Division / Business Unit: Inland Rail
Function: Earthworks (Construction)
Document Type: Specification

Earthworks Materials Specification

ETC-08-03

Applicability

NSW	QLD	VIC	SMS

Publication Requirement

Internal / External

Primary Source

0-9000-PEN-00-SP-1002 – Rev 2.1

Document Status

Version #	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.3	08 Jul 20	Inland Rail & Technical Standards	Stakeholders	Manager Standards	General Manager Technical Standards 24/07/2020

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	12 May 17		First Issue
1.1	23 Nov 17	All	Revision to align with issue of ETC-08-04. Addition of section for geotextile classification and compliance. Additional update to scope following ONRSR comments, as well as clauses 4.1, 4.7 & 4.11.
1.2	25 Sep 19	1.5	Add Procedure Owner section and remove ‘Confidential’ from title page.
1.3	08 Jul 20	All	Minor revision of Sections 1–7. Addition of section for geogrid classification and compliance. Added Earthworks Materials Management Framework to Section 4.1 and flowchart to Appendix B.

Table of Contents

List of Figures

List of Tables

1 Scope and Purpose

1.1 Purpose

The purpose of this Specification is to provide earthworks material types and compliance requirements. Complying earthworks materials shall be used to construct a stable foundation and formation suitable for ballast and track to be constructed upon, along with associated earthworks for drainage elements, such that it maintains stability and meets safety and performance standards over the design life.

1.2 Scope

This Specification defines earthworks material properties for construction of railway earthworks for the Inland Rail Program (the Program).

This Specification is intended to be tailored to suit the materials available within the Program. The design information and values provided in the following sections are deemed to comply. Variation to this Specification requirements must be in accordance with Section 7. The proposed values must be consistent with design requirements and acceptance of the proposed values is at the sole discretion of the Superintendent.

This Specification allows for unconventional alternative engineered materials, such as use of stabilised materials, geosynthetics or other solutions. Proposals for use of alternative engineered materials and their compliance requirements must be in accordance with Section 7 and subject to appropriate ARTC review and acceptance. If an alternative material specification is accepted, material properties and other relevant information must be documented in a Project Specific Specification and on drawings approved by the Superintendent.

1.3 Precedence

The following order of precedence shall be adopted when undertaking construction of earthworks which form part of the Works:

1. the Drawings;
2. Project Specific Specifications;
3. this Specification;
4. ARTC standard drawings;
5. Australian Standard requirements, regulations and industry guidelines.

Where there is a discrepancy, the Contractor must request clarification in writing from the Superintendent prior to proceeding with the works containing the discrepancy.

1.4 Project Documents

The execution of earthworks in accordance with this Specification requires compliance to overarching Project and Program requirements. The Contractor’s attention is drawn to the following documents:

- The Project General Conditions of Contract.
- The Project Environmental Management Plan.
- The Project Primary Approval Document and Conditions of Approval.
- The Project Quality Plan.

1.5 Document Owner

The Manager Standards is the document owner and is the initial point of contact for all queries relating to this Specification.

2 Definitions

Unless defined otherwise in the relevant Contract, terms used in this Specification will have the following meanings assigned in Table 1 to Table 3 and Figure 1 to Figure 4.

Table 1 Contractual Definitions

Term	Definition
Approve(d)	Means approved in writing by the Superintendent.
Contract	Commercial document entered into between the Principal and the Contractor detailing the terms of the engagement of the Contractor by the Principal contractually obligated to perform the Works.
Contractor	Any partnership, joint venture, company, corporation, or trust who has entered into a Contract with the Principal to perform the Works prescribed in the Contract.
Designer	The company/individual engaged by the Principal or the Contractor to undertake design.
Design Services Agreement	Means the agreement entered in to, or to be entered in to, between the Principal and Designer for design works.
Drawing	The latest approved revision of the project drawings.
Geotechnical Engineer	A qualified geotechnical engineer, geologist or engineering geologist, with experience and knowledge in soil-structure interactions.
Principal	A client who awards a contract to a Contractor for completion of a job or project in accordance with terms of the contract.
Project	A package of works within a Program as determined by ARTC.
Program	Means the Inland Rail Program.
Project Quality Plan	Means the Contractor's Project Quality Plan (PQP) for the Project, prepared in accordance with the Program Quality Plan.
Project Specific Specification	Will mean a Specification developed by the Contractor for a project specific requirement that is not covered under the latest revisions of ARTC standards and specifications.
Quality System	A documented Quality System prepared by the Contractor in accordance with this Specification and Australian Standard for Quality System AS/NZ ISO 9001.
Rail Corridor	The rail corridor is the land on which the railway is built. It comprises all property typically bounded from fence line to fence line, or if there are no fences, everywhere within 15 m either side of the outermost parts of track, unless otherwise indicated.
Site	Means the location or portion of land related to the Project works. The site may include land both inside and outside of the rail corridor.
Specification	A Specification consists of a written document that delineates the requirements regarding the materials, products, equipment, systems, standards, workmanship and quality aspects involved with the execution of the work to be undertaken and fulfilment of the Contract. Reference to this specification document includes all other relevant documents referred to in this specification.
Standard	A consensus on what is required or should be done. A Standard consists of a written document that delineates the requirements regarding a particular material, product, process or service.

Term	Definition
Superintendent	Means the person(s) appointed by the Principal to act as the nominated Principal's Representative and includes the Superintendents Representative. In general, the Superintendent's role is to 'administer' the contract and ensure the contractual obligations are performed. Under a traditional construction contract, the superintendent has two separate and distinct roles: to act as agent for the principal; and to act as an independent certifier.
Works	Means the whole of the work to be executed in accordance with the Contract, including variations provided for by the Contract. Work includes the provision of materials unless agreed otherwise.

In addition to the definitions listed in Table 1 the following railway construction definitions appearing in this Specification will have the following meanings:

Table 2 Railway Earthworks Definitions

Term	Definition
Ballast	Ballast is a free draining coarse aggregate used to support railway tracks.
Batter	A constructed slope (cut or fill) commonly of uniform gradient.
Bench	Bench is a near horizontal break in a slope (cut or fill) to break the continuity of an otherwise long slope to improve its stability or to catch and arrest slide material. Bench crossfall and width configuration is determined by slope design.
Borrow Area/Pit	An area/pit where excavations are made for the procurement of additional material.
Bound Material	A granular material with sufficient stabilising agents added to produce a material with a significant tensile strength.
California Bearing Ratio	A measure of the load-bearing capacity of soils, typically in a re-compacted and saturated state, or in situ.
Capping Layer	A layer or layers of graded crushed rock or other engineered fill within the Formation, usually provided for the purpose of sealing the earthworks from surface water and structurally supporting the track.
Certified Materials	Materials certified as virgin materials, clean materials or suitable for the intended land use in accordance with the relevant regulatory waste classification or categorisation requirements.
Cess	The area from the edge of the ballast profile to either the crest of the embankment or the toe of the cutting.
Cess Drain	The surface drain outside the sleepers to drain water from the ballast.
Compaction	The process whereby the dry density of a material is increased by mechanical or other means.
Compacted Lift Thickness	The lift thickness of a placed fill material after compaction.
Contaminated Materials	Any material containing a chemical substance(s) at above background levels and posing, or potentially posing, a risk of harm to human health, the environment, water supply or agriculture, based on applicable legislation and standards.
Cut/Cutting	Earthworks constructed by excavation.
Design CBR	The Californian Bearing Ratio (CBR) determined by design for nominated test conditions using statistical analysis or other appropriate methods.

Term	Definition
Earth Excavation	Rippable or excavatable material. All materials such as earth, clay, sand, gravel, weathered or loose rocks which can be removed by ripping or excavation, without regard to stockpiling, loading or carting, as defined for bulk excavation and confined excavation non-rippable materials in the Earthworks Construction Specification ETC-08-04.
Earth Fill	Fill material consisting of fine and coarse particles evenly distributed throughout the layer filling voids so that when compacted produces a dense stable embankment. As larger sized rock fragments are added to an earth fill, at some point the "earth fill" becomes a "rock fill" with predominantly coarse-grained gravel, cobble and boulder sized rock fragments.
Earthworks Materials Management Framework	The framework for reuse of site won or generated earth and rock materials, where the reuse: • Is genuine, rather than a means of waste disposal. • Is beneficial or fit for purposes. • Will not cause harm to human health, the environment. • Will not adversely impact current and future rail infrastructure, maintenance or operations.
Embankment	Earthworks constructed by placement of fill for the purpose of constructing an overlying formation.
Fill	Earth or rock materials placed as a part of the construction process.
Formation	Earthworks constructed by material, usually capping and structural fill, placed between the Subgrade Level and Formation Level below the ballast (refer to Figure 4).
Formation Level	The level of the formation surface, also referred to as the top of formation.
Foundation	The soil or rock material immediately underlying and supporting any earthworks undertaken as part of the Works.
General Earth Fill	An earth fill material complying with Section 4.4 of this Specification.
General Earth Fill Lower	The bottom portion of a Zoned Embankment (refer to Figure 2).
General Earth Fill Upper	The top portion of a Zoned Embankment (refer to Figure 2).
Geocomposite	A product combining a geogrid layer overlaying a geotextile layer for reinforcement, separation and filtration applications.
Geosynthetics	The range of polymeric products comprising eight main categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells and geocomposites.
Geosynthetic Reinforced Embankment	An embankment that utilises geosynthetics to improves its stability. Geosynthetic reinforcement may be used for the following applications: • As embankment basal reinforcement (e.g. load transfer, piled embankments and platforms). • Within reinforced embankment (batter slope ≤ 70°).
Geosynthetic Reinforced Soil Structure	A structure that utilises geosynthetics in its design so as to form a stable composite structure. Geosynthetic reinforcement may be used for the following applications: • Retaining walls. • Within Reinforced Soil Structure with batter slope ≥ 70°.
Homogenous Embankment	Earthworks constructed by placement of a uniform fill material. Not a Zoned Embankment.
Layer	One or more uniformly compacted lifts of a given material.

