

Earthworks Materials

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1. Scope and application

This specification details the material properties and testing requirements for the supply of soil and other materials used to construct the embankment and the capping layer for track formation.

Embankment and capping materials used for Country Regional Network (CRN) track infrastructure shall comply with the requirements of this specification.

2. References

2.1. Australian and International Standards

AS 1141	Methods for Sampling and Testing Aggregates
AS 1289	Methods of Testing Soils for Engineering Purposes
AS 1726	Geotechnical Site Investigations
AS 3706	Methods for Testing Geotextiles
AS 4133	Methods for Testing Rocks for Engineering purposes
ASTM D720	Standard Test Method for Free-Swelling Index of Coal
ASTM D4542	Standard Test Method for Pore Water Extraction and Determination of the Soluble Salt Content of Soils by Refractometer
ASTM D4647	Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test
ASTM D5333	Standard Test Method for Measurement of Collapse Potential of Soils

Unless otherwise specified, all references relate to the latest standard versions, including amendments and relevant superseding standards.

2.2. CRN documents

CRN CS 410	Earthworks & Formation
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2.3. Other documents

Nil.

3. Embankment materials

3.1. Free draining filter material

The free draining filter material used for construction of drainage blankets shall be clean, crushed rock, river gravel or slag composed of hard, strong and durable particles to satisfy the requirements of this specification.

3.1.1. Particle size distribution

Particle size distribution of the material for drainage blankets should be in accordance with Table 1.

Table 1 – Particle size distribution for filter materials

Description	Criteria	Frequency of Testing
% passing 53.0mm sieve	100	% passing 53.0mm sieve
% passing 37.5mm sieve	90 - 100	One per 50 cubic metres of material. At least one test if less.
% passing 26.5mm sieve	20-55	One per 50 cubic metres of material. At least one test if less.
% passing 19.0mm sieve	0-5	One per 50 cubic metres of material. At least one test if less.
% passing 75µm sieve	0	One per 50 cubic metres of material. At least one test if less.

3.1.2. Maximum deleterious material

The maximum deleterious substances in the material used for drainage blanket shall be limited to the figures given in Table 2.

Table 2 – Limits for deleterious materials

Description	Criteria	Frequency of Testing
Soft and Friable Particles	5%	One per 50 cubic metres of material.
Clay Lumps	0.5%	One per 50 cubic metres of material.

3.1.3. Durability, strength and abrasion resistance

The wet/dry strength variation of the material shall be a maximum of 35% and the Los Angeles Value (Grading A), (tested according to AS 1141, Section 23) shall not be more than 30%. The point-load strength index (I_{s50}) of the material shall be a minimum of 1MPa.

3.2. General fill

General fill shall consist of material that can be compacted to not less than 95% Maximum Dry Density as determined by AS 1289 Tests 5.1.1 and 5.3.1.

Relative compaction specified must be achieved over the full depth of layer. Each compacted layer shall have a uniform thickness as recommended in the specifications. The methods of excavation, transport, depositing and spreading of the fill material shall be selected so as to ensure that the placed material in any lot is homogeneous. The material must be free of tree stumps, roots and refuse.

3.2.1. Unsuitable material

Unsuitable material shall not be used in construction of general fill.

Unsuitable material includes topsoil, peat and other highly organic soils, logs, stumps, material susceptible to spontaneous combustion, soluble material such as gypsum and salt rock, expansive soils, free draining materials susceptible to scouring, very fine sand, non-cohesive silt, organic clay and highly dispersive soils.

Dispersivity potential of soil shall be determined by either using a Pinhole Test apparatus, according to ASTM D4647 (Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test) or Crumb Test in accordance with AS 1289, Test 3.8.1. In using the Pinhole Test, any material classified other than ND1 or ND2 (non-dispersive) will be considered as unsuitable. In using Crumb Test, soils classified as Emerson Class number 1, are considered as unsuitable.

Materials with a free-swell index higher than 3%, soluble substances more than 3% and organic content more than 5% by weight of dry material, are all considered as unsuitable and shall not be used for construction of embankment.

