AS 1085.17:2021

Railway track material: Part 17: Steel sleepers

Infrastructure Standard

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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
Exec. Chair / CEO
Rail Industry Safety and Standards Board

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Railway track material: Part 17: Steel sleepers

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This paragraph is used to indicate if this Standard supersedes other documents in whole or in part. … only change this paragraph if it is applicable

Objective

The objective of this Standard is to provide purchasers and suppliers including owners, operators, designers and manufacturers of railway sleepers with requirements for the specification, manufacture and testing of trough-shaped steel sleepers for use in railway track.

This Standard is Part 17 of the AS 1085 (Railway track material) series.

This Standard includes the following changes to the previous edition:

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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’.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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 J

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Appendix Contents

1 Scope and general

1.1 Introduction

This Standard is intended for use by persons experienced in track design and performance and who have a good knowledge of the duty and environment of the track in which the sleepers are to be used.

The limits given in this Standard are based on the current state of knowledge of steel sleeper behaviour in service; however, service conditions are difficult to define and test criteria that are seen as the most appropriate for the current state of knowledge, have been adopted.

Track constructed using sleepers and fastener components meeting the requirements of this Standard is expected to give satisfactory performance when properly installed and under an appropriate maintenance program.

A critical design aspect of trough-shaped steel sleepers is the interaction of the fastening and the portion of sleeper around the fastening system. The rail seat assembly repeated load test cannot be used to predict the expected in-track fatigue life. It does, however, provide a means of acceptance of a design by comparison with existing proven designs on the basis of experience.

The loads used in testing and design should reflect the use of the sleeper. For example, if sleepers are used in an interspersed pattern, a disproportionate amount of the load may be taken by a particular sleeper and early in-service failure may result.

Loads and calculation methods given in this Standard are in permissible stress format and are not based on limit state principles.

1.2 Scope

This Standard specifies the performance requirements and gives design and testing methods for trough-shaped steel sleepers and their associated components for use in railway track. It provides methods for determining loads on sleepers and refers to AS 1085.19 for requirements for resilient fastening systems. It also sets out requirements for the performance of rail-insulating components.

This Standard does not cover sleepers for use in curves with a radius less than 200 m.

NOTES:

1. Guidance on means for demonstrating compliance with this Standard is given in Appendix B.
2. Guidelines on the design and manufacture of special sleepers and fastenings are given in Appendix C.

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 1085.19: Part 19: Resilient fastening assemblies.
- AS 1171: Non-destructive magnetic testing - Magnetic particle testing of ferromagnetic products, components and structures.
- AS 1199: Sampling procedures and tables for inspection by attributes.
- AS 1365: Tolerances for flat rolled steel products.

- AS 1399: Guide to AS 1199.
- AS 1594: Hot rolled steel flat products.
- AS 2312: Guide to the protection of iron and steel against atmospheric corrosion by the use of protective coatings.
- AS 2758.7: Part 7: Railway ballast.
- AS 1100.101: Technical drawing - General principles.
- AS/NZS 3678: Structural steel—Hot rolled plates, floorplates and slabs.

NOTE: Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.4 Terms and definitions

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

(a) ***end spade***
the turned down end of the sleeper, which provides lateral resistance and stability

(b) ***interspersed***
the placement of different sleepers into an existing track on either a spot basis (e.g. replacing defective sleepers) or regular pattern (e.g. 1 in 2, 1 in 3 etc), as opposed to in-face installation

(c) ***in-face***
where sleepers are installed in every position rather than interspersed with other sleepers in between

(d) ***lateral load***
a load or vector component of a load at the gauge corner of the rail parallel to the longitudinal axis of the sleeper and perpendicular to the longitudinal axis of the rail

(e) ***longitudinal load***
a load along the longitudinal axis of a rail

(f) ***pod***
volume enclosed by the top, end spades and sides of the sleeper

(g) ***rail insulation pad***
a component of a steel sleeper system that electrically insulates the rail from the sleeper

(h) ***shoulder***
a component that is attached to, fitted to or forms part of a steel sleeper, to prevent lateral movement of the rail

(i) ***side***
side of the sleeper projecting into the ballast layer (see Figure 2.1 (c))

(j) ***sleeper design life***
the intended period during which fatigue cracking or bending failure does not occur when the sleeper is subjected to the specified loading and environmental conditions

Note: Actual in-service sleeper life can vary from the sleeper design life depending on actual loading and environmental conditions applied to the sleeper. Actual in-service life may also depend on the extent to which minor deterioration (e.g., cracking, corrosion) may be tolerated using appropriate risk management techniques.

(k) ***toe***
section at the tip of the side of a steel sleeper (see Figure 2.1 (c))

(l) ***top***
top section of the sleeper (see Figure 2.1(c))

(m) ***vertical load***
a load or vector component of a load, perpendicular to a line joining the midpoint of the rail seats of the sleeper and perpendicular to the longitudinal axis of the rail

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

1.5 Abbreviations

(a) ***BOEF***
beam on elastic foundation

(b) ***RIM***
rail infrastructure manager

1.6 Notation

a length of pressure distribution (ballast support) beneath each rail seat, in metres

B maximum internal width of the sleeper section (see Figures D1 and F2), in millimetres

C_{BM} sleeper bending moment coefficient

$C_{BM(n)}$ bending moment coefficient at the field side edge of the sleeper housing

$C_{BM(max.)}$ maximum sleeper bending moment coefficient (maximum of $C_{BM(0)}$ and $C_{BM(n)}$)

$C_{BM(0)}$ bending moment coefficient at the sleeper midpoint

$C_{BM(x)}$ sleeper bending moment coefficient covering the region to the field side of the rail seat

C_x distance from horizontal neutral axis to the top surface of the sleeper (see Figures D1 and D2), in millimetres

c dimension of sleeper from the centre-line of the rail seat to the centre of the sleeper, in metres (see Figure 2.1 (a))

D overall depth of the sleeper section (see Figures D1 and D2) in millimetres

E Young's modulus of rail steel, in megapascals

E_s Young's modulus of sleeper material, in megapascals

F_y yield strength of sleeper material, in megapascals

F_1	factor applied to the rail seat load to incorporate the effects of the interaction of adjacent wheels to the design wheel load
F_2	factor depending on the standard of track maintenance
F_3	distribution factor for lateral loads on the rail seat
G	track gauge, in millimetres
g	distance between rail centres measured at the top of the rail, in metres (see Figure 2.1(a))
g_1	distance between rail centres for larger of dual gauge measured at the top of the rail, in metres (see Figure C1)
g_2	distance between rail centres for smaller of dual gauge measured at the top of the rail, in metres
I_s	sleeper moment of inertia about the horizontal neutral axis, in millimetres^4
$I_{s(new)}$	moment of inertia about the horizontal neutral axis of newly rolled sleeper section, in millimetres^4
I_{xx}	rail moment of inertia about the horizontal neutral axis, in millimetres^4
$\frac{L}{V}$	ratio of lateral to vertical wheel loads. (L - design lateral wheel load and V)
l	sleeper length at the centre-line (see Figure 2.1 (b)), in metres
l_0	overall (maximum) sleeper length (see Figure 2.1 (b)), in metres
M_{C+}	maximum positive bending moment at the mid span of the sleeper, in kilonewton metres
M_{C-}	maximum negative bending moment at the mid span of the sleeper, in kilonewton metres
M_d	design sleeper bending moment, in kilonewton metres
M_R	maximum bending moment at the rail seat, in kilonewton metres
M_{R+}	maximum positive moment at the rail seat of the sleeper, in kilonewton metres
n	dimension from end (on centre-line of bottom edge of end spade) to the centre-line of rail seat, in metres
P_{ab}	average sleeper to ballast bearing pressure, in kilopascals
P_{dL}	quasi-static lateral wheel load, in kilonewtons
P_{dV}	quasi-static vertical wheel load, in kilonewtons
Q	maximum static wheel load, in kilonewtons

R	design rail seat load, in kilonewtons
R_L	quasi-static lateral rail seat load, in kilonewtons
R_V	quasi-static vertical rail seat load, in kilonewtons
r	Curve radius of curvature of track, in meters
s	sleeper spacing, in metres
T	thickness of sleeper top (see Figures D1 and D2), in millimetres
t	thickness of sleeper side measured 10 mm above the toe (see Figures D1 and D2), in millimetres
T_c	confidence limit
U	track modulus (k is used in some publications), in megapascals
U_s	sleeper support modulus, in megapascals
v	vehicle velocity, in kilometres per hour
W	a value used in the empirical method, see Clause 5.4.2 and Paragraph C4
w	maximum external width of sleeper section excluding any localized widening around ends, in millimetres
x	distance from the sleeper end along centre-line of sleeper, in metres
x_l	distance (absolute) between load source and point of analysis, in metres
y	vertical track deflection, in metres
y_l	vertical track deflection due to a wheel load at a distance 'x_l' from the point under consideration, in metres
y_{max}.	maximum sleeper deflection (assumed to occur immediately beneath the rail seat) in metres or millimetres, as appropriate
Z_{toe}	section modulus of sleeper toe about the horizontal neutral axis, in millimetres^3 (for design purposes, taken at the end of the sleeper design life)
β	track stiffness parameter, in metres^{-1}
δ	track condition factor used in determining the design impact factor/load distribution
η	velocity factor used in determining the design impact factor/load distribution
λ	sleeper stiffness parameter, in metres^{-1}

σ_{all} allowable sleeper bending stress (see Clause 2.3.3) in mega pascals

σ_{cont} maximum contact pressure at the sleeper/ballast interface (see Clause 5.5.2) in kilopascals

σ_{d} design sleeper bending stress (see Clause 5.3) in megapascals

ϕ dynamic impact factor.

2 Performance requirements

2.1 General

Sleepers are support members that are part of the structure of railway permanent way. They are embedded into the ballast and support the rails above. They tie the rails together maintaining gauge and rail position and resisting lateral and longitudinal movement of the rail system. Fastenings, as part of the sleeper assembly, secure the rails to the sleeper.

The performance of steel sleepers in track depends on the condition of the rail, the condition and type of rail joints, the ballast support and the rail fastening system. Accordingly, when considering performance, the sleeper and its fastening together with the rail shall be regarded as interdependent components of a system.

Figure 2.1 -Schematic representation of steel sleeper showing principal definitions, shows principal dimensions as symbols, which are defined in Section 1.3.

