

# **Construction of Reinforced Soil Structures**

**(ATS 5120-23, Ed 1.0 MOD)**

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## Preface

This document is the first issue as TfNSW TS 02165, which adopts and modifies Austroads Technical Specification ATS 5120. It sets out the requirements for construction of reinforced soil structures, fill materials, construction sequence, tests and conformity, construction tolerances, monitoring, and document submissions. This document does not cover reinforced slopes or foundations, soil nail walls or reinforced embankments.

This document supersedes the TS 02165.1 (IC-QA-R58) *Construction Of Reinforced Soil Walls (Contractor's Design) – QA* and TS 02165.2 (IC-DC-R58) *Construction Of Reinforced Soil Walls (Contractor's Design) – DC*.

For the purposes of this document, where TfNSW has identically adopted, or adopted and modified, an ATS document as a Transport Standard, the corresponding Transport Standard should be applied.

## Table of contents

|                                                                                  |           |
|----------------------------------------------------------------------------------|-----------|
| <b>1. Scope .....</b>                                                            | <b>6</b>  |
| <b>2. Referenced documents .....</b>                                             | <b>6</b>  |
| <b>3. Definitions .....</b>                                                      | <b>8</b>  |
| <b>4. Quality System Requirements.....</b>                                       | <b>9</b>  |
| <b>5. Design.....</b>                                                            | <b>9</b>  |
| <b>6. Site Investigation .....</b>                                               | <b>10</b> |
| <b>7. RSW System Components .....</b>                                            | <b>10</b> |
| General .....                                                                    | 10        |
| Geosynthetic (Extensible) Reinforcement .....                                    | 10        |
| Steel (Non-Extensible) Reinforcement .....                                       | 10        |
| Facing elements .....                                                            | 10        |
| Connections.....                                                                 | 11        |
| Other Materials .....                                                            | 11        |
| Component Tolerances .....                                                       | 12        |
| Handling and Storage .....                                                       | 12        |
| <b>8. Fill Material .....</b>                                                    | <b>13</b> |
| General .....                                                                    | 13        |
| Reinforced Fill Material .....                                                   | 13        |
| Soil Above and Behind Reinforced Soil Block .....                                | 16        |
| Drainage Layer Material and Filter Fabric .....                                  | 17        |
| Testing Frequencies and Conformity Criteria .....                                | 18        |
| <b>9. Construction .....</b>                                                     | <b>18</b> |
| General .....                                                                    | 18        |
| Base Strip Footings .....                                                        | 19        |
| Erection of Facing elements .....                                                | 19        |
| Placement of Soil Reinforcement and Compaction of Reinforced Fill Material ..... | 21        |
| Capping, Filter and Drainage Materials .....                                     | 23        |
| <b>10. Tolerances .....</b>                                                      | <b>23</b> |
| <b>11. Monitoring .....</b>                                                      | <b>24</b> |
| <b>12. Certification of Construction.....</b>                                    | <b>25</b> |
| <b>Annexure A     Summary of Hold Points, Witness Points and Records .....</b>   | <b>27</b> |
| <b>Annexure B     Frequency of Testing for Each Lot (normative).....</b>         | <b>28</b> |

# 1. Scope

- 1.1 This Specification sets out the requirements for the construction of RSW. It covers RSW designs provided by the Contractor and by the Principal.
- 1.2 It does not cover reinforced slopes or foundations, soil nail walls or reinforced embankments.

# 2. Referenced documents

- 2.1 The following documents are referenced in this Specification:

## Australian / New Zealand Standards

|               |                                                                                                                                                                                                             |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AS 1141.11.1  | Methods for sampling and testing aggregates Particle size distribution – Sieving method                                                                                                                     |
| AS 1214       | Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)                                                                                                                         |
| AS 1237       | Plain washers for metric bolts, screws and nuts for general purposes                                                                                                                                        |
| AS 1289       | Methods of testing soils for engineering purposes                                                                                                                                                           |
| AS 1289.1.1   | Methods of testing soils for engineering purposes – Method 1.1: Sampling and preparation of soils – Preparation of disturbed soil samples for testing                                                       |
| AS 1289.1.2.1 | Methods of testing soils for engineering purposes – Method 1.2.1: Sampling and preparation of soils – Disturbed samples – Standard 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 1289.5.1.1 | 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 1289.5.6.1 | 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                            |
| AS 1379       | Specification and supply of concrete                                                                                                                                                                        |
| AS 1726       | Geotechnical site investigations                                                                                                                                                                            |
| AS 3610       | Formwork for Concrete                                                                                                                                                                                       |
| AS 3700       | Masonry structures                                                                                                                                                                                          |
| AS 4680       | Hot-dip galvanized (zinc) coatings on fabricated ferrous articles                                                                                                                                           |
| AS 5100       | Bridge Design                                                                                                                                                                                               |
| AS/NZS 3678   | Structural steel – Hot-rolled plates, floorplates and slabs                                                                                                                                                 |
| AS/NZS 3679   | Structural steel – Hot-rolled bars and sections                                                                                                                                                             |
| AS/NZS 4455   | Masonry units, pavers, flags and segmental retaining wall units                                                                                                                                             |
| AS/NZS 4671   | Steel reinforcing materials                                                                                                                                                                                 |

|              |                                                                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| AS 1141.11.1 | Methods for sampling and testing aggregates Particle size distribution – Sieving method                                                            |
| AS 4969.1    | Analysis of acid sulfate soil – Dried samples – Methods of test – Pretreatment of samples under Australian / New Zealand Standards                 |
| AS 4969.12   | Analysis of acid sulfate soil – Dried samples – Methods of test Complete suspension peroxide oxidation combined acidity and sulfur (SPOCAS) method |

