Rehabilitation of Unbound Pavements Using Foamed Bitumen Stabilisation
What is Foamed Bitumen?

- Hot Bitumen + Water = Foamed Bitumen
- Enables coating of wet materials
- Foam collapses relatively quickly coating predominantly the finer particles of the material.
Expansion Ratio

Expansion Ratio = $V_1 / V_2$

Maximum Volume After Foaming

Volume After Collapse of Foam
Half-life is the time in seconds for the foam to settle to one-half of the maximum volume which it attained.
"Half-life" is defined as being the time by which the foamed bitumen has reduced its maximum achieved volume by 50%, i.e. half the expansion. After a certain time, the foamed bitumen collapses. The half-life is measured in seconds and usually lies between 10 and 15 seconds. As a rule: The larger the expansion and the longer the half-life, the better the quality of the foamed bitumen.

Important for the assessment of the foamed bitumen quality: As the percentage of added water is increased, the parameters “half-life” and “expansion” develop in opposite directions.
Binder Requirements

- Class 170 Bitumen – 3.5%
  - Equivalent to Pen 80 – 100
  - Inclusion of a bitumen foaming agent
- Hydrated Lime – 2%
  - Superior early strength and performance
Construction Process
Pulverising prior to stabilisation

- Breaks up wearing course (seal or thin asphalt) and any patches
Trimming after pulverising

- Remove irregularities before stabilisation and compaction
Apply Lime

- Quicklime depicted here
- Dust is a hazard to construction personnel and public
Tray tests 1

- To check application rate
- Should be done regularly
- Usually 3 trays, each a third of a square metre
Tray tests 2

- Tare scales with trays before laying out trays
- Stop applicator very soon after passing over trays
Lime applied

- Multiple tests in series if necessary
- Reapply lime in trays
- Rate must be correct before allowing the run/s to be completed
Slake Lime 1

- Necessary for quicklime only
- Multiple passes may be necessary to ensure full slaking
Slake Lime 2

- Slaking generates steam clouds
- Environmental and perhaps safety concerns
Slake Lime 3

- Temperature may indicate if hydration is complete.
Foamed bitumen stabilisation 1

- Foamed bitumen stabilise ASAP after slaking is complete
Foamed bitumen stabilisation 2

- Stabiliser pushes bitumen tanker
- Check foaming of bitumen at start of run (halt if necessary)
Compaction

- Follow stabilising run with compaction equipment
- Be aware if padfoot allowed too close to surface its pattern will reflect through to the seal.
Testing

- Sample ASAP after stabilising for tests such as bitumen content
- Sample ASAP after compaction to obtained reference density
- Complete reference density test ASAP (within 2 hours) after stabilising (binders affect compaction).
Inappropriate Applications

- Cold Environment (<10°C)
- Unsuitable pavement material grading and plasticity.
- Insufficient support below the stabilised layer (< CBR5).
- Mix design testing indicates foamed bitumen is an inappropriate binder.
## Suitable Materials

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percentage Passing by Mass (%)</th>
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<tbody>
<tr>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>26.5</td>
<td>80</td>
</tr>
<tr>
<td>2.36</td>
<td>25</td>
</tr>
<tr>
<td>0.075</td>
<td>5</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td></td>
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</tbody>
</table>
Laboratory Suitability Testing

- No standard method available
- Specialist laboratory equipment
- Usual test parameters
  - Indirect Tensile Strength
  - Indirect Tensile Resilient Modulus
Factors Influencing Test Results

- Reflective of field conditions
  - Bitumen foaming properties
  - Material temperature
- Sample compaction method
  - Marshall versus Gyratory
- Curing regime
  - Accelerated curing 40°C versus 60°C
  - Curing period
Main Roads’ Method

- Material prepared at 70% OMC
- Binder incorporated into the material
- Samples compacted using Marshall Compaction (50 blows)
- Tested for indirect tensile resilient modulus
  - After 3 hours curing at 25°C
  - After 3 days accelerated curing at 40°C
  - After soaking in water under vacuum for 10 minutes
### Preferred Mix Design Requirements

<table>
<thead>
<tr>
<th>Design Traffic (ESAL)</th>
<th>Minimum Soaked Modulus (MPa)</th>
<th>Minimum Retained Modulus Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10^6</td>
<td>1,500*</td>
<td>40%</td>
</tr>
<tr>
<td>10^6 – 10^7</td>
<td>1,800*</td>
<td>45%</td>
</tr>
<tr>
<td>&gt;10^7</td>
<td>2,000*</td>
<td>50%</td>
</tr>
</tbody>
</table>

* Material considered unsuitable where soaked modulus results are less than 1,000MPa
Stockpiling recycled material blended with foamed bitumen. Production of the KMA 150 can be started and stopped from the wheel loader via a remote control unit.
Insitu Stabilisation Performance Issues

Discussion of issues relating to the Performance of Insitu Stabilised Pavements
Foamed Bitumen Stabilised Pavements - SEQ

- Gladfield – Cunningham Highway
- Rainbow Beach – Rainbow Beach Road
- Inglewood – Cunningham Highway
- Allora – New England Highway
- Beenleigh – Beenleigh Connection Road
- Beaudesert – Beaudesert – Boonah Road
- Redland Shire – Various Roads
Gladfield – Built 1997

- 250mm OWP + 200mm IWP stabilised with 4% bitumen & 1.5% cement
- CBR 3 (expansive) subgrade
- Pavement life (prior to fatigue) ~ 2.5 years
- Approx. traffic to failure ~ 2.5 x 10^6 ESA
- Site has been overlaid with 160mm granular material.
Inglewood – Built 1998

• 200mm stabilised layer with 4% bitumen & 1.5% quicklime.
• Insitu subgrade strength CBR 5 – 20
• 3 year prior to the onset of fatigue cracking (only in areas with insitu CBR 5 - 8)
• Calculated fatigue life similar to that achieved in the field
Inglewood – 2001

Fatigue Cracking

Possible CTB Patch?

Fatigue Cracking

Fatigue Cracking
Rainbow Beach – Built 1998

• Trial to assess foamed bitumen against bitumen emulsion stabilisation
• 3 x 200m sections of foamed bitumen stabilisation constructed using 3, 4 & 5% bitumen + 1.5% quicklime
• Still performing adequately and showing few signs of distress
Rainbow Beach – 2003
Allora– Built 1999

• 17km section stabilised 250mm OWP + 200mm IWP with 3.5% bitumen + 1.5% quicklime
• Originally design with a 50 – 120mm asphalt overlay (not constructed)
• Subgrade – expansive black soil
• 1.5km section tested for deflection at regular intervals
Allora - 2002

• Isolated signs of distress
  o Two minor rut / shove failures
    ▪ Possibly material related
  o Longitudinal cracking
    ▪ Subgrade movement
    ▪ IWP fatigue cracking (insufficient depth?)
  o Seal Flushing
Allora Deflection Data

New England Highway (22B) - Southbound Lane
OWP - 40kN

Maximum Deflection (mm)

Chainage (km)
New England Highway

- 17km project stabilised in 1999
- Less than 1% of pavement showing signs of minor distress
New England Highway

- Modulus Testing of Extracted Cores

![Bar chart showing resilient modulus (MPa) for top, middle, and bottom locations after dry and soaked conditions.](image)
New England Highway

- Back-analysis of FWD Testing over time
Capillary Rise Test

• Measures the ability of material to draw in water and become saturated.
Capillary Rise Over Time
Capillary Rise of Various Base Materials