



AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: Engineering (Track & Civil)

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Earthworks, Formation and Capping Material

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Applicability

New South Wales	✓	CRIA (NSW)	
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Primary Source

ARTC NSW Standard RCP 01, RMP 07, TDS 08 and TDS 12

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Version	Date Reviewed	Clause	Description of Amendment
1.0	01 Dec 09		Implementation draft. Supersedes NSW Standards RCP 01 v1.2, RMP 07 v1.2, TDS 08 v1.2 and TDS 12 v1.1
1.1	18 Jun 10		Banner added regarding mandatory requirements in other documents and alternative interpretations.

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Mandatory requirements also exist in other documents.

Where alternative interpretations occur, the Manager Standards shall be informed so the ambiguity can be removed. Pending removal of the ambiguity the interpretation with the safest outcome shall be adopted.

1 Scope

This document provides guidance for the design and construction of railway earthworks.

2 Definitions

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

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

Rail level is defined as the theoretical level of the running surface of the rails. In the case of superelevated track it is the low rail.

Formation level is defined as the finished level at the centre of the formation preparatory to laying ballast. It includes the capping layer.

Earthworks level is defined as the level at the centre of the earthworks prior to placing of the capping level.

Formation width is the width at formation level.

Shoulder distance is the distance from the track centreline to the edge of the formation.

