

AS 1418.18:2024



Cranes, hoists and winches

Part 18: Crane runways and monorails



AS 1418.18:2024

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Preface

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee ME-005, Cranes, to supersede AS 1418.18:2001.

The objective of this document is to specify the minimum requirements for runway girders and monorail beams constructed of structural steel. This revision incorporates improvements in the understanding of the behaviour of and requirements for runway girders and monorails.

The major changes in this edition are as follows:

- (a) The removal of the distinction between “light duty” and “heavy duty” runways, with all runways now requiring design for torsion and detailed design of the web and top flange.
- (b) Differences in the calculation of eccentricities.
- (c) Changes to loads and load combinations.
- (d) A requirement to assess modifications.
- (e) Refinements to the applicable serviceability criteria.
- (f) Emphasis on the importance of top flange tie-backs.
- (g) Changes to the design of end stops, the design of monorails, the design of coped ends of girders, the use of billet rails, construction tolerances, inspection frequencies and interim design criteria.
- (h) Provisions for design by the finite element method.

The terms “normative” and “informative” are used in this document to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a document, whereas an “informative” appendix is only for information and guidance.

This Standard includes a commentary on some of the clauses. 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 document.

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Part 18: Crane runways and monorails

1 Scope and general

1.1 Scope and application

1.1.1 Scope

This document specifies the minimum requirements for runway girders and monorail beams constructed of structural steel.

NOTE If designing runway girders or monorail beams using materials other than structural steel, it is recommended that the relevant principles of this document be adopted in conjunction with the specific requirements of the design Standards for such materials.

Deflection limits and construction tolerances for structures supporting the runway girders are also covered by this document.

1.1.2 Application

The requirements of this document apply to all crane runway girders and monorail beams.

Loads and load combinations shall be determined in accordance with the requirements of AS 5221.1 and ISO 8686-5, but the additional requirements given herein take precedence over the corresponding requirements of those Standards.

This document, in setting out a reasonably practicable framework of minimum requirements, does not prevent a designer or user from implementing another strategy, provided that it affords an equal or better level of safety.

1.2 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 1085.20, *Railway track material, Part 20: Welding of steel rail*

AS 1391, *Metallic materials — Tensile testing — Method of test at room temperature*

AS 1710, *Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate and universal sections—Test methods and quality classification*

AS 2549, *Cranes, hoists and winches — Glossary of terms*

AS 2865, *Confined spaces*

AS 3990, *Mechanical equipment—Steelwork*

AS 4100, *Steel structures*

AS 5221.1, *Cranes – Design principles for loads and load combinations, Part 1: General (ISO 8686-1:2012, MOD)*

AS 5224, *Cranes — Proof of competence of steel structures (ISO 20332:2016, MOD)*

AS 5228.1, *Cranes — Design calculation for rail wheels and associated trolley track supporting structure, Part 1: General (ISO 16881-1:2005, MOD)*

AS 5229.1, *Cranes — Tolerances for wheels and travel and traversing tracks, Part 1: General (ISO 12488-1:2012, MOD)*

AS 5246.1, *Cranes — Classification, Part 1: General (ISO 301-1:2016, MOD)*

AS/NZS 1170.0, *Structural design actions, Part 0: General principles*

AS/NZS 1170.2, *Structural design actions, Part 2: Wind actions*

AS/NZS 1554.1, *Structural steel welding, Part 1: Welding of steel structures*

AS/NZS 1554.5, *Structural steel welding, Part 5: Welding of steel structures subject to high levels of fatigue loading*

AS/NZS 5131, *Structural steelwork—Fabrication and erection*

ISO 8686-5, *Cranes — Design principles for loads and load combinations — Part 5: Overhead travelling and portal bridge cranes*

1.3 Terms and definitions

For the purposes of this document, the terms and definitions given in AS 2549 and the following apply.

1.3.1

dynamic factor

ratio of the peak dynamic load to the static load

1.3.2

end stops

elements at the ends of the runway designed to receive impact load from the crane structure and to transmit it to the crane runway

Note 1 to entry: End stops may or may not have buffers incorporated.

