Technical Note 208

Managing Slaking and Dispersive Soil risks in transport infrastructure projects

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Queensland Government

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1 Purpose

The purpose of this technical note is to provide guidance on the management and treatment of Slaking and Dispersive Soils, where they occur within Transport and Main Roads state-wide road corridors. It is intended to assist planners, designers, project managers, construction contractors and maintenance personnel in minimising the risk of issues arising during construction and underperformance of road assets in-service.

This technical note provides guidelines on:

- the identification of Slaking and Dispersive Soils during project planning
- the assessment and management of project risks in detailed design, and
- options for the treatment of Slaking and/or Dispersive Soils during the construction and operation of a road.

2 What are Slaking and Dispersive Soils

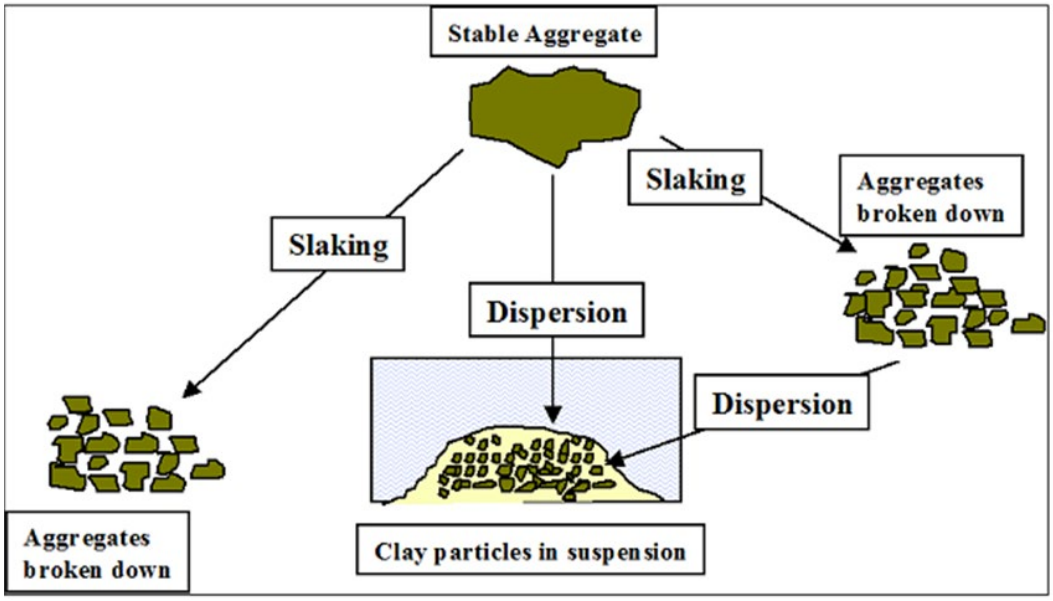
The terms 'slaking' and 'dispersive' refer to the characteristics of a soil that make it highly susceptible to erosion due to its physical and/or chemical properties.

Slaking and dispersion can occur together but are different processes. Soils which slake can also be dispersive, but not all Slaking Soils are dispersive.

The processes of slaking and dispersion both cause structural instability within soil aggregates, ultimately resulting in erosion. However, the mechanisms that cause this instability are different and the soil types that demonstrate these properties are different.

The key differences between the slaking and dispersion processes for soils are simply illustrated in Figure 2(a) below.

Figure 2(a) – Difference between the slaking and dispersive processes



Source: Dairy Australia (2021)

Slaking is the process in which the structure of a soil disintegrates when exposed to moisture[1] , or 'wetting'. Aggregates or agglomerations of air-dry soil are broken down into smaller aggregates as a result of rapid wetting.

The mechanism by which soil slakes is the forced and rupturing escape of trapped air as water is drawn into small pores between soil particles by capillary action, within in the aggregate[2].

The rapid release of air from voids, and the entrance of water breaks soil aggregates apart to form smaller aggregates.

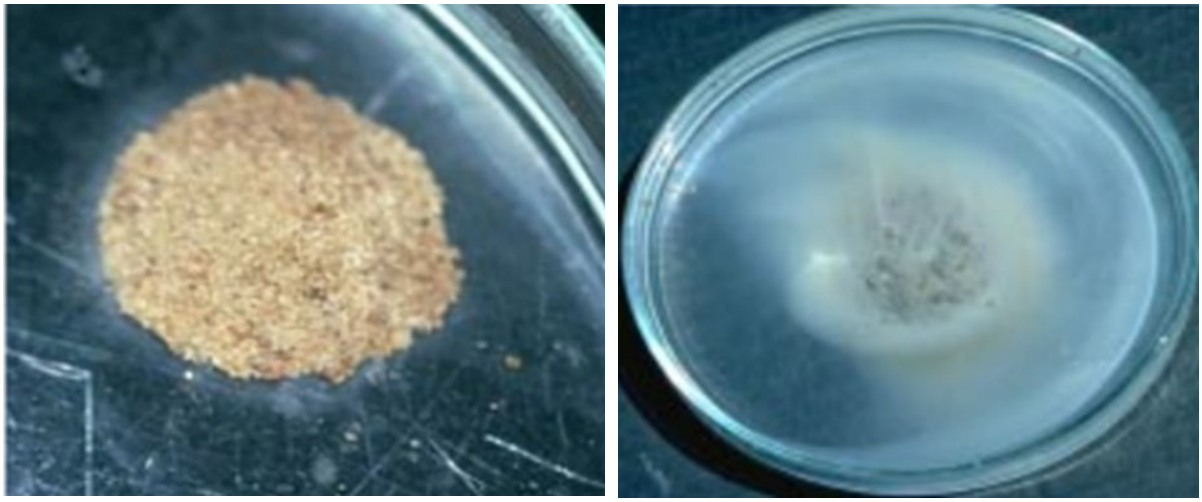
Soils prone to break down due to slaking differ from soils which ‘disperse’ on wetting.