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#### **Austrorads**

|          |                                                                    |
|----------|--------------------------------------------------------------------|
| ATM 710  | Chloride Content of Soil                                           |
| ATS 2160 | Supply and Installation of Geotextiles (Separation and Filtration) |
| ATS 5325 | Supply of Precast Concrete Members                                 |

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#### **TfNSW Standards**

|                            |                                                                               |
|----------------------------|-------------------------------------------------------------------------------|
| TS 01456.1<br>(IC-QA-G71)  | Construction Surveys – QA                                                     |
| TS 01572.1<br>(IC-QA-Q6)   | Quality Management (Major Works) QA                                           |
| TS 01733.1<br>(IC-QA-B80)  | Concrete Work for Bridges – QA                                                |
| TS 01738.1<br>(IC-QA-B115) | Precast Concrete Members (Not Pretensioned) – QA                              |
| TS 02158.1<br>(IC-QA-R44)  | Earthworks                                                                    |
| TS 02164.1<br>(IC-QA-R57)  | Design Of Reinforced Soil Walls – QA                                          |
| TS 02167.1<br>(IC-QA-R63)  | Geotextiles (Separation And Filtration) – QA                                  |
| TS 02794.02<br>(T102)      | Pre-treatment of road construction materials by repeated compaction           |
| TS 02794.03<br>(T103)      | Pre-treatment of road construction materials by artificial weathering         |
| TS 02795.02<br>(T106)      | Coarse particle size distribution of road construction materials (by washing) |
| TS 02795.04<br>(T108)      | Liquid limit of road construction materials                                   |
| TS 02795.05<br>(T109)      | Plastic limit and plasticity index of road construction materials             |
| TS 02795.16<br>(T123)      | pH value of soil (Electrometric method)                                       |
| TS 02795.28<br>(T166)      | Relative compaction of road construction materials                            |
| TS 02795.43<br>(T185)      | Resistivity of sands and granular road construction materials                 |

|                           |                                                     |
|---------------------------|-----------------------------------------------------|
| TS 02811.02<br>(T1002)    | Determination of pH of water using a pH meter       |
| TS 02811.04<br>(T1004)    | Quantitative determination of chloride ion in water |
| TS 02811.10<br>(T1010)    | Quantitative determination of chlorides in soil     |
| TS 02811.14<br>(T1014)    | Quantitative determination of sulfate ion in water  |
| TS 03251.1<br>(IC-QA-G40) | Clearing and Grubbing – QA                          |

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**Other  
references**

|                      |                                                                                                                                                                                                                                              |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Test Method<br>Q181C | Effective angle of internal friction at constant volume conditions for granular materials – coarse grained (contained in Queensland Department of Transport and Main Roads, Materials Testing Manual – Edition 6, Amendment 2 – August 2024) |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 3. Definitions

3.1 The following definitions apply to this Specification:

|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Principal's<br/>Registration<br/>Scheme</b> | Any scheme for the prequalification, registration or approval of products, manufacturers, suppliers and/or Professional Engineers which is in operation in the jurisdiction where the RSW is to be constructed (approved RSW systems as detailed in TS 02164.1).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Professional<br/>Engineer</b>               | A person who: <ul style="list-style-type: none"> <li>a) has at least 5 years of experience in or structural engineering or geotechnical engineering (as appropriate);</li> <li>b) is registered on any scheme of registration of engineers prescribed by legislation in the applicable jurisdiction;</li> <li>c) is appropriately registered or prequalified, if the Principal has implemented an applicable registration or prequalification scheme; and</li> <li>d) satisfies at least one of the following requirements: <ul style="list-style-type: none"> <li>i) is a Chartered Professional Engineer; or</li> <li>ii) holds a 4 year civil engineering degree from a university that is accredited under the Washington Accord and is registered in a relevant area of practice on the National Engineering Register (in Australia).</li> </ul> </li> </ul> |
| <b>RSW</b>                                     | reinforced soil wall; An earth retaining wall, with a wall face within 20° from vertical, comprising reinforced fill behind the wall and soil reinforcement to form a composite structure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Reinforced Fill<br/>Material</b>            | The fill material, complying with Clause 8, in which the soil reinforcement is embedded to form the reinforced soil block. It extends from the rear of the facing to the end of the soil reinforcement.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |



|                           |                                                                                                                                                                                                                                                                            |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RSW system</b>         | A system of reinforced soil wall approved in the Principal' Registration Scheme, and which may be subject to certain conditions for use. It includes the reinforcing elements, wall facings and any associated components such as connections, joint fillers and sealants. |
| <b>Soil Reinforcement</b> | Metallic or synthetic components that are embedded in the select fill and which act through interface friction, bearing or other means to provide the required strength and stability of the RSW.                                                                          |

## 4. Quality System Requirements

- 4.1 The Contractor must prepare and implement a Quality Plan that includes the documentation in Table 4.1.

Table 4.1 – Quality Plan

| Clause | Description of document                                                                                                                                                                                               |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5      | Design documentation, as specified in TS 02164.1 requirements related to design control and design output and certification and supporting calculations (unless the Principal is providing the design).               |
| 7      | Supplier details, type of proposed proprietary RSW system and evidence that the RSW system components are approved under the Principal's Registration Scheme.                                                         |
| 8.2    | Details of the fill materials and the Sampling and Test Plan.                                                                                                                                                         |
| 9      | Details of the method of construction of the RSW including preparation of foundation in accordance with Clause 9, together with a statement that the method of construction will comply with the design requirements. |
| 11     | Details of the method of installing targets and probes for monitoring of the RSW in accordance with Clause 11.                                                                                                        |

| HOLD POINT 1          |                                                                                                                                                                                                                       |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Manufacture of facing elements and/or preparation of the foundation for the RSW.                                                                                                                                      |
| Submission Details    | The Quality Plan must be submitted to the Principal at least 10 working days prior to the commencement of manufacture of the facing elements and/or preparation of the foundation for the RSW whichever occurs first. |
| Release of Hold Point | The Principal will consider the submitted documents, prior to authorising the release of the Hold Point                                                                                                               |

## 5. Design

- 5.1 The design of the RSW must comply with the technical requirements of TS 02164.1 and any other design requirements must be included in the Contract documents.
- 5.2 Unless specified otherwise, the Design Life of the RSW is 100 years.

