

AS 4100:2020



STANDARDS
Australia



Steel structures

Currently in preview, click buy full version



AS 4100:2020

This Australian Standard ® was prepared by BD-001, Steel Structures. It was approved on behalf of the Council of Standards Australia on 31 July 2020.

This Standard was published on 21 August 2020.

The following are represented on Committee BD-001:

- Australian Building Codes Board
- Australian Chamber of Commerce and Industry
- Australian Industry Group
- Australian Steel Association
- Australian Steel Institute
- Austrroads
- Bureau of Steel Manufacturers of Australia
- Consult Australia
- Engineers Australia
- Rail Industry Safety and Standards Board
- University of New South Wales
- University of Sydney
- Weld Australia
- Western Sydney University

This Standard was issued in draft form for comment as DR AS 4100:2019.

Keeping Standards up-to-date

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

www.standards.org.au

ISBN 978 1 76072 947 9

Steel structures

Originated in part as SAA INT 351—1956.
Previous edition AS 4100—1998.
Third edition 2020.

© Standards Australia Limited 2020

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth).

Preface

This Standard was prepared by the Standards Australia Committee BD-001, Steel Structures, to supersede AS 4100—1998.

The objective of this Standard is to provide designers of steel structures with specifications for steel structural members used for load-carrying purposes in buildings and other structures.

Major changes to the 1998 edition include the following:

- (a) Reference to the “construction specification” (as the document containing the particular design data and details to be provided) as one deliverable from the design process. A definition of the construction specification consistent with that in AS/NZS 5131 has also been provided ([Clauses 1.3.16](#) and [1.6.2](#)).
- (b) Introduction of the definition of “construction category” and an informative appendix providing guidance on selection of the appropriate construction category, both consistent with AS/NZS 5131 ([Clauses 1.3.15](#) and [1.7.2](#), and [Appendix L](#)).
- (c) Definition and description of “architecturally exposed structural steelwork” (AESS) ([Clauses 1.3.3](#) and [1.7.3](#)).
- (d) Definition and treatment of “lamellar tearing” consistent with AS/NZS 1554.1 ([Clauses 1.3.40](#) and [3.8](#), and [Appendix M](#)).
- (e) Alignment with AS/NZS 5100.6:2017 (various clauses).
- (f) Referencing of AS/NZS 5131:2016 for the majority of requirements in the fabrication and erection sections of this Standard ([Sections 14](#) and [15](#)).
- (g) Alignment with AS/NZS 1252.1:2016, which includes introduction of an “alternative bolt assembly type” to EN 14399-3 System HR for grade 8.8 bolts and an “additional bolt assembly type” to EN 14399-3 System HR for grade 10.9 bolts. The Australian Steel Institute (ASI), Technical Note TN-001, *High strength structural bolt assemblies to AS/NZS 1252:2016*, provides background and basis for the revision to AS/NZS 1252:1996 ([Clauses 9.1.6](#), [9.3](#), [15.2](#)).
- (h) New specification of geometrical tolerances for fabrication and erection aligned with AS/NZS 5131 ([Clauses 14.4](#) and [15.3](#)).
- (i) New [Appendix K](#) “Statistical data”, aligned with AS/NZS 5100.6.
- (j) Inclusion of shear modulus G at elevated temperature in [Clause 12.4.2](#) and a new [Clause 12.4.3](#), Slenderness at elevated temperature

[Table M.2](#), Criteria affecting the target value of Z_{Ed} , was adapted with permission from Table 3.2 of EN 1993-1-10. Copyright © 2005. CEN, Belgium. www.cen.eu