1.3.3

flexural-torsional buckling

tendency of a girder to displace laterally and rotate about its longitudinal axis when carrying vertical loads, so as to bend about the minor axis and twist

Note 1 to entry: This is also referred to variously as “lateral buckling” and “lateral-torsional buckling”.

1.3.4

global stress cycles

stress cycles for the crane runway as a whole

1.3.5

in-service wind

maximum wind speed under which the crane will operate when subjected to wind load, under either normal operating conditions or when securing the crane, and relevant to external cranes or cranes that are fully or partially exposed to wind loading within buildings

Note 1 to entry: For the purposes of this document, in-service wind shall be the 1:10-year regional wind speed as determined in accordance with AS/NZS 1170.2, adjusted for site factors, unless a rational analysis demonstrates otherwise.

C1.3(A) *In-service wind is relevant to the design of runway girders and monorail beams for strength and serviceability under combinations of wind and crane loads and applies when the girders or beams are subjected to wind load, due to full or partial exposure. When that is the case, in-service wind is the maximum wind speed that can occur prior to the crane being placed out of service. This may be significantly higher than the operating wind speed, which relates to normal operation, as the crane may need to be unloaded and/or travelled to a location where it can be anchored against out-of-service winds, which may typically take in the order of 10 to 30 minutes. A statistical analysis of wind data indicates that the 1:10-year regional wind speed, adjusted for site factors, is a suitable representation. If undertaking a rational analysis, note that it is more probable that this wind speed will be reached from a common operating wind speed of 20 m/s than from a random sample of starting wind speeds.*

1.3.6

inertia loads

loads induced by acceleration or deceleration of the crane, hoist(s) or other mechanisms

C1.3(B) *Deceleration loads are often critical as brake torque usually exceeds drive torque for two-speed drives.*

Lateral loads due to long travel inertia, which only occur because of mass asymmetry, result in skewing of the crane about its vertical axis but the term “skewing loads” is reserved for oblique travel loads alone.

1.3.7

local stress cycles

stress cycles induced in localized elements such as a top flange

1.3.8

may

indicates the existence of an option

1.3.9

monorail beam

beam designed to support trolleys, hoists and/or other devices rolling directly on its bottom flange

Note 1 to entry: For the purposes of this document, the term “monorail beam” includes dual runway girders supporting an underslung bridge crane that rolls directly on their bottom flanges.

1.3.10

monorail crane

crane comprising a monorail beam fixed in location, from which is supported a serial hoist and trolley to enable travelling beneath the monorail beam

1.3.11

oblique travel loads

skewing loads induced by guidance reactions which force the wheels to deviate from their free-rolling, natural travel direction

C1.3(C) *The unrestrained travel path is usually a circle of large radius for cranes intended to travel in a straight path. This is usually due to different drive wheel tread diameters but may also result from lack of wheel axle parallelism or from unusual factors such as floating wheels, differing drive shaft stiffnesses for coupled wheels, or frequency differences for independent drives. The method of determination of these loads is given in AS 5221.1 and ISO 8686-5.*

Lateral inertia loads from long travel are caused by skewing due to acceleration/deceleration acting on asymmetrical mass distribution, whereas oblique travel loads are skewing loads that may occur with no asymmetric mass distribution.

1.3.12

rail fasteners

clips, clamps or other restraining elements preventing the crane rail from lateral displacement relative to the supporting girder

1.3.13**serviceability wind**

1:25-year wind speed as determined in accordance with AS/NZS 1170.2

1.3.14**shall**

indicates that a statement is mandatory

1.3.15**should**

indicates a recommendation

1.4 Symbols and abbreviated terms

Symbols used in this document are listed below.

Where non-dimensional ratios are involved, the numerator and denominator are expressed in identical units.

The dimensional units for length and stress in all expressions or equations are to be taken as millimetres (mm) and megapascals (MPa), respectively, unless specifically noted otherwise.

