

AS 1538—1988

Australian Standard[®]

**Cold-formed Steel Structures
Code**

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Association of Consulting Engineers, Australia
Australian Institute of Steel Construction
Australian Road Research Board
Australian Welding Research Association
Bureau of Steel Manufacturers of Australia
Confederation of Australian Industry
CSIRO, Division of Building, Construction and Engineering
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AS 1538—1988

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Cold-formed Steel Structures Code

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PREFACE

This Standard was prepared by the Association's Committee on Steel Structures to supersede AS 1538–1974.

It is intended that this Standard supplements AS 1250–1981, *SAA Steel Structures Code*.

This Standard is a working stress Standard and is based on permissible and working stress design.

The technical requirements of this Standard are essentially those of the 1974 edition but the opportunity has been taken to introduce a number of significant amendments which include the following:

- (a) Unstiffened compression elements are now treated by effective area reduction, rather than by permissible stress reduction.
- (b) The concept of sub–element is abolished.
- (c) Provision is made for web stiffeners.
- (d) The inelastic reserve capacity of flexural members is introduced.
- (e) The determination of elastic critical stress of laterally unbraced beams has been refined and its scope enlarged. Allowance is made for beams restrained at one flange only.
- (f) In computing the permissible bending stresses in web, the stiffened and unstiffened flanges are now distinguished.
- (g) The web crippling of beams has undergone considerable modification by the introduction of new parameters and interaction with bending.
- (h) The treatment of axially loaded compression members is somewhat simplified.
- (i) Welded connections (treated in the previous edition in a cursory manner or by reference to other publications) are now provided and in line with modern welding practice.
- (j) For some structural members, bracing requirements have been modified.
- (k) A new Appendix provides equations for calculation of 'column properties' of certain sections (Appendix A) and another Appendix lists a large number of related references (Appendix D).

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Australian Standard

COLD-FORMED STEEL STRUCTURES CODE

SECTION 1. SCOPE AND GENERAL

1.1 SCOPE. This Standard specifies requirements for the design and protection of structures or structural members made by cold-forming carbon and low alloy steel strip or sheet. The Standard is intended to supplement AS 1250—1981.

1.2 NEW MATERIALS OR METHODS. This Standard shall not be interpreted to prevent the use of materials or of methods of design or construction not especially referred to in this Standard. If it is desired to seek the opinion of the SAA Committee on Steel Structures as to whether materials or methods of design or construction not covered in this Standard, 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.

1.3 REFERENCED DOCUMENTS. The following documents are referred to in this Standard.

AS

- 1110 ISO metric hexagon precision bolts and screws
- 1111 ISO metric hexagon commercial bolts and screws
- 1112 ISO metric hexagon nuts, including thin nuts, slotted nuts and castle nuts
- 1163 Structural steel hollow sections
- 1250* SAA Steel Structures Code (including Amendment No 1, 1982 and Amendment No 2, 1984)
- 1252 High strength steel bolts with associated nuts and washers for structural engineering
- 1391 Methods for tensile testing of metals
- 1397 Steel sheet and strip—Hot-dipped zinc-coated or aluminium/zinc coated
- 1511 SAA High-strength Structural Bolting Code
- 1553 Covered electrodes for welding
- 1553.1 Part 1: Low carbon steel electrodes for manual metal-arc welding of carbon and carbon-manganese steels
- 1554 SAA Structural Steel Welding Code
- 1554.1 Part 1: Welding of steel structures
- 1559 Fasteners—Bolts, nuts and washers for tower construction
- 1594 Hot-rolled low carbon steel plate, sheet and strip
- 1595 Cold-rolled unalloyed low carbon steel sheet and strip
- 1858 Electrodes and fluxes for submerged-arc welding
- 2203 Carbon steel electrodes, cored (for arc welding)
- 2214 SAA Structural Steel Welding Supervisors Certification Code

- 2311 The painting of buildings
- 2312 Guide to the protection of iron and steel against exterior atmospheric corrosion
- 2812 Welding, brazing and cutting of metals—Glossary of terms

AWS

- D1.3-81 Recommended practice for resistance welding

- C1.1-66 Recommended practice for resistance welding

- AISI Specification for the design of cold-formed steel structural members

1.4 DEFINITIONS. For the purpose of this Standard, the definitions given in AS 2812 and those below apply.

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

Bend—bend adjacent to flat elements and having a maximum inside radius-to-thickness ratio (R/t) of 8 (see Figure 1.4).

