Pavement Overlay Design

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(Newcastle)
Why Overlay?

• Cheaper than reconstruction
• Suitable for shorter life span (asset prioritisation)
• Faster than reconstruction/stabilisation
Types Of Overlay

Several types:

Granular  Ranging from 50 mm to 200 mm or so, pavement material (can be stabilised)
Asphalt  Ranging from 40 mm to 100 mm or so, asphalt (can be several layers). Can be thin or deep lift
Concrete  Mainly over existing rigid pavements (stitched in)
Types Of Overlay

Limits:

Granular overlays up to $10^8$ ESA

Asphalt overlays up to $10^7$ ESA
Basis for Overlay Design

- Based on pavement deflections (and curvature)
- Need to ensure sufficient existing structural thickness
- Improving road structure to allow it to satisfy increased traffic load (i.e. life)
- Remember drainage is an important consideration
Data Collection

Deflection testing of road
  • Benkelman beam
  • Falling weight deflectometer (40 kN)
  • Deflectometer
Data Collection
Data Collection
Data Collection
Data Collection

Curvature = D_{200} – D_0

- Beaming
- Take readings regularly (say 10 m to 20 m in both wheel paths)
- Alternating wheel paths is usually undertaken
- Record rebound deflections at:
  - 200 mm
  - 600 mm
  - 900 mm
  - 2700 mm
  - 9000 mm

- Very important to take pavement temperature

Figure 4.4: Benkelman Beam deflection bowl
Data Collection

• Pavement Condition
  • Inspect pavement for defects:
    • Rutting (can be indicator of subgrade failure)
    • Shoving (subgrade failure or poor gravel)
    • Cracking (cemented material?)
    • Edge break (thinning on edge?)

• Austroads Guide to Visual Assessment of Pavement Condition
  • Draw maps
  • Extent of damage
  • Type of damage
  • Drainage conditions!!!
  • In-ground service trenches
Data Collection
Data Collection
### Overlay Design - Types

- **Heavy Patching**
  - Can be used to correct short sections where full reconstruction is not economical
  - Where finish level constrained (i.e. kerb and gutter)

- **In-situ Stabilisation (incorporating existing)**
  - Improve conditions where existing gravels have high plasticity
  - Allows thinner increase in pavement thickness
  - Re-uses some existing material

- **Granular Overlay**
  - Can be cheaper than AC
  - Use where levels not constrained

- **Asphalt Overlay**
  - Thinner than granular
  - Greater structural improvement

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<table>
<thead>
<tr>
<th>Particle size</th>
<th>More than 25% passing 0.425 mm</th>
<th>Less than 25% passing 0.425 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticity index</td>
<td>PI ≤ 10</td>
<td>10 &lt; PI &lt; 20</td>
</tr>
<tr>
<td></td>
<td>PI ≤ 6 WPI** ≤ 60</td>
<td>PI ≤ 10</td>
</tr>
</tbody>
</table>

**Binder type**

- **Cement and cementitious blends***
- **Lime**
- **Bitumen**
- **Bitumen/cement blends**
- **Granular**
- **Polymers**
- **Miscellaneous chemicals**

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**Key**

- Usually suitable
- Doubtful or supplementary binder required
- Usually not suitable

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* The use of some chemical binders as a supplementary addition can extend the effectiveness of cementitious binders in finer soils and higher plasticities.

** Should be taken as a broad guideline only. Refer to trade literature for further information.
Overlay Design Procedure

- Segment Pavement into areas of similar deflection performance based on coefficient of variation (CV).
  
  \[ CV = \frac{\text{Standard Deviation}}{\text{Mean}} \]

  - Segments should ideally be greater than 100 m.

  One outlier result – service trench?

  Design Deflection – what deflection needs to be to cope with projected traffic.

  Remove result (heavy patch) and remaining road meets deflection criteria.