## 6. Site Investigation

- 6.1
- Refer to TS 02164.1 for the details of site investigation required for the RSW design and construction.

## 7. RSW System Components

### General

- 7.1
- Where a Principal's Registration Scheme is in place for the supply of the RSW system, all components to be used in the system must be approved components of the same approved RSW system. The contractor must submit test certificates of representative samples for the soil reinforcement, connections to the facing elements and associated components demonstrating compliance with this Specification to the Principal. The test certificates must not be more than 12 months old.

| HOLD POINT 2          |                                                                                                                                    |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Commencement of construction of the RSW.                                                                                           |
| Submission Details    | The test certificates (Clause 7.1) must be provided at least 10 working days prior to the commencement of construction of the RSW. |
| Release of Hold Point | The Principal will assess the submitted documents prior to authorising the release of the Hold Point.                              |

### Geosynthetic (Extensible) Reinforcement

- 7.2
- Geosynthetic reinforcements must comply with the requirements specified in the construction drawings.

### Steel (Non-Extensible) Reinforcement

- 7.3
- Steel reinforcing must comply with the grade, thickness and galvanized coating thickness specified on the Drawings.

### Facing elements

- 7.4
- Facing elements may be concrete panels or masonry units. Refer to the Principal's Registration Scheme for approved facing elements of each approved RSW system that can be used in conjunction with this specification.
- 7.5
- Concrete facing elements must:

a. comply with the Drawings;

b. be manufactured from reinforced concrete in accordance with TS 01738.1 and TS 01733.1;

- c. unless specified otherwise on the Drawings, be finished to Class 2 in accordance with AS 3610; and
- d. 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
- e. attain the minimum strengths specified for the RSW system.

7.6 The Contractor may submit to the Principal a proposal to consider facing elements from another project, which are of the same design and are manufactured under identical conditions, as the test panels.

| HOLD POINT 3          |                                                                                                                                                                                          |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Production of facing elements                                                                                                                                                            |
| Submission Details    | The design output and certification detailed in of TS 02164.1 must be provided to the Principal at least 10 working days prior to the commencement of production of the facing elements. |
| Release of Hold Point | The Principal must assess the submitted documents prior to authorising the release of the Hold Point                                                                                     |

7.7 Any concrete blocks and masonry facing elements must comply with AS/NZS 4455 and AS 3700. Testing of specimens cut from facing elements for compressive strength is permissible.

## Connections

- 7.8 Materials connecting the wall facing elements with the reinforcing elements must be electrolytically compatible to ensure that corrosion will not be promoted through the use of dissimilar metals.
- 7.9 Steel components must be hot dipped galvanized in accordance with AS 4680 (for steel) and AS 1214 (for hexagonal bolts, nuts and washers) with a minimum average coating thickness equivalent to an application rate of 600 grams per square metre of zinc.
- 7.10 The Contractor must provide a certificate of compliance certifying that the mass of zinc coating on galvanized steel components meets the specified requirements and that steel components have sufficient sacrificial steel thickness in combination with the galvanizing to achieve the specified design life.

## Other Materials

- 7.11 Bearing pads (ie the pad placed in the joints between two adjacent courses of concrete panels to maintain the correct spacing between panels) must be:
- a. either HDPE, neoprene or ethylene propylene diene monomer;
  - b. durable and inert;

- c. resistant to creep rupture and environmental degradation; and
  - d. able to accommodate differential movements between adjacent panels, during construction as well as throughout their design life.
- 7.12 Filter fabric must be nonwoven geotextile and comply with strength class B and filtration class 2 requirements in TS 02167.1.
- 7.13 Joint fillers and sealants must be composed of durable inert materials resistant to atmospheric degradation and must:
  - a. protect filter fabric from exposure to sunlight;
  - b. maintain the degree of permeability assumed in the design; and
  - c. retain soil fines.
- 7.14 Sealants must be polysulphide or polyurethane based elastomeric compounds.

## Component Tolerances

- 7.15 Notwithstanding any other tolerances specified in ATS 5325, the following tolerances apply to concrete components in RSW:
  - Overall dimension:  $\pm 5$  mm
  - Thickness:  $\pm 5$  mm
  - Location of fasteners:  $\pm 5$  mm.
- 7.16 The following tolerance apply to the dimensions of metallic and geosynthetic reinforcement
  - Length of reinforcement: + 50 mm, – 0 mm
  - Width of reinforcement: + 5 mm, – 0 mm,
  - Thickness of reinforcement: + 1 mm, – 0 mm.

## Handling and Storage

- 7.17 All prefabricated RSW components must be transported and stored carefully to minimise mechanical damage and deterioration, including protection of geosynthetic reinforcement and geotextile from UV degradation until its embedment within the RSW.

