Oberon Tarana Heritage Railway

Engineering Standard

Geotechnical

OTCS 410

FORMATION AND EARTHWORKS

Version 1.0

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Approved by:

Document control

Revision	Date of Approval	Summary of change
1.0	August, 2018	First Issue. Includes content from the following former RIC standards: C 1100, TS 3421, TS 3422, CSI 031 and CRN CS 410

Summary of changes from previous version

Section	Summary of change

Contents

1 Purpose, scope and application

This Standard establishes maintenance requirements for embankments, cuttings and earthworks capping layer. There are no cuttings on the OTHR.

It does not cover design and construction of new earthworks including embankments and cuttings as it is not envisaged OTHR will be constructing any new work.

2 References

2.1 Australian and International Standards

AS 1289	Methods of testing soils for engineering purposes
AS 3798-2007	Guidelines on earthworks for commercial and residential developments

2.2 BBRC documents

OTCS 215	Transit Space
OTCS 330	Miscellaneous Structures
OTCS 420	Track Drainage

2.3 Other references

CRN CP 301	Structures Construction
CRN CP 411	Earthworks Materials

2.4 Definitions

Borrow Pit:	Excavation made for the procurement of material
Capping Layer:	Layer of compacted material that provides a sealing layer to the earthworks.
CBR:	Soaked California Bearing Ratio, determined on a compacted sample.
Cohesionless Soil:	Material consisting mostly of sand and gravel mixture, generally with less than 5% fines (i.e., particles finer than 75 µm diameter).
Cohesive Soil:	Material consisting mostly of silt and clay and has a well-defined moisture-density relationship when tested in accordance with AS 1289.5.1.1 or AS 1289.5.2.1.
Collapsible Soil:	Soil that may suffer a significant decrease in volume under load or when it becomes nearly saturated, which may have existed in this metastable state for a long time
Compaction:	The process whereby the density of soil is increased by mechanical means. This typically involves, rolling, impact or vibration, or a combination of these processes.
Contaminated Material:	Material that may contain toxic substances or soluble compounds harmful to environment, water supply or agriculture.
Cutting:	An earth or rock excavation that is made below an existing surface to create the railway formation.

Dispersive soil:	Soil that has the ability to pass rapidly into suspension in the presence of water
Earthworks:	The activities covered by this standard
Earthworks Level:	Level at the centre of the earthworks prior to placing of the capping layer.
Embankment:	An earth or rock fill structure above an existing and/or excavated surface to create the rail track formation.
Expansive Soil:	Soil that will suffer a high volume change when in contact with water. Any increase or decrease in the moisture content of such soil, would cause swelling or shrinkage, respectively. This type of soil is also called “Reactive Soil” and “Swelling Soil”.
Formation:	The earthworks structure including all foundation, structural treatment and capping layer, on which ballast is laid
Formation Level:	Finished level at the centre of the formation preparatory to laying ballast. It includes the capping layer.
Formation Width:	Width at formation level
Foundation Treatment:	A special layer or treated zone at the base of a formation for the purpose of reinforcing, strengthening or drainage.
General Fill:	The zone below the structural zone of the embankment.
Geosynthetics:	Prefabricated sheet made of polymeric materials which may be permeable or non-permeable. This material may be used as filter-drainage (if permeable) or foundation reinforcement. It includes geotextile, geonet, geogrid and geocell.
Geotechnical Engineer:	A person with delegated engineering authority for geotechnical design activities relating to earthworks.
Rail Level:	Design level of the running surface of the rails. In the case of superelevated track, it is the low rail.
Relative Compaction	For cohesive soils, the dry density ratio determined in accordance with AS 1289.5.4.1, or the Hilf density ratio determined in accordance with AS 1289.5.7.1. For cohesionless soils, the density index determined in accordance with AS 1289.5.6.1.
Relative Density:	The field dry density expressed in terms of maximum/minimum densities established by laboratory test (used for cohesionless soils).
Right of Way:	The strip of land over which railroads are built.
Rockfill:	Fill compacted almost exclusively of fragments of broken rock. It generally consists of a large portion of gravel, cobble, and larger sized fragments, and may contain large open voids.
Shoulder Distance:	Distance from the track centreline to the edge of the formation.
Soluble Soil:	Soil containing perishable particles such as gypsum or rock salt.
Stockpile:	Placement of material that has been selected, loaded, transported and unloaded in a heap outside the confines of a borrow pit or of an excavation that forms part of the works.
Structural Zone:	The upper zone of the embankment below the capping. Its thickness varies from 500mm to 1000mm, depending on the CBR of the general fill.
Top Soil:	A natural surface soil that may contain organic matter.

