AUSTRALIAN RAIL TRACK CORPORATION LTD

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Engineering Practices Manual

Civil Engineering

Track Reconditioning Guidelines

RTS 3430

Issue A, Revision 0

March 2006

1. Scope

This guide has been prepared to assist in the investigation, design and rehabilitation of the existing track formation and ballast.

It is intended to be used in all construction or maintenance activities aimed at modifying the existing formation conditions.

It is recommended that a geotechnical engineer experienced in track geotechnology authorise the formation design.

2. Reason and Nature of Change

Document reissued as ARTC Engineering Practice Manual.

3. Purpose of Track Reconditioning

The purpose of track reconditioning is to reconstruct the track formation and ballast to restore the track structure to a standard appropriate to current track loading. Reconditioning usually involves the removal of rails, sleepers and ballast and a predetermined depth of the existing formation and the reconstruction of those components to current earthworks standard. Modifications to the track drainage are necessary at the same time.

Reconditioning is usually carried out because of bearing capacity failure of the formation or a failure of the drainage, but is at times carried out to replace foul ballast where local conditions prevent the use of ballast cleaners.

4. Determining the Need to Carry Out Reconditioning

Track improvement requires an adequate investigation. It is important to have a clear idea of what the problem is, and its extent.

Consideration of the need to carry out track reconditioning should be given when any one of the following features exist:

a) Continue poor track performance, ie. Rapid deterioration of top, or top and line in spite of repeated attempts at resurfacing, ballasting, or ballast cleaning.

b) Visible signs of formation failure, ie. "heaving" beyond the ends of sleepers or between sleepers.

c) "Bog Holes" – Track and ballast fouled and/or with mud actively pumping through the ballast.

When the track is removed and formation lowered to increase height clearances, the correct ballast depth must be provided and the reconstruction of the lowered formation should follow the investigation and design principles set out in this guide.

Figures 1, 2, 3, 4, 5, 6 and 7 illustrate examples of track formation problems.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Some of the above problems can be solved without removal of the track.

Reconditioning, however, **IS** required when the foundation has failed.

Alternatives that can be considered include:

Methods that do not require track removal:

1) Shoulder and crib ballast replacement (Manual and Machine)

2) Cross Drains (see section 4.1)

3) Sledding

4) Ballast Cleaning

5) Lime Slurry Injection

Methods that require track removal:

1) "Skim" Reconditioning (see section 4.2)

2) Formation reconstruction

4.1. Formation Drainage Option

Track conditions may improve sufficiently without reconditioning if drainage of the formation is improved. Cut off drains across the whole track to a level below the ballast formation interface will drain depressions in the formation. These cut off drains or finger drains need to be at intervals of 5m. This solution may avoid costly track possession.

Removal of the shoulder ballast and replacement with clean ballast will release water trapped in the track profile, and replacement of the crib ballast with clean ballast will improve track performance.

Cess drains must be lowered to below the formation level to permit drainage.

4.2. Skim Reconditioning

Where the formation has not failed, there is no original capping, and it is possible to raise the track, skim reconditioning is a viable solution.

The track is removed and the clean top ballast excavated. The foul bottom ballast is graded and compacted to form a structural capping layer. The track is then relaid and ballasted.

This method is used when replacing timber sleepers with concrete sleepers.

5. Investigations Prior to Track Reconditioning

The causes of the track formation failure and details of the subsurface conditions should not be assumed. All reconditioning projects should have a geotechnical investigation carried out by an experienced geotechnical engineer at early planning stages.

The typical geotechnical investigation will consider the following:

- Subsurface conditions – depth and condition of ballast, capping and subgrade.

- Determination of the cause of failure – foundation failure, ineffective drainage, rock pumping.

- Adjoining structures – effect on platform footings, if any.
- Reconditioning recommendations – ballast clean, skim (remove ballast only) or full reconditioning.
- Reconditioning design – depth of layers etc.
- Subgrade treatment – geosynthetics, rock fill, geocell etc.
- Drainage needs.

5.1. Investigation Procedures

The basic components of an adequate investigation of track constructed on clay or fill consist of the following procedures and aims:

a) Excavation of test pits at regular intervals (10 to 20m, alternate Up & Down Side, in the four foot, and at obviously failed locations) to determine:

- The depth and condition of the ballast.
- The existence of other ballast materials.
- The existence and condition of capping.
- The condition and type of subgrade.
- The degree of saturation of all materials.
- Information about the interface profile, if visible, to indicate the degree of rutting or consolidation.

Investigations should be located between two sleepers and the outside rail or in the 4ft and extend to below the formation level or about 1.2m below the rail level. See Figure 8.

Excavations across the whole track between sleepers provide the most information, especially about the formation profile, but are expensive and intrusive and should be done less frequently as a control.

b) Insitu strength tests using Dynamic Cone Penetrometer (DCP) should be conducted close to the rail. Tests should start from below the ballast and continue to a depth of 2.5m below rail level to provide an estimate of the insitu CBR value.

c) Samples of the subgrade should be selected for classification testing and to assist in the design of graded filters (sub ballast) or geotextiles or to determine if stabilizing materials will assist in improving subgrade performance. Samples of the top and bottom ballast should be taken to determine ballast recovery, should the material be recycled. Samples should be a minimum of 30kg.

d) A description of the degree of saturation of the track should be recorded, as should details of the cess drainage and any system existing and an evaluation of its condition.

e) Survey details of the track, cess drain inverts, culvert inverts and adjacent areas, (and beyond boundary if necessary) are necessary for design of future drainage.

