AS 7639:2021

Track Structure and Support

Infrastructure Standard

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This Australian Standard® AS 7639 Track Structure and Support was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

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The Standard was approved by the Development Group and the Enter Standing Committee Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

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Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Deb Spring
Chief Executive Officer
Rail Industry Safety and Standards Board

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AS 7639:2021

Track Structure and Support

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This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7639 Track Structure and Support. Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

This Standard supersedes the previous version of AS 7639 in whole.

Objective

The objective of this Standard is to outline requirements that encourage rail organisations to adopt a whole-of-life approach to the management of track structure. This approach includes the requirements in relation to track structure in terms of design, supply, construction and maintenance of track for a range of operational track gauges used in Australia.

It is an overarching document that establishes a roadmap to a suite of other AS standards containing details of various lifecycle stages of track components.

This standard complements the requirements for designing and manufacturing of Track structure components given in AS 1085 Railway track materials, suite of standards. This standard is also part of the AS 7600 series for rail infrastructure.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term ‘should’.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A

Contents

Appendix Contents

1 Introduction

1.1 Purpose

The purpose of this Standard is to set out the requirements for ensuring that the track structure is safe and fit for purpose.

1.2 Scope

This Standard specifies functional, performance and design requirements for the track structure, and includes some 'whole of life' aspects of inspection, monitoring and maintenance requirements.

This Standard covers the track structure including fastening system, sleepers, ballast and any interaction with underlying structures. Information relevant to management of rails can be found in AS 1085.1 Railway track material, Part 1: Steel rails and AS 7640 Rail Management.

This Standard excludes requirements of sub-ballast, structural fill and earth works which are covered in AS 7638 - Railway Earthworks.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 1085.3 Railway Track Material – Sleeper Plates
- AS 1085.8 Railway Track Material – Dog Spikes
- AS 1085.10 Railway Track Material – Rail Anchors
- AS 1085.13 Railway Track Material – Spring Fastening Spikes for Sleeper Plates
- AS 1085.14 Railway Track Material – Pre-stressed Concrete Sleepers
- AS 1085.16 Railway Permanent Way Material – Cast Steel Sleeper Plates
- AS 1085.17 Railway Permanent Way Material – Steel Sleepers
- AS 1085.18 Railway Track Material – Screw Spikes and Threaded Inserts
- AS 1085.19 Railway Track Material – Resilient Fastening Assemblies
- AS 1085.22 Railway track materials: Alternative material sleepers
- AS 2758.7 Aggregates and Rock for Engineering Purposes, Part 7: Railway Ballast
- AS 3818.1 Timber – Heavy Structural Products – Visually Graded – General Requirements
- AS 3818.2 Timber – Heavy Structural Products – Visually Graded – Railway Track Timbers
- AS 7630 Railway Infrastructure – Track Classification
- AS 7638 Railway Infrastructure – Railway Earthworks
- AS 7640 Railway Infrastructure – Rail Management
- AS 7643 Railway Infrastructure – Track Stability

NOTE: Documents for informative purposes are listed in a Bibliography in Appendix B.

1.4 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

1.4.1

back cant
rotation of rails outwards from the track centre line from their design cant. It can occur as fastenings and sleepers wear and cause the gauge to widen.

1.4.2

non-elastic fastenings
rail fastenings that allow non-elastic vertical movement of the rail. Dog spikes are an example of non-elastic rail fastenings. See also Fastenings in Appendix A.

1.4.3

pumping
excessive vertical movement of a sleeper, generally indicated by the presence of rounded ballast particles and mud or slurry when wet, and powder when dry.

1.4.4

rail cant
The degree to which the rail is sloped in toward the track centre, usually 1 in 20 or 1 in 40.

1.4.5

shoulder
component cast in, pressed up or locked into an anchor point on the rail seat area of a sleeper, to prevent sideways movement of the rail and enable the attachment of a rail fastener.

1.4.6

skew
variation of alignment of sleepers from perpendicular to rail.

1.4.7

track stiffness
elastic rail deflection that takes place under a wheel loading. Track stiffness is a function of the structural properties of the rail, resilient pads in the track structure, sleepers, ballast, sub-ballast and sub-grade soil(s).

1.4.8

turnouts and other special trackwork
combination of rail and track components that provide for one track to join or cross another while maintaining continuous support and direction to the rolling stock wheels. Examples also include catch points, diamonds and slips, compound crossings, expansion joints, etc

1.4.9

unconsolidated ballast
results from the tamping and ballast renewal processes. It has the potential to cause track instability with

temperature variations. Ballast is consolidated under traffic or by other means such as mechanical ballast stabilisation.

General rail industry terms and definitions are maintained in the RISSB Glossary: https://www.rissb.com.au/products/glossary/

1.5 Abbreviations

1.5.1

BLF
branch line freight

1.5.2

LSP
low speed passenger

1.5.3

MSP
moderate speed passenger

1.5.4

HHF
heavy haul freight

1.5.5

HSP
high speed passenger

2 General

2.1 Track structure as a system

The purpose of the track structure is to provide a mechanism for safe, reliable and efficient transportation of rolling stock. To achieve this goal each component of the track structure should be evaluated to perform its specific function satisfactorily in response to loads and environmental factors imposed. The approach taken is based on managing track as a system and not as individual components, with each component of the system interacting with each other.

The components of the track can be grouped into two general categories: track superstructure and track substructure. The superstructure includes the rails, the fastening system, and sleepers and bearers. The substructure includes the ballast, capping layer, and subgrade. Figure 2.1 shows the main components of ballasted track structures.

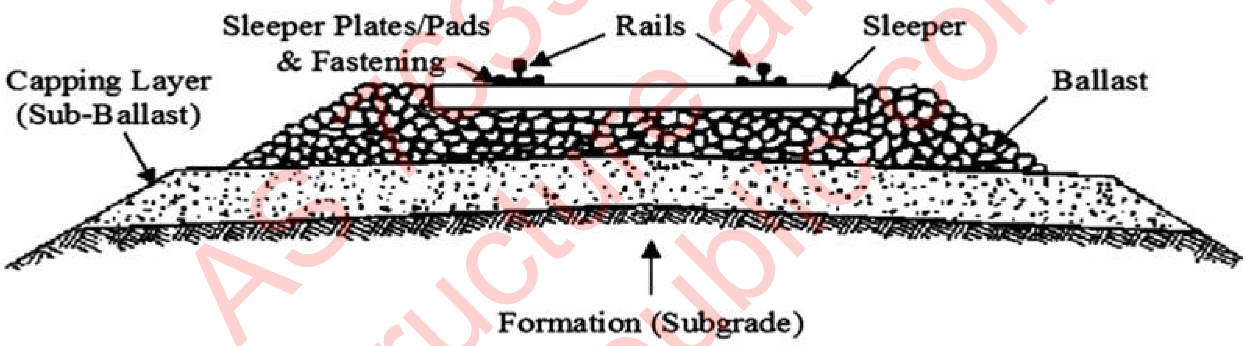

Figure 2.1 Track structure (Sample only)

2.2 Track configuration

Open ballasted track comprises a combination of the following components.

