AUSTRALIAN ASPHALT PAVEMENT ASSOCIATION

advisory note 17

WARM MIX ASPHALT – A STATE-OF-THE-ART REVIEW

Introduction

For several decades the asphalt industry has talked about energy savings and environmental benefits in cold or warm asphalt processes. In spite of all the predictions, it has not happened. Cold mixes occupy various niche market areas but have not had any significant impact on hot mix asphalt as the primary road surfacing material.

The main purpose of this review is to draw attention to some innovative processes that could provide increased opportunity for lower temperatures in asphalt mixes.

Background

The factors that influence any move to cold or warm products fall into three major areas:

1. Product performance
2. Cost
3. Market demand.

Product performance

In general terms, most cold products are inferior to hot mix asphalt. Emulsion binders usually result in higher air voids. Emulsion binders involve slower curing than hot mixes, and tend to work best with coarse and open graded mixtures. Cutback bitumen binders involve extended curing time. Foam bitumen provides rapid curing, but, in its basic form, will only coat the fine particles in the mixture, making it suitable for stabilisation and recycling work but not as a direct hot mix equivalent.

Cost

Bitumen as emulsion costs more. Basic emulsion mixes can be manufactured in simple mixing plants, but more sophisticated products increase the complexity of manufacture and placing. The extra costs and difficulties are not outweighed by energy savings, although the advantages of cold placing are a factor in use of cold mixes in maintenance work, remote locations, etc.

Market Demand

The manufacture and placing of hot mix asphalt has a relatively small environmental impact and hence has not attracted regulation to compel a switch to cold products. The market does not place a significant price premium on products that may be perceived to be more environmentally friendly. Without market demand, there is no pressure on asphalt suppliers to address issues of cost and complexity, or to invest in substantial research to solve the problems of product performance. That is not to say that there has not been on-going research in a number of areas and hence the outcomes described in this report.

Some steps forward

In a conventional hot mix asphalt, coating of aggregates is achieved simply and efficiently by heating the bitumen binder and aggregate to around 160 - 170°C. The product is placed hot and cures immediately on cooling. No volatile components are used and fuming is minimal.

Emulsifying the binder enables mixing and placing at lower temperatures. The principal disadvantage is the time and process of curing of the mixture after placing. Some improvement can be made with higher binder content emulsions and/or mixes that are manufactured and placed warm.

A step forward was the introduction of a two stage emulsion process using one type of emulsion to coat the coarse aggregate particles, followed by a different type of emulsion to coat fine aggregates and provide field handling characteristics. Optimising the emulsion binders in this manner enabled manufacture of dense graded mixtures with improved curing rates.

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Head Office: Level 2, 5 Wellington Street, KEW Victoria 3101
Tel: (03) 9853 3595 Fax: (03) 9853 3484 E-mail: info@aapa.asn.au Web: www.aapa.asn.au

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This concept was developed further by using a high binder content emulsion to coat coarse aggregate particles in the first stage and then foam bitumen, which coated the fine aggregates and provided workability, in the second stage. This significantly improved curing rates while achieving fully coated aggregates. The final product had properties comparable to hot mix asphalt. This development was reported by Maccarrone (1994). It has not had any impact, however, as it does not overcome the hurdles of increased cost, manufacturing complexity, and market demand.

Another innovation to improve the efficiency of the foam mix process was applied by warming the mixture during manufacture. This was reported by Jenkins et al (1999). In the foam mix process, binder coating is only achieved on the very fine aggregate particles. Increasing the temperature of the mix increases the size of particle that can be effectively coated. Cohesion and strength of the mix is improved but the largest particles still remain partially coated.

Warm Asphalt Mix (WAM) process

A warm asphalt mix process (WAM) has been developed in Europe and was reported by Harrison and Christodulaki (2000) at the First International Conference of Asphalt Pavements, Sydney (2000). A more complete report was given by Koenders et al at Eurobitume (2000).

The concept behind WAM is simple, although some of the finer detail is protected by patents. A two-stage process is used. In the first stage, the mixture is made with a soft binder that enables effective coating and mixing at a lower temperature (typically 100 - 120°C) than normal hot mix. In the second stage, a harder binder is added in the form of a powder, emulsion or foam. The two bitumen binder grades are selected so that the combined mixture has a grade comparable to that otherwise selected for the particular hot mix asphalt performance requirement. In field trials, foam bitumen has been found to be the most practical and economical means of adding the second binder component.

The final mixture can be readily handled and compacted at temperatures as low as 80 – 90°C.

It is claimed that CO_2 emissions in manufacture are reduced by a factor of 2 for every 10°C reduction in temperature. Risk of workers exposure to fume is also substantially reduced.

The complexity of manufacture is increased slightly but there is no large increase in the cost of binder materials, and the final product does not require lengthy curing to provide equivalent performance to conventional hot mix asphalt.

It should be noted that the stage 1 binder is not a cutback bitumen or emulsion, but a specially manufactured, soft grade of bitumen binder. The second stage binder is also a conventional bitumen of a suitable grade.

A strong level of interest is claimed in Europe and USA, and the product could also have application in Australia.

References

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