Term	Definition
Land Use Criteria	The maximum concentration of contaminants recommended for safe use under a generic land use scenario applicable to the site as outlined in the National Environment Protection (Assessment of Site Contamination) Measure 1999 Amendment 2013.
Lift	The placement of a fill material within the compacted thickness limits in this Specification.
Loose Lift Thickness	The thickness of a placed fill material prior to compaction.
Lot	A portion of material or a section of the Works which has been constructed and supplied under uniform conditions and contains material of uniform quality and is homogeneous with only minor and random variation in characteristics (such as density, moisture, thickness, material type, colour, and finish) or a single finished item of work which includes several materials or work types (e.g. construction of a culvert in place).
Main line	The line normally used for running trains through and between locations.
Maximum Dry Density	The dry density which can be achieved under a specified compaction effort at the Optimum Moisture Content.
Moisture Ratio	The ratio of moisture content to Optimum Moisture Content.
Optimum Moisture Content	The percentage of moisture in a soil at which the soil can be compacted to its greatest density for a specified amount and type of compaction effort.
Outer Zone	The portion of a Zoned Embankment encapsulating structural fill and general earth fill (refer to Figure 2).
Reinforcement	The improvement of the earthworks by introducing a geosynthetic to enhance lateral restraint or bearing capacity using interlocking of particles.
Rock Fill	A material, meeting the requirements of Section 4.7, which when placed, produces an embankment deriving its stability from the mechanical interlock of the coarser particles, rather than from the compaction of finer material around the coarser particles. Rock fill may contain large open voids.
Select Fill	Material for use adjacent to structures or in other distinct applications that require specific properties defined for that purpose.
Siding	A section of railway track, connected to a running line or another siding, on which rolling stock can be placed clear of the running line and normally used for purposes such as stabling, loading, rolling stock maintenance or passing of trains.
Spoil	Material surplus to the Contract requirements which must be managed onsite or disposed of off the Site, as per Earthworks Materials Management Framework (Appendix B).
Stabilisation	The permanent physical and chemical alteration of materials to enhance their physical properties. Stabilisation binders include, but are not limited to, granular, salts, organic and polymer compounds, hydrated lime, Portland Cement, slag, fly ash, bitumen, and combinations thereof.
Stripped Surface Level	The ground surface after clearing and grubbing and topsoil stripping operations have been completed.
Structural Fill Layer	A layer or layers of engineered fill, usually placed to provide a gradational structural support zone between the Subgrade Level and Capping Layer.
Subgrade Level	The finished surface of an embankment or cutting upon which the formation is constructed.
Surplus	That which remains when use or need is satisfied.

Term	Definition
Topsoil	The upper most layer of the soil usually dark in colour and rich in organic material.
Track	The infrastructure upon which rolling stock travels. Track can be designated as uni-directional or bi-directional. Track is formed through the combination of rails, rail connectors, sleepers, ballast, points, crossings, and substitute devices where used. Also referred to as the Track Structure (refer to Figure 4).
Unsuitable Material	All material identified as unsuitable, as defined in Section 4.11, for use as a foundation for earthworks or structures or for use as fill material in its present position or condition in consideration of both geotechnical and environmental aspects.
Waste	Waste means any: (a) discarded, rejected, unwanted, surplus or abandoned matter; or (b) otherwise discarded, rejected, unwanted, surplus or abandoned matter intended for: (i) recycling, reprocessing, recovery, reuse, or purification by a separate operation from that which produced the matter; or (ii) sale, whether of any value or not (National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998).
Weighted Plasticity Index	Defined as the value of the Plasticity Index (PI) times the percent passing the 0.425 mm sieve.
Zoned Embankment	An embankment comprised of zones of different types of fill materials (refer to Figure 2).

The abbreviations listed below where used in the Specification, will have the following meaning:

Table 3 Abbreviations

Abbreviation	Meaning
ARTC	Australian Rail Track Corporation
AS	Australian Standard
ASTM	American Society for Testing and Materials
BoD	Basis of Design
BS	British Standard
CBR	California Bearing Ratio
D_{50}	Particle size represented by the 50% passing, AS 1289.3.6.1
D_{85}	Particle size represented by the 85% passing, AS 1289.3.6.1
EN	European Standard
EOS	Equivalent Opening Size, AS 3706.1, AS 3706.7 or EN ISO 12956
EOTA	European Organisation for Technical Assessment
G Rating	Geotextile strength rating = $(L \times h_{50})^{1/2}$
h_{50}	Drop cone puncture resistance (mm) of the geotextile material, AS 3706.5
HDPE	High Density Polyethylene
ISO	International Standard
ITP	Inspection Test Plan

Abbreviation	Meaning
L	Burst strength (N) of geotextile material, AS 3706.4
MDD	Maximum Dry Density
MR	Moisture Ratio
NATA	National Association of Testing Authorities
NEPM	National Environmental Protection (Assessment of Site Contamination) Measure
OMC	Optimum Moisture Content
PET	Polyester (polyethylene terephthalate)
PI	Plasticity Index
PP	Polypropylene (also known as polypropene)
PQP	Project Quality Plan
Q_{100}	Flow rate through the geotextile material, in $l/m^2/s$, under 100 m constant head conditions, AS 3706.9
R_c	Reduction factor for creep
R_d	Resistance to installation damage
R_m	Reduction factor for manufacture
R_{uv}	Resistance to UV
RMS	Roads and Maritime Services - NSW
SMDD	Standard Maximum Dry Density
T_s	Tensile Strength
UTS	Ultimate Tensile Strength
Ψ	Permittivity of the geotextile material, in S^{-1}, under 100 m constant head conditions, AS 3706.9

