

Australian Standard[®]

Railway track material

Part 14: Prestressed concrete sleepers



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- Australasian Railway Association
- Australian Chamber of Commerce and Industry
- Australian Industry Group
- Bureau of Steel Manufacturers of Australia
- Department of Transport, Vic.
- Monash University
- Permanent Way Institute
- Queensland Railways
- Rail Track Association Australia
- Railway Technical Society of Australasia
-

Additional Interests:

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-

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Australian Standard[®]

Railway track material

Part 14: Prestressed concrete sleepers

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PREFACE

This Standard was prepared by the Standards Australia Committee CE-002, Railway Track Materials to supersede AS 1085.14—2003, *Railway track material*, Part 14: *Prestressed concrete sleepers*.

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 prestressed concrete sleepers for use in railway track.

This Standard does not cover the use of materials complying with superseded editions of the AS 1085 series or the use of existing or re-used materials. Users should satisfy themselves that such materials are satisfactory for the application intended.

This Standard is Part 14 of the AS 1085 series (Railway track material), which comprises the following parts:

- Part 1: Steel rails
- Part 2: Fishplates
- Part 3: Sleeper plates
- Part 4: Fishbolts and nuts
- Part 7: Spring washers
- Part 8: Dogspikes
- Part 10: Rail anchors
- Part 12: Insulated joint assemblies
- Part 13: Spring fastening spikes for sleeper plates
- Part 14: Prestressed concrete sleepers (this Standard)
- Part 17: Steel sleepers
- Part 18: Screw spikes and threaded inserts
- Part 19: Resilient fastening systems
- Part 20: Welding of steel rail

Of interest to users of this series are the following:

AS 3818.2, *Timber—Heavy structural products—Visually graded*, Part 2: *Railway track timbers* (used in conjunction with Part 1: *General requirements*).

AS 2758.7, *Aggregates and rock for engineering purposes*, Part 7: *Railway ballast*.

The Rail Industry Safety and Standards Board (RISSB) is responsible for the development and management of other rail industry standards, rules, codes of practice and guidelines, all of which have national application. 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.

This revision includes the following changes to the previous edition:

- (a) It specifies the sleeper performance required.
- (b) The scope has been broadened to include high speeds and track other than main line track.

- (c) New factors have been introduced to deal with impact and dynamic effects and system specific related decisions by purchasers.
- (d) Tensile strength for calculation of test moments has been changed.
- (f) The requirement to design for centre negative bending of 14 kNm has been deleted.
- (g) Tolerances and allowable time to undertake tests have been amended.
- (h) The track assembly test to be undertaken with the rails in the centre of the rail seat.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

Notes to the text contain information and guidance and are not considered to be an integral part of the Standard.

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.

In the Standard where the word ‘shall’ is used a mandatory requirement is implied and where the word ‘should’ is used the statement is advisory.

This document includes commentary on some of the Clauses of the Standard. The commentary directly follows the relevant clause is designated by ‘C’ preceding the Clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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STANDARDS AUSTRALIA

Australian Standard
Railway track material

Part 14: Prestressed concrete sleepers

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the performance requirements and gives design and testing methods for new prestressed concrete sleepers for use in railway track with continuously welded rail. It provides methods for determining loads on sleepers and refers to AS 1085.19 for requirements for resilient fastening systems.

This Standard does not cover the following:

- (a) Design of post-tensioned concrete sleepers.
- (b) Design of duo block concrete sleepers.
- (c) Sleepers for use interspersed with other types of sleeper (e.g. timber or steel).
- (d) Techniques and equipment for the manufacture of concrete sleepers.

This Standard is based on knowledge and experience of the following conditions of use:

- (i) Train speeds less than 200 km/h.
- (ii) Sleeper spacing in the range 500 mm to 750 mm.
- (iii) Axle loads less than 50 tonnes.

Where parameters outside these limits are encountered, the general principles given in this Standard may be applied. However, the criteria in the Standard may not be sufficient and consideration should be taken of the intended conditions of use and the factors and methods used for design adjusted accordingly.

