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Temperature Effect on Warm Mix Asphalt Performance

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Background

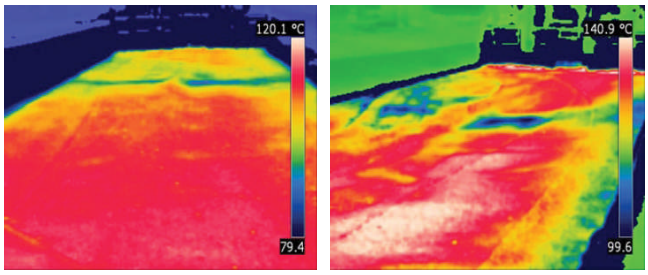
Warm Mix Asphalt (WMA) refers to the bituminous mixtures which are produced at temperatures approximately 28°C to 55°C lower than the typical production temperature of Hot Mix Asphalt (HMA) for the purposes of energy saving and lowering the greenhouse gas emissions. However, as a replacement material for the conventional HMA, WMA should have similar strength, durability, and performance characteristics. During the mixing, delivery or compaction processes, if the mixture's temperature drops under the minimum allowable production temperature at which adequate compaction can be induced, then serious problems are expected for the resultant mixture. In the case of WMA, the effects of temperature decline on the properties of mixture may be more complicated than in HMA. This refers, on the one hand, to the effect of various additives used in several production technologies in order to lower the viscosity, and on the other hand, to the lower level of ageing in WMA binder due to the lower production temperatures.

Aim

The overall aim of this PhD is to study the effect and implications of temperature decline during mixing, delivery, placement and compaction phases on the mechanical performance of WMA along with determination of the fundamental reasons for such performance changes.

Objectives

- Compile/develop instructions for manufacturing Warm Mix Asphalt mixtures using wax, foaming and chemical additive technology.
- Perform a comprehensive matrix of laboratory tests for evaluating the rheological behaviour (G* and ageing) of different types of WMA, using the Dynamic Shear Rheometer (DSR) and a Brookfield Viscometer.
- Perform laboratory tests to evaluate the mechanical performance characteristics of the manufactured WMA mixtures (E*, fatigue and rutting parameters) to investigate the effect of mixing and compaction temperatures.
- Find temperature-dependant relationships between the mechanical performance of the manufactured mixtures and their binders, exploiting mechanical/rheological parameters and viscoelastic micromechanical models.
- Use microstructural investigations, e.g. SEM and X-ray CT, to gain understanding of relevant mechanisms.
- Develop approaches and guidelines to improve/avoid mechanical deficiencies/potential distresses resulting from time delay and temperature decline between mixing and placement/compaction.



Surface temperature and consistency difference between WMA (left) and HMA (right) during placement
(Photo from: www.hotmixmag.com)

Low temperature cracking (left) and fatigue cracking (right)
(Photo from: www.pavementinteractive.org)

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