An asterisk “*” placed after a symbol denotes a design action effect due to the design load for the strength limit state.

B	=	tolerance of horizontal straightness of rail head at each point of rail
B_F	=	distance between the centreline of a beam web or line of web action for a fillet welded box beam and the outside edge of a flange
B_{rb}	=	width of a rail bottom flange
B_T	=	width of a rail head
b_f	=	width of a flange
C_F	=	distance between the vertical line of action of a wheel load and the centreline of a beam web or line of web action for a fillet welded box beam
C_{fcn}	=	crane “n” design full-load cycles, in accordance with the principles of AS 5246.1
$C_{frunway}$	=	runway design full-load cycles
c_b	=	coefficient used to calculate buffer force
c_e	=	contribution coefficient
D	=	depth of a beam section
d_s	=	depth of a stiffener
d_w	=	depth of a web
E	=	Young’s modulus of elasticity (200 000 MPa for structural steel)
e_a	=	design tolerance for the lateral rail misalignment from the centreline of a girder web
e_r	=	design eccentricity of a wheel reaction from the centreline of a rail
e_x	=	distance from the shear centre of a full section to the top of a rail

e_y	=	lateral design eccentricity for a vertical load
e_{yl}	=	local lateral design eccentricity for a vertical load
F_Y	=	guide force on the leading means of guidance of a crane resulting from oblique travel (skewing)
F_{Y11}	=	lateral frictional resistance force on the tread of the leading long travel wheel of a crane, at or near the guide force, resulting from oblique travel (skewing)
F_{Y21}	=	lateral frictional resistance force on the tread of the leading long travel wheel of a crane, opposite the guide force, resulting from oblique travel (skewing)
f_b	=	bending stress (permissible stress method); or
	=	longitudinal bending stress in a beam
f_m	=	maximum von Mises stress
f_n	=	maximum normal stress in the compression flange on the vertical centreline of the girder under factored loads
f_{ob}	=	maximum normal stress on the vertical centreline at elastic lateral buckling at the compression flange, as determined by the finite element method under vertical loads
f_u	=	tensile strength used in design
f_v	=	maximum shear stress under factored loads
f_w^*	=	maximum normal stress resulting from warping torsion
f_y	=	material yield stress used in design
f_z	=	compressive stress (permissible stress method)
G	=	shear modulus of elasticity (80 000 MPa for structural steel)
H_c	=	height of a crane rail above the top of a footing
H_r	=	height of a rail (i.e. the depth of a rail section)
h_G	=	vertical distance between the centroids of the top and bottom flanges of a girder (Gorenc method)
J_f	=	torsion constant of a top flange, including the “top hat” section, if present
J_r	=	torsion constant of a rail
K	=	tolerance for misalignment of a rail from the centreline of a girder web; or
	=	relative rigidity constant
K_L	=	load position factor
K_u	=	design allowance for unintentional misalignment of a rail from the centreline of a girder web
k_w	=	buckling coefficient, as given in Table 5.7.3.5
L	=	span of a runway girder or monorail beam between the effective centres of the supports

