

Australian Standard[®]

SAA Steel Structures Code

The following scientific, industrial and governmental organizations and departments were officially represented on the committee entrusted with the preparation of this standard:

Association of Consulting Engineers Australia
Australian Institute of Building
Australian Institute of Steel Construction
Australian Road Research Board
Australian Welding Research Association
Bureau of Steel Manufacturers of Australia
Confederation of Australian Industry
Department of Housing and Construction
Department of Public Works, N.S.W.
Department of Public Works, W.A.
Experimental Building Station
National Association of Australian State Road Authorities
University of Sydney

This standard, prepared by Committee BD/1, Steel Structures, was approved on behalf of the Council of the Standards Association of Australia on 7 November 1980, and was published on 1 March 1981.

Review of Australian Standards. *To keep abreast of progress in industry, Australian Standards are subject to periodic review and are kept up to date by the issue of amendments or new editions as necessary. It is important therefore that Standards users ensure that they are in possession of the latest edition, and any amendments thereto.*

Full details of all Australian Standards and related publications will be found in the Standards Australia Catalogue of Publications; this information is supplemented each month by the magazine 'The Australian Standard', which subscribing members receive, and which gives details of new publications, new editions and amendments, and of withdrawn Standards.

Suggestions for improvements to Australian Standards, addressed to the head office of Standards Australia, are welcomed. Notification of any inaccuracy or ambiguity found in an Australian Standard should be made without delay in order that the matter may be investigated and appropriate action taken.

Australian Standard[®]

SAA Steel Structures Code

First published	1972
Second edition	1975
Third edition	1981
Reprinted	1981
Amended	October 1982
Reprinted incorporating amendment	1982
Withdrawn	28 October 1991
Available superseded	29 June 1992
Incorporating: Amdt 2—1984	

PUBLISHED BY STANDARDS AUSTRALIA
(STANDARDS ASSOCIATION OF AUSTRALIA)
1 THE CRESCENT, HOMEBUSH, NSW 2140

ISBN 0 7262 2142 2



Documents

Document Sharing Hub

PREFACE

This edition of this standard was prepared by the Association's Committee on Steel Structures to supersede the 1975 edition. This edition is being issued prior to the preparation of the standard in 'limit state' format in order to simplify the use of the standard and to improve clarity. The opportunity has been taken to present the standard in A4, size, thus bringing it into line with the other major structural codes. There have not been any changes of major technical significance in this edition, but some editorial updating has been carried out.

The following have been amended (other than editorially):

- Clause 1.5.3 Technical Definitions
- Clause 1.6 Notation
- Clause 2.1.4 Unidentified Steel
- Clause 2.2.2 Rivets
- Clause 3.1 Loads
- Clause 4.3 Plate Thickness
- Clause 4.5 Sectional Areas of Bolts, Screwed Tension Rods and Rivets
- Clause 4.5.1 Bolts and Screwed Tension Rods
- Clause 5.4.1 Equal-flange I-beams of Channels
- Clause 5.5 Elastic Critical Stress
- Clause 5.10.2 Average Shear Stress in Rolled I-beams and Channels, Plate Girders, Box-sections, Rectangular and Circular Hollow Sections
- Clause 5.11.1 Maximum Permissible Stress
- Clause 5.13.1 Minimal Thickness
- Clause 5.13.3.1 Vertical Stiffeners
- Clause 6.9 Bearing Stresses
- Clause 7.5.3 Pin Connections
- Section 8 Combined Stresses
- Section 9 Design of Connections
- Clause 10.1 Plastic Design—General
- Clause 11.2.3 Length
- Clause 11.3.2 Cutting
- Clause 11.4.2 Setting Out Tolerances
- Appendix B Fatigue
- Appendix C Minimum Yield Stresses for Steel to AS 1163, AS 1204 and AS 1205
- Appendix D List of References on the Elastic Flexural Torsional buckling of Steel Beams
- Paragraph E.15 Application
- Paragraph E2 Effective Length of Struts in Tri-angulated Frames

Attention is drawn to the following Australian and British standards and other documents which may be required for use in connection with this standard:

- AS 1111 ISO Metric Hexagon Commercial Bolts and Screws

- AS 1112 ISO Metric Hexagon Nuts, Including Thin Nuts, Slotted Nuts and Castle Nuts
- AS 1131 Dimensions of Hot-rolled Structural Steel Sections
- AS 1163 Welded and Seamless Steel Hollow Sections for General Structural Purposes (Metric Units)
- AS 1170 SAA Loading Code
 - Part 1—Dead and Live Loads
 - Part 2—Wind forces
- AS 1204 Structural Steels—Ordinary Weldable Grades
- AS 1205 Structural Steels—Weather-resistant Weldable Grades
- AS 1227 General Requirements for the Supply of Hot-rolled Steel Plates, Sections, Piling and Bars for Structural Purposes
- AS 1252 General Grade High-strength Steel Bolts with Associated Nuts and Washers for Structural Engineering (ISO Metric Series)
- AS 1275 Metric Screw Threads for Fasteners (Based on ISO Recommendations)
- AS 1302 Steel Reinforcing Bars for Concrete
- AS 1303 Hard-drawn Steel Reinforcing Wire for Concrete (Metric Units)
- AS 1391 Methods for Tensile Testing of Metals
- AS 1418 SAA Crane Code
- AS 1480 SAA Concrete Structures Code
- AS 1511 SAA High-strength Structural Bolting Code
- AS 1538 SAA Cold-formed Steel Structures code
- AS 1554 SAA Structural Welding Code
- AS 1735 SAA Lift Code
- AS 2074 Steel Castings for General Engineering Purposes
- AS 2121 SAA Earthquake Code
- AS 2214 SAA Structural Welding Supervisors' Certification Code
- AS 2312 Guide to the Protection of Iron and Steel Against Exterior Atmospheric Corrosion
- AS Z5 Glossary of metal Welding Terms and Definitions
- SAA MA1—Manual on Steel Structures
- SAA MA1.5—Protection of Steel from Corrosion
- SAA MA1.8—Fabrication
- SAA MA1.9—Erection
- BS 5135 Metal-arc Welding of Carbon and Carbon Manganese Steels
- Supplement 1 (PD 3343) to BS 449, Part 1 Recommendations for Design

© Copyright — STANDARDS AUSTRALIA

Users of Standards are reminded that copyright subsists in all Standards Australia publications and software. Except where the Copyright Act allows and except where provided for below no publications or software produced by Standards Australia may be reproduced, stored in a retrieval system in any form or transmitted by any means without prior permission in writing from Standards Australia. Permission may be conditional on an appropriate royalty payment. Requests for permission and information on commercial software royalties should be directed to the head office of Standards Australia.

Standards Australia will permit up to 10 percent of the technical content pages of a Standard to be copied for use exclusively in-house by purchasers of the Standard without payment of a royalty or advice to Standards Australia.

Standards Australia will also permit the inclusion of its copyright material in computer software programs for no royalty payment provided such programs are used exclusively in-house by the creators of the programs.

Care should be taken to ensure that material used is from the current edition of the Standard and that it is updated whenever the Standard is amended or revised. The number and date of the Standard should therefore be clearly identified.

The use of material in print form or in computer software programs to be used commercially, with or without payment, in commercial contracts is subject to the payment of a royalty. This policy may be varied by Standards Australia at any time.