3 Construction

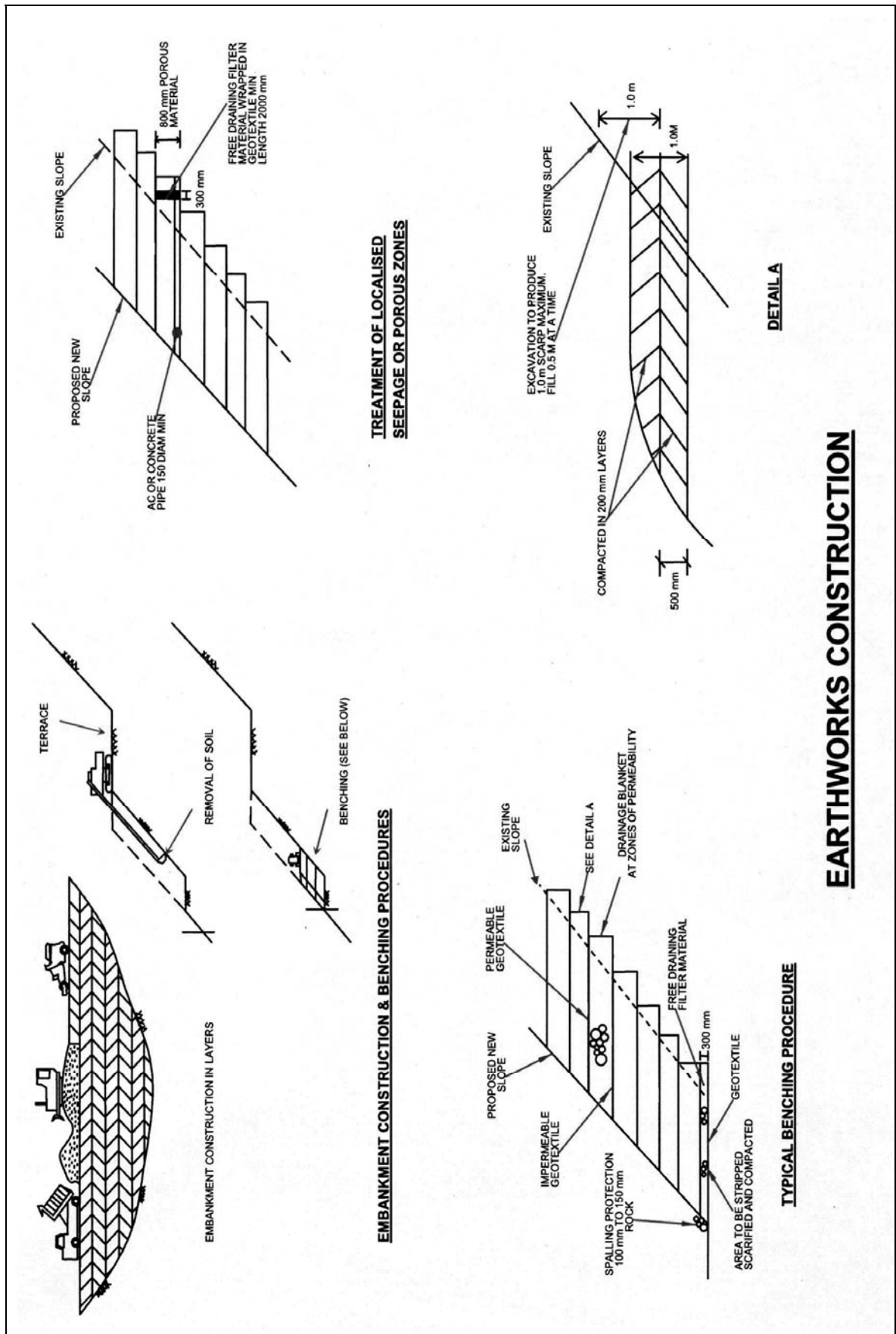
3.1 Clearing and Grubbing

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 (see figure 1).

Fauna habitat logs shall be placed well clear of construction activities where required by ARTC.

Timber and combustible material shall be disposed of 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 of off-site.

Figure 1



3.2 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 2m. 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.

3.3 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. If not otherwise specified, cutting slopes should be in accordance with 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 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 3.7), or shall be solid rock. In addition the finished surface shall not deviate from the bottom of a 3m straight edge laid in any direction by more than 25mm.

3.4 Preparation of Embankment Base

Preparation includes clearing, grubbing, and removal of topsoil and removal of unsuitable material and subsequent restoration under clauses 3.1 and 3.2. 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 3.7).

Where an embankment or formation is to be constructed over soft subgrade, over black soils, or in low lying areas subject to inundation, advice from a Geotechnical Engineer is to be obtained during the design and construction of the earthworks on issues including the retention or removal of topsoil, the use of clayey materials, the use of geosynthetics and the construction methodology.

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 Table 2:

Table 2: Free Draining Material

Test Method Requirement	Description	Criteria	Minimum 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 50cu 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	

The filter material shall be spread in uniform layers to give the specified compacted thickness in such a manner as to avoid damage to the fabric.

Compaction is to be obtained using at least 8 passes of a vibratory roller of static drum load of 6 tonnes.

Bad ground, seepage or springs encountered during embankment preparation may require additional special treatment (refer to Figure 1). Advice of the Geotechnical Engineer should be sought.

3.5 Embankment Material

The embankment shall consist of two zones of embankment material namely Structural Zone and 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	Minimum 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 1000cu 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 3.2 shall not be used as general fill. Material not complying with the above requirements is only to be used with the approval of ARTC.

3.6 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 (see section 4.9).

3.7 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% 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 AS1289 Tests 5.1.1 and 5.3.1 (Standard Compaction) Rock fill or cohesion less soils – No visible deflection of surface under 10 tonnes vibratory rollers after 6-8 passes.
Compaction B	Not less than 95% Relative Compaction as determined by AS1289. Tests 5.1.1 and 5.3.1 (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

3.8 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 to 1 (horizontal to vertical). If stability is expected to be a problem, batters may be flattened to 2 to 1 (horizontal to vertical) or more. Advice should be sought from a Geotechnical Engineer if there is any doubt concerning embankment stability.

Batters 3 to 1 (horizontal to vertical) may be used where grassing is necessary or where provision is required for stock crossings.

3.9 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 the table below 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:

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 $2/3H$ (H=overall height of structure)

3.10 Tolerances for Earthworks

3.10.1 Vertical Tolerances

(a) In Embankments

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

(b) In Cuttings

Floor of cut (top of common earthworks) other than rock	+40 to -40mm
Top of structural zone (refer to Clause 5) other than rock	+0 to -50mm
Floor of cut (top of common earthworks) rock	+0 to -80mm

(c) At Transitions between Cut and Fill

Floor of cut to fill transition	+0 to -50mm
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(d) Top of Benches and Berms

Top of benches and berms	+50 to -50mm
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(e) Formation Capping Material

Refer to clause 4.9.

3.10.2 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.

4 Formation Capping Material

4.1 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 AS1289 as required in this Specification.

4.2 Sampling

Samples of capping material for laboratory testing shall be taken and handled fully in accordance with AS1726 and AS1141, Section 3. Samples of material proposed for use shall be tested and results considered in final selection of material.

4.3 Material Properties

Natural gravels may be combined to provided 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.

4.3.1 Particle Size Distribution

Material shall be well-graded with typical particle size distribution as shown in Table 4 (Tested in accordance with AS1289 Test 3.6.1, Wet Sieve Procedure).

