Technical Specification

Transport and Main Roads Specifications
MRTS06 Reinforced Soil Walls

March 2023

Queensland Government

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1 Introduction

This Technical Specification applies to the design and construction of reinforced soil walls (RSW) in roadworks. It does not apply to reinforced slopes or foundations, soil nail walls and reinforced embankments. Please refer to the department's *Design Criteria for Bridges and Other Structures* for other limitations of its application in departmental projects.

The construction of reinforced soil walls shall use suppliers and products approved by the Transport for New South Wales (TfNSW) as per the Annexure to TfNSW QA Specification R57 *Design of Reinforced Soil Walls*. Use of products shall comply with the conditions on the use of proprietary systems given in the Annexure.

For information regarding registered suppliers and approved products, refer to the departmental website www.tmr.qld.gov.au.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

2 Definition of terms

The terms used in this Technical Specification shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Specifications*. Additional terms used in this Technical Specification shall be as defined in Table 2.

Table 2 – Definition of terms

Term	Definition
Acid Igneous Rock	As defined in AS 1726. Including Rhyolite, Rhyodacite, Dacite, Tuffs (of same composition), Granite, Adamellite and Granodiorite.
Basic Igneous Rock	As defined in AS 1726. Including Basalt, Dolerite and Gabbro.
Capping	The element over the top course of facing elements to complete an RSW to specified finish levels.
Geosynthetic Reinforcement	Soil reinforcement made of polymeric materials used in RSWs, for example, linear straps and geogrids.
Metallic Reinforcements	Soil reinforcement made of metals (predominantly galvanised steel) used in RSWs having a certain resistance to corrosion when buried, for example, sheets, grids, meshes, strips, rods and so on.
Geotechnical Engineer	Engineer with qualifications and experience in geotechnical engineering. The minimum engineering qualification required is Registered Professional Engineers of Queensland (RPEQ).
HDPE	High Density Poly-Ethylene
Intermediate Igneous Rock	As defined in AS 1726. Including Trachyte, Trachyandesite, Andesite, Tuffs (of same composition), Syenite and Diorite.
Metamorphic Rock	As defined in AS 1726. Including Hornsfels, Quartzite, Metagreywacke, Greenstone, Slate and Amphibolite.
NATA	National Association of Testing Authorities
Reinforced Soil Walls	Any earth retaining structure which relies on the interaction between embedded tension members and the earth itself for its structural integrity.

Term	Definition
RSW	Reinforced Soil Wall
Sedimentary and Duricrust Rocks	As defined in AS 1726. Including Limestone, Dolomite, Mudstone, Arenite, Chert and Silcrete.
Soil Reinforcement	Metallic or polymeric components embedded in the reinforced fill material, which ensures the stability and structural adequacy of the RSW.
TfNSW	Transport for New South Wales
TfNSW R57	TfNSW QA Specification R57 *Design of Reinforced Soil Walls*

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
–	*Geotechnical Design Standard – Minimum Requirements*
–	*Design Criteria for Bridges and Other Structures*
–	*Geotechnical Design Standard – Minimum Requirements*
AS 1111	*Iso metric hexagon bolts and screws*
AS 1112	*Iso metric hexagon nuts*
AS 1141.22	*Methods for sampling and testing aggregates, Method 22: Wet / dry strength variation*
AS 1214	*Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)*
AS 1237.1	*Plain washers for metric bolts, screws and nuts for general purposes, Part 1: General Plan*
AS 1289.1.4.2	*Methods of testing soils for engineering purposes, Method 1.4.2: Sampling and preparation of soils – Selection of sampling or test sites – Stratified random number method*
AS 1289.3.6.1	*Methods of testing soils for engineering purposes, Method 3.6.1: Soil classification tests – Determination of the particle size distribution of a soil – Standard method of analysis by sieving*
AS 1289.4.3.1	*Methods of testing soils for engineering purposes, Method 4.3.1: Soil chemical tests – Determination of the pH value of a soil – Electrometric method*
AS 1289.5.1.1	*Methods of testing soils for engineering purposes, Method 5.1.1: Soil compaction and density tests – Determination of the dry density / moisture content relation of a soil using standard compactive effort*
AS 1289.5.4.1	*Methods of testing soils for engineering purposes, Method 5.4.1: Soil compaction and density tests – Compaction control test – Dry density ratio, moisture variation and moisture ratio*
AS 1289.5.5.1	*Methods of testing soils for engineering purposes, Method 5.5.1: Soil compaction and density tests – Determination of the minimum and maximum dry density of a cohesionless material – Standard method*
AS 1289.5.6.1	*Methods of testing soils for engineering purposes, Method 5.6.1: Soil compaction and density tests – Compaction control test – Density index method for a cohesionless material*

Reference	Title
AS 1289.5.7.1	*Methods of testing soils for engineering purposes, Method 5.7.1: Soil compaction and density tests – Compaction control test – Hilf density ratio and Hilf moisture variation (rapid method)*
AS 1289.6.2.1	*Methods of testing soils for engineering purposes, Method 6.2.1: Soil strength and consolidation tests – Determination of the shear strength of a soil – Field test using a vane*
AS 1289.6.2.2	*Methods of testing soils for engineering purposes, Method 6.2.2: Soil strength and consolidation tests – Determination of shear strength of a soil – Direct shear test using a shear box*
AS 1289.6.4.1	*Methods of testing soils for engineering purposes, Method 6.4.1: Soil strength and consolidation tests – Determination of compressive strength of a soil – Compressive strength of a specimen tested in undrained triaxial compression without measurement of pore water pressure*
AS 1289.6.4.2	*Methods of testing soils for engineering purposes, Method 6.4.2: Soil strength and consolidation tests – Determination of compressive strength of a soil – Compressive strength of a saturated specimen tested in undrained triaxial compression with measurement of pore water pressure*
AS 1289.6.5.1	*Methods of testing soils for engineering purposes, Method 6.5.1: Soil strength and consolidation tests – Determination of the static cone penetration resistance of a soil – Field test using a mechanical and electrical cone or friction-cone penetrometer*
AS 1289.6.6.1	*Methods of testing soils for engineering purposes, Method 6.6.1: Soil strength and consolidation tests – Determination of the one-dimensional consolidation properties of a soil – Standard method*
AS 1289.6.7.1	*Methods of testing soils for engineering purposes, Method 6.7.1: Soil strength and consolidation tests – Determination of permeability of a soil – Constant head method for a remoulded specimen*
AS 1726	*Geotechnical site investigations*
AS 3610	*Formwork for Concrete*
AS 3700	*Masonry Structures*
AS 5100	*Bridge Design*
AS/NZS 3678	*Structural steel – Hot-rolled plates, floorplates and slabs*
AS/NZS 3679	*Structural steel*
AS/NZS 4455	*Masonry units, pavers, flags and segmental retaining wall units*
AS/NZS 4671	*Steel for the reinforcement of concrete*
AS/NZS 4680	*Hot-dip galvanized (zinc) coatings on fabricated ferrous articles*
BS 6906	Methods of test for geotextiles
MRTS01	*Introduction to Technical Specifications*
MRTS03	*Drainage Structures, Retaining Structures and Embankment Slope Protections*
MRTS04	*General Earthworks*
MRTS27	*Geotextiles (Separation and Filtration)*
MRTS50	*Specific Quality System Requirements*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*