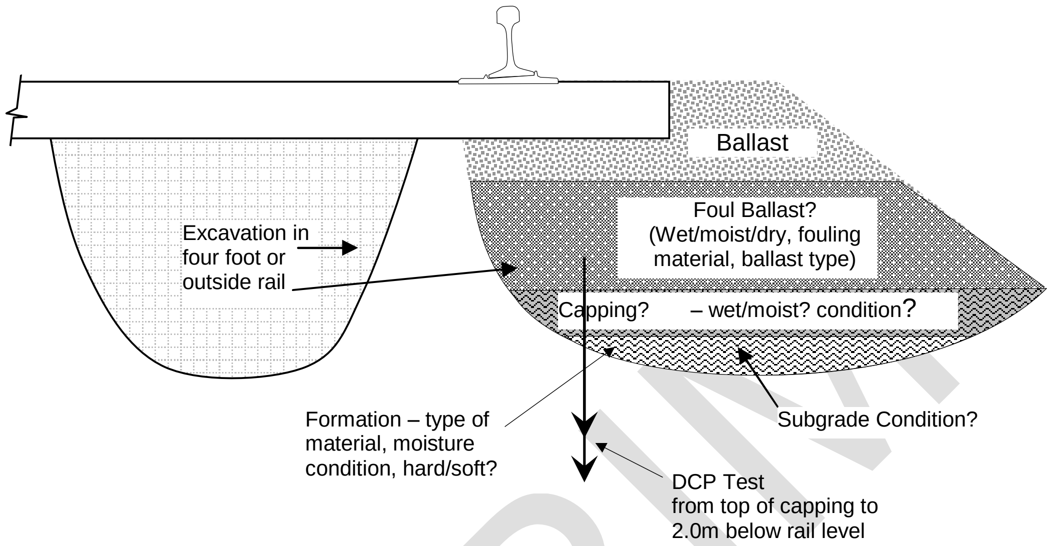


Figure 8 – Ballast depth and formation investigation for reconditioning

6. Track Formation Design

6.1. Basic Design Model

The basic design model consists of the standard 300mm of ballast below the sleeper supported by 150mm of capping material. This is satisfactory provided the underlying material will provide sufficient support. (Relate to TDS 11).

Where the formation consists of hard rock or concrete the ballast thickness must not be less than 250mm otherwise ballast degradation and rock abrasion will accelerate. (Relate to TDS 11).

For track on soil or fill, the material immediately beneath the capping layer (structural fill) is required to have a soaked Californian Bearing Ratio (CBR) ≥ 8. (See Figure 9). The required thickness of this material varies depending on the quality of the founding material. The thickness “H” of structural fill/material is recommended for the following founding material:

Founding Material – CBR	Thickness “H” (mm) Structural Material
≥3	500
1-3	1000

Dynamic Cone Penetrometer (DCP) testing is therefore required to 2.5m below rail. A correlation between DCP tests and CBR is provided in Appendix 1.

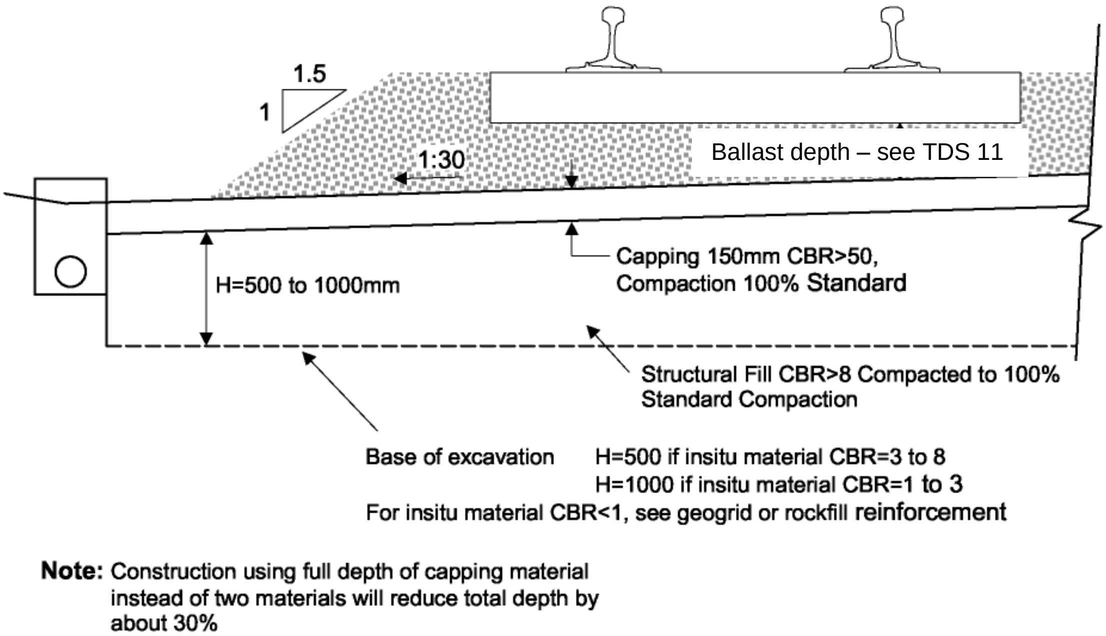


Figure 9 – Track Formation - Basic Design Model

7. Capping Materials

7.1. General

Capping as specified in ARTC standard TDS 12 is used for some or all of the following reasons:

- To improve track support. (Generally a layer 150mm thick is sufficient for normal conditions with increased thickness for soft subgrade).
- To fill in irregular over-break situations in rock excavations to assist in drainage.
- To provide a drainage barrier to shed storm water from subgrade.

The performance of the capping depends on the quality of the material and the quality of its compaction on placement. The material needs to comply strictly with the requirements of TDS 12 and to be compacted in accordance with RCP 01 to provide the ‘Barrier/Support’ features expected.

7.2. Flexible Impermeable Capping

The properties specified for capping of this type are designed to provide a flexible impermeable granular of high strength. For this material to perform correctly the properties of the material supplied must strictly comply with the requirements of TDS 12 for flexible impermeable capping. This layer is designed to seal the formation and shed any surface water. Material suppied as DGB20, or similar, in accordance with specifications prepared for the RTA of NSW do not necessarily comply and will not provide a seal to the formation. The closest road specification to rail requirements is “Road base for unsealed roads”. Material to be used as capping of this type should be tested for compliance prior to use.

It is also very important that the correct compaction levels are obtained. Poorly compacted capping will become saturated quickly, foul the track and become the cause of further track and ballast problems.

7.3. Sub-Ballast

Where the foundation consists of free draining materials such as rock fill or sand a sub-ballast may be more appropriate than an impermeable capping.

Sub-ballast is not impermeable and is designed as a filter material to limit fouling by subgrade material and to prevent itself from fouling the ballast. Its purpose is to:

- Spread vertical load from the ballast.
- Prevent migration of fines from the subgrade.
- Permit migration of moisture.

The grading of the sub-ballast is important and must be specifically designed for a particular subgrade and ballast. Laboratory testing of both the subgrade and the ballast is required to be able to design a grading for sub-ballast.

The performance of the sub-ballast is not destroyed by saturation as is that of the capping and it is much more easily compacted. It may provide a better solution than capping in areas where the subgrade is constantly wet due to, say, a spring or in soft rock formation situations.

7.4. Semi Rigid Capping

In situations where it is difficult to obtain material complying with the specifications for impermeable capping and the formation conditions are relatively stiff a semi rigid capping may be appropriate. It is also appropriate as a capping over soft friable rock foundations. This material may consist of a stabilized material and properties are specified in TDS 12.

The use of this material over soft formation is **not recommended** as it will crack on flexure and rapidly cause track pumping problems. It is advised that thorough geotechnical investigation and analysis be performed before choosing this type of capping.

8. Drainage

The success of any track or reconstructed track formation is governed by the effectiveness of the drainage of water from the ballast above the capping and the subsoil water beneath the capping. An effective surface drainage system must be constructed as part of all reconditioning. For surface drainage to be effective, grades must be uniform, without local hollows. Ponding of water in cess drains or surface drains produces gradual deterioration of the formation strength.

Reconditioning must not create a condition where water ponds beneath the track.

If the investigation discovers saturated conditions a subsoil drainage system must be installed. Subsoil drainage is required to:

- Drain any porous subsoil material.
- Lower water table where it is near the ground surface.

- Reduce pore water pressure due to train loadings in rock foundations or artesian pressure eg.-springs.

Subsoil drainage systems require headwalls at the outlets and flushing points for maintenance. These features need to be clearly visible and signposted.

More detailed information on surface and subsoil drains is available in ARTC Engineering Practice RTS 3433.

9. Geosynthetics

CAUTION

– *Geotextiles are not Magic*

– *They cannot be used to short cut the project*

– *or make up for poor construction materials*

Geotextiles have been used extensively in track reconditioning for some years because it was believed that benefit could be gained in subgrade support and separation of the ballast from the capping. More recent experience and investigations reveal that the geotextile provides little benefit unless used appropriately and may also create problems. The most appropriate uses of geosynthetics in track formation are:

- Filtration and separation.

- Subgrade support.

The geotextiles for these purposes have significantly different properties and the better performance in one means a reduced performance in the other.

9.1. Ballast/Capping Separation

Geotextile was originally placed beneath the ballast in the belief that it would reduce fouling of the ballast by fine material from the formation. In other cases it was placed because the capping had not been sufficiently compacted. However, research of ballast performance has shown that where the formation and capping are constructed properly the major contribution to ballast fouling is from ballast breakdown and contamination from the surface. The presence of geotextile therefore fails to protect the ballast from these contaminations. Local experience has shown in many cases that the material above the geotextile has been more fouled than below.

