Management of Dispersive Soils in Urban Areas.

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- CSIRO – Sustainable Ecosystems
- PhD Candidate.
Problems: Roads and Culverts

Honeywood Estate: Brighton
Problems: **Drains and Culverts**

Honeywood Estate: Brighton
Problems: Excavation & Foundations

Richmond: Vineyard Factory
Problems: **Cables & Pipes**

Dunalley: Dolerite / T. Sandstone

Chain of Lagoons: Granite

Dunalley: T. Sandstone
Problems: Dam Failure

Tunbridge: Blackman Crk. Dam

Penna: Permian Mudstone.
Problems: Removal of Topsoil

Brighton
Problems: Septic Systems

Honeywood: Triassic Sandstone
Problems: Sedimentation & Turbidity

Honeywood: Triassic Sandstone
Problems: Tunnel Driven Gully Erosion

Mt. Rumney
Problems: 10 + Years After Disturbance

Woodbridge: Permian Mudstone
Queensland Examples

- Tunnelling
- Gully formation
- Erosion
- High Suspended Sediment Loads
- Riverine Contamination

Courtesy of Landloch
Tunnelling of sandy material - lateral water flow under road creating with tunnel at lowest point where pore pressures are greatest

Queensland Examples

Courtesy of Landloch YUWOOOMBA
Areas of patched road due to slumpage associated with tunnelling
Tunnel in a dam wall at Withcott

Courtesy of
What is a Dispersive Soil

Dispersive Soils

• Appear to ‘dissolve’ in water.
• Responsible for tunnel erosion.
• Dispersive soils are usually sodic.
• Structurally unstable, require special consideration for development.
**Sodic Soils & Dispersion.**

Normal: Clay Platelets are bunched together.

Dispersion: Process where individual clay platelets separate from clay structures.

Dried Aggregates in Rainwater
Dispersion

Dispersion of Sodium Based Clay Structures

- Weakness caused by large monovalent ion.
- Diffuse double layer of electrons around Na ion
- Double layer of hydration
- Clay swelling
- In low electrolyte water ~ Dispersion
- In high electrolyte ~ Swelling
What is a Sodic Soil

- ESP Greater than 6

Definition of sodic soils

Non-sodic - ESP < 6
Sodic - ESP 6-14
Strongly sodic - ESP ≥ 15
Sodic Soils: National Snapshot.

- 200 million Ha: Area affected by sodicity
- 5 times: Proportion of sodic vs saline affected land
- 90 million ha: Area of pasture and cropping country directly affected.
- $6.75 Billion: Estimated yield loss for wheat alone

(Approx. 30% of Australia is sodic)

(National Audit soil sodicity)
Sodicity and Soil Classification

Chromosol
Vertosol
Sodosol

Fig. 1. Mean ESP values with depth for soil groupings.

Courtesy of

Landloch
Distribution of Sodic Soils in QLD

By area:
25% Strongly Sodic
20% Variably Sodic

(Shaw et al. 1995)
Distribution of Sodic Soils (SE Qld)
Activities that increase likelihood of tunnel erosion / soil dispersion.

- Overgrazing
- Removing topsoil
- Excavation of dispersive soil
- Poor compaction of sodic clay
- Concentration of runoff
- Septic trenches
- Drains and Culverts
Prevention Strategies

1). Awareness and Education
   • Development of Guidelines
   • Extension support & advice (?)

2). Avoidance
   • Test and map presence of dispersive soils

3). Prevent rainwater coming into contact with subsoils
   • Avoid ponding water
   • Don’t remove topsoil
   • Cover exposed subsoils with topsoil
   • Minimise excavations
   • Raintank Outlets, culverts etc
Prevention Strategies

4). Compaction
• Compact exposed subsoils (approx 98% proctor).
• Compact structurally important dispersive soils ie dams

5). Chemical Amendment
• Application of Gypsum or hydrated Lime
• Around 2% by weight for structures, ie dams, reclaimed areas.
• 0.5-1.5 t/ha for broadscale land management
• Get Soil Tests

6). Land & Water Management
• Prevent concentrating surface water ie culverts
• Spread captured water on high areas away from buildings
• Treat water or discharge areas with gypsum.
• Maintain healthy pasture
Identifying Dispersive Soils

Spew Holes

Dribble Patterns

Muddy dams

Pocketing
Identifying Dispersive Soils: Field Techniques

1. Collect soil aggregates (1-2 cm diameter)
2. Dry aggregates in the sun for a few hours
3. Place the aggregates distilled water.
4. Observe presence of milky ring around the aggregates after 20 mins & 60 mins.