(a) Rails:

i. short welded rail;

ii. long welded rail; and

iii. continuous welded rail.

(b) Rail fastening system:

i. non-resilient; and

ii. resilient (elastic).

(c) Sleepers and bearers:

i. timber;

ii. concrete;
iii. steel; and
iv. alternative material.

(d) Ballast

A non-resilient track fastening system is usually limited to use for low-speed passenger (LSP), moderate speed passenger (MSP) and branch line freight (BLF) lines, as defined in AS 7630.

Rails on concrete and steel sleepers are generally fixed using resilient fastening systems.

For new or extensively refurbished tracks, except for BLF and LSP lines as defined in AS 7630, continuous welded rail on concrete sleepers is typically the preferred configuration.

Variations of track fastening assemblies might be required for tracks with more than one gauge.

2.3 Track structure and support systems

Track structure and support systems shall be appropriate to the track classifications as defined in AS 7630 Railway Infrastructure – Track Classification.

Track structure and support systems shall be compatible with, and capable of operation with the infrastructure in adjoining sections.

New works shall be designed to preserve physical and functional interfaces with adjoining sections and equipment.

Special track structure and support systems, such as track on rigid foundation, shall require special arrangement for track stiffness transition.

The support system for the track structure can vary and could comprise of earthworks, bridges, culverts, tunnels, etc. Refer to other standards for further details.

Typically, earthworks are the base support system for track structure and shall be designed, constructed and maintained to conform to the requirements of AS 7638.

3 Rail

The role of rail is to directly guide the train wheels evenly and continuously. Rail shall have sufficient stiffness to serve as a beam to transfer the concentrated wheel loads to the spaced sleeper supports, without excessive deflection between supports. The performance requirements rail shall be in accordance with AS 1085.1 Railway track material, Part 1: Steel rails.

The Rail Infrastructure Manager (RIM) shall assess the impact of the following in the selection of rail.

(a) Railway network operating conditions;

(b) Track system compatibility;

(c) Maintenance and lifecycle cost;

(d) Use of new or serviceable rail; and

(e) Rail characteristics.

Rail shall be selected with sufficient strength, shape stability and wear resistance, to perform to its intended application and to maintain its integrity.

The RIM shall determine the requirements to deem a rail to be fit for purpose and suitable for the railway.

Note: Further details on the management of rails are found in:

- AS 1085.12 Railway track material, Part 12: Insulated joint assemblies
- AS 1085.20 Railway track material, Part 20: Welding of steel rail, and
- AS 7640 Rail Management.

4 Sleepers and bearers

4.1 General

The role of sleepers and bearers is to receive the load from the rail and distribute it to the ballast. The sleepers and bearers hold the rail in place, aided by the fastening system.

Sleepers and bearers shall:

(a) be capable of withstanding the vertical, lateral and longitudinal loads imposed upon them by the traffic to be carried;

(b) spread the loads imposed on the rails onto the underlying supporting ballast or structure, such that the supporting system is capable of withstanding the imposed load;

(c) provide a means of retaining the running rails of a track to the specified gauges;

(d) provide a means whereby the horizontal and vertical alignment of a track can be established and maintained;

(e) assist in restraining the independent vertical and lateral movement of the rails of a track;

(f) assist in restraining longitudinal movement of the rails;

(g) assist in providing structural rigidity to the track; and

(h) contribute to the resistance of the track to lateral and vertical distortions during periods of significantly varying rail temperatures.

The factors in determining the choice of sleepers and bearers include the following.

(i) Loading:

   i. Service loads (and dynamic response), including effects of track alignment, maintenance standards, traffic task and impact of the resulting track structure on wheel rail contact stresses.
   ii. Resistance to impact loading (e.g. wheel flats).
   iii. Rail seat loads, sleeper bending moments, rail to sleeper pressure, and sleeper to ballast pressure.
   iv. Dynamic traction loads causing longitudinal and lateral sleeper movement and/or sleeper skewing.
   v. Torsional effects between rail seats, leading to sleeper skewing.

(j) Materials:

   i. Sleeper material, type and spacing.
   ii. Sleeper acceptance, inspection and testing requirements, and assessment of effectiveness prior to insertion in track.
   iii. Sleeper life and treatment (e.g. timber preservatives).
   iv. Deterioration of the sleeper material (e.g. wear, corrosion, concrete reactivity, fungal rot, white ant attack).

(k) Interfaces with other rail infrastructure:

i. Track circuit requirements.
ii. Support of point switching equipment where necessary.
iii. Level crossing requirements.
iv. Other sleeper mounted equipment (guard rail, check rail, etc).

(l) Support requirements:

i. Track support conditions and deflection criteria.
ii. Required track stiffness.

(m) Performance requirements:

i. Need to provide resistance to the lateral buckling of the track;
ii. Need to provide effective support, positioning and restraint of the rail (in conjunction with the rail fastening system), and to minimise longitudinal and lateral sleeper movement and/or sleeper skewing;
iii. Need to satisfy geometric requirements, length, lateral location and orientation of bearers in turnouts and other special trackwork.

4.2 Spacing

The centre to centre spacing of sleepers and bearers varies generally between 500 mm and 800 mm. This can be measured from edge to edge or centre to centre. It is always measured from the same point to the same point.

The RIM shall determine the spacings required in open track, and in turnouts and other special trackwork.

Where there is a change in track stiffness, sleeper spacing can be adjusted in accordance with the requirements of the RIM.

The following tolerances on sleeper spacing, including sleeper spacings at joints or for transitions on open track, are recommended:

(a) Individual sleeper spacing: ± 25mm;
(b) Skew: ± 20mm from normal position.

Spacing and skew tolerances for turnouts and other special trackwork and direct fixation track shall be determined by the RIM.

4.3 Timber sleepers and bearers

4.3.1 General

Timber grade and performance requirements for timber sleepers and bearers shall be in accordance with AS 3818 Parts 1 & 2.

For the design of new lines, the beam on elastic foundation (BOEF) analysis should be used to determine sleeper size and spacing.

Timber bearers for turnouts and other special trackwork might also be designed using the BOEF analysis similar to that used for sleepers. In such a case, additional consideration should include allowance for:

(a) additional length of timber bearers over standard sleepers;

(b) centrifugal forces through curved pairs of rail; and

(c) forces and moments induced from switch motors and other such equipment.