**Figure 3: Graphical Results of Benkelman beam testing**
Overlay Design Procedure

- **Characteristic Deflection**
  - Indicator of overall performance of pavement segment:
  
  \[ CD = \mu + fs \]
  
  - \( \mu \) = mean of deflection readings
  - \( f \) = factor for road function (how busy the road is)

<table>
<thead>
<tr>
<th>Road Class</th>
<th>( f^* )</th>
<th>Per cent of all deflection measurements which will be represented by the Characteristic Deflection**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway and arterials/highways with lane AADT &gt; 2000</td>
<td>2.00</td>
<td>97.5</td>
</tr>
<tr>
<td>Arterials/highways with lane AADT &lt; 2000</td>
<td>1.65</td>
<td>95</td>
</tr>
<tr>
<td>Other roads</td>
<td>1.30</td>
<td>90</td>
</tr>
</tbody>
</table>

*Where <30 readings, max deflection can be better

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* \( f^* \) values applicable for 30 or more deflection measurements.

** After identifying areas to be patched/reconstructed.
Overlay Design Procedure

- Characteristic Curvature
  - Mean of curvature results in segment

Curvature = D_{200} - D_0

Figure 4.4: Benkelman Beam deflection bowl
Overlay Design Procedure

- Determine design deflection from design traffic

Example: For $10^6$ ESA design deflection is 1.18 mm
Overlay Design Procedure

• Adjust deflection data for
  • Method of collection
  • Seasonal variation
  • Pavement temperature
Deflection Standardisation Factor - Method

Figure 6.3: Deflection standardisation factors
Deflection Standardisation Factor - Method

The design procedures have been developed to utilise deflections generated by the following testing devices:

- 80 kN single axle with dual wheel (tyre pressure 550 kPa) as measured by a Benkelman Beam
- 80 kN single axle with dual wheel (tyre pressure 750 kPa) as measured by a deflectograph
- Falling Weight Deflectometer (FWD) loading with a plate diameter of 300 mm and an applied load of 40 kN (contact stress of 566 kPa).
Deflection Standardisation Factor - Method

Curvature Standardisation Factor

40kN FWD

Benkelman Beam & deflectograph

Asphalt thickness (mm)
Deflection Standardisation Factor - Temperature

WMAPT = mean weighted average pavement temperature – See Austroads
Tmeas = temperature at time of testing

NOTE: Different graphs for Benkelman beam v FWD
Also correction curve for curvature

As AC gets thinner correction gets smaller
Deflection Standardisation Factor - Season

- Correction for time / season of testing
- Applied to deflection and curvature
- Note for silt subgrades could be much greater

Table 6.2: Seasonal moisture correction factors

<table>
<thead>
<tr>
<th>Month when deflections are measured</th>
<th>Winter and spring rain (Temperate climates)</th>
<th>Summer rain (Tropical and sub-tropical climates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January to April¹</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>May to December</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>June to December¹</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>January to May</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1. If the water table is less than 3 m below the surface the correction factor is 1.0.
Design Procedure – Example

- We have determined parameters:
  - Characteristic deflection = 1.2 mm
  - Done in November with Benkelman Beam
  - AC thickness = 40 mm
  - Pavement Temperature = 36 degrees
  - Going to mill off 25 mm of AC
  - Adjust for temperature WMAPT/Tmeas = 1.3

<table>
<thead>
<tr>
<th>Town</th>
<th>WMAPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albury</td>
<td>26</td>
</tr>
<tr>
<td>Armidale</td>
<td>23</td>
</tr>
<tr>
<td>Bathurst</td>
<td>22</td>
</tr>
<tr>
<td>Bega</td>
<td>24</td>
</tr>
<tr>
<td>Bellingen</td>
<td>30</td>
</tr>
<tr>
<td>Blayney</td>
<td>19</td>
</tr>
<tr>
<td>Bourke</td>
<td>33</td>
</tr>
<tr>
<td>Braidwood</td>
<td>20</td>
</tr>
<tr>
<td>Broken Hill</td>
<td>30</td>
</tr>
<tr>
<td>Byron Bay</td>
<td>31</td>
</tr>
<tr>
<td>Campbelltown</td>
<td>27</td>
</tr>
<tr>
<td>Canberra</td>
<td>23</td>
</tr>
<tr>
<td>Casino</td>
<td>31</td>
</tr>
<tr>
<td>Cessnock</td>
<td>28</td>
</tr>
<tr>
<td>Cobar</td>
<td>31</td>
</tr>
<tr>
<td>Coffs Harbour</td>
<td>29</td>
</tr>
</tbody>
</table>
Design Procedure – Example