Furthermore the geotextile suffers severely from abrasion by the ballast and very quickly loses its separating capabilities. Where the geotextile has been used in wet and soft conditions or when capping has not been compacted adequately, the high dynamic loads from rail traffic induces extreme pressures at the ballast formation interface and the filtering action of the geotextile is negligible.

Ballast cleaning operations have also been severely hampered by the presence of the geotextile.

It is therefore not recommended that geotextile be placed beneath ballast at the ballast/capping interface.

A geotextile is necessary, however, between two materials of significantly different grading. When placing capping or sub-ballast material over coarse rock fill a geotextile is necessary to prevent the fine material of the capping from falling into the voids of the coarse fill.

Figure 10 – Excavated geotextile showing complete "clogging" in service

9.2. Filtration

Geotextiles are used to great advantage in subsoil drainage systems and the costly process of graded aggregate filters have been avoided. A geotextile wrapped around coarse aggregate or a slotted pipe provides substantial cost savings.

It is, however, necessary to sample and test the soils in which the subsoil drain will be placed to determine the appropriate geotextile to use. Some soils are not filtered by all geotextiles. Soils with high content of fine silts and clays require close investigation and in some cases cannot be drained by subsoil drains wrapped in geotextile.

The important properties of the geotextile are its filtering properties and the strength properties so that the geotextile will maintain its integrity during the construction process. The properties set out in the following tables are for average conditions. Where there is doubt about the soil/geotextile compatibility, a geotechnical investigation is required.

9.3. Reinforcement

A geotextile is placed below the structural fill to reduce subgrade deformation due to the load and to reduce the amount of structural fill required. A geotextile for such a purpose is required to have a high tensile strength and low elongation and to develop good bond with the contact material.

The best material for this purpose is a geogrid and it is recommended in very soft areas. Other geotextiles providing good reinforcement are the woven type fabrics or bonded fabrics. The properties recommended as minimum for track work are given in Section 9.4 below.

9.4. Properties of Geotextiles in Track Projects

9.5. Subsoil Drainage

Property	Test Method	Value
Tearing Strength, Trapezoidal *	AS 3706.3	200N min
Burst Strength, CBR Method *	AS 3706.4	1700N min
Puncture Resistance, Drop Cone *	AS 3706.5	^{d500} = 33.5mm Max ^{H50} = 900mm Min
Pore Size *	AS 3706.7	240 max
Permittivity	AS 3706.9	3.4 sec* min
* - *Important when used as a separation for rock fill*		

9.6. Subgrade Reinforcement (Below Capping)

Property	Test Method	Value
Tensile Strength, Wide Strip	AS 3706.2	25KN/m min peak
Elongation at Peak Strength	AS 3706.2	25% max
Burst Strength CBR Method	AS 3706.4	2800N min
Permittivity	AS 3706.9	0.12 sec^{-1} min

9.7. Properties of Geogrids

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

The geogrid selection should be on the basis of the grading of the material in contact with it ant the grid opening size is related to the maximum size of the aggregate with which it interlocks. The manufacturers provide a selection criteria for their products for the various uses.

The recommended minimum strength is 20KN/m transverse and 20KN/m longitudinal to the track. The interlocking with aggregates is important. When selecting a geogrid, careful attention should be paid to the profile and rigidity of the grid webbing. A geogrid with a square web profile and high rigidity will perform well in interlocking with aggregate.

10. Track Reconstruction Solutions

Reconditioning is usually required because the subgrade has not met the above criteria. Methods of improving the performance of the existing subgrade material need to be considered in the planning of the reconditioning. The following options are suggestions only and each situation needs to be assessed by a geotechnical engineer for conditions peculiar to the site.

10.1. Reconstruction by Structural Fill Methods

Reconstruction of the formation is conducted by excavation of unsuitable material and replacement with suitable material to suit the basic design model. See Figure 9.

For soft subgrade this option would require sufficient time and space to permit the removal and replacement of what could consist of a substantial amount of material to provide the support defined in the model.

If, however, investigations indicate that the subgrade has a CBR of 8 or greater and that track failure is due to loss of the frictional properties of the ballast due to poor drainage only, minimal excavation is necessary to remove the thin layer of soft material immediately beneath the ballast. In conjunction with the necessary reconstruction of effective drainage, a reduced thickness of structural fill can be used in these situations.

The new material must comply with the requirements of ARTC Standards C1100 and TS 3422 and the work required includes preparation and compaction as normally applies to earthworks construction. A capping layer of 150mm (min) is recommended unless the structural fill also meets the requirements of TS 3422, in which case the fill would continue to below the ballast.

10.2. Reconstruction Using Reinforcements of Rock Fill and Geosynthetics

The use of geotextiles and/or geogrids, geocells and rock fill can assist to reduce the amount of excavation and fill material especially in soft subgrade.

10.3. For Subgrade with CBR = 3-8

Where the subgrade has been found to have an insitu CBR of between 3 and 8 a geotextile below a higher grade imported fill material will reduce the excavation necessary. The fill material is recommended to have CBR of at least 20 at 100% standard compaction and a minimum thickness of 350mm. The geotextile reinforcement must be a high strength, low elongation type material or the benefits will not be realized. See Figure 11.