Column—axially-loaded compression member.

Compound member—structural member consisting of two or more formed members or flat sheets joined longitudinally by structural fastenings.

NOTE: Formed members or sheets which do not contribute to load capacity or stiffness of a compound member are not considered a part of the member.

Effective width (effective design width)(b_e)—flat effective width, determined in accordance with Clauses 2.4.1 and 2.4.5, i.e. the flat width (b) reduced for design purposes.

Elements—simple shapes into which a cold-formed structural member is considered divided (see Figure 1.1) and may consist of the following shapes:

- (a) Flat elements—appearing in cross-section as rectangles.
- (b) Bends—appearing in cross-section as sectors of circular rings, having the inside radius to thickness ratio equal or less than eight ($R/t \leq 8$).
- (c) Arched elements—circular or parabolic elements having the inside radius to thickness ratio greater than eight ($R/t > 8$).

Feed width(w_f)—width of coiled or flat steel used in production of a cold-formed product.

Flat-width ratio (of a single flat compression element) (b/t)—ratio of the flat width (b) exclusive of edge fillets, to the element thickness (t).

Flexural-torsional buckling—mode of buckling in which members bend and twist simultaneously.

* Refers only to AS 1250—1981 edition.

Gauge—transverse spacing between parallel adjacent lines of fasteners.

Load factor (Ω)—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.

Section symmetry—see Figure 1.5.

Stiffeners (see Figure 1.2). Stiffeners are as follows:

- (a) **Edge stiffener**—formed element at the edge of a flat compression element, which may be either a web, flange, or a simple lip (see also Clause 2.4.2.1).
- (b) **Intermediate stiffeners**—formed elements, employed in multiple stiffened segments, and located between edge stiffeners (see also Clause 2.4.2.2).

NOTE: The bends adjacent to compression elements are part of a stiffener.

Stiffening modes (see Figure 1.3). Stiffening modes are as follows:

- (a) **Stiffened compression element**—flat compression element in which both edges parallel to the direction of stress are stiffened by any combination of edge stiffeners.
- (b) **Unstiffened compression element**—flat compression element in which only one edge parallel to the direction of stress is stiffened by an edge stiffener.
- (c) **Multiple stiffened segment**—compression segment in which both edges parallel to the direction of stress are stiffened by edge stiffeners. Between the edge stiffeners the compression segment is composed of elements stiffened by intermediate stiffeners.
- (d) **Arched compression element**—circular or parabolic arch-shaped compression element having an inside radius-to-thickness ratio greater than 8, stiffened at both ends by edge stiffeners.

Tensile strength (F_u)—ultimate tensile strength of a steel or an electrode (see Clause 1.7).

Thickness—nominal steel thickness exclusive of coatings.

NOTE: Usual industrial thickness designations are BMT (for 'base metal thickness') which is the same as (t) defined in this Standard, and TCT (for 'total coated thickness') measured over coating surfaces.

Ultimate failure—a point at which a test sample reaches its maximum load.

Virgin steel—coiled or flat steel prior to the cold-forming operation.

Yield stress (F_y)—see Clause 3.1.2.

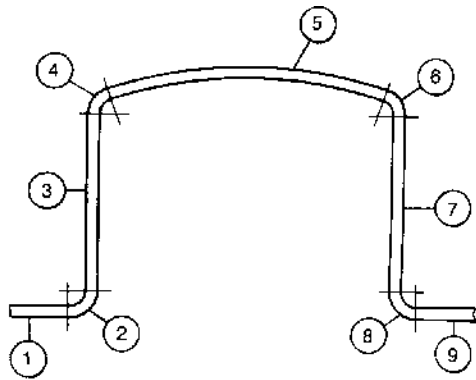
1.5 NOTATION. Every symbol occurring in this Standard is listed and defined below. Symbols which occur in more than one clause are used without further reference. Symbols which occur only in one clause are defined in that clause.

Unless a contrary intention appears, the following applies:

- (a) The symbols shall have the meanings ascribed to them below with respect to the structure, or member, or condition to which a clause is applied.
- (b) Where non-dimensional ratios are involved, both the numerator and denominator are expressed in identical units.
- (c) The dimensional units for length and stress in all expressions or equations are to be taken as

millimetres (mm) and megapascals (MPa) respectively.