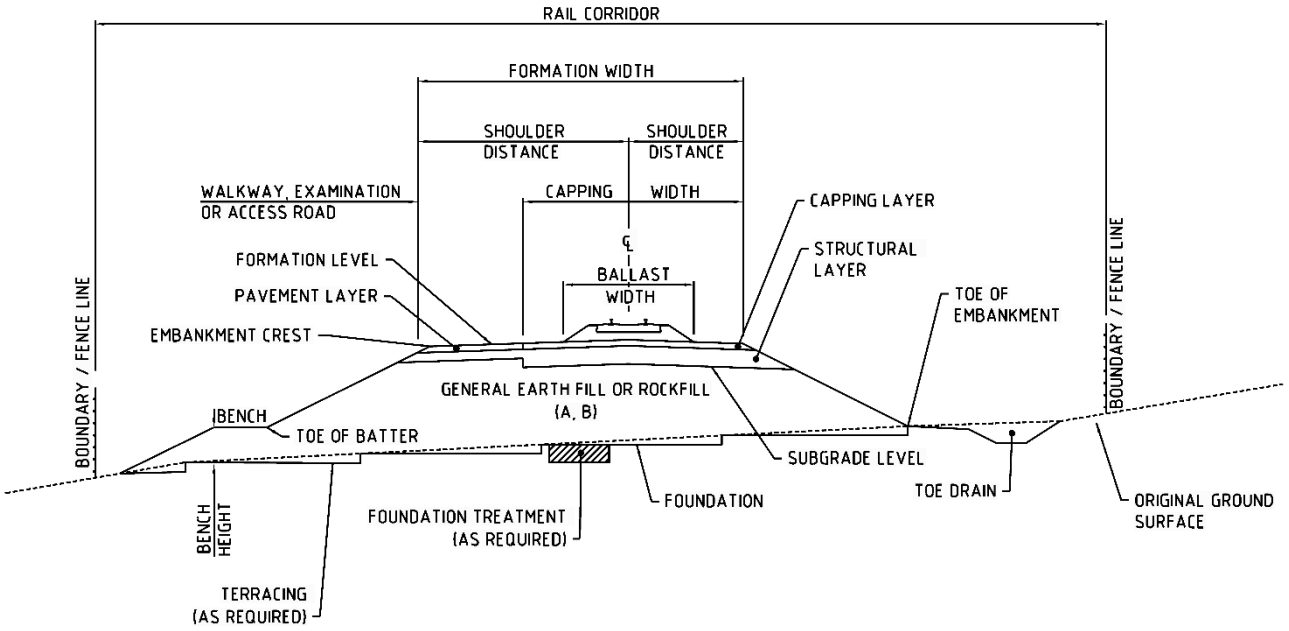

Figure 1 Schematic of Homogeneous Embankment Cross Section

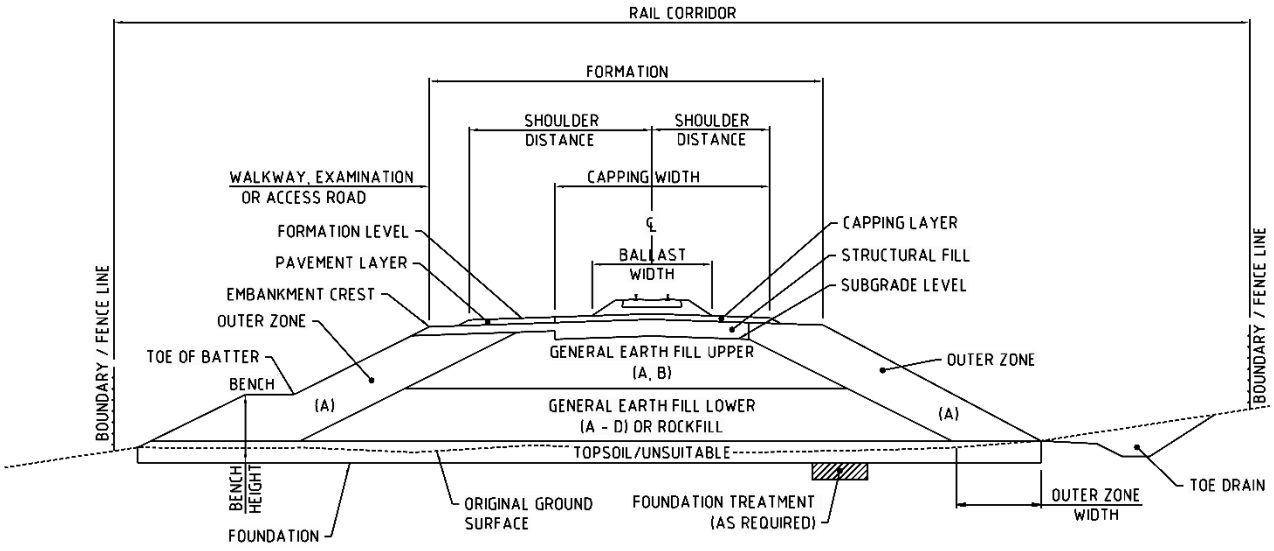

Figure 2 Schematic of Zoned Embankment Cross Section

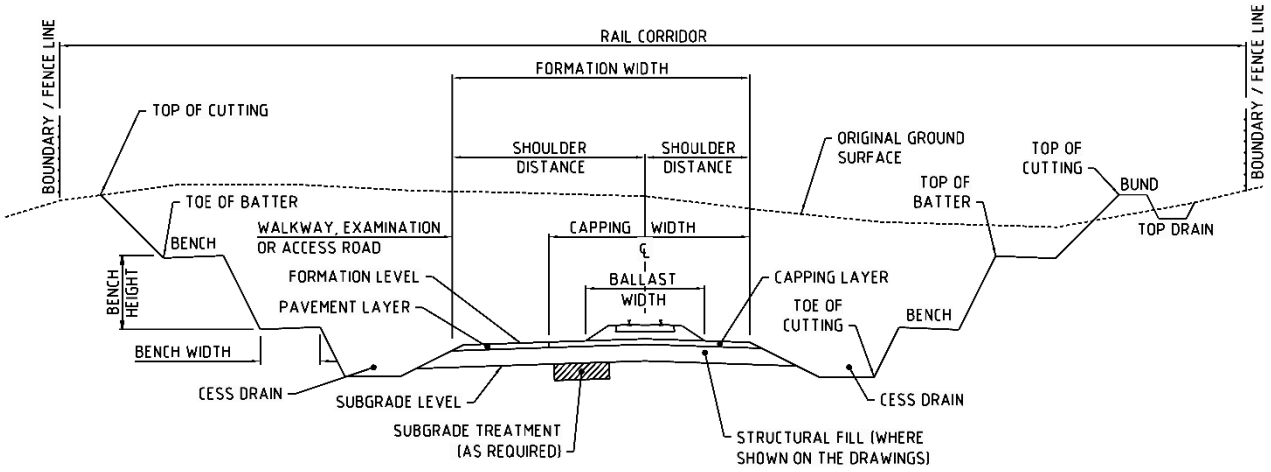

Figure 3 Schematic of Cutting Cross Section

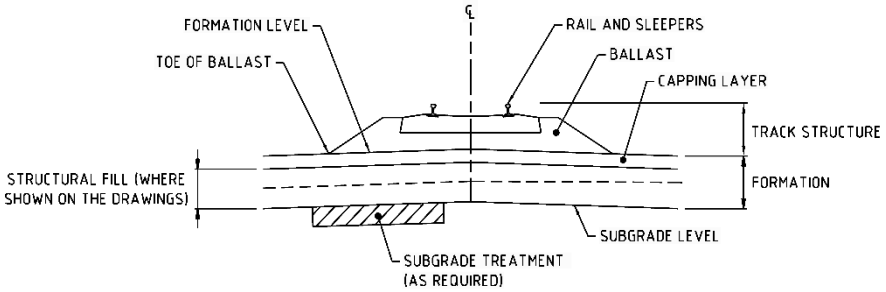

Figure 4 Schematic of Formation and Track

3 Codes and Standards

All design, materials, equipment, workmanship and installations must comply with the latest revision of the Project Standards and Specifications, ARTC Engineering Standards, relevant rail authorities and Australian Standards (AS) relating to the relevant element or component of Works unless otherwise noted in this Specification.

The following codes and standards apply for the Project, and any discrepancy between standards and this Specification must be referred to the Superintendent for clarification.

AS 1012	Methods of testing concrete
AS 1141	Methods for sampling and testing aggregates
AS 1289	Methods of testing soil for engineering purposes
AS 1672	Building Limes
AS 1726	Geotechnical Site Investigations
AS 2001	Methods of test for textiles
AS/NZS 2041	Buried Corrugate Metal Structures
AS 2159	Piling—Design and Installation
AS 2758	Aggregates and rock for engineering purposes
AS 3705	Geotextiles—Identification, marking and general data
AS 3706	Geotextiles—Methods of test
AS/NZS 3725	Design for installation of buried concrete pipes
AS 3972	General purpose and blended cements
AS 4133	Methods of testing rocks for engineering purposes
AS 4489	Test Methods for Limes and Limestones
AS 5101	Methods for preparation and testing of stabilised materials
AS 7638	Railway Earthworks
AS/NZS ISO 9001	Quality management systems - requirements
ASTM D1603	Standard Test Method for Carbon Black Content in Olefin Plastics
ASTM D4355	Standard Test Method for Determination of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc-Type Apparatus
ASTM D4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D5321	Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
ASTM D5818	Standard Practice for Exposure and Retrieval of samples to Evaluate Installation Damage of Geosynthetics
ASTM D6637	Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

ASTM D7737	Standard Test Method for Individual Geogrid Junction Strength
BS 8006-1	Code of practice for strengthened/reinforced soils and other fills
EN ISO 10319	Geosynthetics—Wide-width tensile test
EN ISO 12956	Geotextiles and geotextile-related products—Determination of the characteristic opening size
EOTA TR41	Non-reinforcing hexagonal geogrid for the stabilization of unbound granular layers by way of interlock with the aggregate
RMS T102	Pre-treatment of road construction materials by compaction
RMS T103	Pre-treatment of road construction materials by artificial weathering

The latest ARTC Engineering Standards and Codes of Practice are available from www.artc.com.au/.