Reference	Title
MRTS72	*Manufacture of Precast Concrete Elements*
MRTS78	*Fabrication of Structural Steelwork*
TfNSW	*R57 Design of Reinforced Soil Walls*

4 Standard test methods

The standard test methods specified in Table 4 are referenced in this Technical Specification.

The test methods for soil reinforcement and facing units are specified in Clauses 7.4 and 7.5 respectively.

Testing of all Works shall be undertaken in accordance with Clause 4 of MRTS01 *Introduction to Technical Specifications*.

Table 4 – Standard test methods

Property to be Tested	Method No.
Angle of internal friction	AS 1289.6.4.2, AS 1289.6.2.2
Calculation of characteristic value of a lot	Q020
Chloride content	Q130B or other published or validated classical chemistry technique or instrumentation technique[1]
Coefficient of uniformity (Cu)	Q253
Compaction (density index)	AS 1289.5.6.1
Compaction (dry density ratio of Hilf density ratio) and Moisture (moisture ratio or moisture variation)	AS 1289.5.4.1 or AS 1289.5.7.1
Degradation Factor	Q208B
Effective angle of friction at constant volume conditions	Q181C
Effective cohesion	AS 1289.6.4.2, AS 1289.6.2.2
Electrical Resistivity	Q122B
Minimum density / maximum density	AS 1289.5.5.1
Moisture Density Relationship (MDR)	AS 1289.5.1.1
One-dimensional consolidation properties	AS 1289.6.6.1
Particle size distribution	AS 1289.3.6.1
Permeability	AS 1289.6.7.1
pH	AS 1289.4.3.1
Sampling of soils, crushed rock and aggregates	Q060
Selection of sampling and testing location	Q050, AS 1289.1.4.2
Spot sampling of soils, crushed rock and aggregate	Q061
Sulphate content	Q131B or other published or validated classical chemistry technique or instrumentation technique[1]

Property to be Tested	Method No.
Undrained shear strength	AS 1289.6.2.1, AS 1289.6.4.1, AS 1289.6.5.1
Wet Strength	AS 1141.22
Wet / Dry Strength Variation	AS 1141.22

Note 1: Instrumentation techniques may include Ion Chromatography / Inductively Coupled Plasma / Discrete Analyser and so on. National Association of Testing Authorities (NATA)-endorsed test results are evidence of a validated technique.

4.1 Supplementary requirements for Test Method AS 1289.6.7.1

Constant head permeability testing shall be undertaken at 97% of maximum dry density and 100% of the optimum moisture content as determined using Test Method AS 1289.5.1.1, using standard compaction. For cohesionless materials, the permeability testing shall be undertaken at a density index of 90% as determined using Test Method AS 1289.5.5.1.

4.2 Supplementary requirements for Test Method AS 1141.22

The Wet Strength and the Wet / Dry Strength Variation tests shall both be carried out on the fraction of the coarse component passing the 13.2 mm test sieve but retained on the 9.5 mm test sieve.

The Wet Strength and the Wet / Dry Strength Variation tests must not be undertaken on other fractions.

5 Quality system requirements

5.1 Hold Points and Witness Points

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points, Witness Points and Milestones applicable to this Technical Specification are summarised in Table 5.1.

Table 5.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
7.5.4	1. Sample facing unit		Supply of samples (14 days)
8.5	2. Design of RSW		Submission of design and Drawings (28 days)
9.3	3. Acceptance of foundation	1. Inspection of foundation	
9.6.1	4. Suitability of construction method		Submission of details of erection method (seven days)
9.6.2	5. Construction of second course of facing units		
9.6.3		2. Recording of condition of soil reinforcement and facing connections	
10.1	6. Suitability of the materials		

Clause	Hold Point	Witness Point	Milestone
10.1	7. Audit testing		

5.2 Construction procedures

The Contractor shall prepare written procedures for construction processes, in accordance with Clause 6 of MRTS50 *Specific Quality System Requirements*.

The Contractor shall submit to the Administrator any construction procedures requested by the Administrator during the execution of the Contract.

6 Site investigation

The Contractor shall assess all available site information and carry out any further site investigation as necessary to determine the topography and properties of all relevant soil strata influencing the design of the RSW.

Site investigation shall be generally in accordance with AS 1726 and Transport and Main Roads' *Geotechnical Design Standard – Minimum Requirements*. The assessment of the site investigation data shall be carried out by a Geotechnical Engineer in conjunction with the designer / supplier of the RSW.

The extent and requirements of the site investigation shall address the particular site conditions, as well as the type and complexity of the project.

The site investigation shall take at least the following issues into consideration:

a) surrounding ground as well as that underneath the structure

b) groundwater

c) aggressiveness of soil and groundwater, including assessment of potential acid sulphate conditions likely to be associated with excavations

d) shear strength and compressibility characteristics of the subsurface strata likely to influence the behaviour of the structure, and

e) electrochemical properties of reinforced fill such as pH, electrical resistivity, sulphate content and chloride content and other relevant properties where applicable.