A	=	the full cross-sectional area of a member
A_b	=	the design area for axially-loaded transverse stiffeners at interior and end supports under concentrated load
A_c	=	the design area for yield of transverse stiffeners at interior and end supports under concentrated load
A_{ef}	=	the effective area of a stiffener section or a column section
A_i	=	the area of the i th element
A_s	=	the cross-sectional area of transverse stiffeners
A_{st}	=	the full area of a stiffener section
A_w	=	the effective cross-sectional area of a member
a	=	the shear panel length of the unstiffened web element (Clause 3.4.1(b)); or the length of bracing interval in a beam (Clauses 2.4.4.2(b) and 3.3.3.2)
B_c	=	the tensile yield stress coefficient of bends
b	=	the flat width of any stiffened or unstiffened compression element exclusive of bends
b_e	=	the effective design width of a flat compression element
b_1	=	the width of flange projection beyond the web; or half the distance between webs for box-type or U-type sections; or the length specified in Clause 2.4.4.2(a)
b_2	=	the full width between edge stiffeners of a multiple stiffened segment; or the length specified in Clause 2.4.4.2(a)
C	=	the ratio of total bend area to the total cross-sectional area of the full section or full flange section
C_m	=	the moment coefficient for unequal end moments
C_{mx}, C_{my}	=	the moment coefficients about the x - and y -axes
C_v	=	the shear stiffener coefficient
C_y	=	the compression strain factor
C_θ	=	the web crippling coefficient
c	=	the clear distance of concentrated bearing load from the end of the section
c_f	=	the amount of curling
D	=	the mean diameter of a circular hollow section; or the depth of a section
D'	=	the spacing between top and bottom points of attachment between bracing and beam
d	=	the diameter of a bolt
d'	=	the overall depth of a lip
d_{min}	=	the overall minimum depth required of a simple lip
d_a	=	the average width of a plug or slot weld



NOTE: On the example diagram (Figure 1.1), the member consists of the following nine elements:

- (a) Elements 1, 3, 7, 9 are flat elements (flats).
- (b) Elements 2, 4, 6, 8 are bends ($R/t \leq 8$).
- (c) Element 5 is an arched element ($R/t > 8$).