The process of dispersion is mainly due to the effect of water on clayey soils that have an unstable chemical structure. Soils which contain a high percentage of mineral salts are generally susceptible to dispersion.

When dry soil is wetted, the molecular forces that bind individual clay particles together are disrupted when too many larger ions (typically sodium ions) come between them. The clay particles expand, and as a result, the soil structure that binds the fine aggregates and larger particles together breaks down. The soil then becomes segregated into its constituent components, and clay particles become suspended in the water.

In addition to the presence of sodium (generally referred to as sodicity), dispersion in soils can also be influenced by other contributing factors such as pH, salinity, soil texture, clay type, organic matter in the soil, and the exchangeable cations present.

Figure 2(b) – Images of a Slaking Soil (left) and a Dispersive Soil (right) after wetting



Slaking soil Dispersive soil

Images: Department of Primary Industries (1999)

Slaking and Dispersive Soils can have impact on the functionality, durability and safety of road infrastructure during construction and in-service.

The sedimentation arising from Slaking and Dispersing Soils can damage the ecological health of waterways. Mobilised sediment tends to accumulate in areas of slow-flow and may smother bottom-

[1] Bell, F.G. (2007). Engineering geology (2nd Ed.). Oxford: Butterworth-Heinemann. p. 84.
[2] http://vro.agriculture.vic.gov.au/

dwelling organisms and their habitats. Deep permanent river pools, that are valuable habitats for aquatic fauna and refuges for wildlife during summer and drought, may become filled by coarse sediments[3].

The images below show examples of damage to embankments, cuttings and drains as a result of the exposure of Slaking and Dispersive Soils to rainfall and runoff.

Figure 2(c) – Field evidence of Slaking and Dispersive Soils

Eroded v drain

Rilled and gullied untreated embankment

Sediment in rock-lined drain and culverts

Eroded cut batter

Sediment load to waterway

Fence footing undermined

Source: Transport and Main Roads

3 Locations of Slaking and Dispersive Soils

Soil materials with slaking and dispersive properties make up at least 45% of soils that occur within Queensland[4]. The potential for these soils to be present within Transport and Main Roads project boundaries can be determined by referencing published soil maps of Queensland (https://www.qld.gov.au/environment/land/management/soil/soil-data/mapping).

Transport and Main Roads' Soil Group Classification Maps and the CSIRO Clay Mineralogy Map are also useful references.

The soil groups with slaking and dispersive characteristics are generally mapped as:

- Texture contrast soils (dispersive)

[3] Department of Water and Environmental Regulation – Western Australia
[4] Department of Environment and Science – Queensland

- uniform cracking clays
- uniform non-cracking clays (coarse aggregate size), and
- waterlogged soils (saline).

Dispersive Soils are referred to as *Texture contrast soils* (dispersive) under the Transport and Main Roads' Soil Group Classification.

The locations where *Texture contrast soils* (dispersive) occur are identified in the Transport and Main Roads' Soil Group Classifications layer under the Geotechnical Map in the Transport and Main Roads' Interactive Map Gallery (iMaps) at:

https://imapsapp/TmrHtml5Viewer/Index.html?viewer=GeoTech# (internal link only).

For locations where Slaking Soils may occur, refer to the Clay Minerology layer under the Geotechnical Map Transport and Main Roads' Interactive Map Gallery (iMaps) at:

https://imapsapp/TmrHtml5Viewer/Index.html?viewer=GeoTech# (internal link only).

The soil groups with slaking and dispersive characteristics are also present in many Transport and Main Roads' Soil Group Topsoils and subsoils with smectite[5] minerology.

These soil properties may also occur in the following scenarios:

a) Deeper layers of subsoil, which might exhibit dispersive characteristics and pose a significant risk of erosion when exposed.

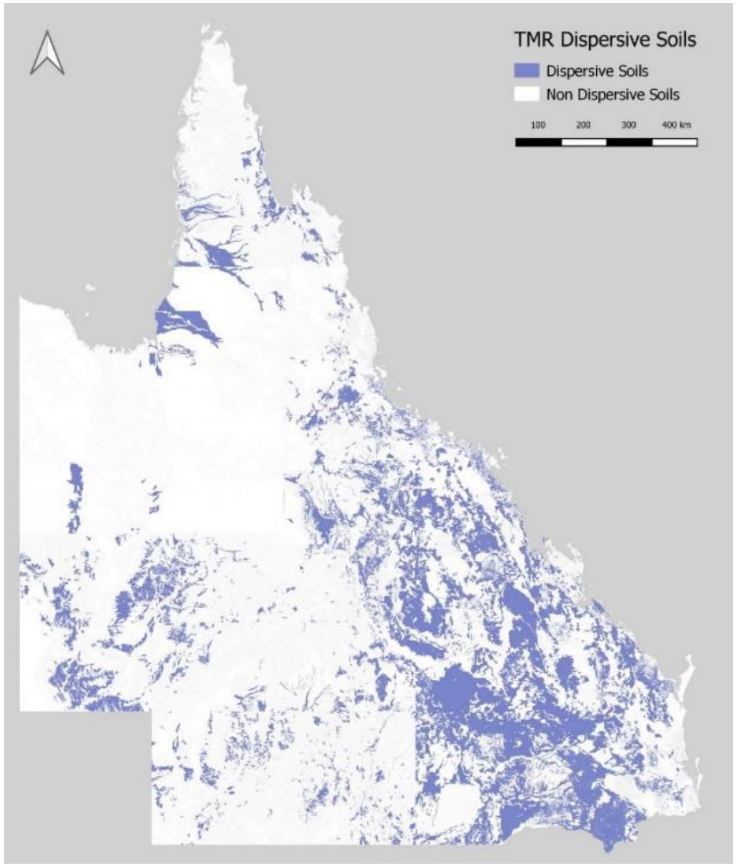
b) Soils that are waterlogged and saline but have been drained and undergone leaching of salts. This process typically leads to the removal of soluble salts, resulting in sodic profiles. Consequently, these soils may possess a moderate to high erodibility rating.

