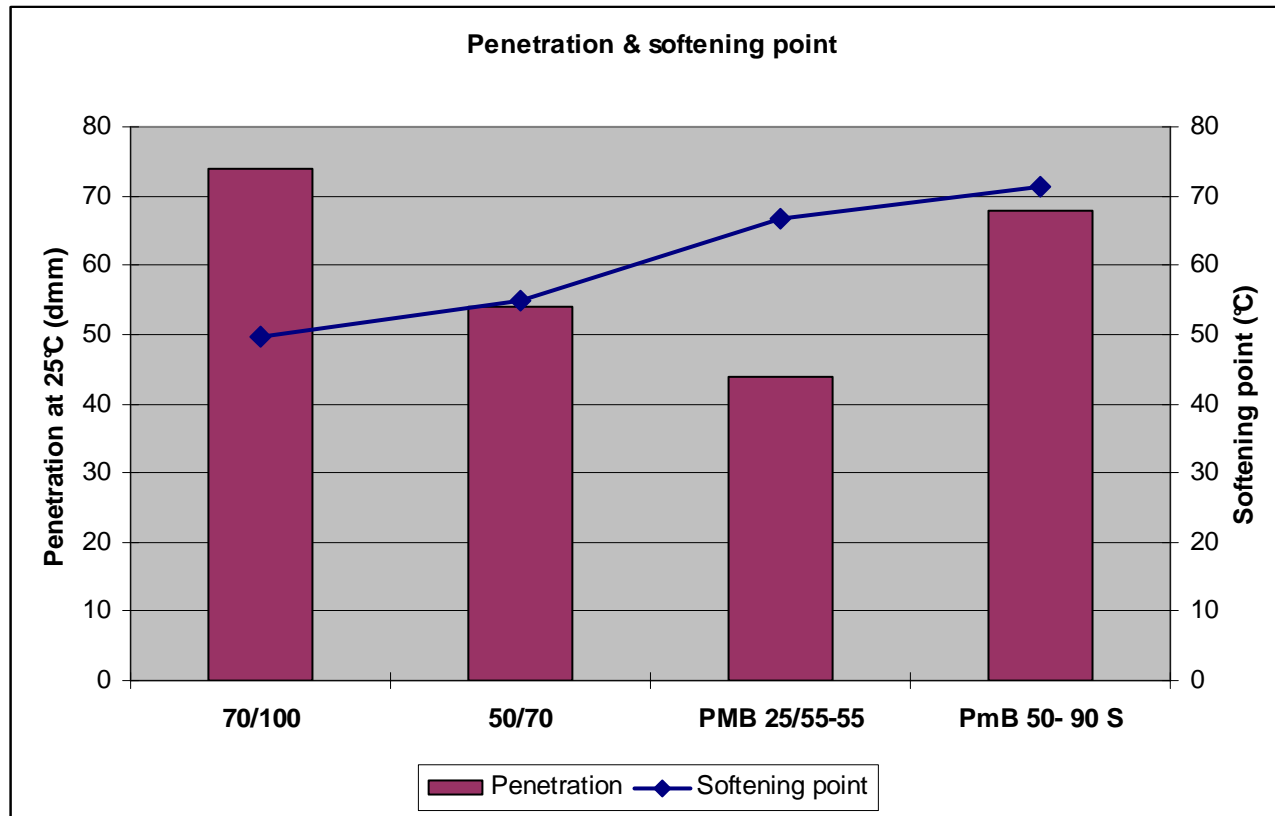
Comparing two methods of mix design there were found minor differences in mix compositions only with binder contents (between 0,1 to 0,2%) for the same bulk characteristics of AM.

Conventional properties

Binder test results (VTI)

Test method	Standard	Unit	Binder			
			70/100	50/70	PMB 25/55-55	PmB 50- 90 S
Penetration at 25°C	EN 1426	mm/10	74	54	44	68
Softening point (RB)	EN 1427	°C	49.6	54.8	66.8	71.2
Fraass breaking point	EN 12593	°C	-19.5	-18.5	-14	-1 2
Kinematic viscosity at 135°C	EN 12595	mm ² /s	416	596	2055	713
Dynamic viscosity at 60°C	EN 12596	Pas	181	528	5029	1 405

