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The Development of a Protocol for Warm Mix Asphalt Pavements in Australia

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AAPA
AUSTRALIAN ASPHALT PAVEMENT ASSOCIATION

In the beginning…

1924

William Calder, first Chairman of Country Roads Board, Victoria, proposes a national road research activity for Australia following a visit to Europe and the USA

William Calder:

born – 31 July 1860, Milton, New Zealand
died – 18 February 1928, East Melbourne, Victoria
A portrait by Tom Roberts hangs outside VicRoads boardroom. Calder Highway named after him.

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
  - more studies continually being reported (e.g. CAPSA)
- When criteria applied, only about 20% provided sufficient information to allow detailed review
- Most trials constructed within the last 5-6 years
- General trend suggests that performance of WMA is at least equivalent to HMA
- APT conducted in USA and more work planned
- Limited information re usage in Australia (SRAs or industry)

WMA technologies

- Over 20 registered WMA technologies in the USA (only three in 2005) and 45 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

- Many demonstration and validation trials established in USA
  - main application is overlays using high RAP-content mixes and severe construction conditions (e.g. construction in cold/wet environments)
- Further developments and improvements in WMA technologies using water (e.g. foam technologies using water injection nozzles) and emulsions
  - reduce the amount of water added to the system in order to address the concern of moisture susceptibility issues associated with the use of the water-based WMA products
- Use in Asia (Japan, Korea, China) increasing

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, RTA 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

Australian Road Research Board

October 1958

NAASRA establishes Australian Road Research Board

– along the general lines of the US Highway Research Board

28th-29th March 1960: first Board meeting

Caleb Roberts (former CEO of CRB) attends as 'advisor'

Tom Roberts (1856-1931)

Caleb Grafton Roberts:
born – 31 January 1898, Balmain, NSW
died – 23 November 1965, Kew, Victoria
Son of artist Tom Roberts, founder of Heidelberg school

Validation project (Melbourne)

- Purpose: to compare performance of HMA and WMA pavements under real traffic conditions
  - NOT to compare performance of one WMA process to another WMA, or one HMA with another HMA
- Three members of industry participating in project
  - industry will remove and replace the pavements at their cost in the event of unacceptable performance

Details of validation project

- 2 additives and 2 foamed WMA
- 3 HMA, 4 WMA (0% RAP), 3 WMA (with up to 50% RAP)
- 3 major asphalt suppliers providing mix (3 aggregates)
- HMA = standard VicRoads mix
- VicRoads Metro North-West provided field site
  - Old Hume Highway, Campbellfield
- Major effort by AAPA members and Austroads
  - industry conducted laboratory testing at their cost
  - industry installed pavements at their cost

View and layout of validation site

South /Melbourne

Distance (m)	Lane 1 Slow lane	Lane 2	Lane 3 Fast lane
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 varies 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: site construction