Table 4:

AS Sieve	% Passing Nominal Size (20mm)	Minimum 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	

4.3.2 Atterberg Limits

As shown below.

Liquid Limits	AS1289 Test 3.1.1 or AS1289 Test 3.9	Maximum 30 (35 for arid areas)
Plastic Limits	AS1289 Test 3.2.1	Maximum 20
Plasticity Index	AS1289 Test 3.3.1 AS1289 Test 3.3.2	Maximum 2-10 (2-15 for arid areas)
Linear Shrinkage	AS1289 Test 3.4.1	Maximum 3%

4.3.3 Maximum Dry Density

AS1289 Test 5.2.1 Minimum 2.0t/cu.m

4.3.4 Soaked CBR

AS1289 Test 6.1.1* Minimum 50

* Compacted to 95% (min) Maximum Dry Density obtained by AS1289 Test 5.2.1 & with 9kg surcharge.

4.4 Preparation for Capping

The earthworks in embankments shall be placed and compacted to a level 30mm 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 the profile shown in clause 3.10, 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.

4.5 Spreading, Placing, Compaction and Trimming of Capping

The capping layer shall be constructed in layers to a total compacted thickness of 150mm 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 150mm or less than 75mm.

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% relative compaction (modified) as determined by AS1289 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:

4.5.1 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.

4.5.2 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 20m apart on the centreline shall not exceed 10mm.
- The deviation from a 3m straight edge laid on the surface parallel to the centreline shall not exceed 10mm.

4.5.3 Transverse Slope

When tested with a 3m straight edge lay perpendicular to the centreline the deviation from design profile shall not exceed 10mm concavity.

5 Formation for New Construction and Major Upgrading Works

5.1 Formation for Main Lines

All crossfalls to the formation are 1:30, unless otherwise shown.

The formation for single track mainlines shall comply with the appropriate dimensions shown in figure 2.

For shoulder distance see Table 5.

5.2 Formation for Sidings

All crossfalls to the formation are 1:30, unless otherwise shown.

The formation for single track sidings shall comply with appropriate dimensions shown in figure 2.

For shoulder distance see table 5.

5.3 Width of Property (Right of Way)

The width of property for new lines shall be specified by ARTC. Allowance shall be made where necessary for 4m access roads on each boundary at normal ground level in addition to the necessary earthworks for the formations and associated drainage.

For new lines, the track should normally be designed in the centre of the property. Single tracks to be ultimately duplicated should be aligned 2.25 m off the centre of the property.

The width of the right of way shall provide for drainage as detailed in this document and associated specifications.

Special consideration is to be given to additional land that may be required for deviation of creeks.

Underground cables for signalling and communications should be located in natural ground, and not in the shoulder areas of the formation.

In multiple tracks and other restricted locations, cable connections to signals may be located in the formation, provided the formation capping is properly restored after completion of the cable laying works.

5.4 Cess Drainage

The drawings shall detail the basic drainage requirements.

Where a cutting is on a grade flatter than 1 in 200, or where additional drainage is required, extra cutting width for drainage must be provided to ensure that the shoulder width is retained free for maintenance and access purposes.

With multiple tracks, drainage is to be provided by sumps over pipes in the 'six-foot' between each alternate track.

5.5 Sub-surface Drainage

Sub-surface drainage shall be provided in locations where the water table is at or near earthworks level.

Sub-surface drainage shall be provided along the cess, between, across, or under tracks as required.

These drains shall be of approved design, and minimum fall of 1 in 200, and with sumps at appropriate intervals.

5.6 Top Drains to Cuttings

Levee banks as shown in the plans must be provided to all cuttings. In special or restricted locations, a concrete or other approved drain may be provided in lieu of the levee bank. All top drawn or levee banks must be designed to prevent access or water to the cutting and to prevent scouring of the drains (see diagram 1).

5.7 Walkways and Train Examination Areas

Where nominated, walkways and train examination areas are to be provided. These areas are to be covered with a 50mm layer of suitable material as shown in figure 2.

Train examination areas are not to be assumed as available for road access purposes.