4 Earthworks Materials

4.1 General

The Contractor must:

- Only use earthworks materials approved for use by the Superintendent. Earthworks materials may include site won earthworks materials and waste material that has been confirmed as suitable for the proposed use in accordance with relevant state authority environmental requirements, in consideration of requirements relating to waste minimisation and classification, geotechnical and environmental properties.
- All earthworks materials must comply with relevant landuse criteria for contaminants.
- Stockpile, test (to Australian Standards) and gain approval of all materials in accordance with their classification prior to placement.
- Ensure all earth fill materials have a uniform grading and must not be gap graded between the coarse limit of the grading envelope to the fine limit of the grading envelope, or vice versa, unless specified otherwise.
- Undertake appropriate testing of all construction material sources to confirm compliance to this Specification.
- Where surplus earthworks materials are proposed to be reused, comply with the requirements of the Earthworks Materials Management Framework in Appendix B.
- Evaluate the suitability of non-potable water by field and laboratory testing at the discretion of and approved by the Superintendent.
- Ensure saline water with chemical composition exceeding the limits specified in AS 2159 is not used in fill material where steel elements or steel reinforced concrete are buried, or where vegetation is to be established.

Subgrade materials must be tested in accordance with General Earth Fill CBR requirements.

Prior to construction, all compliance tests must be completed for each material type and source. Test reports must not be older than 12 months. Classification conformance criteria must be determined by sampling of sources, stockpiles and Lots. Placement conformance criteria must be determined by appropriate test methods post placement.

Embankments must be comprised of materials derived from excavated cuts, borrow pits, quarries and other approved sources.

All variations from the material requirements outlined in Section 4.2 to Section 4.10 must be specified in accordance with Section 7.

4.2 Capping Material

Capping material must be a well-graded natural or artificially blended gravel/soil. It is required to have sufficient fines to allow for compacting to high densities by static or vibratory steel-tyred rollers or by ballasted pneumatic-tyred rollers. Capping material must be capable of providing structural support to the ballast layer and shedding water from the ballast away from the formation.

Capping material must comply with the following Table 4 requirements unless varied by design.

Table 4 Capping Material Requirements

Criteria	Test Method[4]	Compliance
Classification		
Artificial Weathering[1,5]	RMS T103	Pre-treatment
Repeated Compaction[1,5]	RMS T102	Pre-treatment
Particle Size Distribution	AS 1289.3.6.1	
% Passing 26.5 mm sieve		100
% Passing 19.0 mm sieve		80–100
% Passing 9.5 mm sieve		55–100
% Passing 2.36 mm sieve		30–70
% Passing 425 μm sieve		12–40
% Passing 75 μm sieve		5–25
Particle Shape	AS 1141.14	< 30% passing 2:1 caliper ratio
Flakiness Index	AS 1141.15	≤ 40
Wet/Dry Strength	AS 1141.22	≥ 85 kN wet < 35% variation
Liquid Limit	AS 1289.3.1.1 or 3.1.2	≤ 30 (35 for arid areas)
Plastic Limit	AS 1289.3.2.1	≤ 20
Plasticity Index	AS 1289.3.3.1 or 3.3.2	6–12 (6–15 for arid areas)
Linear Shrinkage	AS 1289.3.4.1	3.0–7.5
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1	140–360
Maximum Dry Density	AS 1289.5.1.1	≥ 2.0 t/m^3
California Bearing Ratio[2]	AS 1289.6.1.1/5.1.1 4 day soaked, 9 kg surcharge, to 100% SMDD at OMC	≥ 50%
Classification test frequency[3]		1 test per 1,000 t
Permeability		
Permeability	AS 1289.6.7.1	< 5 × 10^{-7} m/s
Permeability test frequency[3]		Min. 2 tests per source material

Notes:

1 *Material that is susceptible to break down or fracturing during compaction must be subject to pre-treatment. Tests performed post placement for conformity with this table do not require pre-treatment.*

2 *CBR to be determined by design.*

3 *Refer to Section 7.2 for variations to test frequencies.*

4 *Refer to Section 7.3 for alternative test methods.*

5 *These tests to be completed prior to construction works (classification conformance) and may be applied during the construction works at the discretion of the Superintendent.*

4.3 Structural Fill Material

Structural fill must be a material with properties which when placed, provides a gradational support zone over the underlying material. Structural fill is typically used to provide a stable formation for the support of the track infrastructure and a stable construction platform for the placement, compaction and maintenance of the capping layer and track.

Structural fill material must comply with the following Table 5 requirements unless varied by design.

Table 5 Structural Fill Material Requirements

Criteria	Test Method[6]	Compliance
Classification		
Repeated Compaction[1,7]	RMS T102	Pre-treatment
Particle Size Distribution	AS 1289 Clause 3.6.1	
% Passing 75 mm sieve		100
% Passing 53.0 mm sieve		80–100
% Passing 2.36 mm sieve		15–100
% Passing 425 μm sieve		10–70
% Passing 75 μm sieve		5–30
Liquid Limit	AS 1289.3.1.2	≤ 40
Plasticity Index	AS 1289.3.3.1	≤ 20
Wet/Dry Strength[7,8]	AS 1141.22	≥ 85 kN wet < 35% variation
Emerson Class[7]	AS 1289.3.8.1	≥ 3
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1	≤ 800
Maximum Dry Density[7]	AS 1289.5.1.1	≥ 1.8 t/m^3
California Bearing Ratio[2]	AS 1289.6.1.1/5.1.1 4-day soaked[3], 9 kg surcharge[4], to 100% SMDD @ OMC	≥ 8%
Classification test frequency[5]		1 test per 2,000 t

Notes:

1 *Material that is susceptible to break down or fracturing during compaction must be subject to pre-treatment. Tests performed post placement for conformity with this table do not require pre-treatment.*
2 *CBR to be determined by design.*
3 *Period (number of days) of CBR soaking may be varied according to climatic and drainage conditions and the embankment design.*
4 *Surcharge may be increased in accordance with AS 1289.6.1.1.*
5 *Refer to Section 7.2 for variations to test frequencies.*
6 *Refer to Section 7.3 for alternative test methods.*
7 *These tests to be completed prior to construction works (classification compliance) and may be applied during the construction works at the discretion of the Superintendent.*
8 *Wet/dry Strength to be tested when 9.5 mm fraction exceeds 30%.*

4.4 General Earth Fill Material

The purpose of general earth fill is to provide a stable embankment for the support of the track infrastructure and a stable construction platform for the placement, compaction and maintenance of the structural fill layer, capping layer and track superstructure.

Selection of fill materials must be appropriate to the adopted design and performance expectations. General earth fill materials must comply with the following Table 6 requirements unless varied by design.

The outer zone material for a zoned embankment (Figure 2) must be durable, erosion resistant material (General Earth Fill Type A). The general earth fill upper zone must be general earth fill Type A and Type B. The lower zone may be general earth fill (Type A–D) or rockfill in accordance with their respective placement depth criteria.

General earth fill materials are to be compacted using the compacted layer method with density compliance measured using relative compaction tests or using a project specific method specification where the performance is demonstrated by a compaction trial. The thickness of a single stone must be not less than one-third its length and the maximum size of a single stone must not exceed two-thirds of the layer thickness.

Table 6 General Earth Fill Material Requirements

Criteria	**Test Method[5]**	**Compliance**				
		Homogenous Embankment	**Zoned Embankment**			
			A	**B**	**C**	**D**
Classification						
Particle Size Distribution	AS 1289.3.6.1					
% Passing 150 mm sieve		100	100	100	100	100
% Passing 75.0 mm sieve		100	100	80–100	80–100	80–100
% Passing 37.5 mm sieve		60–100	80–100	60–100	60–100	
% Passing 75 μm sieve		15–30	15–30	8–40	< 50	
Plasticity Index	AS 1289.3.3.1	7–30	7–30	7–30	≤ 50	≤ 50
Weighted Plasticity Index	AS 1289.3.6.1 /3.3.1	500–1200	500–1200	< 2200	< 3200	< 4000
Emerson Class	AS 1289.3.8.1	≥ 3	≥ 3	≥ 3	No criteria	
California Bearing Ratio	AS 1289.6.1.1 /5.1.1 4-day soaked[1], 9 kg surcharge[2], to equivalent compaction level[6] of 95% SMDD @ OMC	≥ 3%			≥ 1%	

Criteria	Test Method[5]	Compliance				
		Homogenous Embankment	Zoned Embankment			
			A	B	C	D
Classification test frequency[3]		1 test per 5,000 t			1 test per 10,000 t	
Closest depth below Formation Level (m)[4]		0.35	0.35	1.0	1.5	2.0

Notes:

1 *Period (number of days) of CBR soaking may be varied according to climatic and drainage conditions and the embankment design.*
2 *Surcharge may be increased in accordance with AS 1289.6.1.1.*
3 *Refer to Section 7.2 for variations to test frequencies.*
4 *Closest depth below Formation Level may be varied by geotechnical design and supporting documentation.*
5 *Refer to Section 7.3 for alternative test methods.*
6 *Equivalent Compaction Level is provided as coarse materials may not be able to be tested using standard test methods, alternative test methods (Note 5) are to be nominated to demonstrate general compliance to these compaction levels.*

4.5 Select Fill Adjacent to Structures

Compacted select fill material must be placed adjacent to structures where the fill depth is greater than 3 m. The select fill must be durable and not disintegrate in water or when exposed to the weather, and must comply with Table 7 requirements unless varied by design. At depths equal to or less than 3 m, fill material must comply with Table 5 of this Specification.