L_b	=	bay spacing between adjacent supporting structures
L_c	=	length of a compression flange resisting local transverse bending for directly bedded rails; or
	=	span of a cantilever from the effective centre of support
L_p	=	patch length
L_s	=	length of a compression flange resisting local transverse bending for soft bedded rails; or
	=	spacing of stiffeners
L_t	=	length of a web resisting a local torsional moment
L_{wx}	=	length of a web resisting a vertical wheel load
M^*	=	design bending moment without torsion
M_{bx}	=	nominal member moment capacity of a full girder section in the vertical plane
M_e^*	=	equivalent design bending moment
M_s	=	nominal section moment capacity
M_{sty}	=	nominal section moment capacity of a top flange alone in the horizontal plane
M_t	=	torsional moment
M_{tw}	=	torsional moment at the top of a girder web at the level of the bottom of the root radius or weld
M_x	=	bending moment in a section (permissible stress method)
M_x^*	=	applied factored major axis bending moment in a section in the vertical plane (limit states method)
M_{xall}	=	permissible bending moment in a section (permissible stress method)
M_y^*	=	lateral bending moment in a top (compression) flange due to load(s) N_{i1}
M_1	=	transverse bending moment per unit length (permissible stress method)
M_1^*	=	transverse bending moment per unit length (limit states method)
N_w	=	maximum dynamic vertical wheel load (permissible stress method)
N_{wi}	=	total factored vertical wheel reaction due to wheel “i”
N_{wp}	=	permissible patch load for a stiffened web panel (permissible stress method)
N_w^*	=	maximum factored dynamic vertical wheel load (limit states method)
N_y	=	maximum dynamic lateral wheel load (permissible stress method)
N_{yi}	=	total lateral factored force due to wheel “i”
N_{1i}	=	design equivalent lateral load on a top flange at wheel “i”

N_{2i}	=	design equivalent lateral load on a bottom flange at wheel “i”
n_g	=	number of full-load global stress cycles used in the design of a crane, in accordance with the principles of AS 5246.1
n_w	=	number of wheels in an end carriage
n_1	=	number of local stress cycles for design of the top region of a web
P	=	annual probability of exceedance
P_b	=	buffer force
P_L	=	limiting pressure depending upon material used, as defined in AS 5228.1
$P_{\max}$	=	maximum load on the wheel, as defined in AS 5228.1
P_{mean}	=	higher mean load on the wheel, as defined in AS 5228.1
q_z	=	pressure exerted on the top flange of a girder beneath a soft bedded rail
R	=	radius of a curved monorail beam
R_{CR}	=	radius between the top and side of a rail head
S_{rf}	=	nominal torsional stiffness of a rail and top flange
S_w	=	nominal flexural stiffness of an unstiffened web
T_f	=	thickness of a flange; or
	=	minimum required flange thickness
T_w	=	thickness of a web
t_i	=	sum of the thicknesses of all plates making up the top flange of a runway girder, unless the plates are not connected and will therefore flex independently
t_r	=	root radius or fillet weld size between a girder flange and web
t_{rf}	=	average thickness of a rail flange
V	=	shear force in a section (permissible stress method); or
	=	shear force at the position of a wheel giving the maximum bending moment
V^*	=	design shear force
V_e^*	=	equivalent design shear force
V_w	=	nominal shear yield capacity of a web
Y_1	=	lateral frictional resistance force on the tread of the leading long travel wheels of a crane, at or near the guide force, resulting from oblique travel (skewing); see also F_{Y11}
Y_4	=	lateral frictional resistance force on the tread of the leading long travel wheels of a crane, opposite the guide force, resulting from oblique travel (skewing); see also F_{Y21}

Y_{11}	=	lateral frictional resistance force on the tread of the leading long travel wheels of a crane, at or near the guide (contact) force, resulting from oblique travel (skewing); see also F_{Y11}
Y_{21}	=	lateral frictional resistance force on the tread of the leading long travel wheels of a crane, opposite the guide (contact) force, resulting from oblique travel (skewing); see also F_{Y21}
y_1	=	distance between the centroid of a top flange and the shear centre of a full girder section (Gorenc method)
y_2	=	distance between the centroid of a bottom flange and the shear centre of a full girder section (Gorenc method)
Z_{ex}	=	elastic modulus about the x-x-axis
α_f	=	modification factor for normal stress in a flange
ΔD_{w3}	=	tolerance on differential crane drive wheel diameter, as defined in AS 5229.1
ϕ	=	capacity factor, as defined in AS 4100
ϕ_1	=	factors for hoisting and gravity effects acting on the mass of a crane, as defined in AS 5221.1
ϕ_2	=	factor for hoisting a grounded load, as defined in AS 5221.1
σ_x	=	calculated global stress in a top flange
σ_z	=	bearing stress
τ	=	shear stress in a web at the point of maximum bending moment
τ_u^*	=	maximum shear stress resulting from uniform torsion

1.5 Use of alternative materials or methods of design or construction

This document does not prevent the use of materials, methods of assembly, procedures and the like that do not conform with the specific requirements of this document, or are not mentioned in it, provided the minimum dimensional and performance requirements specified herein are met.