Isolated timber sleepers are sometimes cut to length to avoid drainage pits or other infrastructure within or beside the track.

The use of reduced length sleepers shall be subject to the approval of the RIM.

4.3.2 Boring requirements in timber sleepers, transoms and bearers

Sleepers, transoms and bearers shall be bored to match the track plates used in the track support system.

Holes should generally be bored completely through the timber.

Note: Boring of holes for base plates are generally no closer than 2x screw diameter from the edge of sleeper.

Plugging can be used to permit insertion of preservatives or glue.

In constrained situations at turnouts and other special trackwork, the outer end of sleeper plates typically should be located no closer than 200mm from the end of timber sleepers or bearers.

4.3.3 Rail anchors

Anchors shall comply with AS 1085.10 Railway Track Material – Rail Anchors.

Rail anchors are typically used in timber sleepered tracks and where non-resilient fastenings are in use.

Rail anchors should be applied to the foot of each rail adjacent to and touching each side (box anchored) of at least one sleeper in four, and more frequently (as determined by the RIM) in the vicinity of rail joints, turnouts, level crossings, etc.

Tracks fastened using 1 in 2 or more frequent sleepers with resilient fastenings do not typically require anchoring.

Anchoring pattern should take into account the grade and the direction of loaded traffic.

The anchor type and pattern shall be approved by the RIM.

4.4 Concrete Sleepers and Bearers

4.4.1 General

Pre-stressed concrete sleepers and bearers shall be designed, manufactured, tested and installed in accordance with the methods described in AS 1085.14 Railway Track Material – Pre-stressed Concrete Sleepers.

Concrete sleepers and bearers are typically supplied with shoulders installed (at the time of manufacture).

Concrete sleepers and bearers shall be chosen or designed to suit the track as classified in AS 7630.

Resilient fastening systems shall be used with concrete sleepers and bearers.

Where concrete sleepers or bearers are replaced in a concrete track section (due to damage or other reasons), the replacement sleepers or bearers shall closely match the adjacent concrete track in dimensions and capacity.

4.4.2 Drilling of concrete sleepers and bearers

The permissible positions, methods of drilling holes and types of inserts for use in concrete sleepers and bearers to accept fastenings for signalling equipment or other attachments, shall be specified by the RIM.

The integrity of the sleepers or bearers shall not be compromised (e.g. by cutting reinforcement) in a way that could lead to their failure in service.

4.5 Steel sleepers and bearers

Steel sleepers and bearers shall be designed and manufactured in accordance with the methods described in AS 1085.17 Railway Permanent Way Material – Steel Sleepers.

Steel sleepers are available to meet varying requirements of track gauge, strength or rail cant, and can be supplied with accessories for insulation of the rails from each other.

Steel sleepers and bearers are generally produced with holes for accepting lock-in shoulders as part of the resilient fastening system.

Steel sleepers and bearers rely on the steel to hold the gauge and the ballast beneath to support the load.

The cavities beneath the sleepers and bearers shall be filled with ballast compacted as required by the RIM.

The end spade, which is the turned down end of the sleeper, further assist in providing resistance to lateral movement.

Steel sleepers and bearers shall only be used with rails for which they have been designed and tested, both geometrically and for the relevant loads they are to support, except for the use of a lighter rail as detailed in the clause below.

Spacers or systems with additional holes can be used to provide adjustment, so that more than one rail size can be accommodated.

Where one or more rails are to carry signalling current, the sleepers shall be insulated in accordance with the RIM's requirements.

Even with insulators fitted, when one or more rails are to carry signalling current, steel sleepers should not be used at any signalled location where contamination by conducting material is likely in the area around the fastenings or under the rail. This includes locations where:

(a) contaminants regularly invade the track area (coal, minerals, mud, clay, dirt, etc.), and

(b) the track bed is often wet.

Due to stray electrical current concerns, special considerations apply to the management of steel sleepers and bearers (even if insulated) for tracks with electric traction power, including adjoining non-electrified sidings.

Steel sleepers and bearers should not be used in the following situations where sleeper and bearer support could be compromised including locations where:

(c) the ballast/formation is poor and where deflection under load is high, and

(d) at locations where track dynamic forces are high, such as at joints, or where the inherent rail surface condition is poor.

Installation of steel sleepers in track conditions that have the potential to cause high levels of sleeper fatigue should be avoided, as this situation can drastically shorten the life of the sleepers and cause premature failure of the fastenings and/or insulators. These conditions include where:

(e) there are sleeper and bearer support deficiencies, due to incorrect tamping procedures, and

(f) the steel sleepers are in an interspersed configuration.

4.6 Alternative material sleepers and bearers

Alternative material sleepers and bearers shall be designed and manufactured in accordance with the methods described in AS 1085.22 Railway track materials: Alternative material sleepers.

When alternative material sleepers are used, consideration should be given to address product integrity and environmental factors (e.g. propensity for burning, toxicity, leaching, exposure to biological agents etc) as discussed in AS 1085.22.

Given the availability of a wide range of materials for the manufacture of alternative material sleepers, a diverse range of sleeper properties can be achieved. These can range from sleepers which are lower in strength and more flexible than timber (typically manufactured from low density plastics) through to properties similar to concrete. Hybrid composite sleeper designs also exist which incorporate reinforcement.

Alternative material sleepers can be used in a variety of installations ranging from spot replacement through to 100% on the face applications.

Alternative material sleepers can be manufactured from a diverse range of products. A defined manufacturing process shall be followed to ensure consistency in the end product, especially if recycled materials are used to manufacture the sleepers.

A detailed quality assurance and test program should be implemented, to commensurate with the potential product variability expected. As a minimum, a density and static bending test should be considered.

Alternative material sleepers are typically pre-drilled to accept screw spikes, to allow fixing of the rail or rail plates. When alternative material sleepers are pre-drilled, due consideration should be given to the strong correlation between hole size, screw spike size and the screw pull-out force. Pre-drilling requirements and preferred screw configurations are generally provided by the manufacturer. The majority of sleepers are produced with a flat rail seat. Rail anchors (AS 1085.10) might be used in alternative material sleeper tracks as with timber sleepers.

Unlike timber sleepers, alternative material sleepers can have a tough outer skin which reduces interaction with the ballast, resulting in very low lateral resistance (often further exacerbated by their relatively low weight). To mitigate this effect, most alternative material sleeper design will feature either raised or dimpled markings on the sides and base to interlock with the ballast.

Such markings should not impair the life of the product. Further treatment of the top surface might be necessary to minimise the likelihood of rail workers slipping.

Given the relatively recent adoption of alternative material sleepers and the wide range of examples, failure modes which are not evident with current sleeper material can become evident. Such failure modes could include excessive creep (leading to wide gauge or sleeper deformation), damage due to ultraviolet radiation or significant changes to sleeper properties due to temperature changes.