Table 7 Select Fill Material Requirements

Criteria	Test Method[3]	Compliance
Classification		
Artificial Weathering[1,4]	RMS T103	Pre-treatment
Repeated Compaction[1,4]	RMS T102	Pre-treatment
Particle Size Distribution	AS 1289.3.6.1	
% Passing 53.0 mm sieve		100
% Passing 2.36 mm sieve		< 50
% Passing 75 μm sieve		< 15
Liquid Limit	AS 1289.3.1.2	≤ 30
Plasticity Limits	AS 1289.3.2.1	≤ 20
Plasticity Index	AS 1289.3.3.1	6–15
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1	180–300
Maximum Dry Density[4]	AS 1289.5.1.1	≥ 2.0 t/m^3
California Bearing Ratio	AS 1289.6.1.1/5.1.1 4-day soaked, 9 kg surcharge, to 100% SMDD @ OMC	≥ 50%

Criteria	Test Method[3]	Compliance
Particle Density[4]	AS 1141.6.1	≥ 2.6 t/m^3
Wet/dry Strength[4,5]	AS 1141.22	≥ 85 kN wet < 35% variation
Aggregate Crushing Value[4]	AS 1141.21	≤ 30%
Aggregate Flakiness Index[4]	AS 1141.15	≤ 40%
Degradation Factor[4]	AS 1141.25	≥ 50
Weak Particles[4]	AS 1141.32	≤ 0.5%
Classification test frequency[2]		1 test per 500 t

Notes:

1 Material that is susceptible to break down or fracturing during compaction must be subject to pre-treatment. Tests performed post placement for conformity with this table do not require pre-treatment.

2 Refer to Section 7.2 for variations to test frequencies.

3 Refer to Section 7.3 for alternative test methods.

4 These tests to be completed prior to construction works (classification compliance) and may be applied during the construction works at the discretion of the Superintendent.

5 Wet/dry Strength to be tested when 9.5 mm fraction exceeds 30%.

4.6 Bedding Sand

Bedding sand for pipes, culverts and other miscellaneous structures must be well graded natural or crushed quarry product sands sourced from designated sources, free from organic or other materials harmful to pipes, concrete, structures and the environment and be complying with Table 8 requirements unless varied by design.

Table 8 Bedding Sand Material Requirements

Criteria	Test Method[2]	Compliance
Classification		
Particle Size Distribution	AS 1289.3.6.1	
% Passing 6.7 mm sieve		100
% Passing 0.075 mm sieve		0–20
Plasticity Index	AS 1141.23	≤ 30%
Test frequency[1]		Two per source

Notes:

1 Refer to Section 7.2 for variations to test frequencies.

2 Refer to Section 7.3 for alternative test methods.

4.7 Rock Fill

Rock fill derives its stability from mechanical interlock and requires a method specification for compliance. Rock fill must be strong, hard durable rock obtained from sources approved by the Superintendent and must comply with Table 9 requirements unless varied by design.

Table 9 Rock Fill Material Requirements

Criteria	Test Method[2]	Compliance
Classification		
Particle Size Distribution	Visual assessment for mechanical interlock and size distribution.	
% Passing 600 mm		100
% Passing 4.75 mm		0–10
Point Load Test	AS 4133.4.1	≥ 1.0 MPa
Particle Density	AS 1141.6.1	≥ 2.3 t/m
Wet/dry Strength	AS 1141.22	≥ 85 kN wet < 35% variation
Secondary Mineral Content	AS 1141.26	< 20%
Particle Shape	Visual Assessment	The thickness of a single stone must be not less than one-third its length
Test frequency[1]		1 test per 5,000 t
Closest depth below Formation Level (m)[3]		1.5

Notes:

1 Refer to Section 7.2 for variations to test frequencies.

2 Refer to Section 7.3 for alternative test methods.

3 Closest depth below Formation Level may be varied by geotechnical design and supporting documentation.

4.8 Rock Protection

Rock protection must be clean, sound, dense and durable rock that will not disintegrate in water or when exposed to the weather. Rock protection is to comply with the requirements of Table 9 Rock Fill Material Requirements, with the exception of grading and particle shape. Rock protection should be non-acid forming, angular, blocky and well graded with dimensions ranging nominally from 100 mm to 1000 mm. The thickness of a single stone must be not less than one-third its length. Rock protection may be used for protecting embankments and structures from scour and erosion. Rock protection must be obtained from sources approved by the Superintendent.

4.9 Drainage Blanket Material

Drainage blanket material must be durable, not disintegrate in water or when exposed to the weather, and must comply with Table 10 requirements unless varied by design. The drainage blanket material must be spread in uniform lifts to achieve the specified compacted layer thickness in such a manner as to avoid damage to geosynthetics or structures.

Table 10 Drainage Blanket Material Requirements

Criteria	Test Method[2]	Compliance
Classification		
Particle Size Distribution	AS 1141.11, AS 1141.12	
% Passing 63.0 mm sieve		100
% Passing 37.5 mm sieve		20–100
% Passing 26.5 mm sieve		0–55
% Passing 19.0 mm sieve		0–5
% Passing 75 μm sieve		0–0.5
Los Angeles Value (Grading A)	AS 1141.23	≤ 30%
Particle Shape	AS 1141.14	< 30% passing 2:1 caliper ratio
Flakiness Index	AS 1141.15	≤ 40
Particle Density	AS 1141.6.1	≥ 2.3 t/m^3
Water Absorption	AS 1141.6.1	≤ 2%
Wet/dry Strength	AS 1141.22	≥ 100 kN wet < 25% variation
Test frequency[1]		One per source

Notes:

1 Refer to Section 7.2 for variations to test frequencies.

2 Refer to Section 7.3 for alternative test methods.

4.10 Other Drainage Materials

All other drainage materials, including controlled low strength materials (CLSM, Appendix A of AS 3725), filter material and lean mix concrete (e.g. 5 MPa concrete), must be specified in accordance with the relevant Australian Standards (such as AS 2041 and AS 3725).

4.11 Unsuitable Material

4.11.1 General

The following materials are deemed unsuitable materials and must not be used in the constructed works unless otherwise treated and approved by the Superintendent in accordance with the Earthworks Construction Specification ETC-08-04.

4.11.2 Inherently Unsuitable

Inherently unsuitable materials are:

- Materials susceptible to piping, such as fine single sized sand, windblown sand and non-cohesive silt.
- Materials containing high organic content, vegetable matter, large rocks, gypsum, debris, or other materials that could cause the fill not to compact to specification.
- Organic soils with Unified Soil Classifications of Pt, OH, or OL (AS 1726).
- Contaminated materials or prescribed waste materials as classified by relevant legislation, with the exception of materials deemed suitable from a contamination and geotechnical perspective.

4.11.3 Unsuitable Materials by Virtue of Position

Unsuitable materials by virtue of position are soil having insufficient strength to carry the loads that will be superimposed on the completed fill without excessive settlement, swell, erosion or loss of stability.

4.11.4 Unsuitable by Moisture Content

Unsuitable materials by moisture content will be materials not meeting the specified moisture requirements or having a moisture content that may adversely impact the Works.

4.12 Stabilised Material

A Project Specific Specification for the use of stabilised materials must be developed which includes, but not limited to:

- Results and details of laboratory testing (test methods to demonstrate short and long term performance criteria).
- Stabilisation method (plant mixed or in situ).
- Stabilisation trial sections and Quality Assurance / Quality Control procedures to meet requirements of this Specification and the Earthworks Construction Specification ETC-08-04.
- Alternative test methods (Section 6.3) for stabilised material may be nominated as part of the Project Quality Plan (PQP).

The Project Specific Specification for stabilisation must be submitted to the Superintendent for approval prior to any stabilising work commencing.

Materials may be chemically stabilised by an approved binder(s) to produce a stabilised material. The design criteria for stabilised fill must be determined based on meeting the long-term design performance criteria. Chemical stabilisation may include lime, cement, bitumen, polymers or other proprietary products. In addition to CBR strength requirements, Uniaxial Compressive Strength (AS 1141.51 or AS 5101.4) must be < 1.5 MPa at minimum 28-days curing and 4-hour soak using standard compactive effort to prevent cracking and preclude bound materials from within the formation.

The stabilising agent must be determined based on laboratory mix design testing to confirm the percentage of binders added to a material to meet the specified design criteria.

Bulk lime for stabilisation must comply with requirements of hydrated or quick lime (AS 1672) with a minimum Calcium Hydroxide ($Ca(OH)_2$) of 85% (AS 4489.6.1).

