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Study on the Use of a WMA Surface Agent Additive on Recycled and Asphalt Rubber Mixtures

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- Performance of Mixtures
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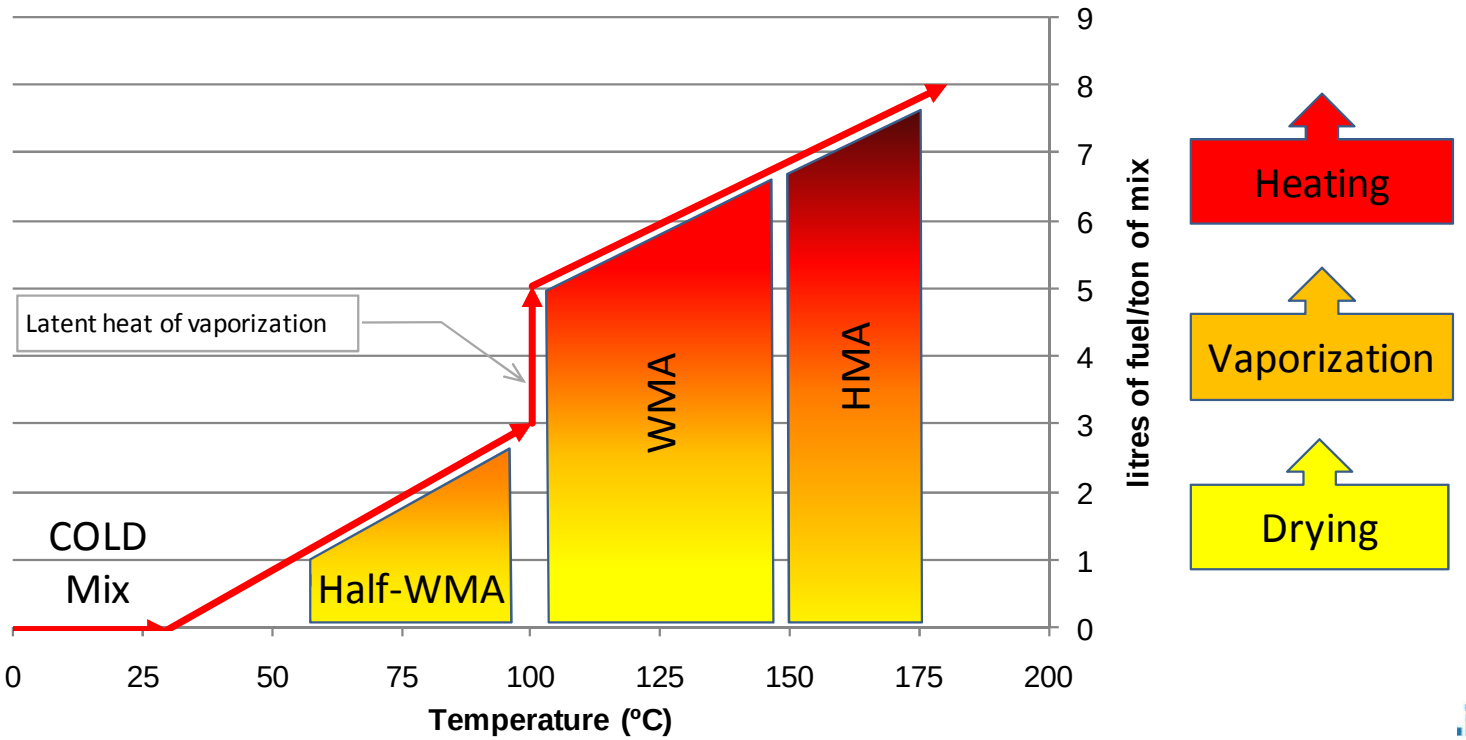
Literature review on WMA mixtures

- Several processes and products are available to produce WMA and half-WMA at lower temperatures



Literature review on WMA mixtures

- Lower plant mixing temperatures of WMAs mean:
  - Reduction in fuel consumption, emissions, odours and health problems
  - Improved workability, longer haul distances and longer construction season
  - Minimized hardening → improves fatigue resistance

