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Hugo Silva *and* ***Joel Oliveira***
Transport Infrastructures Research Group
University of Minho - Portugal

An Evaluation of the Use of WMA Wax Additives in the Production of Unconventional Bituminous Mixtures

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Literature review

- Several processes/products are available to reduce AC production temperatures
  - Physical-chemical means (usually additives, including paraffin waxes)
  - Two phase bitumen introduction
  - Foamed bitumens and emulsions
- These technologies are classified as:
  - WMA (slightly above 100 ºC)
  - Half-WMA (slightly below 100 ºC)

Literature review

- WMA technologies can reduce production temperatures
  - Reducing emissions, fumes and odours
  - Ensuring a cooler work environment and evident energy savings
- However, it is essential that the overall performance of WMA is as good as HMA
  - Otherwise, on a life-cycle basis, WMA will not have long term environmental benefits

Literature review

- The used WMA technology was the addition of a paraffin wax (Sasobit®) to the binder
  - Sasobit® is a Fischer-Tropsch or synthetic wax used as a compaction aid / temperature reducer
  - It melts at approximately 100 ℃ and changes the temperature-viscosity curve of the binder
  - It reduces by 10-30 ℃ the mixing temperatures
  - It improves the compactability and the resistance to deformation of WMAs and does not affect their resilient modulus

Objectives of the Study

- A high modulus bituminous mixture AC 20 Base (HMBM) and a high flexibility bituminous mixture AC 14 Surf (HFBM) were studied
- These HMBMs were produced and compared:
  – with HMA technology (B10/20)
  – with WMA technology (B35/50 + wax)
- These HFBMs were produced and compared:
  – with HMA technology (B50/70)
  – with WMA technology (B160/220 + wax)

Binder Characterisation

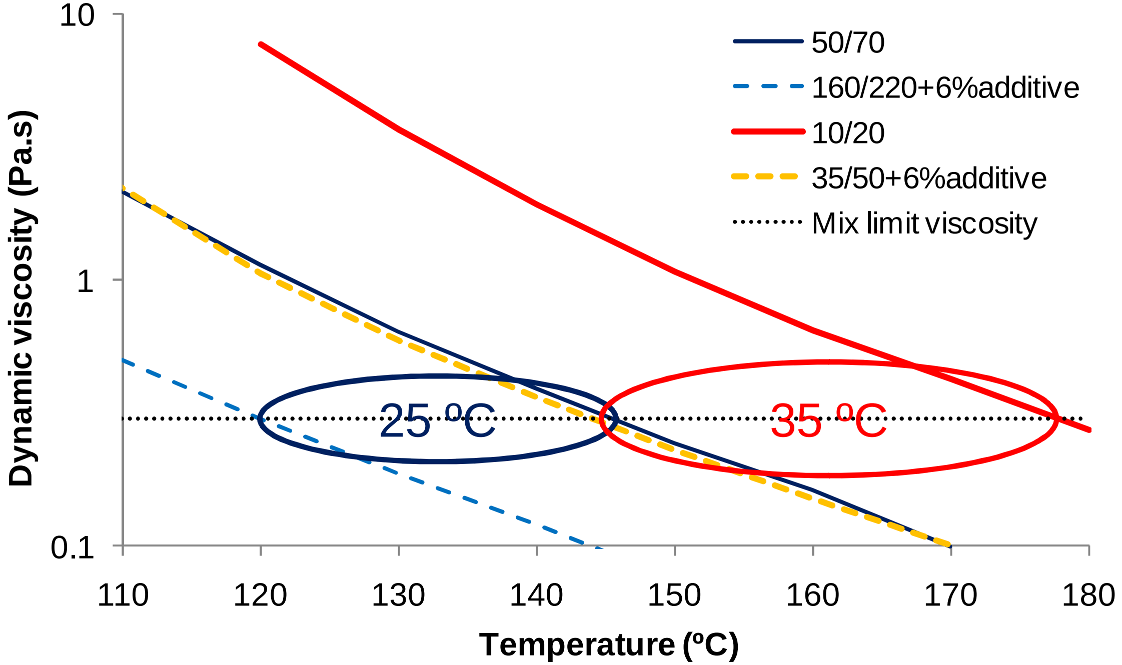
- General properties:
  Penetration and Softening Point test results