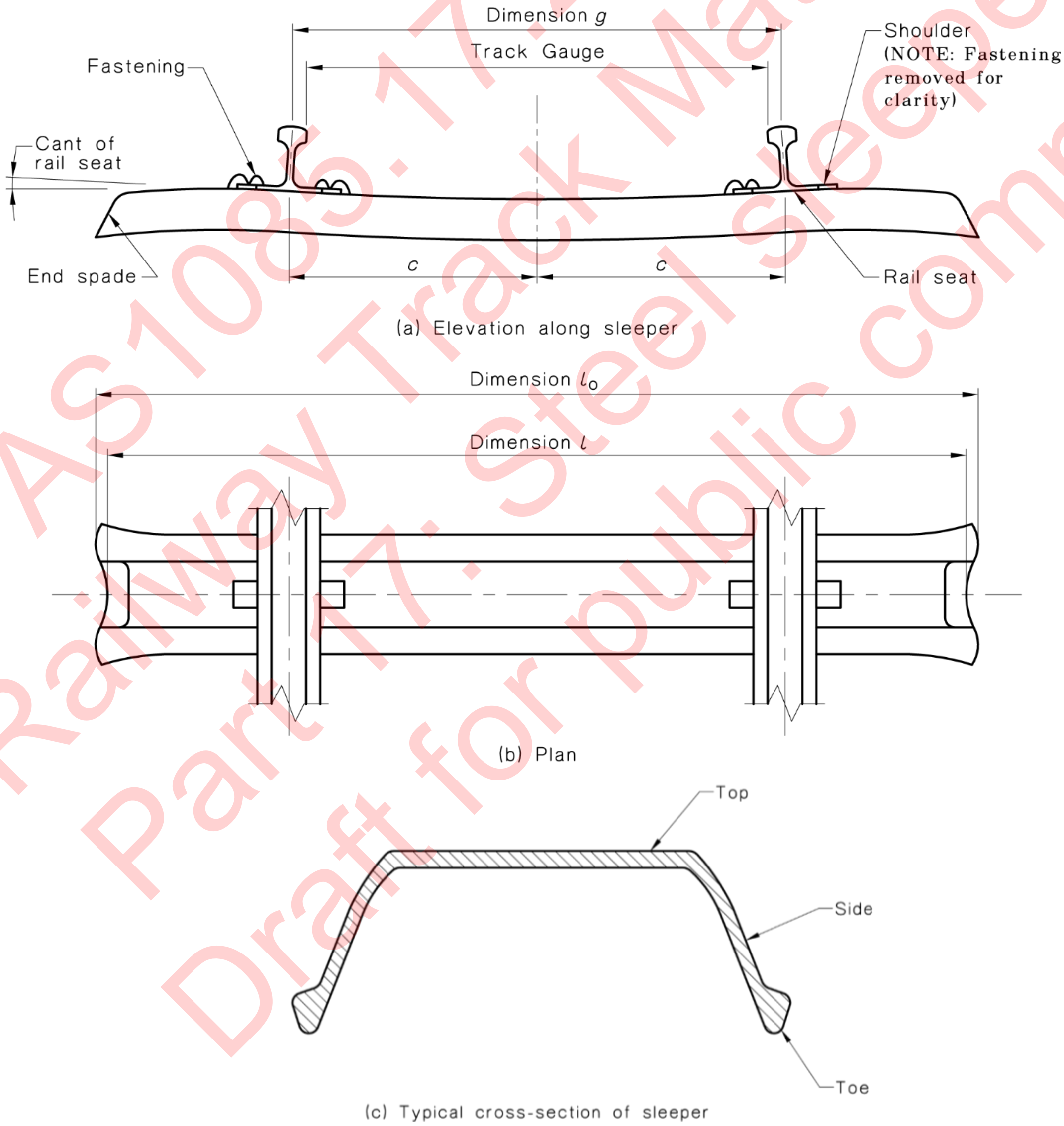


Figure 2.1 Schematic representation of steel sleeper showing principal definitions

The performance requirements for the integrity of the sleeper assembly shall be deemed to be met when the sleeper:

(a) is manufactured with materials conforming to Section 2.3.5,

(b) is tested in accordance with Appendices E-G, and

(c) meets the pass criteria of vertical test loads outlined Section 3.

2.2 Design parameters

2.2.1 General

This Section provides criteria that the purchaser should specify to enable efficient and effective design of steel sleepers, specific to the intended railway.

2.2.2 Minimum inputs

The following list details the minimum information that should be made available for the design of a sleeper:

(a) Nominal track gauge, including tolerance.

(b) Rail size and fastening system.

(c) Sleeper spacing.

(d) Minimum length of sleeper and any additional limits on cross-sectional dimensions.

(e) Design curve radii, including respective super elevation and speed envelopes for each curve.

(f) Maximum static axle load, in tonnes.

(g) Insulation requirements for and type of track signal circuits.

(h) Geographic and climatic extremes.

(i) Factors that affect the corrosion rate of the sleepers.

(j) Requirements for inspection holes.

2.2.3 Design refinement

Additional information relevant for refining the design includes the following.

(a) Name of railway system.

(b) Proposed track standard or Eisenmann track condition factor (δ).

(c) Maximum gradient.

(d) Nominal cant of rails.

(e) The traffic mix as a combination of static wheel loads, in tonnes, and maximum train speeds, in kilometres per hour.

(f) Design lateral to vertical force ratio (L/V).

(g) Lateral load (L) and vertical load (V), in kilonewtons.

(h) Centre of gravity of vehicle types above top of running rail.

(i) Annual gross tonnage, in million gross tonnes per year.

(j) Ballast type, quality and depth of ballast.

(k) Quality of formation.

(l) Track modulus (U).

(m) Minimum value of lateral track stability in kilonewtons per panel of three sleepers.

(n) Any special installation requirements.

(o) Voltage of traction supply if traffic is electrified.

(p) Sleeper design life.

(q) Where appropriate, minimum clamping force (toe load) on one rail seat, in kilonewtons.

NOTE: See AS 1085.19 for requirements for resilient fastening assemblies.

(r) Requirements for type of pad for fastening assembly.

(s) Where appropriate, insulation requirements and level of resistivity, in ohms (where different to that established by AS 1085.19).

NOTE:

1. A designer may not necessarily require all items listed above. However, the design inputs should be agreed between the purchaser and supplier.
2. The RIM should ensure that, in addition to the information set out above, all other matters and options included in this Australian Standard are specified to the manufacturer to permit the design, manufacture and testing of a suitable sleeper and fastening assembly for the particular purpose required

2.3 Service life

2.3.1 General

The performance requirements for the design service life of the sleeper assembly shall be deemed to be met when Clauses 2.3.2 to 2.3.8 are satisfied.

Note: Sleepers are subject to:

- loads imposed by the passage of rolling stock on the rails and during maintenance;
- loads generated by thermal effects on the rail and by ballast movement; and
- fatigue, wear, damage and corrosion.

2.3.2 Shape and dimensions

The shape of the sleeper shall be such that it supports the rails and maintains the gauge under the expected conditions for its design service life. The requirements for sleeper shape for service life shall be deemed to be met when the sleeper complies with the minimum geometric section properties and end detail requirements stipulated by the RIM and is within the tolerances given below. An example shape of a steel sleeper is provided in Appendix D.

Table 2.1 Permissible tolerances for sleepers

Characteristic	Tolerance
1. Overall length of sleeper	±10 mm
2. Individual cross-sectional dimensions of sleepers other than those specified in items 3, 4 and 5>	±3 mm
3. Internal width of sleeper at the section toe B	±5 mm

Characteristic	Tolerance
4. Overall depth of sleeper section, D	±2 mm
5. Thickness of the sleeper top, T	+0.5mm, -0.3 mm
6. Inward cant of rails sets: a. Hot-pressed b. Cold pressed	 ±0.5° ±0.2°
7. Rail seat flatness *(no convexity allowed) Note: Where this tolerance is not met by special sleepers such as turnout and splay bearers (see Appendix E), the flatness may be agreed with the RIM	0.0 to 1.0 mm
8. Differential tilt angle of rail seats in the direction of rail	±0.6°
9. Track gauge, measured between gauge points of rails with the rail placed hard against the outer shoulder (see Figure F3)	±2 mm
10. Distance between inside walls of inner and outer shoulders of each rail measured 2 mm above the rail seat	+1.0 mm, -0.0 mm
11. Inside walls of inner and outer housings of each rail seat to be parallel to longitudinal axis of each rail	±0.2°
12. Sleeper longitudinal straightness (over the nominally straight portion in plain view)	6 mm/m
13. Distance between outer edges of files of the same rail seat	±1 mm
14. Distance between outer edges of fixing holes of the same rail set	±0.5 mm

** Flatness tolerance shall be measured in accordance with AS/NZS 1100.101*

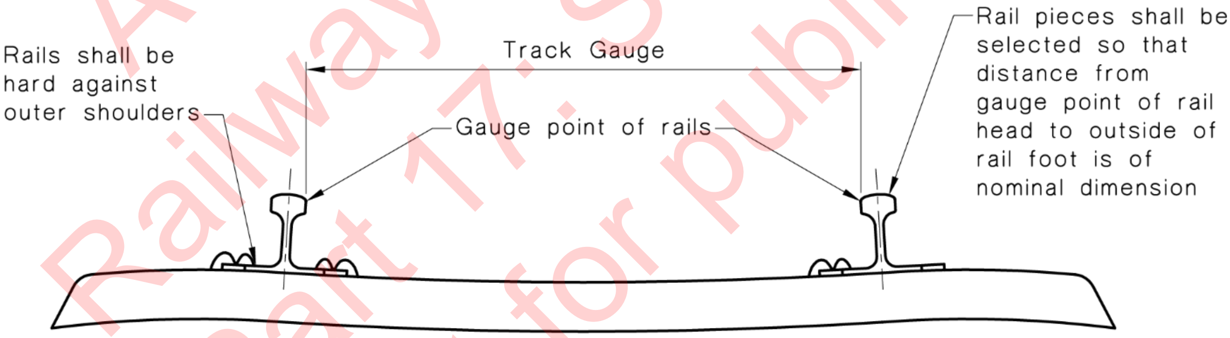


Figure 2.2 Measurement of track gauge

2.3.3 Design stresses and ballast contact pressure

When designed in accordance with the service loads and track conditions specified, the calculated sleeper bending stress in tension and compression, calculated in Section 5, shall not exceed the allowable sleeper bending stress, σ_{all}, of 0.66 F_y, unless it can be demonstrated otherwise the capability of the product through the various tests provided in the appendices.