<table>
<thead>
<tr>
<th>Non-Dispersive</th>
<th>Slightly Dispersive</th>
<th>Dispersive</th>
<th>Highly Dispersive</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Water remains clear though particles may crumble. Boundary of crumbs clearly defined.</td>
<td>Discolouration surrounding particles or distinct cloudiness surrounding some. Boundary of crumbs vaguely defined.</td>
<td>Discolouration and cloudiness surround most or all particles. Boundary of crumbs not able to be defined.</td>
<td>Discolouration and cloudiness throughout extending vertically throughout most or all water.</td>
</tr>
</tbody>
</table>
**Identifying Dispersive Soils - Analytical Approaches**

**Chemical tests.**
- Exchangeable Sodium Percent (ESP)
- Sodium Absorption Ratio (SAR).

**Physical tests**
- Emerson soil crumb test (AS 1289.3.8.1-1997)
- Pinhole test (AS 1289.3.8.3 - 1997)
- Dispersion Index
- Double Hydrometer test

**Combined Chemical & Physical Tests (Rengasamy 2002).**
- Measurement of clay dispersion (514.01)
- Measurement of dispersive potential (514.03).

\[
SAR = \frac{Na^+}{((Mg^{2+} + Ca^{2+})/2)^{1/2}}
\]

\[
ESP = \frac{Na^+}{Na^+ + Mg^{2+} + K^+ + Ca^{2+}}
\]
Example: Penna Tunnel Repair

Basic Steps
1). Excavate tunnel system
2). Repacking trench
3). Gypsum & hydrated lime
4). Topsoil
5). Revegetate

Before

Adding water

Applying Gypsum

75 Meter Long excavation

Penna
• 10m (75m) Long
• Excavation
• Refilling
• Gypsum
• Sandblocks
• (Poor compaction)
• $ ??

UTAS

Tasmania

Engage the possibilities
Use of Sand Blocks

(a) Excavate across trench/tunnel
(b) Geotextile downslope wall
(c) Fill with fine sand and gypsum 5% wt
(d) Leave sand exposed on surface
Finished Repair Jobs

Traditional Approaches of ripping and filling have about 50% success rate.
Compaction

- Prevents the movement of dispersed clay platelets through the surrounding soil.
- Dispersive soils are difficult to compact.
- Compact at 1.5 - 2% above the optimum moisture content.
- Track rolling is not good enough, need sheepsfoot roller.
  - a D6 dozer applies 0.6 kg/cm² pressure compared to 9.3 kg/cm² for a sheepsfoot roller.
- 98% Proctor dry density
- For dams compact to around 10-5 to 10-7 cm/sec.
- Get engineering advice
Use of rock

Mixed results ~ Can't be relied upon.
Excavation, Cut & Fill

- Don’t Cut and Fill
- Use Pier & Post
- Consider Hydrological isolation.

(a). Cross Section

(b). Plan View

Hydrological isolation technique.
Repair of the Dunalley Tunnels

- Replaced Cable
- Low sodicity (ESP 2.4 -9.5) spoil from the excavated trench was treated with 1.0-1.3% gypsum
- 300m³ of non-sodic (ESP <6) soil was carted to the site and treated with 0.1% gypsum.
- Treated soil was repacked into the trench in 150mm thick layers using whacker packers.

Improved Trenches and supply of services

(a). Traditional Trench  
(b). Improved Trench

Improved Trenching
- Compaction with whacker packers.
- Use of Gypsum / hydrated lime.
- Topsoil burial

Consider
• Overhead Power and Telephone
• Rainwater tanks

Imported topsoil
Cable or pipe
Dispersive subsoil
No Ponding Surface Burial
Surface Burial
Improved Compaction
Burial in Topsoil
Topsoil (non-dispersive)
Planning Schemes.

Brighton Example
- Mapping still not suitable at property level.
- Planners didn’t understand the map.
- Scaled response required
- Resulted in limited use
Guidelines for Development and Construction on Dispersive Soils.

Difficulties with
• Obtaining external funding
• Lack of research data & Information.
• Lack of awareness
• Lack of secondary expertise & training.
• Difficulty engaging councils.
• Difficulty engaging engineers.
• Lack of support from regulators / planners.

Long Term
Building Codes
Planning Schemes

Dispersive Soils and Their Management:

Contributions From;

Richard Doyle  Bill Cotching  Tim Duckett  Peter Zund

Marcus Hardie
Land Management Officer
DPIWE
Brisbane City Council Approach

The aim of the procedures ..........soil erosion potential and dispersion risk during land-disturbing activities .......... appropriately manage ....... dispersive soils, ...... degradation of water quality ..... 

Table 3 - Site Assessment Test Requirements

<table>
<thead>
<tr>
<th>Required Testing - Level 1 Assessment</th>
<th>Number of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Emerson Class Number – AS1289 3.8.1</td>
<td>Determined on representative topsoil &amp; subsoil samples, (minimum 1 test from topsoil &amp; subsoil horizon per 2 boreholes (ie. 8 tests for 8 boreholes))</td>
</tr>
<tr>
<td>• An accurate visual &quot;Soil Classification&quot; by a suitably experienced person – AS1726</td>
<td>To be undertaken on each sample.</td>
</tr>
<tr>
<td>• Electrical Conductivity &amp; pH – AS1289 4.3.1</td>
<td>To be determined on a representative upper topsoil sample (ie. for revegetation assessment) and a</td>
</tr>
<tr>
<td>• Particle Size Distribution – AS1289 3.6.1</td>
<td></td>
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<tr>
<td>• Dispersion Index – AS1289 3.8.2</td>
<td></td>
</tr>
<tr>
<td>(including PSD (fine) AS1289 3.6.3)</td>
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