Mixture	HMBM					HFBM				
Bitumen	10/20	35/50				50/70	160/220			
Additive	0%	0%	2%	4%	6%	0%	0%	2%	4%	6%
Pen (0.1 mm)	16.4	37.9	25.7	23.5	21.8	53.5	163.7	96	79.6	70.2
R&B (ºC)	70	52	73	89	94	50	39	52	80	92

– 6% wax additive led to penetration values close to those of std binders and outperformed their R&B temperatures

Binder Characterisation

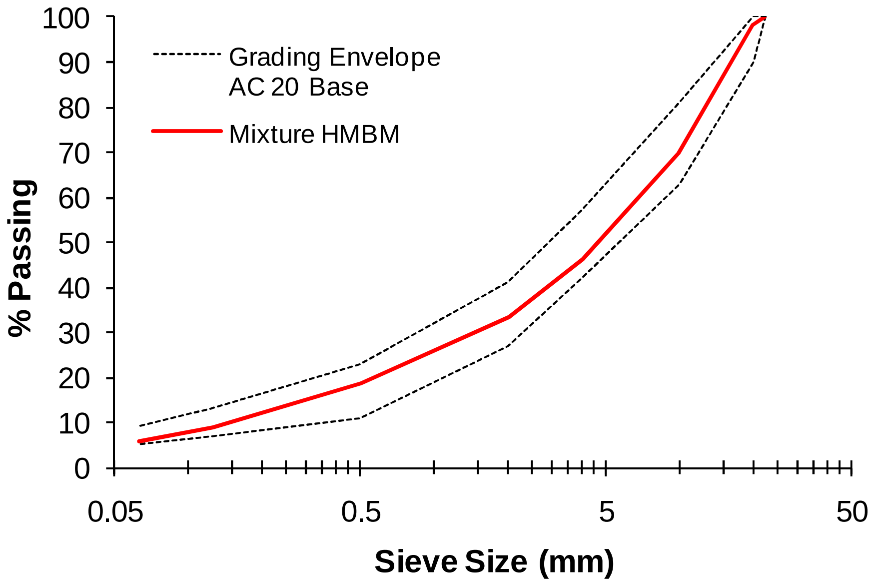
- Viscosity results / Reduction of temperature

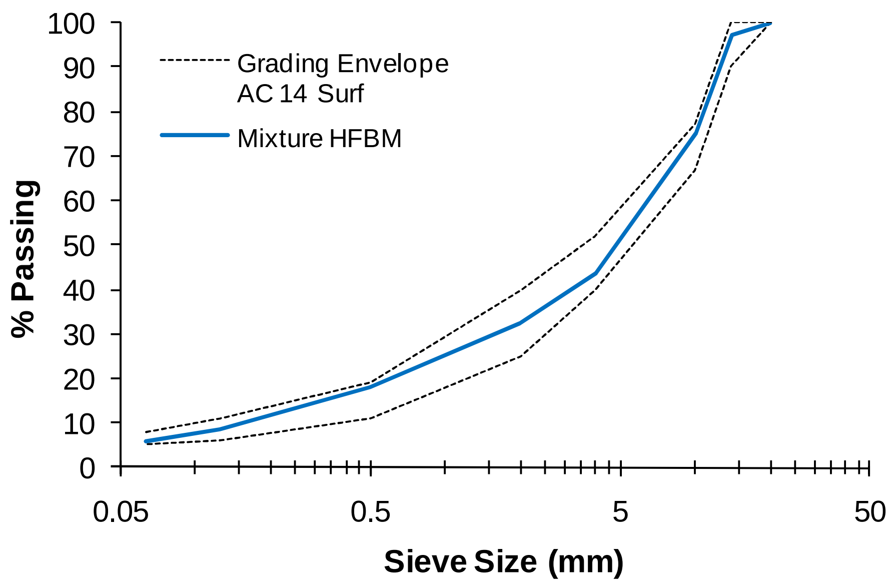


– Compactability test results allowed to increase the temperature reduction from 25 to 30ºC and 35 to 40 ºC

Mixtures composition

Marshall mix design (gradation / binder content)





– The same binder content (HMBM = 5.3%; HFBM = 5.0%), aggregate type and gradation were used for both HMA and WMA mixtures