# 8. Fill Material

## General

- 8.1Section 8 applies to the reinforced fill material placed in the drainage layer (where applicable), filling material placed above and behind the reinforced soil block within a distance of  $H/2$  from the reinforced fill material, where H is the half the mechanical height (H) of RSW as defined in TS 02164.1. Additional requirements for the fill material placed above and / or behind the reinforced soil block may be specified in the Contract documents.
- 8.2The Quality Plan must include:

a. details of the type and source of the materials; and

b. sampling and test plan for each material property (for each material) that demonstrates compliance with the requirements in TS 02164.1 and this specification.
- 8.3The sampling and test plan must nominate the proposed frequency of testing to verify conformity of the item and it must not be less than that specified in Annexure B. Where a minimum frequency is not specified, an appropriate frequency must be nominated.
- 8.4The Contactor must submit a report of test results of representative samples for each of the material zones specified in Clause 8.1. At least 4 sample test results for angle of friction at constant volume, and 7 sample test results for the other properties must be submitted.
- 8.5The material represented by the samples is considered to be nonconforming if any of the sample test result is less than the lower limit, or more than the upper limit as appropriate, of the characteristic value adopted in the design.

| HOLD POINT 4          |                                                                                                                                                 |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Placement of fill material                                                                                                                      |
| Submission Details    | The report of test results (Clause 8.4) must be submitted to the Principal at least 5 working days prior to the commencement of fill placement. |
| Release of Hold Point | The Principal must assess the submitted documents, prior to authorising the release of the Hold Point.                                          |

## Reinforced Fill Material

- 8.6The Reinforced Fill Material must:

a. be composed of inert, hard, durable granular material, with properties that will not cause deterioration of the RSW components;

b. be capable of being compacted in accordance with the specified requirements to form a stable mass of fill and be either soil, decomposed rock or crushed rock;

- c. be free from organic or other deleterious material such as plastic, metal, rubber or other synthetic material, inorganic contaminants, dangerous or toxic material, or material susceptible to combustion;
- d. not be derived from argillaceous rock, such as shales and claystones or other materials which are susceptible to breakdown into a friable material;
- e. not be steel furnace slag; and
- f. reinforced fill material located within the selected material zone of a road embankment must also meet the requirements for selected material specified in TS 02158.1

- 8.7 If steel or polyester soil reinforcement is used, the reinforced fill material, material placed in the drainage layer (where applicable), filling material placed above and behind the reinforced soil block within a distance of  $H/2$  from the reinforced fill material (where  $H$  is the mechanical height of RSW as defined in TS 02164.1) must not contain recycled concrete or cement stabilised soil.
- 8.8 The Reinforced Fill Material must meet the physical properties requirements specified in the RSW design, including the angle of friction at constant volume and the design grading envelope, and must be compactable to a stable mass at the required density.
- 8.9 The characteristic value of the weight per unit volume of the reinforced fill material and filling material placed above and behind the reinforced soil block within a distance of  $H/2$  from the reinforced fill material (where  $H$  is the mechanical height of RSW as defined in TS 02164.1) must be within  $\pm 5\%$  of the value specified in the RSW design. If these limits are exceeded, the Contractor must consult the designer regarding the implications for the design and any necessary action to be taken. Data for this assessment may be obtained from relative compaction tests carried out on the Works.
- 8.10 If the Reinforced Fill Material is designed to be free draining, its permeability must be greater than  $10^{-5}$  m/s when compacted to a dry density ratio not less than 97% (AS 1289.5.1.1) or 90% density index (AS 1289.5.6.1), whichever is applicable.
- 8.11 Reinforced fill material must comply with the properties specified in Table 8.11.

**Table 8.11 – Particle size distribution requirements for fill materials**

| Property                          | Test Method <sup>(1)</sup> | Requirement                                                                                       |
|-----------------------------------|----------------------------|---------------------------------------------------------------------------------------------------|
| Maximum particle dimension        | -                          | Soil reinforcement material:<br>Steel 150 mm <sup>(2)</sup><br>Geosynthetic: 75 mm <sup>(2)</sup> |
| Percentage Passing <sup>(3)</sup> | AS 1289.3.6.1              |                                                                                                   |
| 37.5 mm                           |                            | $\geq 60$                                                                                         |
| 9.5 mm                            |                            | 25 – 100                                                                                          |
| 2.36 mm <sup>(4)</sup>            |                            | 15 – 100                                                                                          |
| 600 $\mu$ m                       |                            | 10 – 100                                                                                          |

| Property                                 | Test Method <sup>(1)</sup> | Requirement |
|------------------------------------------|----------------------------|-------------|
| 75 µm                                    |                            | 0 – 15      |
| Coefficient of Uniformity <sup>(5)</sup> | NA                         | ≥ 5         |
| Liquid Limit LL (%) <sup>(3)</sup>       | TS 02795.04                | ≤ 30        |
| Plasticity Index PI <sup>(3)</sup>       | TS 02795.05                | ≤ 12        |

Notes:

1. Taking and preparing samples must be in accordance with AS 1289.1.2.1 and AS 1289.1.1 respectively.

2. Dimension quoted refers to maximum particle dimension of the reinforced fill material, not the soil reinforcement (made from steel or geosynthetic). This maximum particle dimension must not, in any case, be greater than one third of lift thickness.

3. Prior to testing, pretreat the material in accordance with TS 02794.02 using 3 repeated compaction cycles; and then in accordance with TS 02794.03 by artificial weathering using 5 cycles of alternate wetting and drying.

4. Washing Method.

5. Coefficient of Uniformity =  $D_{60} / D_{10}$ , where  $D_{60}$  and  $D_{10}$  are the equivalent sieve sizes in mm, as interpolated from particle size distribution curve and through which 60% and 10% of Reinforced Fill Material passes respectively.

8.12 The reinforced fill material must meet the chemical and electrical requirements of Clause 8.14.

8.13 Where geosynthetic soil reinforcement is used, the Reinforced Fill Material must meet the pH requirements shown in Table 8.13.

**Table 8.13 – Allowable pH limits of reinforced fill materials for RSW systems with geosynthetic components**

| Soil reinforcement material type | Allowable pH limits in fill material <sup>(1)</sup> |
|----------------------------------|-----------------------------------------------------|
| Polyester                        | 4 – 9                                               |
| HDPE                             | 3 – 12                                              |

Note: 1. Determined using TS 02795.16 carried out at a temperature of  $23 \pm 2^{\circ} \text{C}$

8.14 Where galvanized steel components in the RSW system are used, the Reinforced Fill Material and water used in construction must meet the chemical and electrical properties requirements shown in Table 8.14.

