15th AAPA International
Flexible Pavements Conference

Brisbane
22–25 September 2013

The Development of an Evaluation Protocol for Warm Mix Asphalt Pavements

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Warm mix asphalt: background

- Increasing emphasis on need to reduce emissions and energy usage which contribute to global warming
  - WMA a good option
- However, acceptance of WMA depends on:
  - confirmation of environmental benefits
  - evidence that field performance is at least equal to that of HMA
  - assurance regarding possible impact of use of WMA on current specifications
- Independent review sought by road agencies

Austroads research project: tasks

- Develop draft WMA evaluation protocol:
  - guidance on the evaluation of WMA technologies and processes
- Assemble information on current field validation projects
  - review overseas and Australian studies
  - determine need for APT trial
- Conduct field validation of WMA and HMA pavements
- Literature review of existing carbon emission calculators
  - recommend a system for inclusion in WMA evaluation protocol
- Finalise WMA evaluation protocol

WMA evaluation protocol

- Purpose of WMA Evaluation Protocol:
  - provide a guide to the evaluation of specific WMA technologies and processes such as additives and foamed bitumen
- Protocol sets out the conduct of appropriate laboratory tests and field validation projects in order that the performance of WMA and conventional HMA can be compared
- Protocol an evaluation tool only; not a specification
- Environmental assessment of the impact of WMA not addressed owing to lack of sufficient quality data under local conditions

Review of field/validation trials

- About 120 references identified addressing field testing of WMA in USA, Canada, Europe, Asia and Australasia
- When criteria applied, only about 20% provided sufficient information to allow detailed review
- General trend suggested that performance of WMA was at least equivalent to HMA
- APT conducted in USA
- Limited information re usage in Australia (SRAs or industry)

WMA technologies

- About 50 registered WMA technologies in the USA (only three in 2005) and almost all States are conducting demonstration trials (only 15 States in 2007)
  - WMA technologies associated with water-bearing, chemical and organic additives have received more attention than technologies using water-based mechanical systems
- Commercially-available WMA technologies identified and grouped into six categories depending on:
  - additive content
  - aggregate drying temperature
  - maximum bitumen temperature
  - requirements in terms of plant modifications

WMA technologies

- Sequential aggregate coating and binder foaming
  - low energy asphalt (LEA1)
  - low emission asphalt (LEA2)
  - WAM-Foam®
- Water-based binder foaming
  - AQUABlack®
  - Double Barrel® Green
  - Terex®
  - Ultrafoam GX®
- Binder foaming with water-bearing additive
  - Advera®
  - Aspha-Min®

WMA technologies

- Chemical additive (surfactants / emulsions)
  - CECABASE RT®
  - Evotherm® / Evotherm 3G
  - Rediset® WMX
- Organic additives
  - Asphaltan B
  - Sasobit®
  - LEADCAP®
- Combined binder modifier and organic additives
  - Thiopave®
  - TLA-X®

WMA field evaluations

- Three types of field trials of WMA technology identified:
  - development (least detailed)
  - demonstration
  - validation/implementation (most detailed)
- Each has a different framework depending on:
  - technology developed
  - asphalt producer's marketing strategy
  - road agency's implementation strategy
  - available funding

WMA field evaluations

- Several asphalt producers and road agencies have collaboratively conducted APT trials of WMA and HMA
  - National Center for Asphalt Technology (NCAT) & University of California Pavement Research Center (UCPRC)
  - work to date has suggested that the performance of WMA is at least equivalent to that of HMA; more work planned
  - no immediate need for an accelerated pavement test in Australia
- Published material relating to demonstration or validation trials in Australia limited
  - QTMR, RMS NSW, Brisbane City Council
  - NZTA and one industry member in NZ
  - many industry trials (mainly LG) but details sketchy

WMA field evaluations

- Concerns regarding the use of WMA
  - incomplete drying of aggregate (especially with absorptive limestones)
  - potential for increased moisture susceptibility when using WMA processes that involve the use of water
  - effects of chemical additives on long term performance of the binder
  - ability of WMA to provide enough radiant energy to heat the reclaimed asphalt component in mixes containing RAP
  - general lack of information regarding long term performance of new asphalt mix designs (e.g. high RAP content or rubber asphalt)
- Laboratory trials focussing on moisture susceptibility, rut resistance and durability

Validation project (Melbourne)

- Purpose: to compare performance of HMA and WMA pavements under real traffic conditions
- 2 additives and 2 foamed WMA
- 3 HMA, 4 WMA (0% RAP), 3 WMA (with up to 50% RAP)
- 3 major asphalt suppliers (3 aggregate sources)
- HMA: standard VicRoads mix
- VicRoads Metro North-West provided field site
  - Old Hume Highway, Campbellfield
- Major effort by AAPA members and Austroads