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

Contents

Preface	ii
Section 1 Scope and general	1
1.1 Scope and exclusions	1
1.1.1 Scope	1
1.1.2 Exclusions	1
1.2 Normative references	1
1.3 Terms and definitions	1
1.4 Notation	10
1.5 Use of alternative materials or methods	24
1.5.1 General	24
1.5.2 Existing structures	24
1.6 Design	24
1.6.1 Design data	24
1.6.2 Design details	24
1.7 Workmanship	25
1.7.1 General	25
1.7.2 Construction category	25
1.7.3 Architecturally exposed structural steelwork	25
1.7.4 Fabrication and erection	26
Section 2 Materials	27
2.1 Yield stress and tensile strength used in design	27
2.1.1 Yield stress	27
2.1.2 Tensile strength	27
2.2 Structural steel	28
2.2.1 Australian Standards	28
2.2.2 Acceptance of steels	29
2.2.3 Unidentified steel	29
2.2.4 Properties of steel	29
2.2.5 Through-thickness deformation properties	29
2.3 Fasteners	30
2.3.1 Steel bolts, nuts and washers	30
2.3.2 Equivalent high strength fasteners	30
2.3.3 Welds	31
2.3.4 Welder studs	31
2.3.5 Exposed fasteners	31
2.3.6 Anchor bolts	31
2.3.7 Mechanical and chemical anchors	31
2.4 Steel castings	31
Section 3 General design requirements	32
3.1 Design	32
3.1.1 Aim	32
3.1.2 Requirements	32
3.2 Loads and other actions	32
3.2.1 Loads	32
3.2.2 Other actions	32
3.2.3 Design load combinations	33
3.2.4 Notional horizontal forces	33
3.2.5 Structural robustness	33
3.3 Stability limit state	33
3.4 Strength limit state	33
3.5 Serviceability limit state	34
3.5.1 General	34
3.5.2 Method	35
3.5.3 Deflection limits	35

3.5.4	Vibration of beams	35
3.5.5	Bolt serviceability limit state	35
3.5.6	Corrosion protection	35
3.6	Strength and serviceability limit states by load testing	36
3.7	Brittle fracture	36
3.8	Lamellar tearing	36
3.9	Fatigue	36
3.10	Fire	36
3.11	Earthquake	36
3.12	Other design requirements	37
3.13	Reliability management	37
Section 4	Methods of structural analysis	38
4.1	Methods of determining action effects	38
4.1.1	General	38
4.1.2	Definitions	38
4.2	Forms of construction assumed for structural analysis	38
4.2.1	General	38
4.2.2	Rigid construction	38
4.2.3	Semi-rigid construction	38
4.2.4	Simple construction	39
4.2.5	Design of connections	39
4.3	Assumptions for analysis	39
4.3.1	General	39
4.3.2	Span length	39
4.3.3	Arrangements of live loads for buildings	39
4.3.4	Simple construction	39
4.4	Elastic analysis	40
4.4.1	General	40
4.4.2	First-order elastic analysis	40
4.5	Plastic analysis	46
4.5.1	Application	46
4.5.2	Limitations	46
4.5.3	Assumptions of analysis	46
4.5.4	Second order effects	47
4.6	Member buckling analysis	47
4.6.1	General	47
4.6.2	Member elastic buckling load	47
4.6.3	Member effective length factor	47
4.7	Frame buckling analysis	51
4.7.1	General	51
4.7.2	In-plane frame buckling	51
Section 5	Members subject to bending	53
5.1	Design for bending moment	53
5.2	Section moment capacity for bending about a principal axis	54
5.2.1	General	54
5.2.2	Section slenderness	54
5.2.3	Compact sections	55
5.2.4	Non-compact sections	55
5.2.5	Slender sections	56
5.2.6	Elastic and plastic section moduli	56
5.3	Member capacity of segments with full lateral restraint	56
5.3.1	Member capacity	56
5.3.2	Segments with full lateral restraint	57
5.3.3	Critical section	58
5.4	Restraints	58
5.4.1	General	58
5.4.2	Restraints at a cross-section	59

