Division / Business Unit: Corporate Services & Safety
Function: Track & Civil
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Concrete Sleepers - Design

ETD-02-05

Applicability

ARTC Network Wide SMS

Publication Requirement

Internal / External

Primary Source

ETD-02-01 Concrete Sleepers (Medium Duty) – Design and ETD-02-03 Concrete Sleepers (Heavy Duty) - Design

Document Status

Version #	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.1	01 Jun 20	Standards	Stakeholders	Manager Standards	General Manager Technical Standards 13/08/2020

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	28 Nov 16	All	Initial Issue.
1.1	01 Jun 20	2	Updated for multiple gauges. Updated sleeper details. Added dual gauge design info. Aligned some requirements to ARTC and Australian Standards
		3.1	Added limit state design requirements

Table of Contents

1 Introduction

1.1 Purpose

Provide design requirements for concrete sleepers supplied for use in Australian Rail Track Corporation track.

1.2 Scope

This standard covers the design, manufacture, supply, delivery and type approval requirements for single gauge and dual gauge prestressed concrete sleepers' Special applications such as turnout bearers are not covered by this Standard.

1.3 Responsibilities

The Manager Standards is the document owner and is the initial point of contact for all queries relating to this Specification.

The relevant maintenance budget authority is responsible for accepting final designs.

1.4 References

The design shall be based on relevant Australian Standards and Codes of Practice and/or the referenced standards specified in this document.

Referenced Australian Standards;

- AS 1085.14 – Prestressed Concrete Sleepers
- AS 1085.19 – Resilient fastening assemblies
- AS 1085.1 – Rails
- AS 3610.1 – Formwork for concrete – Part 1: Specifications

ARTC standards relating to;

- Track geometry
- Resilient rail fastenings
- Route Access Standard (RAS)

Other internationally accepted and proven standards providing these are at least equivalent to AS 1085.14.

All references relate to the latest Standard versions, including amendments and relevant superseding Standards.

1.5 Definitions

The following terms are used in this document:

Term	Description
Concrete sleeper	A sleeper consisting of appropriately formed reinforced concrete which, when prestressed, includes the reinforcing steel tendons which are stressed before casting the concrete.
Cast in shoulder	A component that prevents lateral movement of the rail foot and provides anchorage for the resilient rail fastening system.
Resilient Rail Fastenings	Elastic steel clips, insulators and pads attached to sleeper cast in shoulders and designed to engage rail foot flanges. The arrangement fastens rails to sleepers generating toe load at the rail flange providing resistance to longitudinal movement and to rail roll and lateral shift.
Monoblock sleeper	Standard concrete sleeper cast in a single piece.
Medium Duty	Pertains to track having traffic not exceeding nominal 25 t axle loads nor more than 25 MGT annual traffic.
Heavy Duty	Pertains to track having traffic not exceeding nominal 30 t axle loads nor more than 100 MGT annual traffic.

2 Design Requirements

2.1 General Information

Final acceptability of any design will be dependent upon the checking of the proposal to ensure that the requirements of this standard are fulfilled.

The design shall be in accordance with AS 1085.14 or the referenced standards unless otherwise specified in this document.

Sleepers shall be prestressed type cast concrete.

Designs shall be approved and accepted in accordance with ARTC requirements.

The railways on which the sleepers will be used include extensive lengths of sharp curves and steep gradients where sanding is applied for improved traction. Concrete sleepers are to be designed to minimise potential for soffit abrasion and rail seat erosion in this type of operating environment.

Fastenings, cast in shoulders, pads, spacers and insulators shall comply with relevant ARTC Standards.

2.2 Track Details

Track configuration	Route Access Standard
Track gauge	1435mm (Standard) 1067mm (Narrow) 1600mm (Broad)
Track gauge tolerances (new rail)	+6mm wide, 0mm tight (Standard) +2mm wide, -4mm tight (Narrow) +4mm wide, -2mm tight (Broad)
Rail	AS60 (AS 1085.1 or equivalent standard)
Rail cant	1 in 20
Axle Loads/maximum speeds (Standard Gauge only)	Medium Duty 25 tonnes/80km/h
(Narrow, Broad and Dual Gauge to specified by purchaser)	Heavy Duty 30 tonnes/80km/h 23 tonnes/ 110km/h 21 tonnes/115km/h 19 tonnes/160km/h
Track geometry	ARTC Track geometry standard and related documents
Service life	50 years
Service Rating (k_s)	≥ 2.5 (Default value in AS108.14 is 2.5)
Rail seat pads and insulators	Relevant ARTC Standard