A risk assessment prior to implementation of a new product is therefore recommended. The use of trial test sections with well-planned monitoring programs should ensure satisfactory performance prior to widespread adoption across the network. Monitoring performance across all seasons is recommended.

4.7 Interspersed sleepers

The RIM shall determine the correct design for interspersing of different types of sleepers.

Interspersing timber and concrete sleepers or steel and concrete sleepers is not recommended as a permanent track structure for tracks classified as Heavy Haul Freight (HHF) and High Speed Passenger (HSP) in AS 7630.

The RIM may elect to temporarily intersperse timber sleepers in concrete sleepered track as a maintenance expedience or as an emergency repair measure, with the following issues considered:

(a) Appropriate operational restrictions (e.g. axle load or speed).,

(b) Monitoring of track geometry and strength integrity.

(c) Effect on expected life of the track structure.

Subject to the approval of the RIM, as an alternative track structure to timber on a face, interspersing timber and steel sleepers is permitted for tracks classified as BLF and LSP in AS 7630, as follows.

(d) Steel sleepers might be used to strengthen an existing track structure (timber sleepers) by re-lay or during maintenance activities.

(e) Interspersal of steel sleepers with timber is not recommended on of less than 500 m radius.

Interspersing of different sleeper types in the following condition should be avoided as it can drastically shorten the life of the sleepers.

(f) if there is wide or tight gauge in adjoining timber sleepers that would result in a high level of gauge variation (which in turn induces additional fatigue loads in the steel sleepers), and

(g) the steel sleeper or bearer will be required to carry more than its proportionate share of the load due to the poor condition of adjacent sleepers or bearers.

4.8 Serviceable sleepers and bearers

The use of serviceable sleepers or bearers (i.e. sleepers or bearers that have previously been used in track) shall be subject to the approval of the RIM.

Consideration should be given to the remaining life of the serviceable sleepers and bearers before they are installed in track.

Serviceable timber sleepers and bearers can be used in running lines and sidings, provided:

(a) the resulting track structure is capable of holding gauge and supporting the loading imposed on it, and

(b) they have been assessed as having an appropriate remaining life for the new location.

Steel sleepers or bearers that have been bent, welded, cut, or otherwise altered from an approved design should only be used in yards or low speed environments.

5 Fastening systems

5.1 General

Rail fastening systems:

(a) hold rails in the rail seat within tolerance under load,

(b) limit the rotation of the rail about the outer edges of the rail foot,

(c) minimise longitudinal movement of rails,

(d) maintain the desired rail cant,

(e) assist in retention of track gauge, and

(f) should not cause damage to the rail.

The factors to be considered in determining rail to sleeper fastening assembly design should include the following.

(g) Loading:

i. Service loads (and dynamic response), including effects of track alignment, maintenance standards and traffic task.

ii. Attenuation of vertical impact loads and vibration.

iii. Pressure transmitted to the sleeper rail seat, (for example the need for sleeper plates on timber sleepers).

iv. The need to control damage to sleepers by rail seat abrasion.

(h) Interfaces with other rail infrastructure:

i. The need to provide electrical insulation where required, to enable track circuits to be effective and avoid current leakage.

(i) Support requirements:

i. Required track modulus.

(j) Performance requirements:

i. The need to provide effective support, positioning and restraint of the rail (in conjunction with the sleepers and bearers).

ii. The need to hold rails to gauge and at the correct rail cant when subjected to lateral forces caused by vehicles traversing a curve, track alignment irregularities, and wheel set steering and hunting.

iii. The need to provide restraint to the rail against buckling in hot weather.

iv. The need to provide rail longitudinal creep resistance when the rail is subjected to thermal loads and vehicle braking and traction forces.

(k) Designed tie bar systems used to supplement gauge holding.

Fastenings shall be correctly fitted and compatible with the sleeper or bearer type.

5.2 Non-Resilient Fastening Assemblies

5.2.1 Assembly

Non-resilient fastening assembly components shall be designed and manufactured to conform with the appropriate parts of AS 1085.

Each rail seat assembly should consist of:

(a) sleeper plates (AS 1085.3) – these should be double shouldered and provide a nominal rail cant of 1 in 20 or 1 in 40 towards the centre of the track (except in special circumstances, such as turnouts where the rails are generally vertical);

(b) dog spikes (AS 1085.8) – at least two round and/or square shank dog spikes (or RIM approved equivalent) per sleeper plate; and

(c) spring fastening spikes (AS 1085.13) – two lock spikes (or RIM approved equivalent) per sleeper plate.

5.2.2 Non-resilient fastenings on bridges

On ballasted deck bridges, the track should be anchored as for plain track.

The RIM shall specify the non-resilient fastening arrangement and anchoring layout on bridges.

Note: Anchoring arrangements will depend on the construction of the bridge and the type of non-resilient fastening used.

5.3 Resilient fastening Assemblies

5.3.1 Assembly

Resilient fastening assembly components shall be designed, manufactured, tested and installed to conform to the requirements of AS 1085.19.

The components required for rail seat assembly are listed below.

(a) For timber sleepers, transoms and turnout bearers each rail seat assembly should consist of:

  i. sleeper plates (these should generally be double shouldered and provide a nominal rail cant of 1 in 20 or 1 in 40 towards the centre of the track except in special circumstances such as turnouts where the rails are generally vertical),

  ii. resilient rail clips, and

  iii. spring fastening spikes or screws.

(b) For concrete sleepers and bearers, each rail seat assembly should consist of:

  i. cast-in shoulders or ferrules,

  ii. resilient rail clips,

  iii. rail seat pad, and

  iv. suitable rail insulation.

(c) For steel sleepers and bearers, each rail seat assembly should consist of:

  i. lock-in shoulders,

ii. resilient rail clips, and

iii. rail seat pad or clip insulators if required for insulation.

Note: Some steel sleepers might be equipped with pressed rail shoulders for accepting the resilient clips.

5.3.2 Resilient baseplate assemblies

Resilient baseplate assemblies can be used as an alternative to standard base plates on sleepers, transoms and bearers, switches and crossings, and for direct fixation at transition interfaces between ballasted and non-ballasted track, where graded changes in track stiffness are required.

Resilient baseplate assemblies can be used as directed by the RIM, in the following applications. For example:

(a) bridges where noise and/or vibration reduction is required;

(b) ballasted track where noise and/or vibration reduction is required; and

(c) direct fixation track where noise and/or vibration reduction is required.

5.3.3 Resilient fastenings on bridges

For concrete structures the RIM should consider the expansion requirements, such as:

(a) zero toe load restraint fastenings;

(b) expansion switches; and

(c) lower crib expansion air gap.