Bulk cement for stabilisation must comply with requirements of AS 3972, Type GP (General Purpose) or GB (General Blended) cement.

Water used for stabilisation must be of potable standard unless the chemical composition of non-potable water is demonstrated to not adversely affect stabilisation.

5 Geosynthetics

5.1 General

The requirements of this section are applicable to geosynthetics for use as separation, filtration, stiffening and reinforcing elements in earthworks and miscellaneous structures (such as culverts, pipe trenches and drainage blankets). This section does not apply to geosynthetic reinforced embankments or geosynthetic reinforced soil structures (RSS) which require compliance to detailed designs for those elements.

Geosynthetics shall not be placed less than 400 mm below the Formation Level, with the possible exception at stations, turnouts, and other discrete sections of track not likely to be subject to rail bound (mechanised) formation renewal.

Where geocomposites or both geogrids and geotextiles are specified at the same level, geotextiles must be placed below geogrids, and the geotextile layer shall be compliant with Strength Class C and Filtration Class I or II in accordance with Tables 11 and 12 respectively.

A certificate demonstrating compliance with this Specification shall be provided by the Contractor to the Superintendent prior to use for each geosynthetic used. All test results on which the test certificates are based shall not be more than one year old, measured from the date of supply.

A lot size for geosynthetics shall be 10,000 m^2 or part thereof. The Superintendent or the Design Drawings may require additional conformance testing of representative samples from lots by the Contractor.

5.2 Geotextiles

5.2.1 General

The requirements of this section are applicable to geotextiles for use as separation or filtration elements in earthworks.

Unless specified otherwise on the Drawings, geotextiles must meet the following requirements:

- The fibres of the geotextile and thread used in joining lengths must 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 must 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 must be free of any flaws which may have an adverse effect on the physical and mechanical properties of the geotextile.
- Geotextiles must be stabilised against ultraviolet radiation such that when tested in accordance with AS 3706.11 they must have retained strength of at least 50% after 672 hours of test exposure. A certificate not more than a year old must be provided by the manufacturer.
- Testing of geotextiles must be undertaken using test methods in accordance with AS 3706.

5.2.2 Strength Class

Geotextiles, where required for separation or filtration, are referenced by a Strength Class which must meet the requirements of Table 11.

Where a Strength Class is specified on the Drawings for a specific installation, a geotextile with a Strength Class at least equal to that stated must be used and the Contractor must check the strength requirements for the specific application complies with the requirements of the Earthworks Construction Specification.

Table 11 Geotextile Strength Classifications

Strength Class	Elongation[1] AS 3706.4	Grab Strength (N) AS 2001.2.3.2	Tear Strength (N) AS 3706.3	G Rating AS 3706.4
A	≥ 30%	500	180	900
	< 30%	800	300	1350
B	≥ 30%	700	250	1350
	< 30%	1100	400	2000
C	≥ 30%	900	350	2000
	< 30%	1400	500	3000
D	≥ 30%	1200	450	3000
	< 30%	1900	700	4500
E	≥ 30%	1600	650	4500

Notes:

1 Elongation to differentiate woven from non-woven geotextiles must be the elongation % at puncture corresponding to maximum puncture strength determined in accordance with AS 3706.4. In general, woven geotextiles will puncture at elongations less than 30% and non-woven geotextiles will puncture at elongations equal to or greater than 30%.

5.2.3 Filtration Class

Geotextiles, where required for separation or filtration, are referenced by a Filtration Class which must meet the requirements of Table 12.

Table 12 Geotextile Filtration Classifications

Filtration Class	Flow Rate Q_{100} ($L/m^2/s$)[1] AS 3706.9	Permittivity ψ (s^{-1})[1] AS 3706.9	Equivalent Opening Size EOS (mm)[1] AS 3706.1, AS 3706.7 or EN ISO 12956
I	≥ 50	≥ 0.5	≤ 0.12
II	≥ 50	≥ 0.5	≤ 0.25
III	≥ 30	≥ 0.3	≤ 0.12
IV	≥ 20	≥ 0.2	≤ 0.25
V	≥ 10	≥ 0.1	≤ 0.12
VI	≥ 10	≥ 0.1	≤ 0.25
VII	≥ 5	≥ 0.05	≤ 0.3
VIII	≥ 5	≥ 0.05	≤ 0.6

Notes:

1 Slit film woven type geotextile is not permitted for Filtration Classes I, II, III, IV, V and VI.

2 Additional technical advice on EOS, Q_{100} and Ψ is required where water flow may undergo reverse flow characteristics.

3 Additional technical advice on EOS is required for highly dispersive clay soils, gap graded soils, fine silt soils or artificially derived soils such as fly ash. Combined soil/geotextile testing may be required, and additional granular filters may be appropriate.

4 The Superintendent may direct additional testing of geotextiles where unforeseen conditions are encountered which may impede the function of the geotextile. These may include locations where water flow may undergo reverse flow characteristics or where high dispersive clay soils, gap graded soils, fine silt soils or artificially derived soils such as fly ash are encountered.

5.3 Geogrids

5.3.1 General

The requirements of this section are applicable to geogrids (and geocomposites) for use as reinforcement and increasing shear strength by constraining the movement of aggregates in the shear zone of ballast, capping, structural, general fill and subgrade materials in earthworks.

Geogrids are polymeric geogrids formed by a regular network of connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock or earth particles to function primarily as reinforcement.

Geogrids (and geocomposites) may be used for the following applications (Table 13), subject to compliance to Section 5.1:

- Stiffen capping and structural layers to control uneven formation movements and cracking over stabilised or expansive layers.
- Reinforce structural fill layer to improve bearing capacity, reduce layer thickness, reduce vertical deformation and control differential settlement.
- Reinforce subgrades to improve bearing capacity and foundation treatments (E3 and C4, ETC-08-04).
- Reinforce/stabilise the ballast layer to reduce ballast movements, breakage, control differential settlement and reduce maintenance costs.

Table 13 Geogrid Class Applications

Geogrid Class	Grid structure	Application
GC1	Uniaxial or biaxial	Capping, structural, general fill and subgrade CBR > 3%
GC2	Multiaxial	Capping, structural, general fill and subgrade CBR > 2%
GC3	Uniaxial or biaxial	Ballast, general fill and subgrade CBR ≤ 3%
GC4	Multiaxial	General fill and subgrade CBR ≤ 2%
GC5	Multiaxial	Ballast

When the geogrid reinforcement is to be placed directly onto general fill or subgrade, then a geotextile layer compliant with Strength Class C and Filtration Class I or II shall be placed below the geogrid.

The Contractor must provide design documents that include numerical simulation to demonstrate performance of each geogrid and geocomposite used in the earthworks, and test results to demonstrate interlocking and interaction between granular particles and geogrids. Additional performance-based evidence may be provided by the Contractor, or directed by the Superintendent, including but not limited to, large scale triaxial testing and rail based field and/or laboratory trials to determine deformations measured at reinforcement level, subgrade level and sleeper level.

5.3.2 Uniaxial/Biaxial Geogrid

Uniaxial geogrids shall have elongated structure and biaxial shall have a square structure, with polymer bars orientated in two directions.

A uniaxial or biaxial geogrid may be formed by either stretching and drawing a punched sheet of polymer bars, by welding together highly orientated discrete bars of polymer or by weaving together discrete polymer bars into a network that can be coated if necessary to protect the polymer strips. Uniaxial or biaxial geogrids shall be manufactured using High Density Polyethylene (HDPE), polypropylene (PP) and/or polyester (PET).

Uniaxial and biaxial geogrids, where required for reinforcement, are referenced by a Geogrid Class which must meet the requirements of Table 14.

Table 14 Uniaxial/biaxial Geogrid Classification

Geogrid Class	Junction Strength (mm) 2% strain ASTM D7737-11	T_s [1] (kN/m) 2% strain ASTM D6637-11, D4595 or EN ISO 10319	R_d [2] (%) ASTM D5818-11	R_{uv} (%) ASTM D4355-07	Coefficient of direct shear[3] (%) ASTM D5321-14, D5321M-14
GC1	≥ 9.5	≥ 10.5	≥ 85	≥ 90	≥ 75
GC3	≥ 12.5	≥ 14	≥ 85	≥ 90	≥ 75

Notes:

1 *Minimum tensile strength (T_s) in principal direction for uniaxial and both directions for biaxial grids. T_s @ 2% ≤ UTS × R_d × R_{uv} × R_c × R_m.*

2 *Particle size grading used for the installation damage test ASTM D5818 to be the overlying material layer.*

3 *Direct shear test shall apply vertical stress of 50 kPa, 100 kPa and 150 kPa. Base layer shall consist of granular material with friction angle of 30°.*

5.3.3 Multiaxial Geogrid

Multiaxial geogrid shall have a hexagonal structure with ribs orientated in three directions. The resulting triangular-shaped apertures are defined by ribs of rectangular cross section having a high degree of molecular orientation which is continuous through the node. Welded or woven junctions shall not be accepted.

