



AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline
Engineering Specification

Category
Track & Civil

Supplementary Appendix to ARTC Track & Civil Code of Practice

Railway Earthworks

ETC-08-02

Applicability

ARTC Network wide	
New South Wales	
Western Jurisdiction	✓
Victoria	✓

Primary Source

(RIC Specifications C1100 Earthworks Construction Procedures and TS 3422 Standard for formation capping material adapted to fill identified requirement /TCS-08)

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1. Scope

This document provides guidance for the design and construction of railway earthworks for main line and passing loops (running lines). Each location may require specific design and material testing regimes.

2. Definition of Earth and Rock

Earth is defined to include all materials such as earth, clay, sand gravel, weathered or loose rock which could normally be removed by ripping by a bulldozer of nominal 290-kilowatt brake power with heavy duty tynes.

Rock is defined to include any other material, which cannot be so removed and shall include boulders greater than 1 cubic metre in volume.

3. Clearing and Grubbing

The whole area to be occupied by the completed works including ancillary earthworks for drains and diversion levees is to be cleared and grubbed plus a clearance of 2m from tops of cuttings and toes of embankments. Clearing includes removal and disposal of all trees, stumps, logs, timber, scrub, vegetation, minor structures, refuse and other material unsuitable for incorporation in the work. Grubbing is to be carried out to the level of 0.5m below natural surface or 1.5m below finished earthworks level. Holes left after grubbing under proposed embankments are to be filled with sound material and compacted in layers as for embankments.

If required by ARTC, fauna habitat logs shall be placed well clear of construction activities.

Timber and combustible material shall be disposed off - site or shall be burnt in suitable disposal areas with due care and in accordance with any relevant regulations. Non - combustible materials shall be disposed off - site.

4. Removal of Topsoil and Unsuitable Material

Topsoil shall be removed over the area, which will be occupied, by the completed works plus a clearance of 2 meters. Topsoil suitable for vegetation propagation shall be placed in a stockpile clear of the work to enable its re-use in landscaping and revegetation.

Unsuitable material includes topsoil, peat and other highly organic soils, logs, stumps, perishable material, refuse, stones, material susceptible to spontaneous combustion, free draining materials susceptible to scouring very fine sand, silt clay lumps and organic clay and material with CBR<1. Such material shall be excavated and disposed off - site except for topsoil required for vegetation propagation. Dispersive soils can be used only in accordance with guidelines provided by a Geotechnical Engineer. Where unsuitable material exists in excessive depths the advice of a Geotechnical Engineer is required. (See Clause 6)

5. Excavation for Cuttings

Excavation shall be carried out to the lines, levels, dimensions and slopes shown on the drawings. The excavated faces shall be neatly trimmed and the top edges of the cuttings neatly rounded. Under cutting of the slopes will not be permitted under any

circumstances. Batter slopes in rock cuttings in excess of 3m high and closer than 6m from the track centreline shall be determined on the advice of a Geotechnical Engineer or Geologist. If not otherwise specified, cutting slopes should be in accordance with the following table 1:

Table 1: Typical (Minimum) Cutting Slopes

Material		Slope
		Horizontal : Vertical
1	Sand	2 : 1
2	Wet clay, loose gravel	2 : 1
3	Sandy clay, boulders and clay compact gravelly soil, talus	1.75 : 1
4	Poor Rock	1.5 : 1
5*	Sound shale dipping sharply towards railway formation, tight cemented gravel	1 : 1
6*	Ordinary Rock	1 : 1
7*	Solid well bedded rock	0.25 : 1

* Maximum height without bench - 7m

* A Geotechnical Engineer or Geologist shall confirm batter slopes in rocks

Excavation shall be carried out in such a manner as to prevent erosion or slips, working faces shall be limited to safe heights and slopes, and the surface shall be drained to avoid ponding and erosion.

Slopes shown on the Drawings represent the estimated requirements for the expected types of material and will be subject to re-determination on the basis of site inspection and investigation during excavation. Any doubtful cases must be referred to the Superintendent.

Overhanging, loose or unstable material likely to slip should be cut back removed or stabilised.

Rock cuttings and exposed rock surfaces shall be excavated so as to obtain smooth, uniformly trimmed surfaces. Batters in cuttings shall be carried around curves in an even and regular manner. Finished batters shall not have a slope steeper than that specified.