The shear strength parameters of the foundation soil under effective stress conditions shall be determined in accordance with one or more of the Test Methods AS 1289.6.4.2 and AS 1289.6.2.2.

The undrained soil shear strength of foundation soil where relevant, shall be determined by insitu and/or laboratory tests which shall include at least one or more of the Test Methods AS 1289.6.2.1 and AS 1289.6.4.1 and AS 1289.6.5.1.

The compressibility characteristics of the foundation soil shall be determined in accordance with Test Method AS 1289.6.6.1.

The above Test Methods do not apply where the foundation material is rock.

7 Materials

7.1 General

Materials and components to be used in the Works shall meet the design requirements determined by the RSW system owner in addition to those specified in the Drawings and this Technical Specification.

7.2 Reinforced fill material

The material forming the reinforced fill mass shall comply with the following:

a) Reinforced fill material shall be frictional fill material. It shall consist of naturally occurring or processed material which, at the time of excavation or importation, or after selection, processing, mixing and adjustment of the moisture content, is capable of being compacted in accordance with the specified requirements to form a stable mass of fill.

b) Reinforced fill material shall be free from organic materials, plastic, metal, rubber or other synthetic material, inorganic contaminants, dangerous or toxic material, or material susceptible to combustion.

c) It shall be inert, hard, durable, granular material that does not cause unacceptable deterioration of the RSW components. Material such as shales and claystones, or other friable materials which are susceptible to breakdown, shall not be used as reinforced fill material. The reinforced fill material shall meet, as a minimum, the rock strength (Wet Strength) and durability (wet Wet / Dry Strength Variation, Degradation Factor) requirements for Type 2.4 roadbase coarse component. These requirements are listed in Table 7.2(a).

d) The particle size distribution and friction requirements for reinforced fill materials are given in Table 7.2(b).

e) The reinforced fill material shall meet the electrochemical requirements specified in Table 7.2(c).

f) The additional permeability and particle size requirements for free draining reinforced fill material are given in Table 7.2(d).

Table 7.2(a) – Strength and durability requirements for reinforced fill material

Rock Material Group Note 1	Wet Strength (KN) Minimum	Wet / Dry Strength Variation (%) Maximum	Degradation Factor Minimum
Acid Igneous	70	45	30
Intermediate Igneous	80	40	35
Basic Igneous	85	35	40
Metamorphic	80	40	35
Sedimentary / Duricrust	70	45	–

Note 1: Naturally occurring gravels are to be classified into a materials group on the basis of the lithology of the major granular component.

Table 7.2(b) – Particle size distribution requirements for reinforced fill material

Test Sieve Size (mm)	**Percent passing by mass**	
Reinforcement type	*Steel*	*Geosynthetic*
150	100	
75.0		100
9.50	25 – 100	25 – 100
0.600	10 – 100	10 – 100
0.150	Report	Report
0.075	0 – 10	0 – 10
Property		
Coefficient of uniformity (Cu)	5 minimum	5 minimum
Effective angle of friction at constant volume	Report	Report

Notes:

For free draining reinforced fill materials, there is an additional requirement for the percent passing the 0.150 mm test sieve to be not greater (finer) than the results from source as specified in Table 7.2(d).

Prior to placement and compaction, for all soil reinforcement, the maximum size prior to placement and compaction shall not be greater than one third of lift thickness. Maximum lift thickness shall be as per MRTS04 *General Earthworks*.

Table 7.2(c) – Electrochemical properties of reinforced fill materials

Reinforcing Element	**Location †**	**Properties of reinforced fill material**				
		pH		**Maximum Chloride Content (%)**	**Maximum Soluble Sulphate Ion Content (%)**	**Minimum Resistivity (Saturated) (ohm m)**
		Minimum	**Maximum**			
Steel	Dry Land	5	10	0.02	0.10	10
Steel	Submerged	5	10	0.01	0.05	30
Polyester	N/A	4	9	–	–	–
HDPE	N/A	3	12	–	–	–

† Submerged values shall be used where the structure is permanently or regularly submerged. Dry land values shall be used otherwise. Submergence does not include marine environments, which shall be the subject for special study.

Table 7.2(d) – Additional requirement for free draining reinforced fill materials

Property	Properties of free draining reinforced fill material	
Reinforcement type	Steel	Geosynthetic
Permeability (constant head)	> 10^{-5} m/s	> 10^{-5} m/s
Effective angle of friction at constant volume	Report	Report
Test Sieve Size (mm)	**Percent passing by mass**	
0.150	Not greater than initial testing (finer)	Not greater than initial testing (finer)

7.3 Earthworks outside the reinforced fill block

The fill materials comprising the earthworks outside the reinforced fill block, shall comply with MRTS04 *General Earthworks* and the relevant Drawings.

7.4 Soil reinforcement

7.4.1 General

Reinforcement materials shall be selected on the basis of strength, stiffness, bond with the soil, handling and construction behaviour and durability properties to ensure that the ultimate and serviceability limit states of the structure are satisfied.

Soil reinforcement shall comprise one of the materials described in Clauses 7.4.2 and 7.4.3.

7.4.2 Steel reinforcement

Steel reinforcement shall be carbon steel to AS/NZS 3678 or AS/NZS 3679 supplied in accordance with Clause 7.1 of MRTS78 *Fabrication of Structural Steelwork* or reinforcing mesh to AS/NZS 4671 supplied in accordance with MRTS71 *Reinforcing Steel*. Steel reinforcement shall be hot-dipped galvanised in accordance with AS/NZS 4680, with a minimum average zinc coating mass of 600 g/m².