2.3 Sleeper Details and Design

2.3.1 Sleeper Details

Parameter	Value
Design Calculations	AS 1085.14 and Section 2.3.2
Length	2.5m (preferred)
Depth at centre of rail seat	Maximum 250mm
Width at the rail seat	The width of the top of concrete sleepers at rail seats shall be not less than 160 mm plus any chamfer or rounding, or such greater width as may be required for specific pads
Base width	250mm (preferred)
Sleeper centre spacing	667mm Design Actual installation sleeper spacings are defined in Code of Practice Section 2 but shall be designed for 667mm spacing.
Finish	Surface finish shall be as specified by AS1085.14 and AS3610.1.

2.3.2 Dual Gauge Sleeper Design

For the design of dual gauge sleepers carrying loads on the wider gauge rails, the single gauge provisions of AS1085.14 apply. When dual gauge sleepers are carrying loads on the narrower gauge rails, the following ballast pressure distributions and design equations may be used.

Notes:

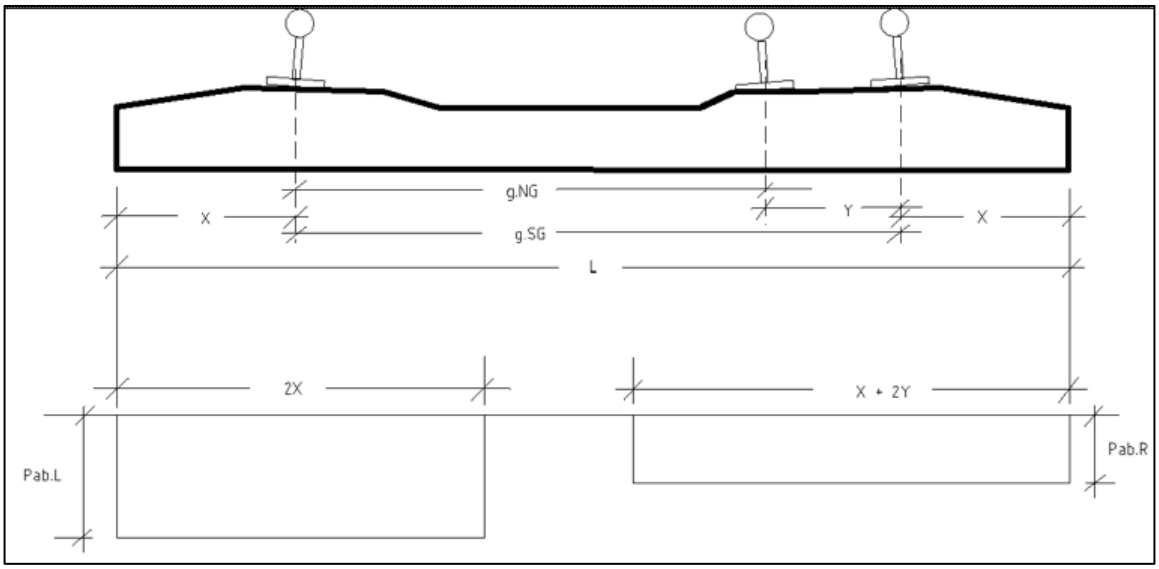
1. For dual gauge sleepers, the design of the rail seat tends to be governed by the bending moments and ballast pressures arising from loads on the narrower gauge rails; the design of the sleeper centre tends to be governed by the bending moments and ballast pressures arising from loads on the wider gauge rails.
2. In the diagrams and equations below, the following terms are used.
    - BG, NG, SG: broad (1600mm), narrow (1067mm), standard (1435mm) gauges
    - g_{BG} distance between centres of broad-gauge rails (m)
    - g_{NG} distance between centres of narrow-gauge rails (m)
    - g_{SG} distance between centres of standard gauge rails (m)
    - L overall length of sleeper (m)
    - M_{C-} maximum negative bending moment at sleeper centre (kNm)
    - M_{R+} maximum positive bending moment at rail seat (kNm)
    - p_{ab} maximum ballast pressure (kPa)

- R rail seat load from AS1085.14 (kN)
- w width of base of sleeper (m)
- X distance from end of sleeper to centre of nearest rail
- Y distance between centres of adjacent dual gauge rails