The average sleeper to ballast contact pressure, calculated in accordance with Clause 5.4 at a position equivalent to the bottom of the sleeper (on a plane intersecting the toes), shall not exceed 500 kPa for high quality, abrasion resistant ballast. If lower quality ballast materials are used, the allowable ballast pressure shall be reduced accordingly.

Sleeper bending stresses, bending moments and contact pressures shall be calculated in accordance with Sections 4 and 5 and sleeper section properties shall be those assumed for the end of the service life of the sleeper (see Clause 5.2).

Where no other information is available, the value of R shall not be less than R_V as determined in accordance with Section 4.

NOTE: The value of R used for design can be subject to other information requiring engineering judgement

2.3.4 Design of details

Sleeper design shall take into account the stresses induced in the sleeper by the interaction with the fastening system (e.g., stress concentrations).

2.3.5 Sleeper materials

2.3.5.1 Pre-formed sections

Sleepers manufactured from pre-formed section shall be made of steel with a characteristic yield strength of at least 250 MPa. The chemical composition of the steel should conform to the limits given in Table 2.1. The steel shall not contain defects such as segregation, pipe, or non- metallic inclusions that reduce the expected sleeper life below the design life.

Table 2.2 Chemical Composition of Steel

Basic chemical composition	
Element	Percent, max.
Carbon	0.24
Manganese	1.5
Silicon	0.5
Sulfur	0.04
Phosphorous	0.04

2.3.5.2 Strip

Where the steel sleeper is manufactured from strip, the material shall conform to the requirements of AS 1365, AS 1594 or AS/NZS 3678 as appropriate.

2.3.6 Surface finish

The sleeper shall be free of surface defects, cracks, scratches, sharp die marks and sharp tooling marks which are likely to initiate failure in service. Defects may be rectified by grinding, provided that the structural adequacy of the sleeper section is not impaired, and tolerances are not exceeded.

2.3.7 Resilient rail fastening assemblies

The performance requirements for the service life of resilient rail fastening assemblies shall be deemed to be met when Clause 2.3.8 and Section 3 are satisfied.

2.3.8 Rail seat assembly repeated load test

When tested in accordance with Appendix F with lateral and vertical rail seat loads as calculated in Section 3, unless the loads are otherwise specified by the purchaser, no fatigue cracking of the sleeper, fastening components or failure of the insulation pad shall occur.

NOTE:

1. This test provides for acceptance of the sleeper on the basis of existing knowledge; however, the test cannot be used to predict the expected in-track fatigue life.
2. Sufficient data is not available on a correlation between the test and in-track performance.
3. In the event of failure under the given loading conditions, full test details should be provided for the consideration of the RIM.

2.4 Rail restraint and support

2.4.1 General

Resilient rail fastening assemblies shall be in accordance with AS 1085.19. The requirements for rail restraint and support shall be deemed to be met when Clauses 2.3.2 to 2.3.3 are satisfied, and the resilient rail fastenings are in accordance with Section 3.

2.4.2 Shape

The requirements for sleeper shape for rail restraint and support shall be deemed to be met when Clause 2.3.2 is satisfied.

2.4.3 Lateral track stability test

When tested in accordance with Appendix G, the maximum load determined shall be not less than the minimum value specified by the RIM.

NOTE:

1. The ability of the track structure to resist track buckling is also affected by the resistance provided by the fastening system to rotation of the longitudinal rail axis in the horizontal plane.
2. Alternative procedures for the determination of track stability may be used where agreement is reached between the manufacturer and the RIM

2.5 Track system compatibility

Sleeper assemblies shall maintain the track gauge within the tolerance given in Table 2.1 when tested in accordance with Appendix E.

2.6 Installation and maintenance

Sleeper assemblies shall be designed to:

(a) provide for safe and easy installation and removal in existing track;

(b) allow for rails to be de-stressed or changed; and

(c) allow for inspection by the provision of inspection holes 20 mm in diameter, located on each side of each rail seat and away from locations of high stress unless specified otherwise by the RIM.

NOTE: Inspection holes allow assessment of ballast compaction within the sleeper pod when the sleepers are installed in the track.

2.7 Traceability

Each sleeper shall be marked by raised or indented letters of not less than 12 mm high, and not more than 2 mm raised or indented, with the following information:

(a) The mark required by RIM.

(b) Year of manufacture.

(c) Mark of manufacturer.

(d) Sleeper identification marks as required.

All markings shall be such as to induce no inherent fatigue weakness zones in the steel sleeper.

All markings shall be located so that they can be readily seen when the sleeper is installed and so that a stack of sleepers can be fully identified.

NOTE: Manufacturers making a statement of compliance with this Australian Standard on product, packaging or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

2.8 Handling

2.8.1 Stacking of sleepers

The finished sleepers shall be handled and stacked in such a manner that there shall be no damage to the sleepers. Stacked sleepers should be able to be easily separated.

2.8.2 Surface finish

Sleepers shall be free of burrs that could cause injury when handled or that could prevent efficient stacking and installation (see Clause 2.3.6).

3 Loads for design and testing

3.1 General

Field measurements shall be used for determining loads to be used for testing and analysis, except that where field measurements are not available, Clauses 3.2 to 3.7 below set out theoretical means for calculating lateral and vertical loads.

Once determined, these loads are used for testing and for calculation of structural capacity.

NOTE: Quasi-static loads account for the effects of the geometrical roughness of the track vehicle response and the effect of unbalanced superelevation. Steel sleepers are not usually designed for high frequency dynamic load effects. Where steel sleepers are to be used in jointed track, dynamic effects may need to be considered.

3.2 Track conditions

All relevant track conditions shall be considered in determining the loading, including dynamic effects. The effects of wheel flats, rail joints and other significant irregularities will determine the magnitude of the dynamic loads used in design.

The methods given in Clauses 3.3 to 3.7 apply to the use of steel sleepers in ballasted railway tracks where they are installed either in-face or in an interspersed pattern. Where sleepers are to be used in an interspersed pattern, the possibility that a disproportionate amount of the load can be taken by a particular sleeper shall be considered in determining the variables to be used (see Clause 3.5).

NOTES:

1. The RIM should define track conditions (see section 2.2).
2. The RIM should ensure that installation and maintenance procedures are suitable for the sleepers selected, including that the pod is correctly packed with ballast and that adjacent sleepers in an interspersed pattern are sound.

3.3 Quasi-static vertical wheel load

Where in-field measurements have not been obtained, the theoretical design quasi-static vertical wheel load (P_{dv}) shall be determined from the maximum of a combination of static wheel loads and vehicle operating speeds in combination with the track condition factor as specified. The quasi-static wheel load shall be calculated from the following equation:

Equation 3.3-1

$$P_{dv} = \phi Q$$

where

P_{dv} = *quasi-static vertical wheel load, in kilonewtons*
ϕ = *quasi-static impact factor*
Q = *maximum static wheel load, in kilonewtons*

Where multiple traffic types exist, the maximum dynamic wheel load shall be used for structural design purposes.

3.4 Impact factor

Where in-field measurements have not been obtained, the theoretical impact factor (ø) for steel sleeper design may be computed by the Eisenmann loading distribution as follows:

Equation 3.4-1

$$ø = 1 + (\delta\ \eta\ t_c)$$

where

δ = *track condition factor*

η = *velocity dependent factor*

t_c = *confidence limit*

The above expression represents a normal distribution of loading around the mean load in which term '$\delta\ \eta$' defines the standard deviation of the loading and 't_c' defines the required number of standard deviations that the design load lies above the mean static load. Impact factors calculated using this formula do not include allowance for the effects of wheel flats, rail joints and other significant irregularities. The factors used in Equation 3.4-1 shall be as follows:

(a) Track condition factor (δ). The track condition factor (δ) should be selected from one of the following:

Description	(δ)
For track maintained in very good condition	0.1
For track maintained in average condition	0.2
For track in poor condition	0.3
For track in very poor condition	0.4

(b) Velocity-dependent factor (η). This factor may be selected from one of the following:

Description	(η)
For velocities up to 60 km/h	1.0
For velocities greater than 60 km/h	1.0 + (v - 60)/140, where v is in km/h.

(c) Confidence limit (t_c): For design purposes, an impact factor that gives a design load lying 3 standard deviations above the mean load (t_c = 3), representing a design load lying at the 99.9 percentile shall be used.

3.5 Quasi-static vertical rail seat load

The beam on elastic-foundation (BOEF) method may be used to determine the proportion of loading applied to individual sleepers. The general BOEF relationship for the calculation of the rail seat load is as follows:

Equation 3.5-1

$$R_v = sUy_{max}$$

and

Equation 3.5-2

$$y_{max} = \sum_{i=l}^{n} y_i$$

Where

R_v = *quasi-static vertical rail seat load, in kilonewtons*

s = *sleeper spacing, in metres*

U = *track modulus, in megapascals*

ymax = *maximum sleeper deflection resulting from multiple wheels, in metres*

y_i = *vertical track deflection due to a wheel load at a distance 'x_l' from the point under consideration, in metres*

NOTE: The track modulus should be chosen to suit the application in which the sleepers are to be used, including use in an interspersed pattern.

Vertical track deflection, using the BOEF analysis, is given by the following equation:

Equation 3.5-3

$$Y_i = \frac{P_{dv}\beta}{2U} e^{-\beta_{x_l}}\left(\cos\beta_{x_l} + \sin\beta_{x_l}\right)$$

Where

P_{dv} = *quasi-static wheel load, in kilonewtons*

x_l = *distance (absolute) between load source and point of analysis, in metres*

β = *track stiffness parameter, in metres to the power of minus one*

$(U/(4\,E\,I_{xx}))^{0.25} \times 10^3$

Where,

E = *Young's modulus of rail steel, in megapascals*

I_{xx} = *rail moment of inertia about the horizontal neutral axis, in millimetres to the power of four.*

Application of this equation allows the track deflection to be computed both immediately beneath a wheel (x_l= 0) and at adjacent wheels. Thus, the effects of wheel interaction on the total deflection (y) can be computed.