3 Engineering authority

Design and selection of infrastructure detailed in this standard may only be undertaken by persons who have been granted appropriate Engineering Authority by the Engineering Manager

4 Design requirements

4.1 General

Earthworks and formation design includes:

- cuttings
- embankments
- capping layer.

4.2 Design investigation

Before any earthwork activity is undertaken, all necessary assessment and investigation shall be carried out to determine the nature and extent of the work.

In the preliminary assessment, planning and design of earthworks, the following items shall be considered:

- Site investigation (Survey and Geotechnical)
- Adjoining property (Drainage issues and other impacts)
- Preservation items
- Rehabilitation (Clean up and revegetation)
- Drainage (Surface and subsoil)
- Erosion and siltation (Prevention and mitigation)
- Sloping ground, (Issues associated with drainage, stability and erosion)
- Slope stability (Stability of temporary and/or permanent slopes)
- Cuttings and trenches, (Stability of excavation and impact on adjoining structures)
- Retaining walls, (considered if required to reduce batter slopes or support adjacent structures)
- Problematic soils requiring special consideration including reactive (expansive) soils, dispersive soils, collapsible soils, soluble soils, soft-compressible soils, and potential acid or sulfate soils.
- Properties of fill material (Maximum dry density, Optimum moisture content)
- Surcharging of slopes
- Calculation of quantities
- Geosynthetics (Geotextile, Geogrid, etc.) Appropriate use of.
- Construction vibrations, (Impact on adjacent structures and properties)
- Non-potable water to be used for soil compaction
- Contamination of soil, (disposal and/or treatment of)”

4.3 Design flood level

Where track is on a flood plain, the formation level shall be designed so that it is not overtopped in a 1 in 100 year flood, subject to environmental impact assessment in accordance with legislation and assessment of the impact of potential flooding on earthworks and other structures.

4.4 Formation

The formation for single track mainlines and single track sidings shall comply with the appropriate dimensions shown in Appendix 1.

The formation for double track mainlines and double track sidings shall comply with the appropriate dimensions shown in Appendix 2.

Track centres shall be in accordance with Engineering Standard OTCS 215 “Transit Space”.

5 Cuttings

There are no cuttings on the BBRC.

6 Embankments

6.1 Embankment base

The natural ground at the base of the embankment plus a clearance of 2 metres shall be prepared by the removal of unsuitable material. Unsuitable material includes topsoil, peat and other highly organic soils, logs, stumps, perishable material, rubbish, material susceptible to spontaneous combustion, free draining materials susceptible to scouring, very fine sand, silt and organic clay and material with a CBR<1

Where unsuitable material exists in excessive depths the advice of the Geotechnical Engineer is required

Sloping ground or rock surfaces steeper than 1V:7H, on which fill material is to be placed, shall be benched in the form of horizontal terraces at a width suitable for construction plant for the full width of the sloping ground to be filled

6.2 Embankment material

Embankment materials shall comply with Engineering Specification BCP 411 “Earthworks Materials”.

The embankment shall consist of two zones of embankment material:

- General Fill
- Structural Zone.

The thickness of the structural zone (H) is determined by the following relationship with the general fill in the embankment:

- for general fill with CBR* of 3 to 8%, H = 500mm
- for general fill with CBR* of 1 to 3%, H = 1000mm.

* (Soaked California Bearing Ratio, Standard Compaction).

Material for use in the structural zone shall comply with BCP 411.

6.3 Compaction standards

To achieve a stable and durable embankment, the material shall be prepared and compacted as specified below.

The Compaction standards shall be as follows:

Compaction A:
- Cohesive soils - Not less than 100% maximum dry density as determined by AS 1289 Tests 5.1.1 and 5.3.1 (Standard Compaction)
- Rock fill or cohesionless soils - No visible deflection of surface under 10 tonne vibratory rollers after 6 to 8 passes.

Compaction B: Not less than 95% maximum dry density as determined by AS 1289 Tests 5.1.1 and 5.3.1 (Standard Compaction).

Embankments shall be compacted to:

General Fill: Compaction B

Structural Zone: Compaction A

6.4 Sampling and testing

After compaction of each layer, sampling locations will be selected for moisture content and relative density tests.

Field (in-situ) density and laboratory tests shall be carried out in accordance with Australian Standards. The test results must be representative of the tested layer at its full depth, width and length.