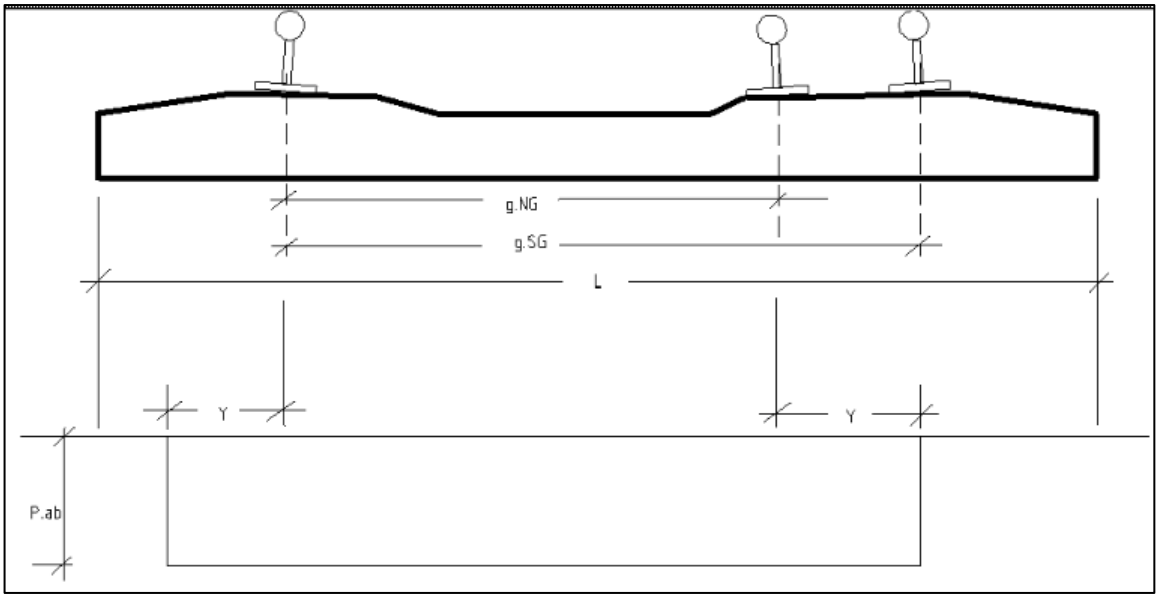
2.3.3 Ballast pressure distributions.

Dual narrow/standard gauge sleepers.

