Category 2: Industry Excellence in Consulting, Research or Education

Performance of Foamed Bitumen Stabilised Materials under Laboratory Simulated Field Conditions

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NACOE
NATIONAL ASSET CENTRE OF EXCELLENCE

Queensland Government

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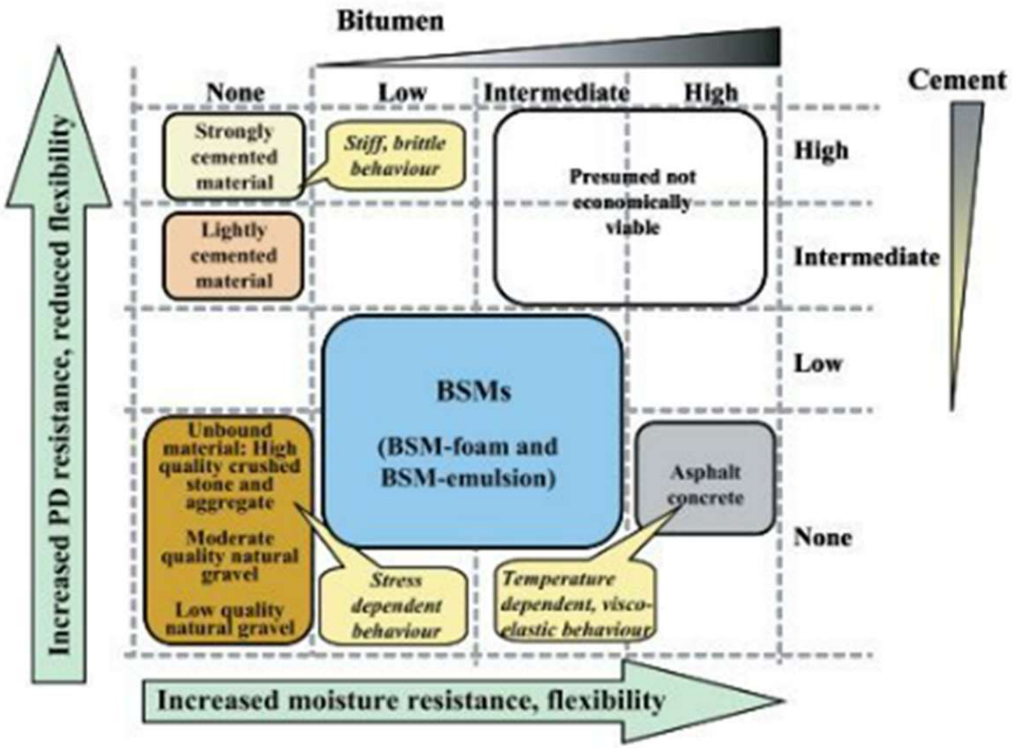
Foamed Bitumen Stabilised (FBS) Road Base

- Granular base and subbase treated material with enhanced properties
- FBS can be used with cost-effective thin bituminous surfacing (sprayed-seal)
- Demonstrated resilience to severe rain/flooding conditions
- Constructed in situ for rehabilitation, or plant produced for new construction
- Well established technology and industry in Australia and New Zealand
- Sustainable benefits with up to 5.4% lower GHG emissions and lower life cycle costs (NACOE P106)
- Suitable for crushed rock and/or recycled material and blends & supporting the circular economy model by promoting in situ reuse