CONTENTS

SECTION		Page	SECTION		Page
SECTION 1.	SCOPE AND GENERAL		SECTION 7.	DESIGN OF TENSION MEMBERS	
1.1	Scope	4	7.1	Axial Stresses in Tension Members	30
1.2	Standards	4	7.2	Tension Members subjected Bending	30
1.3	New Materials or Methods	4	7.3	Distribution of Forces	30
1.4	Design and Supervision	4	7.4	Tension Members with Two or More Main Components	31
1.5	Definitions	4	7.5	Connections	31
1.6	Notation	5	7.6	Bearing Stresses	32
SECTION 2.	MATERIALS		SECTION 8.	COMBINED STRESSES	
2.1	Structural Steel	7	8.1	General	33
2.2	Fasteners and Electrodes	7	8.2	Individual Moments and Forces	33
2.3	Steel Castings	7	8.3	Direct Stress Combinations	33
2.4	Concrete	7	SECTION 9.	DESIGN OF CONNECTIONS	
SECTION 3.	GENERAL DESIGN REQUIREMENTS		9.1	Minimum Design Force on Connections	35
3.1	Loads	8	9.2	Choice of Fasteners	35
3.2	Design Methods	8	9.3	Combined Connections	35
3.3	Other Design Considerations	9	9.4	Connection Stiffeners	35
SECTION 4.	GEOMETRICAL PROPERTIES		9.5	Stresses in Bolts, Screwed Tension Rods, Rivets and Pins	35
4.1	General	11	9.6	Design Details for Fasteners	35
4.2	Geometrical Properties for Calculating Bending Stresses	11	9.7	Design Details for Pins	36
4.3	Plate Thickness	11	9.8	Welds	36
4.4	Holes	11	9.9	Packing	37
4.5	Sectional Areas of Bolts, Screwed Tension Rods and Rivets	12	SECTION 10.	PLASTIC DESIGN	
4.6	Maximum Slenderness Ratios	12	10.1	General	38
SECTION 5.	DESIGN OF BEAMS		10.2	Beams	38
5.1	General	13	10.3	Tension Members	38
5.2	Maximum Permissible Stress	13	10.4	Struts	38
5.3	Maximum Permissible Compressive Stress	13	10.5	Members Subjected to Combined Bending and Axial Force	38
5.4	Maximum Permissible Stress in a Beam Bent About the Axis of Maximum Strength	33	10.6	Shear	38
5.5	Elastic Critical Stress	16	10.7	Stability	38
5.6	Bending Stress for Cased Beams	16	10.8	Minimum Thicknesses	39
5.7	Purlins and Girts	16	10.9	Lateral Restraints	39
5.8	Effective Span of Beams	16	10.10	Web Stiffening	39
5.9	Effective Length of Beams for Lateral Buckling	18	10.11	Load Capacities of Connections	39
5.10	Shear	18	SECTION 11.	FABRICATION AND ERECTION	
5.11	Bearing Stresses	20	11.1	General	40
5.12	Flange Details	20	11.2	Tolerances	40
5.13	Web Details	20	11.3	Fabrication Procedures	40
5.14	Separators and Diaphragms	23	11.4	Erection	41
SECTION 6.	DESIGN OF STRUTS		APPENDICES		
6.1	Axial Stresses in Uncased Struts	25	A	Deflection	43
6.2	Axial Forces in Cased Struts	25	B	Fatigue	44
6.3	Effective Length of Struts	24	C	Minimum Yield Stresses for Steel to AS 1163, 1204 and 1205	50
6.4	Eccentricity for Struts	26	D	List of References on the Elastic Flexural-Torsional Buckling of Steel Beams	52
6.5	Splices	26	E	Effective Length of Struts	53
6.6	Struts With Two or More Main Components in Contact	26	INDEX		56
6.7	Struts With Two Separated Components	26			
6.8	Caps and Bases for Struts	29			
6.9	Bearing Stresses	29			

STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard
for
THE USE OF STEEL IN STRUCTURES

SECTION 1. SCOPE AND GENERAL

1.1 SCOPE. This standard applies to the design, fabrication, erection, repair and alteration of steel-work in structures, including foot and service bridges.

The standard does not apply to the following structures and materials:

- (a) Road and railway bridges.
- (b) Material less than 3 mm thick.
- (c) Steel for which the value F_Y used in design exceeds 450 MPa.
- (d) Cold-formed members other than those complying with AS 1163.

NOTES:

1. The use of cold-formed steel sections in structures is covered by AS 1538. Reference should also be made to Addendum No 1 to BS 449 (PD 4064), and the AISI* Cold-formed Steel Design Manual.
2. Packings may be of any thickness.

1.2 STANDARDS. Unless otherwise noted, a standard referred to in this standard is the current edition thereof.

1.3 NEW MATERIALS OR METHODS. This standard shall not be interpreted to prevent the use of materials or of methods of design or construction not specifically referred to herein. If it is desired to seek the opinion of the SAA Committee on Steel Structures as to whether materials other than those specified, or methods of design or construction not covered herein, are deemed to comply with the intention of this standard, details of such materials or methods, including relevant test results, shall be submitted to the Committee.

NOTE: It will be necessary to seek approval from the Building Authority for the use of new materials or methods.

1.4 DESIGN AND SUPERVISION.

1.4.1 Design. The design of a structure or the part of a structure to which this standard is applied shall be the responsibility of an engineer experienced in the design of such structures.

For the purposes of this standard the term 'Design Engineer' shall mean the engineer responsible for design and shall include his representative.

1.4.2 Supervision. All stages of construction of a structure or the part of a structure to which this standard is applied shall be adequately supervised to ensure that all the requirements of the design are satisfied in the completed structure. Supervision shall be the responsibility of either—

- (a) the Design Engineer, or
- (b) an engineer experienced in such supervision.

For the purposes of this standard, the term 'Supervising Engineer' shall mean the engineer responsible for supervision of construction and shall include his representative.

NOTES:

1. Although the execution of design and supervision may be delegated to other acceptable persons who need not necessarily be qualified, Clause 1.4 requires that design and supervision be the responsibility of qualified and experienced persons.
2. The Clause does not require the Design Engineer to be responsible for supervision also unless he has been assigned this responsibility specifically. The Design Engineer and the Supervising Engineer need not be the same person.
3. Welding inspectors should be qualified to the requirements of AS 2214.

1.5 DEFINITIONS.

1.5.1 General. For the purposes of this standard, the definitions in Clauses 1.5.2 to 1.5.4 shall apply.

NOTE: Other terms having special meanings are defined in the Clause in which they occur.

1.5.2 Administrative Definitions.

1.5.2.1 Approved—according to the context, approved either by the Engineer or the Building Authority.

1.5.2.2 Building Authority—a body having statutory powers to control the design and erection of buildings or structures in the area in which the building or structure concerned is to be erected.

1.5.2.3 Contractor—the person, persons or organization agreeing under a contract to execute the work.

1.5.2.4 Engineer—a person qualified for Corporate Membership of the Institution of Engineers, Australia. (See Clause 1.4.)

NOTE: The definition of engineer does not require that an engineer be a Corporate Member of the Institution of Engineers, Australia.

1.5.3 Technical Definitions.

1.5.3.1 Beam or girder—a structural member, other than a triangulated frame, which supports load primarily by its internal resistance to bending.

1.5.3.2 Dead load—the actual weight of all permanent construction and all permanently installed plant, equipment, and services required for functional purposes.

* American Iron and Steel Institute.

1.5.3.3 Footing—a part of the building or structure in direct contact with and transmitting load to the supporting foundation.

1.5.3.4 Foundation—the soil, sub-soil or rock, either built up or natural, upon which a structure is supported.

1.5.3.5 Gauge—the transverse spacing between parallel adjacent lines of fasteners.

1.5.3.6 High strength bolt—a bolt manufactured to AS 1252 or an equivalent fastener as defined in AS 1511.

1.5.3.7 Live load—the load assumed to arise from the intended use or purpose of a structure, including distributed, concentrated, impact and inertial forces, but excluding wind, snow and earthquake forces.

1.5.3.8 Load factor—the numerical value by which the load which would cause failure of a structure is divided, to give the maximum permissible working load on the structure.

1.5.3.9 Partition—a wall employed solely for the purpose of subdividing a storey of a building into sections and which is not intended to support any load other than its own weight.

1.5.3.10 Pitch—the centre distance between individual fasteners in a line of fasteners.

1.5.3.11 Strut—a compression member including a column or stanchion.

1.5.3.12 Substructure—the general structural base upon which the remainder of a structure is supported, comprising the footings and any retaining or like wall supported by the ground.

1.5.3.13 Tensile strength—the ultimate tensile strength of a steel or electrode as defined in the appropriate Australian Standard.

1.5.3.14 Wind forces—forces on a structure resulting from wind pressure.

1.5.3.15 Yield stress—the minimum yield stress in tension specified for the grade of steel in the appropriate Australian standard.

1.5.4 Welding Terms. Welding terms shall have the meanings given in AS Z5.

1.6 NOTATION. The notation used in any of the Clauses shall have the following meanings with respect to the structure, or member or condition to which the Clause is applied, unless otherwise defined elsewhere in this standard. Unless otherwise stated, a dimension shall mean as specified dimension.