**Table 8.14 – Chemical and electrical properties for RSW systems with steel components**

| Property                                   | Test Method | Allowable limits of reinforced fill material – dry land | Allowable limits of reinforced fill material – submerged <sup>(1)</sup> | Water used in construction |
|--------------------------------------------|-------------|---------------------------------------------------------|-------------------------------------------------------------------------|----------------------------|
| pH <sup>(2)</sup>                          | TS 02795.16 | 5 – 10                                                  | 5 – 10                                                                  | –                          |
| pH                                         | TS 02811.02 | -                                                       | -                                                                       | 6.5 – 8.5                  |
| Chloride ion content                       | TS 02811.04 |                                                         |                                                                         | ≤ 250 mg/L                 |
| Chloride ion content <sup>(3)</sup>        | ATM 710     | ≤ 0.02                                                  | ≤ 0.01                                                                  |                            |
| Sulfate ion content                        | TS 02811.14 |                                                         |                                                                         | ≤ 250 mg/L                 |
| Peroxide sulphur content <sup>(3, 4)</sup> | AS 4969.12  | ≤ 0.06                                                  | ≤ 0.04                                                                  |                            |
| Resistivity (saturated) (ohm metre)        | TS 02795.43 | ≥ 10                                                    | ≥ 30                                                                    | -                          |

Notes:

1 “Submerged” does not include marine environment, which is a case requiring investigation to determine allowable limits. Use “submerged” values where the structure is permanently or regularly submerged. Use “dry land” values otherwise.

2 Determined using TS 02795.16 carried out at a temperature of  $23 \pm 20$  °C

3 % by mass.

4 Prepare samples in accordance with AS 4969.1.

## Soil Above and Behind Reinforced Soil Block

- 8.15 The soil above and behind the reinforced soil block within a distance of  $H/2$  from the reinforced soil block (where  $H$  is the mechanical height of RSW as defined in TS 02164.1), must meet the physical properties requirements specified in the RSW design.
- 8.16 The characteristic value of the weight per unit volume of the soil above, and behind the reinforced soil block within a distance of  $H/2$  from the reinforced soil block, must be within  $\pm 5\%$  of the value specified in the RSW design. If these limits are exceeded, the designer must be consulted regarding the implications for the design and any necessary action to be taken.



- 8.17 The soil above, and behind the reinforced soil block within a distance of H/2 from the reinforced soil block, must meet the pH, physical and chemical properties requirements shown in Table 8.17.

**Table 8.17 – Physical and chemical properties of soil above and behind reinforced soil blocks**

| Soil property                             | Test method | Allowable limits                |
|-------------------------------------------|-------------|---------------------------------|
| pH                                        | TS 02795.16 | As for reinforced fill material |
| Liquid Limit                              | TS 02795.04 | ≤ 30%                           |
| Plasticity Index                          | TS 02795.05 | ≤ 12                            |
| Chloride ion content <sup>(1)</sup>       | TS 02811.10 | ≤ 0.03% <sup>(3)</sup>          |
| Peroxide sulfur content <sup>(1, 2)</sup> | AS 4969.12  | ≤ 0.08% <sup>(3)</sup>          |

Notes:

1. % by weight.
2. Prepare samples in accordance with AS 4969.1.
3. Allowable limits applies only RSW system has steel components.

## Drainage Layer Material and Filter Fabric

- 8.18 Material in the drainage layer must:
- a. be inert, hard and durable, crushed stone or river gravel meeting the grading requirements stated in Table 8.18
  - b. be clean and free of clay or perishable matter, organic or other deleterious material
  - c. not have properties that may cause deterioration of any RSW components.

**Table 8.18 – Drainage zone material particle size distribution determined in accordance with AS 1289.3.6.1**

| Sieve size (mm) | % passing |
|-----------------|-----------|
| 53              | 100       |
| 9.5             | ≤ 5       |

- 8.19 Steel furnace slag must not be used as drainage layer material.
- 8.20 A suitable synthetic filter and separation fabric as specified in the RSW design must be installed.
- 8.21 For RSW with a facing height exceeding 4 m, the drainage layer, where provided, must be granular material wrapped inside a nonwoven geotextile.

- 8.22 Filter fabric must be nonwoven geotextile and comply with strength class B and filtration class 2 requirements in TS 02167.1.
- 8.23 For RSW with a facing height less than 4 m, a prefabricated cellular material wrapped with a synthetic filter fabric with equivalent design drainage and strength properties may be used as an alternative.

## Testing Frequencies and Conformity Criteria

- 8.24 Sampling and testing of the reinforced fill material, drainage layer materials, and soil above and behind the reinforced soil block used in the Works must be carried out in accordance with Clauses 8.2 and 8.3. Statistical techniques must be used in accordance with TS 01572.1 as the basis for verifying conformity for each of the material properties in Annexure B against the corresponding characteristic value adopted in the design.
- 8.25 For the conformity testing, a Lot is taken as an area of work that is essentially homogeneous. This occurs when the material origin and properties, general appearance, moisture condition during compaction, compaction technique, response to compactors, and state of underlying materials are substantially alike.
- 8.26 All conformity test reports on any samples must be submitted within 3 weeks after sampling.
- 8.27 Any Lot that does not conform to all design requirements must be rejected.

## 9. Construction

### General

- 9.1 The Contractor must construct the RSW in accordance with:
- all the requirements specified in the design and TS 02164.1;
  - any requirements specified by the manufacturer of the RSW system; and
  - Sections 9 and 10.
- In the event of an inconsistency, the above order of precedence will apply.
- 9.2 Site preparation, excavation (including removal of any unsuitable material) and placing of fill material must be carried out in accordance with TS 03251.1 and TS 02158.1 and any requirements for foundation improvement specified in the design.
- 9.3 Any over-excavation (ie excavation below or beyond the excavation the design levels or dimensions) must be backfilled and compacted with material that is compatible with the RSW design and the foundation design.