Table 7.4.2 – Sacrificial steel thickness for hot-dipped galvanised steel surfaces

Structure Location	Minimum Sacrificial Thickness (mm)
Land Based (Out of Water)	0.75
Fresh Water Immersion	1.0
Site of special aggressiveness	To be assessed by specific study

7.4.3 Geosynthetic reinforcement

The short-term tensile strength of geosynthetic reinforcement, shall be determined in accordance with the test procedure defined in BS6906 *Methods of test for geotextiles*, Part 1. Creep-testing shall conform to the procedure defined in BS6906: Part 5. The minimum creep-test duration for geosynthetic reinforcement shall be 10,000 hours. To ensure continuity of quality is being maintained, short term creep-tests of minimum duration 1000 hours shall be carried out and shown to be compatible with the long-term results.

Geosynthetic reinforcement shall be demonstrated by testing as sufficiently strong, stable and durable to satisfy the performance and design requirements of this Technical Specification.

Testing shall be carried out, where appropriate, to assess the influence of the following job-specific environmental factors on the durability and performance of the geosynthetic reinforcement, for the design life of the structure:

a) loading

b) water and installation induced damage

c) UV exposure

d) operational temperature

e) chemical / bacterial composition of reinforced fill material, and

f) aggressive fluids.

Any interaction of the above conditions shall be considered in the design. Characteristic values of material parameters for geosynthetic reinforcement used for design shall allow for:

a) any creep-deformation and creep-rupture over the design life of the RSW at the design temperatures

b) loss of strength due to environmental degradation (for example, biological, hydrolysis and chemical attack)

c) variations in manufacturing process

d) extrapolation uncertainties where test duration is less than the design life, and

e) installation damage (including weathering during storage and/or mechanical damage during installation).

7.5 Facing units

7.5.1 General

Facing units shall be discrete concrete panels, or concrete block, or masonry units.

Concrete Panels

Concrete panels shall be manufactured from reinforced concrete in accordance with MRTS72 *Manufacture of Precast Concrete Elements* with a minimum concrete grade of 40 MPa.

The minimum reinforcement to be placed in each direction in the panel shall be as defined by Equation 8.1.4.1(2) of AS 5100.5.

The minimum exposure classification shall be B2 in accordance with AS 5100. Cover to cast-in connections from the front face of the panel, shall comply with these requirements.

The surface finish of all faces exposed to view, shall be as defined in the Drawings or, if not defined, shall be Class 2 in accordance with AS 3610.

All reinforcement shall comply with MRTS71 *Reinforcing Steel*.

Panels shall not be lifted by connection points used to connect soil reinforcement to the facing panel unless connection points are certified and tested for this purpose.

7.5.2 Concrete block and masonry units

Concrete blocks and masonry units shall comply with AS/NZS 4455 and AS 3700. Testing of specimens cut from facing elements for compressive strength is permissible.

7.5.3 Connections

Connections between the reinforcement embedded in the reinforced fill block and the facing units, shall take the form of dowels, rods, screws, nuts and bolts which may consist of stainless steel, coated steel, or geosynthetic.

Materials for connections between facing units, between facing units and reinforcing elements, and between reinforcing elements, shall be electrolytically compatible such that corrosion shall not be promoted through the use of dissimilar metals.

Components shall be provided with corrosion protection adequate for the insitu conditions and the design life.

Acceptable corrosion protection includes hot-dipped galvanising in accordance with AS/NZS 4680 for steel and all steel facing connections.

7.5.4 Sample facing unit

The Contractor shall make available to the Administrator a sample containing a minimum of one full facing unit and reinforcing anchor 14 days prior to production of facing units. **Milestone**

As an alternative, facing units of the same design installed at a nearby project, may be accepted by the Administrator as the sample facing unit.

Production of facing units shall not begin prior to acceptance of the sample by the Administrator. **Hold Point 1**

The sample shall be preserved as a quality benchmark until completion of construction, if it complies with this Technical Specification.

7.6 Joint fillers and sealants

Joint fillers shall be composed of durable, inert material resistant to atmospheric attack.

Horizontal joint fillers shall be High Density Poly-Ethylene (HDPE) plastic strip or similar material which is capable of maintaining joint thickness within design tolerances.

A strip of geotextile material, at least 300 mm wide, complying with MRTS27 *Geotextiles (Filtration and Separation)*, shall be placed between the back of the facing units and the reinforced fill material equidistant across all joints.

Sealants, where used, shall be polysulphide or polyurethane-based elastomeric compounds, applied strictly in accordance with the manufacturer's recommendations and shall include the application of a primer, where recommended by the manufacturer.

7.7 Component tolerances

7.7.1 General

The tolerances specified in Clauses 7.7.2 and 7.7.3 shall apply to individual components.

7.7.2 Concrete

The tolerances on dimensions of concrete components shall be:

Overall dimension	± 5 mm
Thickness	± 5 mm, and
Location of fasteners	± 5 mm.

7.7.3 Metallic and geosynthetic reinforcement

The tolerances on dimensions of metallic and geosynthetic reinforcement shall be:

Length of reinforcement	+ 50 mm, - 0 mm
Width of reinforcement	+ 5 mm, - 0 mm, and
Thickness of reinforcement	+ 1 mm, - 0 mm.

7.8 Filter and drainage materials

Filter and drainage materials shall conform to the relevant Clauses of MRTS03 *Drainage Structures, Retaining Structures and Embankment Slope Protections*.

7.9 Footings and capping

Footings and capping shall be constructed from concrete which complies with MRTS70 *Concrete*. The minimum concrete grade shall be S32 /20.

Reinforcing steel in footings and cappings shall comply with MRTS71 *Reinforcing Steel*.

7.10 Handling and storage

All prefabricated RSW components shall be transported and stored carefully to minimise mechanical damage and deterioration, including protection of geosynthetic reinforcement elements from UV degradation.

8 Design considerations

8.1 General

Design of reinforced soil walls shall comply with Specification R57 *Design of Reinforced Soil Walls* published by Transport for New South Wales (TfNSW).

The Contractor's Design shall be consistent with the provisions of the Contract in all respects, including the requirements for Contractor's Warranties and the Designer's Deed of Covenant.

8.2 Hydrostatic pressures in reinforced soil walls

All RSWs shall be designed for a default water table height equal to 2/3 the RSW height, to allow for the influence of groundwater conditions during the design life of the structure. For walls entirely in cut situations, the default water table height shall be taken as wall height. Facing height shall be taken as wall height.