Source: Asphalt Academy, 2009, Technical Guideline Bitumen Stabilised Materials

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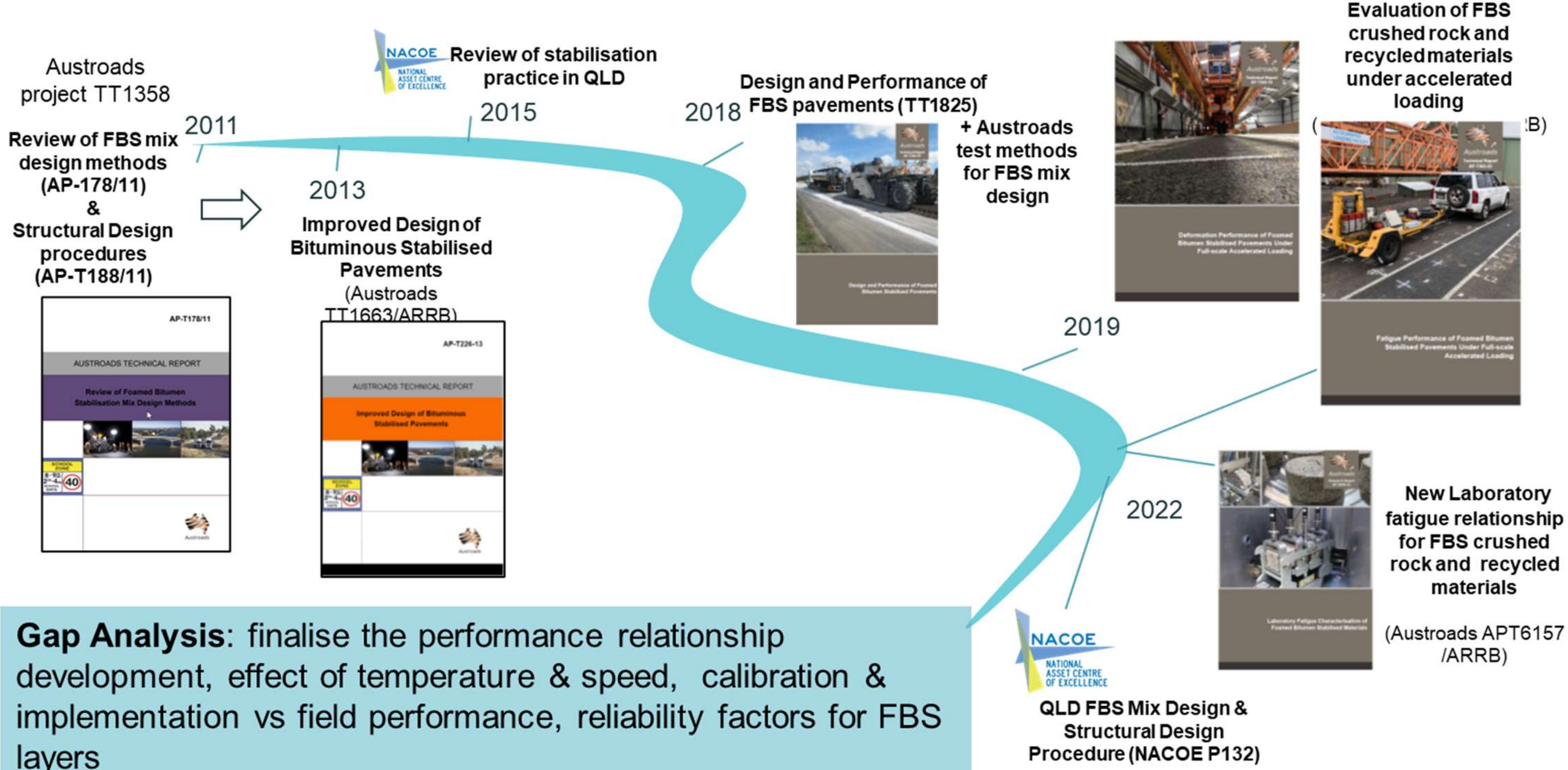
A Journey Towards an Improved Design Approach for FBS Layers in New and Rehabilitated Pavements



Gap Analysis: finalise the performance relationship development, effect of temperature & speed, calibration & implementation vs field performance, reliability factors for FBS layers

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Scope of the Initiative

- Quantify the effect of temperature on the modulus and performance of currently used FBS materials, based on controlled laboratory flexural experiment
- Quantify the effect of loading speed (i.e. traffic speed) on the modulus of currently used FBS materials with laboratory flexural testing
- Investigate fatigue performance in the laboratory with:
  - Beams (unidirectional, unconfined and sinusoidal loading)
  - Extra-large wheel-tracker (XL-WT) with innovative tensile strain measurement (rolling wheel-load, supported and confined specimen bi-directional bending)