- 9.4 Unless specified otherwise, the Contractor must arrange for a Professional Engineer to inspect the foundation and submit a report confirming that either the foundation complies with the RSW design, assumptions made in the design or that additional treatment is required. The Principal must be advised immediately if the Professional Engineer identifies that the specified foundation treatment is inappropriate or the existing foundation material is inadequate to meet the design values of foundation material. In such an event the following applies:
- a. For designs provided by the Principal – the Principal may revise the RSW design and issue amended RSW drawings for construction, or direct that the in-situ material be removed and replaced, or that the in-situ material be modified, so that it meets the design values.
  - b. For designs provided by the Contractor – the details of any revised RSW design or revised foundation treatment required must be provided to the Principal.
  - c. Upon completion of any additional treatment, Hold Pont 4 reapplies.

| <b>HOLD POINT 5</b>   |                                                                                                                                                                           |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Construction of base strip footings                                                                                                                                       |
| Submission Details    | The report from a Professional Engineer must be submitted to the Principal at least 5 working days prior to the commencement of the construction of the footings and RSW. |
| Release of Hold Point | The Principal must assess the submitted documents, prior to authorising the release of the Hold Point                                                                     |

## Base Strip Footings

- 9.5 All construction surveys must be in accordance with TS 01456.1.
- 9.6 Base strip footings must be constructed to the lines levels and dimensions shown on the Drawings within the following tolerances:
- a. Plan dimension – 5 mm;
  - b. Thickness – 10 mm;
  - c. Reduced level of top surface of footing –  $\pm 5$  mm; and
  - d. Maximum variation of top surface from a 3 m straight edge –  $\pm 5$  mm.
- 9.7 Unless another concrete grade is specified in the design, the base strip footing concrete must comply with the requirements of TS 01733.1 and TS 01738.1.

## Erection of Facing elements

- 9.8 If steel soil reinforcement is used, the reinforcement must be thoroughly washed with water complying with Table 8.14. Washing of soil reinforcement made of other materials which are not susceptible to corrosion is not necessary, unless specified by the supplier.

| <b>WITNESS POINT 1</b> |                                                                                              |
|------------------------|----------------------------------------------------------------------------------------------|
| Process                | Washing of soil reinforcement made of steel.                                                 |
| Notification           | At least one working day (not less than 24 hours) prior to the commencement of the activity. |

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

9.10 On completion of the first course of facing elements, the panels must be inspected and surveyed before construction of the second course of facing elements.

| <b>HOLD POINT 6</b>   |                                                                                                                               |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Construction of the second course of facing elements                                                                          |
| Submission Details    | Survey records for the bottom course of facing elements must be provided to the Principal prior to placing the second course. |
| Release of Hold Point | The Principal must assess the submitted documents, prior to authorising the release of the Hold Point                         |

9.11 Prior to placement of each course of facing elements, the level and alignment of the preceding course must be measured to verify that all positions, levels and dimensions of the facing elements are in accordance with the Drawings.

9.12 Adequate support of the facing elements must be provided at each stage of erection. The supporting course of facing elements must be shored to control movement during the placement and compaction of fill material.

9.13 Bearing pads must be placed between precast concrete panels to prevent them from sitting directly on each other. Bearing pads must be placed within 5 mm of the positions shown on the Drawings. Unless shown otherwise on the Drawings, bearing pads are not inserted in vertical joints.

9.14 A strip of geotextile material, at least 500 mm wide, must be placed between the back of the facing elements and the fill material, equidistant across all joints. If shown on the Drawings, a vertical strip drain, at least 300 mm wide, must be placed behind each vertical joint and covered by a non-woven geotextile.

9.15 Sealants may only be used where shown on the Drawings or to protect the geotextile from UV degradation. Sealants (including primers) must be applied in accordance with the manufacturer's recommendations. Sealants must not be used in the following applications:

- a. for joints which will be below finished ground level, or
- b. where the RSW design requires the wall face to be free draining.

## Placement of Soil Reinforcement and Compaction of Reinforced Fill Material

- 9.16 Unless specified otherwise, the placement and compaction must be carried out in a direction parallel to the face of the structure and must be completed in stages to follow closely the erection of facing elements and placement of reinforcing elements. Each fill layer must be horizontal and uniform in thickness over the area to be filled.
- 9.17 Reinforcing elements and facing elements must not be damaged or displaced during placement and compaction of fill. Tracked machines or vehicles must not be operated directly on top of reinforcing elements which are not covered by at least 150 mm of fill material. No plant must be operated in a manner that would cause the displacement of soil reinforcement from the intended positions. Sudden breaking and sharp turning of machines or vehicles must be prohibited.
- 9.18 All vehicles and all construction equipment weighing more than 1000 kg must be kept at least 1.5 m away from the facing elements (unless an alternative distance is specified in the design). Fill material within 1.5 m of the facing elements must be compacted using one or more of the following methods:
- a vibro-tamper;
  - a vibrating plate compactor with mass not exceeding 1000 kg; or
  - a vibrating roller with a mass not exceeding 1000 kg.
- 9.19 Where a compactor cannot reach the material behind the facing panel (eg inclined faces), alternative means such as stabilisation must be used to ensure the units are adequately supported.
- 9.20 RSW fill material must be placed and compacted with a moisture content not greater than the optimum moisture content. After compaction, the absolute value of density and / or the characteristic value of density ratio of the material must not be less than the values specified in the RSW design or elsewhere in the Contract documents.
- 9.21 The maximum layer thickness and required compaction for the 3 zones within the reinforced soil block must be in accordance with Table 9.21. Refer to TS 02158.1 for maximum layer thickness and required compaction of filling material in the zone behind and above the reinforced soil block.