A multiaxial geogrid is formed by stretching and drawing a punched sheet of polymer into a network of hexagonal ribs. Multiaxial geogrids shall be manufactured using PP with a minimum of 2% finely divided carbon black, well dispersed in the polymer matrix to inhibit attack by ultraviolet light, determined in accordance with ASTM D1603-06. Multiaxial geogrids manufactured using HDPE or PET shall not be accepted.

Multiaxial geogrids, where required for reinforcement, are referenced by a Geogrid Class which must meet the requirements of Table 15.

Table 15 Multiaxial Geogrid Classification

Geogrid Class	Hexagon Pitch (mm) EOTA TR41 B.4	Radial Secant Stiffness (kN/m) 0.5% strain EOTA TR41 B.1	Radial Secant Stiffness (kN/m) 2% strain EOTA TR41 B.1	Radial Secant Stiffness Ratio EOTA TR41 B.1	Junction Efficiency (%) EOTA TR41 B.2	Weight (kg/m²) EOTA TR41 B.3
GC2	80 (±4)	390 (-75)	290 (-65)	0.80 (-0.15)	100 (-10)	0.220 (-0.035)
GC4	80 (±4)	480 (-90)	360 (-65)	0.80 (-0.15)	100 (-10)	0.270 (-0.035)
GC5	120 (±6)	540 (-90)	400 (-100)	0.80 (-0.15)	100 (-10)	0.300 (-0.035)

Notes:

1 *Tolerances presented in brackets represent 99.7% tolerance criteria.*

6 Quality Plan

6.1 Contractor's Project Quality Plan

The Contractor's PQP must detail how the Contractor will manage, test and control the quality of the materials under this Specification. The Contractor may develop appropriate statistical techniques to support any request to the Superintendent for variance in the number of samples per Lot or minimum testing frequency for the materials as specified in this Specification using the method for statistical analysis presented in the Earthworks Construction Specification ETC-08-04.

All materials must be tested in accordance with this Specification, Australian Standards and the Earthworks Construction Specification unless approved otherwise by the Superintendent. Samples of material proposed for use must be tested and results considered in the final selection of material and its use within the earthworks.

7 Variations

7.1 Variation to Material Tests, Methods and Compliance Criteria

All variations to ET-08-03 must be documented in Specification Variation Compliance Forms (Appendix A1) and are subject to approval by the Superintendent.

Statistical analysis and criteria for reducing Classification Conformance and Placement Conformance compliance testing must be in accordance with the Project Quality Plan and ETC-08-04.

7.2 Variation of Testing Frequencies

If consistent test results can be demonstrated, the Contractor may apply to the Superintendent for a reduction in test frequency for that particular quality control test method and source. The frequency of testing may be increased at the discretion of the Superintendent if the test results demonstrate a high degree of variability which could affect the design assumptions or the quality of the completed construction.

7.3 Alternative Test Methods

Alternative test methods may be proposed by the Designer or Contractor to confirm the parameters of the earthworks materials.

The Designer or Contractor must obtain approval from the Superintendent prior to using any alternative test methods; and provide a detailed report on trials conducted using the alternative test methods and correlation factors to the compliance test requirements of the applicable materials specification. The report must also include statistical analysis and criteria for reducing compliance testing, in accordance with the Program Quality Plan.

Appendix A – Specification Variation Compliance Forms

A1. Variance to Material Specification and Compliance

Compliant material criteria are specified in Section 4. The forms below are to be completed where there is a deviation from compliant values.

Table 16 Capping Material Variance

Criteria	Test Method[4]	Variance
Classification		
Artificial Weathering[1,5]	RMS T103	
Repeated Compaction[1,5]	RMS T102	
Particle Size Distribution	AS 1289.3.6.1	
% Passing 26.5 mm sieve		
% Passing 19.0 mm sieve		
% Passing 9.5 mm sieve		
% Passing 2.36 mm sieve		
% Passing 425 μm sieve		
% Passing 75 μm sieve		
Particle Shape	AS 1141.14	
Flakiness Index	AS 1141.15	
Wet/Dry Strength	AS 1141.22	
Liquid Limit	AS 1289.3.1.1 or 3.1.22	
Plastic Limit	AS 1289.3.2.1	
Plasticity Index	AS 1289.3.3.1 or 3.3.2	
Linear Shrinkage	AS 1289.3.4.1	
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1	
Maximum Dry Density	AS 1289.5.1.1	
California Bearing Ratio[2]	AS 1289.6.1.1/5.1.1 4-day soaked, 9 kg surcharge, to 100% SMDD at OMC	
Classification test frequency[3]		
Permeability		
Permeability	AS 1289.6.7.1	
Permeability test frequency[3]		

Notes:

1 *Material that is susceptible to break down or fracturing during compaction must be subject to pre treatment. Tests performed post placement for conformity with this table do not require pre-treatment.*

2 *CBR to be determined by design.*

3 Refer to Section 7.2 for variations to test frequencies.
4 Refer to Section 7.3 for alternative test methods.
5 These tests to be completed prior to construction works (classification conformance) and may be applied during the construction works at the discretion of the Superintendent.

Table 17 Structural Fill Material Variance

Criteria	Test Method[6]	Variance
Classification		
Artificial Weathering[1,7]	RMS T103	
Repeated Compaction[1]	RMS T102	
Particle Size Distribution	AS 1289 Clause 3.6.1	
% Passing 53.0 mm sieve		
% Passing 2.36 mm sieve		
% Passing 425 μm sieve		
% Passing 75 μm sieve		
Liquid Limit	AS 1289.3.1.2	
Plasticity Index	AS 1289.3.3.1	
Wet/Dry Strength[7,8]	AS 1141.22	
Emerson Class[7]	AS 1289.3.8.1	
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1	
Maximum Dry Density[7]	AS 1289.5.1.1	
California Bearing Ratio[2]	AS 1289.6.1.1/5.1.1 4-day soaked[3], 9 kg surcharge[4], to 100% SMDD @ OMC	
Classification test frequency[5]		

Notes:
1 Material that is susceptible to break down or fracturing during compaction must be subject to pre-treatment. Tests performed post placement for conformity with this table do not require pre-treatment.
2 CBR to be determined by design.
3 Period (number of days) of CBR soaking may be varied according to climatic and drainage conditions and the embankment design.
4 Surcharge may be increased in accordance with AS 1289.6.1.1.
5 Refer to Section 7.2 for variations to test frequencies.
6 Refer to Section 7.3 for alternative test methods.
7 These tests to be completed prior to construction works (classification compliance) and may be applied during the construction works at the discretion of the Superintendent
8 Wet/dry Strength to be tested when 9.5 mm fraction exceeds 30%.

Table 18 General Earth Fill Material Variance

Criteria	Test Method[5]	Homogenous Embankment	Zoned Embankment			
			A	B	C	D
Classification						
Particle Size Distribution	AS 1289.3.6.1					
% Passing 150 mm sieve						
% Passing 75.0 mm sieve						
Passing 37.5 mm sieve						
% Passing 75 μm sieve						
Plasticity Index	AS 1289.3.3.1					
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1					
Emerson Class	AS 1289.3.8.1					
California Bearing Ratio	AS 1289.6.1.1/5.1.1 4-day soaked[1], 9 kg surcharge[2], to equivalent compaction level[6] of 95% SMDD @ OMC					
Classification test frequency[3]						
Closest depth below Formation Level (m)[4]						

Notes:

1 *Period (number of days) of California Bearing Ratio (CBR) soaking may be varied according to climatic and drainage conditions and the embankment design.*
2 *Surcharge may be increased in accordance with AS 1289.6.1.1.*
3 *Refer to Section 7.2 for variations to test frequencies.*
4 *Closest depth below Formation Level may be varied by geotechnical design and supporting documentation.*
5 *Refer to Section 7.3 for alternative test methods.*
6 *Equivalent Compaction Level is provided as coarse materials may not be able to be tested using standard test methods, alternative test methods (Note 5) are to be nominated to demonstrate general compliance to these compaction levels.*