Conventional properties



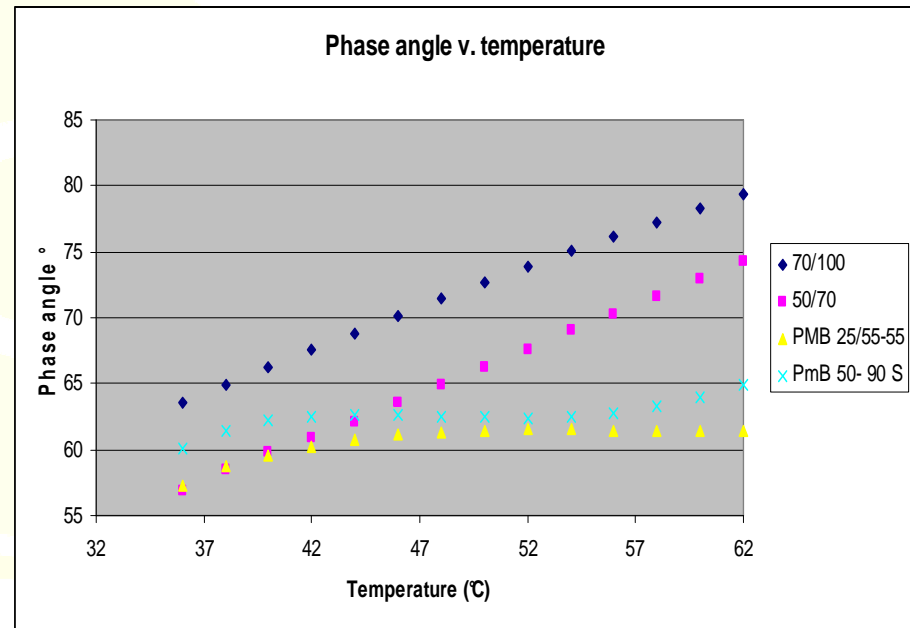
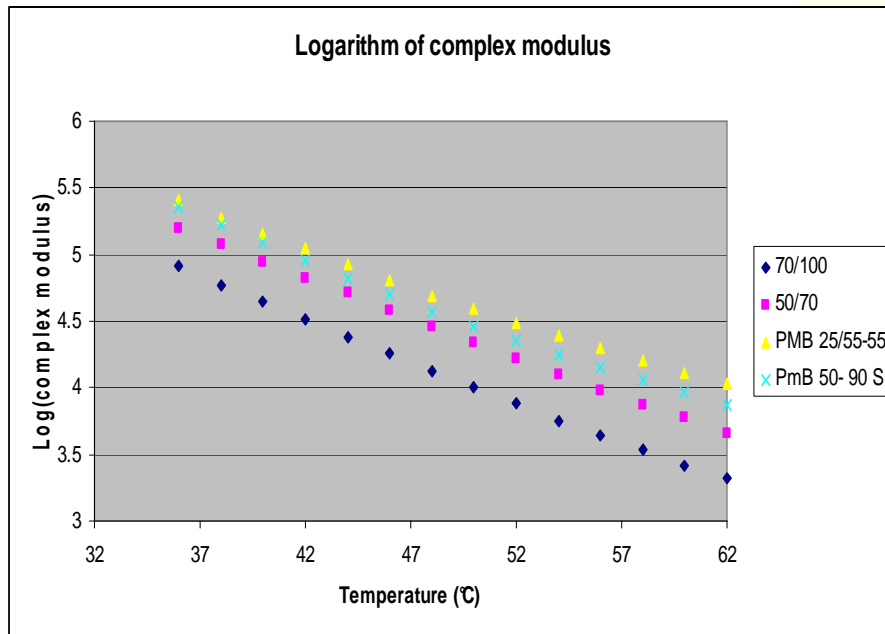
Tensile properties

Elastic recovery and force ductility test results for the PmB

Test method	Standard	Unit	Binder	
			PMB 25/55-55	PmB 50- 90 S
Elastic recovery at 25°C	EN 13398: 2004	%	88.9	99.3
Deformation energy at 10°C	EN 13589: 2004 EN 13703: 2004	J/cm ²	9.1	4.3
Force at elongation at 10°C	EN 13589: 2004 EN 13703: 2004	N	45.1	24.7
Elongation at break at 10°C		cm	53.7	92.1
Deformation energy at 25°C	EN 13589: 2004 EN 13703: 2004	J/cm ²	3.6	2.2
Force at elongation at 25°C	EN 13589: 2004 EN 13703: 2004	N	4.5	1.4
Elongation at break at 25°C		cm	89.1	69.7

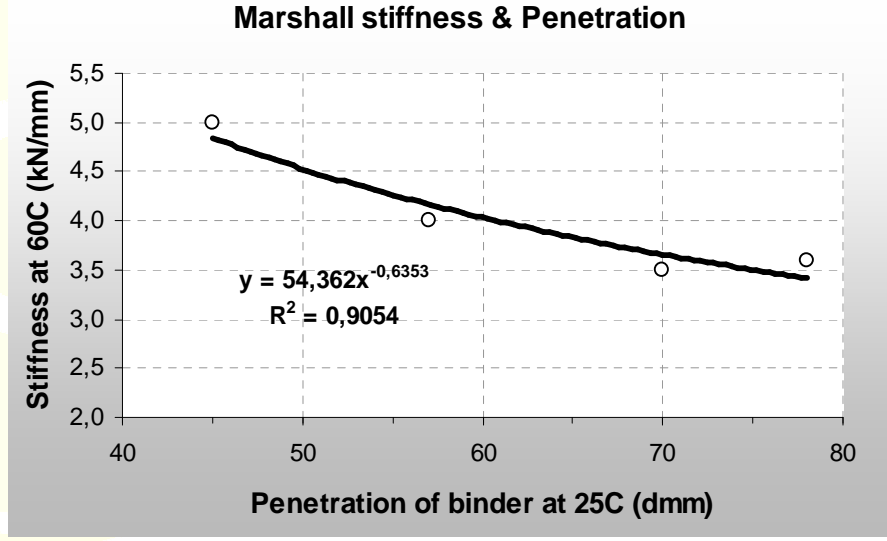
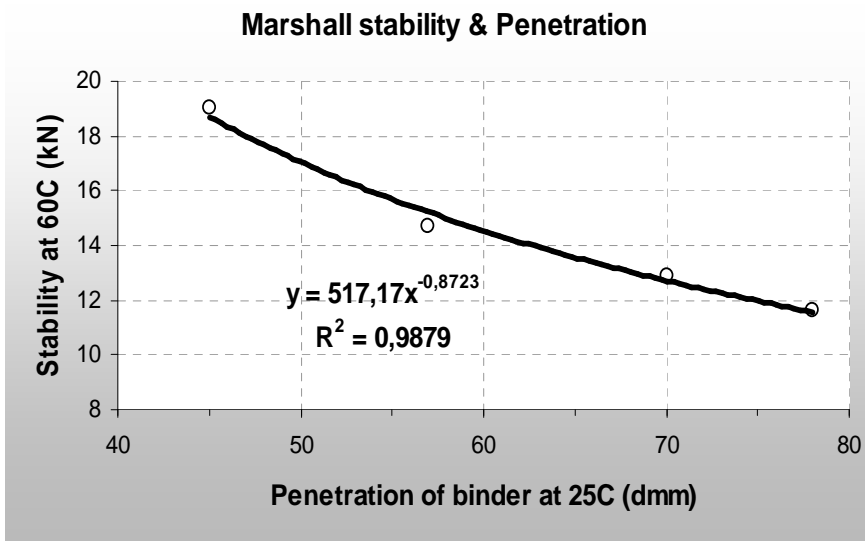
DSR test results