FIGURE 1.1 ELEMENTS

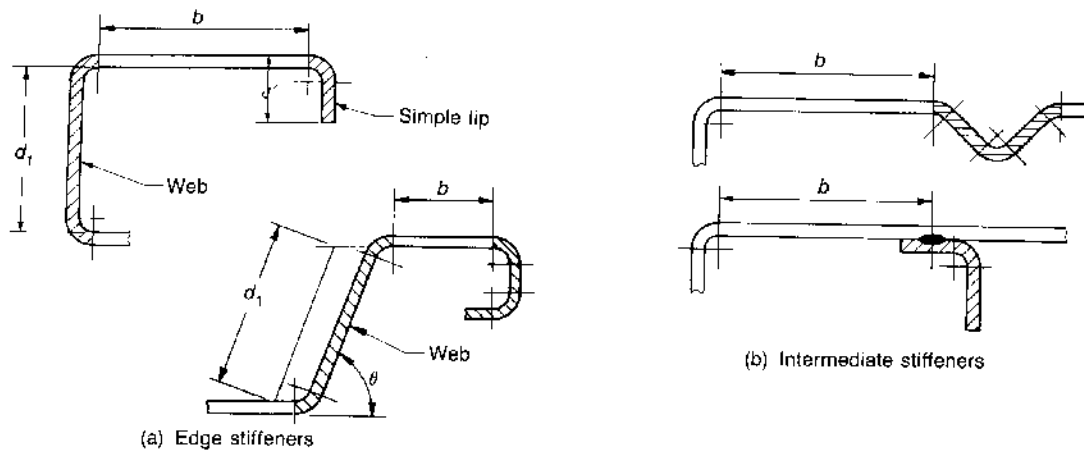


FIGURE 1.2 STIFFENERS

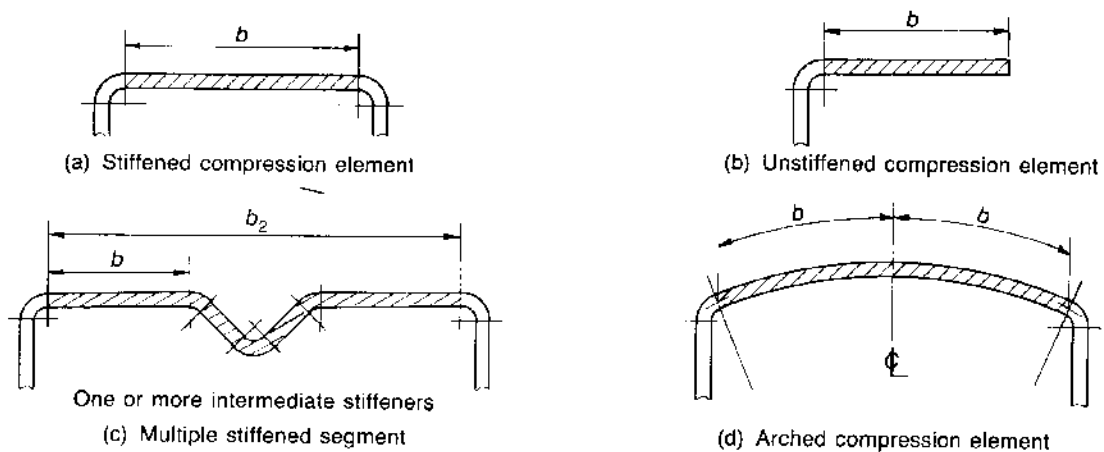


FIGURE 1.3 STIFFENING MODES

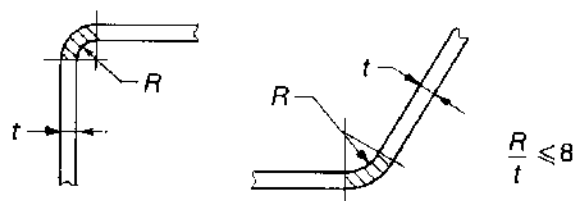
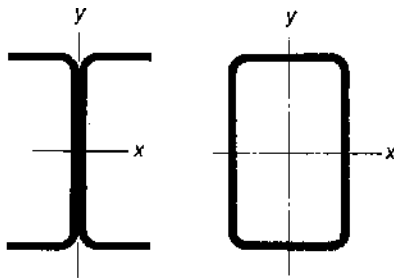


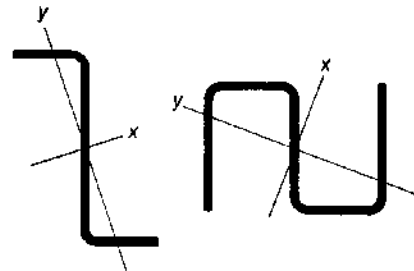
FIGURE 1.4 BENDS

d_e	= the effective width of an arc plug or slot weld at fused surfaces
d_h	= the diameter of a standard hole
d_w	= the width of a plug or slot weld
d_1	= the clear distance between flanges measured parallel to the web
E	= the Young's modulus of elasticity of steel, taken as 200×10^3 MPa in this Standard
e	= the clear distance between concentrated bearing loads acting on opposite sides of the section
$e_{\min}$	= the minimum distance measured in the line of force from the laneway of an arc spot weld to the nearest edge of an adjacent weld or to the end of the connected part
e_y	= the yield strain
F	= the maximum permissible stress on the net section of a tension member; or the maximum permissible stress in tension and compression on the extreme fibres of a beam
F_a	= the maximum permissible average compression stress
F_b	= the maximum permissible stress in tension and compression on the extreme fibres of a laterally unbraced beam

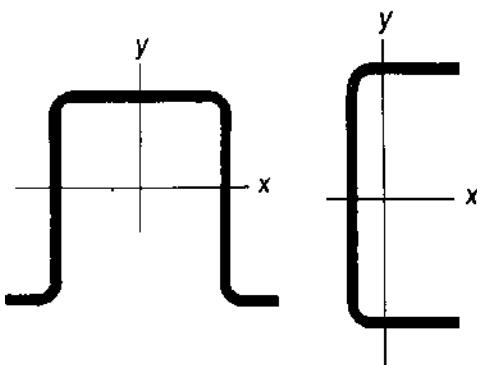
F_{bw}	= the maximum permissible compression stress in the flat web of a beam due to bending
F_{bx}, F_{by}	= the values of F_b for bending about the x - and y -axes
F_{bxo}, F_{byo}	= the appropriate value of F for bending about the x - and y -axes
F_o	= the elastic flexural-torsional buckling stress in a beam
F_{ob}	= the elastic flexural-torsional buckling stress due to moment alone in a member subjected to combined bending and compression
F_{oc}	= the elastic buckling stress in an axially loaded compression member
F_{ox}, F_{oy}, F_{oz}	= The values of F_{oc} for flexural buckling about the x - and y -axes, or torsional buckling
F_{oyz}	= the value of F_{oc} for flexural-torsional buckling about the y - and z -axes
F_r	= the maximum permissible compression stress in circular hollow section