Additional requirements for the design and manufacture of special sleepers and fastenings are given in Appendix C.

NOTES:

- 1 Guidance to purchasers on information needing to be supplied at the time of calling for tenders or quotations and testing of new products is given in Appendix A.
- 2 Information on the means for determining compliance with this Standard is given in Appendix B.
- 3 Information on dynamic effects is given in Appendix D.

CI.1 *The scope of this Standard has been broadened to cover track situations other than main line track. The changes to the determination of loads by using alternative k_s values can include the use of the Eisenmann loading distribution method or other appropriate methods, which allows a wider range of speeds and track conditions to be taken into account.*

1.2 PURPOSE AND CONTEXT OF USE

1.2.1 Function

Sleepers are support members that are part of the structure of railway track. 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. They provide a platform for the fastening systems that hold the rails to the sleeper.

1.2.2 Action

In supporting and guiding railways vehicles, the track structure must restrain repeated lateral, vertical and longitudinal forces. As elements of the track structure, individual sleepers receive loads from the rails or fastenings and in turn transmit loads to the ballast, formation and subgrade. Consequently, the design of a sleeper affects and is affected by characteristics of other components of the track structure.

Sleepers are subject to—

- (a) loads imposed by the passage of rollingstock on the rails and during maintenance;
- (b) loads generated by thermal effects on the rail and by ballast movement;
- (c) impact; and
- (d) fatigue, wear, damage and corrosion.

CI.2 Purpose and context of use, defines the performance aims for the sleepers. The remaining Clauses of the Standard set out how compliance with these performance aims can be achieved.

The critical outcome of sleeper design is the life to be expected in track (see Clause 2.5). Expected life is not directly related to the expected load. For example, a single event such as a derailed rollingstock bogie may damage large numbers of sleepers. A serious wheel flat or wheel burn will reduce the sleeper life.

Cracking and significant damage to sleepers will not necessarily cause closure of the track or require that sleepers be replaced. A program is usually established for inspection and eventual replacement before deterioration reaches the unsafe operational limit.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 1012 Methods of testing concrete
- 1012.11 Method 11: Determination of the modulus of rupture
- 1085 Railway track material
- 1085.1 Part 1: Steel rails
- 1085.19 Part 19: Resilient fastening assemblies
- 1199 Sampling procedures for inspection by attributes
- 1199.0 Part 0: Introduction to the ISO 2859 attribute sampling system
- 1199.1 Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
- 1379 Specification and supply of concrete
- 1478 Chemical admixtures for concrete, mortar and grout
- 1478.1 Part 1: Admixtures for concrete

AS

- 2758 Aggregates and rock for engineering purposes
- 2758.1 Part 1: Concrete aggregates
- 2758.7 Part 7: Railway ballast
- 3582 Supplementary cementitious materials for use with portland and blended cement
- 3582.1 Part 1: Fly ash
- 3582.2 Part 2: Slag—Ground granulated iron blast-furnace
- 3600 Concrete structures
- 3610 Formwork for concrete
- 3610.1 Part 1: Documentation and surface finish
- 3972 General purpose and blended cements
- HB 18.28 Conformity assessment—Guidance on a model third-party certification system for products
- HB 79 Alkali aggregate reaction—Guidelines on minimising the risk of damage to concrete structures in Australia

AS/NZS

- 3582 Supplementary cementitious materials for use with portland cement and blended cement
- 3582.3 Part 3: Amorphous silica
- 4672 Steel prestressing materials
- 4672.1 Part 1: General requirements
- 4672.2 Part 2: Testing requirements

AS/NZS ISO

- 9001 Quality management systems—Requirements
- 9004 Managing for the sustained success of an organization—A quality management approach

Australasian Railways Association

Review of Track Design Procedures. Volumes 1 and 2, 1991.
(ISBN 0 909582 01 7)

HETENYI, M. *Beams on elastic foundation*. The University of Michigan Press: Ann Arbor, 1967.

NOTE: See Appendix D for additional referenced documents.