2 Materials

2.1 Yield stress and tensile strength

The yield stress and tensile strength of plates and sections used in the design of crane runways shall not exceed those given in AS 4100.

2.2 Acceptance of steel

Certified mill test reports or test certificates issued by the mill shall constitute sufficient evidence of conformance to this document, unless otherwise specified in the purchase documents.

2.3 Unidentified steel

Where unidentified steel is used, it shall be free from surface imperfections, and shall be used only where the physical properties of the steel and its weldability will not adversely affect the strength and serviceability of the crane runway. Unless a full test in accordance with AS 1391 is made, the yield

stress of the steel used in design (f_y) shall be taken as not exceeding 170 MPa, and the tensile strength used in design (f_u) shall be taken as not exceeding 300 MPa.

2.4 Welds and weld categories

All welding consumables and the metal deposited by welding shall conform to AS/NZS 1554.1. They shall also conform to AS/NZS 1554.5 when the requirements of Clause 11.1.4 of AS 4100:2020 apply.

2.5 Lamellar inclusions

Flange plates used in the design of welded runway girders shall be inspected for the absence of lamellar inclusions. The flange plates shall be rejected if inclusions exceed level 2 as defined in AS 1710. For definition and treatment of lamellar tearing consistent with AS/NZS 1554.1, refer to [Clause 1.3](#), Clause 3.8 and Appendix M of AS 4100:2020.

3 Classification of runway girders and monorail beams

3.1 Scope of section

This section sets out the method of classification for runway girders and monorail beams for the purpose of design for durability (i.e., fatigue).

C3.1 *It is recognized that different sections of the runway are subject to different load conditions and may be classified accordingly.*

3.2 Classification of crane runways and monorail beams

The requirements of the crane classification system set out in Clause 6.4 of AS 5246.1:2021 shall also apply to the runway girders and monorail beams for the purpose of design for durability, except where otherwise specified by this document.

C3.2 *In addition to classification for durability (i.e., fatigue), AS 5229.1 classifies runways for tolerance. The tolerance class is unrelated to the group classification of the runway.*

3.3 Utilization class

The method of determining the utilization class for global loading shall be in accordance with AS 5246.1, except as otherwise specified in this section. The number of loading cycles shall be varied only if a crane utilization study has been performed and the results are presented in a well-documented form.

Where two or more cranes use the same runway, the number of global load cycles shall be increased. If a load spectrum analysis is not completed then the group classification of the runway system (A_x) shall be determined by the sum of the design full-load cycles of the cranes that use the runway, as follows:

$$C_{\text{runway}} = \Sigma C_{\text{fcn}}$$

where

C_{runway} = runway design full-load cycles

C_{fcn} = crane “n” design full-load cycles

3.4 Local utilization class

Local elements of the runway girder or monorail beam undergo stress cycling with each passage of the long travel wheels. Where a considerable number of long travels is envisaged, the local number of cycles shall be obtained in accordance with [Clause 6.5](#) unless it can be shown by a well-documented crane utilization study that a smaller number of cycles should be expected.

Alternatively, a load spectrum method may be employed to compute the parameters required for the determination of the runway's local utilization class.

Where two or more cranes use the same runway system, and a load spectrum analysis is not completed, the local utilization class shall be determined in accordance with [Clause 3.3](#).

4 Loads and load combinations

4.1 Scope of section

This section sets out the requirements for the determination of loads and load combinations for the design of runway girders, monorail beams and supporting structures.

4.2 Categorization of loads

Loads from cranes shall be categorized in accordance with AS 5221.1 and ISO 8686-5. Acceleration from drives shall include deceleration from drives or brakes. The following additional load types shall be included:

(a) Load Type 1A

Permanent (dead) loads (DL) on the crane runway, including weight of rails and rail fasteners, power conductors, walkways and other elements permanently fixed to the runway girder.