NOTE: The subscripts x, y denote the X-X and Y-Y axes of the section, respectively, X-X denotes the major principal axis, and Y-Y denotes the minor principal axis.

A_g = the gross cross-sectional area of a concrete-encased strut neglecting any casing in excess of 75 mm from the overall dimensions of the steel section and neglecting any applied finish

A_s = the effective cross-sectional area of a steel member

A_w = the effective sectional area resisting shear for calculating the average shear stress or the maximum shear capacity in a member

B = the overall width of the flange of a section

b = the lesser clear dimension of a web panel

b_1 = the outstand of a flange or stiffener beyond the line of connections to a web, or other line of support

b_2 = the unsupported width of a flange or element between two adjacent faces of support or between two adjacent lines of connections to other elements of the member.

D = the overall depth of a section measured parallel to the web

d = the clear depth of the web of a rolled I-section or channel between root fillets

d_1 = for the web of a beam without horizontal stiffeners, the clear distance between the flanges, neglecting fillets, or the clear distance between the inner toes of the flange angles, as appropriate

= for the web of a beam with horizontal stiffeners, the clear distance between the horizontal stiffener and the tension flange, neglecting fillets, or the inner toes of the tension flange angles, as appropriate

d_2 = twice the clear distance from the neutral axis of a beam to the compression flange, neglecting fillets, or the inner toes of the flange angles, as appropriate

E = the modulus of elasticity for steel, taken as 2×10^5 MPa in this standard

F'_c = the minimum compressive strength of concrete as defined in AS 1480

F_{ac} = the maximum permissible compressive stress in an axially loaded strut not subjected to bending

F_{at} = the maximum permissible tensile stress in an axially loaded tension member not subjected to bending

F_b = the maximum permissible stress due to bending in a member not subjected to axial force

F_{bc} = the maximum permissible compressive stress due to bending in a member not subjected to axial force

F_{bt} = the maximum permissible tensile stress due to bending in a member not subjected to axial force

F_{ob} = the elastic buckling stress of a beam

F_{oc} = the elastic buckling stress of a strut

F_p = the maximum permissible stress in bearing in a member

F_u = the tensile strength pertaining to the steel used in a member

F_v = the maximum permissible average stress in shear in a member

F_{vm} = the maximum permissible stress in shear in a member

F_Y = the yield stress pertaining to the steel used in a member; where F_Y is used in a dimensionally inconsistent expression in this standard, its value shall be expressed in MPa (see Appendix C)

f_{ac} = the calculated average stress in a member due to an axial compressive force

f_{at}	= the calculated average stress in a member due to an axial tensile force	P_y	= the calculated maximum load capacity of a tension member
f_{bc}	= the calculated compressive stress in a member due to bending about a principal axis	Q	= a force applied transversely to a member
f_{bt}	= the calculated tensile stress in a member due to bending about both principal axes	R	= the reaction of a beam at a support
I_s	= the second moment of area (moment of inertia) of the cross-section of a pair of web stiffeners about the centreline of a beam web, or of a single stiffener about the face of a beam web, as appropriate	r	= the radius of gyration of a section
L	= the span of a member	S	= the longitudinal spacing between the centres of successive vertical stiffeners in a beam
l	= the effective length of a beam or strut	T	= in a flanged section, the mean thickness of the flange, or the area of the flange divided by its width, or the thickness of the flange as given in AS 1131, as appropriate
M_p	= the calculated maximum moment capacity of a beam	T_1	= the thickness of the flange of a section or of a plate in compression, or the aggregate thickness of plates if connected together in accordance with Section 9, as appropriate
M_{pc}	= the calculated maximum moment capacity of a member subjected to bending and axial load	t	= the thickness of the web of a section
P	= an axial force, compressive or tensile, in a member or part of a member	t_T	= the thickness of the thinner of two components joined
P_{ac}	= the calculated maximum load capacity of a strut	W	= the total load on a beam between supports

SECTION 2. MATERIALS

2.1 STRUCTURAL STEEL.

2.1.1 Australian Standards. Except as otherwise permitted in Clause 2.1.2 below, all structural steel coming within the scope of this standard shall, before fabrication, comply with the requirements of the following Australian standards, as appropriate:

AS 1131	Dimensions of Hot-rolled Structural Steel Sections
AS 1163	Structural Steel Hollow Sections
AS 1204	Structural Steels—Ordinary Weldable Grades
AS 1205	Structural Steels—Weather-resistant Weldable Grades

NOTE: See also Clause 3.3.8.

2.1.2 Other Structural Steels. If structural steels or shapes other than those referred to in Clause 2.1.1 are used they shall comply with Australian standards or with specifications issued by bodies accredited by the Building Authority, such as the British Standards Institution and the American Society for Testing and Materials. The maximum value of the yield stress F_y to be used in the application of this standard shall be 450 MPa. A steel intended to be welded shall be suitable for welding.

2.1.3 Acceptance of Steels. Certified mill test reports, or test certificates issued by the mill shall constitute sufficient evidence of compliance with material specifications referred to in this standard. At the discretion of the Design Engineer, and subject to the approval of the Building Authority, it shall be permissible to use a test certificate provided by an approved testing laboratory or an affidavit from the fabricator instead of a certified mill test report or mill test certificates.

2.1.4 Unidentified Steel. If unidentified steel is used it shall be free from surface imperfections, and shall be

used only where the particular physical properties of the steel and its weldability will not adversely affect the strength and serviceability of the structure. Unless a full test in accordance with AS 1391 is made, the yield stress F_y of the steel for design purposes shall be taken as not exceeding 170 MPa.

2.2 FASTENERS AND ELECTRODES.

2.2.1 Steel Bolts, Nuts and Washers. Steel bolts, nuts and washers shall comply with the following standards, as appropriate:

AS 1110	ISO Metric Hexagon Precision Bolts
AS 1111	ISO Metric Hexagon Commercial Bolts
AS 1112	ISO Metric Hexagon Nuts including Thin Nuts, Slotted Nuts and Castle Nuts
AS 1252	General Grade High Strength Steel Bolts with Associated Nuts and Washers for Structural Engineering (ISO Metric Series)
AS 1559	Tower Bolts with Associated Nuts and Washers (Metric Series)

Other high-strength fasteners may be used provided that they comply with the requirements for 'equivalent fasteners' as defined in AS 1511.

2.2.2 Rivets. All rivets shall comply with an approved standard.

2.2.3 Electrodes. All electrodes shall comply with the appropriate requirements of AS 1554.

2.3 STEEL CASTINGS. All steel castings shall comply with the appropriate requirements of AS 2074.

2.4 CONCRETE. Unless otherwise required by this standard, all structural and fire-protective concrete used in association with structural steel shall comply with the appropriate requirements of AS 1480.

SECTION 3. GENERAL DESIGN REQUIREMENTS

3.1 LOADS. A structure, and part of a structure shall be designed for the loads laid down by the following standards, as appropriate:

AS 1170 SAA Loading Code
Part 1-Dead and Live Loads
Part 2-Wind Forces

AS 1418 SAA Crane Code

AS 1735 SAA Lift Code

NOTE: Attention is drawn to AS 2121, SAA Earthquake Code, where it is required to take earthquake forces into account.

3.2 DESIGN METHODS.

3.2.1 General. A structure and part of a structure shall be capable of sustaining the most adverse combination of static and dynamic forces that may reasonably be expected from all the loads specified in Clause 3.1. Except as qualified by Clause 3.2.4 or where a load factor is applicable, every part of the structure shall be so proportioned that the permissible stresses specified in this standard are not exceeded. Where applicable, a load factor used in design shall not be less than that specified in this standard.

A design method specified in this standard shall be used, at the choice of the Design Engineer, as the basis for design. The stiffness, stability and serviceability of the structure shall be such that the appropriate requirements of Clause 3.3 are satisfied.

3.2.2 Simple Design Method. The method specified herein and known as the simple design method, applies to the design of a structure, or part of a structure, in which the ends of members will not develop restraining moments adversely affecting the remainder of the structure or its parts.

(a) *Rectangular framed structures, conventional method.* For the purpose of this method of design for a rectangular framed structure, the following assumptions shall be made:

- (i) Beams and trusses are simply supported.
- (ii) All connections of beams and trusses are subjected to reaction shear forces applied to the eccentricity appropriate to the connection detail.
- (iii) Members in compression are subjected to axial forces applied at the eccentricities given by applying Clause 6.4 and have the effective lengths given in Clause 6.3.
- (iv) Members in tension are subjected to concentric axial forces applied over the net area of the section, as specified in Clause 7.3.