Excavation at the base of cutting shall be finished at a level to suit the capping thickness, normally 150mm, and with crossfalls shown on the drawings. Compaction of the top 150mm layer in the base of cuttings or of material required to fill over - excavation shall be compacted to compaction standard A (refer to Clause 9), or shall be solid rock. In addition the finished surface shall not deviate from the bottom of a 3 metre straight edge laid in any direction by more than 25mm.

6. Preparation of Embankment Base

Preparation includes clearing, grubbing, and removal of topsoil and removal of unsuitable material and subsequent restoration under Clauses 3 and 4. It also includes cutting of terraces into slopes, scarifying and compaction of embankment base and provision of drainage works as specified below.

Where embankments are to be constructed on a natural slope or on the slope of an existing embankment steeper than 4 to 1 (horizontal to vertical), the existing slope is

to be cut in horizontal terraces at least 1.5m wide. The terraces are to be cut progressively as the embankment is constructed. Suitable material excavated in cutting the terraces may be incorporated in the embankment but unsuitable material must be disposed off -site.

The area of the base of the embankment shall be scarified to a depth of 100mm, parallel to the embankment axis. A layer of general fill 100mm thick shall be spread over the scarified area, and the whole shall be compacted to compaction standard B (refer to Clause 8.2.9).

Where shown on the drawings a drainage blanket is to be provided at the base of the embankment. It will comprise a geotextile fabric (as approved by a Geotechnical Engineer) laid along the base and around a layer of free draining filter material to a depth of 300mm, and spall protection at the outlet. Manufacturer's instructions concerning installation of the fabric shall be followed. The free draining filter material shall be crushed rock, river gravel or slag composed of hard, strong and durable particles, and complying with the following table 2:

Table 2: Free Draining Material

Test Method Requirement	Description	Criteria	Min frequency of Testing
AS1289, Test C6.1	Particle Size Distribution % Passing 53.0mm sieve % Passing 37.5mm sieve % Passing 26.5mm sieve % Passing 19.0mm sieve	100 90-100 20-55 0-5	One per 50 cu metres
AS1141, section 32	Soft and friable particles	Max. 5%	
AS1141, section 30	Clay Lumps	Max. 0.5%	
AS1141, section 23	Los Angeles Value (Grading A)	Max. 30%	
AS1141, section 6	Particle density	Min. 2.3t/cu.m	

7. Embankment Material

The embankment shall consist of two zones of embankment material.

- 1) Structural Zone
- 2) General Fill

The zones of the embankment shall be defined by the thickness of the structural zone (H) at the top of the embankment as determined by the following relationship with the general fill.

General Fill CBR*3-8% - H = 500mm

General Fill CBR*1-3% - H = 1000mm

* (Soaked California Bearing Ratio, Standard Compaction).

Material for use in the structural zone shall comply with the following table 3:

Table 3: Structural Fill Material

Test Method Requirement	Description	Criteria	Min frequency of Testing
AS1289, Test C6.1	Particle Size Distribution % Passing 53.0mm sieve % Passing 2.36mm, sieve % Passing 425um, sieve % Passing 75um, sieve	80-100 15-100 0-70 0-30	One per 1000 cu metres
AS1289, Test C1.1	Liquid Limit	Max.40	
AS1289, Test C3.1	Plasticity Index	Max.20	
AS1289, Test E1.1	Maximum dry density	Min.1.8t/cu.m	
AS1289, Test F1.1	Soaked California Bearing Ratio (Standard compaction)	Min.8%	

Unsuitable material as defined in Section 5 shall not be used as general fill. Material not complying with the above requirements is only to be used with the approval of ARTC.

8. Placing Embankment Material

Embankments shall be constructed in full width horizontal layers. Normally layers should not exceed 200mm thickness unless it can be shown that the specified compaction can be obtained for a thicker layer. Layers or pockets of substantially varying material should be avoided. The maximum particle size should be less than 2/3 of the compacted layer thickness. Construction shall be carried out in such a manner as to ensure adequate drainage of the works, and to avoid scour and erosion. The top of the earthworks is to be trimmed in accordance with the requirements for preparation for capping.

9. Compaction on Embankment Material

Compaction shall be carried out at a moisture content, which will allow the specified compaction to be achieved, normally within 2 per cent of optimum moisture content. Where necessary water shall be added uniformly or drying carried out. Bond between layers is to be ensured, if necessary by wetting or scarifying.