The default water table height requirement may be relaxed and zero water pressure on the rear face of the RSW block can be adopted, if one of the following conditions is satisfied:

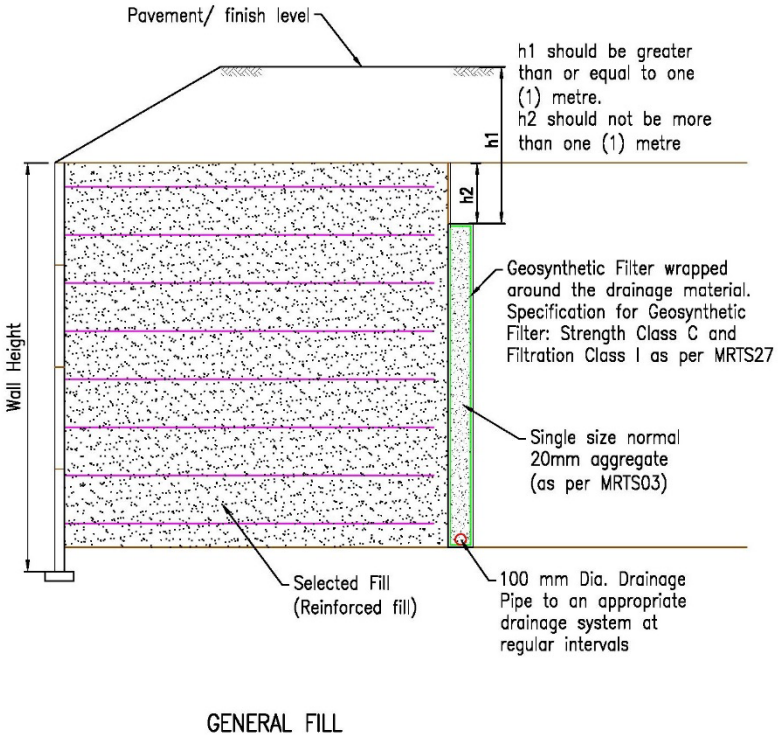
a) provision of a full height continuous granular drainage blanket, as shown in the following Figure 8.2, behind the reinforced fill RSW block (that is, interface between the reinforced fill block and general backfill). Alternatively, for RSWs with height less than 4 m, a prefabricated cellular material as per MRTS03 *Drainage Structures, Retaining Structures and Embankment Slope Protections*, wrapped with a geosynthetic filter fabric with equivalent design drainage and strength properties as per MRTS27 *Geotextiles Separation and Filtration* may be provided, or

b) provision of a free draining reinforced fill material, conforming to requirements of Clause 7.2 and the additional requirements in Clause 7.2 f). Permeability testing on compacted free draining reinforced fill material shall be performed to confirm the permeability. Constant head permeability testing, effective angle of friction at constant volume, particle size distribution, Wet Strength, Wet / Dry Strength Variation and Degradation Factor shall be performed from the same sample lot, preferably by the same laboratory. During construction, additional particle size distribution testing, shall be performed to check the compliance with Clause 7.2 f), while ensuring the percentage passing 0.150 mm test sieve is not greater (finer) than the initial test results.

   The testing frequencies for shear strength and other properties pertaining to the selected fill, shall conform to Appendix A. A geosynthetic filter, the properties of which are given in Figure 8.2, shall be installed between the reinforced fill material and general fill interface.

This does not address extreme events such as inundation, potential draw down due to flooding and so on. These requirements shall conform to TfNSW R57 and shall address a minimum 1% AEP flood event.

Figure 8.2 – Typical details of a drainage blanket behind RSW block



8.3 Global stability analysis

Notwithstanding the provisions of Clause 4.7.4 of TfNSW R57, the following minimum requirements shall apply to the assessment of global stability:

a) Geotechnical Model: Scaled cross-sections of the RSW with idealised sub-soil models depicting the design material properties, pore water pressure conditions and their associated parameters shall be established.

b) Method of Analysis: Morgenstern and Price method of limit equilibrium analysis shall be the primary method of limit equilibrium analysis using Geo-Slope SLOPE / W software.

c) Presentation of Stability Analysis: The Drawings shall include a report on the RSW global stability analysis. The report shall clearly indicate the geotechnical models and design strength parameters and pore water pressure conditions adopted, loading conditions considered, design standards complied with and shall be supported with design calculations where appropriate. The report shall also include cross-sections showing the centres of slip circles investigated and the locus of the most critical circle or non-circle surface for the design life.

8.4 Allowance for pile foundations

Where piles are to pass through the RSW, the following minimum provisions shall apply:

a) the Drawings shall coordinate the reinforcing strip and pile locations, allowing for all construction tolerances for both

b) where there is the possibility of disturbing a facing unit during pile driving, special provisions shall be made (for example, a compressible filler placed adjacent to the earth face of the unit at the pile location), and

c) if piles are to be driven after construction of the RSW, rigid liners shall be installed in the RSW block during construction. Alternatively, pre-boring may be used where it is demonstrated that reinforcement will not be disturbed. Liners and/or pre-boring shall be extended at least 500 mm below the underside of the RSW block.

8.5 Design documents

The Contractor's Design Documents shall include the following:

- Design Calculations (including global stability analysis)
- duly completed Design Checklist in Annexure MRTS06.1
- Contractor's Construction Drawings
- Contractor's Construction Specifications including RSW-construction sequence
- any particular requirements for ground and/or foundation improvement, and
- arrangements for monitoring the performance of the RSW over the nominated period.

The Contractor shall include in the Design Documents for the RSW:

a) A certificate from the Contractor's Designer which confirms that the design:

   i. adequately allows for the site conditions, applied loadings, and relevant material properties for all components of the design, and

   ii. ensures the structural integrity and serviceability of the RSW for the nominated design life.

b) A statement that the specification for materials to be used in the Works complies with the Drawings, and this Technical Specification, including conformance with any minimum and/or maximum property requirements detailed therein. This statement shall be in a form which demonstrates and/or quotes the basis on which it is made, including reference to relevant test certificates for select fill, general fill, soil reinforcement, facing units, facing connections and associated components. All such test certificates shall be not more than 12 months old at the time of commencement of construction of the RSW and shall be made available for examination by the Administrator if required, and

c) A report certified by the Contractor's RPEQ Geotechnical Engineer who carried out the geotechnical design.