1.4 DEFINITIONS

For the purpose of this Standard, the definitions given below apply. Figure 1 shows principle dimensions as symbols, which are defined in Clause 1.5.

1.4.1 Bearer

A transverse concrete unit supporting rails.

1.4.2 Bed of sleepers

All the sleepers that are stressed and cast together in the one concreting operation, and then cured in the same batch.

1.4.3 Cant

The inward tilt of the rails with respect to the sleeper.

1.4.4 Construction joints

A joint, including a joint between precast segments, that is located in a part of a structure for convenience of construction and made so that the load carrying capacity and serviceability of the structure will be unimpaired by the inclusion of the joint.

1.4.5 Fastening

Component or group of components of a sleeper system that fastens the rail to the sleeper.

1.4.6 Gauge corner

Transition surface separating the rail running surface from the rail side.

1.4.7 Gauge point

The point on the gauge side of the rail head 16 mm beneath the top surface, at the centre-line of the rail at which track gauge is measured.

NOTE: Refer to Appendix D in AS 1085.1 for rail profiles which show the gauge point of the rails.

1.4.8 Insert

One or more of the fastening components that is cast into the sleeper at the time of manufacture.

1.4.9 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.

1.4.10 Line of sleepers

All the sleepers in a bed that share the same prestressing tendons.

1.4.11 Negative bending

Bending of a sleeper by application of a load that produces tension in the top surface of the sleeper.

1.4.12 Positive bending

Bending of a sleeper by application of a load that produces tension in the bottom surface of the sleeper.

1.4.13 Prestressed concrete sleeper

A sleeper utilizing concrete and prestressing tendons to resist flexure.

1.4.14 Prestressing tendon

A strand or wire within the sleeper that, under tension, compresses the concrete.

1.4.15 Proof testing (control testing)

Testing of samples taken from routine production.

1.4.16 Rail pad

A part of the fastening that fits between the rail and the sleeper and acts to absorb impact, isolate electrically or protect components against abrasion.

1.4.17 Rail seat

The area on the top of the sleeper on which the rail sits extending between the field and gauge shoulders.

1.4.18 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 may 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.

1.4.19 Soffit

Underside of the sleeper.

1.4.20 Structural cracking

In sleeper tests, hair-line cracking that originates at the tension face of the concrete sleeper, that extends up both sides of the sleeper to the nearest outside edge of the reinforcement or tendon, and that can be visually detected using an illuminated 5× magnifying glass with no other visual assistance from chemical or other methods.

1.4.21 Track gauge (*G*)

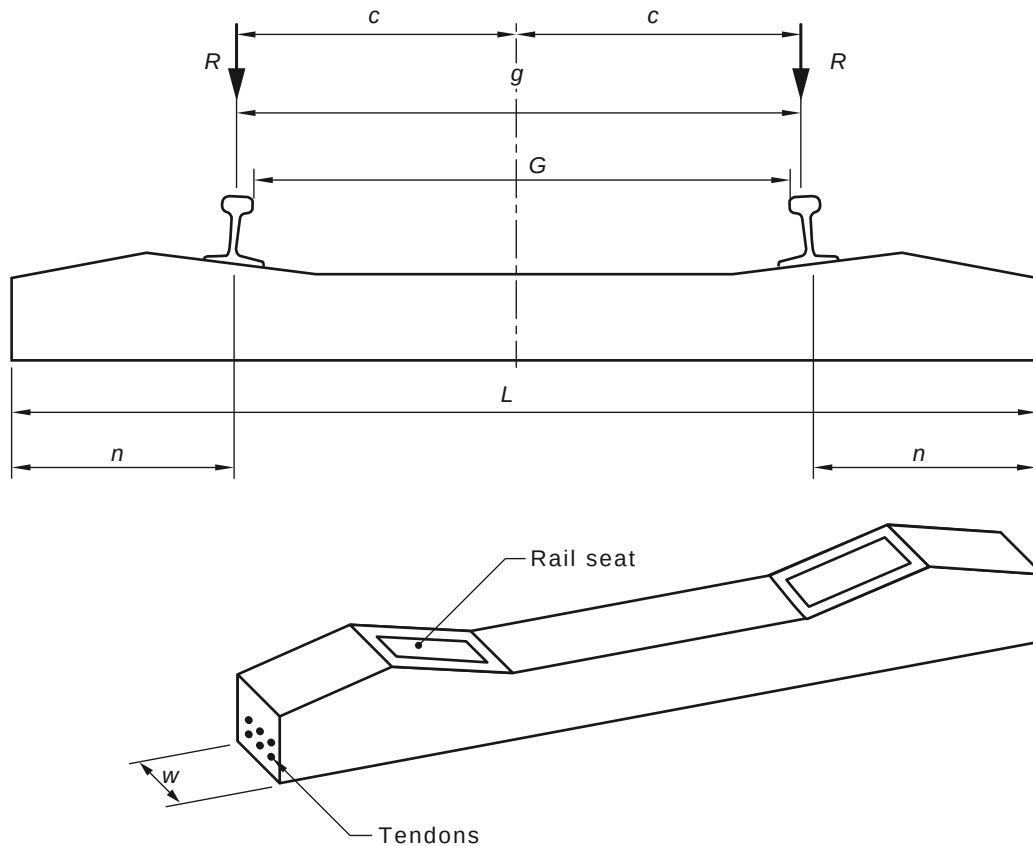
Distance between the gauge points of the rails.

