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II MIĘDZYNARODOWA KONFERENCJA
Nowoczesne nawierzchnie drogowe - recykling i dekarbonizacja

II INTERNATIONAL CONFERENCE
Modern road pavements - recycling and decarbonization

EFFECT OF FOAMED ASPHALT ON THE PROPERTIES OF THE ASPHALT MIXTURE WITH RECLAIMED ASPHAT PAVEMENT

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Presentation Program

Characteristics of Foamed Asphalt
Asphalt Mixture Testing
Rejuvenation of Reclaimed Asphalt from RAP
Asphalt Mixture Properties
Construction of the Experimental Section
Conclusions

Characteristics of Foamed Asphalt

Fig.1. Laboratory foamed asphalt production device

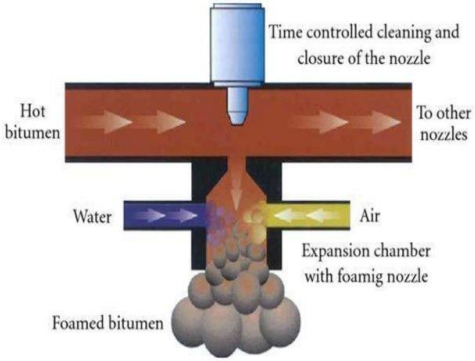


Fig.2. Asphalt foaming mechanism*

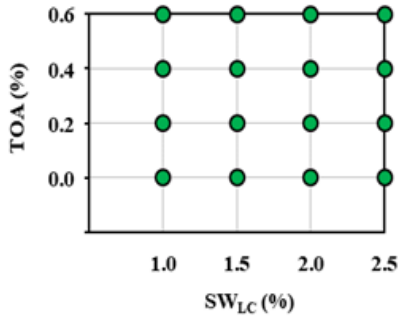


Fig.3. Experimental plan for bitumen modification

Bitumen modifiers

SW_{LC} – Synthetic wax with reduced carbon footprint

TOA – Tall Oil Amidopolyamines

Foaming parameters:

- maximum expansion **ER**,
- bitumen foam half-life $t_{1/2}$ (HL)[s].

*_Wirtgen Cold Recycling Technology_, 1st ed. Wirtgen GmbH, Windhagen, Germany, 2012

Table 1. Essential characteristics of WS_{LC} synthetic wax

Property	Unit	Value
Colour	-	white, yellowish
Flash point	°C	285
Solidification temperature	°C	95
Density at 25°C	Mg/m^3	0.9
Molecular weight	g/mol	approx. 1000

Table 2. Essential characteristics TOA

Property	Unit	Value
Appearance	-	Brown liquid
Density at 20°C	Mg/m^3	0.88-0.98
Dynamic viscosity at 20°C	m·Ps	3000
Solidification temperature	°C	<0
Flash point	°C	>218

Table 3. Performance of foamed asphalt with optimal amount of SW_{LC} and TOA

Characteristics	Unit	Value	Requirements
Maximum expansion of ER	-	16.6	Wirtgen
Half-life of HL	s	14.4	Wirtgen]
Penetration at 25°C	0.1 mm	49.4	PN-EN 1426
Softening temperature	°C	56.6	PN-EN 1427
Modulus of rigidity Sm at temp:	MPa		PN-EN 14771
- 10°C		105	
- 16°C		204	
- 22°C		421	
Creep rate m_{value}	-		
-10°C		0.327	
-16°C		0.290	
-22°C		0.276	