For concrete structures where resilient fastenings are installed consideration should be given to installing resilient fastenings on the entire length of each span.

The design of track fastenings on bridges should take into account the longitudinal movement of the bridge structure.

The use of a rail fastening system on bridges shall be as approved by the RIM.

5.3.4 Zero toe load assemblies

Zero toe load restraint assemblies allow longitudinal rail movement while retaining gauge and limiting upward movement of the rail.

When used in conjunction with resilient baseplate assemblies, special configurations shall be required to fit the dimensional restrictions of the baseplate.

Where zero toe load restraint assemblies are installed on sharp curves on bridges, consideration should be given to mitigate against rail roll.

6 Ballast

The following factors should be considered in the ballast material and track cross-sectional ballast profile design.

(a) Service loads including effects of track alignment, maintenance standards and traffic task.

(b) Ballast consolidation requirements as detailed in AS 7643 Track Stability.

(c) Interfaces with other rail infrastructure including:

   i. sleeper material, type and spacing, and

   ii. electrical properties in track circuited areas and / or electric traction.

(d) Support requirements including:

   i. required track modulus,

   ii. track support conditions and deflection criteria, and

   iii. track formation material and condition

(e) Performance requirements including:

   i. the need to interlock sufficiently, to provide resistance against excessive vertical, lateral and longitudinal movement of sleepers and bearers,

   ii. the need to reduce excessive loading on and failure of the track formation,

   iii. the need to provide adequate drainage of the track structure to the cess, and allow fines to migrate from the track structure, and

   iv. the need to be durable enough to resist crushing when subjected to the normal loadings.

6.1 Ballast material and grading

Ballast shall comply with the requirements of AS 2758.7 Aggregates and Rock for Engineering Purposes, Part 7: Railway Ballast.

Alternative gradings to meet special requirements shall be as approved by the RIM.

6.2 Recycled Ballast

The use of recycled ballast (i.e. ballast that have previously been used in track) shall be subject to the approval of the RIM.

Recycled ballast can be used in running lines and sidings, provided it complies with the requirements of AS 2758.7 and is free of contamination.

6.3 Ballast profile

6.3.1 Ballast Depth

A typical track cross-section, illustrating ballast profile, is shown in Figure 6.1 .

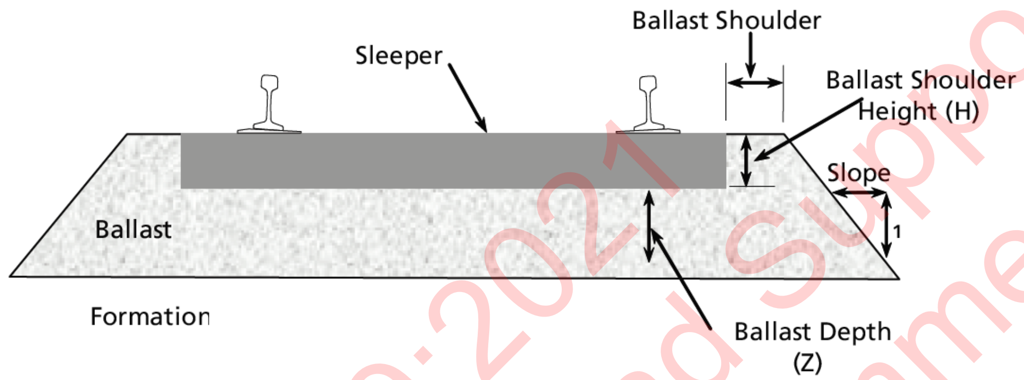

Figure 6.1 Typical track cross section and ballast profile

Ballast depth shall be based on AS 7630, or as determined by the RIM.

The ballast depth generally varies between 200mm and 500mm.

Note: Inadequate ballast depth with poor sub-grade could cause sub-grade to fail.

6.3.2 Ballast Shoulder Width

The RIM shall determine the ballast shoulder width based on AS 7630 and AS 7643.

The design ballast shoulder width contributes to the overall track stability.

Additional ballast shoulder might be necessary:

(a) in areas of poor track lateral stability to provide adequate resistance to prevent potential track buckling and movement; and

(b) on sharp curves to maintain lateral stability.

Note: Typically, ballast shoulder width for concrete sleepered track is 300mm and for timber and steel sleepered track is 400mm.

Additional ballast shoulder width above the minimum and/or a ballast windrow up to rail height outside the sleeper might be necessary in areas of poor track stability or to provide additional resistance to prevent potential track buckling on sharp curves where design the radius is less than normal limits.

6.3.3 Ballast Glue

Ballast glue can be used as a temporary maintenance measure to improve the performance of ballast. This is achieved through bonding the ballast together, to improve the behaviour, load transitioning and absorbing capacity of the ballast.

Typically ballast glue can be used:

(a) at bridge ends and approaches to level crossings;

(b) at bog or mud holes in the track;

(c) on the outside shoulder of tight curves;

(d) adjacent to joints and welds;

(e) through turnouts and other special trackwork; and

(f) in areas of soft track formation.

Ballast bonding through the use of ballast glue can also be used to provide a track stiffness transition zone.

In most cases, application of this product is a temporary solution, and prevents further track deterioration and provides the opportunity for the RIM to plan and execute conventional track repairs.

7 Formation

7.1 General

The track formation is the base under the track and is divided into capping layer or sub ballast, sub-grade and embankment fill. The railway formation shall be designed, constructed and maintained to conform to the requirements of AS 7638.

A typical design model for track formation is given in figure 7.1.