Sensitivity to Environment and Loading Conditions

- The effect of temperature and the loading speed on modulus is inherent to bituminous materials
  - Relationships established from IT modulus of field cores (Leek 2001)
  - Limited recent data reflecting current practice
- Limited evidence about the influence of temperature on fatigue cracking.
  - Pitawala (2020) showed ~10 shorter lives for 31 °C vs 22 °C
  - Performance in QLD with WMAPTs 30 to 40 °C do not show significant performance differences

⇨ New research was initiated under NACOE project P132 to re-assess temperature and loading speed sensitivity relationships

⇨ Exploratory work to understand how flexural fatigue testing compares with field performance based on an innovative use of a laboratory XL-WT

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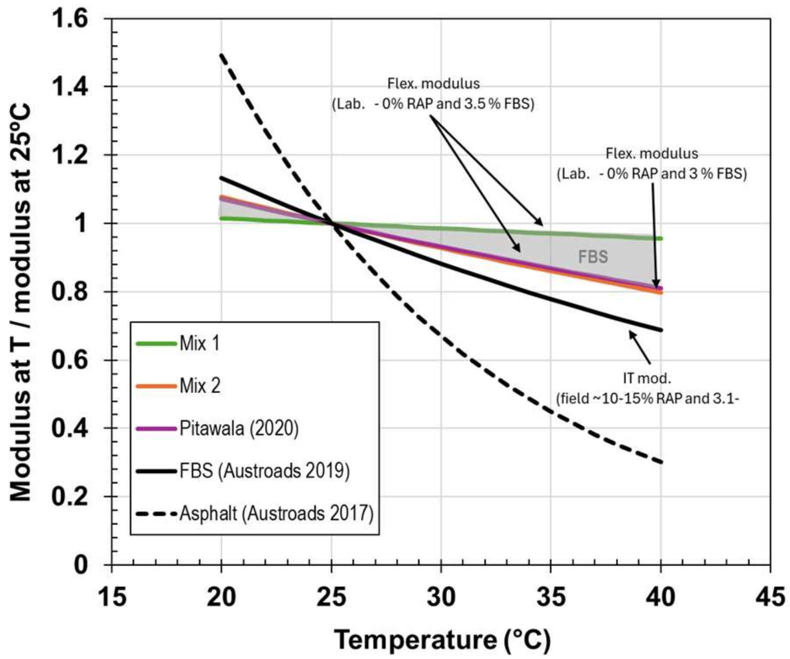
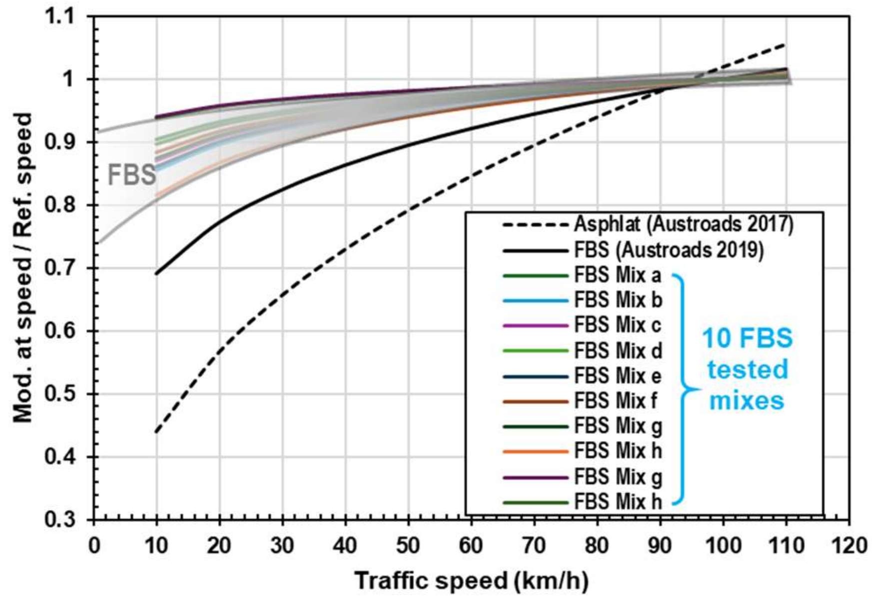
Flexural Beam Modulus Testing Results

- Temperature (20, 25 and 35°C) and varying frequencies





- New flexural testing showed lower sensitivity to temperature and speed than currently assumed from past data