- Adjust for temperature WMAPT/Tmeas = 1.3 and therefore adjustment factor of 1.05
- Seasonal factor (temperate climate in Nov) therefore 1.0

Asphalt thickness

1.05

Douglas Partners
Geotechnics • Environment • Groundwater
Design Procedure – Example

• Seasonal factor (temperate climate in Nov) therefore 1.0

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<tr>
<td>January to April(^{(1)})</td>
<td>May to December</td>
</tr>
<tr>
<td>1.3</td>
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</tr>
<tr>
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<td>1.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1. If the water table is less than 3 m below the surface the correction factor is 1.0.
Design Procedure – Example

• We have determined parameters
  • Characteristic deflection = 1.2 mm
  • Done in November with Benkelman Beam
  • AC thickness 40 mm
  • Pavement Temperature = 35 degrees
  • Possibly going to mill off 25 mm of AC
  • Kerb and Guttering

• Corrected CD = 1.58 mm
• Corrected CC = 0.33 mm
• For milling depths of up to 50 mm, increase CD and CC by 15% to 25% for each 25 mm of asphalt milled
Design Procedure – Example
Design Procedure – Asphalt Overlay

• Determine thickness required to avoid asphalt fatigue

Two thicknesses can work – very thin <40 mm or above curved line

Either AC >88 mm (say 90 mm) or less than 50 mm (say 40 mm)
Design Procedure – Asphalt Overlay

- Can adjust traffic – and hence overlay thickness for non-standard asphalts (provided resultant overlay is less than 50 mm)

<table>
<thead>
<tr>
<th>Pre-1990 description of binder type</th>
<th>Austroads binder grade</th>
<th>Allowable traffic loading adjustment factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multigrade</td>
<td>Multigrade 1000/320</td>
<td>1</td>
</tr>
<tr>
<td>~5% EVA</td>
<td>A30P</td>
<td>1</td>
</tr>
<tr>
<td>~5% EMA</td>
<td>A35P</td>
<td>1.5</td>
</tr>
<tr>
<td>~3% SBS</td>
<td>A20E</td>
<td>2</td>
</tr>
<tr>
<td>PBDA</td>
<td>A25E</td>
<td>2</td>
</tr>
<tr>
<td>~5% SBS</td>
<td>A15E</td>
<td>2.5</td>
</tr>
<tr>
<td>~6% SBS</td>
<td>A10E</td>
<td>3</td>
</tr>
</tbody>
</table>
Design Procedure – Asphalt Overlay

- Asphalt overlay – thickness required from characteristic deflection based on WMAPT of 25° and C320 binder.

![Graph showing asphalt overlay thickness vs. characteristic deflection before overlay.](image-url)
Design Procedure – Asphalt Overlay

- Where WMA PT > 25° or lower stiffness binder used adjust overlay
Design Procedure – Granular

• Use following chart for granular overlay thickness required

Need 140 mm
Overlay Design Example

• For our example:

  • **Asphalt overlay**
    • 40 mm ok for curvature and deflection (or 90 mm AC)
    • If mill 20 mm existing: need 65 mm for deflection (but this would be an issue for asphalt fatigue and would need 95mm AC for curvature)

  • **Granular Overlay**
    • Need 140 mm (but existing kerb and gutter)
Overlay Design Example
Pavement Overlay Design

THANKS