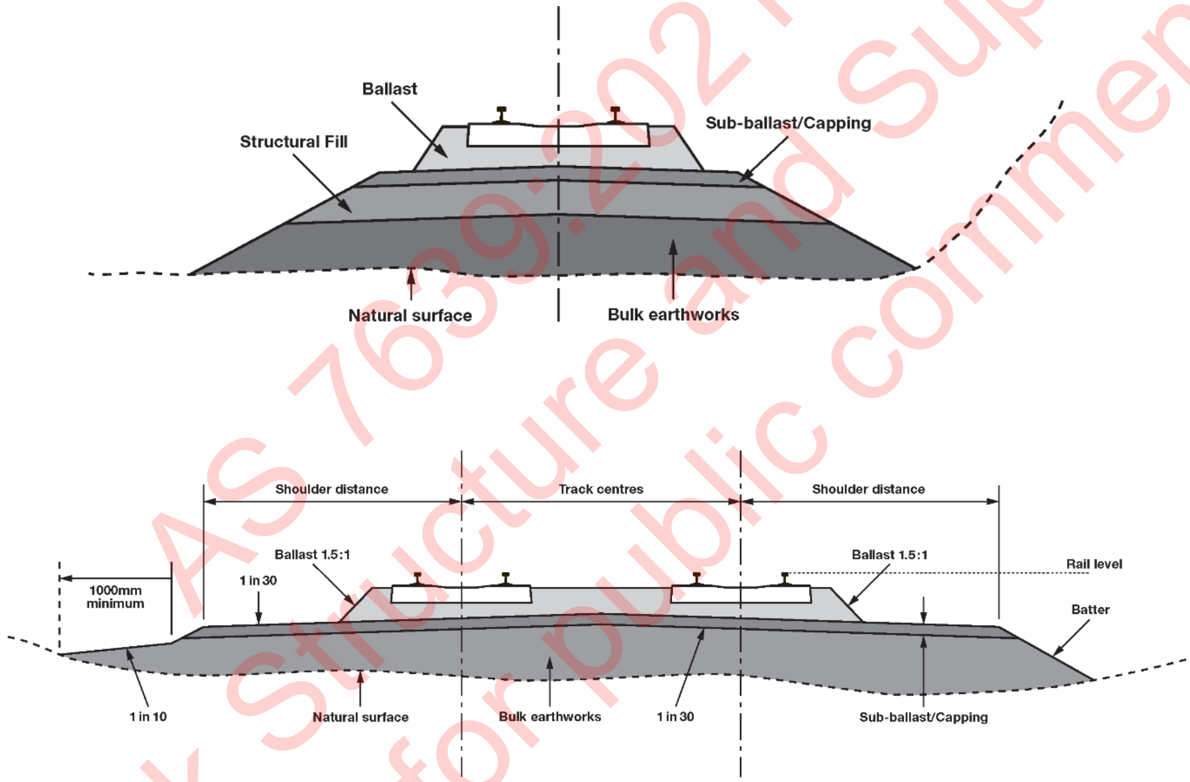

Figure 7.1 Track formation typical design

7.2 Capping layer

The capping layer is usually considered as part of the formation and its construction requirements are detailed in AS 7638.

Ground improvement or geofabric can be used to improve the strength of the capping layer and formation.

The capping layer surface shall be graded to allow runoff into the cess drain or sub-surface drain.

8 Ballastless Track

8.1 General

Ballastless track is a non-ballasted form of superstructure in which the load base function of the ballast is performed by a layer of concrete (EN 16432).

Ballastless track can typically take one of the following forms.

(a) Direct fix(ation) – a system of fixation of track directly to a structure or continuous concrete invert, concrete deck, floating slab or open deck structure without the use of track or bridge ballast. Direct fixation can take various forms, commonly:

i. encasing the rail in concrete as a monolithic pour; or

ii. mounting the rail on short pedestals integral with or mounted on the concrete.

(b) Floating slab track – a track slab which is isolated from the ground or supporting structure using resilient bearings.

(c) Rigid track slab – a track slab which is directly fixed to the ground or supporting structure.

(d) Plinth type ballastless track – the continuous plinth track system is a continuously supported rail with discrete shoulders retained by rail clips.

(e) Embedded rail – the rail is attached without the use of traditional rail fastenings, instead anchored in a concrete or steel channel by “embedding” it with adhesive compound or a rubber boot.

8.2 Concrete slab track

The use of concrete slab track should be considered in the following situations.

(a) Locations with limited vertical and/or horizontal clearances.

(b) Existing tunnels where clearances to the track need to be increased to allow the use of larger rolling stock, or to increase the clearance to the overhead wiring.

(c) New tunnels where the use of non-ballasted track can enable a smaller tunnel profile to be used, ongoing maintenance requirements to be minimised, or where the attenuation of noise and vibration is critical.

(d) Locations where the attenuation of noise and vibration is necessary.

(e) Heavily used level crossings.

(f) Logistics terminals, where rail is typically embedded.

Slab track design should take into account the stiffness of the formation, slab, rail fastening assemblies and rail.

Slab track design should:

(g) minimise the risk of derailment due to track irregularities,

(h) provide uniform transmission of all rail-borne forces to the track structure,

(i) incorporate continuous rail with no mechanical joints,

(j) provide appropriate electrical insulation and electrolysis mitigation measures,

(k) allow for isolation arrangements, where required in track circuited and electrified areas,

(l) incorporate rail lubrication systems where maintenance requirements dictate,

(m) provide for future track maintenance, including rail replacement, in-situ rail welding and emergency rail clamping,

(n) take into account any dynamic deflection and behaviour of the slab, and

(o) provide for drainage and clearing of debris.

The design of the track slab should consider the interaction with the track including longitudinal effects, thermal effects, concrete shrinkage and traction/braking loads.

The design should consider the effect on both the track and the track slab, including interaction of slab expansion and rail expansion.

9 Track Stiffness

9.1 Principles

Track stiffness is the resistance of the entire track structure to deformation in relation to the applied force (EN 16432-2). Track stiffness and its variability has a significant influence on the performance of the track structure. Track stiffness is dependent on the effective stiffness of all the individual components of the track structure; rail, fastening system, sleepers, ballast and formation.

When evaluating track stiffness, the track structure should be divided into the following.

(a) Rail.

(b) Rail Support System which includes:

i. fastening system & sleepers; and

ii. ballast and formation.

Track stiffness should be considered in track structure design and maintenance to ensure it lies within the RIM specified limits to effectively manage:

(a) vertical deflection,

(b) manage track geometry,

(c) track component condition and degradation; and

(d) asset life.

The RIM should nominate an equivalent or composite track stiffness for its track structure upon which P2 forces can be calculated as per AS7508: Track Forces and Stresses.

Note:

1. Track stiffness is usually considered as part of the track stability and further information on track stability management can be found in:
   - AS 7643 Railway Infrastructure – Track Stability
   - Code of Practice: Track Stability
2. Some track components have a stiffness which is relatively easy to define. For example, standard rail types have a well-defined flexural rigidity as do fastening systems and sleepers, whilst ballast and formation (or the trackbed) stiffness can vary more significantly, and therefore is more difficult to control and measure.

9.2 Transition between track support systems

Designed stiffness transition sections should be provided in locations where two differing track structures with significantly different track stiffness properties interface. Whilst continuous linear variation is preferred, practically this can be achieved by a series of steps in track stiffness.

A transition in track structure should be positioned on straight track at an adequate distance from turnouts or other special trackwork.

Typical locations where transitions might be required include approaches to:

(a) embedded rail level crossings,

(b) bridges and tunnels,

(c) slab track,

(d) underpasses and culverts,

(e) switches and crossings,

(f) differing capping layer and/or subgrade conditions,

(g) differing ballast depth and/or sleeper spacing, and

(h) differing sleeper and fastening types and/or rail weights.