Collapsible soils in foundation are also considered as unsuitable material and shall be treated before construction of embankment. Collapse index is determined according to ASTM D5333 - 03 (Standard Test Method for Measurement of Collapse Potential of Soils).

3.2.2. Plasticity index and soaked CBR

The general fill material shall have a minimum plasticity index of 9 and a soaked-CBR of at least 3%.

3.2.3. Frequency of testing

All recommended tests, including Atterberg Limits, Soaked CBR, Dispersivity Potential, Free Swell Index and Soluble Content shall be carried out as one test per 1000 cubic metres of the material. If the volume of the material to be used is less, at least one set of tests shall be carried out.

3.2.4. Specifications of subgrade material

All specifications and limitations provided for fill material, apply to the subgrade as well.

3.3. Structural zone fill material

The structural zone-fill material shall have higher quality than General Fill and shall comply with the specification requirements in this section.

3.3.1. Particle size distribution

The particle size distribution and minimum testing frequency of material for structural zone shall be in accordance with Table 3.

Table 3 – Particle size distribution for structural fill materials

Description	Criteria	Frequency of Testing
% passing 53.0mm sieve	80 - 100	One per 1000 cubic metres of material. At least one test if less.
% passing 2.36mm sieve	15 - 100	One per 1000 cubic metres of material. At least one test if less.
% passing 425µm sieve	5 - 70	One per 1000 cubic metres of material. At least one test if less.
% passing 75µm sieve	0 - 30	One per 1000 cubic metres of material. At least one test if less.

3.3.2. Atterberg limits

The Atterberg Limits and minimum testing frequency of material for structural zone shall be in accordance with Table 4.

Table 4 – Atterberg limits for structural fill materials

Description	Criteria	Frequency of Testing
Liquid Limit	Maximum 40	One per 1000 cubic metres of material. At least three tests if less.
Plasticity Index	Maximum 20	One per 1000 cubic metres of material. At least three tests if less.

3.3.3. Dry density and soaked CBR

The Maximum Dry Density, minimum Soaked CBR, and minimum testing frequency of material for structural zone shall be in accordance with Table 5.

Table 5 – Material compaction limits for structural fill materials

Description	Criteria	Frequency of Testing
Maximum Dry Density	Min.1.8t/m ³	One per 1000 cubic metres of material. At least three tests if less.
Minimum Soaked CBR (Standard Compaction)	Min. 8%	One per 1000 cubic metres of material. At least three tests if less.

4. Capping material

4.1. Performance requirements

Material proposed for the capping layer shall be a well graded natural or artificially-blended gravel/soil.

It shall have sufficient fines to permit it to be compacted to high densities by static or vibratory steel-tyred rollers or by ballasted pneumatic-tyred rollers.

Finished capping material shall provide a semi-impermeable layer to the underlying formation.

Materials such as natural-ridge gravel free from vegetable matter, ripped sandstones with low clay content, as well as crushed and blended tough, durable rock or slag, have been found to meet the material properties of this specification.

4.2. Material properties

Natural gravels may be combined to provide material that conforms to this specification.

Crushed rock shall include such added material as necessary for the combined material to satisfy the requirements of this specification.

The material shall have properties that conform to the following requirements.

4.2.1. Particle size distribution

Material shall be well graded with maximum nominal size of 20mm, and with typical particle size distribution as shown in Table 6.

Table 6 – Particle size distribution for capping materials

Description	Criteria	Frequency of Testing
% passing 53mm sieve	100	Three per 500 cubic metres of material. At least three tests if less.
% passing 37.5mm sieve	100	Three per 500 cubic metres of material. At least three tests if less.
% passing 26.5mm sieve	100	Three per 500 cubic metres of material. At least three tests if less.

Description	Criteria	Frequency of Testing
% passing 19.0mm sieve	95-100	Three per 500 cubic metres of material. At least three tests if less.
% passing 9.5mm sieve	-	Three per 500 cubic metres of material. At least three tests if less.
% passing 4.75mm sieve	-	Three per 500 cubic metres of material. At least three tests if less.
% passing 2.36mm sieve	30-80	Three per 500 cubic metres of material. At least three tests if less.
% passing 75µm sieve	6-10	Three per 500 cubic metres of material. At least three tests if less.