5.8 Track Centres and Shoulder Widths

Shoulder widths are shown in Table 5

Table 5: Shoulder Distance

Plain Track and Turnouts		mm
1	Main Line and Passing Loops	3500 Minimum
	Siding	3000
Special Requirements		
2	Shunters and guards parallel walkways	4250
3	Train Examination areas	5500
	Train Examination areas with parallel access road	7750
	Clear width of road from back of any structure	3000

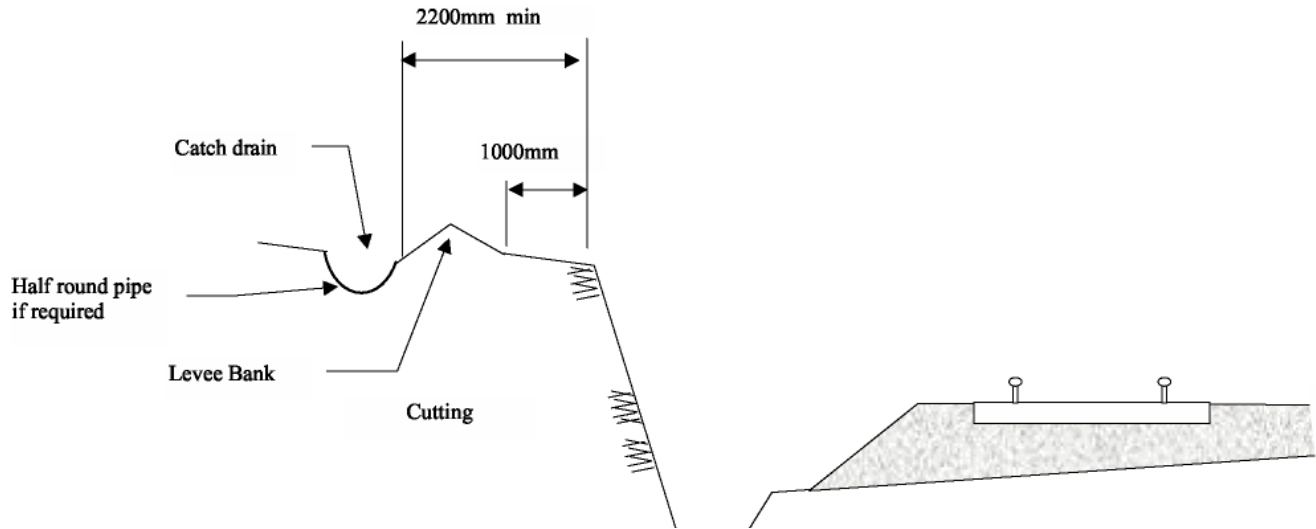
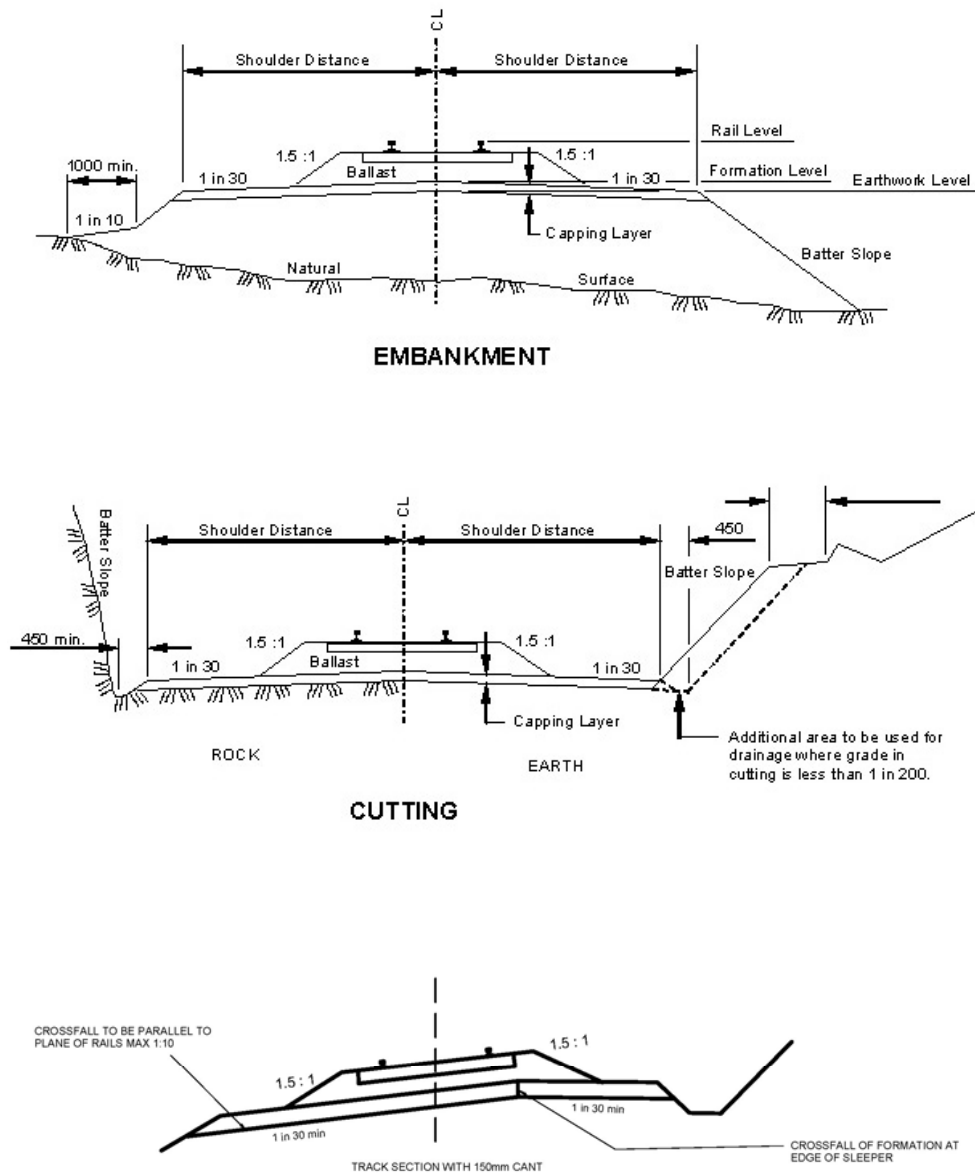