The track stiffness transition should be designed to:

(i) provide a gradual change in track stiffness and limit differential settlement;

(j) provide an easily maintained track structure transition, which will not be prone to differential settlement and mitigate geometry faults;

(k) provide accurate matching of track alignment under all load conditions, in order to avoid stress concentrations in components or uneven ride characteristics;

(l) achieve the nominated levels of vibration and regenerated noise attenuation;

(m) minimise the number of transition sections.

The designed length of each transition section is dependent on the loading and support conditions, axle load and sleeper spacing, and traffic type and speed, and the differences in settlement and stiffness characteristics between adjacent track structures.

Track stiffness transition can be achieved by:

(n) increasing the stiffness of the approach track;

(o) decreasing the stiffness of the stiffer track;

(p) adding damping to the stiffer track.

A transition section should be considered for all changes in track support, except for low speed and low axle load environments, such as for lines classified as BLF and LSP defined in AS 7630.

9.3 Products for modifying track stiffness

9.3.1 General

The following mechanisms are typically used to modify track stiffness.

(a) Modification of rail pad stiffness.

(b) Introduction of insertion layers between the sleeper and ballast (under sleeper pads)

(c) Insertion layer between the ballast and the substructure (under ballast mats)

The use of products to manage track stiffness shall form part of the track structure design to ensure their use does not adversely affect overall track stiffness and track lateral resistance. Investigation should be undertaken to understand the impact if any track structure design proposes to utilise several products which modify track stiffness.

9.3.2 Ballast mats

Under ballast mats (UBM) should be considered for installation in the following circumstances.

(a) Ballast is on a rigid foundation such as a concrete bridge deck.

(b) On a tunnel floor.

(c) Where required for noise and vibration attenuation.

(d) Ballast is on a weak formation.

(e) Where there is insufficient ballast depth.

The factors to be considered when evaluating whether a UBM should be installed, and if a UBM is proposed, to select the most appropriate type and product, include:

(f) operational parameters; such as type of track, loading and speed;

(g) driver for use such as vibration and ground-borne noise attenuation, ballast and structure protection, or for transition zones;

(h) track stiffness;

(i) vertical deflection;

(j) track lateral resistance;

(k) ballast depth.

The RIM shall determine the specific requirements for the installation of UBMs including its use for transitioning areas of different track stiffness.

UBM's have a range of vertical stiffness, static and dynamic properties to meet a designed purpose typically classified from very soft to hard, based on bedding modulus. Typically, the softer the UBM the increased vertical deflection.

9.3.3 Under sleeper pads

Under Sleeper Pads (USP) should be considered for installation in the following circumstances:

(a) Poor track quality

(b) Switches & Crossings

(c) Transition zones

(d) Track sections with reduced ballast

(e) Reduction of long-pitch corrugation

(f) Reduction of ground-borne vibrations

The factors to be considered when evaluating whether USP should be installed, and if a USP is proposed, to select the most appropriate type and product, include:

(g) operational parameters such as type of track, loading and speed;

(h) driver for use such as poor track quality, transition zones, in switches & crossings, rail defect management, reduced ballast thickness or for vibration and ground-borne noise attenuation;

(i) track stiffness;

(j) vertical deflection; and

(k) track lateral resistance.

The RIM shall determine the specific requirements for the installation of under sleeper pads including for transitioning areas of different track stiffness.

Under sleeper pads have a range of stiffness', typically classified from very soft to stiff based on their bedding modulus, with properties to meet their design purpose.

9.3.4 Geogrids / Geotextiles

There are beneficial applications for geosynthetics in the track formation, although their use will be determined by the site-specific characteristics and expected outcome of the formation design. The two principal applications where their use can be advantageous are as a:

(a) reinforcing element, subgrade support and/or improvement; and

(b) filtration/drainage or separation layer.

Geogrids are mainly used as a reinforcing element, even though they also provide a separation layer. Geotextiles are mainly chosen for their filtration/drainage characteristics, even though they can also improve the subgrade support.

Calculation methodologies vary for its use but should consider the materials below and above the geosynthetic product as both can change the performance.

RIM should provide guidance on its use. Restrictions can apply on their use to suit mechanized maintenance plant requirements.

10 Inspection, monitoring and maintenance

10.1 General

The RIM shall determine the frequency of inspection of the various track support systems.

Inspection of track support systems shall be carried out in a manner and at an interval appropriate to the track classification, location, rates of deterioration and any other local factors as determined by the RIM.

10.2 Sleepers and fastening assemblies

10.2.1 Inspection

Track patrol inspections should observe sleeper and fastening condition (i.e. indicators of a defect) that might affect the integrity of the track structure, including the following:

(a) damaged, split, cracked, broken or missing components;

(b) indications of lateral movement of fastenings and sleeper plates on timber sleepers;

(c) indication of sleeper movement (e.g. bunching, skewing);

(d) indications of incorrect rail cant;

(e) abnormal deterioration of sleepers and fastening condition; and

(f) other obvious defects that can affect the track structural integrity or stability.

General inspections of sleeper and fastening condition should be carried out visually in a manner and at an interval appropriate to the sleeper and fastening type, condition, rates of deterioration and other local and seasonal factors.

General inspections should identify locations of sleeper and fastening degradation that require action or further specialist inspection, or both.

General inspections of sleepered track should be carried out by a walking inspection.

Walking inspections should further include identification of:

(g) clusters and distribution of ineffective sleepers or fastenings;

(h) any skewing, misalignment or poor sleeper spacing;

(i) misplaced pads, spacers and other fastening components;

(j) any sleeper movement and ballast displacement; and

(k) other defects or missing components.

10.2.2 Assessment

10.2.2.1 Timber sleepered track

An individual sleeper/fastening assembly should be considered ineffective if the sleeper/fastener does not provide adequate lateral, longitudinal and vertical support to the rail as a result of one or more of the following conditions.

(a) Sleeper deterioration affecting the rail support (e.g. ageing, rot).

(b) Sleepers split, cracked or otherwise deteriorated at or through fastening components, rendering the fastening ineffective.

(c) Sleepers broken through.

(d) Excessive loss of sleeper cross-section or other properties as specified in the sleeper design.

(e) Excessive rail back cant.

(f) Excessive lateral sleeper plate movement relative to the sleeper;

(g) Loose or missing shoulder inserts.

(h) Missing sleepers or complete sleeper failure.

(i) Fastening assembly components not to specification (e.g. inadequate number of dog spikes or lock spikes, or incorrect components).

(j) Fastening assembly components missing, broken or loose (e.g. loose or missing shoulder inserts, anchors), resulting in loss of gauge, alignment or rail holding capacity.