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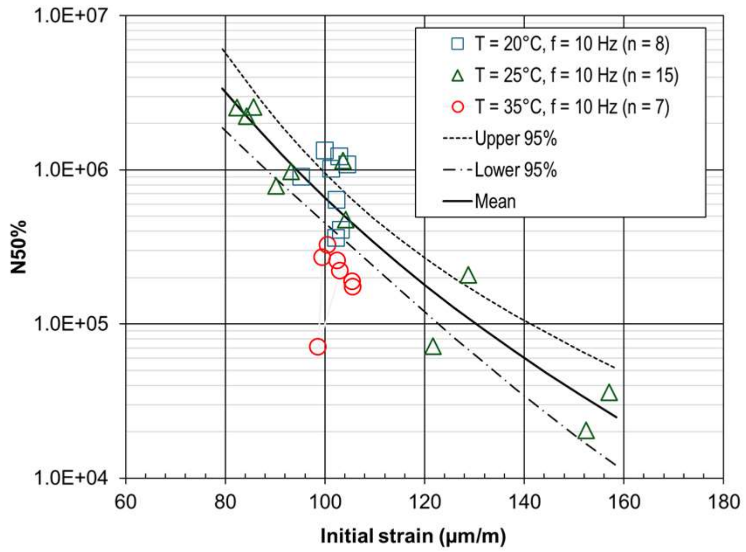
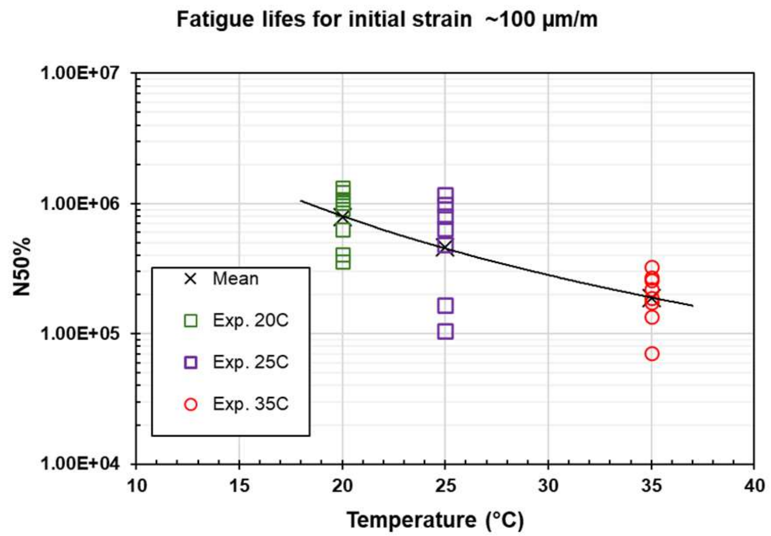
Laboratory Flexural Fatigue Performance Assessment

- Procedure developed under (Austroads report AP-R666-22)
- Varying temperature (20, 25 and 35 °C) and f = 10 Hz





- Effect of temperature on fatigue performance showed a drop in fatigue 4 to 5 times between 20 to 35 °C (based on two mixtures dataset) more that 50% lower than what academic research showed.

