Construction Materials
Volume 166 Issue CM1

Book review
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Proceedings of the Institution of Civil Engineers
Construction Materials 166 February 2013 Issue CM1
Pages 55–56 http://dx.doi.org/10.1680/coma.11.00063
Paper 1100063
Published online 06/07/2012

ice | **proceedings**

Book review

PPR560 – Pilot-Scale Trial of Advera WMA Asphalt Mixtures for Binder Course and Surface Course

J. C. Nicholls, M. Wayman and P. D. Sanders. Transport Research Laboratory, Wokingham, UK, 2011, ISBN 978-1-84608-970-1, £45·00 (printed) or £35·00 (PDF), 84 pp.

The use of additives to reduce the mixing temperature of asphalt has become of increasing interest with increases in the cost of fuel to heat and dry the aggregates and the political desire to reduce the carbon dioxide emissions or 'carbon footprint' of UK industry.

There are several such additives whose main aim is to reduce the viscosity of the bitumen at elevated temperatures so that it can adequately coat the aggregates but at a lower temperature than is the case with conventional paving grade bitumen alone. However, it is important that the essential properties of the resultant asphalt are not adversely affected at the temperatures recorded in a road or airfield pavement in the UK and in the cool, wet UK climate.

There are various technologies which are being marketed to achieve this aim. Some are organic additives which are low viscosity liquids above about 100°C but are solids below this temperature; others incorporate small quantities of water that, as steam creates bubbles which dramatically reduce the viscosity of the bitumen, then revert to water as the bitumen cools. The amount of water thus trapped within the installed asphalt is claimed to be so small that it does not affect the performance.

Many of these products originated in the USA and Advera is one such material. As an aid to marketing the product in the UK, the Philadelphian producer, in co-operation with Aggregate Industries, a major supplier of asphalt in the UK market, commissioned Transport Research Laboratory (TRL) to review the producers' laboratory test results and monitor a pilot installation trial in a new car park access road in one of Aggregate Industries' quarries in Shropshire. Although the results of the trial and testing carried out are covered there is no mention of the review of the supplier-provided data. The report reviewed herein was prepared for PQ Corporation, PQ Silicas UK Ltd.

The technology is based on the use of zeolite (an aluminosilicate) as an additive. Zeolite contains about 20% structurally and chemically bound moisture. This is released at 120°C causing the bitumen to foam, filling all the voids in the loose mix and coating the fine and coarse aggregate. This enables a reduction of some 40°C in the mixing temperature. It is claimed that any remaining water in the mix after cooling could be re-absorbed by the zeolite, which then acts subsequently as additional filler or very fine aggregate in the mix.

The trials were organised to measure the parameters of most interest to the UK asphalt industry; those parameters are listed here.

(*a*) Mixing temperature reduction possible at the plant.
(*b*) Effect on mixing capabilities of the reduced temperature.
(*c*) Effect of the reduced delivery temperatures on laying and compaction activities on site.
(*d*) Reduction in time after completion of a layer such that traffic can run on it without causing damage.
(*e*) Effect of the use of the additive on the life cycle carbon footprint of the material using the 'asPECT' computer program, developed for calculating this value for UK asphalts.

The trial was carried out in June 2010. A standard asphalt concrete (AC) binder course with 20 mm aggregate and stone mastic asphalt (SMA) surface course with 10 mm aggregate were manufactured with 40/60 pen grade bitumen without and with 0·3% Advera additive.

Although the plant had little difficulty in controlling the mixing temperatures of the mix asphalt in the range 120 to 160°C, below this, it proved difficult to reduce the mixing temperature as required by the experiment. Additional mixing time, from 30 to 45 s was found to be necessary with the product to achieve full coating of the aggregate.

Both the hot mix and the warm mix experienced a numerically similar temperature drop: namely just a few degrees through the paver but about 40°C between delivery and completion of compaction. In the case of the mixtures with this product, the temperatures were around 70°C (binder course) and 90°C (surface course) before compaction was completed. The air temperature was cool for June, being 7°C for the binder course and 16°C for the surface course.

The binder course was laid in a thickness range of 58 to 104 mm (mean 79 mm), the surface course was laid in the thickness range 20 to 60 mm (mean 42 mm), values which are sadly not infrequently found in normal practice.