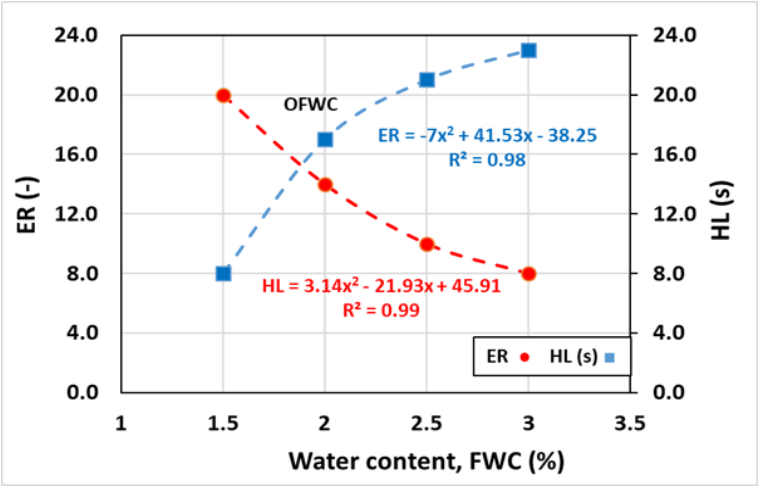


Fig. 4. Foaming characteristics of asphalt 50/70 with optimal amount of SW_{LC} and TOA (1.5% + 0.4%)

AC 16W asphalt mixture

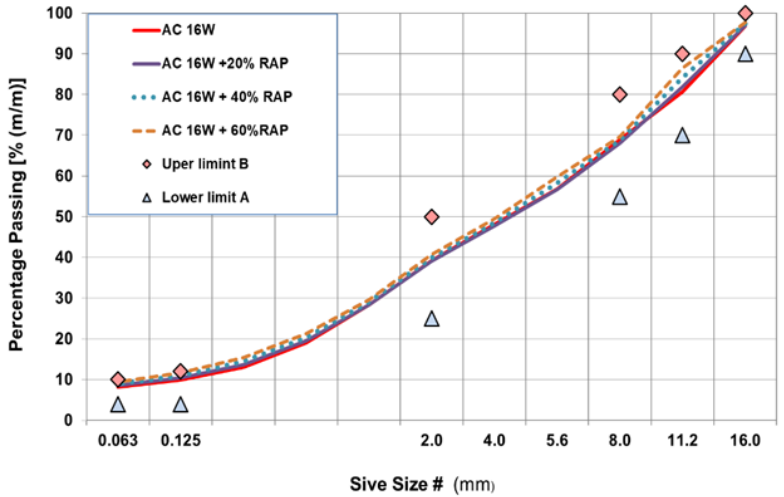


Fig. 5. Design AC 16W asphalt mixtures without and with RAP (20%, 40%,60%)

Table 4. Properties of the AC 16W asphalt mixture

Properties	Unit	Category	Value	Standard
Air voids content in MMA, V_m	% (v/v)	$V_{min4.0}$ $V_{max7.0}$	5.2	PN-EN 12697-8
Water resistance, *ITSR*	%	$ITSR_{80}$	92.8	PN-EN 12697-12 Annex 1 to WT-2 p.1.
Resistance to permanent deformation: - WTS_{AIR} - PRD_{AIR}	mm/10^3 cycles %	$WTS_{AIR\ 0.15}$ $PRD_{AIR\ 7.0}$	0.108 6.2	PN-EN 12697-22

Analysis of changes in the following properties of the recovered asphalt:

- penetration at 25°C according to EN 1426 (Pen),
- softening temperature in accordance with EN 1427 ($T_{R\&B}$),
- viscosity at 60°C, 90°C and 135°C according to EN 13302 (η),
- Blanc curves according to EN 14770,

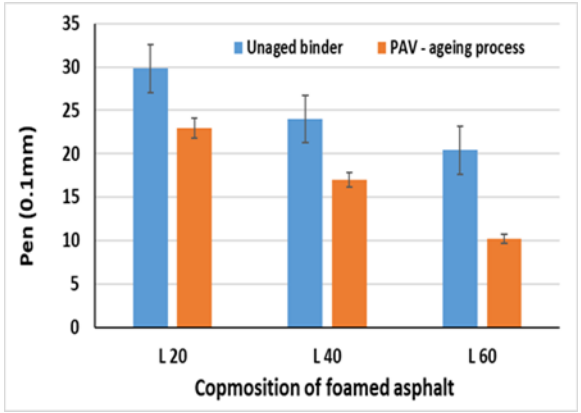
The test programme for the asphalt mixture with RAP:

- air void content *Va* (%) according to EN12697-8,
- water sensitivity *ITSR* (%) according to EN 12697-12, Annex 1 to WT-2 p.1,
- resistance to permanent deformation according to EN 12697:26:
  - WTS_{AIR} (mm/10^3 cycles),
  - PRD_{AIR} (%).
- *ITS* indirect tensile strength according to EN 12697-23, at -10°C, 0°C, +10°C and +20°C.