**Table 9.21 – Maximum layer thickness and required relative compaction**

| Zone | Extent of zone                                                                      | Maximum layer thickness and required relative compaction                                                 |
|------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| 1    | Beyond 1.5 m from RSW facing elements and up to underside of selected material zone | As specified for 'material placed in formations up to underside of selected material zone' in TS 02158.1 |

| Zone | Extent of zone                                                          | Maximum layer thickness and required relative compaction                                                                                                                                                                                                                 |
|------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2    | Beyond 1.5 m from RSW facing elements and within selected material zone | As specified for selected material zone' in TS 02158.1                                                                                                                                                                                                                   |
| 3    | Within 1.5 m from RSW facing elements                                   | As specified for zone 1 but with following exceptions: <ul style="list-style-type: none"> <li>• maximum compacted layer thickness of 150 mm, unless approved otherwise by the Principal.</li> <li>• lower limit of relative compaction of 95% <sup>(1)</sup>.</li> </ul> |

Note: 1 When tested in accordance with TS 02795.28

9.22 Synthetic soil reinforcement must not be spliced or joined in the primary strength direction. Where connections are made of synthetic soil reinforcement such as geogrids, the geogrid layers must not be spliced or joined in the primary strength direction.

9.23 Soil reinforcement must be laid horizontally on the compacted fill at the location and levels specified in the Drawings. It must be connected securely to facing elements in accordance with the Drawings. Geosynthetic reinforcement must be pulled taut before placing the overlaying fill material. The method of fill placement and compaction must ensure that slack is not introduced into the soil reinforcement as fill is placed. The condition of the soil reinforcement and the connections to the facing elements at each level must be recorded just before placing the next fill layer over it.

| WITNESS POINT 2 |                                                                                   |
|-----------------|-----------------------------------------------------------------------------------|
| Process         | Placement of fill over soil reinforcing                                           |
| Notification    | At least one working day (not less than 24 hours) prior to the placement of fill. |

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

9.25 The fixing of the soil reinforcement and placement of reinforced fill must be carried out in one plane at a time.

9.26 During construction, the earthworks fill material behind the RSW block must 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 must 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.

- 9.27 At the end of each day's operations, the top layer of fill must be shaped to permit drainage away from the face and the remainder of the RSW.

## Capping, Filter and Drainage Materials

- 9.28 Filter and drainage materials must be constructed in accordance with the Drawings and/or the manufacturer's instructions. Where granular material is used as a drainage material, the compaction of drainage material must be carried out with the same compactor and number of passes as Reinforced Fill Material. It must be constructed progressively in layers matching the Reinforced Fill Material.
- 9.29 If the surface above the RSW block is unpaved, an impermeable layer of fill material must be placed above the reinforced soil zone which prevents water infiltration into the RSW block. The material must be placed and compacted in accordance with the applicable general earthworks specification and any requirements specified in the design.
- 9.30 Filter fabric must be placed to cover all joints to prevent loss of fill through the joints. Filter fabric across a joint must be continuous along any direction, and must extend to a minimum of 200 mm to either side of the centre line of the joint.

## 10. Tolerances

- 10.1 Construction tolerances measured immediately after completion of the RSW and the application of all dead load surcharges, must comply with Table 10.1. Negative deviations are measured towards the RSW block. Where no other tolerance is given, a measurement (dimension, level, position) which falls within  $\pm 6$  mm of the required value must be deemed to be conforming. The Contractor must submit survey results, demonstrating compliance with Table 10.1, to the Principal.

**Table 10.1 – Construction tolerances**

| Element              | Tolerance                                                                                                                                                                                                                                                                                        |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reinforcing elements | within $\pm 100$ mm of the design levels and locations specified in the Drawings.                                                                                                                                                                                                                |
| Wall face            | No point on the face of the completed RSW deviates from the specified position by more than $\pm 50$ 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 wall.                                                     |
|                      | The vertical alignment of the face of the completed panel type wall must not deviate from the specified vertical inclination by more than + 5 mm, – 10 mm per metre height. For segment block type walls, vertical alignment must not deviate more than +10 mm, –10 mm per metre of wall height. |

| Element                | Tolerance                                                                                                                                                                                                                                                                                                     |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | The flatness of the wall must be such that the maximum deviation from a 4.5 metre straight-edge must not exceed $\pm 20$ mm. In the case of walls curved in plan, the horizontal deviation must be measured from a 4.5 metre long reference line, curved to the specified curvature measured at panel joints. |
|                        | The horizontal step between adjacent facing elements must not exceed 10 mm.                                                                                                                                                                                                                                   |
| Top and bottom of wall | For walls adjacent to bridge abutments, the top and bottom of the wall must be within $\pm 15$ 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 must be within $\pm 30$ mm of the design alignment specified in the Drawings.                                                                                                               |
| Level                  | The level of any point on the wall must not deviate from the specified level by more than $\pm 20$ mm, except where it is necessary to permit the tops to join neatly to adjacent structures or to result in a visually smooth alignment along the top surface.                                               |

## 11. Monitoring

- 11.1 As a minimum, the performance of RSW wall must be monitored through the measurement of the deflection of the RSW wall facings. The contractor must provide reference points (survey points) vertically on the facing at a cross-section of the wall. The top survey point must be at one metre down from the top of the wall. The bottom survey point must be at one metre up from the bottom of the wall. The rest of the survey points must 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.
- 11.2 The x, y and z co-ordinates of each survey points must be measured to an accuracy of 5 mm. Sufficient control points must be established so that vertical and horizontal movement can be measured to an accuracy of 1 mm.
- 11.3 The minimum monitoring cross-section requirements are as given in Table 11.3.