Literature review on WMA mixtures

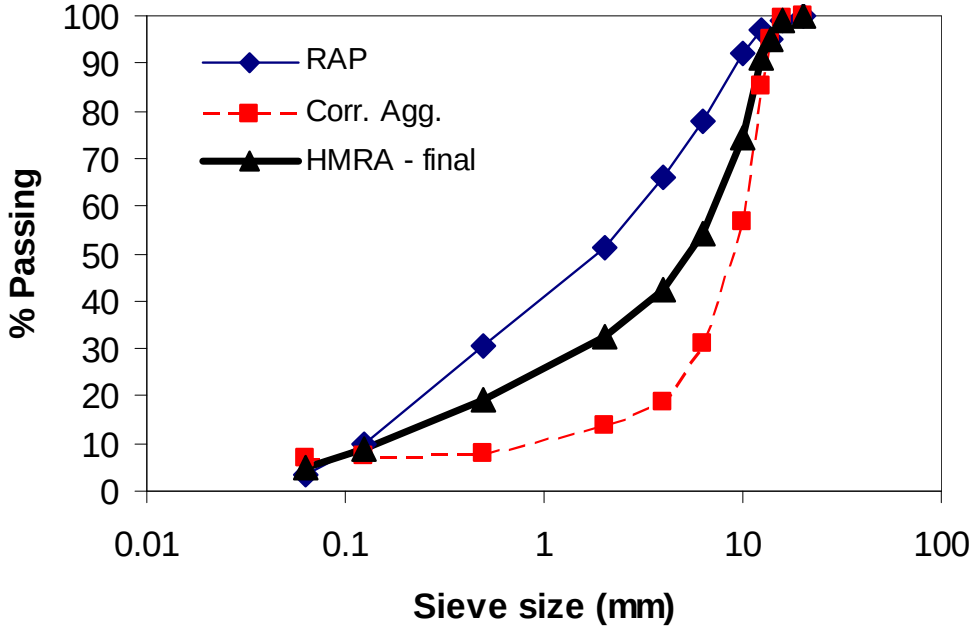
- WMA technologies have some engineering challenges:
  - Minimized hardening → higher potential for rutting
  - The relationships between engineering properties of WMAs and their field performance need to be investigated

Composition of the studied mixtures

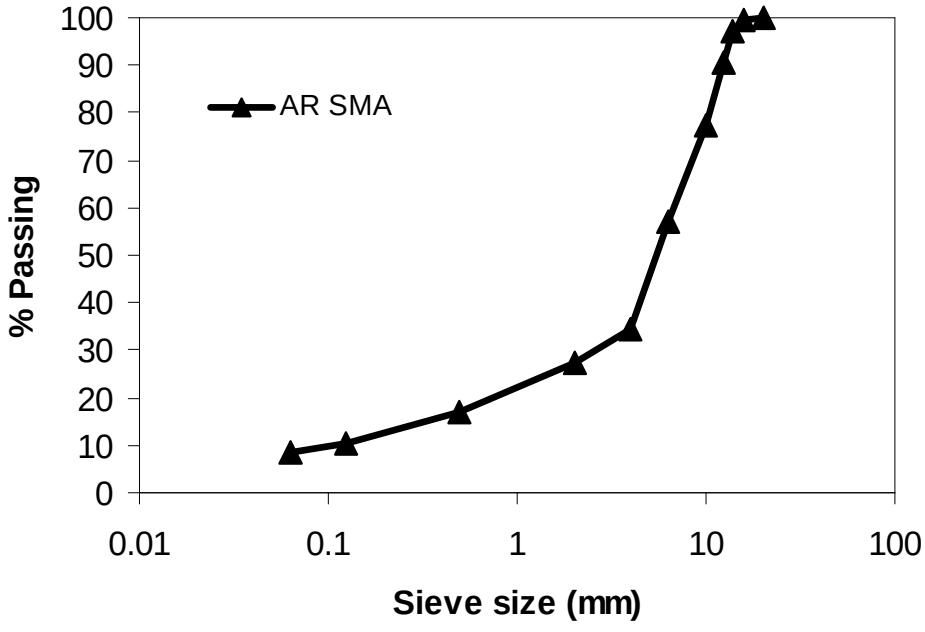
- Hot Mix Recycled Asphalt (HMRA – AC 0/14), with 50% RAP and 5.2% binder (by mass of mixture);
- Asphalt rubber (AR-SMA), with 9% binder (modified with 21% rubber);
- Two mixtures were produced for each type (with and without 0.5% surfactant additive) using a 50/70pen base bitumen;

Composition of the studied mixtures

- Grading curves of the aggregates used in the HMRA (a) and AR (b) mixtures



a)



b)