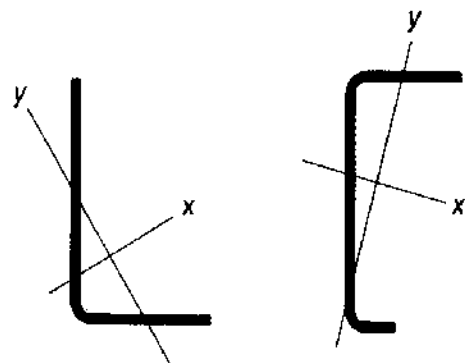
(a) Doubly-symmetric sections



(b) Point-symmetric sections



(c) Monosymmetric sections



(d) Asymmetric sections

FIGURE 1.5 EXAMPLES OF SECTION SYMMETRY

F_u	= the tensile strength of virgin steel	L_{st}	= the total length of a transverse stiffener
F_{uw}	= the nominal tensile strength of the deposited weld metal from an electrode	l_x, l_y, l_z	= the effective lengths for buckling about the x-, y- and z-axes
F_v	= the maximum permissible average shear on the gross area of a flat web	M	= the design moment capacity of a flexural member
F_Y	= the yield stress of the steel	M_{max}	= the maximum permissible bending moment, if bending moment only exists
F_{Ya}	= the average yield stress of the full cross-section or full flange section	M_c	= the elastic flexural-torsional buckling moment
F_{Yc}	= the yield stress of bends	M_u	= the ultimate bending moment
F_{Yf}	= the weighted average yield stress of the flat portions of a section	M_y	= the moment causing a maximum strain of e_y
f	= the calculated uniform maximum compressive stress assumed to be acting over the effective design width (b_e) of a flat compression element	M_1, M_2	= the smaller and the larger end moments
f_a	= the calculated axial stress in a member, equal to the axial force divided by the full cross-sectional area of the member	m	= the distance of shear centre of a section from mid-plane of the web; or a term for determining the tensile yield stress of bends
f_{av}	= the calculated average stress in the full unreduced flange width	N	= the actual length of bearing
f_{bx}, f_{by}	= the calculated maximum tensile or compressive stresses in a member bent about the x- and y-axes	P	= the total force on a compression member; or a concentrated applied load or reaction in the presence of bending moment; or the force transmitted by a bolt; or the force transmitted by a weld
f_{bw}	= the calculated compression stress at the junction of flange and web	P_L	= the force to be resisted by an intermediate beam brace
f_v	= the calculated average shear stress	P_{max}	= the maximum permissible concentrated load or reaction for one transverse stiffener (Clause 2.4.4.2(a)); or the maximum permissible concentrated applied load or reaction to avoid crippling of unreinforced flat webs of beams (Clauses 3.5.1 and 3.5.2(b))
G	= the shear modulus of elasticity, taken as 80×10^3 MPa in this Standard	Q	= the form factor of a compression member
g	= the vertical distance between two rows of connections near or at the top and bottom flanges	q	= the intensity of loading on a beam, with the dimensions of force/length
I_{min}	= the minimum permissible second moment of area of a stiffener about its centroidal axis parallel to the plane of the stiffened element	R	= the inside radius of a bend
I_s	= the second moment of area of the full area of a multiple stiffened segment including the intermediate stiffeners, about its own centroidal axis	r	= the bolt force ratio
I_w	= the warping section constant	r_{cy}	= the radius of gyration of one channel about its centroidal axis parallel to the web
I_x, I_y	= the second moments of area of the full section about the x- and y-axes	r_o	= the polar radius of gyration of a cross-section about the centroid
$I_{x'}$	= the second moment of area of the full section about the centroidal axis perpendicular to the web	r_{ol}	= the polar radius of gyration of a cross-section about the shear centre
$I_{xy'}$	= the product moment of area of the full section about the centroidal axes parallel and perpendicular to the web	r_x, r_y	= the radii of gyration of the full section about the x- and y-axes
J	= the torsion section constant	r_1	= the radius of gyration of the I-section about the axis perpendicular to the direction in which buckling would occur
K	= the plate buckling coefficient	s	= the spacing of connections in line of stress; or the spacing of bolts perpendicular to the line of stress; or the width of the sheet in the case of a single bolt
K'	= a constant for channels and Z-sections	s_{max}	= the maximum permissible longitudinal spacing of welds or other connectors joining two channels to form an I-section
K_v	= the shear buckling coefficient		
L	= the span of a beam; or the distance between points of effective lateral support; or the distance between inflection points in a continuous beam; or twice the length of a cantilever beam; or the unbraced length of the compression member; or the length of a fillet weld		