Due to the fact that 20%, 40% and 60% of the RAP was used in the asphalt mixtures, so the composition of the binder in the asphalt mixtures was as follows:

- asphalt mixtures with 20% RAP: - 3.6% foamed asphalt +0.9% recycled asphalt (L 20),
- asphalt mixtures with 40% RAP: - 2.6% foamed asphalt +1.9% recycled asphalt (L 40),
- asphalt mixtures with 60% RAP: - 1.7% foamed asphalt +2.8% recycled asphalt (L 60).

a)



b)

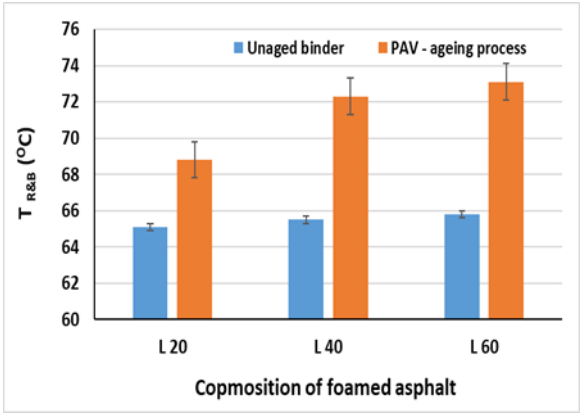


Fig. 6. Influence of foamed asphalt on penetration and softening point of binder with asphalt recovered from RAP; (a) penetration at 25°C, (b) softening point

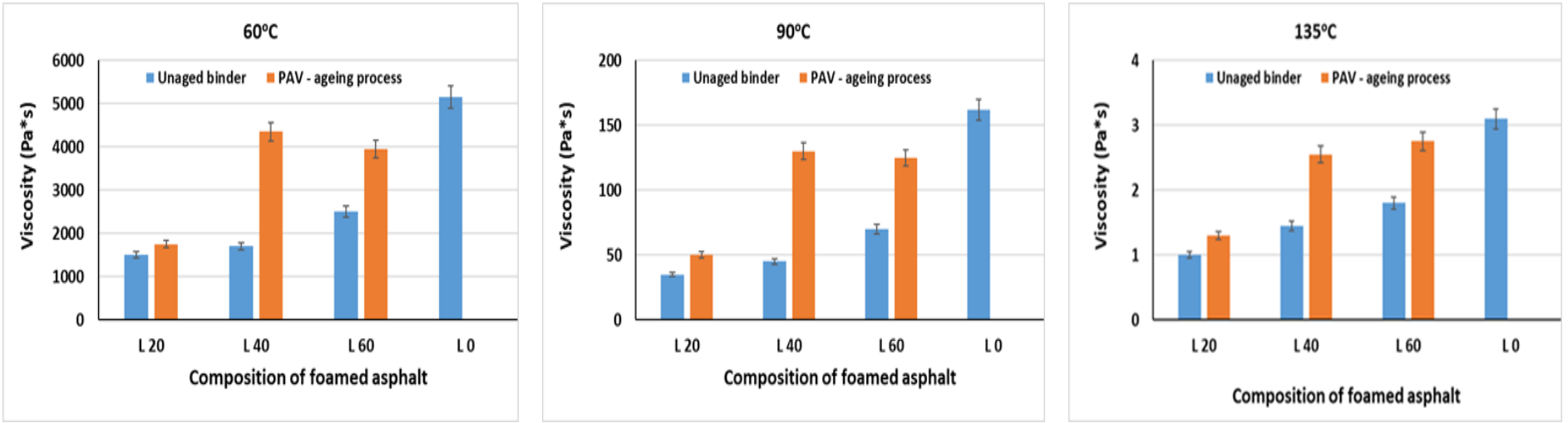


Fig. 7. Results of dynamic viscosity tests of the analysed asphalt binders at: a) 60°C, b) 90°C, c) 135°C