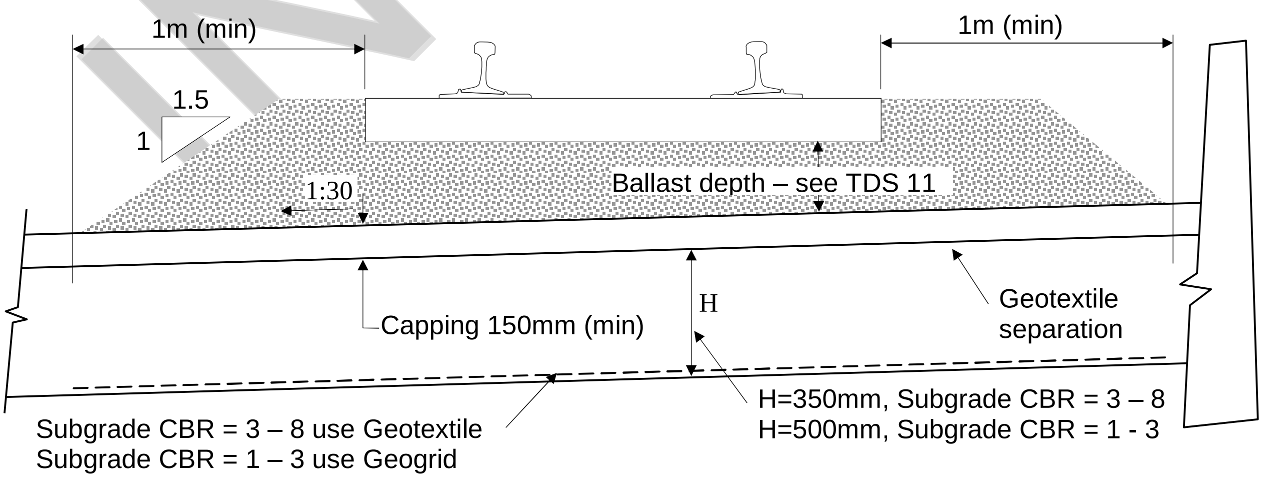


Figure 11 – Geogrid Reinforcement

10.4. For Subgrade with CBR = 1-3

Where the subgrade has been found to have a CBR of between 1 and 3 a geogrid is recommended in place of a geotextile at the subgrade level. The same recommendations for the type of fill as in Section 11.3.1 apply with a thickness of 500mm. See Figure 11.

10.5. For Subgrade with CBR = 1 or Less (Rock Fill)

Where the subgrade had been found to have a CBR of 1 or less it will be necessary to use coarse rock fill to reduce the amount of excavation. A minimum excavation of 500mm is recommended. Obtain geotechnical advice for resolving these conditions.

Coarse rock fill, 50-150mm in size (no fine material) is tipped or rolled into the soft material. More is added until the rock fill no longer penetrates the mud and the surface is just free of mud. A geogrid is then laid and filling continued with rock fill up to the underside of capping, with appropriate static rolling. No wheeled or tracked machinery should be permitted on the subgrade until sufficient rock fill has been placed to support it. An additional layer of geogrid should be added where the filling exceeds 500mm.

The surface of the rock fill must be covered with a geotextile for separation between rock fill and capping. See Figure 12.

