KEY ASPECTS OF MECHANISTIC DESIGN FOR THIN SEALED PAVEMENTS
Kings Road - 4yrs
OVERVIEW

• Axle Loadings
• Pavement Stress Levels - Stress Locus - Stress Limits
• Shear Strength Classification System
• Stress (and $E_r$) profiles within granular Pavements - sub-layer thicknesses
• Vertical compressive strains within pavements
• Failure Criteria - revised
### AXLE LOADINGS

- Variable loadings create stress / strain variations

<table>
<thead>
<tr>
<th>Reference Axle Type</th>
<th>Total Design Axle Loading</th>
<th>Loading Model for Pavement Structural Analysis</th>
<th>Wheel Contact Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australia:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>isolated single axle, dual wheel</td>
<td>80.4kN (8.2t force)</td>
<td>40.2kN half axle: represented as two 20.1kN dual wheel footprints (radius 96mm) with 330mm centre-to-centre separation</td>
<td>700kPa</td>
</tr>
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<td><strong>France:</strong></td>
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<tr>
<td>isolated single axle, dual wheel</td>
<td>130kN (13.25t force)</td>
<td>65kN half axle: represented as two 32.5kN dual wheel footprints (radius 125mm each) with 375mm centre-to-centre separation</td>
<td>662kPa</td>
</tr>
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<td><strong>Sweden:</strong></td>
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<tr>
<td>isolated single axle, dual wheel</td>
<td>100kN (10.19t force)</td>
<td>50kN half axle: represented as two 25kN dual wheel footprints (radius 100mm) with 300mm centre-to-centre separation</td>
<td>800kPa</td>
</tr>
<tr>
<td><strong>UK:</strong></td>
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<td></td>
</tr>
<tr>
<td>isolated single axle, dual wheel</td>
<td>80kN (8.15t force)</td>
<td>40kN half axle: represented as two 20kN dual wheel footprints (radius 113mm) with 376mm centre-to-centre separation</td>
<td>500kPa</td>
</tr>
<tr>
<td><strong>USA:</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>isolated single axle, dual wheel</td>
<td>80kN (8.15t force)</td>
<td>40kN half axle: represented as two 20kN dual wheel footprints (radius 115mm) with 345mm centre-to-centre separation</td>
<td>483kPa</td>
</tr>
</tbody>
</table>

**STANDARD LOADING USED BY DIFFERENT COUNTRIES FOR PAVEMENT STRUCTURAL ANALYSIS**
**PAVEMENT STRESS LEVELS**

- Plot stress data points for a range of pavements

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**STRESS DATA**

- $p = 700\text{kPa}$
- $p = 550\text{kPa}$
- Plot stress locus boundaries
• Grouped specific Stress levels within each pavement layer
• Upper Stress limits for layers are formed
• Upper stress limits for layers

- maximum stress combinations in layers under standard design loadings,
- min. thickness pavement, ie BST, 150mm base, and 100 to 150mm sub-base
SHEAR STRENGTH CLASSIFICATION

- Shear Strength requirements for each pavement layer material
System places stress limits on the materials depending on their intended layer usage - test materials to establish compliance.
RLT Stress Regime

STRESS PATHS - New and Basecourse and Sub-base Layer Stress Levels

- Confining pressure $\sigma_3 = 150$ kPa (constant)
- Stress Ratio $\sigma_1/\sigma_3 = 3.0$ (const.)
- Preconditioning Basecourse
- Preconditioning Sub-base
- Upper Limit of Sub-base
- Upper Limit of Fill
- Stress Paths for different $q/p$ ratios: $q/p = 1.25, q/p = 1.5, q/p = 1.75, q/p = 2.0, q/p = 2.25, q/p = 2.5$

Locus Australia
Locus France
BASECOURSE STRESS STAGES
SUB-BASE/FILL STRESS STAGES
Condition Boundaries
STRESS (& $E_r$) PROFILES - WITHIN THINLY SURFACE PAVEMENTS

STRESS (kPa) or PAVEMENT SUB-LAYER MODULUS (MPa)

DEPTH (mm)