View and layout of validation site

Distance (m)	Lane 1 Slow lane	Lane 2	Lane 3 Fast lane
	South /Melbourne		
215	WMA	WMA RAP	WMA
210	HMA	HMA	HMA
210	WMA	WMA RAP	WMA
215	HMA	HMA	HMA
150	Intersection Mix HMA	Intersection Mix WMA	Intersection Mix WMA
175	WMA	WMA RAP	WMA RAP
160	HMA	HMA	WMA
Distance (m)	Slow lane Lane 1	Lane 2	Fast lane Lane 3
	North		

Direction of Traffic

sites constructed over three nights in April 2010

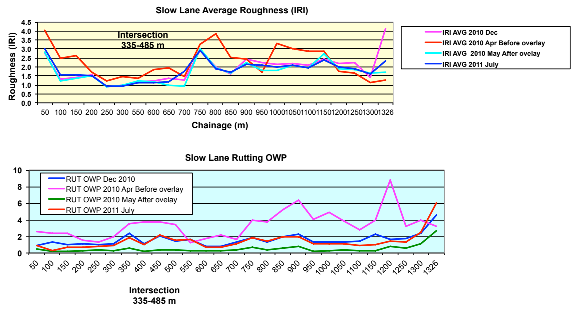
Site conditions

- site approximately 1.3 km long
- constructed along three lanes, each 3.5 m wide
- length of sites varied from 160 m to 215 m
- thin (40 mm thick) layer placed over existing pavement
  - existing site milled and patched prior to placement of mixes
- sites laid out so WMA and HMA mixes subject to same testing conditions, including traffic levels
- AADT ≈ 23,000, incl. ≈ 11% CVs (2010)
- posted speed limit = 80 km/h

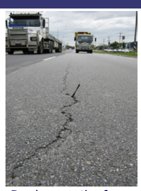
Validation project: data collection

- Cracking/patching data collected before construction
- Temperature data (ex auger, field) collected during construction
- Condition surveys (FWD, MLP) before/after construction and about every 6 months
  - roughness, rutting, texture, strength
- Cracking surveys (cameras on MLP, manual surveys)
- Laboratory testing of samples manufactured during construction (industry)

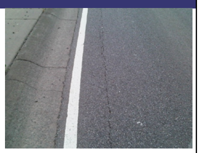
Condition data (roughness, rutting)



Crack survey - September 2011



Bus bay south of intersection (Type V asphalt)



- Almost all cracking identified developed over existing cracks, regardless of asphalt type
- Slightly more cracking in HMA than WMA

Validation project: laboratory testing

- Industry participants conducted own laboratory testing in line with draft Protocol
  - observers from SRAs and ARRB present during testing

Sampling from bulk sample (time of asphalt production, asphalt temperature, etc.)	Deformation resistance (wheel-tracking)
Mixing compacting and conditioning – Gyropac, Marshall	Fatigue (repeated flexural bending) – AGPT/T233-2006
Bulk density – 1 hour conditioning	Marshall stability and flow – AS2891.5-2004
Modulus (indirect tensile) – AS2891.13.1-1995	Air voids and bulk density at design binder content – AS2891.8-2005
Max density / voids free bulk density	Viscosity of recovered bitumen – ARRB Test Method No. 7 & AS2341.5
Moisture content – VicRoads RC211.01	Normal production testing for VicRoads
Moisture sensitivity / stripping potential – Tensile Strength Ratio / RTA T649	Field density of cores

Validation project: laboratory testing

- Protocol too demanding in terms of what can be practically achieved
- Need hierarchy of testing depending on type of trial, e.g.
  - development (least detailed)
  - demonstration
  - validation/implementation (most detailed)
- Need to set minimum requirements and then 'desirable' requirements

Summary

- Performance of WMA and HMA pavements at validation site in Melbourne excellent after 18 months
  - almost all observed cracking reflective from original surface
  - draft protocol in line with requirements for a 'validation' trial
- Laboratory testing conducted in line with draft Protocol
  - Protocol too demanding in terms of what can be practically achieved
    - need to set minimum requirements and 'desirable' requirements
- Monitor overseas projects (e.g. NCHRP, NCAT, UCPRC) and examine outputs in terms of possible application to Australia
- Premature to recommend a carbon calculation system for inclusion in Protocol
  - need to develop data sets to allow local carbon dioxide emissions factors for the main components of road construction