Proof rolling shall be carried out on all layers to detect any possible soft or unstable pocket.

Proof rolling must not exhibit visible deformation, rutting, or yielding and/or show signs of distress or instability. Should any of the above occur the affected material shall be reworked and re-tested with subsequent confirmation of compliance to include test rolling.

6.5 Drainage blanket

Where specified or directed by the Geotechnical Engineer, a free draining filter layer consisting of hard durable crushed rock, river gravel or slag which is called drainage blanket, shall be provided under the embankment.

6.6 Embankment profile

Embankment batter slopes up to a height of 3 meters, shall be 2:1 (horizontal: vertical). For higher embankments, the batter slopes shall be determined by stability analysis taking into account of materials properties, height, foundation conditions, static and dynamic loading, and potential seepage forces . Advice shall be sought from the Geotechnical Engineer if there is any doubt concerning the embankment stability.

Batters of 3:1 may be used where grassing is necessary or where stock have to cross the line.

The completed batter must be free of rills running down the face of batter. Any loose material on the batter shall be promptly removed as the work progresses.

6.7 Rock facing of embankments

Where shown in the design, embankment batters (including embankments at bridge structures) shall be provided with a facing of clean, hard, durable rocks (Rip-rap) separated from the earth fill embankment with a graded filter or geotextile sheet in accordance with specifications given by CRN CP 411. Rock facing shall be placed outside of the general embankment dimensions.

7 Capping layer

The capping layer shall be constructed in a single layer having a compacted thickness of minimum 150 millimetres.

The material shall be spread in uniform horizontal layer so as to achieve the specified compacted thickness for the full width of the capping layer. Capping shall be laid on subgrade with a minimum CBR of 8%.

Capping material shall comply with CRN CP 411.

Compaction shall achieve a minimum relative dry density of 95 per cent Maximum Dry Density as determined by AS 1289, Test 5.2.1.

The capping material shall be well mixed throughout the 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 a uniform surface of the sealing layer.

8 Earthworks near structures

8.1 General

For the purpose of this section, structures include bridge piers and abutments, wing walls, box culverts, pipe culverts, headwalls, tunnels, retaining walls, platform walls, noise walls, signal gantries and towers.

8.2 Construction

Care shall be exercised in constructing earthworks within 5m of structures to avoid damage to the structures.

Hand held compaction equipment shall be used within this distance and adjacent to the structure as defined in Table 4:

Structure	Compaction Method
Bridge abutment and wing walls	Hand held compaction equipment for full structure height for a distance of 2/3 H from wall (H = overall height of structure)
Pipe Culverts	Hand held compaction equipment for distance D from pipe to top of pipe (D = diameter of pipe)
Box culverts & culvert wing walls & retaining wall	Hand held compaction equipment for full structure height for a distance 2/3 H from wall (H = overall height)

Table 4 – Compaction of earthworks near structures

Selected backfill shall be placed adjacent to structures in accordance with the requirements of Table 5. The selected backfill shall consist of a granular material having a maximum dimension not exceeding 50mm and a plasticity index, determined in accordance with AS 1289.3.3.1, neither less than 2 nor more than 12. In the table, H = overall height of the structure.

Structure Type	Selected Backfill	
	Width	Height
Bridge Abutments	2 m	H
Box Culverts, Precast Culverts	H/3	H + 300mm
Corrugated Steel Pipes and Arches	0.5 m	H + 500mm
Retaining Walls	H/3	H

Table 5 – Select fill adjacent to structures

The fill shall be placed in horizontal layers with a compacted thickness between 75mm and 100mm.

Layers shall be placed simultaneously on both sides of box culverts to avoid differential loading.

Compaction shall start at the wall and proceed away from it.

The existing slope behind the structures shall be cut in the form of successive horizontal terraces, each terrace being at least 1m in width and 600mm in height.

In case of spill-through abutments, rocks shall not be dumped against the columns or retaining walls but shall be built up evenly by hand placing around or against such structures.

In the case of framed structures, embankments at both ends of the structure shall be brought up simultaneously and the difference between the levels of the embankments at the respective abutments shall not exceed 500mm unless otherwise specified in the design or within the specifications.

Adjacent to weep holes, free draining filter material encapsulated in a suitable geotextile fabric should be placed, horizontally for at least 300mm from, and vertically for 450mm above the weep - hole. Free draining material must be provided by broken stone or river gravel consisting of clean, hard, durable particles graded from 50mm to 10mm such that:

- the maximum particle dimension does not exceed 50mm; and
- no more than 5% by mass passes the 9.5mm AS sieve.