Binder Characterisation

Penetration and Softening Point Test Results

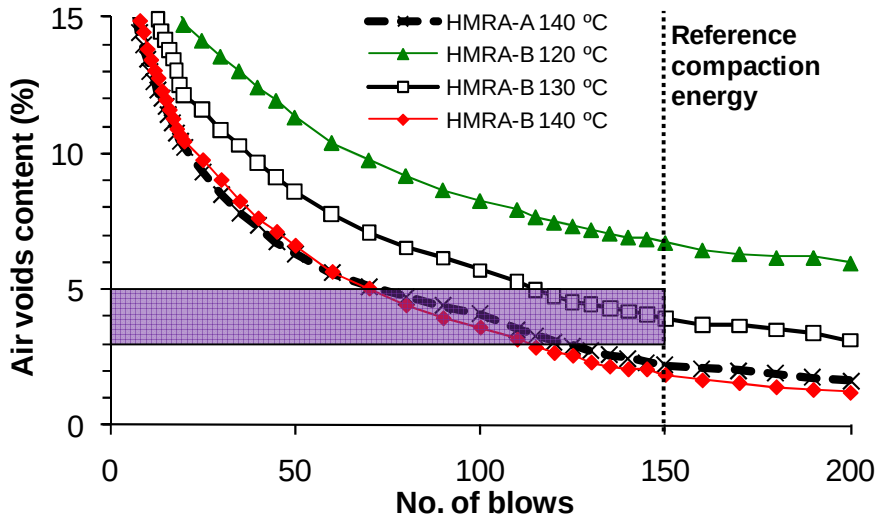
Mixture	Binder	% additive	Penetration (0.1mm)	R&B temperature (ºC)
---	50/70	0.0	60.9	50.7
---	50/70	0.5	63.7	50.8
AR SMA-A	AR	0.0	25.6	76.2
AR SMA-B	AR	0.5	25.5	76.6
HMRA-A	Recycled*	0.0	18.1	68.0
HMRA-B	Recycled*	0.5	18.5	66.0

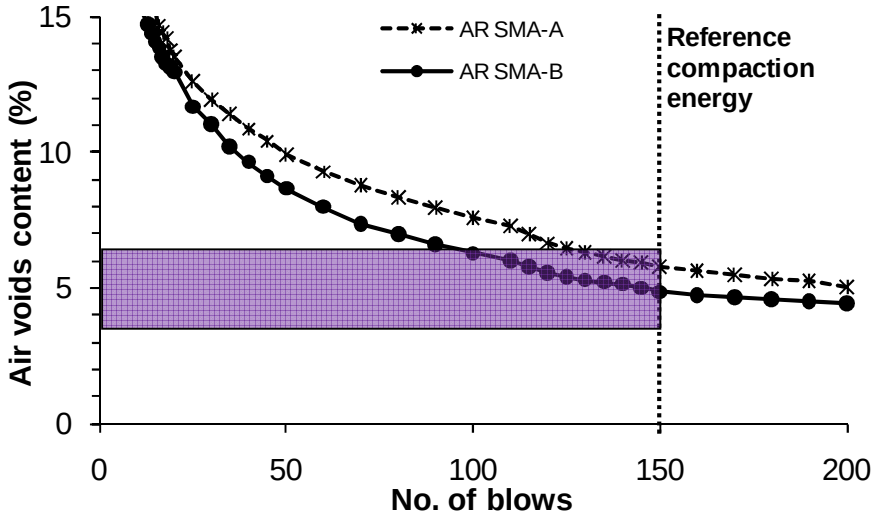
* this binder was recovered from the HMRAs using a centrifuge and a rotary evaporator apparatus

Temperature reductions

- Surfactants barely change the binder properties;
- Temperature reduction was based on compactability tests (EN 12697-10);
- The control mixtures were compacted at 140 ºC (HMRA-A) and 170 ºC (AR-SMA-A);
- Three HMRA-B mixtures were compacted at 140, 130 and 120 ºC;
- One AR-SMA-B was compacted at 140 ºC.

Compactability test results using impact compactor





- Compaction temperatures could be reduced by 10 ºC (40 ºC in heating the virgin agg.) for the HMRA and 30 ºC for the AR mixtures

Water Sensitivity

The mixtures were tested for water sensitivity according to the EN 12697-12 standard (Indirect Tensile Strength Ratio – ITSR)