For a detailed explanation of these datasets, refer to the Geotechnical Map - Metadata Factsheet at https://imapsappdev/metadata/Factsheet_GeotechReports.pdf.

NOTE: Where the Project Team is external to Transport and Main Roads, the mapping can be provided with the project brief or upon request from the department.

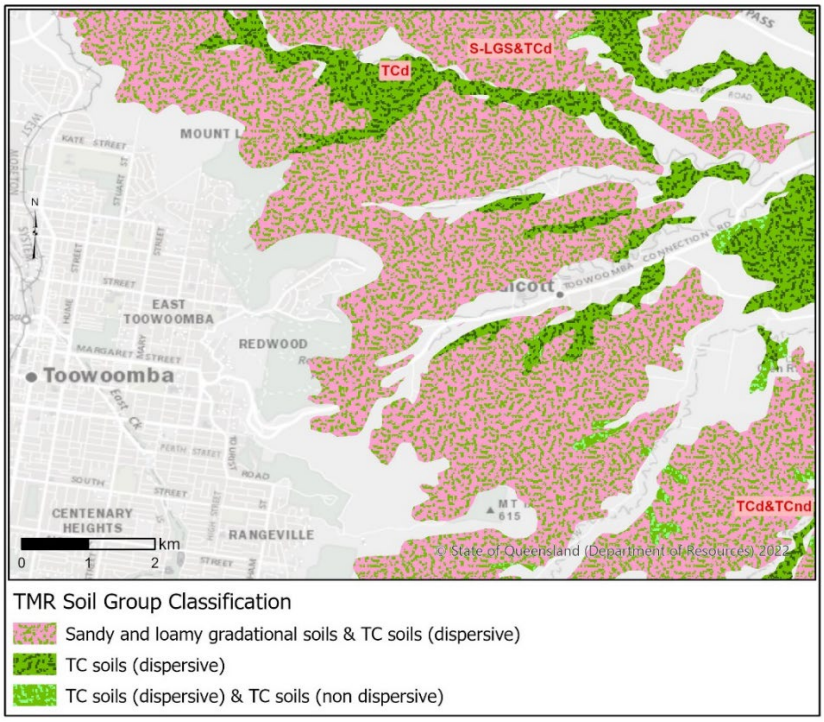
[5] Smectite is a clay mineral which undergoes large volume changes when exposed to water.

Figure 3(a) – Dispersive Soils mapped across Queensland



Source: Transport and Main Roads

Figure 3(b) – Example Transport and Main Roads Soil Classification Map – Withcott, Lockyer Valley Region



Source: iMaps, Transport and Main Roads

4 Identification and risk assessment - concept and planning phase

4.1 Methodology for Identification of Slaking and Dispersive Soils

During the concept and planning phase of an infrastructure project, the presence of Slaking and Dispersive Soils and the potential risks associated with them can be identified through:

a) desktop mapping

b) consultation with industry experts

c) field observations, and

d) field and laboratory testing, as required.

It is recommended that the Project Manager engage a suitably qualified soil scientist[6] at the concept and planning stages of a project to provide advice on the Slaking and Dispersive Soil risks.

NOTE: For environmental desktop assessments, the requirement to identify risks associated with Slaking and Dispersive Soils should form a component of the report.

4.1.1 Desktop mapping

The potential for Slaking and Dispersive Soils to be present within the boundaries of a project can initially be determined by referencing published soil maps of Queensland.

Transport and Main Roads Soil Group Classification Maps (Figure 3(b)) and the CSIRO Clay Mineralogy Map are useful references.

It should be noted that mapping is indicative and should be confirmed with field observations. Where there is uncertainty or significant earth works planned for a project, field sampling and laboratory testing should also be undertaken to confirm and characterise soil materials.

4.1.2 Field observations

The presence of Slaking and Dispersive Soils at a particular Site may be identified through observations from field inspections. Evidence of significant rilling, gully or tunnel erosion, or sediment build up at the project Site, and also adjacent land or adjoining properties, can be indicators of the presence of Slaking and Dispersive Soils (refer to Figure 2(c) above)).

4.1.3 Site sampling and laboratory testing

To verify observations from desktop mapping and field inspections, it is recommended that some additional Site sampling and laboratory testing be undertaken as part of the geotechnical assessment during the business case stage of the project. This will enable further characterisation of soils that may potentially be impacted by construction and may assist in the quantification of risk to the project.

[6] A suitably qualified soil scientist should be either:
a) Certified professional soil scientist (CPSS), or
b) Accredited soil scientist or agronomist with:
   i. Educational qualifications relating to soil science, and
   ii. At least ten years relevant experience in soil assessment and management.

4.2 Assessment of risk and concept phase outputs

If Slaking and Dispersive Soils are identified within the project boundaries, the Project Manager should seek advice from a suitably qualified soil scientist to understand the level of risk to the project based on:

- the presence of Dispersive Soils in desktop mapping datasets
- any laboratory test data from Site investigations
- visual / anecdotal evidence and/or asset owner experience of significant erosion in proximity to the Site
- proximity to other assets / stakeholders that may be affected by erosion
- scope and extent of earthworks, including clearing limit, proposed drainage and cut / fill volumes, and
- depth of cuttings, as this may remove the mapped soils (i.e. upper layers) and expose soil materials that are not represented on the Transport and Main Roads soil group mapping.