Rail seat moments

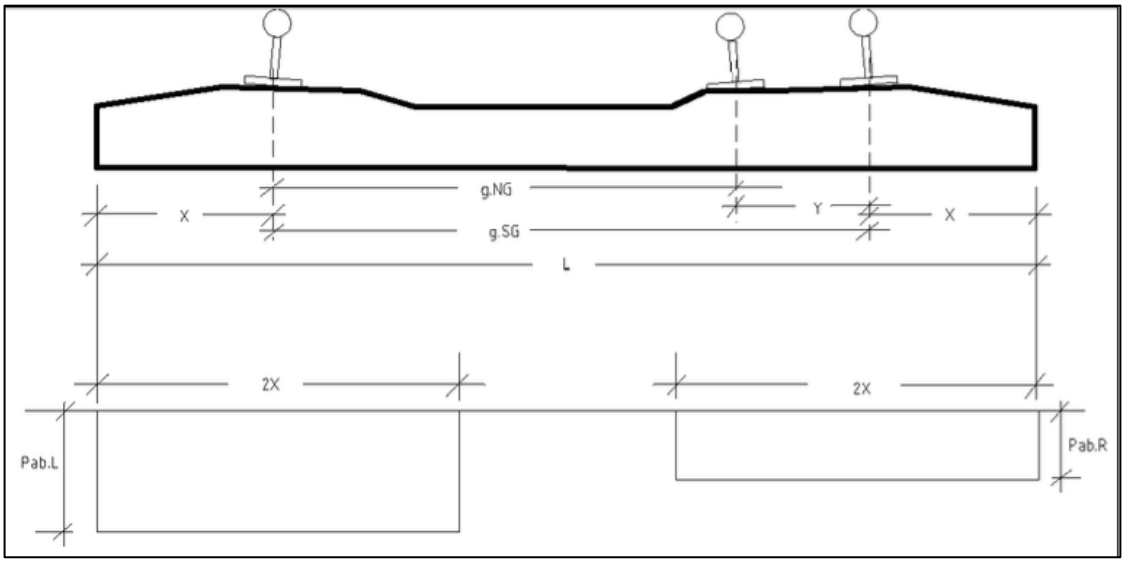


Sleeper centre moments

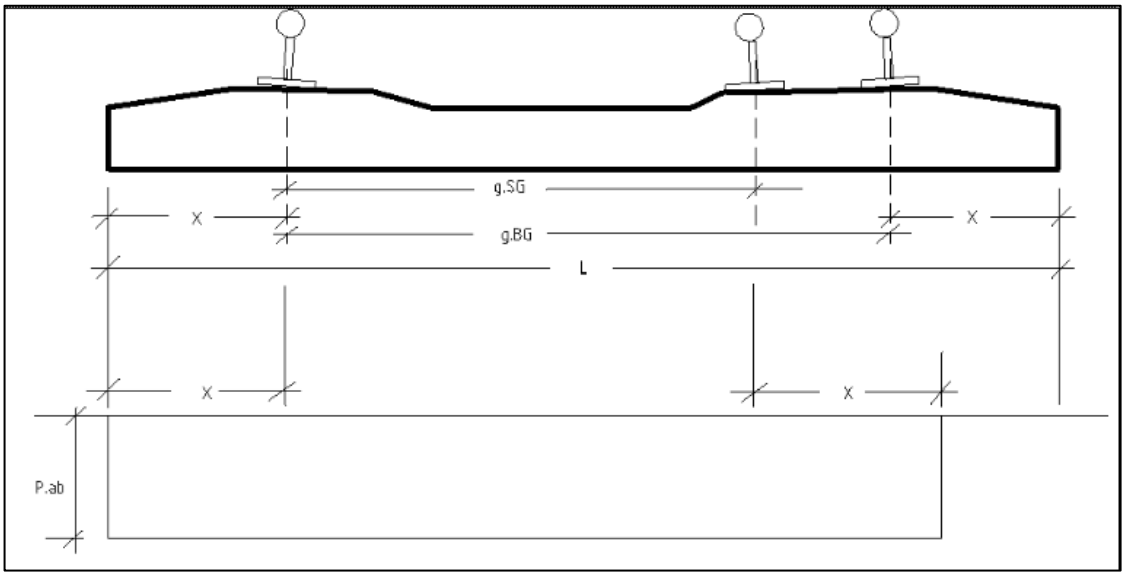


Dual standard/broad gauge sleepers

Rail seat moments



Sleeper centre moments



Type*	Design values	
	kPa or kNm	
NG/SG sleeper, positive moments	Design ballast pressure (p_{ab})	$p_{ab} = \frac{2R}{w(L-g_{SG})}.(1-\frac{2g_{NG}}{(L-g_{SG}+4g_{NG})})$
	Design positive bending moment at rail seat (M_{R+})	$M_{R+} = w(L+g_{SG}-2g_{NG})^2.\frac{(\frac{2R}{w}-p_{ab}(L-g_{SG}))}{4(L+3g_{SG}-4g_{NG})}$
NG/SG sleeper, negative moments	Design ballast pressure (p_{ab})	$p_{ab} = \frac{2R}{w(2g_{SG}-g_{NG})}$
	Design negative bending moment at the centre (M_{C-})	$M_{C-} = \frac{R(2g_{SG}-3g_{NG})}{4}$
SG/BG sleeper, positive moments	Design ballast pressure (p_{ab})	$p_{ab} = \frac{R(2-\frac{g_{SG}}{g_{BG}})}{w(L-g_{BG})}$
	Design positive bending moment at rail seat (M_{R+})	$M_{R+} = \frac{Rg_{SG}(L+g_{BG}-2g_{SG})^2}{8g_{BG}(L-g_{BG})}$
SG/BG sleeper, negative moments	Design ballast pressure (p_{ab})	$p_{ab} = \frac{2R}{w(L-g_{BG}+g_{SG})}$
	Design negative bending moment at the centre (M_{C-})	$M_{C-} = \frac{R(L-g_{BG}-g_{SG})}{4}$

* NG = 1067mm narrow gauge; SG = 1435mm standard gauge; BG = 1600mm broad gauge.

2.4 Interface with Signalling and Electrical

Sleepers will be installed in track both with and without signalling circuits; insulation is therefore required.

Track may be with and without electrification at 1.5 kV DC and may in future be electrified at 25 kV AC.