5.4.3	Restraining elements.....	61
5.5	Critical flange.....	62
5.5.1	General.....	62
5.5.2	Segments with both ends restrained.....	62
5.5.3	Segments with one end unrestrained.....	62
5.6	Member capacity of segments without full lateral restraint.....	62
5.6.1	Segments fully or partially restrained at both ends.....	62
5.6.2	Segments unrestrained at one end.....	65
5.6.3	Effective length.....	77
5.6.4	Design by buckling analysis.....	74
5.7	Bending in a non-principal plane.....	69
5.7.1	Deflections constrained to a non-principal plane.....	69
5.7.2	Deflections unconstrained.....	69
5.8	Separators and diaphragms.....	69
5.9	Design of webs.....	70
5.9.1	General.....	70
5.9.2	Definition of web panel.....	70
5.9.3	Minimum thickness of web panel.....	70
5.10	Arrangement of webs.....	70
5.10.1	Unstiffened webs.....	70
5.10.2	Load bearing stiffeners.....	71
5.10.3	Side reinforcing plates.....	71
5.10.4	Transversely stiffened webs.....	71
5.10.5	Webs with longitudinal and transverse stiffeners.....	71
5.10.6	Webs of members designed plastically.....	71
5.10.7	Openings in webs.....	72
5.11	Shear capacity of webs.....	72
5.11.1	Shear capacity.....	72
5.11.2	Approximately uniform shear stress distribution.....	72
5.11.3	Non-uniform shear stress distribution.....	73
5.11.4	Shear yield capacity.....	73
5.11.5	Shear buckling capacity.....	74
5.12	Interaction of shear and bending.....	76
5.12.1	General.....	76
5.12.2	Proportional method.....	76
5.12.3	Shear and bending interaction method.....	76
5.13	Compressive bearing action on the edge of a web.....	77
5.13.1	Dispersion of force to web.....	77
5.13.2	Bearing capacity.....	77
5.13.3	Bearing yield capacity.....	77
5.13.4	Bearing buckling capacity.....	78
5.13.5	Combined bending and bearing of rectangular and square hollow sections.....	79
5.14	Design of load bearing stiffeners.....	81
5.14.1	Yield capacity.....	81
5.14.2	Buckling capacity.....	82
5.14.3	Outstand of stiffeners.....	83
5.14.4	Fitting of load bearing stiffeners.....	83
5.14.5	Design for torsional end restraint.....	83
5.15	Design of intermediate transverse web stiffeners.....	83
5.15.1	General.....	83
5.15.2	Spacing.....	84
5.15.3	Minimum area.....	84
5.15.4	Buckling capacity.....	84
5.15.5	Minimum stiffness.....	85
5.15.6	Outstand of stiffeners.....	85
5.15.7	External forces.....	85
5.15.8	Connection of intermediate stiffeners to web.....	85
5.15.9	End posts.....	86

5.16	Design of longitudinal web stiffeners	86
5.16.1	General	86
5.16.2	Minimum stiffness	86
Section 6	Members subject to axial compression	87
6.1	Design for axial compression	87
6.2	Nominal section capacity	87
6.2.1	General	87
6.2.2	Form factor	87
6.2.3	Plate element slenderness	88
6.2.4	Effective width	88
6.3	Nominal member capacity	89
6.3.1	Definitions	89
6.3.2	Effective length	89
6.3.3	Nominal capacity of a member of constant cross-section subject to flexural buckling	90
6.3.4	Nominal capacity of a member of varying cross-section	93
6.4	Laced and battened compression members	93
6.4.1	Design forces	93
6.4.2	Laced compression members	94
6.4.3	Battened compression member	95
6.5	Compression members back to back	96
6.5.1	Components separated	96
6.5.2	Components in contact	97
6.6	Restraints	98
6.6.1	Restraint systems	98
6.6.2	Restraining members and connections	98
6.6.3	Parallel braced compression members	98
Section 7	Members subject to axial tension	99
7.1	Design for axial tension	99
7.2	Nominal section capacity	99
7.3	Distribution of forces	99
7.3.1	End connections providing uniform force distribution	99
7.3.2	End connections providing non-uniform force distribution	100
7.4	Tension members with two or more main components	101
7.4.1	General	101
7.4.2	Design forces for connections	101
7.4.3	Tension member composed of two components back-to-back	101
7.4.4	Laced tension member	101
7.4.5	Battened tension member	101
7.5	Members with pin connections	102
Section 8	Members subject to combined actions	103
8.1	General	103
8.2	Design actions	103
8.3	Section capacity	103
8.3.1	General	103
8.3.2	Uniaxial bending about the major principal x-axis	104
8.3.3	Uniaxial bending about the minor principal y-axis	104
8.3.4	Biaxial bending	105
8.4	Member capacity	105
8.4.1	General	105
8.4.2	In-plane capacity — Elastic analysis	106
8.4.3	In-plane capacity — Plastic analysis	107
8.4.4	Out-of-plane capacity	109
8.4.5	Biaxial bending capacity	110
8.4.6	Eccentrically loaded double bolted or welded single angles in trusses	111
Section 9	Connections	113