Where the risk is considered moderate to high, further soil investigations should be recommended in the scope of any Geotechnical Site Assessments for the preliminary and development stages of the project.

It is generally the Project Manager's responsibility to ensure that the risks of potential impacts of Slaking and Dispersive Soils, during construction and the service life of the road, are understood and documented for the Business Case. It is also the Project Manager's responsibility to ensure the estimate of the project budget is sufficient to undertake:

a) focussed field sampling and laboratory testing for identification and characterisation of any Slaking and Dispersive Soils, as part of geotechnical investigations for preliminary and detailed design, under the guidance of a suitably qualified soil scientist

b) design options for the management and treatment of Slaking and Dispersive Soils (for example, minimising or avoiding disturbance, revegetation, hard armouring, and modified drainage), and

c) amelioration (or other treatment options) during construction, if required.

5 Development phase – assessment of risk and management by design

5.1 General

Strategies for the management of Slaking and Dispersive Soil risks should be incorporated within the project design and construction Contract documentation. The hierarchy for the management and treatment of Slaking and Dispersive Soils should be to avoid where possible or mitigate risks through design treatments.

To ensure suitable management strategies and treatment options (where required) are developed for Slaking and Dispersive Soils during design, a properly scoped Site investigation is important. Section 5.2 provide some guidance on the minimum requirements for Site sampling and laboratory testing for developing Site investigation scoping briefs.

5.2 Investigations for Slaking and Dispersive Soils

5.2.1 General requirements

Based on the results of the desktop study, where the presence of Slaking and Dispersive Soils has been identified, the field sampling and laboratory testing guidelines in Tables 5.2.1(a) and (b) respectively should be considered as a part of any Site investigation undertaken for the identification and characterisation of Slaking and Dispersive Soils.

Table 5.2.1(a) – Recommended soil sampling frequency

Design element	Minimum sampling frequency
Cuttings and subgrade	1 sample for each soil material and every 50 m to 150 m length of cut
Major drainage channels	Minimum of 1 sample for each channel location
Earth Fill / verge sources	1 sample for each soil type or every 5000 m³ whichever is more frequent

Table 5.2.1(b) – Recommended laboratory tests

Soil property	Test method
Clay content	AS 1289.3.6.3
pH	4A1 – Rayment and Lyons
Electrical conductivity	3A1 – Rayment and Lyons
Emerson class number	Q168 (preferred) or AS 1289.3.8.1
Calcium magnesium ratio	15B3 or 15C1 – Rayment and Lyons
Exchangeable sodium percentage (ESP)	15N1 – Rayment and Lyons
Cation exchange capacity (CEC)	15F3 – Rayment and Lyons
Soluble chloride	5A – Rayment and Lyons

It is also recommended that the designer should seek advice from a suitably qualified soil scientist when determining the scope of any proposed Site investigation and for the interpretation of laboratory results. *NACoE Report O21 Dispersive and Slaking Soils Management* (2022) also provides some guidance on the interpretation of the results of testing for Slaking and Dispersive Soils.

5.2.2 Assessment and reporting

Where the presence of Slaking and Dispersive Soils is confirmed from the results of the Site investigation, the designer should consider the characteristics of these soils and the risks associated with them.

The assessment of the level of risk to the project will depend on several factors including, but not limited to:

- the slaking and dispersive potential of the soil materials present
- the scope and extent of earthworks proposed, including clearing limit, proposed drainage and cut / fill volumes, and
- climatic conditions (such as intensity and frequency of rainfall).

For projects assessed as moderate to high risk, it is recommended that the designer should seek advice from a suitably qualified soil scientist in the development of a Soil Management Plan – Planning (SMP-P).

A suggested planning outline for the development of an SMP-P is listed below in Table 5.2.2.

The SMP-P should be included in the final Geotechnical Interpretative Report for the project.

Table 5.2.2 – Table of minimum requirements for a Soil Management Plan - Planning

Soil Management Plan – Planning Outline
1. Location 2. Scope of Works 3. Existing condition and visual observations 4. Soil Group Classification from mapping 5. Soil sample locations and methodology 6. Laboratory test results 7. Interpretation 8. Recommended management and treatment options (including amelioration plan if required).

5.3 Design considerations

In developing the detailed design, the designer should consider the risks identified for the insitu soil types present on the project Site. Where the results of the Site investigation indicate presence of Slaking and/or Dispersive Soils, the designer should minimise or eliminate the impacts of these soils through:

- avoiding the disturbance or use of these soils
- protecting or covering the soils from rainfall or runoff (landscaping or 'hard-scape' solutions)
- reducing the impacts of erosion through geometric design of exposed surfaces
- minimising the concentration of water flows, and ponding of water, and/or
- soil amelioration treatments such as adding lime or gypsum.

Where soil amelioration treatments are considered during design, Table 7.4.3 below may be used for guidance on types of ameliorants and minimum application rates required. The designer should also include provisional items in the Contract for the supply and installation of ameliorants.

5.3.1 Cuttings

The following design options should be considered for the management of Slaking and Dispersive Soil risks, where they comply with other geotechnical requirements:

- include hard landscaping 'hardscape' material options such as shotcrete or concrete facings (for this treatment, care should be taken to protect the top edge from ingress with water)
- minimise benching to reduce the formation of rills, gullies, slumps, and tunnels
- where possible, flatten cut batters to 1V:4H and include amelioration of the surface and landscaping treatments
- for some situations, steepening cut batters to 1V:1.5H to minimise the surface area impacted by rainfall.