Complex modulus and phase angle of binders vs. temperatures measured with Dynamic Shear Rheometer (VTI)



Correlations

Correlation between Marshall test and penetration of binder



ITSM - NAT



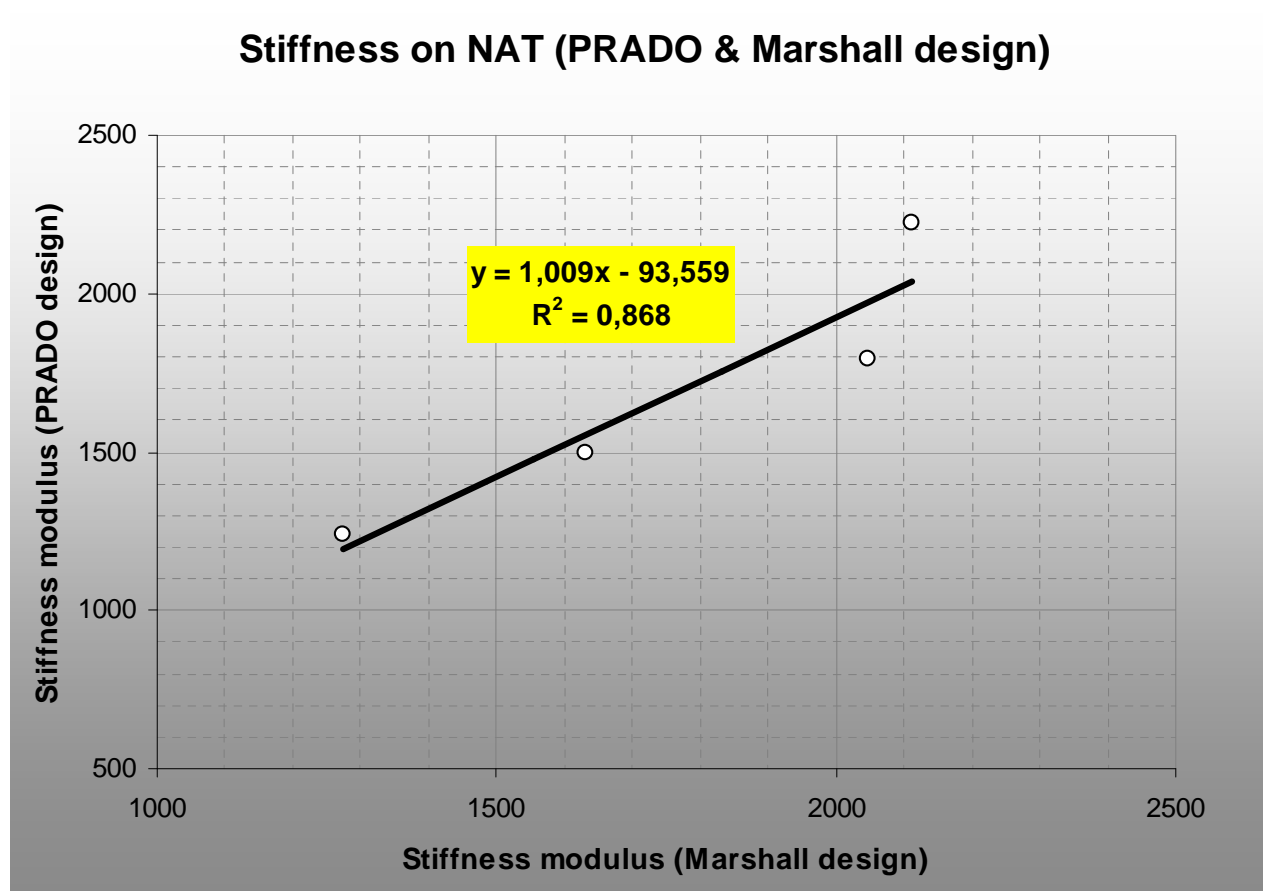
Device for testing indirect tension stiffness modulus (E*) (ITSMT) (NAT) (IP)

EN 12697-26/2004)

- temperature: 20°C
- time of load rise: 124 ms
- load cycles: 5
- number of pulse: 3s