(b) *Rectangular framed structures, wind connection method.* If a rectangular framed structure is designed for vertical loads using (a) above, the lateral forces may be assumed to be carried by fully rigid connection action in accordance with Clause 3.2.3, Method 1, if the structure complies with the following requirements:

- (i) Under lateral forces, the connections shall be designed elastically and shall satisfy Section 9.

- (ii) Under vertical forces, only the welds and fasteners used in the connections shall satisfy Section 9, and the remaining elements of the cross-section shall possess sufficient deformation capacity to ensure that over-stressing of the welds or fasteners cannot occur.
- (iii) Where welds or fasteners are stressed by both lateral and vertical forces the combined stresses shall satisfy the requirements of Section 9.

(c) *Triangulated structures.* For the purpose of this method of design for a triangulated structure, axial forces shall be found by assuming that all members are pin connected. Where any eccentricity occurs, all stresses arising therefrom shall be kept within the limits of this standard.

3.2.3 Fully Rigid Design Method. The method specified herein, and known as the fully rigid design method, applies to the design of a structure, or part of a structure, in which the beam-to-strut connections have sufficient rigidity to hold the angles between the members virtually unchanged irrespective of the load.

A structure and part of a structure proportioned according to this method shall be analysed using one of the following methods:

Method 1. Adequate elastic analysis to show that the permissible stresses specified in this standard are not exceeded.

Method 2. Adequate analysis to show the load-carrying capacity is not less than that required when a load factor of 1/0.60 is applied to the loads or to the load combinations in Clause 3.3.1. The structure or part shall also comply with Section 10. Nevertheless, the deflections and other movements under working loads shall not exceed the limits imposed by Clause 3.3.5.

3.2.4 Semi-rigid Design Method. The method specified herein, and known as the semi-rigid design method, applies to the design of a structure, or part of a structure, in which the connections between the members are capable of furnishing a dependable and known degree of flexural restraint in accordance with the recommendations of Supplement No 1 (PD3343) to BS 449, or as specified below.

In cases where this method of design is employed, calculations based on general or particular experimental evidence shall be made to show that the stresses in the structure are nowhere in excess of the appropriate stresses laid down in this standard. Alternatively, where riveted or bolted connections are employed, and only steel with a yield stress not exceeding 280 MPa is used, the requirements of this standard with respect to stresses shall be deemed to be satisfied if the design is made in accordance with Supplement No 1 to BS 449. The design of continuous struts shall comply with Clause 6.4.

3.2.5 Experimentally Based Design. Where a structure is of an unconventional or complex nature and the Design

Engineer shows by full-scale or model tests that the limits on deflections, stability and serviceability, and stress or load factor imposed by Clause 3.2.1 are satisfied, the corresponding design requirements of this standard shall be deemed also to have been satisfied, subject to the following conditions:

- (a) In the case of a full-scale test of a prototype structure, the prototype shall be accurately measured before testing to determine the dimensional tolerances in all relevant parts of the structure. The tolerances then specified on the drawings shall be such that all successive structures shall be in practical conformity with the prototype.

Where the design is based on failure loads, a load factor of not less than 2.0, on the loads or load combinations in Clause 3.3.1 shall be used.

Loading devices shall be previously calibrated, and care shall be exercised to ensure that no artificial restraints are applied to the prototype by the loading systems.

The distribution and durations of forces applied in the test shall be representative of those to which the structure is deemed to be subjected under this standard.

- (b) In the case where design is based on the testing of a small-scale model structure, the model shall be constructed with due regard for the principles of dimensional similarity. The thrusts, moments and deformations under workings loads shall be determined by physical measurements made when the loading is applied to simulate the conditions assumed in the design of the actual structure.
- (c) When it is desired to justify a structure or any of its parts by testing a prototype or model, prior notice shall be given to the Building Authority, and all the relevant tests shall be carried out to the satisfaction of the Authority.

3.3 OTHER DESIGN CONSIDERATIONS.

3.3.1 Loading Combinations. A structure or part of a structure shall be so designed that the maximum permissible stress is not exceeded under any of the following load combinations:

- (a) $X_D + X_L$;
 (b) $0.75 (X_D + X_L + X_w)$; or
 (c) $X_D' + X_w'$;

where

- X_D = dead load
 X_L = live load
 X_w = wind load
 X_w' = wind load causing stresses of the opposite sign to the dead load
 X_D' = that part of the dead load which cannot be removed from the structure

3.3.2 Stability. A structure shall comply with the following requirements for stability:

- (a) The stability of a structure as a whole and of each part shall be investigated, and weight and anchorage shall be provided so that the structure or part is in equilibrium for the resultant of —

1.0 times the whole of the dead load tending to prevent overturning,

1.2 times the dead load, if any, tending to cause overturning, and

1.4 times the static-load equivalent of other loads tending to cause overturning.

- (b) Due account shall be taken of possible variations in loading during construction and repair or other temporary conditions, so as to ensure stability at all times.

3.3.3 Lateral Forces. Adequate provision shall be made to resist the lateral forces that can occur during and after erection of a structure. Where the lateral forces cause twisting in a structural frame, provision shall be made to resist all resulting increases in horizontal shear but all resulting decreases in horizontal shear shall be neglected in the design.

When considering the effect of lateral forces proper allowance shall be made for the strength and stiffness of all structural components as follows:

- (a) Where structural components such as walls, roofs, floors and other additional bracing structure are capable of transmitting all lateral forces to the substructure, it shall be deemed that the structural steelwork is not loaded by such forces.
- (b) Where these other structural components are strong enough to transmit only part of the lateral forces to the substructure, the lateral forces shall be distributed through the structural system in accordance with the relative stiffnesses of the frame and other components, and the structural steelwork shall be designed accordingly.
- (c) Where resistance to lateral forces provided by other structural components is obviously low or not ascertainable, the structural steelwork shall be designed to resist all the lateral forces and transmit them to the substructure.

3.3.4 Lateral Restraining Systems.

3.3.4.1 General. Lateral restraints required to act as intermediate lateral restraints for beams (Clause 5.9.2.2) or to reduce the effective lengths of struts shall meet the requirements of this Clause (3.3.4).

3.3.4.2 Forces. A single lateral restraint shall be designed to resist a force of $0.025P$, in addition to any other forces to which it may be subjected, where P is the maximum axial force in the critical flange or chord.

3.3.4.3 Stiffness. A single lateral restraint shall be designed in such a way that the transverse deflection of the critical flange or chord at the point being restrained shall not exceed $0.0025L$, where L is the span of the restrained member (Clause 5.8), when subjected to the force of $0.025P$ defined in Clause 3.3.4.2. This is equivalent of a minimum force/extension stiffness of $10P/L$.

3.3.4.4 Multiple restraints. When more than one lateral restraint is used and the various restraints are uniformly distributed along the restrained member, then the force and stiffness requirements defined in Clauses 3.3.4.2 and 3.3.4.3 shall be distributed evenly amongst the various restraints, provided that the stiffness of an individual brace shall not be less than $4P/L$.

3.3.4.5 Parallel restrained members. When a series of parallel members are restrained by a line of restraints, the forces and stiffnesses determined by Clauses 3.3.4.2 and 3.3.4.3 shall be summed for all members and the restraints designed for the total force and stiffness so obtained. However, for seven or more parallel members, only the seven members with the largest P values need be considered.

3.3.4.6 Attachment of restraints. Lateral restraints shall be attached to a beam such that the force defined in Clause 3.3.4.2 can be transferred and such that the critical flange or chord deflection limit laid down in Clause 3.3.4.3 is not exceeded.

3.3.4.7 Critical flange or chord. The critical flange or chord of a member is that part which would deflect the furthest during buckling in the absence of the restraint being designed. If an exact analysis is not available this shall be determined as follows:

- (a) When adjacent points of load application are restrained, the critical flange or chord of a beam between such points is the compression flange or chord.
- (b) When a point of gravity load application is unrestrained, the critical flange or chord is the top flange.
- (c) When the load is directly due to wind, the critical flange is the windward flange.