9.1	General	113
9.1.1	Requirements for connections	113
9.1.2	Classification of connections	113
9.1.3	Design of connections	113
9.1.4	Minimum design actions on connections	114
9.1.5	Intersections	115
9.1.6	Choice of fasteners	115
9.1.7	Combined connections	115
9.1.8	Prying forces	115
9.1.9	Connection components	115
9.1.10	Deductions for fastener holes	116
9.1.11	Hollow section connections	117
9.2	Design of bolts	117
9.2.1	Bolts and bolting category	117
9.2.2	Bolt strength limit states	118
9.2.3	Bolt serviceability limit state	121
9.3	Assessment of the strength of a bolt group	122
9.3.1	Bolt group subject to in-plane loading	122
9.3.2	Bolt group subject to out-of-plane loading	123
9.3.3	Bolt group subject to combinations of in-plane and out-of-plane loadings	123
9.4	Design of a pin connection	123
9.4.1	Pin in shear	123
9.4.2	Pin in bearing	123
9.4.3	Pin in bending	124
9.4.4	Ply in bearing	124
9.5	Design details for bolts and pins	124
9.5.1	Minimum pitch	124
9.5.2	Minimum edge distance	125
9.5.3	Maximum pitch	125
9.5.4	Maximum edge distance	125
9.5.5	Holes	125
9.6	Design of welds	125
9.6.1	Scope	125
9.6.2	Complete and incomplete penetration butt welds	126
9.6.3	Fillet welds	129
9.6.4	Plug and slot welds	135
9.6.5	Compound weld	136
9.7	Assessment of the strength of a weld group	137
9.7.1	Weld group subject to in-plane loading	137
9.7.2	Weld group subject to out-of-plane loading	137
9.7.3	Weld group subject to in-plane and out-of-plane loading	138
9.7.4	Combination of weld types	138
9.8	Packaging in construction	138
Section 10	Brittle fracture	139
10.1	Methods	139
10.2	Notch-ductile range method	139
10.3	Design service temperature	139
10.3.1	General	139
10.3.2	Basic design temperature	139
10.3.3	Modifications to the basic design temperature	140
10.4	Material selection	140
10.4.1	Selection of steel type	140
10.4.2	Limitations	141
10.4.3	Modification for certain applications	141
10.4.4	Selection of steel grade	142
10.5	Fracture assessment	144
Section 11	Fatigue	145

11.1	General	145
11.1.1	Requirements	145
11.1.2	Notation	145
11.1.3	Limitation	146
11.1.4	Designation of weld category	146
11.1.5	Method	146
11.1.6	Thickness effect	147
11.2	Fatigue loading	147
11.3	Design spectrum	148
11.3.1	Stress determination	148
11.3.2	Design spectrum calculation	148
11.4	Exemption from assessment	149
11.5	Detail category	149
11.5.1	Detail categories for normal stress	149
11.5.2	Detail categories for shear stress	149
11.6	Fatigue strength	158
11.6.1	Definition of fatigue strength for normal stress	158
11.6.2	Definition of fatigue strength for shear stress	159
11.7	Exemption from further assessment	160
11.8	Fatigue assessment	160
11.8.1	Constant stress range	160
11.8.2	Variable stress range	161
11.9	Punching limitation	161
Section 12	Fire	162
12.1	Requirements	162
12.2	Definitions	162
12.3	Determination of period of structural adequacy	163
12.4	Variation of mechanical properties of steel with temperature	163
12.4.1	Variation of yield stress with temperature	163
12.4.2	Variation of modulus of elasticity and shear modulus with temperature	163
12.4.3	Slenderness at elevated temperature	164
12.5	Determination of limiting steel temperature	164
12.6	Determination of time at which limiting temperature is attained for protected members	165
12.6.1	Methods	165
12.6.2	Temperature based on test series	166
12.6.3	Temperature based on single test	167
12.7	Determination of time at which limiting temperature is attained for unprotected members	167
12.8	Determination of R _{SA} from a single test	168
12.9	Three-sided fire exposure condition	168
12.10	Special considerations	169
12.10.1	Connections	169
12.10.2	Web penetrations	169
Section 13	Earthquake	171
13.1	General	171
13.2	Definitions	171
13.3	Design and detailing requirements	171
13.3.1	General	171
13.3.2	Stiff elements	171
13.3.3	Non-structural elements	172
13.3.4	Structural ductility factor and structural performance factor	172
13.3.5	Requirements for "limited ductile" steel structures ($\mu = 2$)	172
13.3.6	Requirements for "moderately ductile" steel structures ($\mu = 3$)	172
13.3.7	Requirements for "fully ductile" structures ($\mu > 3$)	173
Section 14	Fabrication	174
14.1	General	174