If wheel interaction is not computed, the design rail seat load may be calculated from the following equation:

Equation 3.5-4

$$R_v = 0.5F_1 P_{dV}\ s\beta$$

where

F_1 = factor to account for wheel interaction

For this case, a nominal value of 1.25 for F1 may be adopted based on the typical combinations of track modulus and wheel distribution. This assumption is valid where the track modulus is greater than 20 MPa and two axle bogie vehicles are used which have a minimum distance between axles of not less than 1.75 m and between axles on adjacent vehicles of not less than 2.30 m. Where rail smaller than 68 kg/m, or track moduli greater than 20 MPa are used in combination with these wheel spacings, the value of 1.25 is conservative. Conversely, a track modulus less than 20 MPa or closer wheel spacings could lead to F1 values greater than 1.25 and a full analysis of wheel interaction should be carried out.

3.6 Quasi-static lateral wheel load

Quasi-static lateral wheel load (P_{dL}) shall be established from one of the following:

(a) In-field measurements.

(b) Calculated from the quasi-static vertical wheel load (P_{dv}) as calculated using Clauses 3.3 and 3.4 and adjusted for the effect of curve radius by means of the $\frac{L}{V}$ ratio as follows:

Equation 3.6-1

$$P_{dL} = P_{dv}\left(\frac{L}{V}\right)$$

Where the $\frac{L}{V}$ ratio shall be determined as follows (see Figure 3.1 for a graphic representation):

$$L/V = 0.13 + (0.07\ G/r)$$

but not exceeding the range 0.2 to 0.8.

where

G = track gauge, in millimetres

r = curve radius, in metres

Note: On the graphical representation below, the gauge is in millimetres and radius is in metres. While this standard is not recommended for radii less than 200 m, where applied, it is recommended in-field measurements are taken to understand the loading environment.

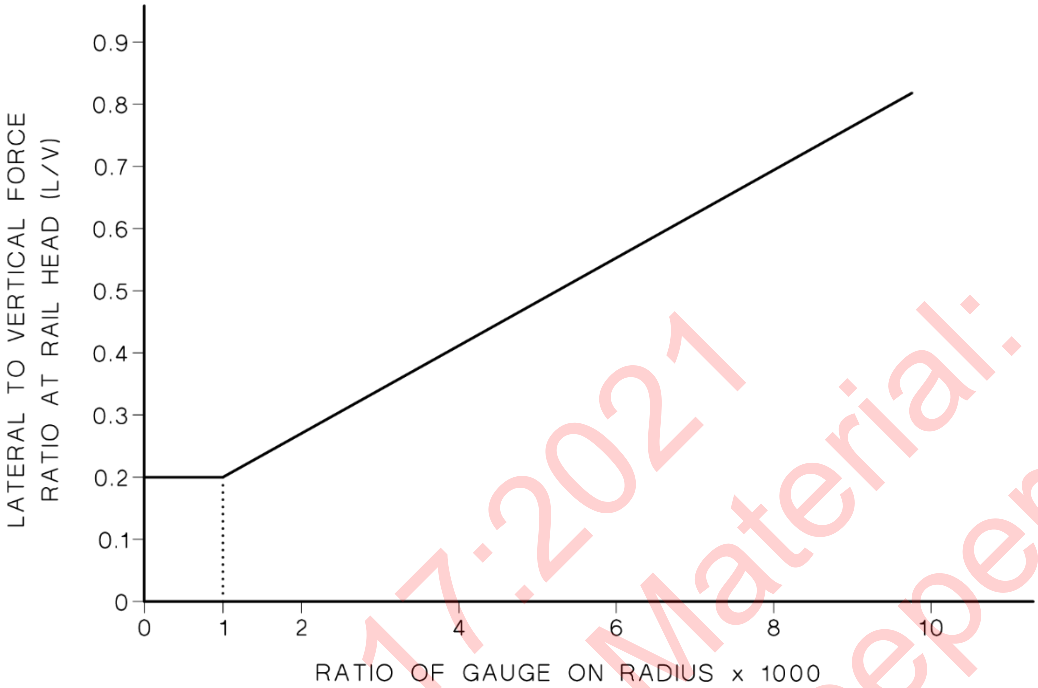


Figure 3.1 L/V ratio versus ratio of gauge on curve radius

3.7 Quasi-static lateral rail seat load

The quasi-static lateral rail seat load (R_L) shall be calculated using the quasi-static lateral wheel load (P_{dL}), which is adjusted for the distribution of the lateral load on the rail seat as follows:

Equation 3.7-1

$$R_L = F_3 P_{dL}$$

where

F_3 = *distribution factor for lateral loads on the rail seat*

Note: The factor F_3 may be selected from direct field measurement or finite element modelling, or a nominal value of 0.75 may be used if the actual measurement is not available.

4 Structural analysis

4.1 General

This Section gives methods for determining the bending stress, sleeper bending moment (M_d) and the sleeper to ballast contact pressure. The Section does not include methods for designing the details of sleepers affected by fatigue and localized stress concentrations. The two methods given are the empirical method in section 4.4 or the BOEF method in section 4.5.

The empirical method is usually more conservative than the BOEF method.

Other methods of analysis may be used provided that they result in sleeper performance equal to or better than the performance resulting from the methods given in this Standard.

NOTE: A method for determining maximum sleeper spacing based on allowable bending stress is given in Appendix H.

4.2 Corrosion and wear

Allowance shall be made for corrosion and wear appropriate to the specified sleeper design life, climate and corrosive environment in track. Section properties used in design calculations shall be based on the expected sleeper cross-section at the end of the specified sleeper design life. In the absence of site-specific data, corrosion rates may be estimated in accordance with AS 2312

NOTE: Corrosion should be assumed from both top and bottom surfaces. Consideration of higher corrosion and wear rates may be necessary where sleepers are used with reactive ballast in coastal regions or in poor ballast conditions. These conditions have led to sleepers having a significantly reduced service life of less than half that planned.

4.3 Design bending stress

Maximum stresses in the sleeper due to bending generally occur in the sleeper toe. The magnitude of this stress shall be calculated from the following equation:

Equation 4.3-1

$$\sigma_d = M_d / Z_{toe}$$

Where

σ_d]= *design sleeper bending stress, in megapascals*

M_d = *design sleeper bending moment, in kilonewton metres*

z_{toe} = *section modulus of sleeper toe about the horizontal neutral axis, in cubic millimetres*

4.4 Empirical method

4.4.1 Ballast contact pressure

The average sleeper to ballast contact pressure, in kilopascals, shall be calculated from the following equations:

Equation 4.4-1

$$P_{ab} = \frac{R}{w10^{-3}(l-g)}F_2$$

Or for narrow gauge

Equation 4.4-2

$$P_{ab} = \frac{R}{w10^{-3}(l-g)0.8}F_2$$

Where

P_{ab} = *average sleeper to ballast bearing (contact) pressure, in kilopascals*
R = *design rail seat load, in kilonewtons*
w = *maximum width of sleeper section, in millimetres*
l = *sleeper length at centre-line, in metres*
g = *distance between rail centres measured at the top of the rail, in metres*
F_2 = *factor depending on the standard of track maintenance*

Note: Current experience indicates F_2 = 1 is adequate.

4.4.2 Bending moment calculation by the empirical method

An empirical method of calculating the sleeper design bending moment (M_d) where M_d is taken as the greater of the values of M_R, M_C+ and M_C- is as follows:

(a) Moments at rail seat: The maximum bending moment at the rail seat (M_R) and the ballast support conditions may be calculated as follows:

i. For standard gauge 1435 mm and broad gauge 1600 mm:

Equation 4.4-3

$$a = l - g$$

Equation 4.4-4

$$M_R = R(l-g)/8$$

Where

a = *Length of ballast support, in metres*
l = *length of sleeper in metres*
g = *distance between rail centres measured at the top of the rail, in metres (see Figure 4.1)*

ii. For narrow gauge 1067 mm:

Equation 4.4-5

$$a = 0.8\,(l-g)$$

Equation 4.4-6

$$M_R = R\frac{l-g}{6.4}$$

(a) Positive moments at the centre of the sleeper: The maximum positive moment at the centre of the sleeper (M_{c+}) may be based on a pressure distribution beneath each rail seat as shown in Figure 4.1(a) and may be calculated as follows:

i. For standard gauge and broad gauge:

Equation 4.4-7

$$a = 0.9\,(l - g)$$

$$M_{c+} = 0.05R\,(l - g)$$

Equation 4.4-8

ii. For narrow gauge:

Equation 4.4-9

$$a = 0.8\,(l - g)$$

Equation 4.4-10

$$M_{C+} = 0.1R\,(l - g)$$

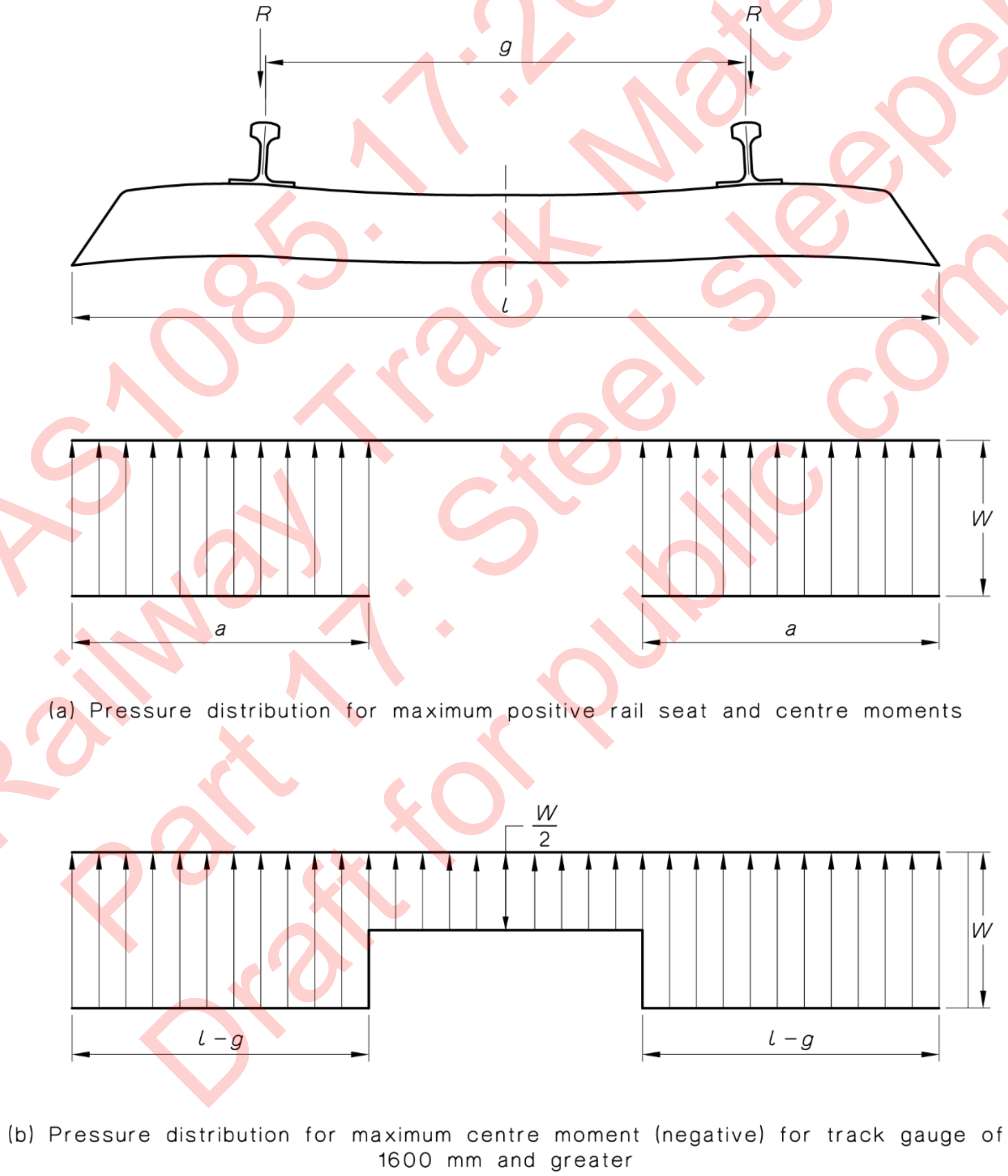


Figure 4.1 Pressure distribution

(b) Negative moments at the centre of the sleeper: The maximum negative design moment at the centre of the sleeper (M_{C-}) may be based on a pressure distribution beneath the sleeper for partially or totally centre bound conditions as shown in Figure 4.1(b) and may be calculated as follows:

i. For broad gauge:

Equation 4.4-11

$$M_{c-} = 0.5\left[Rg - Wg(l-g) - \frac{w(2g-1)^2}{8}\right]$$

Where

$$W = \frac{4R}{3l - 2g}$$

ii. For standard gauge

Equation 4.4-12

$$M_{C-} = \frac{R(2g-l)}{4}$$

iii. For narrow gauge:

Equation 4.4-13

$$M_{C-} = M_R$$

4.5 Beam on elastic foundation (BOEF) method

4.5.1 General

The calculations in this Clause give sleeper bending moment coefficients and sleeper deflections for determining bending moments and sleeper to ballast contact pressure. They are based on the BOEF analysis. Figure 4.2 shows schematically the case considered.

NOTE: The full derivation has been presented by HETENYI, M. Beams on elastic foundation. The University of Michigan Press: Ann Arbor, 1967, and represents the case of a finite beam loaded by two equal concentrated forces placed symmetrically (at the centre of the two rail seats).

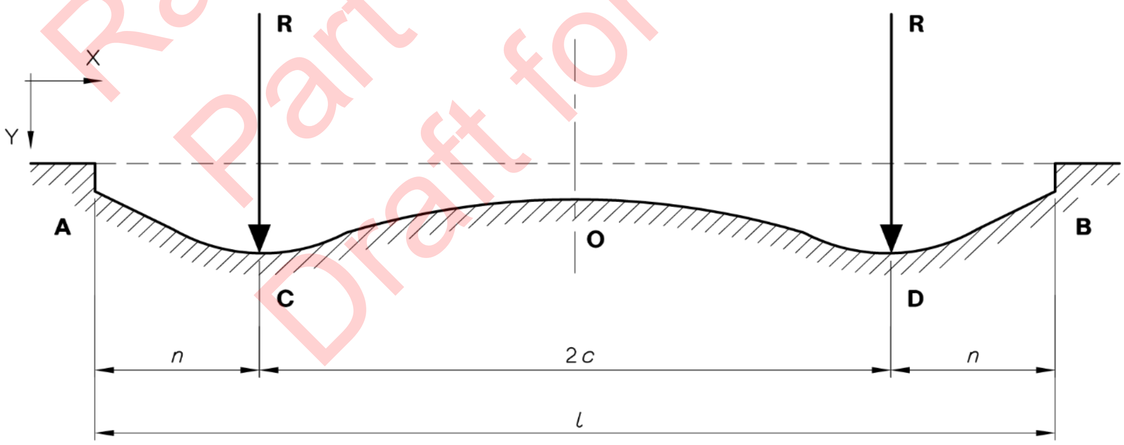


Figure 4.2 BOEFF Formulation for sleeper moments and deflection calculations

4.5.2 Sleeper to ballast maximum contact pressure

The maximum sleeper deflection and, hence, sleeper to ballast contact stress occurs immediately beneath the rail seat and assumes a uniform contact pressure distribution over the estimated effective area of the sleeper for ease of calculations. The BOEF analysis gives the maximum contact pressure at the sleeper to ballast interface by the following equation:

Equation 4.5-1

$$\sigma_{cont} = \frac{y_{max}\, U_s 10^3}{w}$$

Where

σ_{cont} = *maximum contact pressure at the sleeper to ballast interface in kilopascals*

y_{max} = *maximum vertical sleeper deflection, in millimetres*

U_s = *sleeper support modulus, megapascals*

w = *maximum external width of sleeper section, in millimetres*

It is noted that, in general, the sleeper support modulus is approximately half the track modulus. More accurate values can be computed by equating the track deflection defined in Clause 3.5 and the sleeper deflection at the rail seat given in Clause 4.5.3.

Note: In the case of a soft insulation pad, track deflection as described by the track modulus will exceed the sleeper deflection.

4.5.3 Sleeper stiffness and deflection

The sleeper stiffness may be computed by solving the following equation iteratively, equating the maximum sleeper deflection to the maximum track deflection by using Equations 3.5(3) and 3.5(4) as necessary:

Equation 4.5-2

$$y_{max} = \frac{R\lambda}{2U}\frac{1}{sin\lambda l + sin\lambda l}\Big[2\cosh^2 \lambda n \left(cos2\lambda c + cosh\, \lambda l\right)$$
$$+2\cos^2 \lambda n(cosh\, 2\lambda c + cos\, \lambda l) + sinh2\lambda n(sin2\lambda c - sinh\lambda l)$$
$$-sin\ 2\lambda n\,(sinh2\lambda c - sin\lambda l)\Big]$$

Where

$y_{max.}$ = *maximum vertical track deflection, in millimetres*

R = *design rail seat load, in kilonewtons*

U = *track modulus, in megapascals*

l = *sleeper length at centre-line, in metres*

c = *dimension of sleeper from centre-line of rail seat to centre of sleeper, in metres*

n = *dimensions from end (on centre-line at toe) to centre-line of rail seat, in metres*

λ = *sleeper stiffness parameter, in metres to the power of minus one =* $[U_s/(4E_sI_s)]^{0.25} \times 10^3$

U_s = *sleeper support modulus, in megapascals*

E_s = *Young's modulus of sleeper material, in megapascals*

I_s = *sleeper moment of inertia about the horizontal neutral axis, in millimetres to the power of four*

Note: Typical values for the sleeper support modulus (U) lie in the range 10 MPa to 40 MPa.

4.5.4 Bending moment

Using the BOEF analysis, the design moment (M_d) may be calculated from the following equation:

Equation 4.5-3

$$M_d = RC_{BM\ (max.)}$$

Where

M_d = *design sleeper bending moment, in kilonewton-metres*
R = *design rail seat load, in kilonewtons*
$C_{BM\ (max.)}$ = *maximum sleeper being moment coefficient, in metres*

Two equations are utilized in the derivation of the sleeper bending moment coefficients (C_{BM}). One covers the region to the field side of the load source (region A-C in Figure 4.2) and is used to determine the moment coefficient adjacent to the rail foot ($C_{BM(n)}$). The second covers the midpoint of the sleeper (location 0) and is used to determine the bending moment at the sleeper centre ($C_{BM(0)}$). Although larger bending moments will be computed immediately beneath the load source (due to the assumption of a point load), these values will in practice be reduced due to the rail foot distributing the load.

The value of $C_{BM(max.)}$ for use in calculating M_d is the larger of $C_{BM(0)}$, and $C_{BM(n)}$, which shall be calculated as follows:

(a) Bending moment along portion A-C (x varies from 0 to n):

Equation 4.5-4

$$C_{BM(x)} = \frac{1}{2\lambda}\frac{1}{\sinh\lambda l + \sin\lambda l}\{2\sinh\lambda x \quad \sin\lambda x[\cosh\lambda n \cos\lambda(l-n) + \cosh\lambda(l-n)\cos\lambda n] + (\cosh\lambda x \sin\lambda x - \sinh\lambda x \cos\lambda x)\,[\cosh\lambda n \sin\lambda(l-n) - \sinh\lambda n \cos\lambda(l-n) + \cosh\lambda(l-n)\sin\lambda n - \sinh\lambda(l-n)\cos\lambda n]\}$$

(b) Bending moment at sleeper centre (x = ½):

Equation 4.5-5

$$C_{BM(0)} = \frac{1}{2\lambda}\frac{1}{\sin\lambda l + \sin\lambda l}\{\sinh\lambda c\,[\sin\lambda c + \sin\lambda\,(l-c)] + \sin\lambda c\,[\sinh\lambda c + \sinh\lambda\,(l-c)] + \cosh\lambda c \cos\lambda\,(l-c) - \cos\lambda c \cosh\lambda(l-c)\}$$

Where

$C_{BM(x)}$ = *sleeper bending moment coefficient covering the region to the field side of the rail seat, in metres.*
$C_{BM(0)}$ = *bending moment coefficient at sleeper midpoint, in metres*
x = *distance from sleeper end, in metres*

Appendix A ARRM risk table

Hazardous event	Publishable consequence / Hazardous event / Publishable precursor
Poor specifications, manufacture and QA (Quality Assurance) of material (6.8.1.9)	
Poor design and manufacture (6.9.1.36)	
Derailment (6.14)	
Track failure (6.15)	
Track and civil infrastructure design failure (6.28)	

Appendix B Product conformity (Informative)

B.1 Scope

This Appendix sets out the following different means by which compliance with this Standard can be demonstrated by the manufacturer or supplier:

(a) Evaluation by means of statistical sampling.

(b) The use of a product certification scheme.

(c) Assurance using the acceptability of the supplier's quality system.

(d) Other such means proposed by the manufacturer or supplier and acceptable to the customer.