Water Sensitivity

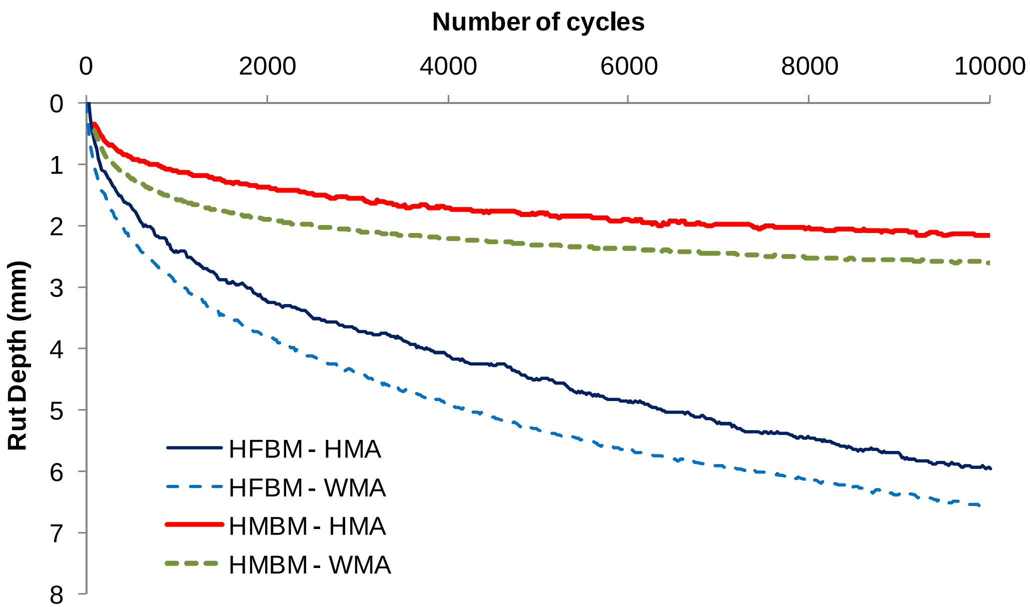
Water sensitivity tests were carried out according to EN 12697-12 (Indirect Tensile Strength Ratio)

Mixture	ITSR (%)
HMBM-HMA (10/20)	85
HMBM-WMA (35/50+wax)	92
HFBM-HMA (50/70)	69
HFBM-WMA (160/220+wax)	72

– ITSR is slightly higher for WMAs (waxes + softer bitumens)
– The influence of the base bitumen penetration is higher than that of the wax additives

Resistance to permanent deformation

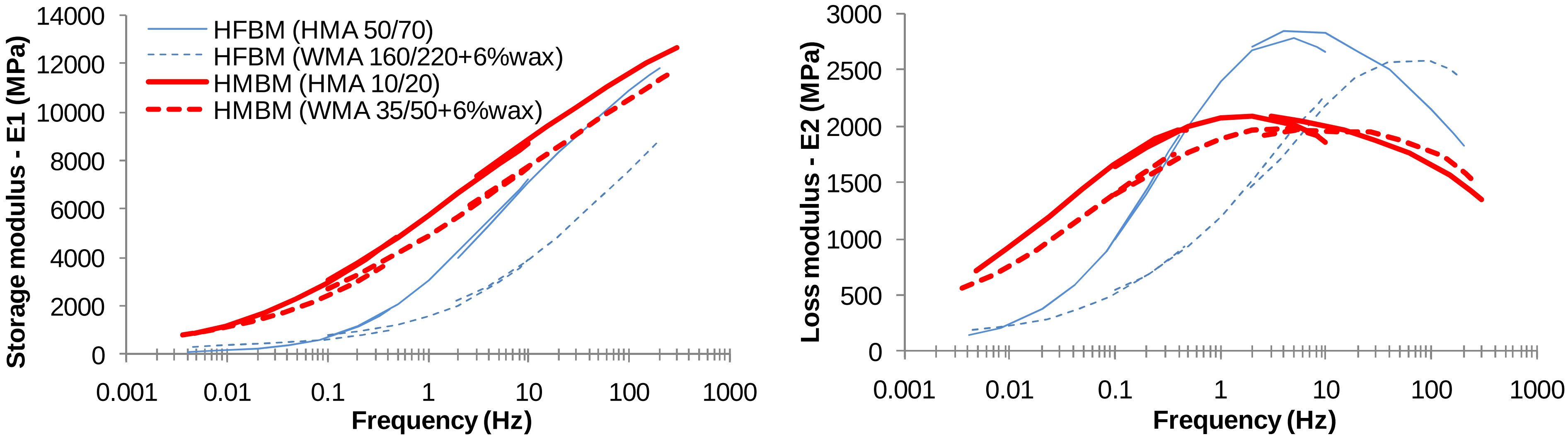
- Wheel tracking test results at 50 ºC



Mixture		WTS_{AIR} (mm/10^3 cycles)	PRD_{AIR} (%)
HMBM	HMA	0.07	5.13
	WMA	0.06	6.16
HFBM	HMA	0.24	13.55
	WMA	0.25	15.60