3.3.5 Deflection. Under the most adverse loading conditions, the deflections of neither a structure as a whole, nor any of its parts, shall be such as will impair the strength or serviceability of the structure or part, or lead to damage of other building components, or be unsightly. The responsibility for selecting deflection

limits used in design shall rest with the Design Engineer.

NOTE: Guidance on maximum permissible deflections in specific cases is given in Appendix A.

3.3.6 Fatigue. For members subjected to frequent fluctuations of live load, the maximum permissible stress range shall be determined in accordance with Appendix B, as appropriate to the number of cycles, the class of constructional details adopted, and the materials used.

3.3.7 Corrosion Protection. Where steelwork in a structure is to be exposed to a corrosive environment, the steelwork shall be given adequate protection against corrosion, and the Design Engineer shall specify this protection. The degree of protection to be employed shall be determined after consideration has been given to use of the structure, climatic or other local conditions, and maintenance provisions.

NOTE: Recommendations for corrosion protection may be found in AS 2312 and SAA MA1.5.

3.3.8 Brittle Fracture. Where steelwork in a structure is welded and parts subject to tensile stress may become liable to brittle fracture, an assessment of the required notch toughness of the fabricated steel may be made using the guidance given in Appendix D of AS 1554, Part 1.

NOTE: Welded structures of steel to AS 1204 are normally satisfactory but, under certain conditions, parts subjected to tensile stress may become liable to brittle fracture.

This type of failure should be considered possible when there is any combination of low temperatures and the following factors; thick plates or thick sections; reduction in the ductility of the steel connections or details giving rise to severe stress concentrations; or the possibility of undetected defects in welding such as cracks or lack of fusion or root penetration.

Specialist literature dealing with the problem of brittle fracture may also be consulted. (Refer to AWRA Technical Note 10 'Fracture Mechanics').

SECTION 4. GEOMETRICAL PROPERTIES

4.1 GENERAL. The geometrical properties of the gross and the effective cross-sections of a member or part of a member, shall be calculated on the following bases:

- (a) The properties of the gross cross-section shall be calculated from the specified size of the member or part.
- (b) The properties of the effective cross-section shall be calculated by deducting from the area of the gross section the following:
 - (i) The cross-sectional areas of excessive plate widths as given in Clause 4.3.
 - (ii) The sectional areas of all holes in the section, except that for parts in compression, a bolt or rivet hole shall not be a deduction. (See Clause 4.4.)

4.2 GEOMETRICAL PROPERTIES FOR CALCULATING BENDING STRESSES. It shall be permissible to calculate the bending stresses in a beam or girder by using properties equivalent to those of the effective cross-section. Such equivalent properties shall be obtained by multiplying the properties of the gross cross-section by the ratio of the effective flange cross-sectional area to the gross flange cross-sectional area.

In welded construction the flange cross-sectional area shall be that of the flange plates alone.

In bolted or riveted construction, the cross-sectional area of the flanges shall be taken as the sum of the cross-sectional areas of the flange plates, flange angles and the portion of the web and side plates (if any) between the flange angles.

4.3 PLATE THICKNESSES.

4.3.1 Plate and Flange Outstands. If the projection, b_1 , of a plate or flange beyond its connection to a web, or other line of support or the like, exceeds the relevant values given in (a), (b) and (c) below, the area of the excess flange shall be neglected when calculating the effective geometrical properties of the section.

- (a) Flanges and plates in compression with un-stiffened edges $256T_1/\sqrt{F_Y}$.
- (b) Flanges and plates in compression with stiffened edges $20T_1$ to the inner face of the stiffening.
Stiffened flanges shall include flanges composed of channel or I-sections or of plates with continuously stiffened edges.
- (c) Flanges and plates in tension $20T_1$.

In this Clause, T_1 shall be taken to be the thickness of the plate, irrespective of whether the plate is a flange or other part of the member.

4.3.2 Flanges and Plates-Unsupported Widths. Where a plate is connected to other parts of a built-up member along lines generally parallel to the longitudinal axis of the member, the width, b_2 , (see Clause 1.6):

- (a) For plates in uniform compression $\frac{1440}{\sqrt{F_Y}} T_1$

However, where the width exceeds—

$\frac{560}{\sqrt{F_Y}} T_1$ for welded plates which are not stress-relieved, or

$\frac{800}{\sqrt{F_Y}} T_1$ for other plates,

or $\frac{635}{\sqrt{F_Y}} T_1$ for cold-formed hollow section members

the excess width shall be assumed to be located centrally, and its sectional area shall be neglected when calculating the effective geometrical properties of the section.

- (b) For plates in uniform tension $100T_1$.

However, where the width exceeds $60T_1$, the excess width shall be assumed to be located centrally, and its sectional area shall be neglected when calculating the geometrical properties of the section.

In this Clause, T_1 shall be taken to be the thickness of the plate, irrespective of whether the plate is a flange or a web of the member.

4.3.3 Circular Hollow Sections. If a circular hollow section is used as a strut or a beam, the effective geometrical properties of the section shall be calculated using the specified outside diameter and a value for wall thickness which shall be the lesser of—

$$\frac{23 \times 10^3}{F_Y (D/t)} t \text{ and } t$$

where

D = the specified outside diameter of the section.

t = the specified wall thickness of the section.

NOTE: For fabricated tubes, design criteria can be found in Section 3.5 of Column Research Council—Guide to Design Criteria for Metal Structures, Ed. B. G. Johnston, 2nd Ed., John Wiley, New York 1966.

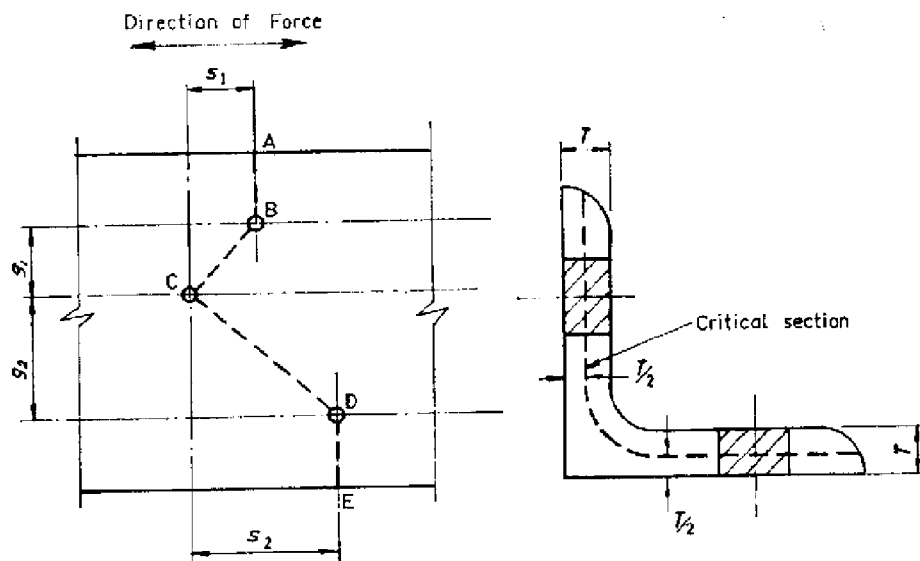
4.4 HOLES.

4.4.1 Effective Diameters. In calculating the area to be deducted for rivets, bolts or pins the diameter of the hole shall be used.

For countersunk holes the effective diameter of a hole shall be assumed to be the cross-sectional area of the hole, including the countersunk portion in the plane containing the axis of the hole, divided by the thickness of the material holed.

4.4.2 Combinations of Holes. Except as specified below, the area to be deducted from the gross cross-sectional area of a member, when making deductions for combinations of holes, shall be the sum of the sectional areas of the holes in that cross-section at right angles to the direction of stress in the member in which such sum is a maximum.

Where bolt or rivet holes are staggered, the area to be deducted shall be the sum of the sectional areas of all holes in a chain of lines extending progressively across the member, less $s^2T/4g$ for each line extending between holes at other than right angles to the direction of stress, where s , g and T are respectively the staggered pitch, gauge and thickness associated with the line under



Chain ABCDE:

$$\text{Deduction} = (\text{Sum of sectional areas of holes B, C and D}) - \left(\frac{s_1^2 T}{4g_1} + \frac{s_2^2 T}{4g_2} \right)$$

Fig. 4.4.2. STAGGERED PITCH, s , and GAUGE, g

consideration (see Fig. 4.4.2 (a)). The chain of lines shall be chosen to produce the maximum such deduction. For non-planar sections, such as angles with holes in both legs, the gauge, g , shall be the distance along the centre of the thickness of the section between hole centres (see Fig. 4.4.2(b)).