(b) Load Type 1B

Imposed (live) loads (LL) on the crane runway from elements other than cranes, such as fixed platforms and walkways.

4.3 Determination of loads

Unless otherwise specified herein, the loads on monorail beams from underslung cranes and crabs shall be determined in the same way as that specified for loads from top-mounted cranes.

Specific data on wheel reactions and other parameters required by AS 5221.1 and ISO 8686-5, as applicable, shall be obtained from the crane manufacturer, wherever possible, and from AS 5228.1, as applicable.

C4.3(A) AS 5228.1 is relevant when the bottom flange of the runway girder or monorail beam acts as the rail due to $P_{\max}$ and P_{mean} governing the limiting pressure P_L .

AS 5228.1 is also relevant for runways supporting top-mounted cranes if the runway girder is designed as a composite section with a welded billet rail, in which case special attention should be given to the limiting pressure P_L .

The information that shall be supplied with the crane is given in [Appendix A](#).

[Table 4.3](#) lists the main load types applicable to runway girders and monorail beams. For loads applicable to serviceability of supporting structures, see [Clause 5.13.3.2](#).

Where crane or hoist manufacturer's data are not available at the time of designing a crane runway or monorail, the designer may use interim information and the guidance given in [Appendix B](#), as appropriate, provided that the design for the runway or monorail is checked and modified as necessary upon receipt of the crane or hoist manufacturer's data. The relevant crane and hoist data used in the design of the crane runway or monorail shall be listed in the design documentation, e.g. drawings.

NOTE 1 Guidance on earthquake loads is given in AS 1170.4.

Table 4.3 — Load types applicable to runway girders and monorail beams

Load group	Load type	Description	Method of determination
Regular	1A	DL of runway	By computation without dynamic factor
	1B	LL other than from cranes	By computation without dynamic factor, as determined by AS/NZS 1170.1
	1	DL of crane	From wheel reactions due to DL of crane bridge and trolley
	2	Hoisted load	From maximum wheel reactions due to hoisted load
	3	Acceleration	Long travel: AS 5221.1/ISO 8686-5 Cross travel: AS 5221.1/ISO 8686-5
	4	Displacement	By analysis of the interaction between the structure and the crane
Occasional	5	In-service wind	See Clause 1.3.5 , with forces calculated in accordance with AS/NZS 1170.2
	6	Snow and ice	As determined by AS/NZS 1170.3
	7	Temperature	By analysis
	8	Skewing (oblique travel) ^{a, b}	AS 5221.1/ISO 8686-5
Exceptional	9 to 19 ^c	For off-vertical lifting, out-of-service wind load, buffer impact and other exceptional loads refer to AS 5221.1 or ISO 8686-5	
^a Not applicable to monorail beams supporting hoists, but applicable to runway girders supporting underslung bridge cranes.			
^b For the purposes of design for fatigue life, oblique travel loads shall be considered to be regular loads with a minimum frequency of 10 % of all travel events, unless individual assessment indicates a higher frequency, and shall be accounted for in the fatigue assessment (see Clause 6.1).			
^c Load types 9 to 19 are those listed as Exceptional loads type 1) to 11) in Table 3 of AS 5221.1:2021.			

C4.3(B) Wall cladding should not be supported from runway girders and/or associated surge trusses or surge plates. If this does occur, in-service wind should be the serviceability wind, if the cranes and girders are otherwise protected from wind loads, due to the higher operating wind speed expected, with the tributary area from the cladding accounted for. Under such circumstances, special attention should be given to the serviceability criteria.

4.4 Load combinations

4.4.1 General

Loads shall be combined in accordance with AS 5221.1 and ISO 8686-5, except as varied herein.

Load Type 1A shall be included with the Type 1 loads.