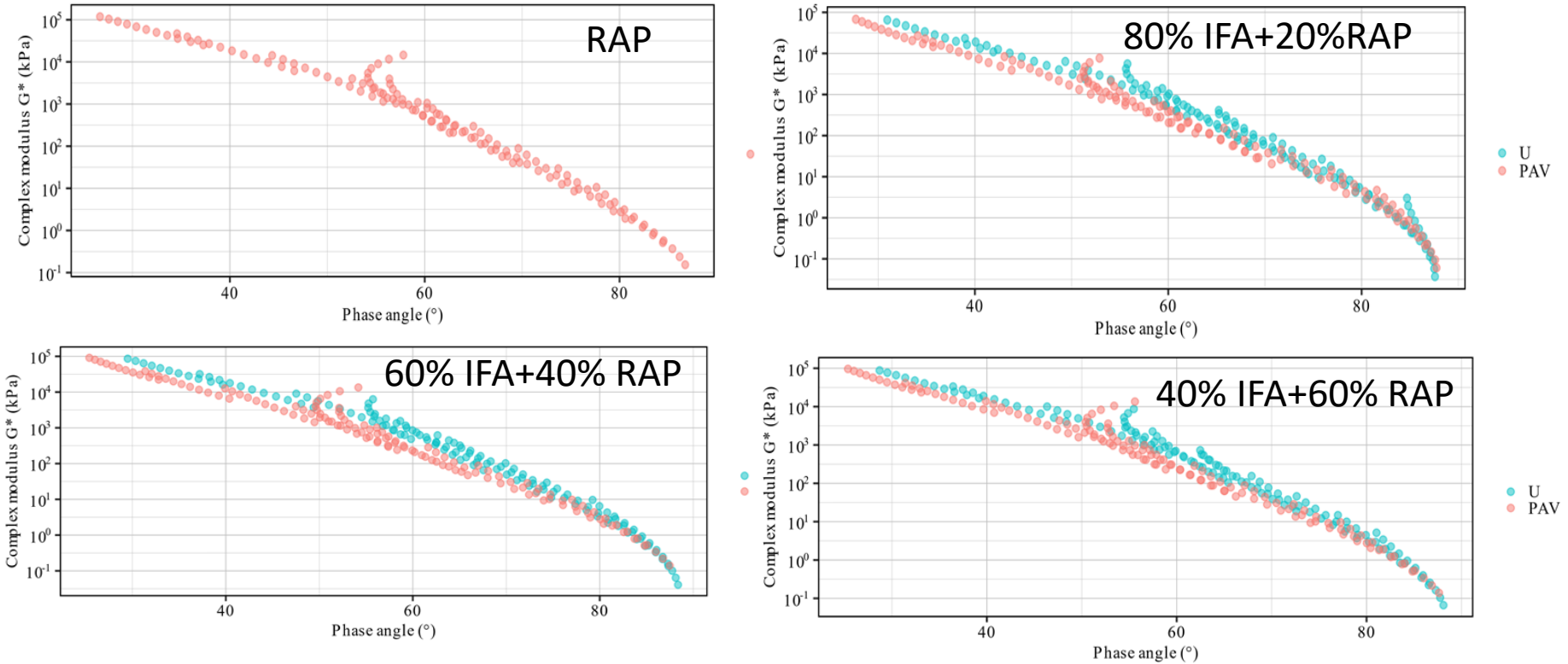


Fig. 8. Black curves for an asphalt binder of composition: innovative foamed bitumen (IFA) 50/70 and binder recovered from RAP