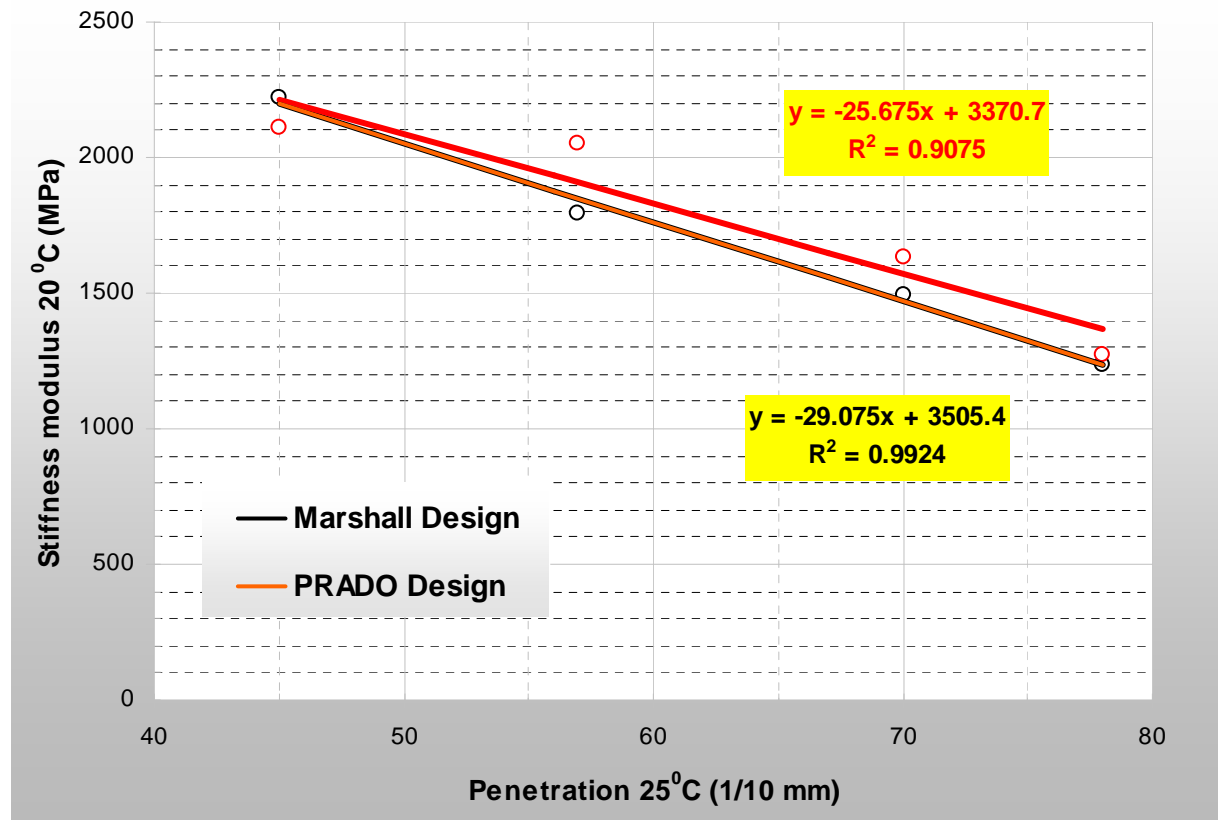
Sample: cylindrical 100 mm

Stiffness modulus (PRADO - NAT)



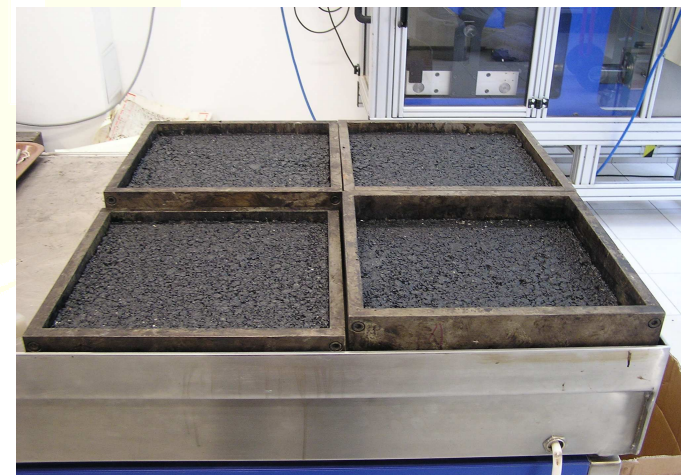
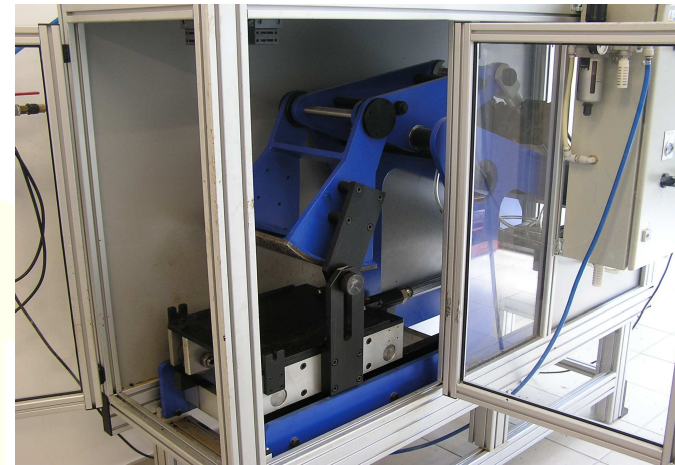
Correlations