4.2.2. Atterberg limits

Material for the capping layer shall comply with the limits in Table 7.

Table 7 – Atterberg Limits for capping materials

Description	Criteria	Frequency of Testing
Liquid Limit	Maximum 30 (35 for arid areas)	Three per 500 cubic metres of material. At least three tests if less.
Plastic Limit	Maximum 20	Three per 500 cubic metres of material. At least three tests if less.
Plasticity Index	4 to 15	Three per 500 cubic metres of material. At least three tests if less.
Linear Shrinkage	Maximum 4.5%	Three per 500 cubic metres of material. At least three tests if less.

4.2.3. Dry density and soaked CBR

The maximum Dry Density and minimum Soaked CBR of the material for the capping layer shall be in accordance with Table 8.

Table 8 – Material compaction limits for capping materials

Description	Criteria	Frequency of Testing
Maximum Dry Density	Minimum 2t/m ³	Three per 1000 cubic metres of material. At least three tests if less.
Soaked CBR (95% Standard compaction with 9kg surcharge)	Minimum 50%	Three per 500 cubic metres of material. At least three tests if less.

5. Rockfill material

Rockfill material shall be made of strong, hard, durable, and clean pieces of sound rock, having the following requirements:

- Point Load Strength Index (I_{s50}) greater than 1 MPa
- Maximum Wet/Dry Strength variation of 35%
- Minimum dimensions are determined based on the application. A minimum dimension of 500 mm is required for rock facing. Smaller dimensions may be permitted for gabions and rock fills.

6. Geotextile and geogrid

These materials may be used as separation, strengthening or filtration elements in earthworks. The most appropriate uses of geosynthetics in track formation are:

- Filtration and separation
- Subgrade support.

6.1. General characteristics of geotextiles

The fibres of geotextile and thread used for joining lengths, shall consist of long-chain synthetic polymers composed of at least 95% by mass of polyolefins or polyesters. The geotextile filaments must be rot proof, chemically stable and shall have low water absorbency. Filaments must resist delamination and maintain their relative dimensional stability in the geotextile.

Non-Woven geotextiles must have filaments bonded by needle punching, heat or chemical-bonding processes. Woven geotextiles must have filaments interlaced in two sets, mutually at right angles. One set must be parallel to the longitudinal direction of the geotextile.

Geotextiles shall be free of any flaws which may have an adverse effect on their physical and mechanical properties. Geotextiles must be stabilised against ultraviolet radiation such that when tested in accordance with AS 3706.11, they shall have retained strength of at least 50% after 627 hours of test exposure.

The properties of geotextiles to be used in track projects shall be as per Table 9 and Table 10 as appropriate

Table 9 – Material Geotextile properties for subsoil drainage

Property	Test Method	Value
Tearing Strength, Trapezoidal *	AS 3706.3	200N min
Burst Strength, CBR Method *	AS 3706.4	1700N min

Property	Test Method	Value
Puncture Resistance, Drop Cone *	AS 3706.5	d ₅₀₀ = 33.5 mm Max H ₅₀ = 900 mm Min
Pore Size *	AS 3706.7	240 max
Permittivity	AS 3706.9	3.4 sec ⁻¹ min

Table 10 – Geogrid properties for subgrade reinforcement

Property	Test Method	Value
Tensile Strength, wide strip	AS 3706.2	25 kN/m min peak
Elongation at peak Strength	AS 3706.2	25% max
Burst Strength CBR Method	AS 3706.4	2800N min
Permittivity	AS 3706.9	0.12 sec ⁻¹ min

6.2. General characteristics of geogrids

A geogrid is specifically designed to provide tensile reinforcement to the track substructure. Geogrids are superior to geotextiles in this function because of their higher modulus and tensile strength and their performance is not destroyed by coarse aggregate.