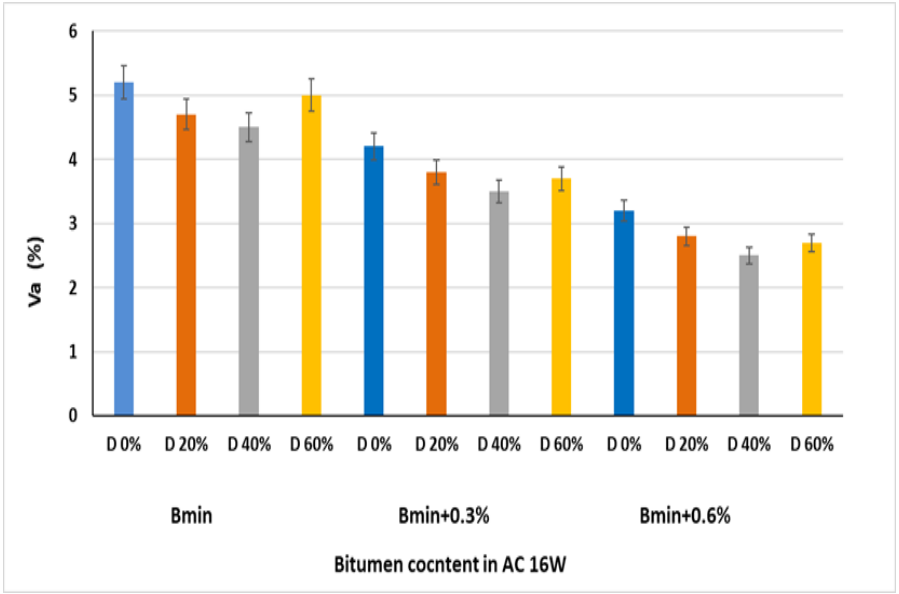


Fig. 9. Influence of the binder on the *Va* in the asphalt mixture in terms of the quantity of RAP

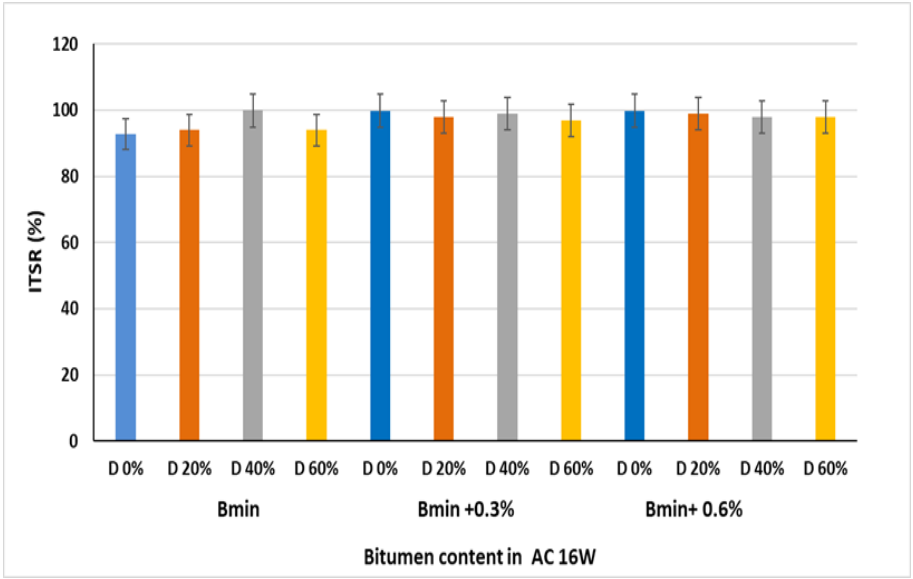
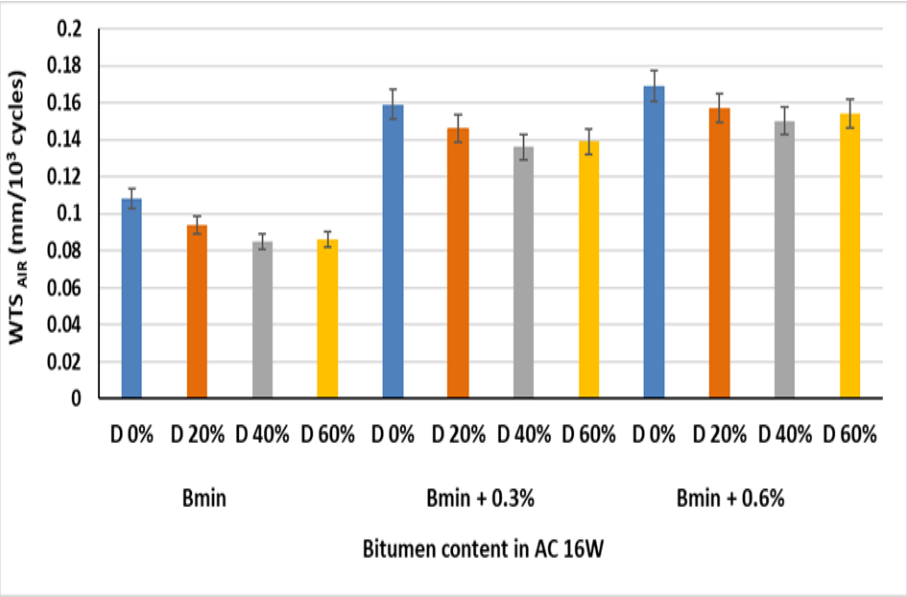