Stiffness Modulus & Penetration



Rutting properties - WTT

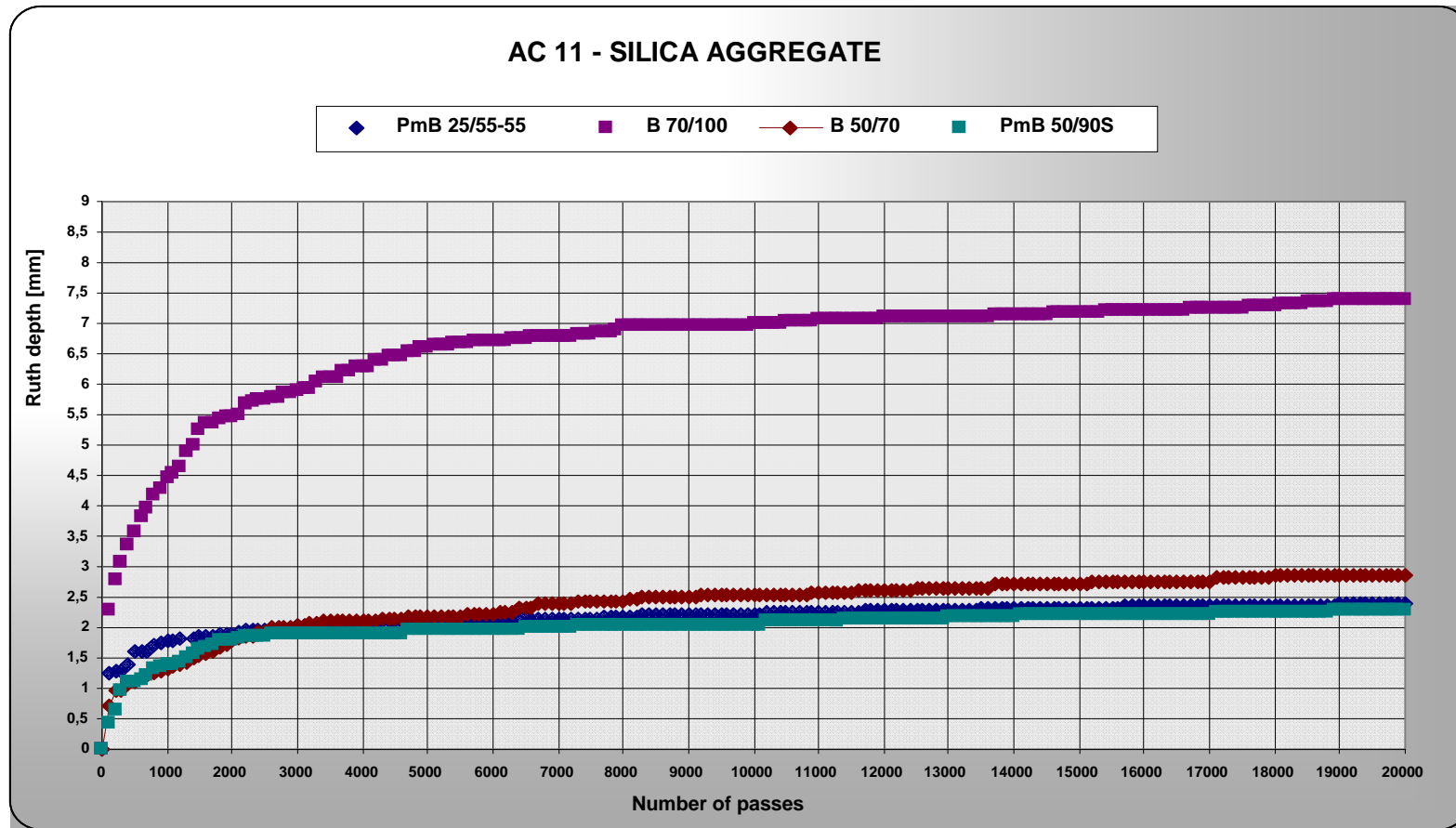
Wheel Tracking Tester (WTT) (IGH)



Samples: 305mm x 305mm x 50mm

Rutting properties - WTT

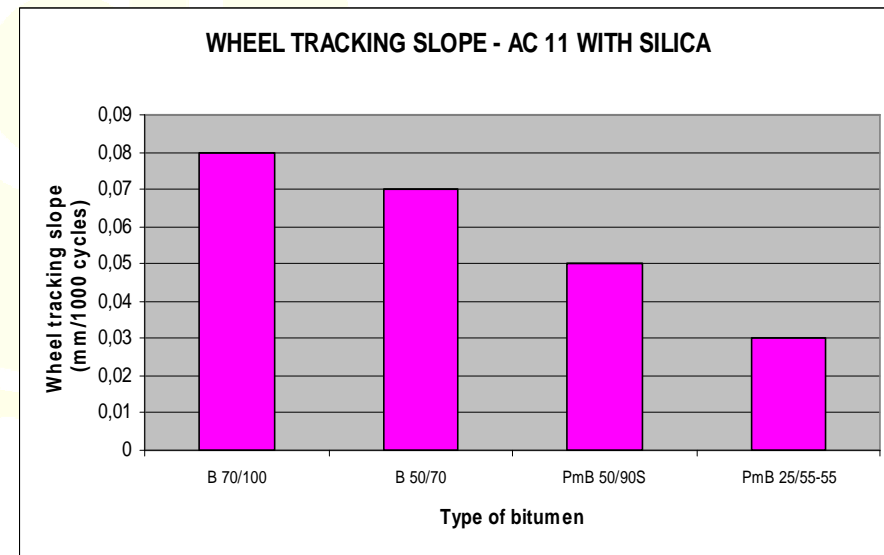
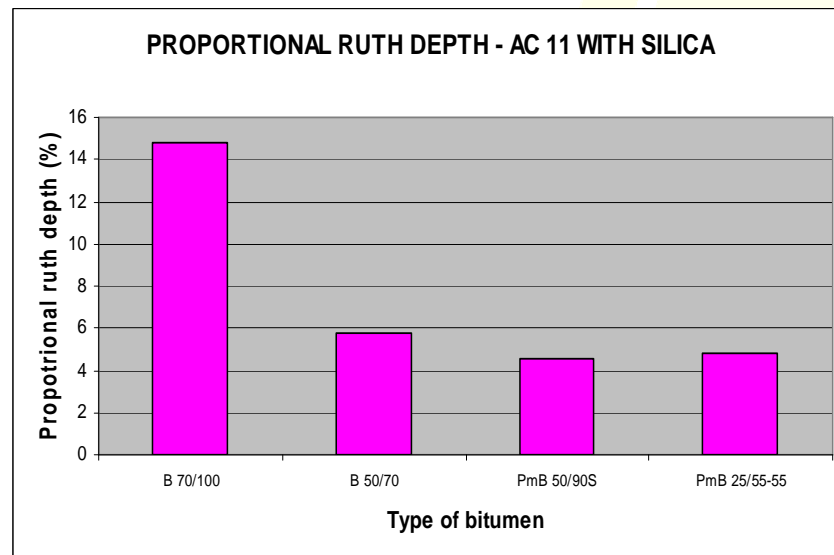
Results of Wheel Tracking Test 60°C / 10.000 ciklusa (EN 12697-22)