Diagram 1

Note: A top drain training bank 500mm high is to be provided where the slope of the drain is between 1 in 100 and 1 in 200 otherwise 450mm minimum half round pipes are to be used as shown above

Figure 2



6 Embankment Widening

6.1 General

Embankments are widened:

- To dispose of spoil from other works;
- To provide access to the track side;
- To provide width for structures;
- To provide for additional tracks

Although embankments are often widened as a spoil disposal measure, the widened section becomes part of the embankment structure. Hence it is necessary for the work to be done in accordance with proper earthworks practice.

All work is to be in accordance with this standard as applicable for the section of line.

Sites for embankment widening are to be specified by the Engineer supervising the work with the approval of the ARTC.

6.2 Preparation

6.2.1 Survey

The embankment widening shall be properly set out using batter pegs for toe of embankment and necessary survey for drainage structures.

6.2.2 Foundation Preparation

Unsuitable material including vegetable matter, organic clays and silts, ashes and materials which are unstable when wet are to be moved from the base of the embankment widening and side of existing embankments. Refer to Sections 3.

The embankment base is also to be prepared in accordance with Section 3.

6.2.3 Drainage Structures

Existing culverts and drains are to be located, extended and cleared by hydroblasting or similar to ensure satisfactory flow of watercourses. Care is to be taken to ensure that moisture is not trapped between the existing and the widened embankment, and water does not pond against the toe of the embankment.

6.2.4 Drainage Blanket

A drainage blanket is to be laid at the base of the embankment in accordance with Section 3.

The procedure is:

- Excavate into the embankment toe to give a 1m scarp.
- Spread and compact layer of coarse rock 300mm thick. Scour protection shall be provided
- by placing large boulders on the outer edge of the drainage layer.
- Place geotextile over the drainage layer.
- The geotextile is to be covered with a layer of fill material 500mm thick compacted to
- Compaction Standard B.in section 3.

6.2.5 Embankment Construction

The embankment shall be constructed by a benching procedure as specified in section 3 as follows:

- Excavate into the embankment to give a 1 metre scarp.
- Dispose of vegetation and other unsuitable material.
- The exposed material is to be identified as either non-porous such as clay or free draining such as ash.
- If free draining, this bench must be connected to the lower drainage blanket, or an additional drainage layer may be constructed using coarse rock 300mm thick.

A capping layer using spent ballast or other suitable material is to be provided at the top of the embankment, constructed in accordance with section 4. The capping layer is to be at a level below the track capping level or track formation level, with a crossfall of 1 in 30 away from the track.

7 Drainage and Erosion Control

A windrow is to be provided on the embankment shoulder in sandy soils. Catch drains, toe drains and mitre drains are to be provided in accordance with other standards.

Drains down the embankment are to be protected from erosion.

In environmentally sensitive areas, appropriate erosion control is to be carried out including topsoiling, mulching and re-vegetation of embankment slope with grass.