Fig. 10. Influence of the binder on the effect of *ITSR* water in the asphalt mixture in terms of the amount of RAP



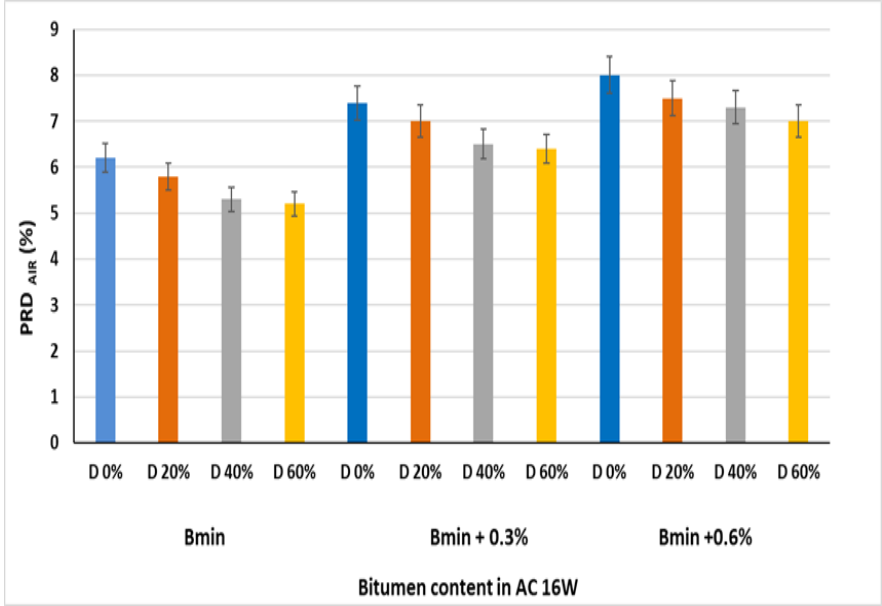
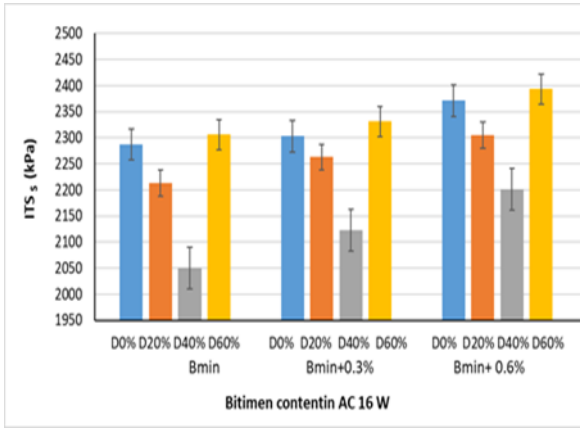
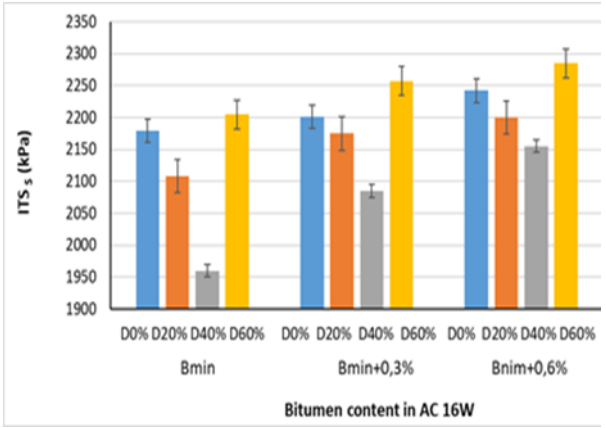


Fig. 11. Influence of the binder on the resistance to permanent deformation of WTS_{AIR} and PRD_{AIR} in an asphalt mixture in terms of the amount of RAP