Some variation in texture depth in the SMA surface course was visible as one might expect from this thickness range.

Comprehensive photographs of the trial being laid are provided in an Appendix.

The results from the air voids measured after compaction are presented graphically in the report. In summary, the same air voids are achieved with a mix containing 0·3% of the product as with a conventional mix that is 20°C hotter; so to that extent the product could be said to 'work'. The stiffness modulus of the binder course was measured on the cores using the indirect tensile stiffness test, and with both modified and unmodified mixes followed the air voids content, with lower stiffness as voids increased.

Mixtures based upon water-based bubbles suffer a risk of being sensitive to water after installation and other zeolite-based mixtures have shown this to be the case. Cores taken from the trial were tested using the water sensitivity test used for thin surface course systems; namely three cycles each consisting of vacuum soaking at 20°C for 20 min, 6 h soaking at 60°C and finally 2 h soaking at 5°C. After only two cycles, damage was apparent and three out of 10 specimens fell apart even under this reduced regime. The authors took some comfort that the modified mix performed better than the unmodified control mix when compacted at the same low temperature.

The effect of the product on deformation resistance of cores taken from the trial was found to be minimal.

One of the claimed benefits of warm mix asphalt is that a layer can be trafficked earlier than a conventional hot mix. To check this, TRL inserted thermocouples into the cooling compacted mat. Actual, as opposed to theoretical data (as for example in PPR13 [Nicholls JC and Daines M. *Acceptable Weather Conditions for Laying Bituminous Materials*. Project report 13, TRL, Wokingham, UK, 1993] is quite sparse and is very helpful to installers in deciding when a road can be opened. It is, of course, necessary to define the temperature at which a mix becomes adequately stable to permit trafficking; this is dependent upon the mix. The report suggests 35°C and on this basis the use of the additive saves 0·5 h against the conventional mixture in a 40 mm thick layer.

The carbon footprint calculations showed considerable benefits for the mixture containing the product in the cradle-to-gate footprint. This was 50% lower than the conventional hot mix in the binder course and 40% lower in the SMA surface course. However, this assessment was based on single point data for a hot mix at 160°C, with quoted values of 90 kgCO_{2e}/t (AC) and 98 kg CO_{2e}/t (SMA) compared with 50 kg CO_{2e}/t for mixtures with the product at 120°C. However, these conventional hot mix figures are very high.

Repeating the original aims of the study, the conclusions for each are presented here.

(*a*) Mixing temperature reduction possible at the plant: yes, provided a minimum temperature greater than 120°C is achieved instead of the more normal 160°C.
(*b*) Effect on mixing capabilities of the reduced temperature: a 50% increase in mixing time was necessary to achieve good aggregate coating.
(*c*) Effect of the reduced delivery temperatures on laying and compaction activities on site: the additive permitted compaction at a lower temperature and similar air voids could be achieved.
(*d*) Reduction in time after completion of a layer that traffic can run on it without causing damage: the additive permitted traffic to run on the layer about 30 min earlier than on a conventional mix.
(*e*) Effect of the use of the additive on the life cycle carbon footprint of the material: the additive reduced the carbon footprint by between 40 and 50% in the material delivered out of the plant.

The study aims presumed that the durability of the resultant mixture with Advera would be unaffected. This proved not to be the case. Whereas the effects on stiffness modulus and deformation resistance were minimal, some loss of fatigue resistance was reported, but of most significance was the lack of durability in the wet; the material fell apart. In hot, dry climates this is of no significance, but in the UK it is a serious fault which may well prevent the widespread acceptance of the product.

Although not mentioned in the report, it is known that the cost of this and other similar additives exceeds the savings made from reduced energy usage. This was investigated for example in Denmark in 2007 by Kristjánsdóttir (2007) who found increases in cost of between US$1 and US$4 per tonne depending upon the additive.

Aggregate Industries are still evaluating whether this product can usefully feature among the other technologies they are considering to meet their carbon footprint targets.

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REFERENCE

Kristjánsdóttir IIO (2007) Warm mix asphalt technology adoption. *NVF 33 Annual Meeting, June 2007 Trondheim, Norway*. See http://www.vegagerdin.is/nvf33.nsf/…/FoU_NVF33_2007-Island.pdf (accessed 24/04/2012).