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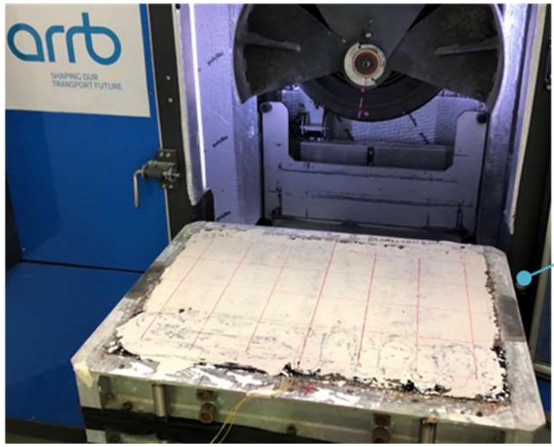
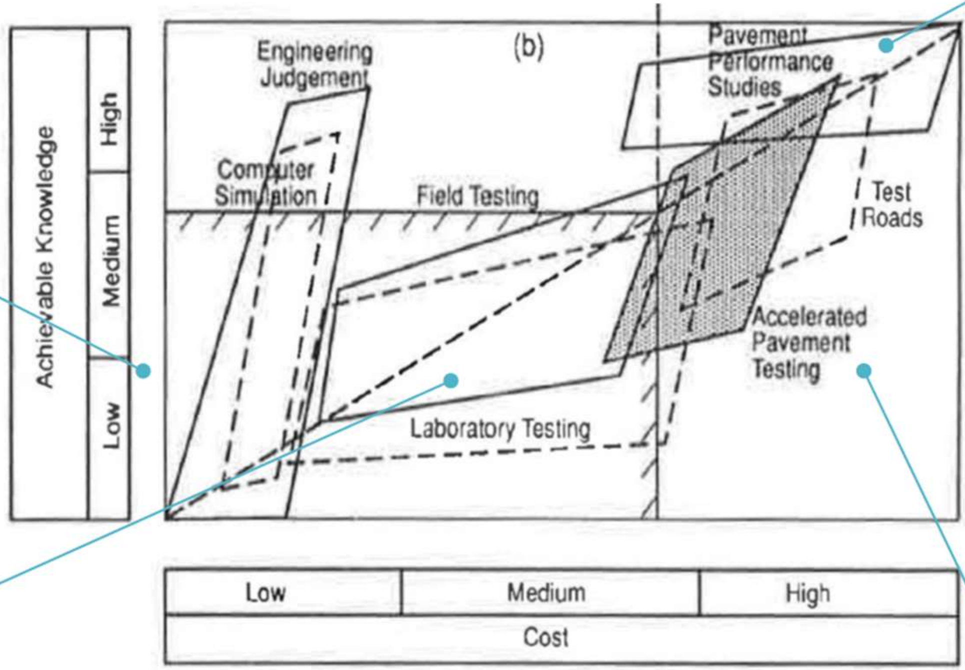
Explore Performance under Rolling Wheel-load Laboratory Testing and Compare with Beam Testing





Source: Hugo et al. (1991)