B.2 Statistical sampling

Statistical sampling is a procedure that enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

(a) The sample shall be drawn randomly from a population of product of known history. The history shall enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.

(b) For each different situation, a suitable sampling plan shall be defined. A sampling plan for one manufacturer of given capability and product throughput could not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier shall demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199, guidance to which is given in AS 1399.

B.3 Production certification

The purpose of product certification is to provide independent assurance of the claim by the manufacturer that products comply with the stated Standard.

The certification scheme should meet the criteria described in HB 18.28 in that, as well as full type testing from independently sampled production and subsequent verification of conformance, it requires the manufacturer to maintain effective quality planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of the Standard.

B.4 Supplier's quality management system

Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or international Standard for a supplier's quality management system or systems, this can provide the necessary confidence that the specified requirements will be met. The quality assurance requirements shall be agreed between the customer and supplier and should include a quality or inspection and test plan to ensure product conformity.

Information on establishing a quality management system can be found in AS/NZS ISO 9001 and AS/NZS ISO 9004.

B.5 Other means of assessment

If the above methods are considered inappropriate, determination of compliance with the requirements of this Standard may be assessed from the results of testing coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform to the full requirements of the Standard.

Appendix C Special sleepers and fastenings (Informative)

C.1 General

Special sleepers and fastenings should conform to the requirements set out in Section 2 of this Standard and with the additional requirements given in this Appendix. Special sleeper types include the following:

(a) Dual gauge sleepers.

(b) Turnout bearers.

(c) Sleepers with additional rails (other than dual gauge sleepers).

C.2 Special sleeper types

C.2.1 Dual gauge sleepers

Dual gauge sleepers enable two separate groups of rolling stock, each with its own identifiable wheel gauge, to run on the same track. Each sleeper has fastenings to accommodate three rails (see Figure C1).

C.2.2 Turnout bearers

A turnout consists of a number of bearers of varying lengths. Rails are readily secured to the bearers at predetermined fastening locations to enable one track to be connected to an adjacent track.

Where parallel tracks are to be connected, a crossover consisting of two turnouts of the same orientation (either both left-handed or both right-handed) is used. A crossover can have discontinuous bearers midway along the connection or it can have bearers that are continuous through both parallel tracks.

A turnout normally has zero cant and typically consists of about 70 individual bearers each varying from its neighbouring bearers in length and in fastening locations. Transition sleepers with varying cants could be required to connect turnouts to canted track.

C.2.3 Sleepers with additional rails

C.2.3.1 General

There are two types of sleepers that require additional rails that are not traversed by the wheels of railway vehicles. They are guardrail sleepers and splay rail sleepers.

C.2.3.2 Guardrail sleepers

A guardrail sleeper has provision for fastening parallel rails in the centre of the sleeper (see Figure C2) in a manner so that derailed wheels are prevented from moving further than the edge of the fastened guardrail. This system can prevent or minimize damage to a bridge structure.

C.2.3.3 Splay rail sleepers

A set of splay rail sleepers consists of a number of sleepers of variable lengths that facilitate connection of special rails to guide derailed wheels into the guardrails provided on sleepers. A typical layout of guardrail and splay rail sleepers is shown in Figure C3.

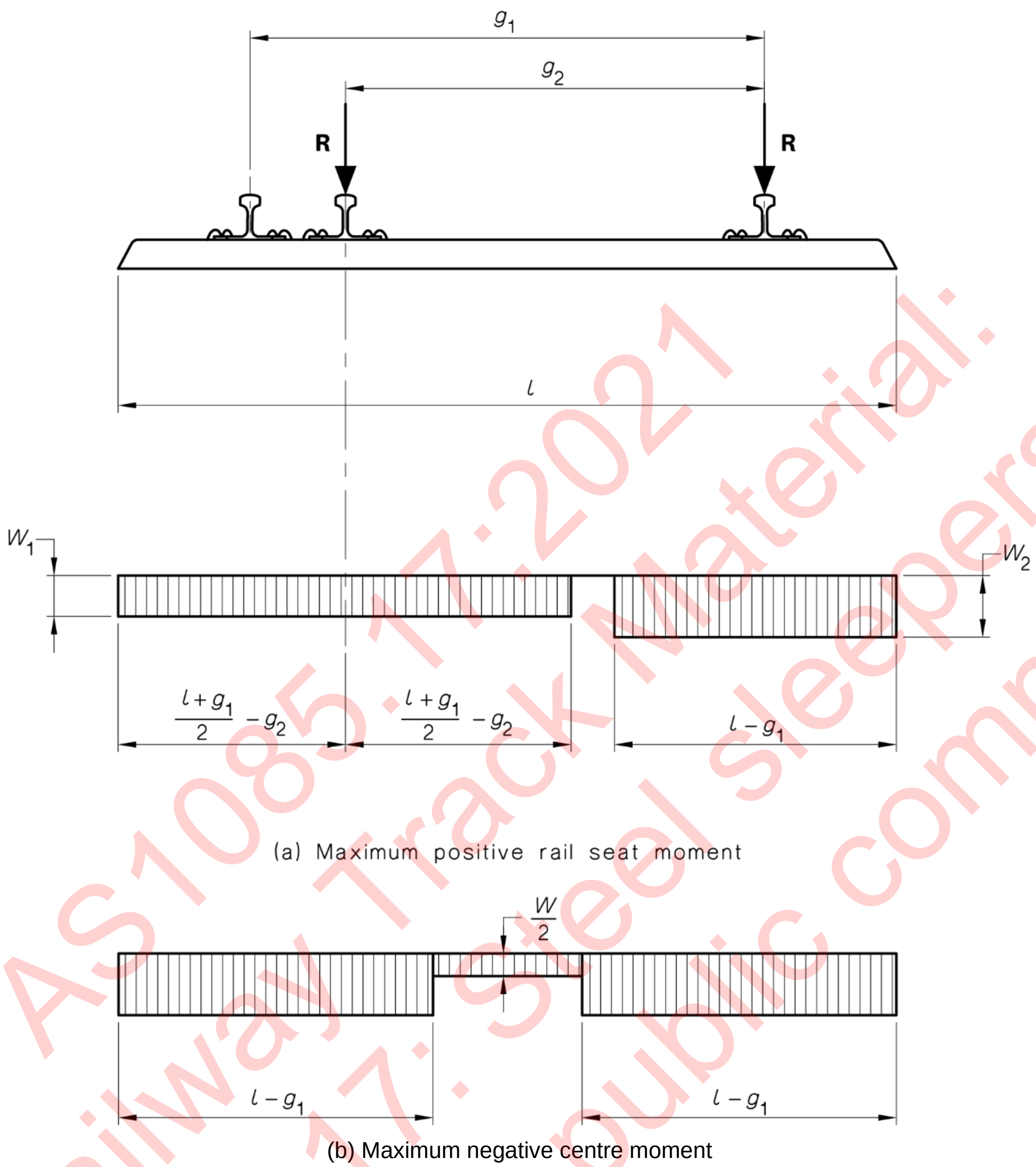


Figure C1 Pressure distribution for dual gauge sleeper

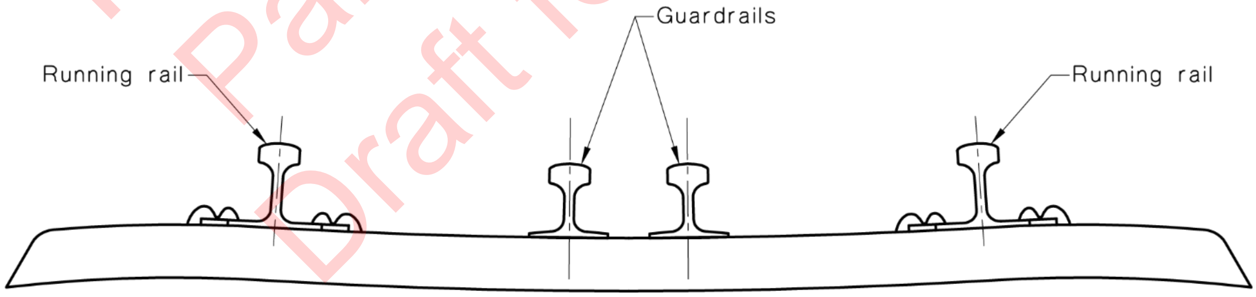


Figure C2 Typical guardrail sleeper

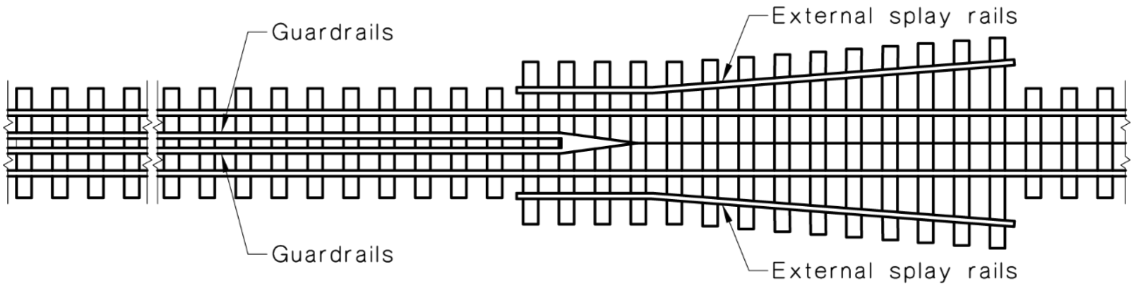


Figure C3 Typical splay rails and guardrails

C.3 Manufacturing details

Because of the specialized nature of turnout bearers, splay rail sleepers and guardrail sleepers, the manufacturing procedure can be different from that for main line sleepers; however, it is common practice to modify main line sleepers to produce guardrail sleepers.

As each bearer or sleeper forms part of a set-in turnouts or splay rail sets, it should be clearly branded to indicate its position and orientation in the set.

A trial assembly should be carried out on the first set of bearers or sleepers with the rails, plates and fastenings specified by the RIM to ensure that all components fit together as intended and that basic track parameters such as gauge comply with the RIM's requirements and the specified tolerances.

C.4 Loadings and design

C.4.1 Dual gauge sleepers

Examples of the load distributions for dual gauge sleepers are shown in Figure C1(a) and C1(b). These examples apply to dual gauge track with the narrower gauge greater than or equal to 1435 mm.