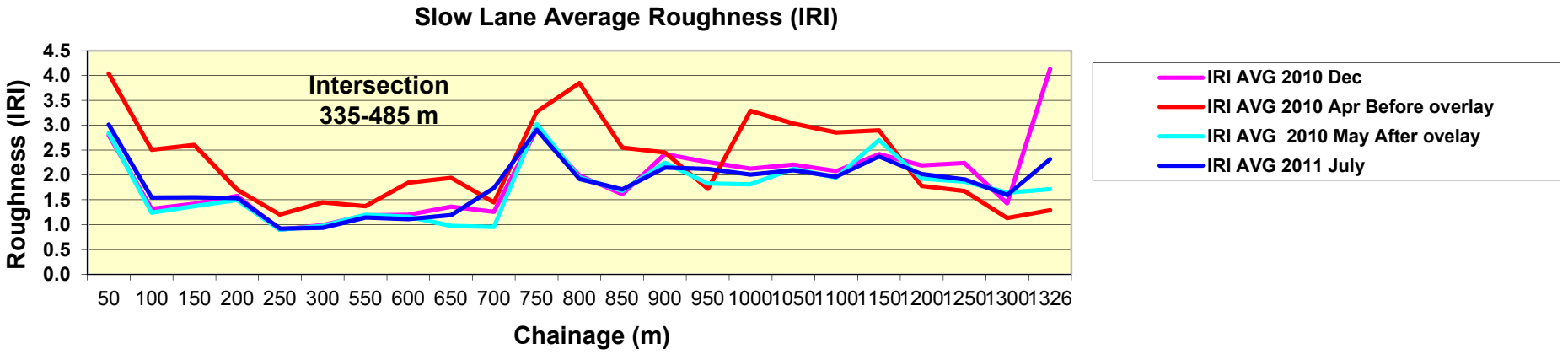
Prior to overlay

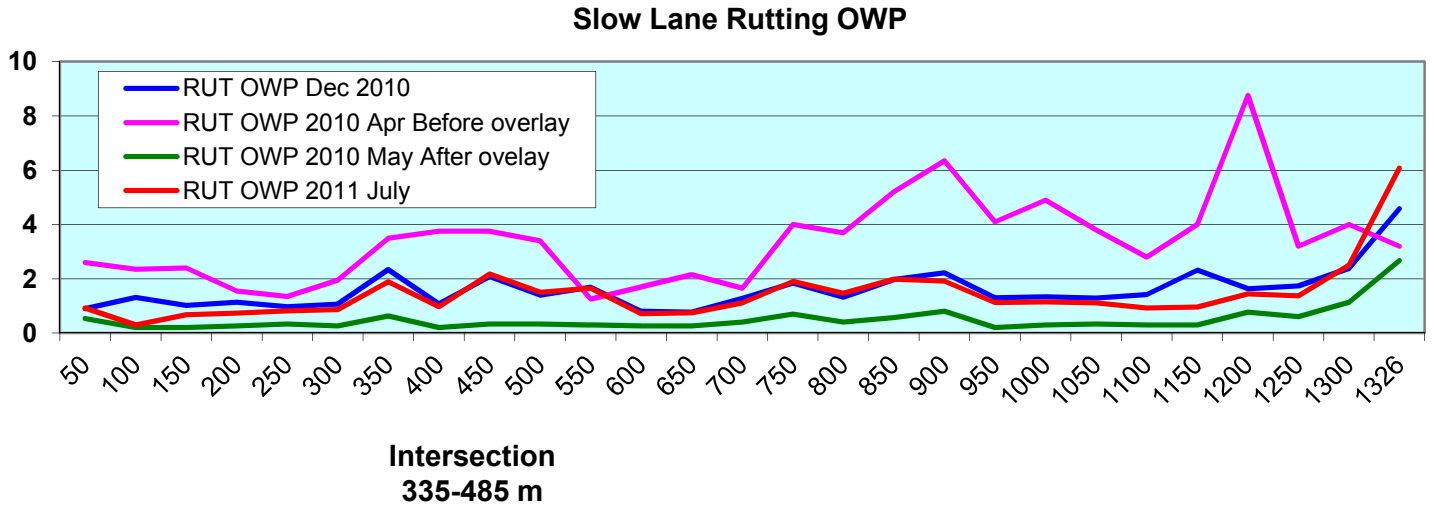
Construction

Validation project: data collection

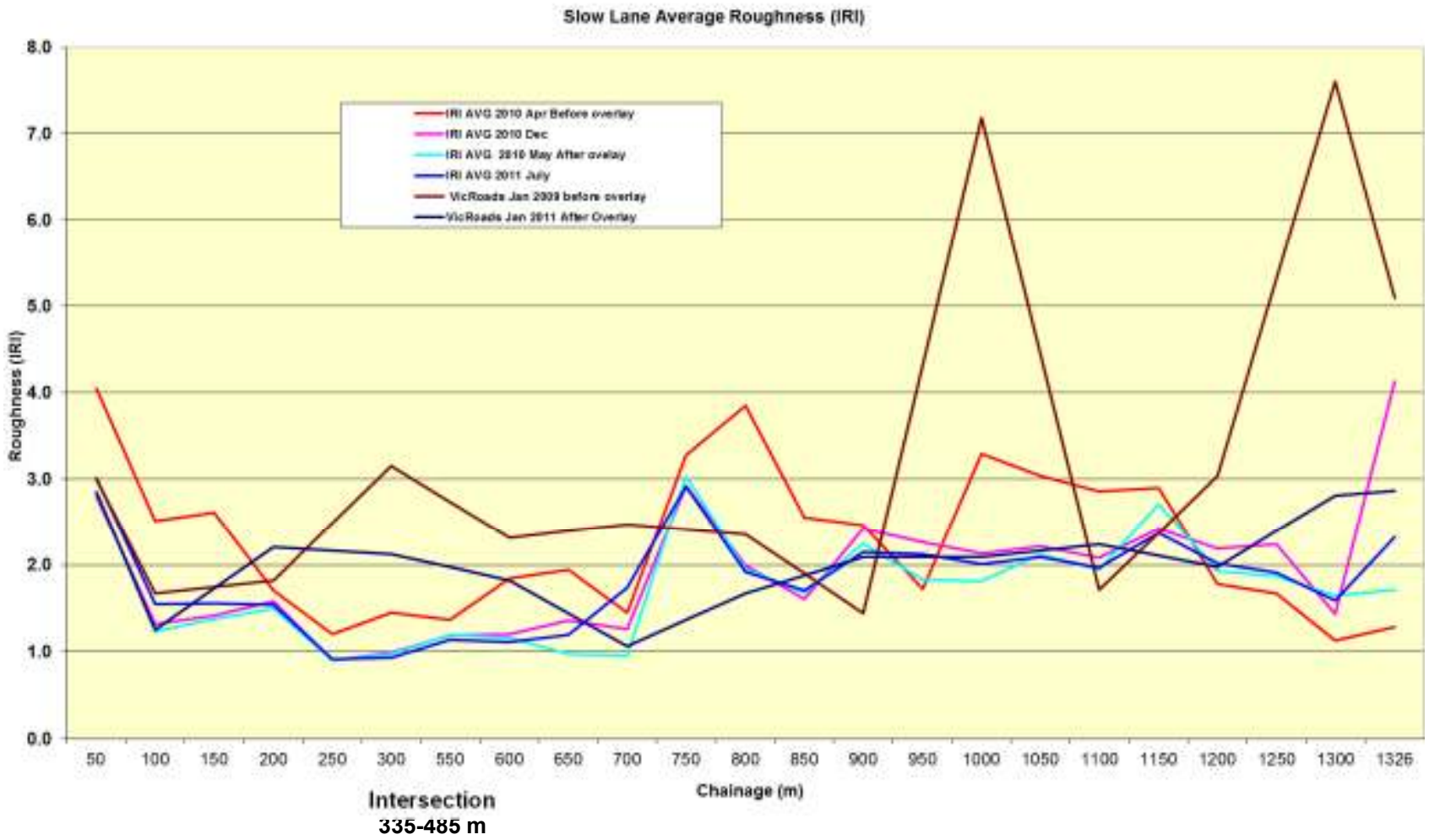
- Cracking/patching data collected before construction
- Temperature data (ex auger, field) collected during construction
- Condition surveys (FWD, MLP) before/after construction and about every 6 months
  - roughness, rutting, texture, strength
- Cracking surveys (cameras on MLP, manual surveys)
- Laboratory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

Condition data (roughness, rutting)

