Main Roads
Technical Standard

MRTS06

Reinforced Soil Structures

October 2010

Queensland Government

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Reinforced Soil Structures

1 INTRODUCTION

This Technical Standard applies to the design and construction of reinforced soil structures (RSS) in roadworks. It does not apply to reinforced slopes or foundations, soil nail walls and reinforced embankments.

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

This Technical Standard forms part of the Main Roads Specifications and Technical Standards Manual.

The construction of reinforced soil structures shall use suppliers and products approved by the Roads and Traffic Authority of New South Wales (RTA, NSW) as per Annexure to RTA 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 products refer to –

Queensland Department of Transport and Main Roads
Director (Geotechnical)
35 Butterfield Street
Herston Qld 4006

2 DEFINITION OF TERMS

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

Table 2 – Definition of Terms

Term	Definition
capping	The element over the top course of facing elements to complete an RSS wall to specified finish levels.
geosynthetic reinforcement	Soil reinforcement made of polymeric materials used in reinforced soil structures eg linear straps and geogrids.
Geotechnical Engineer	Engineer with qualifications and experience in geotechnical engineering. The minimum engineering qualification required is Registered Professional Engineers of Queensland (RPEQ).
Reinforced Soil Structure	Any earth retaining structure which relies on the interaction between embedded tension members and the earth itself for its structural integrity.
RSS	Reinforced Soil Structure (which may be plural).
RTA	Roads and Traffic Authority of New South Wales.
RTA R57	RTA QA Specification R57 *Design of Reinforced Soil Walls*.
soil reinforcement	Metallic or polymeric components embedded in the reinforced fill material which ensures the stability and structural adequacy of the RSS.

3 REFERENCED DOCUMENTS

Table 3 lists documents referenced in this Technical Standard.

Table 3 – Referenced Documents

Reference	Title
AS 1726	Geotechnical site investigations
AS/NZS 3678	Structural steel – Hot-rolled plates, floorplates and slabs
AS/NZS 3679	Structural steel – Hot-rolled bars and sections
AS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS 5100	Bridge Design Set
AS 3610	Formwork for Concrete
AS/NZS 4455	Masonry units, pavers, flags and segmental retaining wall units
AS 3700	Masonry structures
AS 1214	Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
AS 1111	Iso metric hexagon bolts and screws
AS 1112	Iso metric hexagon nuts
AS 1237	Plain washers for metric bolts, screws and nuts for general purposes
AS 1289	Methods of testing soils for engineering purposes

4 STANDARD TEST METHODS

The standard test methods given in Table 4 shall be used in this standard for earthen materials.

The test methods for Soil Reinforcement and Facing Units are specified in Clauses 7.4 and 7.5 respectively.

Further details of test numbers and test descriptions are given in Clause 4 of MRTS01 *Introduction to Technical Standards*.

Table 4 – Standard Test Methods

Property to be Tested	Method No.
Angle of internal friction.	Q177 Q178 Q181B
Chloride content.	Q130B
Effective angle of friction at constant volume conditions.	Q181C
Effective cohesion.	Q177 Q178 Q181B
Los Angeles Abrasion.	Q206
One-dimensional consolidation properties.	Q183
Particle size distribution.	Q103A
Permeability.	Q125A
pH.	Q121
Electrical Resistivity.	Q122B

Property to be Tested	Method No.
Moisture Density Relationship (MDR).	Q142A
Relative Dry Density (RDD).	Q141B Q140A
Sulphate content.	Q131B
Undrained shear strength.	Q152A Q173A
Ten Percent Fines Values (wet)	Q205B
Degradation Factor	Q208B
Minimum/maximum density of cohesionless material	Q142E

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 Standards*.

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

Table 5.1 – Hold Points and Witness Points

Clause	Hold Point	Witness Point	Milestone
7.5.5	1. Sample facing unit.		Supply of samples (14 days)
8.5	2. Design of RSS.		Submission of design and drawings (28 days)
9.3	3. Acceptance of foundation.	Inspection of foundation.	
9.5.1	4. Suitability of construction method.		Submission of details of erection method (7 days)
9.5.2	5. Construction of second course of facing units.		
9.5.3		Recording of condition of soil reinforcement and facing connections.	

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.

5.3 Testing Frequencies

In addition to the testing frequencies stated in the Contract, the frequencies listed in Table 5.3 shall also apply.