Where geotechnical standards for cuttings require benching, the design should:

- Specify ameliorant treatment to the top 200 mm of soil of the bench including spreading ameliorant agent.
- Avoid excessive ripping of bench surfaces as this will increase water infiltration.
- Provide for the installation of a catch drain at the back of the bench, including appropriate armouring, and
- Specify 100 - 200 mm Topsoil where seeding or turf is to be applied.
- Where the natural surface falls towards a cut face:
  - include a 1V:4H layback section at the top of the cut batter to allow for the establishment of vegetation to stabilise the top of the cut face and minimise runoff over the cut face, and
  - include a catch bank (avoiding catch drains) just beyond the hinge point of the cut and where practicable, provide access to catch banks for maintenance activities.
- Consider concrete capping at the back of kerb to allow removal of sediment during maintenance.
- Include a construction note to avoid undercutting the toe of the batter when carrying out final trimming operations or forming drains to prevent water concentrating and undermining batter faces.
- Where individual rocks are exposed in a cut face, the designer should consider the inclusion of soil amelioration and vegetation treatments with erosion protection mattings and/or rock-fall fencing.
- Specify a hard treatment such as shotcrete or rock armouring – refer to the limitations on the use of shotcrete in the *Road Landscape Manual* and project brief. Ensure surface flows or seeps are drained away from treatment as flows may erode underlying soil resulting in failure of the hard treatment.

When preparing design documents, the designer must:

- clearly identify the cut batters or specific sections of batters that need to be treated
- clearly state the surface protection treatment and any necessary subsoil preparation, and
- include the relevant work item in the schedule of items for the supply and application of ameliorant to cuttings, when amelioration treatments are required.

5.3.2 Earth Fill material

This section applies to Earth Fill materials as specified in MRTS04 *General Earthworks*. These materials may be sourced on-site from excavations (such as for cuttings) or imported from off-site external sources (such as quarries or borrow pits).

Where possible, avoid using Slaking and Dispersive Soils as Earth Fill material.

Where avoidance of Slaking and Dispersive Soils for Earth Fill material is not possible, the following options should be considered by the designer:

- Zoned embankment construction:

  Placement of Slaking and Dispersive Soils in the embankment core zone and protected by non-dispersive or ameliorated soils in the outer and upper zones. Ameliorant treatment should be applied for each lift for the soil within the outer 2.5 m zone. Material requirements for embankment subject to permanent / semi-permanent inundation shall be as per the department's *Geotechnical Design Standard*.

- Homogeneous embankment construction:

  All soil used for Earth Fill to be treated with ameliorant within stockpiles and placed throughout the embankment. Alternatively, ameliorant could be applied to each soil layer / lift as the embankment is being constructed.

Figure 5.3.2 – Treatment of Dispersive Soils with ameliorant provides long term improvements in stability

Ameliorant applied to outer embankment.

Ameliorant applied to cut batters.

Ameliorant applied to embankment benches Source: Sinclair Knight Merz 2008.

Source: Transport and Main Roads

5.3.3 Open channel drains

This section provides some suggested approaches for the design of open channel drains to be constructed within Slaking and Dispersive Soils.

Figures 5.3.3(a) and (b) below show some examples of types of erosion that can occur in drains constructed in Slaking and Dispersive Soils and some examples of protective treatments that can be used to reduce erosion.

Depending on the design flow conditions, the designer should consider some of the mitigation options below:

- Avoiding ground disturbance in Slaking and Dispersive Soils where possible.
- Minimising the concentration and velocity of flows.
- Avoid sudden changes in invert levels.
- Avoiding overly flat invert levels where water can pond.
- Ameliorating and vegetating exposed areas. Also ensure adequate establishment and maintenance periods for soft treatments.

- Adopting hard surface protections such as shotcrete or concrete.
- The use of alternative surface protection such as:
  - geosynthetic surface treatments
  - jute mesh matting over ameliorated subsoil with Topsoil and seed, or
  - organics blanket with grass seed mix (and ameliorant), or
  - bituminous emulsion with Topsoil and seed, in addition to soil amelioration.
- Avoiding rock-based treatments including dumped rock, rock mattresses and rock check dams.

Figure 5.3.3(a) – Examples of erosion in drains constructed in Dispersive Soils

Eroded v-drain will continue to erode until vegetation establishes (unlikely in this instance) or invert reaches rock layer.

Sediment deposits and filter sock direct water around sock increasing extent of erosion.

Source: Transport and Main Roads

Figure 5.3.3(b) – Examples of soft treatments of drain surfaces

Jute mesh matting and bituminous emulsion with grass seed strike.

Established cover crop and perennial grass species.

Established perennial grass species.

Source: Transport and Main Roads

Note: Soft treatments can be successful in Dispersive Soils with the addition of ameliorants to subsoils, the use of Topsoil and turf, as well as reinforced revegetation treatment such as jute mesh

For further guidance on the design of open channel drainage, and other drainage elements, refer to the department's *Road Drainage Manual*.

5.3.4 Disturbed areas

Where Slaking and Dispersive Soils are known or suspected, it is recommended that the designer specifies that all ground surface disturbed during construction should be ameliorated and seeded (or otherwise revegetated) to reduce risk of post-construction erosion.

5.3.5 Road furniture

For the design and installation of road furniture, the designer should consider installing guideposts, signs, guardrail and fencing posts by ramming instead of excavation and backfilling. Installation by ramming should reduce the risk of water ingress to Slaking and Dispersive Subsoils. In addition, the ground surface at the base of any installed road furniture should be treated with a waterproof sealant.