8.3 Excavation

Care should also be exercised when excavating within 5m of structures (for example near bridge abutments or platforms when benching into slopes for embankment widening or when excavating for track reconditioning).

When excavating adjacent to structures, there is a risk that the footings may be undermined or the structure destabilized, resulting in structural failure and potential collapse.

Excavations in the vicinity of structure footings are therefore not permitted unless documented engineering advice and approval are obtained.

No excavation should be made within this 5m distance without prior analysis of structure stability with respect to the effects of the excavation.

No excavation shall be made below the base of the footings of any structure (for example bridges, retaining walls and station platform walls) without prior analysis of structure stability with respect to the effects of the excavation.

The approval will be in the form of a certification by a competent geotechnical/structural engineer with relevant engineering authority, based on the results of an appropriate geotechnical and/or structural investigation.

9 Tolerances for earthworks

Tolerances for different sections of earthworks shall comply with the following provisions:

9.1 Vertical tolerances

9.1.1 In embankments

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

9.1.2 In cuttings

- Floor of cut (top of common earthworks): other than rock + 40mm to – 40mm
- Floor of cut (top of common earthworks): rock + 0mm to – 80mm
- Top of Structural Zone: other than rock + 0mm to – 50mm

9.1.3 At transitions between cut and fill

- Floor of cut to fill transition +0 to –50mm

9.1.4 Top of benches and berms

- Top of benches and berms +50 to –50mm

9.1.5 Capping layer

- The finished surface of the capping shall be within 25mm of the design level and:
- The algebraic difference of the deviations from the correct level for any two points 20 metres apart on the centreline shall not exceed 15mm.
- The deviation from a three (3) metre straight edge laid on the surface parallel to the centreline shall not exceed 10mm.

9.2 Horizontal tolerances

The width of the base and top of cuts and fills and the widths of benches and berms shall not to be less than specified dimensions. Maximum positive tolerance is 300mm, unless approved by the Geotechnical Engineer.

The width of the capping layer from the design centreline to the finished top of embankment slopes or toe of batters in cuttings shall be not less than the dimensions required by Table 1.

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

10 Drainage

Cess drains; sub-surface drains, top drains and interceptor drains shall be provided for cuttings and shall comply with the requirements in Engineering Standard BCS 420 “Track Drainage”.

11 Train examination areas and walkways

Where train examination areas or walkways are provided, they shall meet the following requirements:

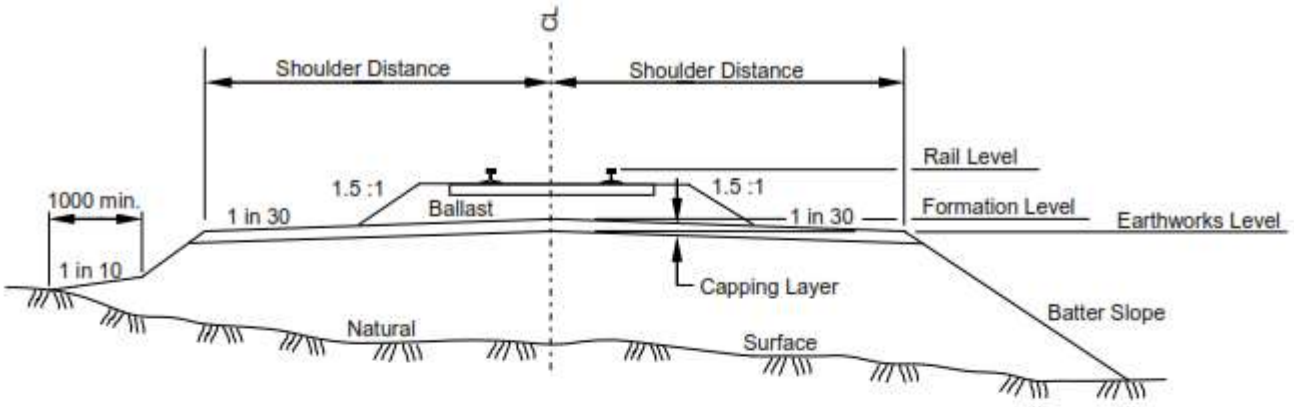
- They shall be free draining, permitting uninterrupted flow of water from the track formation away from the track
- They shall not impact on the performance or maintenance of track infrastructure,
- They shall be suitable for the purpose for which they have been designed.