1.4.22 Type testing

Testing of samples from initial production to establish the performance of the specific design and the manufacturing methods.

1.4.23 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.



NOTE: The definitions of symbols in this Figure are given in Clause 1.5.

FIGURE 1 SCHEMATIC REPRESENTATION OF SLEEPER SHOWING PRINCIPAL DIMENSIONS

1.5 NOTATION

Except where specifically noted, this Standard uses the SI units of kilograms, metres, seconds, pascals, newtons, hertz and tonnes (kg, m, s, Pa, N, Hz, t). For the purposes of this Standard, the term 'tonnage' indicates metric tonnes and not tons ('short' or 'long').

For the purposes of this Standard, the following notation applies:

- A_t = transformed area of nominal section being tested, in millimetres squared
- a = length of pressure distribution (ballast support) beneath each rail seat, in metres
- $C_{BM(max.)}$ = maximum sleeper bending moment coefficient, in metres
- $C_{BM(O)}$ = bending moment coefficient at the sleeper midpoint, in metres
- $C_{BM(n)}$ = bending moment coefficient at the field side adjacent to the rail foot
- $C_{BM(x)}$ = sleeper bending moment coefficient covering the region to the field side of the rail seat, in metres
- c = dimension of sleeper from the centre-line of the rail seat to the centre of the sleeper, in metres (see Figure 1)
- DF = load distribution factor, in percent
- d = depth of wheel flat (see Paragraph D5)
- d_{rs} = distance from the rail restraining face of the outside shoulder to the rail seat centre-line, in metres