Where installation by excavation and backfilling is unavoidable, the design should specify:

- amelioration treatment of the excavated hole and backfill material
- full compaction of backfill and spray seal over the surrounding ground
- weathered-off footings and surrounding finished surfaces, and
- vegetation, ensuring positive surface drainage.

6 Preparation of Contract documentation and tendering

6.1 Contract documentation

All design requirements for the management and treatment of Slaking and Dispersive Soils must be specified in the drawings and other design documents such as Annexure MRTS04.1.

All relevant work items (as per MRS04 *General Earthworks* Measurement Specification) should be included in the tender schedule for:

- the supply of amelioration agents and installation through mechanical mixing of the ameliorant into the Earth Fill or Cut Surfaces under MRTS04 *General Earthworks*
- the supply of amelioration agents and installation as part of landscaping treatments under MRTS16 *Landscape and Revegetation Works*.

6.2 Tendering

All tender documents should incorporate the work items relevant to materials with slaking and dispersive properties. Tenderers should evaluate the likely amelioration requirements and costs associated with their application to Dispersive Soils.

All pre-construction results of testing should be provided to tenderers as supporting information within the Contract documentation package.

Tenderers should consider:

- possible insitu materials on-site
- cut to fill volumes, and
- the intended sources of Earth Fill material and Topsoil.

For insitu materials and proposed imported materials, the tenderers should consider:

- the potential likelihood of materials having slaking and dispersive properties
- avoiding using Earth Fill with slaking and dispersive properties within the outer zone (outer 2.5 m) of an Earth Fill embankment, and
- consideration of soil amelioration or other protective measures, if Slaking and Dispersive Soils cannot be avoided.

NOTE: For Earth Fill materials that are to be supplied by the Contractor, any amelioration treatments required for the materials should be undertaken by the Contractor at the Contractor's expense.

7 Construction

7.1 Scope clarification between MRTS04 General Earthworks and MRTS16 Landscaping and Revegetation

The interface between MRTS04 and MRTS16 testing, and amelioration is outlined below:

Earth Fill materials:

- Sample and test all Earth Fill materials from their source prior to use in embankment construction. Manage Slaking and Dispersive Soils as per design documents, MRTS04.1 requirements and the Contractor's Earthworks Construction Procedure (MRTS04).
- Where Earth Fill batters are to be revegetated, the outer 150 mm should also be tested and managed in accordance with MRTS16 requirements.

All Cut Surfaces (excluding non-erodible rock) and for each Cut Surface prior to finishing of batters:

- If landscaping and revegetation treatments are specified in design, properties of the subsoil shall comply with MRTS16 requirements.
- If no landscaping and revegetation treatments are specified in design documents, properties of subsoils shall comply with MRTS04 requirements.

Table 7.1 – Clarification of scope and process across MRTS16 and MRTS04 for management of Slaking and Dispersive Soils

	MRTS16 ***Landscape and Revegetation***	**MRTS04** ***General Earthworks***
Scope	Assessment and management of soils in Cut Surfaces and embankment batters for suitability of revegetation and landscaping treatment. Includes ground preparation works such as: • sampling and testing • spreading ameliorants • ripping • cultivation, and • roughening.	Assessment of Earth Fill and Cut Surfaces for stability and erosion risk. Includes: • sampling and testing, and • provision for incorporating treated slaking and dispersive materials into the Works. Where exposed Cut Surfaces or Earth Fill materials are to be revegetated, they are to be additionally tested and treated under MRTS16 requirements for subsoils.
Tender process	Provisional items for: • supply of ameliorant, and • installation of ameliorant.	Provisional items for: • supply of ameliorant • installation of ameliorant.
Construction procedures	Develop and submit Soil Management Plan – Construction prior to commencement of Works stipulating soil management and amelioration processes.	Develop and submit Construction Earthworks Procedure prior to commencement of Works to include management and treatment options for Earth Fill material and Cut Surfaces.

7.2 MRTS04 General Earthworks Construction Procedure

All project specific design requirements for the management of Slaking and Dispersive Soils during construction are specified in the department's Contract documents.

Following the awarding of a Contract, the successful Contractor must include procedures for the management, and treatment of Slaking and Dispersive Soils in their Earthworks Construction Procedure (Clause 5.2 of MRTS04 *General Earthworks*), to comply with design requirements.

Where there are no design requirements specified, the Contractor's Earthworks Construction Procedure should include provisional management options for situations where Slaking and Dispersive Soils have not been identified during the design process but are encountered on-site during construction.

Where the Contractor proposes to use Slaking and/or Dispersive Soils from the Site as Earth Fill materials for the Works, the Contractor is able to submit a Soil Amelioration Treatment Plan for approval by the Administrator.

Where soil is to be supplied for use as Earth Fill from an external source, the Contractor must provide evidence to the project Administrator that the material does not have slaking and dispersive properties. Alternatively, the Contractor must provide an Amelioration Plan for the externally supplied material, as part of their Earthworks Construction Procedure.

7.3 Construction testing

During construction, the Contractor is required to undertake verification testing of Earth Fill material and Cut Surfaces in accordance with MRTS04 Appendix A, Tables A1 and A2.

Testing may also be required for the application of Landscaping and Revegetation treatments, in accordance with MRTS16 *Landscape and Revegetation Works*. Where applicable, this testing should be undertaken in addition to the MRTS04 *General Earthworks* testing requirements.

7.4 Conditional use and treatment options

7.4.1 General

The intent of this section is to provide a management process for situations where Slaking and/or Dispersive soils are encountered unexpectedly during construction. These soils may be acceptable for use in construction subject to additional conditions and requirements.

The conditional use of Slaking and Dispersive Soils, as Earth Fill or in Cut Surfaces, is outlined in Table 7.4.1 below.