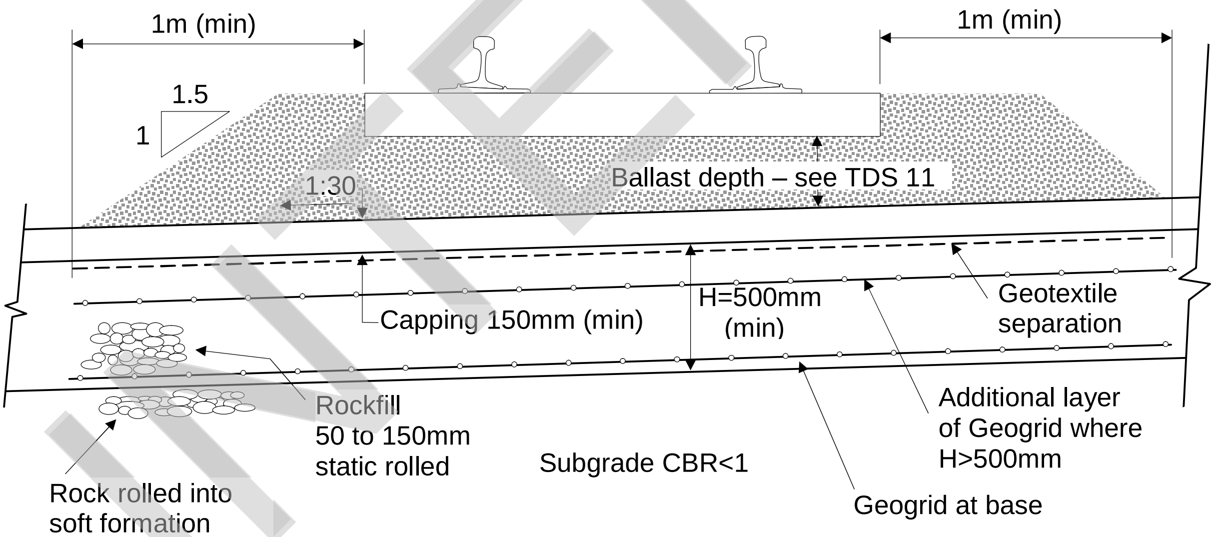


Figure 12 – Rockfill Reinforcement

10.6. For Subgrade with CBR = 1 or Less (Geocells)

An alternative to the solutions outlined in 10.3.3 is to install Geocells to improve the load support capacity of soft subgrade. It is often recommended for swampy conditions where the ground water is close to the surface. Geocells consist of an array of plastic hexagonal cells infilled with granular material. These are installed immediately below the ballast and filled with ballast. Geocells are available in panels 2.44m x 6.1m with thickness varying between 102 and 203mm.

The thickness and number of geocell layers must be individually designed for each particular situation. An excavation is made to the designed level of the geocell base. A geotextile is laid over the excavation to minimize the transmission of fines through the geocell into the ballast. The geocell is laid out, filled and the infill lightly compacted. No capping is required above the geocell, however in situations where the subgrade needs to be protected from surface water, an impermeable geomembrane may be installed at the geocell base instead of a geotextile. Impermeable membranes are not required when Geocells are installed in swampy ground conditions. See Figure 13.

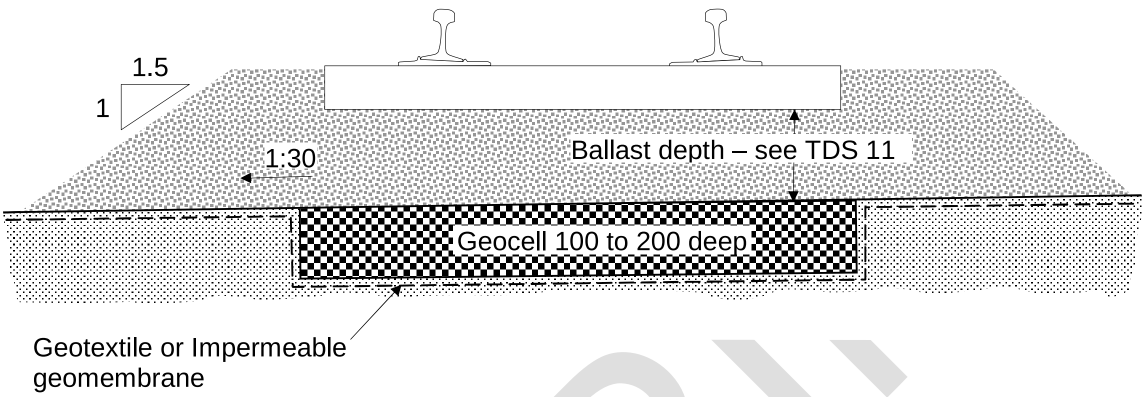


Figure 13 – Geocell Reinforcement, Formation CBR<1

It should be noted that you still need to install the depth of ballast specified in TDS 11 above the geocell. The geocell installation is a solution to provide support, not to reduce ballast.

11. Chemical Stabilisation

Stabilisation of subgrade is the improvement of the subgrade by mixing in lime or injection of lime or a lime/fly ash mixture.

Lime stabilisation is very relevant for high plasticity clays because of the reaction of lime with the clay minerals and can be used to reduce the shrink/swell behaviour of active soils. For the best results the subgrade must be scarified and lime spread and mixed uniformly. This requires adequate track possession and work space.

Lime injection methods require numerous inspection points to guarantee that the lime is uniformly distributed in the subgrade.

For less plastic clays the effect of lime is more a cementation action that is not strong. Procedures are available for lime and fly ash injection that provides an improvement in strength of the subgrade. These procedures provide high-pressure injection to significant depths at close spacing.

In general, lime injection or stabilisation is not recommended without sufficient investigation to support their use. Geotechnical advice and laboratory testing is necessary to determine the appropriate percentage of lime for the soil in question.

Stabilisation by the injection of cement slurry is not recommended.

Other chemicals are offered to assist in stabilisation of the subgrade and need to be evaluated as to practicability or effectiveness. Obtain geotechnical advice to assist in the evaluation of products that are being marketed as possible stabilisation measures.

12. Construction Issues

1) Minimise or eliminate construction traffic over exposed subgrade material.

   After excavation of the ballast the formation is usually not firm and the passage of wheeled or tracked machinery will cause significant additional damage.

   Where possible, the construction method must be designed to avoid trafficking over the exposed formation. Excavating spoil by placing excavating machinery on adjacent undisturbed track or ground and pushing new fill in front of construction equipment is necessary when dealing with soft formation. The structure of some clay is destroyed by the remoulding action of construction equipment. This damage to the soil structure is permanent and may reduce the strength and affect the future performance of the formation.

2) Compact new fill in layers no deeper than 200mm loose. Thinner for light compaction equipment.

3) Use proper compaction equipment and compact to specified density.

4) Construct the correct cross fall.

5) Construct adequate drainage.

13. Rock Foundation

The investigation of track on a rock base follows the basic steps set out earlier. Where there is evidence of track fouling as a result of foundation problems and the investigation reveals that the track is constructed on hard shale or sandstone, the potential of foundation rock pumping must also be investigated by geotechnical personnel.