Electrical Insulation shall be as per AS1085.14

2.5 Installation, Handling and Maintenance

Sleepers must be suitable for efficient transportation on rolling stock used with track laying machines and be stable for stacking on conventional flatbed rolling stock or on-site.

Sleepers must be suitable for installation by track laying machines and sleeper insertion equipment of a type used for partial re-sleepering.

Trackwork fitted with these concrete sleepers shall be suitable for maintenance with track maintenance equipment. Such equipment may include tamping and regulating machines, dynamic stabilisers, track adjustment jacks, track lining machines, fastening insertion/removal equipment, ballast shoulder cleaners and undercutting machines.

For the purpose of track adjustment, rails must move freely on the rail seats. To achieve this, fastening systems must be able to be released for the adjustment and re-fastened on completion of the work.

2.6 System Performance

System performance requires the concrete sleeper assembly to function as part of the track structure. The sleeper must be able to transfer all the relevant track forces generated by train operations and the forces of rail thermal expansion and contraction to the ballast.

The full range of Australian climatic conditions from alpine to desert may apply. The thermal expansion and contraction forces act on the continuously welded rails with a temperature range from approximately –10° C to 65° C about a nominal neutral temperature in the range of 25° C to 45° C. Design neutral temperature is typically 38° C.

Fastening assemblies shall meet the requirements of ETD-02-02 and ETD-02-03 as appropriate.

2.7 Allowance for Retrofit

The longitudinal centre line of the sleepers must have a vertical section of at least 50mm wide which is clear of any reinforcing steel (excluding the area of fastening) to allow for the attachment of ancillary equipment including train stops.

2.8 Sleeper Marking

The following marks shall be displayed on each sleeper, with markings being raised or indented to suit the manufacturer. Note that some are mandatory, and some are optional:

- Year of manufacture (Mandatory)
- Batch number (including a design type designator) (Mandatory)
- Mark of Manufacturer (Optional)
- The letters “ARTC” (Optional)

Lettering and marks shall be on the upper sleeper surface between rail seats.

3 New products

3.1 Product Approval

3.1.1 General Requirements

All new (not previously used in ARTC) sleeper designs shall be submitted to the ARTC Manager Standards for product approval. As part of the submission, the following data shall be provided by the supplier:

One set of design calculations which should include the following.

- Rail seat load.
- Positive and negative resisting moments at the rail seat and at the centre of the sleeper (monoblock sleeper type).
- Fastening assemblies with all cast-in components.
- Tendon and/or reinforcement design stress including strain relaxation.
- Tendon and/or reinforcement bond stress including losses from interface bond/anchorage.
- Concrete strength including shrinkage, creep and curing effects.
- The effects on sleeper strength of manufacturing tolerances (e.g. concrete shape and tendon placement) and the design attrition allowance.

Independent design check of the design shall be undertaken by a competent designer, and details of this design check and information shall be provided.

Two sets of fully detailed drawings are to be supplied for each combination of sleeper type, fastening assembly and rail size.

The drawing shall detail the following:

- Sleeper and fastening system dimensions including tolerances.
- Tendon type, size, material, number and location.
- Cast in Shoulder type, detail and material.
- Concrete mixture specification and properties.

The supplier will also be required to provide documentation of testing outcomes as specified in Section 3.2 below.

3.1.2 Requirements for Limit State Design

Where a sleeper has been designed according to limit state principles, the set of design calculations should also include the following information.

- The limit states which were adopted in the design together with justification for excluding any of the usual limit states, including strength (eg bending, shear, compression and torsion), serviceability (eg deformation, vibration and cracking) and fatigue.
- Design loadings in each limit state and number of load cycles for fatigue calculation
- Design life
- Applied limit states load and capacity reduction factors
- Limit states load combinations (such as compression and bending or thermal and longitudinal effects together)
- Dynamic impact factor(s) applied to static analysis
- The manner in which the design material properties were derived for each limit state evaluation and the values of those properties.
- The methods used to determine the responses of the sleeper for each limit state evaluation and for each action applied.
- The thresholds for each limit state, how they were determined and how those thresholds were not exceeded.

3.2 Sleeper Performance and Tests

For the supply of sleepers, performance and testing shall be in accordance to AS1085.14 and this Standard.

Proof testing frequencies shall be determined by the manufacture and approved by ARTC.

General description of manufacturing procedure shall be provided.