E	= Young's modulus of rail steel, in megapascals
E_s	= Young's modulus of sleeper material, in megapascals
e	= eccentricity of the centroid of prestress at the section being tested, in millimetres (see Clause 2.4)
F_p	= insert pull-out test load (specified value), in kilonewtons
f'_c	= the characteristic 28-day compressive strength of concrete specified by the design, in megapascals
f_{cp}	= the minimum compressive strength of concrete specified by the design at transfer, in megapascals
f_p	= the tensile strength of the prestressing steel, in megapascals
f'_t	= flexural tensile strength of the concrete in the extreme fibre at testing, in megapascals
G	= track gauge, in millimetres
g	= distance between rail centres measured at the top of the rail, in metres (see Figure 1)
g_{sh}	= distance between the rail restraining faces of the outside shoulders of the assembly, in metres
g_1	= distance between rail centres for larger dimension of dual gauge measured at the top of the rail, in metres (see Figure C1)
g_2	= distance between rail centres for smaller dimension of dual gauge measured at the top of the rail, in metres
I_s	= second moment of area for the sleeper section, in millimetres to the fourth power
I_x	= rail second moment area about the horizontal neutral axis, in millimetres of the power of four
k	= a value used to calculate bending (used in the empirical method), see Clause 4.2 and Paragraph C4
k_s	= service factor
L	= length of the sleeper at the base
L_w	= length of wheel flat (see Paragraph D5)
l	= sleeper length at centre-line, in metres
M_d	= design sleeper bending moment, in kilonewton metres
M_{C+}	= design positive bending moment at the mid-span (centre) of the sleeper, in kilonewton metres
M_{C-}	= design negative bending moment at the mid-span (centre) of the sleeper, in kilonewton metres
M_{R+}	= design positive moment at the rail seat, in kilonewton metres
M_{R-}	= design negative moment at the rail seat, in kilonewton metres
M^{cr}	= cracking moment (calculated) at the section being tested, in kilonewton metres
M^{cr}_{C+}	= positive cracking moment (calculated) at the mid-span (centre) of the sleeper, in kilonewton metres

M_{C-}^{cr}	= negative cracking moment (calculated) at the mid-span (centre) of the sleeper, in kilonewton metres
M_{R+}^{cr}	= positive cracking moment (calculated) at the rail seat, in kilonewton metres
M_{R-}^{cr}	= negative cracking moment (calculated) at the rail seat, in kilonewton metres
n	= dimension from end (on centre-line of bottom edge of end) to the centre-line of rail seat, in metres
P	= calculated pre-stress force at the time of test, in newtons
P_1	= test load required to produce the required rail seat negative moment (rail seat vertical load test), in kilonewtons
P_2	= test load required to produce the required rail seat positive moment (rail seat vertical load test), in kilonewtons
P_3	= test load required to produce the required negative centre moment (centre negative bending moment test), in kilonewtons
P_4	= test load required to produce the required positive centre moment (centre positive bending moment test), in kilonewtons
P_{dV}	= vertical design wheel load, in kilonewtons
P_{ab}	= design sleeper to ballast bearing pressure, in kilopascals
Q	= maximum static wheel load, in kilonewtons
R	= design rail seat load, in kilonewtons
R_V	= vertical design rail seat load, in kilonewtons
r	= wheel radius (see Paragraph D5)
s	= sleeper spacing, in metres
T	= test torque for insert torque test, in newton metres
t_c	= confidence limit (see Clause 3.3.5)
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	= maximum load per unit length of sleeper, in kilonewtons per metre (see Figure C1)
W_1	= maximum load per unit length of sleeper for wider gauge of dual gauge, in kilonewtons per metre
W_2	= maximum load per unit length of sleeper for narrower gauge of dual gauge, in kilonewtons per metre
w	= average width of sleeper soffit supported by ballast, in millimetres
x	= distance from the sleeper end, in metres
x_ℓ	= distance (absolute) between load source and point of analysis, in metres
y	= vertical track deflection, in metres
y_i	= 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 millimetres

Z = the transformed section modulus of the nominal uncracked section referred to the extreme fibre at which cracking occurs, in millimetres to the third power

β = track stiffness parameter calculated from the EI of the rail, in metres to the minus one, as follows (note this is different to ' λ ' which is used in the structural analysis Section):

$$\left(\frac{U}{4EI_x} \right)^{0.25} \times 10^3$$

λ = sleeper stiffness parameter calculated from the EI of the sleeper, in metres to the minus one, as follows:

$$\left(\frac{U_s}{4E_s I_s} \right)^{0.25} \times 10^3$$

σ_{cont} = contact pressure at the sleeper/ballast interface (see Clause 4.3.2), in kilopascals

SECTION 2 PERFORMANCE REQUIREMENTS AND TESTING

2.1 GENERAL

This Section sets out the performance requirements for the sleeper and the tests and pass criteria to satisfy these requirements.