4.5 SECTIONAL AREAS OF BOLTS, SCREWED TENSION RODS AND RIVETS.

4.5.1 Bolts and Screwed Tension Rods. The gross area of cross-section of a bolt or a screwed tension rod shall be taken as the area of cross-section of the body of the bolt or tension rod. The effective area of cross-section in tension shall be taken as the stress area.

The effective area of cross-section in shear shall be taken as the gross area of the cross-section or the core area as appropriate.

NOTE: Stress areas are calculated using a diameter equal to the shank diameter less 0.9382 times the thread pitch and are tabulated in AS 1275. Core areas are tabulated in AS 1275, Table 1, column 17.

4.5.2 Rivets. The nominal diameter of a rivet shall mean the specified diameter cold before driving. The gross area of a rivet shall be taken to be the cross-sectional area of the rivet hole as specified in Rule 4.4.1 excluding any countersunk portion.

4.6 MAXIMUM SLENDERNESS RATIOS. The maximum slenderness ratio of a beam, strut or tension member given in Table 4.6 shall not be exceeded. In this

Clause, l is the effective length of the member (see Clauses 5.9 and 6.3) and the radius of gyration, r , shall be based on the effective section defined in Clause 4.1.

TABLE 4.6
MAXIMUM SLENDERNESS RATIOS

Member	Maximum slenderness ratio l/r
(a) A strut carrying compressive forces from dead load or from dead load and live load	180
(b) A discontinuous single-angle strut, single bolted or riveted	
(c) A beam	300
(d) A strut carrying compressive forces resulting only from wind load	
(e) A tension member carrying force from dead or live load where the minimum tensile force is less than 10 percent of the maximum tensile force	

NOTE: The above limits may be exceeded for tension members if deflection stresses and vibrations are not excessive.

SECTION 5. DESIGN OF BEAMS

5.1 GENERAL. The calculated stress in a member shall not exceed any of the appropriate maximum permissible stresses given in Clauses 5.2, 5.3, 5.4 and 5.6 for bending, in Clause 5.10 for shear, and in Clause 5.11 for bearing, except that Clause 5.4 shall not apply in the following cases:

- (a) a beam bent about its axis of minimum strength;
- (b) an I-beam or channel with equal flanges and with a value of l/r_y less than $960/\sqrt{F_Y}$;
- (c) a rectangular hollow section beam with B/D and t/T both greater than 0.15 (this includes hollow sections to AS 1163).

5.2 MAXIMUM PERMISSIBLE STRESS. The maximum calculated stress due to bending in a member shall not exceed the maximum permissible stress F_b , determined by formula 5.2(1) or 5.2(2):

For solid round and square bars, and for solid rectangular bars bent about the axis of minimum strength—

$$F_b = 0.75 F_Y \dots\dots\dots 5.2(1)$$

For all other beams—

$$F_b = 0.66 F_Y \dots\dots\dots 5.2(2)$$

5.3 MAXIMUM PERMISSIBLE COMPRESSIVE STRESS. The maximum calculated compressive stress due to bending in any part of a beam shall not exceed the maximum permissible stress F_{bc} , which shall be the greater of—

$$F_{bc} = 0.60 F_Y,$$

and the value determined by formula 5.3(1), 5.3(2), 5.3(3) or 5.3(4) as appropriate:

$$F_{bc} = \left(0.72 - \frac{0.12}{256} \times \frac{b_1}{T_1} \sqrt{F_Y} \right) F_Y \dots\dots 5.3(1)$$

$$F_{bc} = \left(0.72 - \frac{0.12}{560} \times \frac{b_2}{T_1} \sqrt{F_Y} \right) F_Y$$

for welded flanges or plates which are not stress-relieved 5.3(2)

$$F_{bc} = \left(0.72 - \frac{0.12}{800} \times \frac{b_2}{T_1} \sqrt{F_Y} \right) F_Y$$

for other flanges or plates 5.3(3)

$$F_{bc} = \left(0.72 - \frac{0.12}{635} \times \frac{b_2}{T_1} \sqrt{F_Y} \right) F_Y \dots\dots 5.3(4)$$

for cold-formed rectangular hollow section members

where

b_1 = the outstand of the flange or plate of thickness T_1 in compression (see Clause 4.3.1)

b_2 = the unsupported width of the flange or plate between faces of support which is of thickness T_1 and in compression (see Clause 1.6 and Clause 4.3.2).

5.4 MAXIMUM PERMISSIBLE STRESS IN A BEAM BENT ABOUT THE AXIS OF MAXIMUM STRENGTH.

5.4.1 Equal-flange I-beams or Channels. For an I-beam or channel with equal flanges bent about the axis of maximum strength, the maximum calculated stress shall not exceed the maximum permissible stress F_b , given directly in Tables 5.4.1(1), 5.4.1(2), 5.4.1(3), 5.4.1(4) for a yield stress F_Y of 250 or 350 MPa*, or calculated from formula 5.4.3(1) or 5.4.3(2), as appropriate, and an elastic flexural-torsional buckling analysis.

In Tables 5.4.1(1), (2), (3) and (4)—

T = the flange thickness as defined in Clause 1.6.

NOTE: Tables 5.4.1(1), (2), (3) and (4) have been derived from Clauses 5.4.3 and 5.5.

5.4.2 Laterally Unsupported Angle Sections. For a laterally unsupported angle section, the maximum stress F_b , may be calculated from formula 5.4.3(1) or 5.4.3(2) and an elastic flexural-torsional analysis.

NOTE: Alternatively, it is permissible to use either the approximate solutions or the tabulated load capacities for laterally unsupported angles in the 'Safe Load Tables for Structural Steel' (published by The Australian Institute of Steel Construction.)

5.4.3 Other Sections. The maximum calculated stress due to bending in a beam not otherwise covered by Clauses 5.4.1 and 5.4.2 shall not exceed the maximum permissible stress F_b , determined by formula 5.4.3(1) or 5.4.3(2), as appropriate:

Where F_{ob} is equal or less than F_Y —

$$F_b = \left[0.55 - 0.10 \frac{F_{ob}}{F_Y} \right] F_{ob} \dots\dots\dots 5.4.3(1)$$

Where F_{ob} is equal to or greater than F_Y —

$$F_b = \left[0.95 - 0.50 \sqrt{\left(\frac{F_Y}{F_{ob}} \right)} \right] F_Y \dots\dots\dots 5.4.3(2)$$

In formulas 5.4.3(1) and 5.4.3(2) above, the maximum stress F_{ob} in the beam at elastic buckling, shall be calculated in accordance with Clause 5.5 or by an elastic flexural-torsional buckling analysis.

* See Appendix C.

TABLE 5.4.1(1)
MAXIMUM PERMISSIBLE BENDING STRESSES, F_b (MPa),
IN EQUAL-FLANGE I-BEAMS OR CHANNELS

with $F_Y = 250$ MPa and $\frac{T}{t} > 2.0$ or $\frac{d_1}{t} > 85$

l/r_y	D/T														
	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100
50	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
60	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
70	165	165	165	165	165	164	162	159	157	156	155	154	154	153	153
80	165	165	165	161	158	156	154	150	147	146	145	143	142	142	141
90	165	165	159	155	151	148	146	141	138	136	134	132	131	130	129
100	165	160	154	149	145	141	138	133	129	126	124	121	120	118	118
110	163	156	149	144	139	135	131	125	120	117	114	110	108	105	104
120	160	151	144	138	133	129	125	117	111	106	102	97	95	92	90
130	156	147	140	134	128	123	119	109	101	95	92	87	84	81	79
140	153	144	136	129	123	117	113	100	92	87	83	78	75	71	70
150	150	140	132	124	118	112	105	93	85	79	75	70	67	64	62
160	147	137	128	120	113	105	99	86	78	73	69	64	60	57	56
170	144	133	124	116	108	99	93	81	73	67	63	58	55	52	50
180	141	130	121	112	102	94	88	76	68	62	58	53	50	47	45
190	138	127	117	107	97	89	83	71	64	58	54	49	46	43	41
200	136	124	114	102	93	85	79	67	60	54	51	46	43	39	38
210	133	121	110	98	89	81	75	64	56	51	48	43	40	36	35
220	130	118	106	94	85	77	72	61	53	48	45	40	37	34	32
230	128	116	102	90	81	74	68	58	51	46	42	37	35	31	30
240	126	113	98	87	78	71	66	55	48	43	40	35	32	29	28
250	123	109	95	84	75	68	63	53	46	41	38	33	31	27	26
260	121	106	92	81	73	66	60	51	44	39	36	32	29	26	24
270	119	103	89	78	70	64	58	49	42	38	34	30	27	24	23
280	116	99	86	76	68	61	56	47	41	36	33	29	26	23	21
290	114	97	83	73	65	59	54	45	39	35	32	27	25	22	20
300	112	94	81	71	63	57	52	44	38	33	30	26	24	21	19

NOTE: Values above solid line may be reduced by Clause 5.3.