From the load distributions shown in Figure C1(a) and C1(b), the design moment equations for dual gauge with a narrower gauge of 1435 mm or greater are as follows:

Equation C4-1

$$M_{R+} = 0.25R\left(\frac{l + g_1}{2} - g_2\right)$$

Equation C4-2

$$M_{c}- = 0.5\left[Rg_1 - \left(Wg_1(l - g_1)\right) - \frac{W(2g_1 - l)^2}{8}\right]$$

Equation C4-3

$$M_{c+} = 0.05R(l - g_2)$$

Where

Equation C4-4

$$W = \frac{4R}{3l - 2g_1}$$

For dual gauge track with a track gauge less than 1435 mm, allowance should be made for variations in the load distribution and design moment equations similar to those detailed for single gauge track in section 4.3.

C.4.2 Turnouts and crossovers

A turnout bearer is a member of a complex grillage system in which rails are connected by elastic fastenings to bearers that are supported on a non-rigid foundation. This affects the loadings for such bearers.

The following guidelines may be used for making an assessment of forces and moments where more detailed mathematical methods are not available.

(a) Distribution of axle load: The same method as used for standard sleepers may be adopted.

(b) Impact factor: In order to allow for quasistatic loading, the bearer should be designed as specified for standard sleepers.

(c) Centrifugal force: The effects of centrifugal force should be allowed for on the curved pair of rails.

(d) Other forces: Forces and moments from points motors and other equipment should be allowed for where appropriate.

(e) Load distribution: The method of distribution of the forces from rails and crossings should be specified by the RIM.

(f) Support conditions: Generally, it may be assumed that the bearer will be supported over its whole length by tamped ballast. Exceptions can occur such as where a bearer extends beyond the ballast shoulder to carry points-operating equipment. Moments and shears should be calculated assuming that the ballast and subgrade behave as an elastic foundation.
The foundation modulus may be calculated in accordance with the recommendations given in A review of track design procedures, Volumes 1 and 2, Australasian Railways Association, 1991.
In very poor ground or formation, consideration should be given to improving the subgrade in the area of the turnout to reduce the magnitude of the induced bending moments. Field testing is also used to confirm assumptions.

(g) Shear forces and bending moments: The values obtained from the above assumptions should be used to produce design bending moments and shear force envelopes for the bearer; however, in some cases this analysis can yield small values of negative (hogging) bending moment.

C.4.3 Sleepers with additional rails (other than dual gauge sleepers)

Guardrail sleepers and splay rail sleepers are both likely to suffer impact from the wheels of derailed vehicles.

Forces arising from this impact are very difficult to quantify. It is suggested that sleepers be designed for loads from derailed wheels equivalent to at least twice the static wheel load, but designers may use their own judgement in this matter.

Sleepers with additional rails should be designed on the same basis as the turnout sleepers but with allowance for forces from derailed vehicles also acting on the guardrails and splay rails. Ballast under these sleepers should be assumed to be uniformly tamped and the design sleeper moments calculated accordingly.

C.5 Fastenings

Fastenings discussed in this Appendix include elastic resilient fastenings as well as cast iron or formed steel hook-in shoulders or bolts to secure plates.

Where plates are specified to hold the rails, the methods of attaching plates to sleepers and rails to plates should be specified.

Insulation, where required should conform to the requirements of Section 2 of this Standard.

Plates may be secured by two or four bolt systems. Bolts pass through the top of the sleeper and engage nuts welded underneath.

C.6 Testing

C.6.1 General

Testing should be carried out in accordance with the provisions of Section 2.

C.6.2 Additional fastening tests

In addition to fastening types covered in Section 2.4 of this Standard, sleepers covered by this Appendix can have fastenings of the types described in Paragraph C5.

Additional tests could be required by the RIM (see also AS 1085.19).

NOTE: Evidence of adequate performance may be negotiated between the supplier and the RIM.

Appendix D Sleeper shape (Informative)

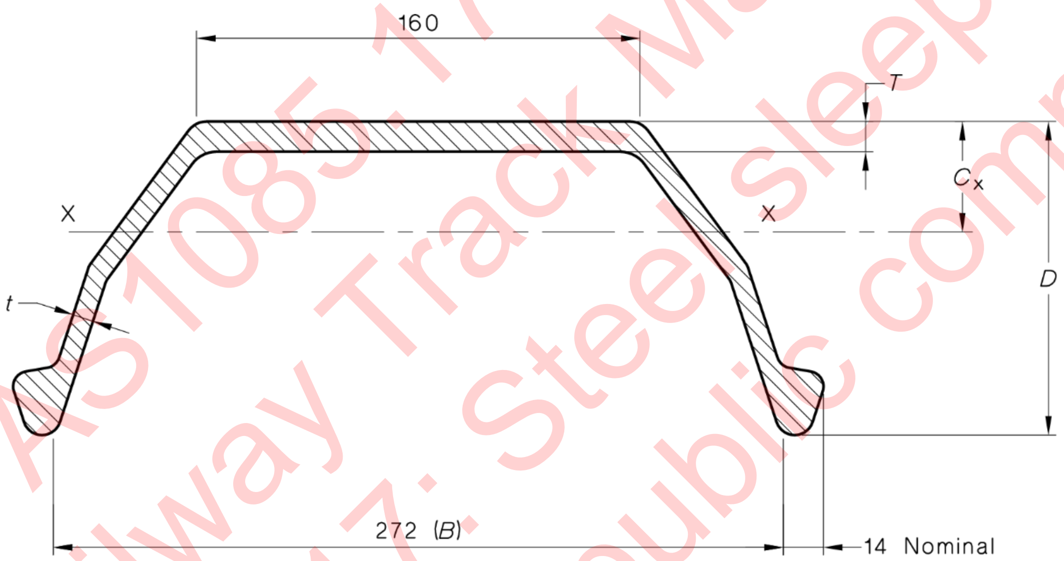
D.1 General

This Appendix sets out typical sleeper cross-sections in Figures D1 and D2 and end details in Paragraph D2.

D.2 End details

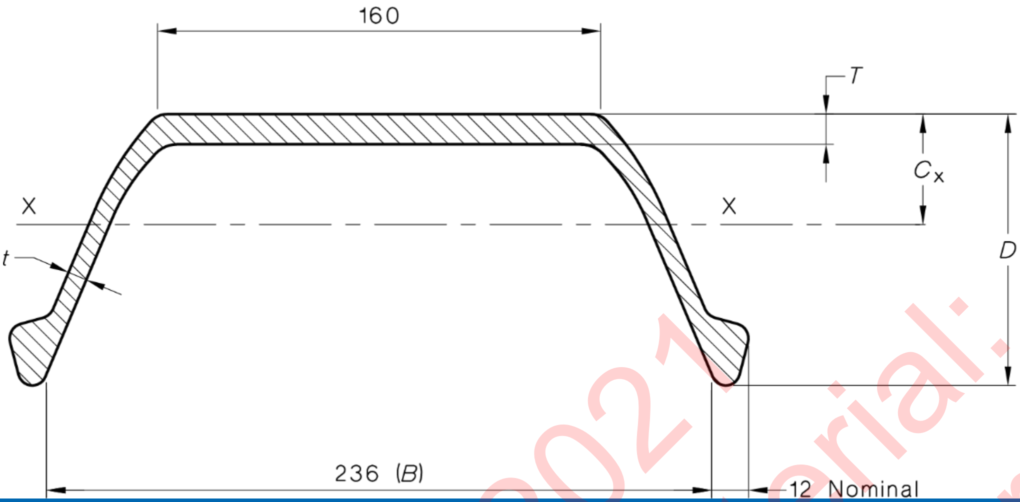
Ends should be folded down (spaded) to a depth not less than the depth of the sleeper. Each spade angle along the sleeper centreline should be not greater than 30 degrees from the vertical.

NOTE: End spading details will typically govern the lateral stability performance of the sleeper and effect ballast containment and vibration performance.



Heavy duty designation	Nominal mass per unit length	Nominal area of cross-section	Nominal thickness		Nominal depth	Nominal geometric properties of section		
			T	t	D	$I_{s(new)}$	Z_{toe}	C_x
mm	kg/m	mm^2	mm	mm	mm	$10^6 mm^4$	$10^3 mm^3$	mm
W9	28.1	2581	9.0	6.0	117	5.68	74.14	40.33
W10	30.5	3884	10.0	6.3	118	6.12	78.52	40.10
W12	35.3	4490	12.0	7.0	120	6.98	87.27	39.96
W14	40.0	5098	14.0	7.7	122	7.86	95.99	40.12

Figure D1 heavy duty steel sleeper details



General duty designation	Nominal mass per unit length	Nominal area of cross-section	Nominal thickness		Nominal depth	Nominal geometric properties of section		
			T	T	D	$I_{s(new)}$	Z_{toe}	C_x
mm	kg/m	mm^2	mm	mm	mm	$10^6 mm^4$	$10^3 mm^3$	mm
M6.5	19.5	2478	6.7	5.1	97.2	2.73	41.88	32.06
M7.5	21.1	2687	7.5	5.4	98.0	2.94	44.40	31.71
M8.5	23.1	2948	8.5	5.7	99.0	3.22	47.61	31.43
M10	26.2	3341	10.0	6.2	100.5	3.64	52.56	31.26

Figure D2 General duty steel sleeper details

Appendix E Track panel assembly test (Normative)

E.1 Scope

This Appendix sets out the method of testing six assembled sleepers and their components by assembling them together with rails to ensure that basic track parameters such as track gauge and cant are met. Assembly procedures can also be evaluated using this test.

E.2 Apparatus

The apparatus necessary for the test is given below.

(a) 6 steel sleepers.

(b) 12 sets of rail fastening assemblies including pads.

(c) 2 rails, each 4 m long.

E.3 Procedure

The procedure shall be as follows.

(a) Assemble a track panel consisting of two rails of the appropriate rail profile and of suitable length and six sleepers with the fastening assemblies and any other components to be supplied. All components used to assemble the track panel shall be shown to be of nominal dimensions except the sleepers being tested.

(b) Check the assembly to ensure that all components of the assembly fit together as intended and that basic track parameters such as track gauge are met.

(c) Compare the assembled track panel against the design and ensure that the requirements of the RIM are met.

(d) Measure the track gauge achieved by the rail (see Figure F3).

E.4 Report

The following shall be reported.

(a) Any parameters that fail to comply with the design.

(b) The measured track gauge.

(c) The number of this Australian Standard, i.e., AS 1085.17.

Appendix F Rail seat assembly repeated load test (Normative)

F.1 Scope

This Appendix sets out the method of conducting the rail seat assembly repeated load test.

F.2 Apparatus

The following apparatus is required.