Table 5.3 – Compliance testing of fill material for Reinforced Soil Block

Quality Verification Requirement		Normal Testing Level		
Description	**Test Required**	**Maximum Lot Size**	**Minimum Testing Frequency**	**Minimum Number of Tests**
Frictional Fill Material (All System)	Effective angle of friction at constant volume – Q181C	Material Type	2 tests per 2 500 m^3	2 tests per material type
	Permeability** – Q125A	Material Type	2 tests per 2 500 m^3	2 tests per material type
	Los Angeles Abrasion Q206	Material Type	1 test per 2 500 m^3	2 per material type
	Ten Percent Fines Value (wet) Q205B	Material Type	1 test per 2 500 m^3	2 per material type
	Degradation Factor Q208B	Material Type	1 test per 2 500 m^3	2 per material type
	Grading Q103	1 Compacted Layer	1 test per 300 m^2 of plan area of layer	2 per lot
		1 Compacted Layer	1 test per 120 m^2** of plan area of layer	2 per lot
	RDD Q111A	1 Compacted Layer	1 test per 300 m^2 of plan area of layer	2 per lot
Frictional Fill Material (for steel reinforced systems)	PH – Q121	Material Type	2 tests per 2 500 m^3	2 tests per material type
	Electrical Resistivity – Q122B			
	Chloride Content – Q130B			
	Sulphate Content – Q131B			

Note: ** For Free Draining Frictional Fill only (if applicable, see Clause 8.2)

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 RSS.

Site investigation shall be generally in accordance with AS 1726. The assessment of the Site investigation data shall be carried out by a Geotechnical Engineer in conjunction with the designer of the RSS.

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) the aggressiveness of soil determined in accordance with the test methods Q121, Q122B, Q130B, Q131B and other relevant tests.

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 Q177, Q178 and Q181B.

The undrained soil shear strength of foundation soil where relevant, shall be determined by in–situ and/or laboratory tests which shall include at least one or more of the test methods Q151B, Q152A and Q173A.

The compressibility characteristics of the foundation soil shall be determined in accordance with Test Method Q183.

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 RSS system owner in addition to those specified in the Drawings and this standard.

7.2 Reinforced Fill Material

The selected fill forming the reinforced soil mass shall comply with the following –

a) reinforced fill 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 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 RSS 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 the durability requirements specified in Table 7.2-C.

d) the maximum size prior to placement and compaction shall not be greater than one third of the layer depth nor greater than 150 mm for steel reinforcement and 75 mm for geosynthetic reinforcement;

e) the particle size distribution requirements for frictional fill materials are given in Table 7.2-A;

f) the coefficient of uniformity (C_u) shall not be less than 5; and

g) the reinforced fill material shall meet the electrochemical requirements specified in Table 7.2-B.

Table 7.2-A – Particle Size Distribution Requirements for Fill Materials

AS Sieve Size	% Passing
125	100
90	85 – 100
9.5	25 – 100
600 µm	10 – 100
75 µm	0 – 10

Table 7.2-B – Electrochemical Properties of Reinforced Fill Materials

Reinforcing Element	Location †	Properties of fill				
		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-C – Durability Requirements for Reinforced Fill Materials

Property	Value
Ten Percent Fines Values (wet)	Minimum 70 kN
Degradation Factor	Minimum 40
Los Angeles Abrasion	Less than 30%

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 or reinforcing mesh to AS/NZS 4671 supplied in accordance with MRTS71. Steel reinforcement shall be hot dipped galvanised in accordance with AS 4680 with a minimum average zinc coating mass of 600 g/m^2

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 standard.

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 RSS at the design temperatures;

b) loss of strength due to environmental degradation (eg 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.

7.5.2 Concrete Panels

Concrete panels shall be manufactured from reinforced concrete in accordance with MRTS72 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 5100.5-2004.

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.

7.5.3 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.

7.5.4 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 in situ conditions and the design life.

Acceptable corrosion protection includes –

a) hot–dipped galvanising in accordance with AS 4680 for steel; and

b) hot dip galvanising to AS 1214 for hexagonal bolts, nuts and washers to AS 1111, AS 1112 and AS 1237.

7.5.5 Sample Facing Unit

14 days prior to production of facing units, the Contractor shall make available to the Administrator a sample containing a minimum of one full facing unit and reinforcing anchor. **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, provided that it complies with this standard.

7.6 Joint Fillers and Sealants

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

Horizontal joint fillers shall be 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 fill material, equidistant across all joints.

Sealants, where used, shall be polysulphide or polyurethane based elastomeric compounds applied strictly in accordance with 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, Retaining Structures and Protective Treatments*.

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 RSS 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 structures shall comply with Specification R57 *Design of Reinforced Soil Walls* published by the Road and Traffic Authority of New South Wales (RTA).

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 Structures

All RSS walls shall be designed for a default water table height equal to 2/3 the RSS wall 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.