12 Rehabilitation of formation

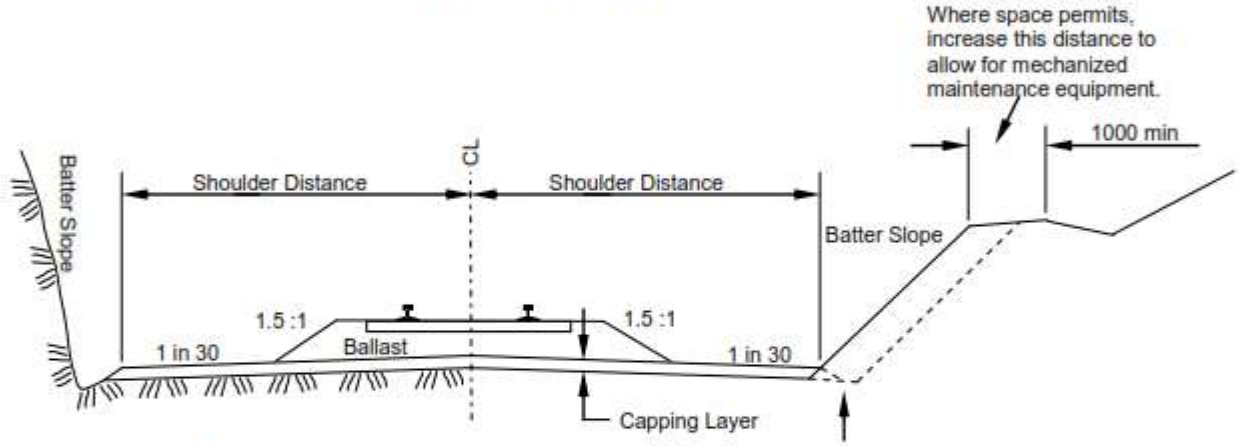
In rehabilitating the formation, the following shall be taken into account when preparing the work plan and design:

- Investigation and assessment of ground condition by the Geotechnical Engineer;
- Rectification of drainage deficiencies;
- Removal and disposal of failed ballast to the formation level;
- Removal and disposal of failed formation material;
- Provision of capping material on the original formation;
- Provision of structural fill
- Provision of hard rock fill to replace soft subgrade
- Provision of trench (ballast filled) drains;
- Repair/rectification of degraded, ineffective, blocked or sagging culverts..

