APS-fL Project : Genesis in UK

**Deflection Histories of In-Service Motorways (Deflectograph)**

- **Standard deflection**: mm
- **Cumulative standard axles (millions)**
- **Deflection Histories**
- **Investigatory Level**
- **Conventional Life Curve**

**UK Highways Agency Design Chart**

- **Total Asphalt Thickness (mm)**
- **Design Life (millions)**
- **Interpretation**: If pavement survives 80MSA it is above the threshold thickness for a "Long Life Pavement".

APS-fL Project : Local Background

- **LTPP Projects AAPA and SRA’s since 1980’s**
- **Regular positive reports on the studies**
- **Sharp & Tepper 2001**
- **Youdale 2004**
- **Foley 2008**
- **Rickards 2009**
- **Armstrong & Rickards 2010**
- **AAPA Study Tour 2010**

APS-fL Project Elements

- **Literature Review**
- **Project Management Team**
- **National Asphalt Materials Characterisation**
- **International Validation – NCAT and others**
- **Calibrate model against LTPP data**
- **Information Dissemination**
- **LLAP Design Software and Manual**
- **LLAP Construction Guidelines**
- **Environment & Sustainability Factors**
- **Education and promotion**
2011 MASTER CLASS IN FLEXIBLE PAVEMENTS

Outcomes

LONG LIFE ASPHALT PAVEMENT PRINCIPLES

- Do LLAPs exist?
- Is there a threshold design thickness?
- Are stable/decreasing deflection and curvatures characteristic of LLAPs?

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Enabling Features

- Is the cumulative strain distribution suitable as a transfer function? (validate for high temp)
- Is the dynamic modulus (E*) a suitable means of materials characterisation? (correlate with overseas materials)
- Do not include asphalt curing as part of the design method. (too hard, but impact is conservative)

2011 Master Class - Summary of Outcomes

- The principles of Long Life Asphalt Pavements are firmly established globally.
- The means of structural design, including materials characterisation and transfer functions are available but require harmonisation to suit local conditions.
- Software can be readily developed to align with currently used Austroads methodology.
- Strong links were forged with overseas experts in this field.

Australian Materials Characterisation

Tests

- Dynamic modulus E* using AMPT
- Binder complex shear modulus G* using DSR

Materials tested

- Commercial project mixes ex production plant (from all states)
- 28 mixes in total: 14 x AC14: 14 x AC20
- Binders: C 320; C 450; C 600; A15E; Multigrade
Gradation range – AC14 mixes

Gradation range – AC20 mixes

NCAT Parallel Test Validation

Materials Characterisation Summary

- Dynamic Modulus characterisation
  - 28 standard production mixtures tested
  - The ability now exists to characterise Australian mixtures for any load time or temperature
- Link established link between Australian test results and NCAT
- Characterising materials using dynamic modulus
  - Repeatability
  - Captures time/temperature measurements
  - International test methods
  - Links to international research and field performance data

E* Comparisons AAPA study

Master Curve Confidence Limit
**Master Curves Confidence Limits**

- Based on grouping common Australian production mixtures
- Confidence based on t-distribution around common mixtures
- No statistically significant difference between Australian mixtures with same binder class

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**Empirical calibration - NCAT**

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**Strain Measurements**

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**Lab to Field Modulus**

- No laboratory test ($E^*$ or fatigue) can fully capture the effects of:
  - Loading Time
  - Temperature distributions
  - State of stress / confinement etc
- A tentative relationship has been established between the dynamic modulus in the lab and the field

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**NCAT findings: field performance v cumulative distribution of strain**

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**Pavement Temperature Spectrum**

- Pavement temperature spectrum is a critical design element
- $E^*$ can be determined over the spectrum to enable the calculation of the strain distribution
- Austroads commissioned ARRB TR report “Pavement Temperature and Load Frequency Estimation” (Denneman)
The Calculation of the Cumulative Distribution of Strain

- Select candidate pavement profile and materials
- Determine the cumulative distribution of pavement temperature
- Determine the E* values over the temperature spectrum specific to the mix used and traffic speed
- Use CIRCLY to calculate asphalt strain over the temperature spectrum and plot cumulative distribution
- Adopt design if to the left of the limiting criterion

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**Australian Pavement Temperature Spectra – Dickinson studies 1970’s**

**E* v Temperature spectra**

**E* v Asphalt Strain Distribution**

**E* v Asphalt strain distribution compared with NCAT tentative limit**
NCAT findings: field performance v cumulative distribution of strain

APS-fL validation study VALMON Data

Outline of validation procedure

- Assemble and review data to ensure adequate deflection data and details of pavement structure
- Estimate pavement temperature gradient relative to surface temperature data using local model
- Conduct back analysis of raw deflection data to estimate asphalt modulus at temperature at time of test
- Develop master curves extrapolating from back analysed data (generally limited range) at a frequency appropriate to traffic speed
- Estimate pavement temperature spectrum from local climatic records
- Determine modulus values over the temperature spectrum
- Calculate cumulative distribution of strain under legal axle limit 11.5t
- Compare with NCAT and modify as appropriate

Flexible Framework of APS-fL

Framework Goal is to be flexible to adopt changes and developments as they appear along the path of the project elements:

- Literature Review
- Material Characterisation
- Validation of modulus with field measurements
- Temperature with depth profile
- Frequency with depth
- Strain calibration
- Fatigue Damage Equation
- Seasonal analysis
- Damage Threshold
  - Cumulative distribution of strain
  - Healing
  - Threshold strain
- Calibration and Validation

Summary

- Work on the development of a validated LLAP design process is well underway
- The technical elements of the process have been and will continue to be subjected to peer review
- The active involvement and contributions from Austroads and ARRB TR experts is welcome and constructive
- The asphalt characterisation study is complete and provides a basis for comparison with international R&T

Summary

- The properties of Australian asphalt materials have been established and are available for design purposes.
- The cumulative distribution of strain is considered to be an improved limiting design criterion avoiding the uncertainty of endurance limit and healing models
- Work aimed at calibrating the limiting cumulative distribution is advancing based on NCAT and UK data
- This work is unique in Australian history
Summary

- The framework of the project is flexible – we are committed to the implementation of a LLAP design process – and if there is good evidence for us change direction then so be it
- The project team is confident we can soon make recommendations to deliver change based on the work to date and the considerations of the Master Class

Australian Asphalt Pavement Association

Brisbane
22–25 September 2013

AAPA Pavement Research & Technology State of Play & Future Directions - in liaison with Client Organisations
Ian Rickards
AAPA Consultant

Pavement Temperature Spectra

Annual Pavement Temperature Distribution
At Depth 100mm (after Dickinson)

Cumulative Distribution %

Pavement temperature °C

Melbourne
Canberra
Sydney
Darwin