10.2.2.2 Steel sleepered track

Steel sleepered track assessment should include:

(a) details and dimensions of any cracking, especially in the rail seat or clip housing;

(b) adequacy of ballast within the sleeper pod;

(c) corrosion level;

(d) details and dimensions of any other damage such as buckling or indentations; and

(e) the type and condition of all fasteners, including clips, shoulders, pads and insulators.

10.2.2.3 Concrete sleepered track

Concrete sleepered track assessment should include:

(a) rail seat abrasion;

(b) significant chips or damage on each sleeper, especially around the edges and rail seat shoulders;

(c) deterioration of the concrete as a result of acid attack, alkali silica reaction (ASR), delayed ettringite formation (DEF), concrete cancer or other chemical degradation;

(d) significant cracking around the rail seat area within 300 mm of either side of the rail foot;

(e) significant cracking elsewhere on the body of the sleeper; and

(f) the condition of all fastenings, including clips, shoulders, pads and insulators.

Where there is a history of manufacturing defects, such as ASR or DEF, a special inspection regime should be considered.

10.2.2.4 Alternative material sleepered track

An individual sleeper and fastening assembly should be considered ineffective if the sleeper and fastener does not provide adequate lateral, longitudinal and vertical support to the rail as a result of one or more of the following conditions.

(a) Sleeper deterioration affecting the rail support (e.g. ageing, deterioration due to ultraviolet radiation).

(b) Excessive sleeper deformation due to long term creep.

(c) Excessive rail seat abrasion.

(d) Buckling or surface wrinkling.

(e) Deterioration of material properties due to the exposure to biological agents or water.

(f) Sleepers split, cracked or otherwise deteriorated at or through fastening components, rendering the fastening ineffective.

(g) Sleepers broken through, excessive loss of sleeper cross-section or other properties as specified in the sleeper design.

(h) Excessive rail back cant.

(i) Excessive lateral sleeper plate movement relative to the sleeper.

(j) Loose or missing shoulder inserts.

(k) Missing sleepers or complete sleeper failure.

(l) Fastening assembly components not to specification (e.g. inadequate number of dog spikes or lock spikes, or incorrect components).

(m) Fastening assembly components missing, broken or loose (e.g. loose or missing shoulder inserts, anchors), resulting in loss of gauge, alignment or rail holding capacity.

10.2.2.5 Sleeper and fastener defects contributing to a cluster

When considering whether a cluster exists, both the sleeper and fastenings should be inspected and assessed.

The potential cluster should be assessed separately on the basis of defect effect, as follows.

(a) Defect leading to reduced rail support in bearing.

(b) Defect leading to reduced gauge holding capacity including potential for rail roll.

(c) Defect leading to reduced longitudinal constraint, (i.e. ability to restrain creep forces).

The size of clusters should be determined by considering sleepers that are ineffective or that have ineffective fasteners.

Once the assessment for the individual effects has been undertaken separately, consideration should be given to assess the combined effects to understand, if it might lead to increased risk.

10.2.3 Maintenance Actions

When considering maintenance actions, the following factors should be considered.

(a) The loads and speed of the traffic to which the sleeper is subjected.

(b) The type and frequency of traffic.

(c) The risk or presence of environmental factors that can contribute to the rate of degradation of the defect.

(d) The creep forces to which the track is subjected and the effect of the fastener defect(s) on overall track stability.

(e) The risk or presence of other factors that can limit the remaining life of the fastener or associated component.

(f) The condition of adjacent sleepers.

(g) Anticipated rates of deterioration considering traffic task and environmental effects.

(h) Consequences of failure if the maintenance is not carried out.

Speed restrictions can be imposed by the RIM as a course of action to make track safe until repairs can be undertaken.

Defects to sleepers and fasteners could be repaired to extend the life of the asset until replacement is required.

Repair methods shall be as approved by the RIM.

10.3 Ballast and capping layer interface

Inspections of ballast condition and capping layer should be carried out in a manner and at an interval appropriate to the ballast type, condition, rates of deterioration and other local factors.

Inspection should include track drainage, ballast defects, ballast profile deficiencies and conditions that affect track stability, such as:

(a) track sections with inadequate ballast profile;

(b) track sections where the ballast profile interfere with the operation of infrastructure (e.g. signals or switches) or rolling stock;

(c) bog or mud holes or wet spots that affect the deterioration rate of the track condition;

(d) indications of poor sleeper support by ballast (e.g. cracking of sleepers and bearers, or excessive vertical sleeper movement);

(e) heaped ballast or gaps between sleepers that indicate longitudinal track movement, sleeper skewing or a lack of crib ballast ;

(f) heaped ballast or gaps at sleeper ends that indicate lateral track movement or a migration of ballast away from the track;

(g) accelerated loss of track geometry (e.g. following wet or dry weather) that indicate poor ballast quality;

(h) evidence of excessive track vibration (e.g. powdered or rounded ballast);

(i) areas and extent of fouled ballast or poor ballast drainage that have resulted or can result in wet spots or mud holes in wet weather;

(j) heaving of soil adjacent to the track, that indicate sub-grade failure;

(k) location and extent of narrow formation (i.e. formation that is too narrow to maintain the design ballast profile);

(l) location and extent of substantial weed growth;

(m) pumping;

(n) unconsolidated ballast; and

(o) other defects affecting track support and stability.

Inspection might be carried out using 'ground penetrating radar' or other methods approved by the RIM.

Where the ballast profile is assessed to be deficient, the RIM shall consider imposing a speed restriction if immediate repairs cannot be carried out.

10.3.1 Re-use and disposal of ballast

The re-use and disposal of ballast material shall be approved by the RIM. The process for disposal should consider relevant environmental requirements.

Any removed material should be placed clear of the track to prevent contamination of the track or adjacent property, or cause any obstruction to rail operations.

Appendix A Australian Rail Risk Model (ARRM) Risk Table

Hazardous Event	Publishable Consequence / Hazardous Event / Publishable Precursor
Maintenance Vehicle derailment in Yard	Misaligned track Spread track Structural failure of the permanent way, e.g. due to subsidence/landslip/washout
Maintenance Vehicle derailment on Running Line	Misaligned track Spread track Structural failure of the permanent way
Non-Passenger-Train derailment in Yard	Misaligned track Spread track Structural failure of the permanent way, e.g. due to subsidence/landslip/washout
Non-Passenger-Train derailment on Running-Line	Misaligned track Spread track Structural failure of the permanent way
Passenger-Train derailment on Running-Line	Misaligned track Spread track Structural failure of the permanent way

Appendix B BIBLIOGRAPHY

The following referenced documents are used by this Standard for information only:

(a) AS 1085.1 Railway Track Material – Steel Rails

(b) AS 7508:2017 Track Forces and Stresses

(c) EN 16432-2:2017 Railway Applications - Ballastless Track Systems - Part 2: System Design, Subsystems and Components

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