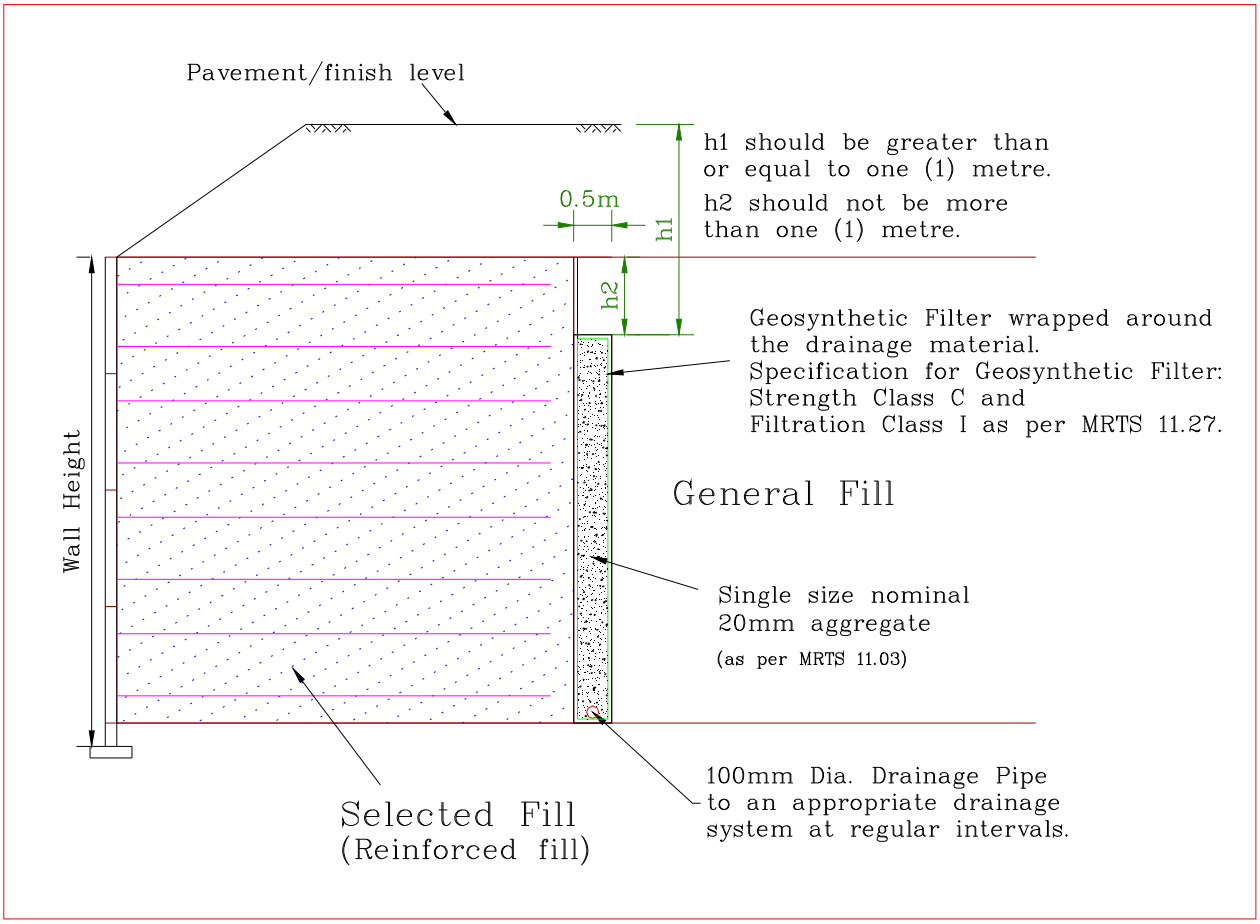
The default water table height requirement may be relaxed under the following circumstances. Zero water pressures on the rear face of the RSS block can be adopted, if one of the following conditions is satisfied –

a) by providing a full height continuous granular drainage blanket, as shown in the attached Figure 8.2, behind the RSS block (i.e. interface between the selected fill and general backfill). Alternatively for RSS walls with height less than 4 m, a prefabricated cellular material (as per MRTS03) wrapped with a geosynthetic filter fabric with equivalent design drainage and strength properties (as per MRTS27) may be provided; or

b) by providing a free draining (permeability > 10^{-5} m/s), durable (Los Angeles Abrasion Value, loss < 30%), frictional, selected fill material. Permeability testing on compacted selected fill shall be carried out to confirm the above permeability. Constant head permeability testing (Test No. Q125A) shall be carried out on the selected fill material compacted to not less than 97% RDD (Test No. Q142A) or 90% density index (Test No. Q142E) whichever is applicable. Internal angle of friction Q181C, grading Q103A and Los Angeles Abrasion Q206 shall be carried out from the same sample lot used for the permeability test, by the same laboratory. The Los Angeles Abrasion test grading shall be chosen from Table 1 of Q206 such that the majority of significant fractions present in the samples are included in the test portions. During construction, additional grading as per Q103 shall be carried as per Table 5.3 to ensure the percentage passing 0.150 mm sieve is not greater than the initial test results. The testing frequencies for shear strength and other properties pertaining to the selected fill shall conform to Clause 5.3. A geosynthetic filter whose properties are given in Figure 8.2 shall be installed between the selected fill and general fill interface.