- $\dot{\sigma}_1$ (kPa), 35mm A/C pavement
- $\dot{\sigma}_3$ (kPa), 35mm A/C pavement
- $E_r$ (MPa), 35mm A/C pavement

35mm A/C seal
• Sub-layer thicknesses (& boundaries) should match with:
  - the different material layer thicknesses as constructed
  - the nature of the non-linearity,

in order to correctly model the pavement response
Notes:

• Stress levels, and modulus vary significantly within the upper constructed UGM base layer of a thinly surfaced pavement.
• The materials experience increasing non-linear behaviour as the stress conditions increase within the upper base layer - the gradients of vertical and horizontal stress are also greatest here.
• Below this depth, thicker sub-layers could be used - as reduced stress dependence.
• Each sub-layer is assigned a modulus consistent with the stress levels (both vertical and horizontal) within them.
Recommend:

- **UGM base layer sub-division** to be applied depending on the surfacing thickness.

<table>
<thead>
<tr>
<th>Surfacings Thickness (mm)</th>
<th>Extent of Non-linear Region Below Pavement Surface (mm)</th>
<th>No. of sub-layers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50mm sub-layer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75mm sub-layer</td>
</tr>
<tr>
<td>0</td>
<td>260</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>215</td>
<td>3</td>
</tr>
<tr>
<td>80</td>
<td>160</td>
<td>2</td>
</tr>
</tbody>
</table>

Depth to which the Non-linear Region Extends Into the Pavement
VERTICAL COMPRESSIVE STRAIN IN A PAVEMENT

VERTICAL COMPRESSIVE STRAIN (microstrain)

DEPTH INTO PAVEMENT (mm)

Case 1 (summer)
Case 2 (winter)

All granular layers at 50% of modified OMC (summer condition)
All granular layers at 85% of modified OMC (winter condition)
VERTICAL COMPRESSIVE STRAIN IN A PAVEMENT

VERTICAL COMPRESSIVE STRAIN (microstrain)

Higher levels of strain occur in the BC2 layer when this layer (only) is of high moisture content, compared to the top base layer.

Need to control the upper strain limit tolerable in both layers in order to maintain sound performance throughout the wetter months of the year.
Recommend:

- **upper limit** on the vertical compressive strain of at the top of the base layer under a thin surfacing (1600 microstrain),
- a value for the top of the second base layer should also be specified (900 microstrain),

These values, in effect, tend to act to control both the material quality and, indirectly, the moisture state tolerable in the basecourse 1 and 2 layers to ensure acceptable pavement performance (35mm asphalt surfacing) - address potential drainage issues by identification in the design process.
FAILURE CRITERIA \textit{(present)}

Spacing of dual wheels

$\varepsilon_{A/C}$

$BC\ 1$

$BC\ 2$

$SB$

$\varepsilon_{S/G}$

Fill
Material resisting stress capability to withstand applied stresses

Addressed by Shear Strength Classification System

FAILURE CRITERIA (proposed)

Unlikely to be a problem unless a marginal / poor quality material or a material effected by higher moisture (saturation) levels used as BC2 or SB layer(s)

Material resisting stress capability to withstand applied stresses

Addressed by Shear Strength Classification System

FAILURE CRITERIA (proposed)

Unlikely to be a problem unless a marginal / poor quality material or a material effected by higher moisture (saturation) levels used as BC2 or SB layer(s)
CORRELATION OF LAB. STRAIN RATE TO FIELD CURVATURE

PERMANENT STRAIN RATE

OWP Correlation, no dry-back
IWP Correlation, no dry-back
OWP Correlation, dry-back
IWP Correlation, dry-back

STRAIN RATE determined at:
\( \sigma_1 = 300 \text{kPa}, \sigma_3 = 50 \text{kPa} \)

\( N = 3000 \) cycles

LIMIT ZONE

1, failed, RMC = 85%
2, failed, RMC = 61%

4, sound, RMC = 66%
3, sound, RMC = 54%

1, sound, RMC = 63%

Deflection Curvature Function \( D_0 - D_{200} \) (mm)