Compaction Standards shall be as follows:

- Compaction A - Cohesive soils - Not less than 100% Relative Compaction as determined by AS.1289-1977 Tests E1.1 and E3.1 (Standard Compaction)
- Rock fill or cohesion less soils - No visible Deflection of surface under 10 tonne Vibratory rollers after 6 - 8 pass.
- Compaction B Not less than 95% Relative Compaction as Determined by AS.1289.1977 Tests E1.1 And E3.1 (Standard Compaction).

Embankments shall be compacted to:

General Fill: Below Structural Zone
= Compaction B

Structural Zone: To 500mm or 1000mm below formation layer
(i.e Earthworks Level)
= Compaction A

10. Embankment Profile

Embankment batter slopes shall be as shown on the drawings. Unless shown otherwise, the standard batter slope for embankments shall be 1.75:1 (horizontal: vertical). If stability is expected to be a problem, batters may be flattened to 2:1 or more. Advice should be sought from a Geotechnical Engineer if there is any doubt concerning embankment stability.

Batters 3:1 may be used where grassing is necessary or where provision is required for stock crossings.

11. Earthworks near Structures

Care shall be exercised in constructing earthworks within 5m of structures to avoid damage to the structures. Non-vibratory equipment should be used within this distance and adjacent to the structure further limitations, as defined in Table 4, apply. Adjacent to weep - holes free draining filter material encapsulated in geotextile fabric should be placed, horizontally for at least 300mm from, and vertically for 450mm above the weep - hole. Select back fill material complying with the requirement for capping material except that a minimum of 60% shall be retained on 2.36mm sieve, shall be used adjacent to structures as follows:

Table 4

Structure	Minimum width & height of selected fill	Compaction method
Bridge abutment and wing walls	2m wide for full height	Hand held compaction equipment for full structure height for a distance of 2/3 H (H=overall height of structure)
Pipe culverts	300mm width each side and above top pipes	Hand held compaction equipment for distance D from pipe to top pipe (D=diameter of pipe)
Box culverts and culvert wing and retaining walls	H/3 wide for full height (H=overall height)	Hand held compaction equipment for full structure height for a distance of 2/3 H (H=overall height of structure)

12. Tolerances for Earthworks

12.1. Vertical Tolerances

12.1.1 In Embankments

Top of structural zone	+0 to -50mm
Top of general fill zone	+40 to -40mm

12.1.2 In Cuttings

Floor of cut (top of common earthworks) other than rock	+40 to –40mm
Top of structural Zone (Refer Clause 5) other than rock	+0 to –50mm
Floor of cut (top of common earthworks) rock	+0 to –80mm

12.1.3 At Transitions between cut and fill

Floor of cut to fill transition	+0 to –50mm
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12.1.4 Top of benches and berms

Top of benches and berms	+50 to –50mm
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12.1.5 Formation capping material

Refer to clauses 13.8 and 13.9.

12.2. Horizontal Tolerances

Base at top of cuts and fills, widths of benches and berms – not to be less than specified dimensions. Maximum positive tolerance 300mm, unless otherwise agreed with ARTC.

13. Formation Capping Material

13.1. General Requirements

Material proposed for capping 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. Materials such as natural ridge gravel free from vegetable matter, ripped sandstones with low clay content and crushed and blend tough, durable rock or slag, have been found to meet material properties of this specification.

The material shall be tested in accordance with AS.1289 as required in this Specification.

13.2. Sampling

Samples of capping material for laboratory testing shall be taken and handled fully in accordance with AS.1726, and AS.1141, Section 3. Samples of material proposed for use shall be tested and results considered in final selection of material.

13.3. Material Properties

Natural gravels may be combined to provide material, which 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.