Table 7.4.1 - Conditional use of Slaking and Dispersive Soils

Passing 0.075 mm sieve (%) AS 1289.3.6.1	Emerson Class (modified) (Q168)	Electrical Conductivity (µS/cm) 3A1[1]	Soluble Chloride (mg/kg) 5A[1]	Conditions for use (Earth Fill and Cut Surfaces)
≥15	2, 3 or 5	< 1200	< 900	Earth Fill: • Outer zone with amelioration treatment. Cut Surfaces: • with amelioration treatment. Drainage structures – seek direction from designer.
	2, 3 or 5	> 1200	> 900	Earth Fill: • Material shall only be used within the core zone in embankment construction and above the 1% AEP design flood level. Cut Surfaces and drainage structures - Seek direction from the designer.

Note 1. - Raymont and Lyons.

Note 2 – Materials with an Emerson Class Number of 1 are unsuitable for use in earthworks. They should not be considered for use, unless it can be demonstrated that they can be treated or managed effectively to ensure they meet the Transport and Main Roads minimum design requirements.

7.4.1.1 Management options for Earth Fill material with slaking and dispersive properties

Where on-site Earth Fill materials are found to have slaking or dispersive properties, from MRTS04 *General Earthworks* source or construction testing, the Contractor may elect to either:

a) manage the material as a Waste in accordance with MRTS51 *Environmental Management* and Engineering Policy EP175 *Deposition of Surplus Material – Assessment Methodology*.

b) ameliorate the soil prior to use, or

c) use the soil within the core zone of an embankment, where zoned embankment construction is permitted by the design.

7.4.1.2 Management options for subsoils in Cut Surfaces with slaking and dispersive properties (including open drains)

Where Cut Surfaces are found to have slaking and dispersive properties, from MRTS04 *General Earthworks* source or construction testing, the Contractor may elect to either:

a) ameliorate the top 150 mm of the Cut Surface material, or

b) propose an alternative protective treatment or management option.

7.4.2 Types of ameliorants

It is recommended that a suitably qualified soil scientist be engaged to advise on soil amelioration options and the most appropriate amelioration agent for use.

Some commonly used ameliorants for the treatment of Dispersive Soils include agricultural lime and agricultural gypsum. Clause 7 of MRTS16 *Landscape and Revegetation Works* details the minimum requirements for the supply of soil ameliorant agents for departmental projects.

7.4.3 Application of ameliorants

Where amelioration of Dispersive Soils is to be undertaken, the amount of amelioration agent to be applied should be determined based on:

a) the area or volume of material required to be ameliorated, and

b) nominal rates of application as per advice from a suitably qualified soil scientist.

Table 7.4.3 below provides some suggested minimum rates of application for agricultural lime and gypsum. These rates should be used as a guide only for the development of a Soil Amelioration Plan. Further advice should be sought from a suitably qualified soil scientist.

Table 7.4.3 – Suggested minimum rates for application of ameliorants to Dispersive Soils (Earth Fill and Cut Surfaces)

Emerson Class (Modified)		Classes 2, 3 and 5			
Electrical Conductivity (µS/cm)		< 1200			
Soluble Chloride (mg/kg)		< 900			
pH		< 5.5			≥ 5.5
Ameliorant		Blend of Agricultural Lime and Agricultural Gypsum			Agricultural Gypsum
		Lime	Gypsum	Lime / Gypsum Blend (Maximum rate)	
Earth Fill Application Rates	Bulk stockpile (kg/m³)	5 - 10	5 - 10	15	10 - 15
	150 mm layer (kg/m²)	0.75 - 1.5	0.75 - 1.5	2.5	1.5 – 2.25
	200 mm layer (kg/m²)	1.0 - 2.0	1.0 - 2.0	3.0	2.0 – 3.0
	250 mm layer (kg/m²)	1.25 - 2.5	1.25 - 2.5	3.75	2.5 – 3.75
	300 mm layer (kg/m²)	1.5 - 3.0	1.5 - 3.0	4.5	3.0 – 4.5
Cut Surface Application Rate	150 mm depth (kg/m²)	0.75 - 1.5	0.75 - 1.5	2.25	1.5 – 2.25

7.4.4 Amelioration of Earth Fill materials

For Earth Fill used in embankment construction, if treatment by amelioration is required, it should be applied to the following sections:

- the Outer Zone (2.5 m), and
- the outer 2.5 m of the Upper Zone, and
- verge material.

7.4.4.1 Amelioration in stockpiles

Where Earth Fill materials are to be ameliorated within stockpiles, prior to incorporation into the Works, the amelioration agent should be added and thoroughly mixed into the stockpiled material using as an excavator or front-end loader (or other equipment as nominated in the Contractor's Construction Procedure). A nominal moisture content for curing should be targeted for within the stockpile to facilitate the soil-ameliorant reaction.

7.4.4.2 Amelioration in layers

Earth Fill materials can also be ameliorated at the time of their placement and prior to compaction. For this application, the ameliorant should be uniformly applied over the required area of treatment after each layer is initially placed. An agricultural tractor spreader (or other equipment nominated in the Contractor's Construction Procedure), may be used to apply the ameliorant.

The installation of the ameliorant must be a controlled process, with spread rates verified and supply quantities recorded. This is due to the amelioration process being slow acting and therefore verification testing post amelioration is not practical.

The nominated amelioration rate should be verified using Test Method Q719 prior to the commencement of the spreading of the ameliorant.

Once the ameliorant has been spread, it should be mixed into the Earth Fill material either by a grader, disc plough or a rotary hoe (or other equipment nominated in the Contractor's Construction Procedure) to the full depth of the layer.

