**Stabilisation**

**AAPA training**

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**Definition In Situ Soil Stabilisation**

In-Situ process of mixing additional material to improve the physical or chemical properties of pavement materials to suit particular pavement design or construction requirements.

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**Today's Discussion**

- Stabilisation Benefits
- Types of Stabilisation
- Binder Selection & Mix Design
  - *The Theory behind Stabilisation*
  - *Applying Stabilisation Theory using Purpose Built Plant*
- The Design & Construct Cost v Benefits
- Accredited Contractor

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**Benefits of Stabilisation**

Lime & cement has been found in the Roman Roads

- **Bearing Capacity/strength**
- **CBR Californian Bearing Ratio**
- **PI Plasticity Index**
- **Moisture Content**
- **Grading Curve**
- **Compaction Density**
- **Permeability**

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**Stabilisation Benefits**

- **Environmental Benefits:** Treat saturated or unsuitable site materials in-situ rather than exporting to a tip & importing new quarry products.
- **Design & Construct Cost Efficiency:** Increase the strength of the lower pavement layers and save on the thickness of the more expensive upper pavement layers.
- **Reduced Traffic Disruption & Construction Loading:** Stabilisation in situ saves construction time instead of double handling by excavating & replacing.
- **Reduce Permeability:** Forms a consistent stable barrier between the pavement and expansive inconsistent sub soils bridging soft spots and reducing differential settlement.
- **Reduce Earthworks:** Stabilising the subgrade means that layer does not have to be excavated for placement of quarry products.

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**Types of Stabilisation**

- **Lime Stabilisation** *(Quicklime)*
  - Quicklime is the industry standard for stabilisation
  - Hydrated Lime is quicklime with water added
  - Agricultural Lime is lime stone
- **Cement**
- **Granular**
- **Moisture**
- **Foamed Bitumen**
- **Polymer**
**Binder Selection**

- **Clay Soils**
  - Lime: PI greater than 15
  - Greater than 25% passing 75µm

- **Granular soils**
  - Cement: PI less than 15
  - Less than 25% passing 75µm

**Binder Addition Rates**

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Binder</th>
<th>% Addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clayey sub grades</td>
<td>Lime</td>
<td>2 – 6%</td>
</tr>
<tr>
<td>Clay gravel for basecourse</td>
<td>Lime</td>
<td>1 – 3%</td>
</tr>
<tr>
<td>Gravel for floodways</td>
<td>Cement</td>
<td>1 – 3%</td>
</tr>
<tr>
<td>Recycling of pavements</td>
<td>Bitumen</td>
<td>3 – 5%</td>
</tr>
<tr>
<td>Hardstands</td>
<td>Cement</td>
<td>4 – 8%</td>
</tr>
</tbody>
</table>

**Stabilisation Theory**

- **Quicklime to Stabilise Cohesive Soils.**
  - Permanently reduces the PI and expansive nature of cohesive soils.
  - Increases strength (CBR).
  - Can quickly reduce moisture content in soils wet of optimum or saturated.
  - Reduces moisture susceptibility.

- **Cementitious Binders to Stabilise Non-Cohesive Soils.**
  - Non-cohesive soils are non-expansive therefore the particles can be bound using cementitious binders for increased strength.
  - More cement = more strength (too much cement can cause cracking)

**Chemical Reaction: Quicklime + Water + Soil**

\[
\begin{align*}
\text{CaO (quicklime)} + \text{H}_2\text{O} & \rightarrow \text{Ca(OH)}_2 \text{ (Hydrated Lime)} + \text{HEAT} \\
56 & + 18 \rightarrow 74 & \rightarrow \text{HEAT} \\
\text{QUICKLIME} + \text{WATER} & \rightarrow \text{HYDRATED LIME} + \text{DRYING} \\
5.5 \text{ TONNE} & + 3 \text{ TONNE} \rightarrow 7.5 \text{ TONNE} \\
5.5 \text{ TONNE} & + 3 \text{ TONNE} \rightarrow 7.5 \text{ TONNE} + 1 \text{ TONNE EVAPOURATION} \\
\end{align*}
\]

The reaction rapidly commences producing heat and hydrated lime.

This in turn reacts with such SOL compounds as silica and alumina in clay to permanently change soil molecular compounds and enhance soil properties.

\[
\begin{align*}
\text{Ca}^{2+} + 2\text{(OH)}^- & \rightarrow \text{SiO}_2\text{(Clay Silica)} \rightarrow \text{CaSiO}_2\text{(Calcium Silicate)} \\
\text{Ca}^{2+} + 2\text{(OH)}^- & \rightarrow \text{Al}_2\text{O}_3\text{(Clay Alumina)} \rightarrow \text{CaAl}_2\text{O}_4\text{(Calcium Aluminate)} \\
\end{align*}
\]
Lime saturation

Applying Stabilisation Theory in the Field

- Ensure levels are correct before stabilisation commences.
- Rip / premix the material to be Stabilised

Binder Delivery

Binder Spreader

Spreading Quicklime
**Spreading Cement**

**Stabilisation of a Heavy-duty Dockside Pavement**

**Reclaimer/Mixer**

**Stabilisation - Rural Road**

**Stabilisation - Urban Road**

*Assessing moisture conditions of stabilised material*

**Stabilisation - Rural Road**

*Stabilising and Compacting*
Foamed Bitumen Stabilisation – Rural Road

Foamed Bitumen Stabilisation

Stabilisation - Urban Road

Stabilisation - Urban Road
Sealing a Stabilised Pavement

Investigation

- Pavement
  - Determine pavement profile (rarely what you think)
- Samples for testing to match final composition

Testing

- Soil Type
  - Particle Size Distribution
- Attenbergs
- C.B.R. (soaked)
- Unconfined Compressive Strength (U.C.S)
- Resilient Modulus