(a) A length of the specified rail section (for lateral-to-vertical force ratios above 0.6, part or all of the rail head and part of the web could require removal to prevent rail rollover).

(b) A segment of the sleeper including a rail seat with dimensions as shown in Figure F1.

(c) A set of the appropriate rail fastening components including shoulders, clips, insulation and spacers as required.

(d) Crack detection kit.

(e) Wire brush.

(f) Test rig as shown in Figure F2.

F.3 Procedure

The procedure shall be as follows.

(a) Wire brush the piece of rail section and sleeper to remove all loose mill scale and foreign matter.

(b) Inspect the sleeper to ensure that it is free of any original cracking by checking the sleeper, its shoulder and rail seat regions for cracking by using suitable crack detection techniques, such as dye penetrant or magnetic particle techniques in accordance with AS 1171.

(c) Assemble all new components.

(d) Set up the test assembly in the test rig.

(e) Apply a cyclic downward load over a range equal to the resultant of the specified lateral and vertical loads. No uplift loading is required.

(f) Load the sleeper for a minimum total of three million cycles (3 000 000) at a maximum frequency of 10 Hz.

NOTE: One cycle consists of a downward and upward loading.

(g) Carry out periodic inspection of the sleeper every 500 000 cycles as specified in Step (b).

(h) Examine fastening components including pads for cracking and other damage.

F.4 Report

The following shall be reported:

(a) Identification of the sleeper and its components (e.g., fastening and hole spacing where applicable).

(b) Loading and lateral-to-vertical force ratio used for the test.

(c) Fatigue cracking or other failure of any component (e.g. rail insulation pads) and when occurred.

NOTE:

1. Undue wear of the insulation pad can result in loosening of the fastening due to changes in the operating range.
2. Fretting fatigue is commonly seen when testing non-insulated sleepers. It is believed that this is a result of the dry and highly repetitive nature of the laboratory test. Whilst such failures need to be reported, the RIM may choose to ignore such failure modes.

   a. Any additional information as required by the RIM.
   b. The apparatus used.
   c. The name of the operator.
   d. The number of cycles at which failure occurred.
   e. The number of this Australian Standard, i.e., AS 1085.17.

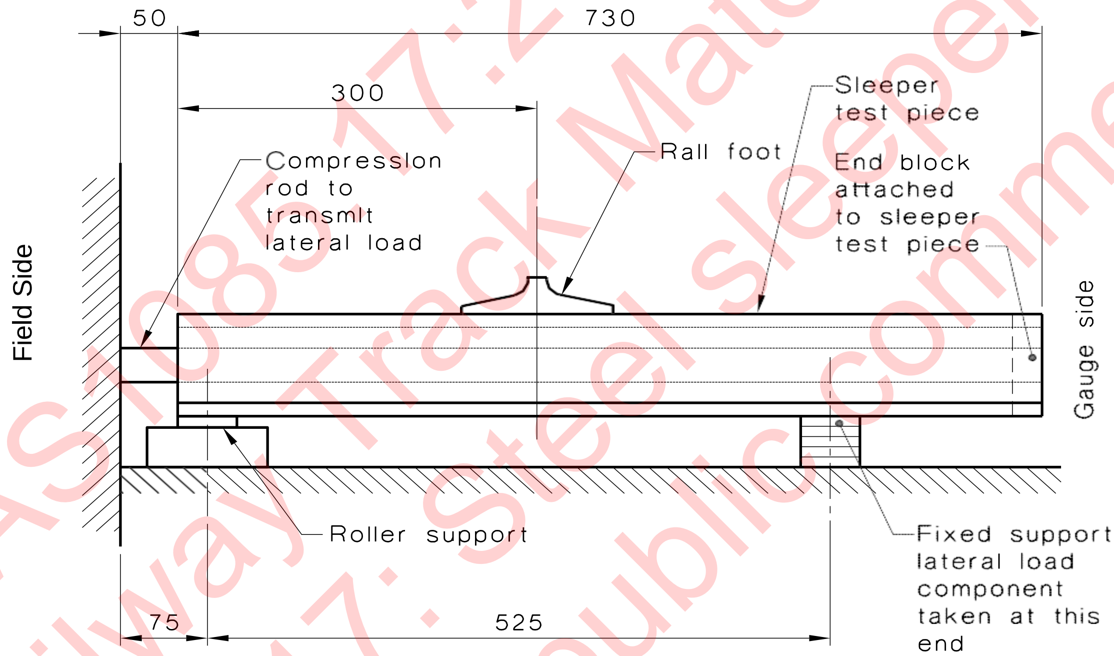


Figure F1 Seat repeated load test sleeper test piece set-up

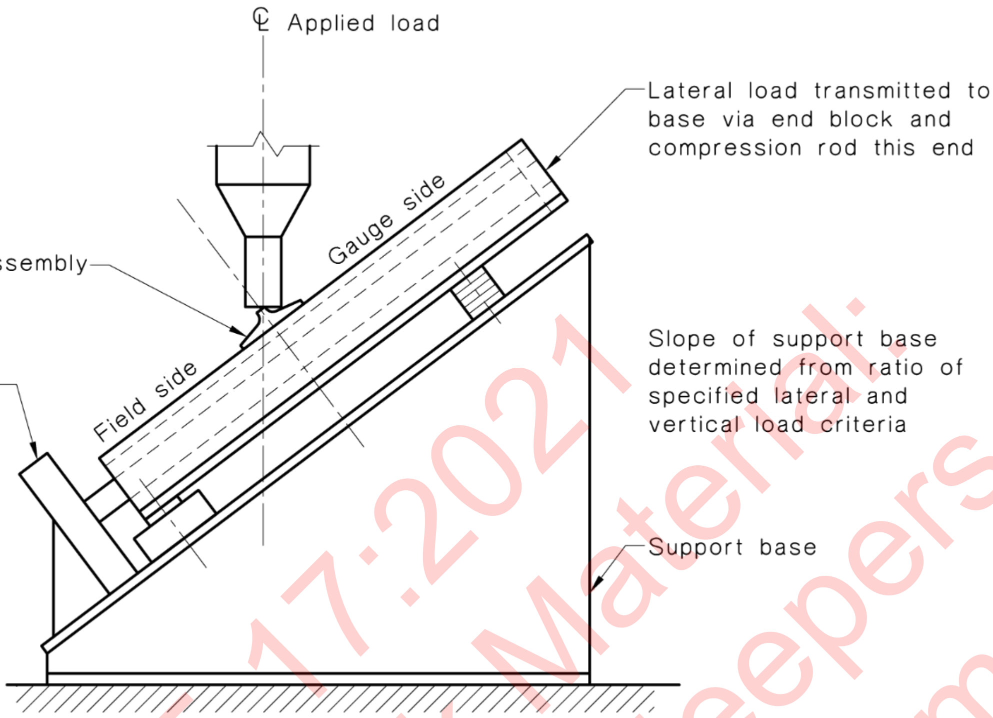


Figure F2 Rail seat repeated load test rig assembly

Appendix G Lateral resistance test (Normative)

G.1 Scope

This Appendix sets out a method for determining the lateral resistance of steel sleeper panels in ballast.

G.2 Apparatus

The apparatus necessary for the test is given below.

(a) Three steel sleepers.

Note: Alternative number of sleepers may be used by agreement with the RIM.

(b) Six sets of rail fastening assemblies including pads if required.

(c) Ballast bed (with ballast generally in accordance with AS 2758.7).

(d) Two lengths of rail, 1.5 m long each.

(e) Three reference sleepers, including fasteners to be used for comparison.

NOTE: The reference sleepers should have a known satisfactory performance in track. They are tested in the same rig for comparative purposes. A sleeper type that the RIM has already installed, and is therefore familiar with, can be appropriate.

(f) A displacement transducer.

G.3 Procedure

The procedure shall be as follows.

(a) Form the panel comprising sleepers, rails and fasteners in the ballast bed such that a quasi-static vertical loading and lateral loading can be applied to the system through the rail.

(b) Apply a cyclic vertical loading at a suitable load to provide consolidation of the sleeper panel in the ballast. The loading shall be applied over the length of each rail.

(c) Following consolidation of the sleeper panel, form a ballast shoulder, not exceeding 300 mm, level with the sleeper. Apply a lateral load by means of two chains fastened to the web at each end of one of the rails. Measure lateral deflection of the panel on the adjacent rail by means of a displacement transducer mounted from a fixed reference to the rail head.

(d) Perform the lateral resistance test by increasing the load until there is a panel displacement of minimum 50 mm. The load deflection curve for the panel shall be recorded on an X Y recorder.

(e) Repeat Steps (a) to (d) on the panel of reference sleepers.

G.4 Report

The following shall be reported.

(a) For both the steel sleeper panel being tested and the reference panel, the lateral location when the test load reaches:

i. 25 % of the maximum load;

ii. 50 % of the maximum load;

iii. 75 % of the maximum load;

iv. 90 % of the maximum load; and

v. the maximum load.

(b) The number of this Australian Standard, i.e., AS 1085.17.

Appendix H Sleeper spacing (Informative)

This Appendix gives a method for determining the sleeper spacing beyond which bending capacity is exceeded.

The maximum sleeper spacing (based on sleeper bending) may be calculated by an iterative process using the following equation:

Equation H-1

$$s = \frac{2\sigma_{all}\, Z_{toe}\, 10^{-6}}{F_1\, P_{dV}\, \beta\, C_{MB(Max)}}$$

Where

s	= sleeper spacing, in metres
σ_{all}	= allowable sleeper bending stress, in megapascals
F_1	= *factor applied to the rail seat load to incorporate the effects of the interaction of adjacent wheels to the design wheel load*
P_{dV}	= quasi-static vertical wheel load, in kilonewtons
β	= t rack stiffness parameter, in metres -1
$C_{MB(Max)}$	= maximum sleeper bending moment coefficient, in metres

This relationship, based on the BOEF theory and equations described in Clause 4.5.4, is derived by equating the design bending stress to the allowable stress in tension and compression. Where alternative formulations are used, the above equation has to be duly modified.

NOTE: Sleeper spacing will have a major effect on the fatigue performance of the sleeper.

Appendix I Bibliography

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

(a) AS1085: Railway track material series.

(b) AS 2758: Aggregates and rock for engineering proposes.

(c) AS/ANZ 1100: Technical drawing.

(d) HB18: Guidelines.

(e) HB18.28: Guide 28 - General rules for a model third-party certification scheme for products.

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