Rutting properties - WTT

Comparison the rut depth for AC 11 with different binders

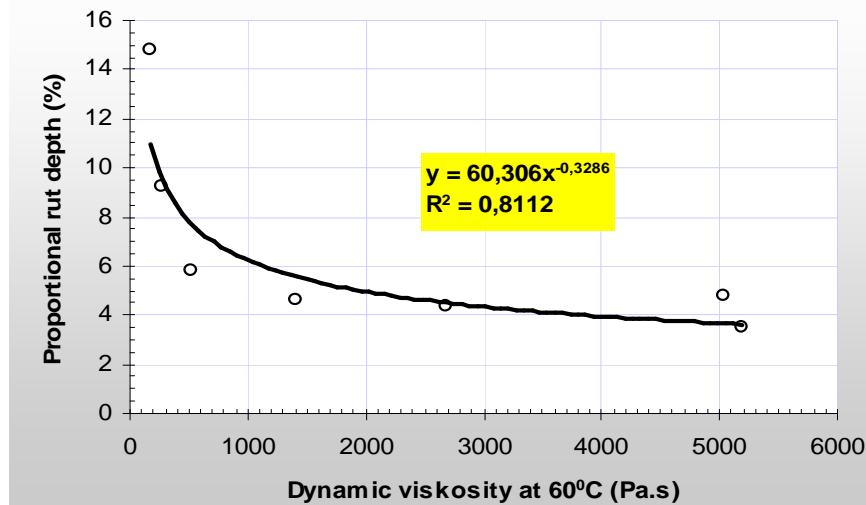
Rut characteristics	B 70/100	B 50/70	PmB 50/90S	PmB 25/55-55
Rut depth (mm)	7,4	2,9	2,3	2,4
Proportional rut depth (%)	14,8	5,8	4,6	4,8
Wheel tracking slope (mm/1000 cycles)	0,08	0,07	0,05	0,03