- Design Criteria
  - Lime Improvement in CBR
  - Cementitious U.C.S
  - Bitumen Resilient Modulus Wet / Dry ratio

Construction Aspects

- Specialised equipment
  - Spreaders
  - Stabilisers / recyclers
- Work organisation
  - Get the shape right
  - Uniform spreading
  - Mixing uniformly
  - Cut to waste
- Compaction is king
  - Use the correct plant
- Curing
  - Use water for min 4 days (damp, not flooded)
  - Apply seal or another layer
- Sealing
  - Spray and 7 - 10mm cutback primer seal then 3 - 6 months final seal

Stabilisation of Centre Court for Supercross Masters

Stabilisation of Centre Court

Cost Benefit of Stabilisation

<table>
<thead>
<tr>
<th>Traditional Pavement Design</th>
<th>Lime Stabilised Subgrade</th>
<th>Lime &amp; Cement Stabilised Subgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>300mm Crushed Rock</td>
<td>150mm Crushed Rock</td>
<td>100mm Crushed Rock</td>
</tr>
<tr>
<td>Existing Subgrade CBR 5%</td>
<td>Effective Lime Subgrade</td>
<td>Effective Lime &amp; Cement Subgrade</td>
</tr>
<tr>
<td></td>
<td>CBR 10%</td>
<td>CBR 15%</td>
</tr>
<tr>
<td></td>
<td>3% Quicklime</td>
<td>3% Quicklime &amp;</td>
</tr>
<tr>
<td></td>
<td>Stabilised to 300mm</td>
<td>2% G.P. Cement</td>
</tr>
<tr>
<td></td>
<td>=&gt; minimum CBR 20%</td>
<td>Stabilised to 300mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=&gt; minimum CBR 30%</td>
</tr>
</tbody>
</table>
### Stabilisation Cost v Benefit

**Worked Example For Existing Subgrade 5% CBR**

Cost calculations based on 3,000m²

<table>
<thead>
<tr>
<th>Method</th>
<th>Costs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>FCR 2,160T @ $20.00T</td>
<td>$43,200</td>
</tr>
<tr>
<td>Lime Stabilised</td>
<td>FCR 1,080T @ $20.00T</td>
<td>$21,600</td>
</tr>
<tr>
<td></td>
<td>Stabilising 1 day $5.00/m²</td>
<td>$15,000</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$36,600</td>
</tr>
<tr>
<td>Lime &amp; Cement Stabilised</td>
<td>FCR 702T @ $20.00T</td>
<td>$14,400</td>
</tr>
<tr>
<td></td>
<td>Stabilising 2 days $8.50/m²</td>
<td>$25,500</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$39,900</td>
</tr>
</tbody>
</table>

 Crushed Rock = Supply Only  
Stabilisation = Supply, Spread and Mix Only  
Larger areas should reduce stabilisation costs $/m²

### Stabilisation Summary

- **Lime Stabilise Clay** to increase strength, reduce plasticity PI & the expansive nature of clay.
  - **Quicklime** is the industry standard for Lime Stabilisation
  - **Then Cement Stabilise** for further strength gains, bitumen for flexibility.
- Recycle Roads by in-situ Stabilisation rather than burden tip sites and limited quarry material.
- Optimise your Pavement Design by strengthening the subgrade using in-situ stabilisation and reducing the thickness required in the more expensive upper pavement layers.
- Treat Soft, Wet and other Unsuitable Material on site and reduce cartage offsite.

### Operational Features

- **Fast**
- **Clean** – single action in cutting and loading
- **Self-contained operation**
- **Removes asphalt, crushed rock and concrete** (non-reinforced)
- **Automatic level-control from stringline, laser or preset level data**

### Work Planning

- **Site investigation**  
  - material involved, dimensions and service locations
- **Assessment of traffic conditions**
- **Selection of profiling machine**  
  - cutting widths from 250mm to 3,200mm and depths of up to 300mm
- **Organisation of trucks to haul millings**
Selection of Machine Type
Cold Planer

Selection of Machine Type
Rotor Width

Selection of Machine Type
Larger Machine - 2.5m cut
Discharge to trucks

Selection of Machine Type
Cut Width about 1.5m
Discharge to pavement for later pick-up
Selection of Machine Type

Smaller Machine 0.75m cut

Cutting Mandrel

Vertical face After Profiling

Applications

- Removal of:
  - unsuitable grades or crossfalls
  - humps
  - ruts
  - old cracked pavement
- Changing levels
- Providing a textured surface prior to an overlay
- Shoulder pavement rectification

Improvement to Cross-fall

Dangerous step

Improvement to Cross-fall

Macadam Base – highly prone to ravelling
Trenching for Cables

Removal of Hump in New Work

Transverse Joint between paver runs

Shoulder Pavement Rectification Work

Shoulder Pavement Rectification Work

Removal of Concrete Median Strip

Pavement Widening
<table>
<thead>
<tr>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
</tr>
<tr>
<td>– small crew</td>
</tr>
<tr>
<td>– suitable for overnight operations (noisy in urban areas)</td>
</tr>
<tr>
<td>– by-product in recyclable form</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specialised</strong></td>
</tr>
<tr>
<td>– Narrow trenches for services–300mm wide</td>
</tr>
<tr>
<td>– Flattening of pavement crowns with feathered edges</td>
</tr>
<tr>
<td>– Edge planing beside kerb and gutter to allow overlaying of whole road</td>
</tr>
<tr>
<td>– Excavation of poor quality shoulder material prior to improvement</td>
</tr>
<tr>
<td>– Removal of rubberised athletic track surfaces</td>
</tr>
<tr>
<td>– Removal of clogged open graded asphalt layers</td>
</tr>
</tbody>
</table>