**Table 11.3 – Minimum monitoring cross-section requirements**

| Wall height | Minimum number of monitoring cross-sections                                                                                                                                   |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 must 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 must be targeted. |



| Wall height | Minimum number of monitoring cross-sections                                                                                                                   |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| > 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 must be targeted. |

- 11.4 In addition to the above, the contractor must provide additional monitoring cross-sections at high risk areas such as follows:
- wall curvature on plan – concave outwards (bowl facing backfill)
  - heavily loaded walls
  - walls that are located at a high risk area for example, close to public or heavy traffic
  - walls that are located adjacent to other structures/utilities which may be affected by the wall movement
  - walls subject to abutment/bridge horizontal loadings, and
  - walls where there is some uncertainty in the design/construction.
- 11.5 Monitoring of vertical and horizontal movement at the survey points must start as soon as the wall reaches the maximum height. The monitoring frequency must be as follows:
- initially every two weeks for two months
  - then monthly for another two months, and
  - then three monthly for a period of 2 years or any other period specified in the Contact.
- 11.6 After each measurement, the Contractor must plot the measurements on a log time scale plot and extrapolate these measurements in order to predict the position of the RSW at the end of its design life. The results of each measurement and the log time scale plot must be submitted to the Principal within 14 days of each measurement.

## 12. Certification of Construction

- 12.1 Within 10 working days of the completion of construction of RSW block, the Contractor must forward the following documentation to the Principal:
- Electronic files containing fully detailed “as-constructed” Drawings, Specifications and Test Reports in Clause 8.24 in a format acceptable to the Principal. The Drawings must also include the horizontal and vertical positions of the soil reinforcement within 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 11 must 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 specification.
- c. A certificate from the Contractor's Designer (if applicable) which confirms that the as constructed Drawings and the construction specifications and the as constructed RSW fulfil the structural integrity and serviceability criteria stipulated under the design. This certificate must be signed by a principal of the Contractor's Designer, and
- d. All guarantees and warranties required by the Contract.

| <b>HOLD POINT 7</b>   |                                                                                                                                                                                                                                                 |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Process Held          | Imposition of surcharge loading above the zone of reinforced fill material                                                                                                                                                                      |
| Submission Details    | Certificates verifying that the construction materials used and the method of construction comply with the design requirements and this specification (Clause 12.1) must be provided to the Principal prior to imposition of surcharge loading. |
| Release of Hold Point | The Principal must assess the submitted documents, prior to authorising the release of the Hold Point                                                                                                                                           |

## Annexure A Summary of Hold Points, Witness Points and Records

- a. The following is a summary of the Witness Points / Hold Points that apply to this Specification and the Records that the Contractor must submit to the Principal to demonstrate compliance with this Specification.

| Clause | Hold point                                                                               | Witness point                                   | Identified Records                                      |
|--------|------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------|
| 4.1    | 1. The manufacture of facing elements and the preparation of the foundation for the RSW. |                                                 | Quality Plan                                            |
| 7.1    | 2. Commencement of construction of the RSW.                                              |                                                 | Test certificates for RSW components                    |
| 7.5    | 3. Production of facing elements                                                         |                                                 | Design output and certification detailed in TS 02164.1  |
| 8.4    | 4. Placement of fill material                                                            |                                                 | Report of fill material test results                    |
| 9.4    | 5. Construction of base strip footings                                                   |                                                 | Foundation Inspection Report                            |
| 9.8    |                                                                                          | 1. Washing of soil reinforcement made of steel. |                                                         |
| 9.10   | 6. Construction of the second course of facing elements                                  |                                                 | Survey records for the bottom course of facing elements |
| 9.23   |                                                                                          | 2. Placement of fill over soil reinforcing      |                                                         |
| 12.1   | 7. Imposition of surcharge loading above the zone of reinforced fill material            |                                                 | Documentation in Clause 12.1                            |

## Annexure B Frequency of Testing for Each Lot (normative)

Table B shows the minimum test frequency for each lot for each material property and the test method to be used for each material property.

**Table B – Frequency of testing for each lot for each material property**

| Clause                 | Material property                                                      | Test method                                  | Minimum frequency                                                                                                                                                                      |
|------------------------|------------------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8.4, 8.9               | Angle of friction at constant volume under effective stress conditions | Test Method Q181C <sup>(1)</sup>             | 1 test per 400 m <sup>3</sup> , with a minimum of 5 tests for each type of material.<br>2 tests per 2,500 m <sup>3</sup> , with a minimum of 2 tests for each type of material         |
| 8.4, 8.9               | Grading                                                                | AS 1289.3.6.1                                | 1 sample per 200 m <sup>3</sup> or part thereof, but not less than 1 sample per layer.                                                                                                 |
| 8.4, 8.9, 8.12, 8.16   | LL and PI                                                              | TS 02795.04 and TS 02795.05                  | 1 sample per 200 m <sup>3</sup> or part thereof, but not less than 1 sample per layer.                                                                                                 |
| 8.12, 8.13, 8.14, 8.17 | pH, electrical and chemical properties                                 | As shown in Tables 8.13, 8.14, 8.15 and 8.17 | 1 sample per 400 m <sup>3</sup> or part thereof but not less than 1 sample per layer.                                                                                                  |
|                        | Relative compaction <sup>(2)</sup>                                     |                                              |                                                                                                                                                                                        |
| 9.20, 9.21             | Zones 1 and 2                                                          | In accordance with TS 02158.1                | In accordance with TS 02158.1 and TS 01572.1                                                                                                                                           |
| 9.20, 9.21             | Zone 3                                                                 | In accordance with TS 02158.1                | 1 test per 100 m <sup>2</sup> , with minimum of 1 test every two adjacent continuous layers compacted on the same day, provided that the material has uniform treatment and appearance |
| 9.20, 9.21             | Moisture content                                                       | In accordance with TS 02158.1                | In accordance with TS 02158.1                                                                                                                                                          |

Notes:

1. Prior to testing, material must be pretreated in accordance with TS 02794.02 using 3 repeated compaction cycles.
2. Samples must be taken at the time of placement of the layer. Subsequent layers must not be placed before confirming the test results of previous layers,