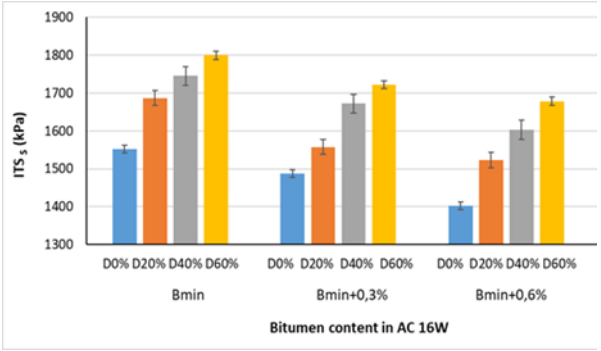
a)



b)



c)



d)

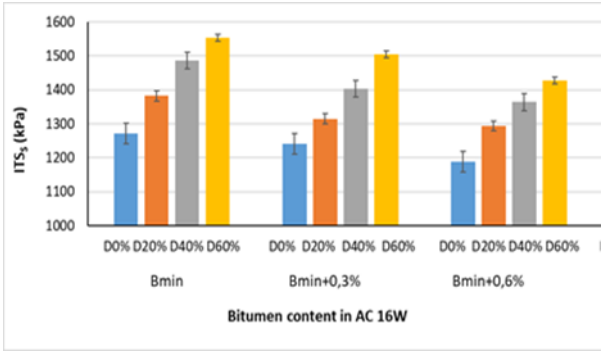


Fig. 12. Indirect tensile strength *ITSs* of the asphalt mixture with RAP at; a) -10°C; b) 0°C; c) +10°C; d)+20°C

Construction of an experimental section of the road

Fig.13. Built-in AC 16W

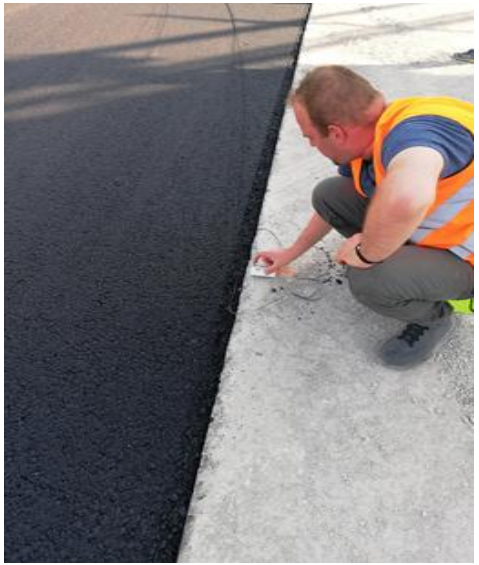


Fig.14. Measurement of the compaction temperature 100°C

Fig.15. Collection of asphalt mixture for testing

Conclusions

On the basis of the studies carried out on the effect of foamed asphalt with the addition of 1.5% synthetic wax and 0.4% tall oil amidopolyamine on the properties of the AC 16W asphalt mixture with RAP, the following conclusions can be drawn:

1. Innovative foamed asphalt has a rejuvenating effect on the properties of asphalt recovered from RAP. The intensity of its impact depends on the amount of bitumen recovered and decreases as its proportion in the composed binder increases. The most favourable binder composition contains 60% innovative foamed asphalt and 40% recycled asphalt,
2. The developed asphalt mixture containing RAP and an innovative binder composition behaves in the same way when increasing the binder quantity above Bmin as a traditional hot asphalt mixture,
3. The innovative foamed asphalt combined with asphalt recovered from RAP at Bmin yields more favourable basic physical and mechanical properties for the asphalt mixture than for the traditional asphalt mixture,
4. The use of innovative foamed asphalt ensures that the required parameters of the asphalt mixture with RAP are achieved at the reduced compaction temperature of 100^{o}C.

The positive results obtained for the basic physico-mechanical properties of the asphalt mixture with.

The positive results obtained for the basic physico-mechanical properties of the asphalt mixture with RAP and innovative foamed asphalt indicate the need for further research into its complex rheological parameters. Obtaining a comprehensive study will indicate the potential feasibility of implementing this type of asphalt mixture into road practice

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I invite you to cooperate

Thank you very much for your attention

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