TABLE 5.4.1(2)
MAXIMUM PERMISSIBLE BENDING STRESSES, F_b (MPa),
IN EQUAL-FLANGE I-BEAMS OR CHANNELS

with $F_Y = 340$ MPa and $\frac{T}{t} > 2.0$ or $\frac{d_1}{t} \geq 72.9$

l/r_y	D/T														
	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100
50	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224
60	224	224	224	224	222	220	218	215	213	211	211	209	209	208	208
70	224	224	218	213	209	206	203	199	196	194	193	191	190	189	189
80	224	215	208	202	197	193	190	184	180	178	176	174	172	171	170
90	218	207	199	192	186	181	177	170	165	162	159	156	154	152	151
100	211	200	191	183	176	171	166	157	150	144	140	135	132	129	128
110	205	193	183	174	167	160	155	141	132	126	122	117	114	111	109
120	199	186	175	166	158	150	141	127	118	112	107	102	99	96	94
130	194	180	168	158	148	138	130	115	106	100	96	90	87	84	82
140	189	174	162	150	137	128	120	105	96	90	86	80	77	74	72
150	184	169	155	141	128	119	111	97	88	82	78	72	69	65	64
160	179	163	148	133	121	111	103	90	81	75	71	65	62	59	57
170	174	158	140	125	114	104	97	84	75	69	65	59	56	53	51
180	170	153	133	119	107	98	91	78	70	64	60	55	51	48	46
190	166	146	127	113	102	93	86	73	65	60	56	50	47	44	42
200	161	140	121	108	97	88	82	69	61	56	52	47	43	40	38
210	157	134	116	103	92	84	77	66	58	52	48	43	40	37	35
220	153	129	111	98	88	80	74	62	55	49	46	41	37	34	32
230	148	124	107	94	84	77	70	59	52	47	43	38	35	32	30
240	143	120	103	90	81	73	67	56	49	44	41	36	33	30	28
250	138	115	99	87	78	70	65	54	47	42	39	34	31	28	26
260	134	111	96	84	75	68	62	52	45	40	37	32	29	26	24
270	130	108	92	81	72	65	60	50	43	38	35	30	28	24	23
280	126	104	89	78	70	63	57	48	41	37	33	29	26	23	21
290	122	101	86	76	67	61	55	46	40	35	32	28	25	22	20
300	119	98	84	73	65	59	54	44	38	34	31	26	24	21	19

NOTE: Values above solid line may be reduced by Clause 5.3.

TABLE 5.4.1(3)
MAXIMUM PERMISSIBLE BENDING STRESSES, F_b (MPa),
IN EQUAL-FLANGE I-BEAMS OR CHANNELS

with $F_y = 250$ MPa and $\frac{T}{t} \leq 2.0$ and $\frac{d_1}{t} \leq 85$

l/r_y	D/T														
	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100
50	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
60	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165
70	165	165	165	165	165	165	165	165	164	163	163	162	161	161	160
80	165	165	165	165	165	163	161	158	155	154	153	151	151	150	150
90	165	165	165	162	159	156	154	149	147	145	143	141	140	139	139
100	165	165	161	157	153	150	147	142	138	136	134	132	130	129	128
110	165	163	157	152	147	144	141	135	130	127	125	122	120	118	117
120	165	159	153	147	142	138	135	128	123	119	116	113	110	106	105
130	163	155	148	143	137	133	129	121	115	111	106	101	98	94	92
140	160	152	145	138	133	128	124	115	107	101	96	91	87	84	82
150	157	149	141	134	128	123	119	108	99	92	88	82	79	75	73
160	155	145	138	130	124	119	114	100	91	85	81	75	71	67	66
170	152	142	134	127	120	114	108	94	85	79	74	68	65	61	59
180	149	140	131	123	116	109	102	88	80	73	69	63	59	56	54
190	147	137	128	120	112	104	97	83	75	69	64	58	55	51	49
200	144	134	125	116	108	99	92	79	70	64	60	54	51	47	45
210	142	131	122	113	103	95	88	75	66	61	56	50	47	43	41
220	140	129	119	109	99	91	84	71	63	57	53	47	44	40	38
230	138	126	116	105	95	87	80	68	60	54	50	44	41	37	35
240	135	124	113	101	91	83	77	65	57	51	47	42	39	35	33
250	133	121	110	98	88	80	74	62	55	49	45	40	36	33	31
260	131	119	106	94	85	77	71	60	52	47	43	38	34	31	29
270	129	117	103	91	82	75	69	58	50	45	41	36	33	29	27
280	127	114	100	88	79	72	66	55	48	43	39	34	31	27	25
290	125	112	97	86	77	70	64	53	46	41	38	33	29	26	24
300	123	109	94	83	74	68	62	52	45	40	36	31	28	25	23

NOTE: Values above solid line may be reduced by Clause 5.3.

TABLE 5.4.1(4)
MAXIMUM PERMISSIBLE BENDING STRESSES, F_b (MPa),
IN EQUAL-FLANGE I-BEAMS OR CHANNELS

with $F_y = 340$ MPa and $\frac{T}{t} \leq 2.0$ and $\frac{d_1}{t} < 72.5$

l/r_y	D/T														
	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100
50	224	224	224	224	224	224	224	224	224	224	224	224	224	224	224
60	224	224	224	224	224	224	224	224	222	221	220	219	219	218	218
70	224	224	224	223	219	216	214	210	207	205	204	203	202	201	201
80	224	224	218	213	208	205	202	196	193	190	189	187	185	184	183
90	224	217	210	203	198	194	190	183	179	176	173	171	169	167	166
100	221	211	202	195	189	184	179	171	166	162	159	155	153	150	148
110	215	204	195	187	180	174	169	160	153	146	142	136	132	129	127
120	210	198	188	180	172	166	160	147	137	130	125	119	116	112	110
130	205	193	182	172	164	157	150	134	124	117	112	106	102	98	96
140	201	187	176	166	157	148	139	123	113	106	101	95	91	87	85
150	196	182	170	159	149	138	129	114	103	96	91	85	81	77	75
160	192	177	164	153	140	130	121	105	95	88	83	77	73	69	67
170	187	172	159	145	132	122	114	98	88	82	77	70	67	63	61
180	183	168	154	138	125	115	107	92	82	76	71	65	61	57	55
190	179	163	147	132	119	109	101	87	77	71	66	60	56	52	50
200	175	159	141	126	113	104	96	82	72	66	61	55	52	48	46
210	172	155	135	120	108	99	91	77	68	62	58	52	48	44	42
220	168	149	130	115	104	94	87	74	65	59	54	48	45	41	39
230	164	144	125	110	99	90	83	70	61	55	51	45	42	38	36
240	161	139	120	106	95	87	80	67	58	53	48	43	39	35	33
250	158	134	116	102	92	83	76	64	56	50	46	40	37	33	31
260	154	130	112	99	88	80	73	61	53	48	44	38	35	31	29
270	150	126	108	95	85	77	71	59	51	46	42	36	33	29	27
280	146	122	105	92	82	74	68	57	49	44	40	35	31	28	26
290	142	118	102	89	79	72	66	55	47	42	38	33	30	26	24
300	138	115	99	86	77	70	64	53	45	40	37	31	28	25	23

NOTE: Values above solid line may be reduced by Clause 5.3.