This does not address extreme events such as inundation, potential draw down due to flooding etc. These requirements shall conform to RTA R57 and shall address a minimum 100 year ARI flood event.

Figure 8.2 – Typical Details of a Drainage Blanket behind RSS Block



8.3 Global Stability Analysis

Notwithstanding the provisions of Clause 4.7.3 of RTA R57 the following minimum requirements shall apply to the assessment of global stability –

a) Geotechnical Model: Scaled cross-sections of the RSS 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: Morgenstren 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 RSS 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 RSS, 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 (eg 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 RSS, rigid liners shall be installed in the RSS 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 RSS 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 Appendix MRTS06.1
- Contractor's Construction Drawings;
- Contractor's Construction Specifications including RSS construction sequence;
- Any particular requirements for ground and/or foundation improvement; and
- Arrangements for monitoring the performance of the RSS over the nominated period.

The Contractor shall include in the Design Documents for the RSS –

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 RSS 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 standard, 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 RSS 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 RSS. **Milestone**

Construction of the RSS 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 RSS shall comply with the Contractor's Construction Drawings and Specifications. Construction of the RSS 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 3 days notice of such inspection **Witness Point**

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 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 Erection of Facing Units and Placement of Soil Reinforcement and Fill Material

9.5.1 General

One week prior to the commencement of facing panel erection or placement of 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 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**

9.5.2 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 fill material. Joint fillers and geotextile strip shall be installed progressively as erection of facing units proceeds so as to ensure that there is no loss of fine material from the in-place fill.

The degree of inclination of the facing elements towards the fill shall be adjusted where necessary as placement and compaction of 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**

9.5.3 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 RSS fill materials.

The construction of the RSS 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 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 2 metres away from the facing units. Fill material within 2 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.

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

d) RSS fill material shall be placed and compacted with a moisture content not greater than the optimum moisture content. After compaction, the characteristic value of RDD shall not be less than 97%;

e) Soil reinforcement shall be laid horizontally on the compacted fill 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 fill material. The method of fill placement and compaction shall ensure that slack is not introduced into the soil reinforcement as fill is placed. The condition of the soil reinforcement and facing connections at each level shall be recorded just before covering. **Witness Point**;

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

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

h) During construction, the earthworks fill material behind the RSS block shall be maintained at the same level as the RSS 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 fill material is not disturbed and the formation of voids is prevented; and

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

9.6 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.

9.6.1 Piling

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

9.7 Tolerances

9.7.1 General

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

9.7.2 Reinforcing Elements

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

9.7.3 Wall Face

No point on the face of the completed RSS 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 RSS wall.

The vertical alignment of the face of the completed wall shall not deviate from the specified vertical inclination by more than + 5 mm, - 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 long reference, curved to the specified curvature.

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

9.7.4 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 RSS from bridge abutments, the top and bottom of the wall shall be within ± 30 mm of the design alignment specified in the Drawings.

9.7.5 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.

9.8 Monitoring

As a minimum, the performance of RSS wall shall be monitored through the measurement of the deflection of the RSS wall 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 1 metre down from the top of the wall. The bottom survey point shall be at 1 metre up from the bottom of the wall. The rest of the survey points shall be at no greater than 2 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 the 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, below.

Table 9.8 – 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 2 months;
- Then monthly for another 2 months; and
- And then every 3 monthly until Practical Completion.

Monitoring results shall be submitted to the Administrator within 2 weeks.

10 COMPLIANCE INSPECTION AND TESTING

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

11 CERTIFICATION OF CONSTRUCTION

On completion of construction of RSS 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 RSS block, together with any necessary information which would enable any roadwork furniture (for example, posts) to be installed with minimal damage to the RSS. 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 RSS has been completed and constructed using construction materials and construction processes that are in accordance with the Drawings, Specifications and this standard;

c) A certificate from the Contractor's Designer which confirms that the as constructed drawings and the construction specifications and the as constructed RSS fulfil 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 RSS.