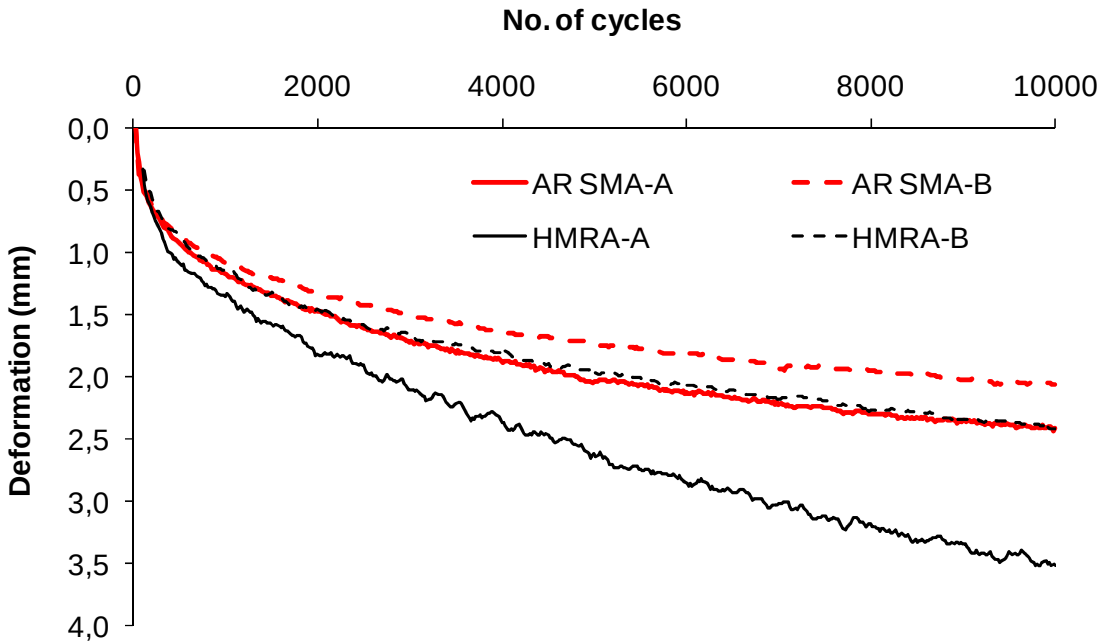
Mixture	ITSR (%)
HMRA-A	92
HMRA-B	87
AR SMA-A	90
AR SMA-B	93

- The effect of the additive in the water sensitivity is negligible
- Good performance of the mixtures (ITSR > 85%)

Resistance to permanent deformation

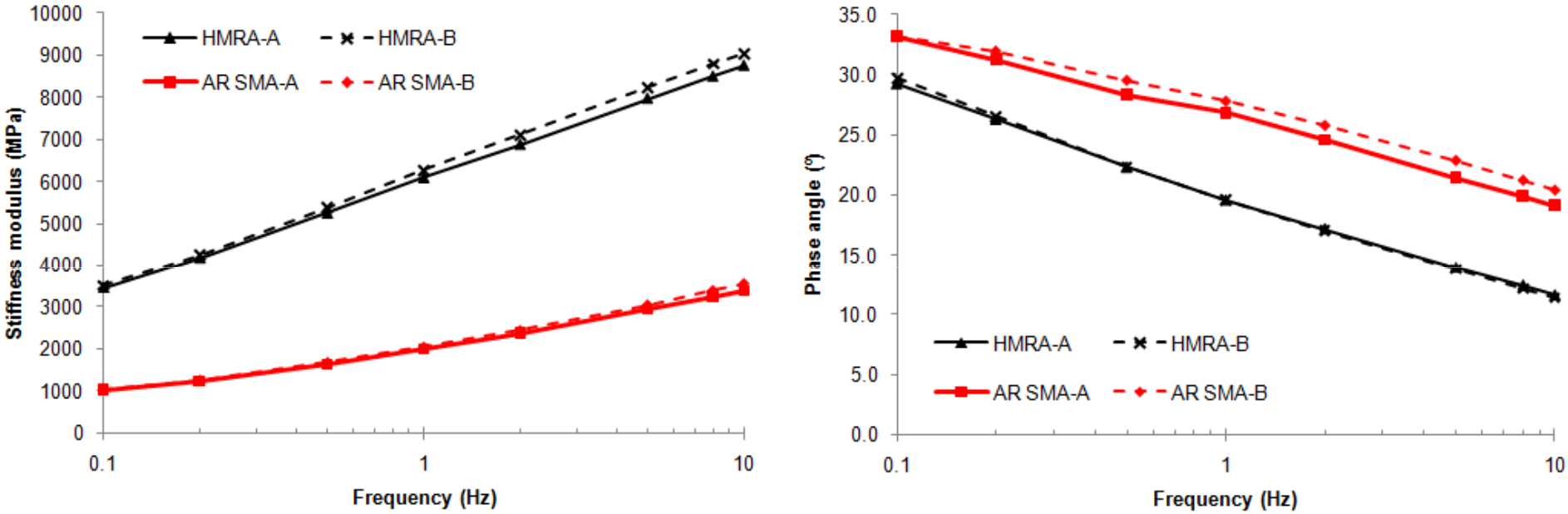
Wheel tracking test results (at 50 ºC)