14.2	Material.....	174
14.2.1	General.....	174
14.2.2	Identification.....	174
14.3	Fabrication procedures.....	174
14.3.1	General.....	174
14.3.2	Hole size.....	174
14.3.3	Bolting.....	176
14.4	Geometrical tolerances.....	176
14.4.1	General.....	176
14.4.2	Nonconformance of tolerances.....	177
Section 15	Erection.....	178
15.1	General.....	178
15.1.1	Rejection of an erected item.....	178
15.1.2	Safety during erection.....	178
15.2	Erection procedures.....	178
15.2.1	General.....	178
15.2.2	Assembly of a connection involving bolts.....	178
15.3	Geometrical tolerances.....	179
15.3.1	General.....	179
15.3.2	Nonconformance of tolerances.....	179
Section 16	Modification of existing structures.....	180
16.1	General.....	180
16.2	Materials.....	180
Section 17	Testing of structures or elements.....	181
17.1	General.....	181
17.1.1	Scope of Section.....	181
17.1.2	Circumstances requiring tests.....	181
17.2	Definitions.....	181
17.3	Test requirements.....	181
17.4	Proof testing.....	181
17.4.1	Application.....	181
17.4.2	Test load.....	181
17.4.3	Criteria for acceptance.....	182
17.5	Prototype testing.....	182
17.5.1	Test specimen.....	182
17.5.2	Test load.....	182
17.5.3	Criteria for acceptance.....	182
17.5.4	Acceptance of production units.....	182
17.6	Report of tests.....	182
Appendix A	(normative) Not used.....	184
Appendix B	(informative) Suggested deflection limits.....	185
Appendix C	(informative) Selection of corrosion protection requirements.....	187
Appendix D	(normative) Advanced structural analysis.....	189
Appendix E	(normative) Second order elastic analysis.....	190
Appendix F	(normative) Moment amplification for a sway member.....	191
Appendix G	(normative) Braced member buckling in frames.....	192
Appendix H	(informative) Elastic resistance to lateral buckling.....	194
Appendix I	(informative) Strength of stiffened web panels under combined actions.....	200
Appendix J	(normative) Standard test for evaluation of slip factor.....	203
Appendix K	(normative) Statistical data.....	207
Appendix L	(informative) Guidance on determination of the construction category.....	209

Appendix M (informative) Selection of materials for the avoidance of lamellar tearing	212
Bibliography	215

Australian Standard®

Steel structures

Section 1 Scope and general

1.1 Scope and exclusions

1.1.1 Scope

This Standard sets out minimum requirements for the design and the engineering aspects of fabrication and erection, and modification of steelwork in structures in accordance with the limit states design method.

This Standard applies to buildings, structures and cranes constructed of steel.

NOTE For design of box and longitudinally stiffened girders, refer to AS/NZS 5100.6.

1.1.2 Exclusions

This Standard does not apply to the following structures and materials:

- (a) Steel elements less than 3 mm thick, with the exception of sections in accordance with AS/NZS 1163 and packers.
- (b) Steel members for which the value of the yield stress used in design (f_y) exceeds 690 MPa.
- (c) Cold-formed members, other than those in accordance with AS/NZS 1163, which are designed in accordance with AS/NZS 4600.
- (d) Composite steel-concrete members, which are designed in accordance with AS/NZS 2327.
- (e) Road, railway and pedestrian bridges, which are designed in accordance with AS 5100.1, AS 5100.2 and AS/NZS 5100.6.

NOTE The general principles of design, fabrication, erection, and modification embodied in this Standard may be applied to steel-framed structures or members not specifically mentioned herein.

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.

NOTE Documents for informative purposes are listed in the Bibliography.

AS 1101.3, *Graphical symbols for general engineering, Part 3: Welding and non-destructive examination*

AS 1110.1, *ISO metric hexagon bolts and screws—Product grades A and B, Part 1: Bolts*

AS 1110.2, *ISO metric hexagon bolts and screws—Product grades A and B, Part 2: Screws*

AS 1111.1, *ISO metric hexagon bolts and screws—Product grade C, Part 1: Bolts*

AS 1111.2, *ISO metric hexagon bolts and screws—Product grade C, Part 2: Screws*

AS 1112.1, *ISO metric hexagon nuts, Part 1: Style 1—Product grades A and B*

AS 1112.2, *ISO metric hexagon nuts, Part 2: Style 2—Product grades A and B*

AS 1112.3, *ISO metric hexagon nuts, Part 3: Product grade C*

AS 1112.4, *ISO metric hexagon nuts, Part 4: Chamfered thin nuts—Product grades A and B*