C2.1 *The performance of concrete sleepers in track depends on the condition of the rail and the joints provided, and on the rail fastening system, which comprises resilient fastenings, rail pads and insulators (see AS 1085.19). Accordingly, when considering their performance, the concrete sleeper and its fastening together with the rail and supporting ballast must be regarded as interdependent components of a system.*

The analysis of requirements for such systems must necessarily involve not only the sleeper but all components of the track system, their interdependency and the conditions under which they must be applied. Thus, concrete sleeper track systems involve—

- (a) *rail, sleeper fastenings, ballast, formation and subgrade;*
- (b) *design of each component, method of manufacture, installation and maintenance;*
- (c) *direction, magnitude and frequency of traffic-imposed loads;*
- (d) *effect of environmental factors such as temperature and weather;*
- (e) *overall economics of installation and maintenance; and*
- (f) *need to support and guide railway vehicles while restraining repeated lateral, vertical and longitudinal forces.*

Item (c) will be influenced by the condition and interaction of both the track and the rolling stock.

2.2 TESTING

2.2.1 General

Testing shall be carried out on sleeper assemblies or elements that have been produced using the processes and the plant, and with the materials that the manufacturer uses or intends to use in mass production.

Where appropriate, testing shall be carried out using the rail profile (or part of the rail profile, as appropriate) and the sleeper assembly (including rail fastening) that is intended to be used. This includes the use of spacers or other variation in configuration (e.g. multiple sets of holes).

Testing facilities shall be appropriately qualified to carry out the required tests in accordance with the purchaser's requirements (see Paragraph A2(f)).

2.2.2 Type testing

The manufacturer shall carry out a track assembly test as detailed in Clause 2.7.1 and type tests as detailed in Clause 2.8.1 and (unless otherwise specified) on components that have been produced by the plant, materials and processes that the manufacturer intends to use in mass production when—

- (a) a new design is submitted to the purchaser;
- (b) a new manufacturing plant or process is adopted by the manufacturer before or during production; or

- (c) the characteristic strength of the concrete or the prestressing is varied by the manufacturer.

2.2.3 Proof testing

Proof testing shall be carried out on a routine basis in accordance with Clause 2.8.2.

2.3 PRE-STRESSED CONCRETE SLEEPER DESIGN

2.3.1 Design principles

Sleepers shall be designed as fully prestressed sections.

The stresses shall be calculated from the design bending moments calculated in accordance with Section 4 using the design loads calculated in accordance with Section 3.

Where no other information is available, the value of R used for the calculations in Section 4 shall not be less than R_v as determined in accordance with Section 3.

Loads and calculation methods given in this Standard are in permissible stress format and are not based on limit state principles. Alternative design techniques and materials may be used where the manufacturer can demonstrate compliance with the requirements of Sections 5 and 6 and other requirements, to the satisfaction of the purchaser.

NOTES:

- 1 The value of R used for design may be subject to other information requiring engineering judgement.
- 2 Background on design of sleepers can be found in Appendix N and on dynamics in Appendix D.

2.3.2 Shape and dimensions

The depth and width of the sleeper may vary throughout its length. The minimum length of the sleeper shall be determined by the bond development requirements of the prestressing tendons and the base width shall then be not less than that determined by the allowable bearing pressure.

The tolerances on sleeper manufacture shall be as given in Table 2.1. The manufacturer's tolerance of rail seat centre-line distance shall be consistent with track gauge tolerance as specified by the purchaser.

NOTE: See Appendix A for guidance on information to be provided by the purchaser.

2.3.3 Design ballast contact pressure

When designed in accordance with the service loads and track conditions specified using the methods given in Sections 3 and 4, the calculated ballast pressure shall not exceed 750 kPa for high-quality, abrasion-resistant ballast.

Where lower quality ballast materials than specified using AS 2758.7 are used, consideration shall be given to reducing the allowable ballast pressure.