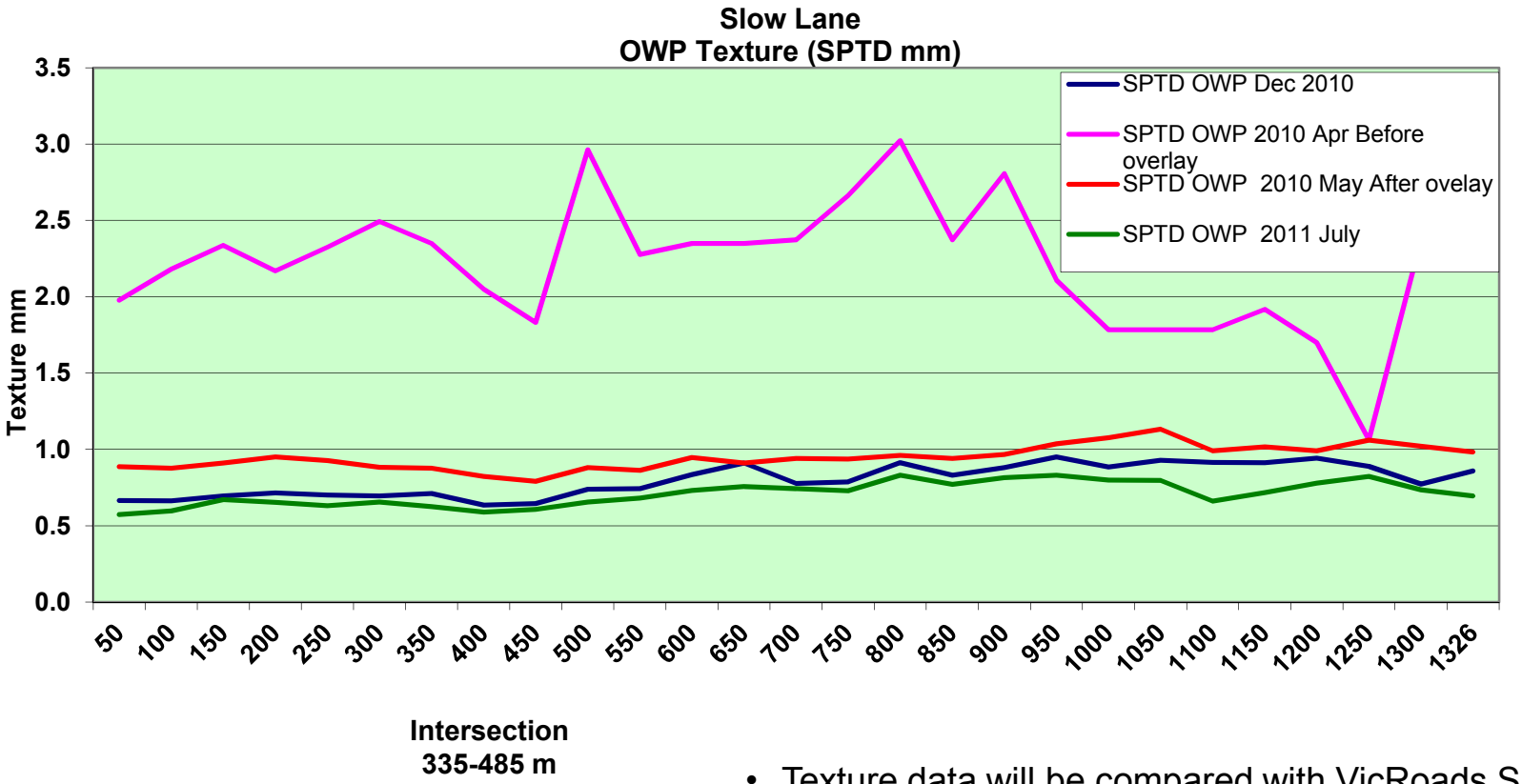




Roughness (ARRB VicRoads)