An additional load combination, B6, shall be applied to all runway girders supporting cranes. It shall consist of the following:

- (a) Mass of the crane, factored by ϕ_1 .
- (b) Mass of gross load, factored by ϕ_1 .
- (c) Acceleration from drives and deceleration from drives or brakes, factored by ϕ_1 .
- (d) Displacement-induced loads, unfactored.
- (e) Snow or ice loads, unfactored.

- (f) Temperature-induced loads, unfactored.
- (g) Oblique travel loads (skewing), unfactored.

Oblique travel (skewing) forces shall be calculated in accordance with AS 5221.1 and/or ISO 8686-5, obtained from the crane manufacturer, or estimated in accordance with [Appendix B](#) and then verified.

For a 4-wheel crane with independent long travel drives, the larger of the frictional lateral forces on the leading wheels, F_{Y11} and F_{Y21} according to AS 5221.1 or Y_1 and Y_4 (formerly Y_{11} and Y_{21}) according to ISO 8686-5, shall be applied as a load either outwards or inwards to the rail at the more heavily loaded leading wheel.

NOTE 1 If applying Figure E.3 of AS 5221.1:2021 to cranes with four flanged wheels, note that F_Y , the guide force imposed on the means of guidance, acts as shown in the figure: inwards on the crane's inner means of guidance at the left leading wheel, for the anti-clockwise skewing indicated. The net load on the rail and thus runway girder is then in the opposite direction, outwards on the left rail. If Figure E.3 is adjusted for clockwise skewing, the contact force on the means of guidance is inwards on the inner means of guidance at the right leading wheel and the net load on the rail is outwards on the right rail.

NOTE 2 Depending upon the location of the crab relative to the pattern of drive wheel tread wear, and upon the effective span of the rails as worn relative to the effective crane span between centres of tread width of the long travel wheels as worn, the guide force F_Y may act at the means of guidance at either the more heavily loaded or less heavily loaded leading wheels and the resulting load may act outwards or inwards on the rail.

When assessing the serviceability of structures supporting runway girders, a special load combination, B7, shall be considered, as detailed in [Clause 5.13.3.2](#).

C4.4.1 When assessing supporting structures for strength, load combinations should include those from Table 3 of AS 5221.1:2021 relating to combinations of in-service wind and crane loads, as well as load combination C2 for out-of-service wind plus stationary cranes. For structures in which the cranes and runways are fully shielded from wind, allowing operation at higher wind speeds, serviceability wind should be used in lieu of in-service wind, applying in that case to loads on the building rather than on the cranes and runways.

For design to AS 4100, load factors from AS/NZS 1170.0 and [Clause 4.4.4](#) herein shall be used and not the partial load (safety) factors in AS 5221.1 and ISO 8686-5.

4.4.2 Two or more cranes on the same runway

Notwithstanding the method of combining the loads given in AS 5221.1 and ISO 8686-5, where two or more cranes are intended to be installed on the same runway, the exceptions shown in [Table 4.4.2](#) for the load combinations shall apply.

The wheel loads shall be positioned such that the most unfavourable loading is obtained in the section being considered. The dynamic factors ϕ_1 and ϕ_2 for the highest capacity crane shall be in accordance with AS 5221.1 and ISO 8686-5. These dynamic factors may be reduced to 1.0 for other cranes.

C4.4.2 The intent is that if two or more cranes, or parts thereof, can possibly be within the same runway girder span between supports, or on adjacent spans of a continuous girder, the runway girders should be designed for the worst-case positioning of the cranes unless fail-safe means are provided to achieve the degree of separation upon which the design is based. Stating on design drawings or documentation "One crane per bay", or similar wording, without such means for crane separation does not satisfy this requirement. Similarly, use of proximity-based anti-collision systems to achieve the degree of separation required in a girder span should be carefully considered, as it is not the primary purpose of anti-collision systems and may not provide for fail-safe separation of the cranes. If methods of separation are used that are not fail-safe, allowance should be made in the design for the worst-case positioning of the cranes.