TABLE 2.1
PERMISSIBLE TOLERANCES

Dimension/Part/Condition	Tolerance
Length immediately after transfer	±6 mm
Cross-sectional dimensions	±3 mm
Location of centroid of tendons relative to the moulded surface of the sleeper	±3 mm
Location of individual tendons subject to complying with clear cover requirements	±5 mm
Longitudinal straightness	±6 mm
Concavity or convexity of rail seat in any direction	±0.5 mm
The inward cant of the rail seats	1 in 250
Differential tilt of the rail seats in the direction of the rail	1 in 100
Rail seat centre-line to the rail restraining face of the fastening (tolerance on d_{rs})	+0.75, -0.25 mm
Distance between gauge restraining faces of the outside shoulder (tolerance on g_{sh})	+2.0, -1.0 mm

NOTES:

- 1 Track gauge and track gauge tolerance are to be specified by the purchaser (see Appendix A2(d)). A typical track gauge tolerance has a range of 6 mm, for example, +4, -2 mm.
- 2 Track gauge can be influenced by the sleeper tolerances, the fastening tolerances and the rail tolerances.

2.4 SLEEPER INTEGRITY

2.4.1 General

The performance requirements for the integrity of the sleeper assembly shall be deemed to be met when Clauses 2.4.2 to 2.4.5 are satisfied.

2.4.2 Sleeper materials

Materials shall conform to the requirements set out in Section 5.

2.4.3 Manufacture

Manufacture shall be carried out in accordance with Section 6.

2.4.4 Permissible stresses for design

When designed in accordance with the service loads and track conditions specified using the methods given in Sections 3 and 4, the calculated sleeper bending stresses in tension and compression shall not exceed the permissible stresses given in Table 2.2 for the cases described.

Consideration need not be given to checking sleeper sections for stresses other than flexural stresses (e.g. shear stresses), subject to the design complying with all other Clauses of this Standard.

TABLE 2.2
PERMISSIBLE STRESSES

Material	Design situation	Type of stress	Permissible stress (MPa)
Concrete	Immediately after transfer and before deferred losses	Maximum compressive stress, where the distribution of stress is triangular or approximately triangular	$0.6 f_{cp}$
	Immediately after transfer and before deferred losses	Maximum compressive stress, where the distribution of stress is uniform or approximately uniform	$0.5 f_{cp}$
	Working conditions in track assumed by the designer after allowing for all losses of prestress	Maximum compressive stress	$0.45 f'_c$
	Working conditions in track assumed by the designer after allowing for all losses of prestress	Maximum tension (flexure)	$0.4 (f'_c)^{0.5}$
	Without any applied load, after all losses of prestress	Minimum compressive stress at any cross-section through the rail seat area	1.0
Prestressing tendons	Jacking stress after losses due to jack friction only, under the working conditions assumed by the designer	Maximum tensile stress	$0.8 f_p$
	Initial stress immediately after transfer, under the working conditions assumed by the designer	Maximum tensile stress	$0.7 f_p$

NOTES:

- 1 Where f_p is the minimum of the range given in AS/NZS 4672 (series), as appropriate.
- 2 The loss of prestress shall be determined by the methods specified in AS 3600.

C2.4.4 Where there is doubt on which category of distribution is appropriate, $0.55f_{cp}$ is commonly adopted as the maximum permissible compressive stress at transfer.

The permissible concrete flexural tensile stress of $0.4 (f'_c)^{0.5}$ is based on the flexural tensile strength of $0.6 (f'_c)^{0.5}$ given in AS 3600.

2.4.5 Vertical load tests

When tested in accordance with Appendices E to I (rail seat vertical load test, rail seat repeated load test, development length test, centre negative bending moment test and centre positive bending moment test) using the loads given in Table 2.3, the sleeper shall not fail the pass criteria given in Table 2.3.