13.4. Particle Size Distribution

Material shall be well graded with typical particle size distribution as follows (Tested in accordance with AS1289 Test 3.6.1, Wet Sieve Procedure):

Table 5

AS Sieve	Percentage Passing Nominal Size (20mm)	Min frequency of Testing
53mm	100	One per 500 cu metres
37.5mm	100	
26.5mm	100	
19.0mm	95-100	
9.5mm	-	
4.75mm	-	
2.36mm	30-80	
0.075mm	6-10	

13.5. Atterberg Limits

Liquid Limits	AS.1289 Test 3.1.1 or AS.1289 Test 3.9	Maximum 30 (35 for arid areas)
Plastic Limits	AS.1289 Test 3.2.1	Maximum 20
Plasticity Index	AS.1289 Test 3.3.1 AS.1289 Test 3.3.2	2-10 (2-15 arid areas)
Linear Shrinkage	AS.1289 Test 3.4.1	Maximum 3%

13.6. Maximum Dry Density

AS.1289 Test 5.2.1 Minimum 2.0t/cu.m

13.7. Soaked CBR

AS.1289 Test F1.1* Minimum 50

*Compacted to 95% (min) Maximum Dry Density obtained by AS.1289 5.2.1 & with 9 kg surcharge.

13.8. Preparation for Capping

The earthworks in embankments shall be placed and compacted to a level 30 millimetres above the base of the capping layer. Immediately prior to the placement of the capping, the fill shall be trimmed by grading to the final profile and compacted by a minimum of three passes of a smooth steel drum roller, which has a static mass not less than 10 tonnes.

The finished, rolled surface shall be true to profile to a tolerance of +0 to -40mm, and shall be free of depression and ruts.

No traffic other than that required to place the capping shall be allowed on the finished surface.

The capping material shall be transported from the source to the work in vehicles which are so constructed that loss of material does not occur. It shall be suitably

damp to prevent segregation during transit.

13.9. Spreading, Placing, Compaction and Trimming of Capping.

The capping layer shall be constructed in layers to a total compacted thickness of 150 millimetres unless otherwise specified. The material shall be spread in uniform horizontal layers. Spreading shall be undertaken by a full width of the capping layer. Spreading shall be undertaken by a method which will ensure segregation does not occur, and so as not to rut or disturb the compacted thickness greater than 150 millimetres or less than 75 millimetres.

Where required for compaction purposes, water shall be added as necessary to achieve optimum moisture content and mixed uniformly with the capping material by approved mechanical means. Compaction shall achieve a minimum density of 95 per cent relative compaction (modified) as determined by AS 1289 Test 5.2.1.

Rock and rock fines shall be distributed throughout each layer so that all voids are filled. The top of the final layer shall be graded and trimmed, and material shall be added as necessary to produce an even surface. The following tolerances shall apply.

13.9.1 Width

The width from the design centreline to the finished top of embankment slopes or toe of batters in cuttings shall in no case be less than the dimensions required by the Schedule of Earthworks.

13.9.2 Level

The finished surface of the formation shall be within 25mm of the level shown on the Drawings and: -

- The difference of the deviations from the correct level for any two points 20 meters apart on the centreline shall not exceed 10mm.
- The deviation from a three (3) metre straight edge laid on the surface parallel to the centreline shall not exceed 10mm.

13.9.3 Transverse Slope

When tested with a three (3) metre straight edge lay perpendicular to the centre line the deviation from design profile shall not exceed 10mm concavity.

14. Repairing and Overhaul Track Formation

In repairing and overhauling the track formation, the following shall be taken into account when preparing the work plan and design:

- Rectification of drainage deficiencies
- Removal and disposal of fouled ballast to the formation level.
- Removal and disposal of failed formation material.
- Provision of Capping Material on the original formation. (See Clause 13).
- Provision of trench (ballast filled) drains.

- Repair/rectification of degraded, ineffective, blocked or sagging culverts.

Reference should be made to “ARTC Manual on what to do and what not to do when performing sub-grade maintenance” prepared by Cantrell Rail Services.

15. Formation for New Construction and Major Upgrading Works

The formation for mainlines and loops shall comply with the appropriate dimensions shown on Drawing ARTCS3060149.

The following elements shall be taken into account in design:

- Cess and sub surface drainage.
- Special requirements for drainage in multiple track areas.
- Top Drains to Cuttings
- Train Examination Areas - such areas where specified, are to be covered with a 50mm layer of approved material.
- Walkways - where specified walkways are to be covered with a 50m layer of approved material.

16. Access Roads

Where access roads are specified they shall consist of a fit for purpose roadway with a surface providing normal weather access for heavy maintenance and four wheels drive vehicles.

Appendix 1 – Reference Drawings

ARTCS3060149 Standard track sections