Mixture	WTS_{AIR} (mm/10^3 cycles)	PRD_{AIR} (%)
HMRA-A	0.18	8.19
HMRA-B	0.09	5.68
AR SMA-A	0.08	5.54
AR SMA-B	0.07	4.78



The additive increased the resistance to permanent deformation of both mixtures

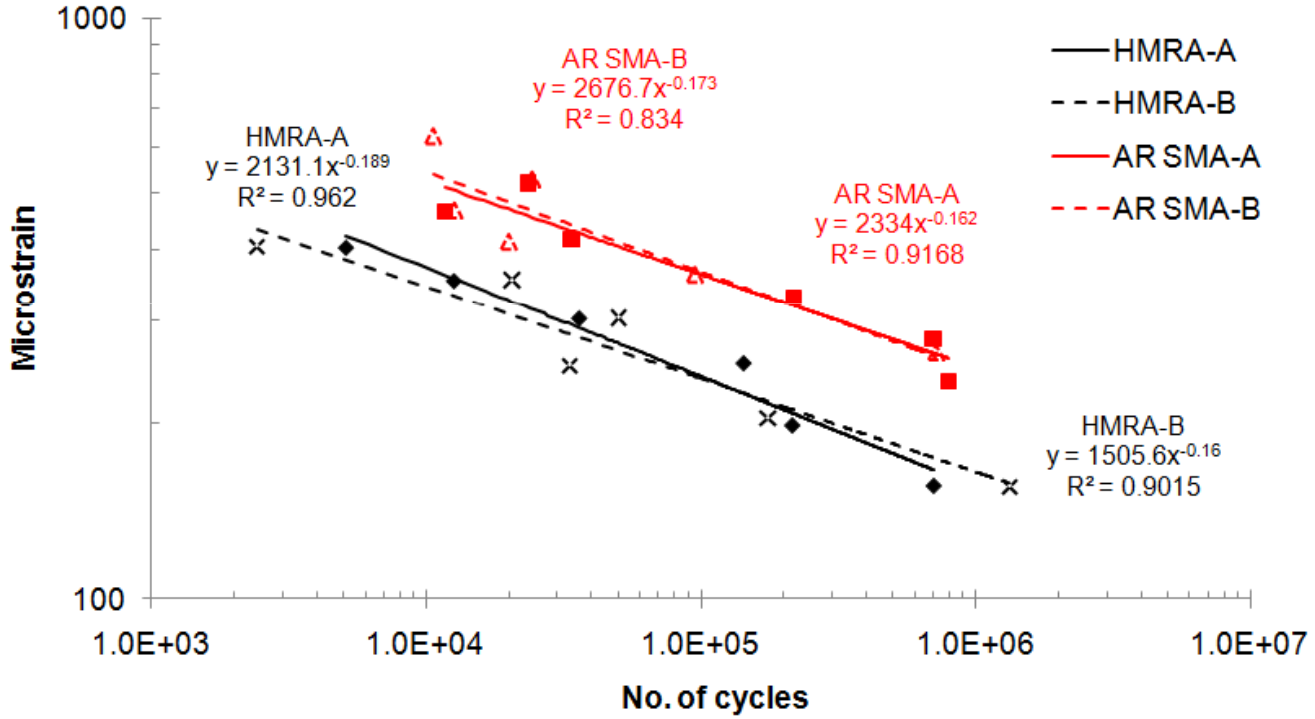
Stiffness modulus



Stiffness test results, carried out at 20 ºC, using 4-point bending apparatus

The additive barely affects the stiffness and the phase angle of the mixture

Fatigue cracking resistance



The additive does not affect the fatigue resistance of both types of mixture

Fatigue test results, carried out at 20 ºC, using 4-point bending apparatus

This confirms the possibility of using lower production temperatures

Conclusions

- By using 0.5% of additive, it was possible to reduce the production temperature by 40 or 30 ºC, for the recycled (virgin aggregates) and AR mixtures;
- The surfactant has increased the resistance to permanent deformation of both mixtures;
- The use of surfactants and the reduction of temperature barely affected the performance of the mixtures, in terms of:
  - Water sensitivity
  - Stiffness modulus
  - Fatigue resistance

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Thank you for your attention