5.5 ELASTIC CRITICAL STRESS. If an elastic flexural-torsional buckling analysis is not carried out, the elastic critical stress F_{ob} , shall be determined by formula 5.5:

$$F_{ob} = K_1 (A + K_2 B) \frac{c_2}{c_1} \dots \dots \dots 5.5$$

For an I-beam with values of T/t not greater than 2.0 and d_1/t not greater than $1344/\sqrt{F_y}$, the value of F_{ob} shall be multiplied by a factor of 1.20.

In this Clause (5.5) —

$$A = B \sqrt{\left[1 + \frac{1}{20} \left(\frac{IT}{r_y D} \right)^2 \right]}$$

$$B = \frac{26.5 \times 10^5}{(lr_y)^2} \text{ MPa}$$

For beams with a varying value of r_y , the value of r_y at the point of maximum moment shall be used.

NOTES:

1. Values of A for various values of l/r_y and D/T , and of B for various values of l/r_y are given in Table 5.5(1).
2. For T see Clause 5.4.1.
3. Guidance in calculating elastic buckling forces will be found in the references listed in Appendix D.

c_1, c_2 = respectively, the lesser and greater distances from the section neutral axis to the extreme fibres

K_1 = a coefficient to allow for the reduction in thickness or breadth of the flanges between the points of effective lateral restraint. Values of K_1 are given in Table 5.5(2) for various values of N_F .

N_F = the ratio of the total area of both flanges at the point of least bending moment to the corresponding area at the point of greatest bending moment between points of effective lateral restraint. The minimum value of N_F shall be 0.25 and flange reductions shall be limited accordingly. The removal of a flange at the end of a beam shall be neglected when calculating N_F , provided that the length of flange removed does not exceed a length equal to the flange width at midspan.

K_2 = a coefficient to allow for the inequality of the flanges. Values of K_2 are given in Table 5.5(3) for various values of M_F .

M_F = the ratio of the moment of inertia of the compression flange alone to the sum of the moments of inertia of the flanges, each calculated about its own axis parallel to the axis of minimum strength of the beam, at the point of maximum bending moment.

T = the flange thickness as defined in Clause 1.6. Where the flanges are unequal, T shall be calculated from the flange having the greater moment of inertia, calculated about its own axis parallel to the axis of minimum strength of the beam.

5.6 BENDING STRESSES FOR CASED BEAMS. If a beam is to be designed to take advantage of concrete encasement, the following conditions shall be satisfied:

- (a) The section shall be of I-form with equal flanges and a single web, or of double open channel form with the webs not less than 40 mm apart, and have a depth not exceeding 800 mm and a width not exceeding 500 mm overall.
- (b) The beam shall be unpainted and be encased in concrete conforming to Grade 15, as defined in AS 1480.
- (c) The minimum width of casing shall be equal to $(B + 100)$ mm, where B is the overall width of the steel flange or flanges (mm).
- (d) The outer faces and edges of the flanges of the beam shall have a concrete cover of not less than 50 mm.
- (e) The casing shall be reinforced with wire complying with AS 1303. The diameter of the wire shall be at least 5 mm. Alternatively, the reinforcement shall be structural grade bars complying with AS 1302. The diameter of the bars shall be at least 6 mm. In either case, the reinforcement shall be in the form of stirrups or binding at not more than 150 mm pitch and so arranged as to pass through the centre of the covering to the flanges and supported by and attached to at least four longitudinal spacing bars.

The maximum calculated bending stress shall not exceed the lesser of—

- (i) the value of any of the appropriate maximum permissible stresses permitted by Clauses 5.2, 5.3 and 5.4 in which the radius of gyration, r_y , shall be $0.2 (B + 100)$ mm, and D/T shall be as for the uncased section; and
- (ii) 1.5 times that permitted for the uncased section.

NOTE: This Clause does not apply to box sections. See Clause 6.8.4 for grillage beams.

5.7 PURLINS AND GIRTS. Sheeting shall be not deemed not to restrain effectively the lateral deflection of the connected flange of a purlin or girt except in cases where experimental data are available to show that the sheeting and its fixings are able to provide such restraint and that twisting of the member will not occur.

Where special allowance for expansion is made in long-length sheeting, the fixings shall be deemed not to provide lateral support.

5.8 EFFECTIVE SPAN OF BEAMS. The effective span, L , of a beam shall be taken to be the distance between the centres of the supports, except for Clause 3.2.3 and where in Clause 6.4 the point of application of the reaction is taken as eccentric to the support, when it shall be permissible to take the effective span as the distance between the assumed points of application of the reactions.

For a member framing into a channel, the effective span shall be measured from—

- (a) the shear centre of the supporting channel, or
 - (b) the distance between supports,
- whichever is greater.

TABLE 5.5(1)*
VALUES OF A AND B FOR CALCULATING F_{ob}

$$\text{where } A = B \sqrt{1 + \frac{1}{20} \left(\frac{LT}{r_y D} \right)^2}$$

$$B = \frac{26.5 \times 10^5}{(l/r_y)^2} \text{ MPa}$$

l/r _y	D/T															
	A															B
	8	10	12	14	16	18	20	25	30	35	40	50	60	80	100	
40	2484	2222	2066	1965	1897	1849	1814	1759	1728	1709	1697	1683	1675	1667	1663	1656
45	2103	1856	1708	1612	1546	1499	1465	1411	1380	1362	1349	1335	1357	1319	1315	1309
50	1822	1590	1449	1357	1293	1248	1214	1161	1131	1113	1101	1086	1078	1070	1067	1060
55	1607	1389	1254	1166	1105	1061	1028	976	947	929	917	902	894	886	883	876
60	1437	1232	1104	1020	961	918	886	835	806	788	776	762	754	746	743	736
65	1301	1107	985	904	847	806	775	726	697	679	667	653	645	637	634	627
70	1188	1005	889	811	757	717	687	638	610	592	581	567	559	551	547	541
75	1094	920	810	735	682	644	615	567	540	522	511	497	489	481	478	471
80	1014	849	743	672	621	584	556	509	482	465	454	440	432	424	421	414
85	945	788	687	618	570	533	506	461	434	417	406	392	385	377	373	367
90	886	735	639	573	526	491	464	420	394	377	366	353	345	337	334	327
95	833	689	597	534	488	454	428	385	360	343	332	319	311	304	300	294
100	787	649	560	499	455	423	397	356	331	314	304	290	283	275	272	265
110	708	582	499	443	402	371	347	307	283	268	257	244	237	229	226	219
120	644	527	451	398	359	330	308	270	247	232	222	209	202	194	191	184
130	591	482	411	361	325	298	277	240	218	204	194	181	174	167	163	157
140	546	444	378	331	297	271	251	217	195	181	172	160	153	145	142	135
150	508	412	350	306	274	249	230	197	177	163	154	142	135	128	124	118
160	474	385	326	284	254	230	212	181	161	148	139	127	121	113	110	104
170	445	360	305	265	236	214	197	167	148	135	126	115	109	102	98	92
180	420	339	286	249	221	200	184	155	137	125	116	105	98	92	88	82
190	397	320	270	235	208	188	172	145	127	115	107	96	90	83	80	73
200	376	304	256	222	197	177	162	136	119	107	99	89	83	76	73	66
210	358	288	243	210	186	168	153	128	112	101	93	82	76	70	66	60
220	341	275	231	200	177	159	145	121	105	94	87	77	71	64	61	55
230	326	262	220	191	169	152	138	115	99	89	82	72	66	60	56	50
240	312	251	211	182	161	145	132	109	94	84	77	67	62	55	52	46
250	299	241	202	175	154	138	126	104	90	80	73	64	58	52	49	42
260	288	231	194	167	148	133	121	99	85	76	69	60	55	48	45	39
270	277	222	186	161	142	127	116	95	82	72	66	57	52	46	42	36
280	267	214	180	155	137	122	111	91	78	69	63	54	49	43	40	34
290	257	207	173	149	132	118	107	88	75	66	60	52	46	41	38	32
300	249	200	167	144	127	114	104	84	72	64	57	49	44	38	35	29

* See Note 1 to Clause 5.5.

TABLE 5.5(2)
VALUES OF K_1 FOR BEAMS WITH CURTAILED FLANGES

N_F	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
K_1	1.0	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2

TABLE 5.5(3)
VALUES OF K_2 FOR BEAMS WITH UNEQUAL FLANGES

M_F	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
K_2	0.5	0.4	0.3	0.2	0.1	0	-0.2	-0.4	-0.6	-0.8	-1.0