13.1. Foundation Rock Pumping

Foundation rock pumping occurs in horizontally bedded rock under track work where the cyclic loading conditions cause deflections of the rock strata and abrasion along rock bedding planes. In the presence of water, fine material, resulting from the abrasive action, is forced through fractures in the rock and contaminates the ballast. Depending on drainage conditions at the track level, isolated cones of rock fines will exist in the ballast or the ballast will eventually be completely fouled with mud. See Figure 14.

This pumping can exist up to 2.0m below the track formation level.

In cases where foundation rock pumping is believed to be occurring more detailed investigation methods are recommended with a geological evaluation of whatever rock is exposed in adjacent cuttings. The cores would be examined for signs of abrasion at bedding planes to determine at which depth this is taking place. This type of investigation must be carried out by geotechnical engineers or geologists experienced with this problem.

When the fouling of ballast due to pumping is severe and the track geometry is badly affected remedial measures to address rock pumping are required. The presence of water close to the formation level is a major contributor to the problem and deep drains are necessary to control the pumping. These drains may need to be in excess of 1m below the formation.

Alternative solutions to reconditioning may need to be considered where deep drains cannot be achieved. These solutions may include structural concrete slabs and ground anchors and specialist geotechnical and structural advice is required.

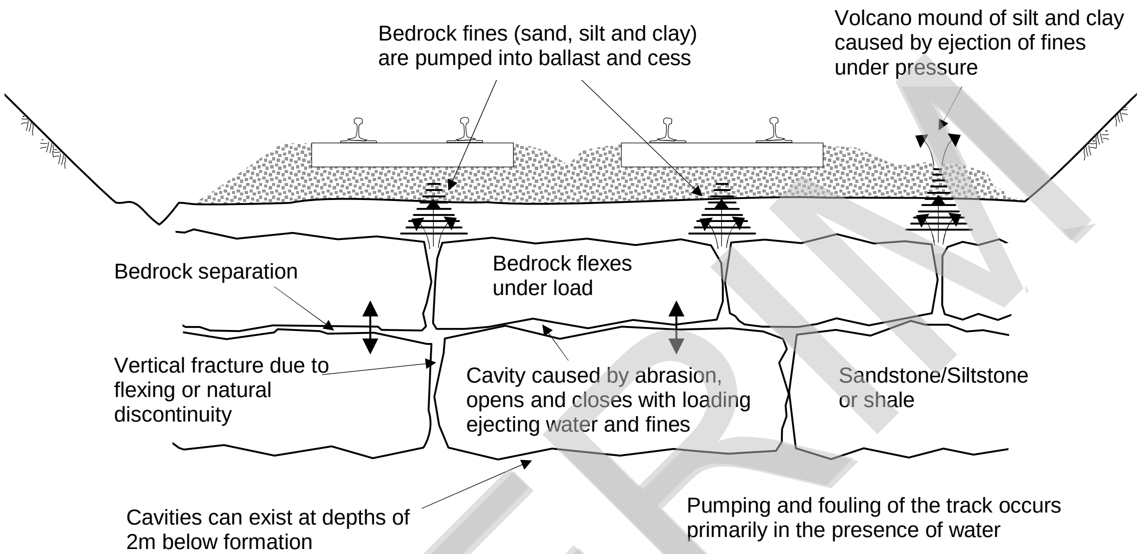


Figure 14 – Bedrock Formation pumping mechanism

Figure 15 – Example of Bedrock Formation pumping

13.2. Irregular Rock Excavation

Track reconditioning may be required because of the fouling of the ballast in rock foundation areas due to failure of the capping or abrasion of the rock. In rock cutting s where the excavated rock surface is irregular water can be trapped in depressions under the track. This condition will produce accelerated abrasion of the surface of the rock formation and fouling of the ballast. This situation may also arise during the reconditioning exercise where rock has been removed by ripping or hydraulic rock breaker.

It is important to ensure that there is a uniform cross fall on the top of the rock formation. In these situations any over-break or depression should be filled with material with characteristics as close as possible to those of the rock. A cement stabilized road base material, semi rigid capping or roller compacted dry concrete are satisfactory. Layers of cement stabilized material need to be greater than 50mm to prevent disintegration under traffic.

Appendix 1

Dynamic Cone Penetrometer (DCP) – Guide to Use and Interpretation

The dynamic cone penetrometer (DCP) has become a valuable tool in geotechnical engineering to identify soft material and the boundary between suitable and unsuitable material. Because of past correlations by Scala (1956) and the Australian Road Research Board (ARRB, 1973) a measure of soil strength can be found. Scala's work was carried out predominantly on clays and the report by ARRB was for flays in the Bankstown area.