The geogrid selection should be on the basis of the grading of the material in contact with it. The grid opening size is related to the maximum size of the aggregate with which it interlocks.

The recommended minimum strength is 20 kN/m transverse and 20 kN/m longitudinal to the track. The interlocking with aggregates is important. A geogrid with a square-web profile and high rigidity will perform well in interlocking with aggregate.

7. Validation requirements

7.1. Sampling

Samples of materials for laboratory testing shall be taken and handled in accordance with AS 1726, and AS 1141, Section 3 by a NATA registered laboratory.

Samples of material proposed for use shall be tested and the results considered in the final selection of material.

7.2. Test requirements for free draining filter material

The following tests (see Table 11) shall be carried out on the free-draining filter material to confirm compliance with the specified performance requirements:

Table 11 – Test requirements for free draining filter material

Requirement	Test
Particle size distribution	AS 1289 Test 3.6.1
Soft and friable particles	AS 1141.32
Clay lumps	AS 1141.30
Los Angeles Value	AS 1141.23
Particle density	AS 1141.6

7.3. Test requirements for general fill material

The following tests (see Table 12) shall be carried out on the general fill material to confirm compliance with the specified performance requirements:

Table 12 – Test requirements for general fill material

Requirement	Test
Soaked CBR (Standard compaction)	AS 1289 Test 6.1.1
Dispersion – Determination of Pin Hole Dispersivity Classification	ASTM D4647
Dispersion – Determination of Emerson Class Number of a soil	AS 1289 Test 3.8.1
Collapse Test	ASTM D5333 – 03
Free Swell Index	ASTM D720-91(2004) e1
Soil Soluble Contents	ASTM D4542-95(2001)

7.4. Test requirements for structural zone fill material

The following tests (see Table 13) shall be carried out on the structural-zone fill material to confirm compliance with the specified performance requirements:

Table 13 – Test requirements for structural zone fill material

Requirement	Test
Particle Size Distribution	AS 1289 Test 3.6.1
Liquid Limit	AS 1289 Test 3.1.1
Plastic Limit	AS 1289 Test 3.2.1
Plasticity Index	AS 1289 Test 3.3.1
Maximum Dry Density	AS 1289 Test 5.1.1
Soaked CBR (Standard compaction)	AS 1289 Test 6.1.1

7.5. Test requirements for capping material

The following tests (see Table 14) shall be carried out on the capping material to confirm compliance with the specified performance requirements:

Table 14 – Test requirements for capping material

Requirement	Test
Particle Size Distribution	AS 1289 Test 3.6.1 (Wet Sieve Procedure)
Liquid Limit	AS 1289 Test 3.1.1 or AS 1289 Test 3.9
Plastic Limit	AS 1289 Test 3.2.1
Plasticity Index	AS 1289 Test 3.3.1 AS 1289 Test 3.3.2
Linear Shrinkage	AS 1289 Test 3.4.1
Maximum Dry Density	AS 1289 Test 5.2.1
Soaked CBR	AS 1289 Test 6.1.1* *Compacted to 95% (min) Maximum Dry Density obtained by AS 1289 5.2.1 & with 9kg surcharge.

7.6. Test requirements for rockfill materials

The following tests (see Table 15) shall be carried out on the rock material to confirm compliance with the specified performance requirement:

Table 15 – Test requirements for rockfill materials

Requirement	Test
Point- Load Strength Index	AS 4133.4.1-2007
Wet/Dry Strength Variation	AS 4133.4.2

7.7. Test requirements for geotextiles and geogrids

The following tests (see Table 16) shall be carried out on geotextiles and geogrids to confirm compliance with the specified performance requirements:

Table 16 – Test requirements for geotextiles and geogrids

Requirement	Test
Elongation at Peak Strength	AS 3706.2
Tensile Strength, Wide Strip	AS 3706.2
Burst Strength, CBR Method	AS 3706.4
Puncture Resistance, Drop Cone	AS 3706.5
Pore Size Determination	AS 3706.7
Determination of Permittivity (ψ)	AS 3706.9