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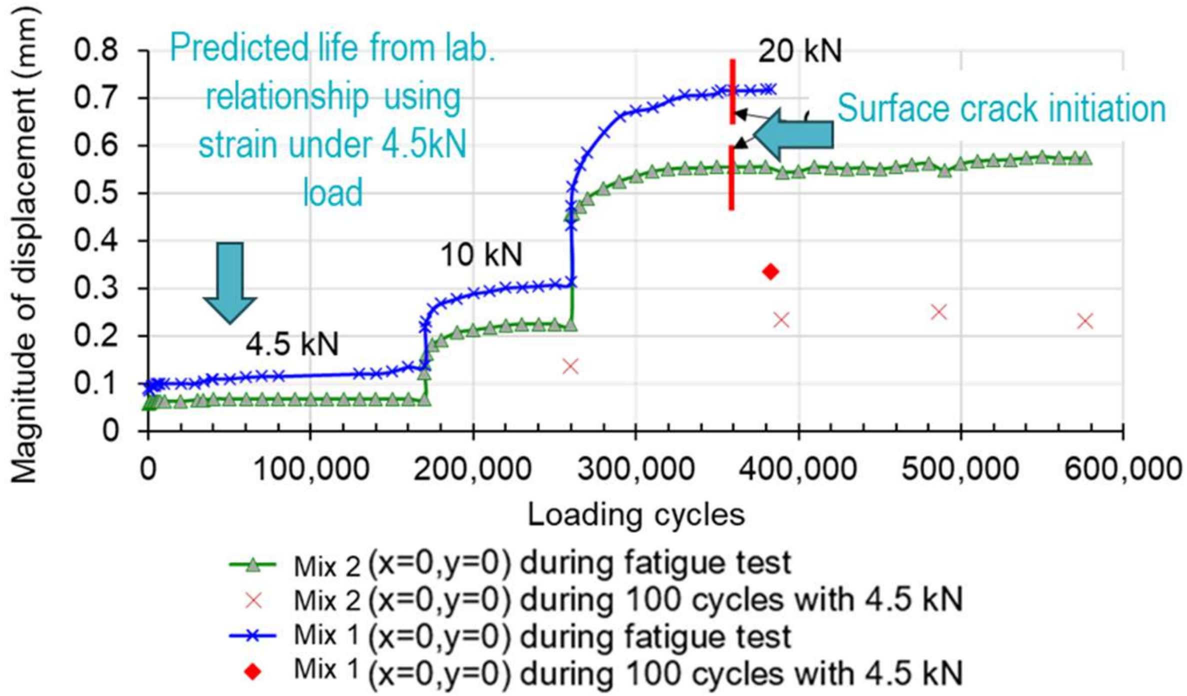
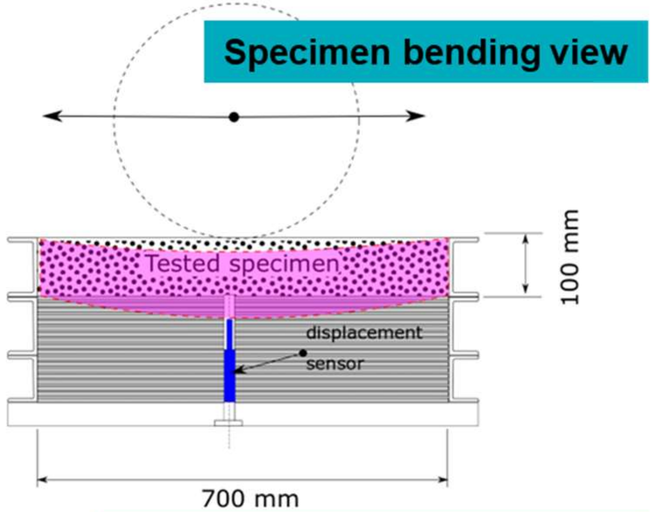
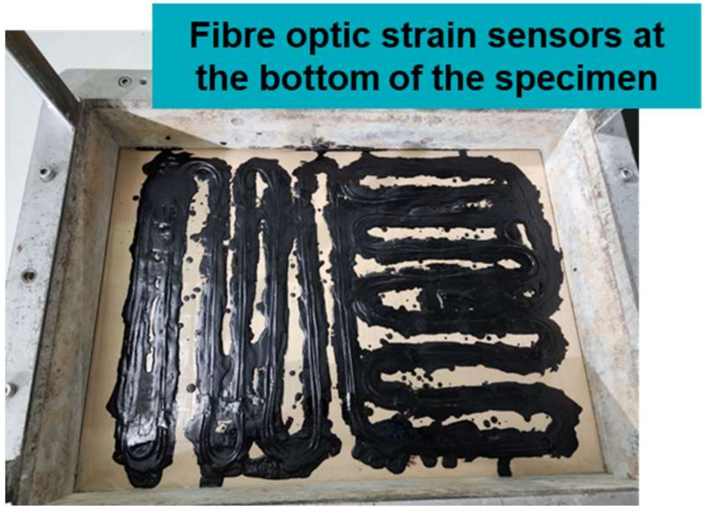
XL-WT Testing (Simulated Rolling Wheel & Confinement)

- Slab testing under 20 kN rolling wheel-load
- Strain instrumentation
  - transverse ~ longitudinal tensile strain = bi-directional loading
- Increase in deflection magnitude = microcracking (i.e. fatigue)







- Number of cycles to develop cracking in XL-WT far exceeded prediction s based on strain and lab fatigue relationship

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Conclusion

- New temperature factors for the sensitivity of FBS materials to temperature and frequencies have been determined based on flexural testing of 90 –day lab cured beam specimens.
- Effect of the temperature on the fatigue of two materials representatives of QLD practice showed a drop in fatigue life between 20 and 35 °C but lower than what recent academic research suggests.
- Innovative XL-WT testing with fiber optic strain measurement
  - bi-directional loading of the material under wheel-loading (transverse and longitudinal tensile strains)
  - the number of load repetitions to show apparent surface cracking at the surface of the slab far exceeded the predicted failure for the lab. beam fatigue relationship

Implementation

- If confirmed (ongoing IT modulus testing to cross-check results) the new parameters can be easily implemented in structural design procedures
- Shift factor (SF) for FBS is anticipated to exceed SF used for asphalt and need to be explored further

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