TABLE 2.3
TEST LOADS

Test method	Description	Load definition	Pass criteria
Appendix E	Rail seat negative bending	$P_1 = \frac{2M^{cr}_R -}{(0.33 - 0.075)}$	No structural cracking at P_1
Appendix E	Rail seat positive bending	$P_2 = \frac{2M^{cr}_R +}{(0.33 - 0.045)}$	No structural cracking at P_2
Appendix F	Rail seat repeated load (positive bending)	$P_2 = \frac{2M^{cr}_R +}{(0.33 - 0.045)}$	At the end of cyclic loading at $1.15P_2$ — Support a static test load of $1.15P_2$ for at least 3 min without collapse Slippage of the tendon not exceeding 0.025 mm under $1.5P_2$ (development length test)
Appendix G	Development length	$P_2 = \frac{2M^{cr}_R +}{(0.33 - 0.045)}$	Slippage of the tendon (under $1.5P_2$) not exceeding 0.025 mm
Appendix H	Centre negative bending	$P_3 = \frac{2M^{cr}_C -}{(0.5g - 0.075)}$	No structural cracking at P_3
Appendix I	Centre positive bending	$P_4 = \frac{2M^{cr}_C +}{(0.5g - 0.075)}$	No structural cracking at P_4
Appendix J	Insert pull-out test	$F_p = 60 \text{ kN}$	No yielding or cracking other than mortar cracking (see Clause 2.6.3) Residual relative movement not exceeding 0.2 mm
Appendix K	Insert torque test	$T = 0.34 \text{ kNm}$	No rotation, cracking of the concrete or permanent deformation (see Clause 2.6.4)

LEGEND:

$$M^{cr} = Z(f'_t + P/A_t) + eP \quad \dots 2.4$$

$$f'_t = 0.75(f'_c)^{0.5}$$

NOTES:

- 1 Where agreed between the manufacturer and the purchaser, f'_t may be determined in accordance with AS 1012.11 for specimens cured in the same environment as the concrete sleepers.
- 2 Transformed section properties are used as this allows for the contribution of the prestressing steel to the stiffness of the uncracked section.
- 3 Prestress at the time of test can be calculated in accordance with AS 3600. If the sleeper is steam cured then the basic relaxation of tendons as given in AS 3600 should be used.

C2.4.5 *The vertical load tests (Clause 2.4.5) function as a compliance test of the sleeper. The loads are intended to create a bending moment that will just crack the sleeper. They are calculated from the flexural tensile strength of the concrete, f'_t .*

The repeated load test bends the sleeper at just above the cracking moment.

The tendons must have sufficient reserve bond strength that they will not fail if the sleeper cracks. This is tested following the repeated load test.

2.5 SERVICE LIFE

2.5.1 General

The performance requirements for the expected service life of the sleeper assembly shall be deemed to be met when Clauses 2.5.2 to 2.5.4 are satisfied.

NOTE: Sleepers designed to this Standard may be expected to have a life of 50 years; however, abrasion of the soffit particularly in poor ballast conditions will reduce that life. This may need to be taken into account when determining the bottom cover to the tendons.

2.5.2 Concrete durability

Materials shall conform with the requirements of Section 5 and concrete cover shall be in accordance with Clause 2.5.3.

2.5.3 Clear tendon cover

The minimum clear concrete cover to tendons generally shall be 25 mm with the exception that the tendon may be exposed at the end faces. However, minimum cover to soffit of the sleeper shall be 35 mm.

The minimum clear tendon cover to an insert hole or fitting shall be 12 mm. Dissimilar metals shall not be in contact with any steel tendon.

2.5.4 Rail seat repeated load test

When tested in accordance with Appendix F with test load as given in Table 2.3, the sleeper shall not fail the pass criteria given in Table 2.3.

NOTE: 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. Sufficient data is not available on a correlation between the test and in-track performance. In the event of failure under the given loading conditions, full test details should be provided for the consideration of the purchaser.

2.6 RAIL RESTRAINT AND SUPPORT

2.6.1 General

The requirements for rail restraint and support shall be deemed to be met when Clauses 2.6.2 to 2.6.4 are satisfied.

2.6.2 Rail fastening systems

The fastening system shall be in accordance with AS 1085.19.

Where cast-in components are used, they shall be designed for the full life of the sleeper. The cast-in component shall be set in the concrete to a level below that of the top tendons.

NOTE: Alternative arrangements of cast-in components may be considered if their suitability is proven.