Evaluation of Recycled Asphalt Pavement Contents in Warm Mix Asphalt Technologies

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R&D in ARKEMA

- **Arkema** is a leader in key chemical production sectors such as chlorine, thiochemicals, acrylics, fluorochemicals and hydrogen peroxide, our products include intermediate chemicals, polymers, fine chemicals and **specialty chemicals**.

- Arkema produces **bitumen additives** (adhesion promoters, emulsifiers, process aids and warm mix asphalt additives)

- There are 8 **R&D** centers. The road applications **laboratory** is in the CRRA in Lyon, France
There are several reasons to use reclaimed asphalt pavement (RAP) in our asphalt formulations:

- **Cost savings** (mostly bitumen)
  ~$5 per ton (+20% RAP)*

- **Reduction** of waste → Landfill

- **Environment** protection (less resources consumed)

* Brochure NCAT RAP FAQ
RAP and WMA

RAP at room T
= overheated aggregates

→ WMA can increase the amount of RAP added

[Graph showing calculated temperatures for different mix temperatures (Tmix 120°C, Tmix 160°C) and RAP content (% RAP). The graph indicates that WMA can increase the amount of RAP added by up to 15%.]
WMA technologies

Different technologies → different physical phenomena

- **Water Foam Processes** – Water is added to form a bitumen foam when it evaporates. (Zeolites, partial drying of mineral aggregates, emulsion, foaming nozzles, etc.)

- **Waxes** – Solid additives (2-3 wt% used) that melt at paving temperatures ($T > \sim 100\,^\circ C$), reducing the bitumen viscosity.

- **Chemical Additives** – Liquid surfactant-based additives

Different technologies → different effect on RAP ??
Potential issues with RAP

Fresh bitumen + RAP

0% mixing

100% mixing

Heterogeneous mix, changes in time ??
In this work....

1. Develop a **laboratory method** to evaluate the amount of fresh binder and RAP binder **blending**
   - Rheology
   - Asphalt mix testing

- Test different **WMA technologies** to see if we can see any differences
  - Foam additive
  - Wax
  - Chemical additive
Simple inspection of RAP/bitumen

Manual mixing of 6/10 mm RAP, virgin aggregates and 2% fresh binder at 120°C

Chemical additive
Zeolite additive
Reference
+ 20% fluxant
Wax
No fresh binder (180°C)

No clear results
Hard/Soft bitumen rheology

As previously shown by Karlsson et al*. The diffusion between two different types of bitumen may be evaluated by rheology → very large times

Shorter times, and more significant observations might be achieved by a continuous shear experiment and higher temperatures

Calculation of 2 layers viscosity

\[ \tau = \eta \dot{\gamma} = \text{constant through } h \]

Simple **model** for apparent two layer viscosity

\[ \eta_{\text{apparent}} = \frac{\eta_{\text{soft}} \cdot \eta_{\text{hard}}}{\eta_{\text{soft}} h_{\text{hard}} + \eta_{\text{hard}} h_{\text{soft}}} \]
Viscosity of complete blend

Model for complete blend viscosity

$$\ln \eta_{\text{Total}} = x_{\text{soft}} \ln \eta_{\text{soft}} + x_{\text{hard}}^\alpha \ln \eta_{\text{hard}}$$

Blends of a soft 70/100 (~PG 58-58) and a hard 10/20 (~PG 82-16) binders were done
Sample preparation

The layers of different binders (soft and hard) were carefully assembled sequentially in the rheometer.
2 layer rheology

The **apparent viscosity** was measured at 120°C and a 30/s shear rate.

A viscosity **increase** indicates **blending** of the binders.

![Graph showing viscosity over time](image)
2 layer rheology - issues

- Assembly of layer is a relatively complex operation.
- Highly dependent on each layer thickness (to 0.05mm precision).
- Assembly sequence conditions (temperatures and times) dependent on specific bitumen → different source of 10/20, parameters need to be modified.

Modification of assembly procedure and ....practice → Better reproducibility → other conditions tested.
2 layer rheology – other conditions

Different shear rates

WMA chemical additive in soft bitumen

Still some work to do…
Asphalt mixtures containing 100% RAP (0/10mm) were prepared at 120°C, with 2% of fresh bitumen using different WMA technologies:

- Zeolites
- Waxes
- Chemical Additives

References samples were carried out (without any WMA technique) with different fresh binder grades for comparison.

The samples were then tested for ITS at room temperature.
Results - ITS

- Fresh binder grade seems to control the mix ITS (references)
- Only the chemical additive showed a difference with respect of reference
Conclusions

- Visual inspection of simple mixing don’t allow to evaluate differences.

- Rheological 2 layer test allows to see the blending of two different binders. However, the procedure is complicated.

- Mechanical properties (ITS) of a 100% RAP mix showed importance of fresh binder added. No difference were observed with WMAs except with the chemical additive.

- Further work is necessary to fully understand the role of WMA technologies in asphalt mixtures containing RAP
Thank You

CRRA Bitumen applications R&D Team