The Contractor's Design Documents shall be submitted by the Contractor to the Administrator a minimum of 28 days prior to commencement of construction of the RSW. **Milestone**

Construction of the RSW shall not be started prior to the Contractor receiving notification from the Administrator as to the suitability of the design. **Hold Point 2**

9 Construction

9.1 General

Construction of the RSW shall comply with the Contractor's Construction Drawings and Specifications. Construction of the RSW shall ensure that the design requirements are met.

The method of construction shall make due allowance for any existing and/or proposed services and structures.

9.2 Preparation of foundation

Site preparation, excavation (including removal of any Unsuitable Material) and placing of fill material shall be carried out in accordance with MRTS04 *General Earthworks* and any requirements for foundation improvement specified in the design.

9.3 Certification of foundation

On completion of the preparation of the foundation, the Contractor shall arrange for its RPEQ Geotechnical Engineer to inspect the foundation. The Contractor shall give the Administrator three days' notice of such inspection. **Witness Point 1**

A report from the Contractor's Geotechnical Engineer confirming that the profile of ground water and the strength and stiffness characteristics of foundation soil comply with the design assumptions shall be forwarded to the Administrator.

The concrete base / strip footings shall not be constructed prior to the Contractor receiving notification from the Administrator as to the suitability of the foundation. **Hold Point 3**

9.4 Concrete base / strip footings

The concrete base / strip footings required to support the bottom course of facing units shall be cast accurately to line and level in accordance with the Drawings. Concrete shall comply with MRTS70 *Concrete* and reinforcement shall comply with MRTS71 *Reinforcing Steel*.

9.5 Compaction standard

The minimum characteristic value requirements for compaction of reinforced fill materials, must comply with the requirements specified in Table 9.5. For moisture content requirement, refer Clause 9.6.3(e) following.

Table 9.5 – Compaction requirements

Material	Property	Minimum value
Reinforced fill material, free draining reinforced fill material – all reinforcement system	Dry density ratio	97%
	Hilf density ratio	97%
	Density index	90%

9.6 Erection of facing units and placement of soil reinforcement and reinforced fill material

9.6.1 General

One week prior to the commencement of facing panel erection or placement of reinforced fill material, the Contractor shall submit to the Administrator details of the method of erection of facing units, method of installation of the soil reinforcement and compaction of the reinforced fill material, including details of plant. **Milestone**

Erection of facing units, placement of soil reinforcement and reinforced fill material shall not commence prior to the Contractor receiving notification from the Administrator as to the suitability of the construction method. **Hold Point 4**

9.6.2 Facing units

Facing units shall be erected in accordance with the Drawings. Adequate support of the facing units shall be provided at each stage of erection. The supporting course of facing units shall be shored to prevent movement during the placement and compaction of reinforced fill material. Joint fillers and geotextile strip shall be installed progressively as erection of facing units proceeds, to ensure that there is no loss of fine material from the in-place reinforced fill material.

The degree of inclination of the facing elements towards the reinforced fill material shall be adjusted where necessary, as placement and compaction of reinforced fill material proceeds, to ensure that the specified tolerances are not exceeded.

Following construction of each course of facing units, sufficient measurements shall be taken to verify that all positions, levels and dimensions of the facing units are in accordance with the Drawings.

On completion of the first course of facing units, an inspection shall be carried out before construction of the second course of facing units. **Hold Point 5**

9.6.3 Placement of soil reinforcement and compaction of reinforced fill material

Unless specifically stated otherwise in the Drawings, the provisions of this Clause shall represent the minimum requirements for placement of RSW reinforced fill material.

The construction of the RSW fill shall be carried out in accordance with the requirements specified in MRTS04 *General Earthworks* and the following additional requirements:

a) The placement and compaction shall be carried out in a direction parallel to the face of the structure and shall be completed in stages to follow closely the erection of facing units and placement of reinforcing elements.

b) Reinforcing elements and facing units shall not be damaged or displaced during placement and compaction of fill. Tracked machines or vehicles shall not be operated directly on top of reinforcing elements which are not covered by at least 150 mm of reinforced fill material. No plant shall be operated in a manner that would cause the displacement of soil reinforcement from the intended positions.

c) All vehicles and all construction equipment weighing more than 1500 kg shall be kept at least two metres away from the facing units. Reinforced fill material within two metres of the facing units, shall be compacted using one or more of the following methods:

   i. a vibro-tamper

   ii. a vibrating plate compactor roller with mass not exceeding 1000 kg, or

   iii. a vibrating roller with a mass per metre of width of not more than 1300 kg and a total mass of not more than 1500 kg.

d) Where a compactor cannot reach the material behind the facing unit (for example, inclined faces), alternative means such as stabilisation shall be used to ensure the units are adequately supported.

e) Reinforced fill material shall be placed and compacted with a moisture content not greater than the optimum moisture content. After compaction, the characteristic value of compaction shall not be less than 97%. The maximum lift thickness shall be as per MRTS04 *General Earthworks*.

f) Soil reinforcement shall be laid horizontally on the compacted reinforced fill material at the location and levels specified in the Drawings. It shall be connected securely to facing elements in accordance with the Drawings. Geosynthetic reinforcement shall be pulled taut, before placing the overlaying reinforced fill material. The method of reinforced fill material placement and compaction shall ensure that slack is not introduced into the soil reinforcement, as reinforced fill material is placed. The condition of the soil reinforcement and facing connections at each level shall be recorded just before covering. **Witness Point 2**

g) Where overlapping of soil reinforcement is required, for example, for curved walls, a minimum thickness of 75 mm of compacted reinforced fill material shall be provided between the overlapping soil reinforcement.

h) The fixing of the soil reinforcement and placement of reinforced fill material shall be carried out in one plane at a time.

i) During construction, the reinforced fill material behind the RSW block shall be maintained at the same level as the RSW block. Where the material is an existing earthwork or material slope which requires temporary support by shoring, the shoring shall be removed in such a manner that the stability of the adjacent ground is maintained, the compacted reinforced fill material is not disturbed and the formation of voids is prevented, and

j) At the end of each day's operations, the top layer of reinforced fill material shall be shaped to permit drainage away from the face and the remainder of the RSW.