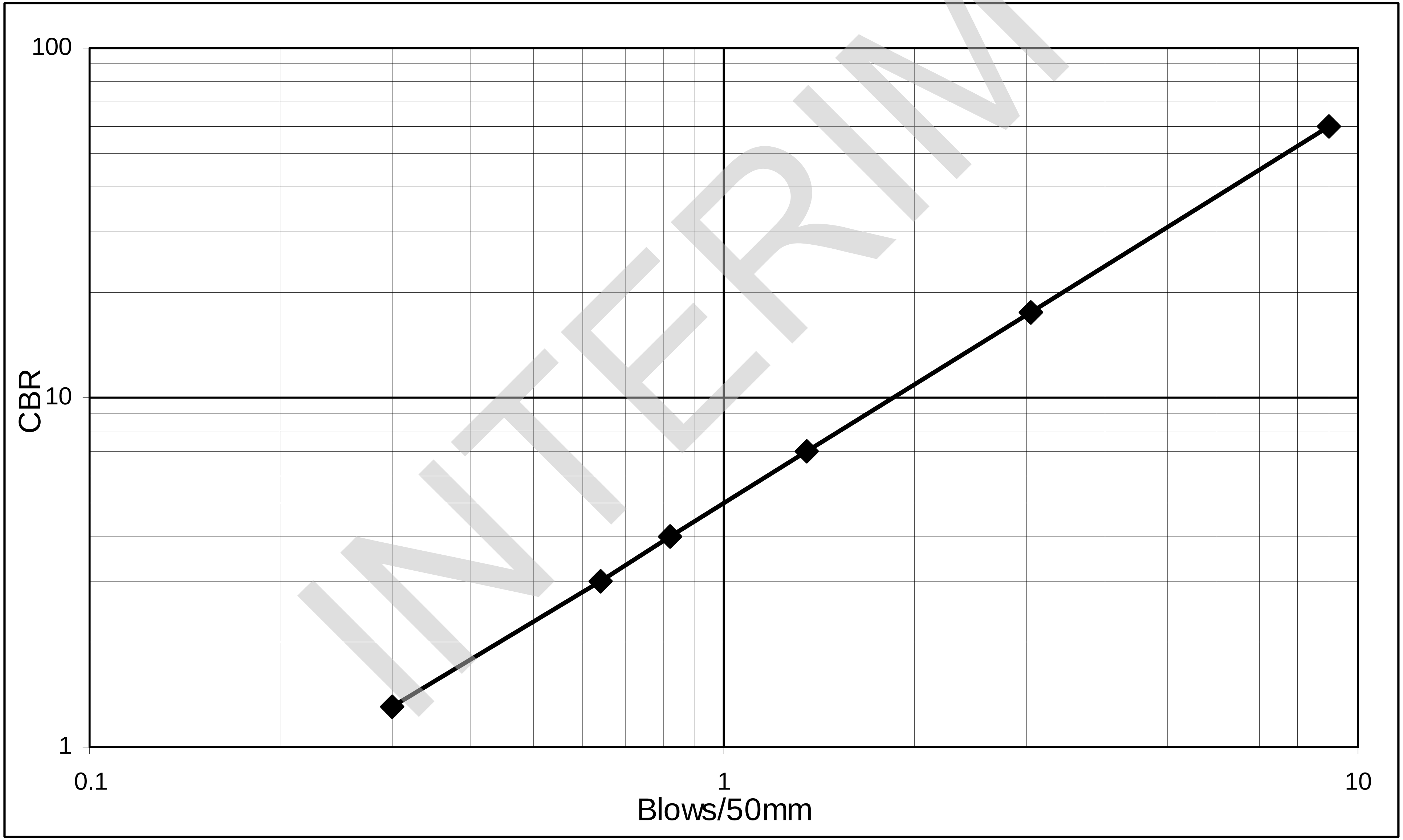
The results of the dynamic cone penetrometer are recorded on the attached record sheet as blows for 50mm of penetration and using the following graph, an equivalent Californian Bearing Ratio (CBR) can be obtained.

For clay material a reasonable level of confidence is possible, however with sands and ashes little correlation exists to obtain shearing or bearing capacity values.

The results obtained from layers of sand or ash will indicate much lower resistance to penetration than for clay but do not indicate correspondingly low bearing capacities. Experience in geotechnical engineering is necessary to make reliable interpretation of low DCP results in ashes and sand.

The information from the DCP sounding in blows per 50mm is plotted on a linear scale with depth and correlated if possible with information from boreholes or test pits to identify critical layers.

Consistently high values in excess of 3 blows/50mm over 350-500mm can be interpreted as a layer of material that may provide good track support. Inconsistent values indicate non homogeneous material and the possibility of doubtful support. Rocky fill material will provide extreme variations and needs to be interpreted carefully.


100
10
1
CBR
0.1
1
10
Blows/50mm
INTERIM

Project No.: ……………………….

DYNAMIC CONE PENETROMETER TEST

Project: ………………………………………………………………………… **Date:** ………………………………………………

Feature: ………………………………………………………………………… **Tested by:** ………………………………………………

Location: ………………………………………………………………………… **Supervisor:** ………………………………………………

Hole No.												
Ground Level (m)												
Depth below ground level (m)	**Number of Blows per 50mm**											
	0.000	+2.000	+4.000	0.000	+2.000	+4.000	0.000	+2.000	+4.000	0.000	+2.000	+4.000
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1.800 - 1.850												
1.850 - 1.900												
1.900 - 1.950												
1.950 - 2.000												