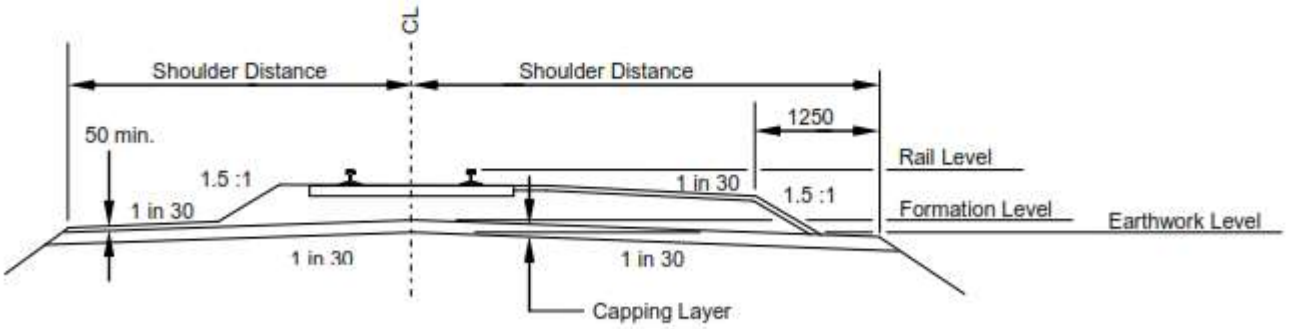
Appendix 1 Single track cross section



EMBANKMENT



CUTTING

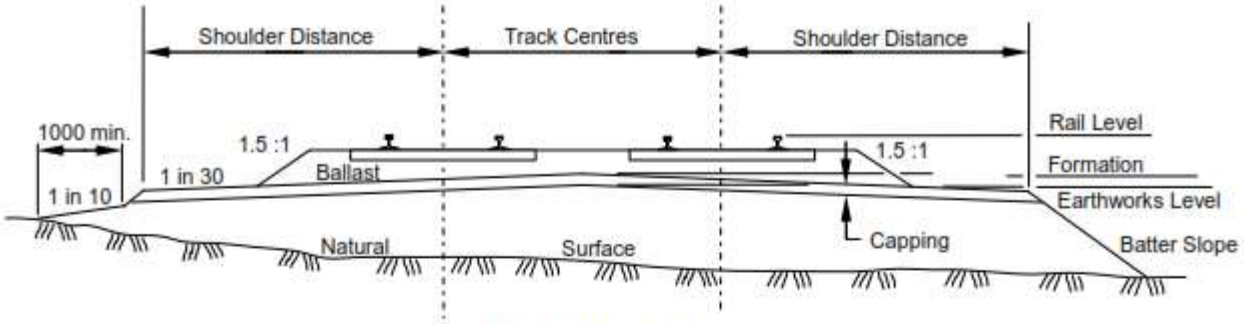


Typical section where shunters' and guards' walkways are required.

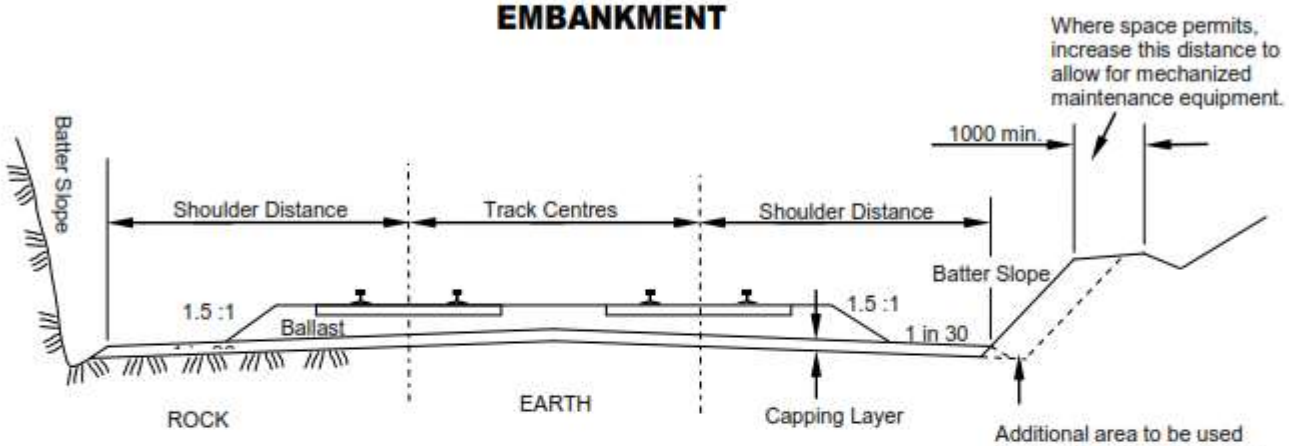
Typical section where examinations areas are specified.

SPECIAL WIDTH REQUIREMENTS

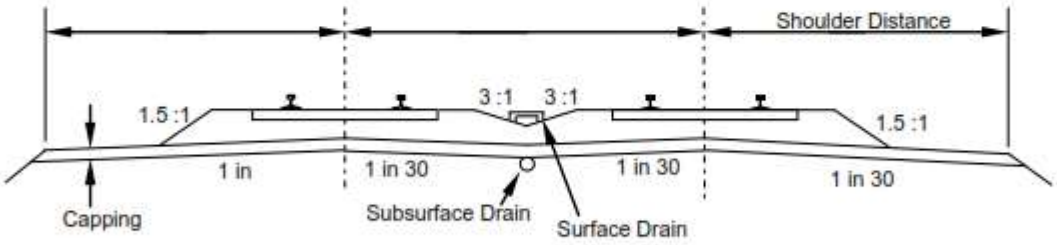
Appendix 2 Double track cross section



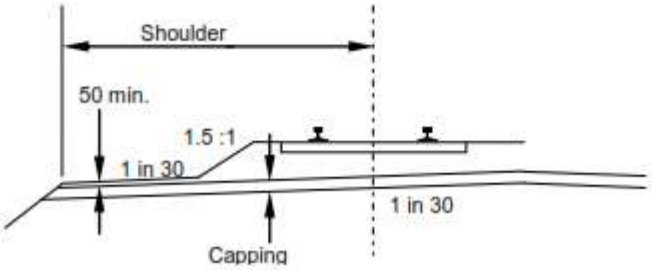
EMBANKMENT



CUTTING



CENTRE DRAIN



Typical section where shunters' and guards' walkways are required.

SPECIAL WIDTH REQUIREMENTS