– WMA mixtures showed resistance to permanent deformation similar to that of HMA mixtures

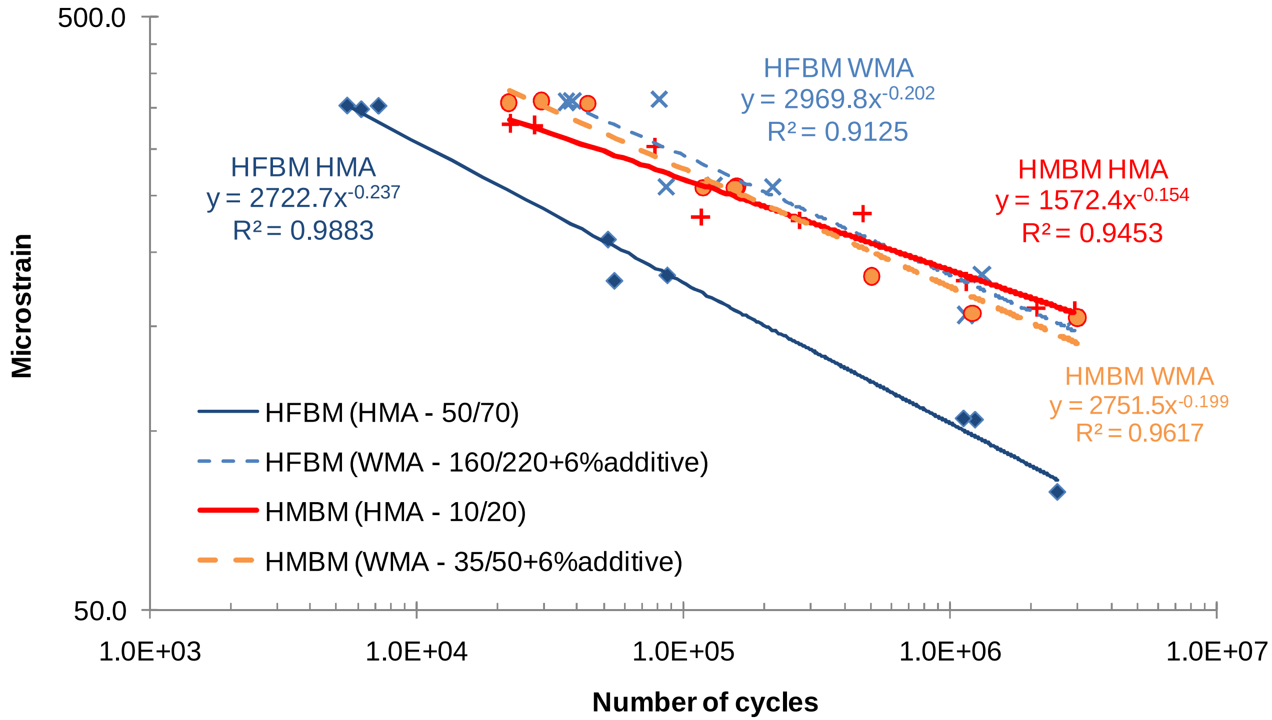
Stiffness modulus



4-point bending stiffness test results, carried out at 10, 20 and 30 ºC

– Both WMAs have lower stiffness moduli than HMAs, especially at lower temperatures (higher penetration)

Fatigue cracking resistance



4-point bending fatigue test results, carried out at 20 ºC and 10 Hz

– HMBMs showed similar fatigue performance

– HFBM WMA showed significantly higher fatigue resistance than HFBM HMA

Conclusions

- Softer base bitumens with synthetic wax additives are good to maximise WMA's temperature reductions (40 ºC – HMBM; 30 ºC – HFBM)
- This additive significantly increases the resistance to permanent deformation of WMA mixtures
- The stiffness moduli of both WMAs was lower than those of corresponding HMAs (soft base bitumen)
- The fatigue resistance of the HFBM WMA was significantly higher than HFBM HMA, while the behaviour of both HMBMs was similar

Thank you for your attention