Lime Stabilisation of Subgrades & Marginal Materials – Western QLD

Characteristics, Properties, Design and Construction
So Why LIME?
1st is Expansive Clay Soils in QLD
Cracking & Rutting on the Flinders Hwy
2nd is that Lime Reacts with Clay

- Lime is an effective additive for plastic soils improving both workability and strength
- Not effective in cohesionless soils or materials without the addition of pozzolanic additives.
Benefits of Lime Stabilisation

• Modification of material.
• Reduced plasticity.
• Improved workability.
• Strength gain.
• Improved effective grading.
• Reduced sensitivity to moisture changes (shrinkage).
• Modification of compaction properties.
• Reduced permeability with sufficient lime.
Uses for Lime Stabilisation in Western Regions

• Improve subgrade materials into subbase materials.
• Reduce overlying pavement depths.
• Improves Marginal Gravel Materials that have high plasticity (Lime blends)
• Provides moisture resistance, and Cracking (shrink/Swell).
Lime Terminology

- Hydrated Lime
- Quicklime
- Limestone (Rock) $\text{CaCO}_3$
  - No structural gain, used for acid sulphate soils etc
# Hydrated Lime vs Quicklime

<table>
<thead>
<tr>
<th></th>
<th>Hydrated Lime</th>
<th>Quicklime</th>
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<tbody>
<tr>
<td><strong>Composition</strong></td>
<td>Ca(OH)$_2$ Calcium Hydroxide</td>
<td>CaO Calcium Oxide</td>
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<tr>
<td><strong>Form</strong></td>
<td>Fine powder</td>
<td>Granular</td>
</tr>
<tr>
<td><strong>Equiv. CaO</strong></td>
<td>1.32</td>
<td>1.00</td>
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<tr>
<td><strong>Bulk density</strong></td>
<td>0.45 to 0.56</td>
<td>0.9 to 1.3</td>
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Construction Considerations
Hydrated Lime and Quicklime

• Hydrated Lime
  • Susceptible to dusting
  • Used in laboratory testing (specified in design)
  • Spread and mix only

• Quicklime
  • Cheaper per quantity of active lime (direct cost and transport)
  • Involves the slaking process for strength gain
  • Requires additional water for slaking
Slaking of Quicklime - Considerations

- For heavy application rates, utilise multiple spreading passes
- Ensure adequate addition of water to ‘hydrate lime’
- Ensure uniform mixing of binder application
- Understand the potential consequences of non-hydrated quicklime within the pavement!
Lime Reactions

Two-Stage Reaction Process

- First Stage - Modification
- Second Stage - Strength Gain
Lime Reactions

First Stage - Modification

• Promotes flocculation of the clay particles, immediately improving grading and handling properties.

• Base exchange - calcium ions displace sodium and hydrogen cations.
Lime Reactions

Figure 1 – Flocculation – Reorientation Of Clay Particles
Lime Reactions

Second Stage - Strength Gain

• Dissolution of the clay, particularly at the edges of clay plates.
• Formation of calcium silicate and calcium aluminate hydrates.
• These cementitious products are similar in composition to cement paste.
Lime Reactions - Considerations

• Occurs with higher lime addition rates
• Highly alkaline environment (pH > 12.4)
• Greater effect on montmorillonite clays than kaolinite clays
• Effect depends upon clay minerals/pozzolanic material present

Therefore important to carry out adequate investigation and mix design!
Investigation and Design

- Subgrade investigation
- Host material investigation
- Lime demand test
- Undertake mix design
  - CBR Method
  - UCS Method
Design – Lime Demand Test

Determine the binder application rate at which the pH reaches the ideal alkaline environment of pH 12.4 for the host material.
Design – Effect on Basecourse Depth

Figure 8.4  Design chart for granular pavements with thin bituminous surfacing
Case Study – Highway Subgrade Stabilisation

Constraints
• Traffic Management
• Reinstall basecourse
• Contamination
• Production
Construction Process - Mill and Sidecast
Construction – Spreading Lime
Construction - Mixing

First Mixing Pass
Construction - Mixing

Second Mixing Pass
Construction Process
- Trim and Compact
Construction Process
- Reinstall Basecourse
Core samples QDMR job Dalby

13 months after lime stabilising, black soil subgrade (UCS 2.5 to 3.5MPa)
Further Info & Technical References

• Auststab – Technical Work Tips, Stabilisation Guide
• QTMR – MRTS 07A & B
UNSEALED ROADS
Lime adds strength

Lime stabilised of unsealed road after rain

The same (non-stabilised) unsealed road adjacent to the stabilised section after rain
LIME BLENDS
Benefits of Lime Blends

- Can be Taylor made to suit most host Materials.
- Of use where there are Materials with a Plastic content eg Ridge Gravels.
- Strength improvement in Marginal Gravels.
- Can be combined with Slag, Cement, or Fly Ash.
- Ideal when using top up gravel with existing pavement or subgrade incorporation.
- The other benefits of Stabilisation are efficient Mixing and Incorporation of Moisture!
Balonne Hwy – Slag Lime Blend (85% Slag /15% Lime) @2%
Moisture Conditioning
Summary

➢ Fixing the subgrade using lime stabilisation is easier than a lot of people think.

➢ When done properly, the strength gain from lime stabilisation is permanent and on going, as with cement.

➢ The benefits of:
  ▪ direct cost savings
  ▪ speed and lack of disruption
  ▪ environmental advantages

are SIGNIFICANT.
Any Questions?