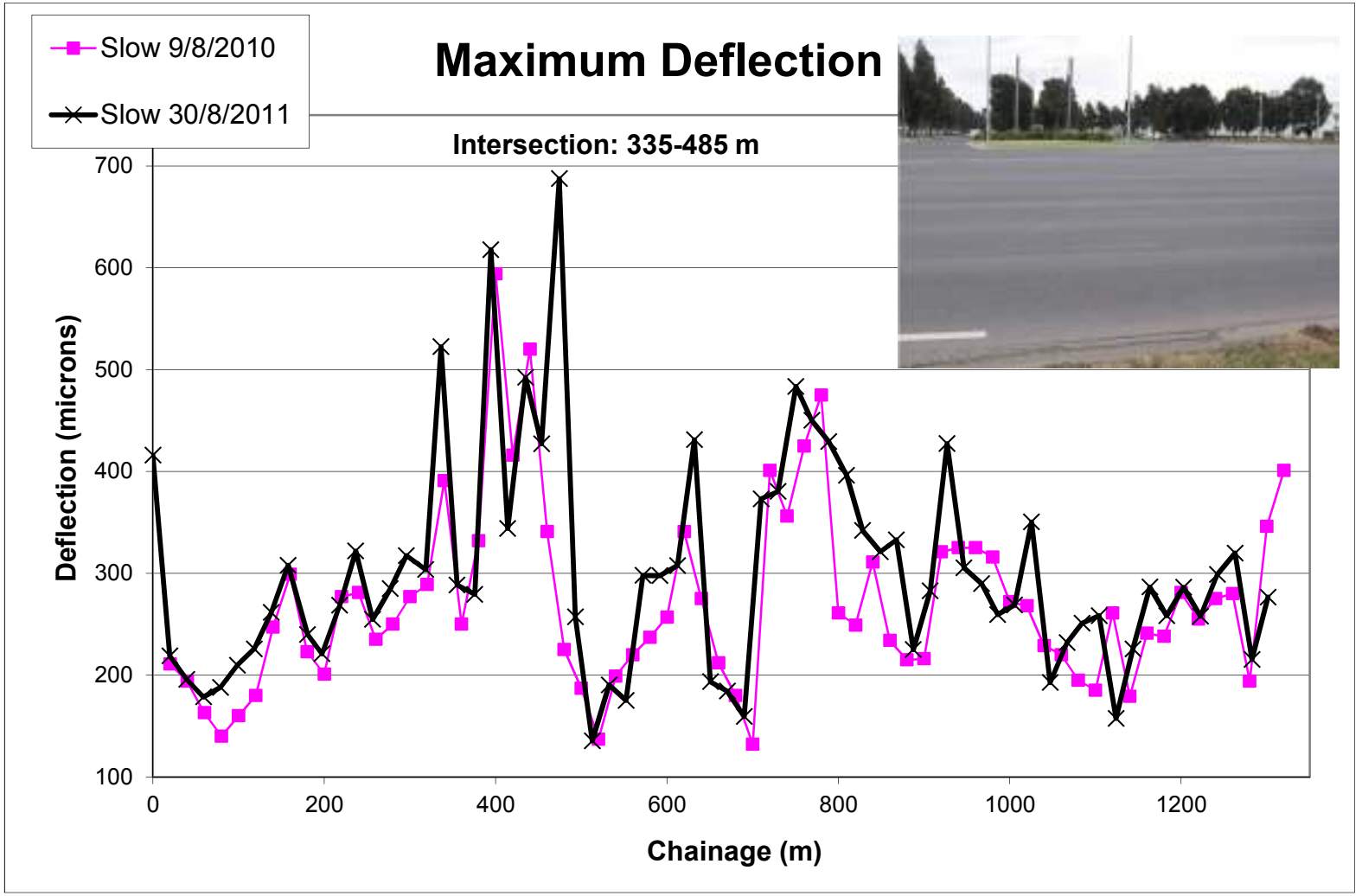


Condition data (texture)



- Texture data will be compared with VicRoads Sand Patch data
- SCRIM data on all 3 lanes: June 2010, September 2010, February 2011 and May 2011

Validation project: FWD deflection



Crack survey - September 2011

Bus bay south of intersection (Type V asphalt)

- Almost all cracking identified on 21st September 2011 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

- Laboratory data currently being analysed
- Protocol too demanding in terms of what can be practically achieved
- Suggest 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

Carbon footprint

- Several carbon calculators reviewed
  - tools to determine carbon footprint of road infrastructure and life-cycle analysis methodologies to assist with materials and technologies selection
- Greenhouse gas emissions factors for road construction most developed in Europe and the UK
  - asPECT calculator applicable to Australia but would need to be populated with Australian-based emissions factors
- In the absence of sufficient Australian-based emissions factors, it is premature to recommend a carbon calculation system for inclusion into the WMA evaluation protocol
- Further work needed which focuses on local data collection

Summary

- Review of field testing of WMA in USA, Canada, Europe, Asia and Australasia
  - only 20% provided sufficient information to allow detailed review
  - performance of WMA generally at least equivalent to HMA
  - limited information re use in Australia (SRAs or industry)
  - three types of field trials of a WMA technology identified
  - commercially-available WMA technologies identified and grouped into six categories
  - SRAs need to develop specifications for the use of WMA
    - imperative that material specifications nominate the technology
  - some concern regarding long-term performance (moisture susceptibility, rut resistance, durability) associated with lowering WMA production temperatures

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

ARRB Hall of Fame

John Scala

David Potter

John Metcalf

Ted Dickinson

Max Lay