After mixing, the ameliorated layer should be compacted to the requirements of MRTS04 *General Earthworks* Table 15.3(b). Water must be added to the material for the wetting of the ameliorated material and to comply with the requirements of MRTS04 *General Earthworks* Table 15.3(c) or Table 15.3(d).

It is important for the Contractor to monitor the addition of water during construction to ensure the ameliorated materials are placed at a moisture condition closer to the upper limit of the ranges specified in MRTS04 *General Earthworks* Table 15.3(c) and Table 15.3(d). This will ensure there is adequate moisture to enable the chemical alteration of the soil.

7.4.5 Amelioration of Cut Surfaces

Where amelioration is required for Cut Surfaces, the amelioration agent should be uniformly spread over the Cut Surface. For batter slopes less than or equal to 1V: 4H, an agricultural tractor spreader may be used for the spreading of ameliorant or other equipment as nominated in the Contractor's Construction Procedure.

The nominated amelioration rate (refer to Clause 7.3.3) should be verified using Test Method Q719.

Once the ameliorant has been spread over the Cut Surface, it should be mixed into the insitu material using a rotary hoe (or other equipment nominated in the Contractors Construction Procedure) to a minimum depth of 150 mm.

After mixing of the ameliorant the batter should be finished in accordance with MRTS04 *General Earthworks* Clause 16. Nominal compaction should be applied to the Cut Surface (for example, using a 'pinwheel').

In general, amelioration of Cut Surfaces where the slope geometry is less than or equal to 1V:4H should be achievable as outlined above. However, for all slopes steeper than 1V:4H, a risk

assessment should be undertaken by the Contractor to identify any safety or operational issues before proceeding with this method of amelioration.

Where amelioration by this method is unsafe or not practical, advice should be sought on alternative treatment methods from an experienced geotechnical engineer or a suitably qualified soil scientist.

8 Maintenance and rehabilitation

Due to the widespread occurrence of Slaking and Dispersive Soils within Queensland, significant lengths of the state road network have, to date, been constructed within regions where these soils exist.

Unfortunately, suitable management and treatment options have not always been prescribed during design or applied during construction. Consequently, there are areas of the network where these soils are continuing to erode and are causing serviceability and safety issues to infrastructure. The erosion of these soils also creates sediment discharge problems for waterways and the general environment.

When programmed road maintenance activities are undertaken and Slaking and Dispersive Soil issues are identified, options for remediation treatments should be considered in accordance with this technical note, or by seeking advice from a suitably qualified soil scientist.

8.1 Identification as part of maintenance

8.1.1 Visual observations

Field observations during maintenance inspections can identify possible areas of high risk to erosion. Tunnelling and piping, rilling of batters and headward gully erosion in drainage lines can all be indicative signs of Slaking and Dispersive Soils. Some examples of erosion of Slaking and Dispersive Soils are shown in Figure 8.1.1 below.

Figure 8.1.1 - Examples of damage to road infrastructure due to erosion of Slaking and Dispersive Soils

Example of tunnelling erosion in road shoulder

Example of void around guard rail post foundation

Example of gully erosion in a drainage channel

Example of rilling of cut batter

Source: Transport and Main Roads

8.1.2 Field sampling and laboratory testing of soil

Where visual observations appear to indicate the presence of Slaking and Dispersive Soils, field sampling and laboratory testing of representative soil materials should be undertaken to verify that the soils are dispersive and to determine whether amelioration is practicable. Sampling and testing should be carried out in accordance with the guidelines in Table 5.2.1(a) and 5.2.1(b), or as otherwise advised by a suitably qualified soil scientist or geotechnical engineer.

The information provided in Table 7.4.3 above, presents the characteristics of soil that can be improved through the application of agricultural lime or gypsum. It also includes guidance on the recommended application rates of ameliorant required to promote soil stability. However, it is crucial to highlight that the analysis of laboratory test results and the choice of suitable treatment options should be undertaken by a suitably qualified soil scientist.

8.2 Maintenance practices

Where Slaking and Dispersive Soils are identified within the existing road network, maintenance practices can be modified to improve outcomes and reduce the risk of disturbing these soils further, as per below. However, as a general approach, it is recommended that advice on treatment options be sought from a suitably qualified soil scientist.

- **RMPC Activity 215 – 219 Shoulder grading activities**
  - Spread and incorporate ameliorant into shoulder materials to aid in stabilising the material.
  - Supply and installation of ameliorants in accordance with Clause 7.4 above.
- **RMPC Activity 301 install earth surface drains**
  - Build catch banks above cuttings rather than surface drains.
  - Spread and incorporate ameliorant into the Cut Surfaces of drains to assist with stabilising soils (Clause 7.4).

- **RMPC Activity 302 repair earth surface drains**
  - Reform surface drains with flat bottom and incorporate regular turnouts if practicable.
  - Spread and incorporate ameliorant into the surface of the drains to assist with stabilising soils (Clause 7.3).
- **RMPC Activity 305 clean earth and concrete surface drains**
  - Minimise deep grading of table drains.
  - Spread and incorporate ameliorant into the surface of the drains to assist with stabilising soils (Clause 7.4).
- **RMPC Activity 407 herbicide spraying**
  - Limit broad application of herbicides along the road verge to mitigate against exposure of Slaking and Dispersive Soils. Use spot spraying application of herbicide instead.

9 References

Rice Z., O'Connor G., & Dutton L. (2022), *Slaking and Dispersive Soils Management*, NACoE Report

Materials Testing Manual, Transport and Main Roads

Road Drainage Manual, Transport and Main Roads

Technical Specification MRTS04 *General Earthworks,* Transport and Main Roads

Technical Specification MRTS16 *Landscape and Revegetation Works,* Transport and Main Roads