Table 4.4.2 — Permitted exceptions to load combinations

Crane operation	Variation to the load combination
Two cranes in tandem	Load Type 8 shall be applied only to the crane that gives the most unfavourable result for the crane runway.
Cranes at random	Load Types 3, 4 and 8, and off-vertical loads, out-of-service wind loads, test loads and buffer impact loads shall be applied only to the crane that gives the most unfavourable result for the crane runway.

4.4.3 Multiple bays

In the design of the supporting structure, e.g. columns and frames, where several parallel crane bays are in operation, the loads of Types 3 and 8 to 13 shall be applied to the crane in each bay that produces the most unfavourable results in the runway girder and the supporting structure.

4.4.4 Application of load combinations

The application of the load combinations for a runway girder can be illustrated as —

- (a) permissible stress method: Σ (dynamic factor $\times$ working static load); or
- (b) limit states design: Σ (dynamic factor $\times$ working static load $\times$ load factor), where the load factors used in the limit states design are as follows:

Hoisted load	1.5
Inertial loads	1.4
Permanent (dead) loads	1.2
Limit states wind load	1.0
Earthquake load	1.0
All other loads	1.5

Dynamic factors shall be determined in accordance with AS 5221.1 and/or ISO 8686-5.

In addition to the load combinations specified in [Clause 4.4.1](#), the runway shall be adequate for permanent (dead) loads only using a load factor of 1.35.

5 Design of runway girders and monorail beams

5.1 General

This section sets out the requirements for structural design of runway girders and monorail beams constructed from structural steel, and specific load and serviceability requirements for their supporting structures. [Clauses 5.3](#) and [5.7](#) to [5.10](#) generally apply to runway girders, while [Clause 5.12](#) has special provisions for monorail beams. [Clauses 5.2](#), [5.4](#) to [5.6](#), [5.11](#), [5.13](#) and [5.14](#) apply to both runway girders and monorail beams.

5.2 Forms of construction

5.2.1 General

The runway girders and monorail beams may be designed as simply supported, continuous or cantilevered, as illustrated in [Figure 5.2.1](#).

Where continuous runway girders or monorail beams are proposed, thermal expansion and maintenance-related issues shall be taken into account.

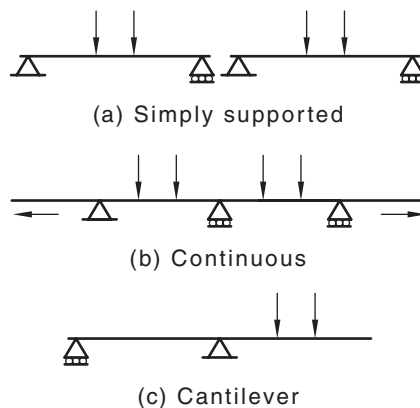


Figure 5.2.1 — Forms of construction

5.2.2 Simply supported girders

The girder span shall be taken as the distance between the points of application of the girder reactions. The bending moments and shear forces shall be determined by a procedure that allows the wheel load train to be positioned in a least favourable location that produces maximum load effects (moments or shears) at a particular section.

5.2.3 Continuous girders

The girder span shall be taken to be equal to the distance between the girder bearings. The bending moments and shear forces shall be determined by an elastic method of analysis. The loads shall be taken at their maximum or minimum value, as necessary, to obtain the least favourable load effects at any position on the girder. Loads in adjacent spans shall be positioned to obtain the worst load effects.

Semi-continuous girders featuring pin connections at or near quarter points are not recommended, as maintenance problems are usually encountered in these details.

The effects of differential lateral deflection of supports upon girders continuous over two or more spans shall be taken into account.

5.2.4 Cantilevered girders

The span of the cantilever shall be taken to be the distance between the centre of the bearing supports and the furthest possible location of the crane wheel at the free end. In computing the deflection at the outward wheel on the cantilever, the rotation of the structural members at the support shall be included.

5.2.5 Coped girders

Where the ends of girders are coping, adequate provision shall be made for the transfer of forces in the bottom flange by lapping or sloping it, as shown in [Figure 5.2.5](#).