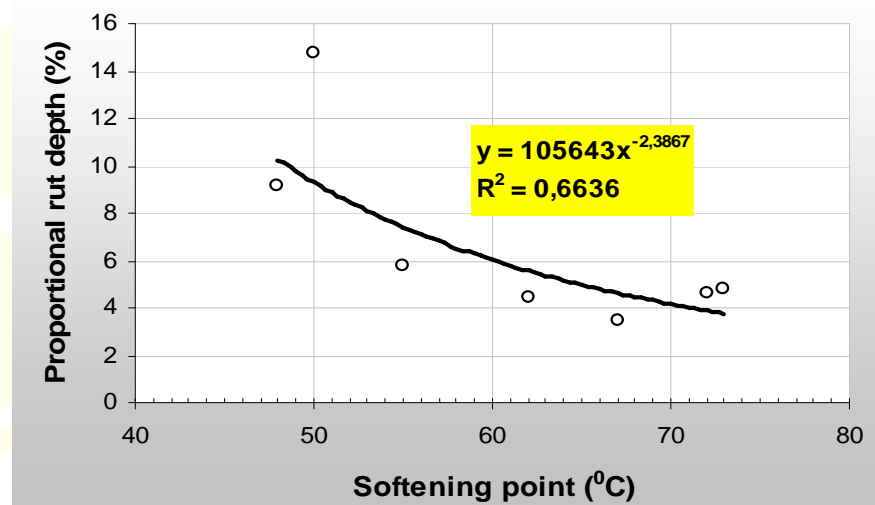
Correlations

Comparison the rut depth of AC-11 with binder characteristics

Rut depth & Viscosity



Rut depth & Softening point



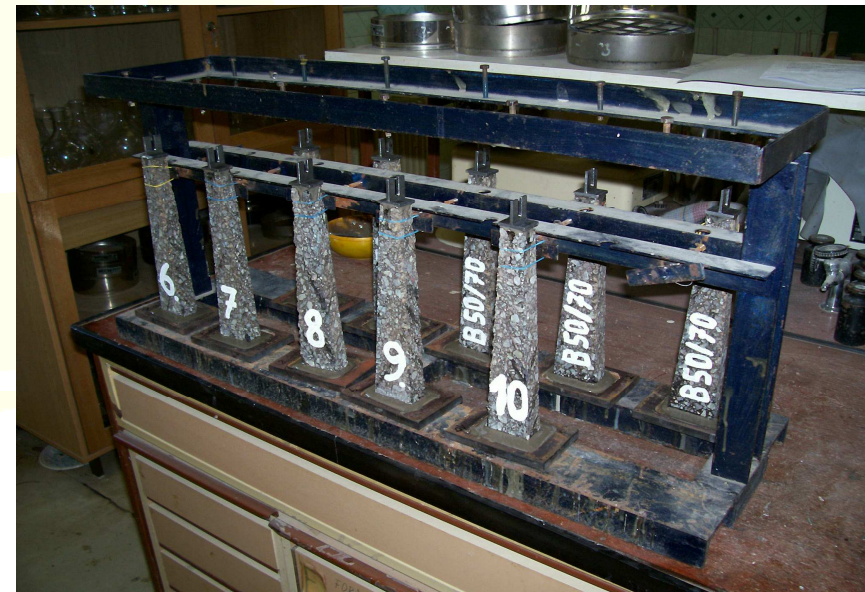
Fatigue properties – 2PBT



Two Point Bending Fatigue Test (TUZA)