Table 19 Select Fill Material Variance

Criteria	Test Method[3]	Variance
Classification		
Artificial Weathering[1,4]	RMS T103	Pre-treatment
Repeated Compaction[1,4]	RMS T102	Pre-treatment
Particle Size Distribution	AS 1289.3.6.1	
% Passing 53.0 mm sieve		
% Passing 2.36 mm sieve		
% Passing 75 μm sieve		
Liquid Limit	AS 1289.3.1.2	
Plasticity Limits	AS 1289.3.2.1	
Plasticity Index	AS 1289.3.3.1	
Weighted Plasticity Index	AS 1289.3.6.1/3.3.1	
Maximum Dry Density[4]	AS 1289.5.1.1	
California Bearing Ratio[4,5]	AS 1289.6.1.1/5.1.1 4-day soaked, 9 kg surcharge, to 100% SMDD @ OMC	
Particle Density[4]	AS 1141.6.1	
Wet/dry Strength[4,5]	AS 1141.22	
Aggregate Crushing Value[4]	AS 1141.21	
Aggregate Flakiness Index[4]	AS 1141.15	
Degradation Factor[4]	AS 1141.25	
Weak Particles[4]	AS 1141.32	
Classification test frequency[2]		

Notes:

1 *Material that is susceptible to break down or fracturing during compaction must be subject to pre-treatment. Tests performed post placement for conformity with this table do not require pre-treatment.*

2 *Refer to Section 7.2 for variations to test frequencies.*

3 *Refer to Section 7.3 for alternative test methods.*

4 *These tests to be completed prior to construction works (classification compliance) and may be applied during the construction works at the discretion of the Superintendent.*

5 *Wet/dry Strength to be tested when 9.5 mm fraction exceeds 30%.*

Table 20 Bedding Sand Material Variance

Criteria	Test Method[2]	Variance
Classification		
Particle Size Distribution	AS 1289.3.6.1	
% Passing 6.7 mm sieve		
% Passing 0.075 mm sieve		
Plasticity Index	AS 1141.23	
Test frequency[1]		

Notes:

1 Refer to Section 7.2 for variations to test frequencies.

2 Refer to Section 7.3 for alternative test methods.

Table 21 Rock Fill Material Variance

Criteria	Test Method[2]	Variance
Classification		
Particle Size Distribution	Visual assessment for mechanical interlock and size distribution.	
% Passing 600 mm		
% Passing 4.75 mm		
Point Load Test	AS 4133.4.1	
Particle Density	AS 1141.6.1	
Wet/dry Strength	AS 1141.22	
Secondary Mineral Content	AS 1141.26	
Particle Shape	Visual Assessment	
Test frequency[1]		
Closest depth below Formation Level (m)[3]		

Notes:

1 Refer to Section 7.2 for variations to test frequencies.

2 Refer to Section 7.3 for alternative test methods.

3 Closest depth below Formation Level may be varied by geotechnical design and supporting documentation.

Table 22 Drainage Blanket Material Variance

Criteria	Test Method[2]	Variance
Classification		
Particle Size Distribution	AS 1141.11, AS 1141.12	
% Passing 63.0 mm sieve		
% Passing 37.5 mm sieve		
% Passing 26.5 mm sieve		
% Passing 19.0 mm sieve		
% Passing 75 μm sieve		
Los Angeles Value (Grading A)	AS 1141.23	
Particle Shape	AS 1141.14	
Flakiness Index	AS 1141.15	
Particle Density	AS 1141.6.1	
Water Absorption	AS 1141.6.1	
Wet/dry Strength	AS 1141.22	
Test frequency[1]		

Notes:

1 Refer to Section 7.2 for variations to test frequencies.

2 Refer to Section 7.3 for alternative test methods.

A2. Variance to Formation Geometry Specific Design Requirements

Track configurations, including minimum layer thicknesses, track centres and shoulder distances, must comply with those dimensions detailed in Table 20 below. All crossfalls to the formation are 1:30, unless otherwise shown on the Drawings.

Table 23 Design Specific Formation and Shoulder Geometry Requirements

Item	Minimum Value	Design Value
	mm	
Formation Geometry		
Capping layer thickness	150	
Capping width (from track centreline)	3500	
Structural Fill layer thickness	200	
Structural Fill width (from track centreline)	3500	
General Earth Fill A compacted layer thickness	150	
General Earth Fill B-D compacted layer thickness	150	
Outer Zone width	1000	
Distance from toe of embankment to toe drain	2000	
Distance from toe of cutting to cess drain	0	
Formation Shoulder Geometries (from track centreline)		
Main Line and Passing Loops	3500	
Siding	3000	
Special Width Requirements Shoulder Geometries (from track centreline)		
Shunters and guards parallel walkways	4250	
Train examination areas	5500	
Train examination areas with parallel access road	7750	
Clear Access Road Geometry		
Clear access road width	3000	

Requirements of EGH-20-01 shall apply to formation geometry.

A3. Variance to Cutting Geometry Project Specific Design Requirements

Batter slopes in cuttings in excess of 3 m high and closer than 6 m from the track centreline must be determined on the advice of a geotechnical engineer. Variations to the typical geometry values provided must be supported by a geotechnical risk assessment and geotechnical design.

Table 24 Design Specific Cutting Geometry Requirements

Material		**Slope**			
		Typical		**Design**	
		Horizontal	**Vertical**	**Horizontal**	**Vertical**
1	Sand	2	1		
2	Wet clay, loose gravel	2	1		
3	Sandy clay, boulders and clay, compacted gravelly soil, General Earth Fill A and rockfill, talus	1.75	1		
4	Residual soil to extremely weathered, very low strength, highly fractured rock	1.5	1		
5[1]	Sound shale dipping sharply towards railway formation, tight cemented gravel	N/A	N/A		
6[1]	Distinctly weathered, low strength, well developed, closely spaced bedding or fractured rock	N/A	N/A		
7[1]	Slightly weathered, medium strength, massive to widely spaced bedding or fractured rock	N/A	N/A		

Notes:

1 A geotechnical engineer must confirm batter slope design.

Requirements of EGH-20-01 shall apply to cutting geometry.

Appendix B – Earthworks Materials Management Framework

Page B-1

EARTHWORKS MATERIALS REUSE (Cont.)

NOTES TO CHART 1

1. General

All sampling and analysis date/reports (geotechncial, contamination & hydrological) must be tracked and registered to teh material movements and stockpile locations for the duration of the project, and following project handover particularly where permanent spoil mounds are built.

2. Reference Material

- National Environmental Protection (Assesment of Site Contamination) Measure 1999 Amendment 2013 (NEPM 2013).
- Earthworks Materials Specification ETC-08-03 and Earthworks Construction Specification ETC-08-04.
- Wastem Contamination and/or Hazardous Materials Assessment Management Plans.
- Hydrological Investigations and Plans.
- All applicable Approval Conditions, Environmental Impact Assessments, and Hydrology and Flooding Programmes.

3. Potentially Contaminating Activities

- Acid / alkali plant and formulation
- Acid sulfate soils sites
- Acid sulfate rock sites
- Ammunition manufacture and usage (e.g. shooting ranges)
- Any land registered on ARTC Contaminated Land Database or any state regulatory authority's database
- Asbestos production, handling or disposal
- Asphalt/bitumen manufacturing
- Commercial engine and machinery repair sites
- Battery manufacturing or recycling
- Boat/ship building, marinas, slip ways and associated boat yards
- Boiler or kiln usage
- Chemical manufacture and formulation (e.g. fertilisers, paints, pesticides, photography, plastics, solvents)
- Chemical pesticide and storage usage
- Defence use
- Drum conditioning works
- Dry cleaning establishments
- Environmental incidents or spills
- Electrical transformers
- Ethanol production plant
- Explosives industries
- Fertiliser manufacturing plants
- Fill material imported onto a site from a potentially contaminated source
- Foundry Operations
- Gas works
- Herbicide manufacture
- High salinity areas
- Illegal dumping
- Industrial activities involving hazardous chemicals in significant quantities
- Iron and steel works
- Landfill sites, including on-site waste disposal and refuse pits
- Depots - machinery, vehicle, locomotive maintenance
- Metal treatments (e.g. electroplating) and abrasive blasting
- Firefighting training and use of firefighting foam
- Metal smelting, refining or finishing
- Mineral processing
- Mine sites involving waste rock or tailings deposits
- Naturally occurring asbestos
- Oil or gas production or refining
- Paint formulation and manufacture
- Pesticide manufacture and formulation sites
- Petroleum product or oil and chemical storage (including Underground Petroleum Storage Systems)
- Pharmaceutical manufacture and formulation
- Power stations
- Printing Radio-active material usage (e.g. hospitals)
- Railway yards
- Refuelling locations (including Direct into Locomotive - DIL refuelling)
- Scrap yards and recycling facilities
- Sewage treatment plant
- Sheep and cattle dips
- Sites of fires involving hazardous materials, including fire fighting foam use
- Sites of incidents involving release of hazardous materials
- Spray storage and mixing sites (e.g. for orchards)
- Spray painting industries
- Tanning and associated trades
- Textile operations
- Tyre manufacturing and retreading works
- Wood preservation and storage or cutting of treated timber
- Wool scouring

EARTHWORKS MATERIALS SPOIL MOUNDING

CHART 2