9.7 Filter and drainage materials

Filter and drainage materials shall be constructed in accordance with the Drawings and/or the manufacturer's instructions. Where granular material is used as a drainage material, the drainage material shall be compacted to the same requirements as reinforced fill material. It shall be constructed progressively in layers matching the reinforced fill material.

9.7.1 Piling

All piling Works shall conform to the requirements specified in the Drawings and in relevant Specifications.

9.8 Tolerances

9.8.1 Reinforced soil walls

Construction tolerances measured immediately after completion of the RSW and the application of all dead load surcharges, shall comply with Clause 9.7. Negative deviations are measured towards the RSW block.

Where no other tolerance is given, a measurement (dimension, level, position) which falls within ± 6 mm of the required value, shall be deemed to be conforming.

9.8.1.1 Reinforcing elements

The reinforcing elements shall be within ± 100 mm of the design levels and locations specified in the Drawings.

9.8.1.2 Wall face

No point on the face of the completed RSW shall deviate from the specified position by more than ± 50 mm at bridge abutments, and +50 mm to -100 mm for walls outside a distance from bridge abutments equal to the height of the RSW.

The vertical alignment of the face of the completed wall shall not deviate from the specified vertical inclination by more than +5 mm to -10 mm per metre height.

The flatness of the wall shall be such that the maximum deviation from a 4.5 metre straight-edge shall not exceed ± 20 mm. In the case of walls curved in plan, the horizontal deviation shall be measured from a 4.5 metre metre-long reference, curved to the specified curvature.

The horizontal step between adjacent facing units shall not exceed 10 mm.

9.8.1.3 Top and bottom of wall

For walls adjacent to bridge abutments, the top and bottom of the wall shall be within ± 15 mm of the design alignment specified in the Drawings.

For walls outside a distance equal to the height of the RSW from bridge abutments, the top and bottom of the wall shall be within ± 30 mm of the design alignment specified in the Drawings.

9.8.1.4 Level

The level of any point on the wall shall not deviate from the specified level by more than ± 20 mm, except where the provision of such tolerances shall not permit a neat join to adjacent structures.

9.9 RSW monitoring

As a minimum, the performance of RSW shall be monitored through the measurement of the deflection of the RSW facings. The Contractor shall provide reference points (survey points) vertically on the facing at a cross-section of the wall. The top survey point shall be at one metre down from the top of the wall. The bottom survey point shall be at one metre up from the bottom of the wall. The rest of the survey points shall be at no greater than two metre intervals between the top and bottom points in a cross-section avoiding two points on one facing panel.

The x, y and z co-ordinates of each survey points shall be measured to an accuracy of 5 mm. Sufficient control points shall be established, so that vertical and horizontal movement can be measured to an accuracy of 1 mm.

The minimum monitoring cross-section requirements are as given in Table 9.8, following.

Table 9.9 – Minimum monitoring cross-section

Wall Height	Minimum Number of Monitoring Cross-Section
6 m – 8 m	For every 100 m length of wall section within the wall height between 6 m and 8 m, at least one cross-section. The maximum height within the wall section shall be targeted.
> 8 m – 10 m	For every 75 m length of wall section within the wall height between > 8 m and 10 m, at least one cross-section. The maximum height within the wall section shall be targeted.
> 10 m	For every 50 m length of wall section within the wall height > 10 m, at least one cross-section. The maximum height within the wall section shall be targeted.

In addition to the above, the Contractor shall provide additional monitoring cross-sections at high risk areas such as follows:

a) wall curvature on plan – concave outwards (bowl facing backfill)

b) heavily loaded walls

c) walls that are located at a high risk area for example, close to public or heavy traffic

d) walls that are located adjacent to other structures / utilities which may be affected by the wall movement

e) walls subject to abutment / bridge horizontal loadings, and

f) walls where there is some uncertainty in the design / construction.

Monitoring of vertical and horizontal movement at the survey points, shall start as soon as the wall reaches the maximum height. The monitoring frequency shall be as follows:

- initially every two weeks for two months
- then monthly for another two months, and
- then every three months until Practical Completion.

Monitoring results shall be submitted to the Administrator within two weeks.

10 Compliance testing

10.1 General

Construction tolerances for the RSW are specified in Clause 9.8. Measurement of the requirements in Clause 9.8 shall be determined by survey, unless otherwise agreed by the Administrator.

Sufficient sampling, testing and checking of measurements, shall be carried out to ensure that the RSW complies with the Drawings.

Compliance testing of RSW shall be undertaken on a lot basis in accordance with MRTS01 *Introduction to Technical Specifications*. A lot shall include only material of the same type.

For each lot, the Contractor is responsible for performing sufficient tests to ensure that the RSW complies in all regards with the requirements of this Technical Specification. As a minimum, the Contractor's testing program shall not be less than that specified in this Clause.

The Contractor shall ensure that sufficient, clearly-documented construction compliance records are provided to the Administrator, to ensure that traceability of materials is provided from their source to the RSW.

The Contractor shall not incorporate materials into the Work, unless it has demonstrated that the material complies fully with the requirements of this Technical Specification before delivery of the material to site. **Hold Point 6** Such conformance results shall be no more than 12 months old, unless otherwise agreed by the Administrator.

When test results are more than six months old, where requested by the Administrator, the Contractor shall undertake audit testing prior to submitting to demonstrate the material still complies with the requirement of this Technical Specification. **Hold Point 7**

10.2 Sampling

Representative sampling shall be undertaken as detailed in Test Method Q060. Spot sampling shall be undertaken as detailed in Test Method Q061.

10.3 Test locations

Unless indicated elsewhere in this Technical Specification, samples for material compliance testing shall be taken from the stockpile.