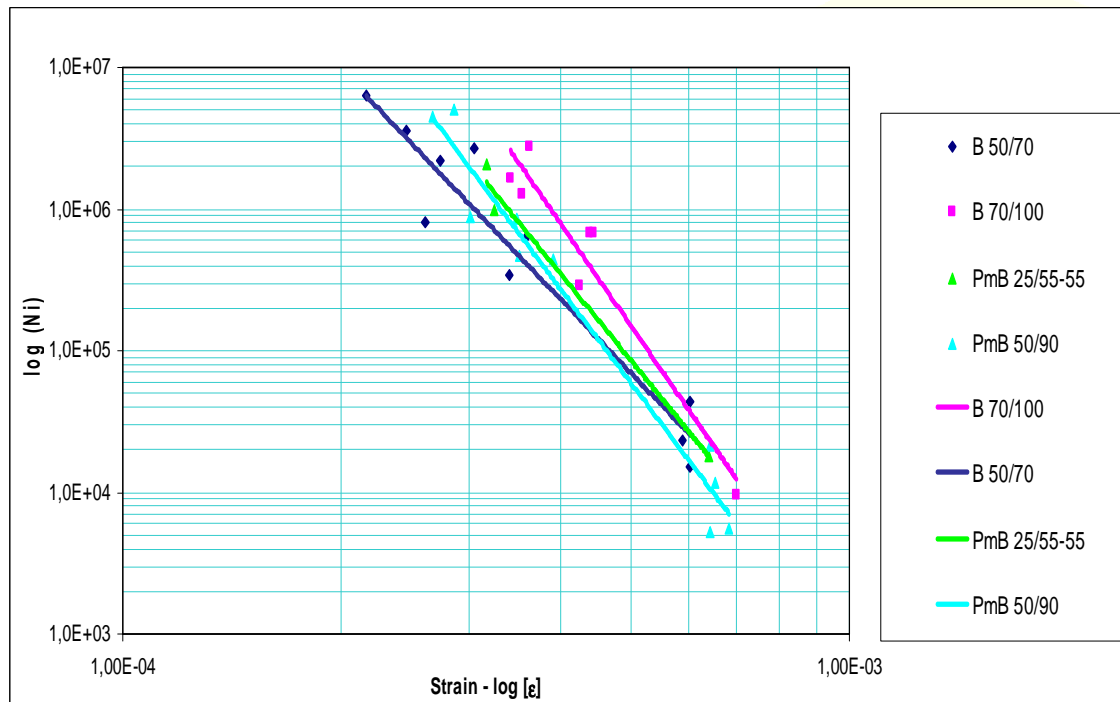
+10°C / 20Hz

EN 12697-24 Annex A



Fatigue properties – 2PBT

Results of two point bending fatigue test AC 11 with different binders

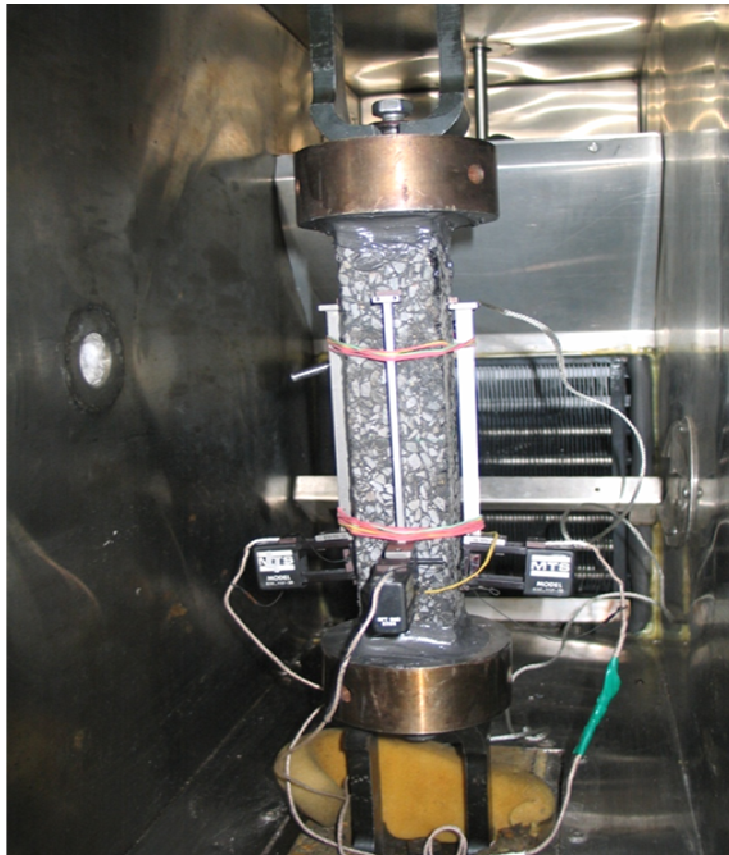


EN 13108-1

	Mixture	Measured value of $\epsilon_6 \cdot 10^{-6}$	Category ϵ_6
1.	B 50/70	304,55	$\epsilon_6 - 260$
2.	PmB 50/90	331,14	$\epsilon_6 - 310$
3.	PmB 25/55-55	338,96	$\epsilon_6 - 310$
4.	B 70/100	387,93	$\epsilon_6 - 310$

Low temperature properties - TSRST

Device for measuring the resistance to thermal cracks of AM Thermal Stress Restrained Specimen Test – TSRST (AASHTO TP10)



Initial temperature: 5°C

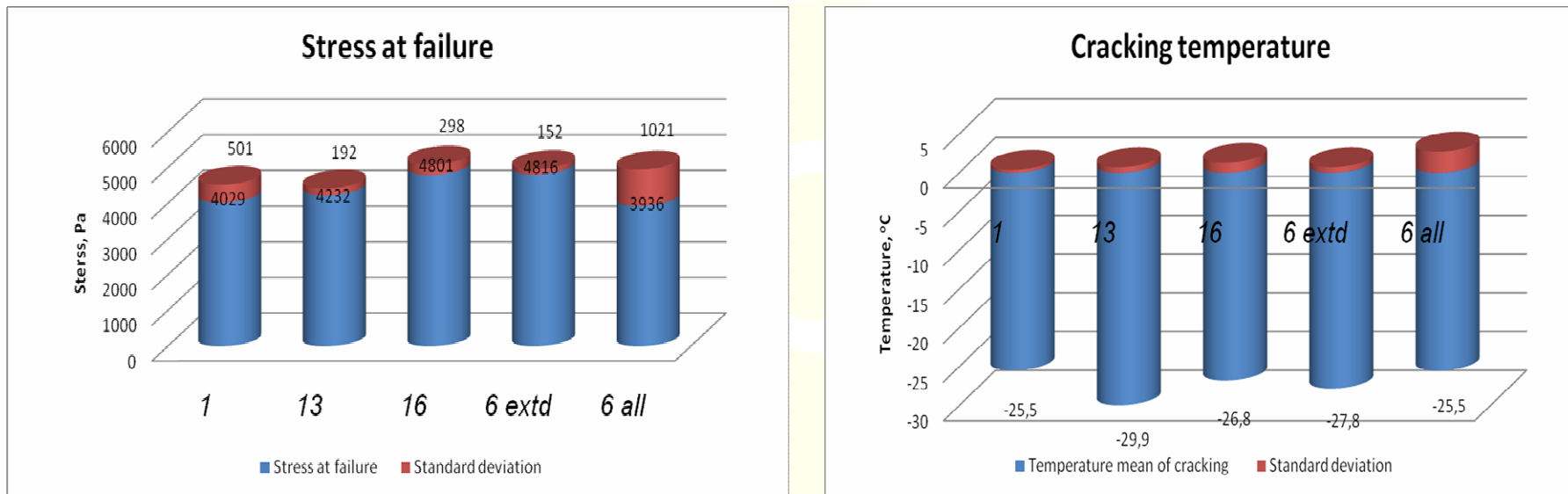
Cooling speed: 10°C/h

Dimension of samples: 50 x 50 x 250 mm



Low temperature properties - TSRST

Results of asphalt mixture with different binders (TSRST) (IBDiM)



1 – B 50/70
13 – B 70/100
16 – PmB 25/55-55
6 – PmB 50/90

Conclusions:

- By using PRADO software it is possible to make a lot of variation of composition of asphalt mixture and to study the dynamic characteristics without need of expensive laboratory equipment and to get the same mixture composition as with Marshall method,
- Thorough research performed in Task 3.3 there were shown that none of tested binder can satisfy the all performance criteria of asphalt mixture needed at low and high air temperatures,
- To obtain asphalt mixture with higher stiffness modulus and higher resistance to permanent deformation it is necessary to use harder types of binder whilst for higher resistance to fatigue cracks softer types of binder is preferable,
- The polymer modified binders in comparison with conventional bitumen, due to good visco-elastic properties and optimal temperature susceptibilities has better resistance to rut at high air temperatures and better resistance to fatigue and thermal cracks at low air temperatures,

Conclusions:

- Asphalt mixtures with polymer modified binders (PmB 50/90, PmB 25/55-55) can be used for pavements with heavy traffic condition and severe temperatures changes.
- The binder properties such as: viscosity, penetration, softening point, deformation energy, phase angle and elastic recovery (with PmB) are performance related characteristics which influence to the dynamic parameters of asphalt mixture.
- The penetration of binder has influence to stability and stiffness modulus of asphalt mixture,
- The viscosity, softening point and deformation energy of binder affect to the resistance of permanent deformation of asphalt mixture,
- The phase angle and elastic recovery of PmB has influence to fatigue resistance of asphalt mixture,
- Research is need to continue on other types of asphalt mixture so that correlations established in Task 3.3 can be confirmed and improved.

Acknowledgments:

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**THANK YOU
FOR ATTENTION !**