Locations for compliance testing shall be selected by random stratified sampling as specified in Test Method Q050 or AS 1289.1.4.2.

10.4 Maximum lot sizes

Maximum lot sizes for reinforced fill material shall be as specified in Table A1 of Appendix A.

10.5 Testing frequencies

Minimum testing frequencies and the minimum number of tests required for reinforced fill materials source and product testing shall be as specified in Table A2 and A3 of Appendix A.

10.6 Compliance testing requirements

10.6.1 Reinforced fill materials

The minimum testing frequencies for reinforced fill materials source and product testing shall be as specified in Tables A2 and A3 of Appendix A.

10.6.2 Compaction

Minimum testing frequencies for compaction shall be as specified in Table A3 of Appendix A.

The compaction standard for each lot shall be represented by the minimum characteristic value. The characteristic value shall be calculated in accordance with Test Method Q020 using the individual results reported for each lot.

10.6.3 Particle size distribution

Minimum testing frequencies for particles size distribution of reinforced fill materials, shall be as specified in Table A3 of Appendix A.

The sample to be tested shall:

a) be sampled from the compacted fill

b) be sampled using Test Method Q061, and

c) be sampled at a location adjacent to the location of sampling for the compaction testing.

11 Certification of construction

On completion of construction of the RSW block, the Contractor shall forward the following documentation to the Administrator:

a) Three sets of As Constructed Drawings and Specifications in a form and containing such details as may be required by the Administrator.

   The Drawings shall also include the horizontal and vertical positions of the soil reinforcement within the top 1.5 metres of the RSW block, together with any necessary information which would enable any roadwork furniture (for example, posts) to be installed with minimal damage to the RSW. The locations of all monitoring points specified in Clause 9.8 shall also be included.

b) A certificate from the Contractor which confirms that the RSW has been completed and constructed using construction materials and construction processes that are in accordance with the Drawings, Specifications and this Technical Specification.

c) A certificate from the Contractor's Designer which confirms that the As Constructed Drawings and the construction Specifications and the As Constructed RSW fulfill the structural integrity and serviceability criteria stipulated under the design. This certificate shall be signed by a Principal of the Contractor's Designer, and

d) All guarantees and warranties required by the Contract.

The provision of these certificates and their acceptance by the Administrator shall in no way absolve the Contractor of any responsibility for the satisfactory performance of the RSW.

Appendix A – Maximum lot sizes and minimum testing frequencies

Table A1 – Maximum lot size requirements

Construction Activity	Maximum Lot Size
Supply of reinforced fill material	5000 t
Construction of reinforced fill block	1 day production or 1 compacted layer

Table A2 – Reinforced fill material – Source testing

No.	Activity	Verification requirements		Normal testing level			Reduced testing level [1]		
		Description	**Test required**	**Maximum Lot size**	**Minimum testing frequency**	**Minimum no. of tests**	**Maximum Lot size**	**Minimum testing frequency**	**Minimum no. of tests**
2.1	Reinforced fill material (Clause 7.2) – All reinforcement systems	Effective angle of friction at constant volume	Q181C	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Wet / Dry Strength Variation	AS 1141.22	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Wet Strength	AS 1141.22	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Degradation Factor	Q208B	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Particle size distribution	AS 1289.3.6.1	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
2.2	Free draining reinforced fill material (Clause 7.2) – All reinforcement systems	Effective angle of friction at constant volume	Q181C	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Permeability	AS 1289.6.7.1	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Wet / Dry Strength Variation	AS 1141.22	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Wet Strength	AS 1141.22	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Degradation Factor	Q208B	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Particle size distribution	AS 1289.3.6.1	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type

No.	Activity	Verification requirements		Normal testing level			Reduced testing level [1]		
		Description	Test required	Maximum Lot size	Minimum testing frequency	Minimum no. of tests	Maximum Lot size	Minimum testing frequency	Minimum no. of tests
2.3	Reinforced fill material (Clause 7.2) – Steel reinforcement system	pH	AS 1289.4.2.1	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Electrical Resistivity	Q122B	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Chloride Content [2]	Q130B	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type
		Sulphate Content [2]	Q131B	Material type	2 per 2500 m^3	2 per type	Material type	2 per 5000 m^3	2 per type

Notes:

1. Reduced frequency can only be considered, if the reinforced fill material is won from a registered quarry with demonstrated controls over quality. (Also refer to MRTS50 *Specific Quality System Requirements*, Clause 8.6.).
2. Instrumentation techniques may include Ion Chromatography / Inductively Coupled Plasma / Discrete Analyser and so on. NATA-endorsed test results are evidence of a validated technique.

Table A3 – Reinforced fill material – Product testing

No.	Activity	Verification requirements		Normal testing level			Reduced testing level[1]		
		Description	**Test required**	**Maximum Lot size**	**Minimum testing frequency**	**Minimum no. of tests**	**Maximum Lot size**	**Minimum testing frequency**	**Minimum no. of tests**
3.1	Reinforced fill material (Clause 7.2) – All reinforcement systems	Particle size distribution	AS 1289.3.6.1	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot	1 compacted layer	1 test per 600 m^2 of plan area of layer	2 per Lot
		Compaction (dry density ratio or Hilf density ratio)	AS 1289.5.4.1, or AS 1289.5.7.1	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot
		Compaction (density index)	AS 1289.5.6.1	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot
3.2	Free draining reinforced fill material (Clause 7.2) – All reinforcement systems	Particle size distribution	AS 1289.3.6.1	1 compacted layer	1 test per 120 m^2 of plan area of layer	2 per Lot	1 compacted layer	1 test per 250 m^2 of plan area of layer	2 per Lot
		Compaction (dry density ratio or Hilf density ratio)	AS 1289.5.4.1 or AS 1289.5.7.1	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot
		Compaction (density index)	AS 1289.5.6.1	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot	1 compacted layer	1 test per 300 m^2 of plan area of layer	2 per Lot

Note 1:

Reduced frequency can only be considered, if the fill material is won from a registered quarry with demonstrated controls over quality. (Also refer to MRTS50 *Specific Quality System Requirement*, Clause 8.6.).