T_s	=	the strength of a connection in tension
t	=	the nominal steel thickness of any element or section exclusive of coatings
t_s	=	the equivalent thickness of a multiple-stiffened segment
w_f	=	the feed width
x, y	=	the principal axes of the cross-section
x', y'	=	the axes perpendicular and parallel to the web of a section
x_o, y_o	=	the coordinates of the shear centre of the cross-section
$\bar{x}$	=	the distance between the web and the y-axis.
Y	=	the yield stress of web steel divided by yield stress of stiffener steel
Z	=	the section modulus
$Z_{x'min}$	=	the smaller value of the section modulus computed about the x' -axis perpendicular to the web
z	=	the centroidal axis of the cross-section
α	=	the reduction factor for calculating the effective area of a stiffener section
β_f	=	see Table A2, Appendix A
β_L	=	see Table A2, Appendix A
β_w	=	see Table A2, Appendix A
β_x, β_y	=	the monosymmetry section constant about the x - and y -axes
δ	=	the non dimensional monosymmetry section constant
η	=	the imperfection parameter
θ	=	the angle between plane of web and plane of bearing surface
Ω	=	the load factor for compression members

1.6 DESIGN AND SUPERVISION.

NOTE: This Standard is intended to supplement AS 1250—1981 and as such the design and supervision clauses in that Standard apply.

1.7 MATERIALS.

1.7.1 Structural steel.

1.7.1.1 Standards. Structural members or steel used for the manufacture shall comply with one of the following Standards: AS 1163, AS 1397, AS 1594, and AS 1595 or with other similar Standards.

1.7.1.2 Other steels. Clause 1.7.1.1 shall not be interpreted to exclude the use of other steels, the properties and suitability of which are established through analysis, tests, and other controls, to the extent and in the manner prescribed.

1.7.1.3 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.

NOTE: Contract documents may specify that the evidence from other sources is equally acceptable.

1.7.1.4 Unidentified steel. If unidentified steel is used, it shall be free from surface imperfections. Unless a full test complying with AS 1391 is made, the yield stress (F_y) of the steel for design purposes shall be taken as not exceeding 170 MPa.

1.7.2 Fasteners and electrodes.

1.7.2.1 Steel bolts, nuts and washers. Steel bolts, nuts and washers shall comply with the following Standards: AS 1110, AS 1111, AS 1112, AS 1252, and AS 1559 as appropriate.

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

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

1.7.3 Delivered minimum thickness. The uncoated minimum steel thickness of the cold-formed product as delivered to the job site shall not, at any location, be less than 95% of the thickness (t) used in its design.

NOTE: Due to cold-forming effects, the thickness may be less at bends, such as corners.

1.8 CORROSION PROTECTION. Where steelwork in a structure is to be exposed to a corrosive environment, the steelwork shall be given protection against corrosion. The degree of protection to be employed shall be determined after consideration has been given to the use of the structure, its maintenance and the climatic or other local conditions.

NOTE: Recommendations for corrosion protection may be found in Appendix B.

SECTION 2. DESIGN REQUIREMENTS AND SECTION PROPERTIES

2.1 LOAD COMBINATIONS. A structure, and part of a structure, shall be designed for the load combinations prescribed in AS 1250—1981.

2.2 DESIGN METHODS.

2.2.1 Basis of methods. Design shall be based on the forces and moments determined by an elastic analysis unless —

- (a) member strength is established by testing in accordance with Section 6; or
- (b) it is ensured that any plastic hinges have adequate strength and ductility to perform their intended purpose, in which case the forces and moments may be determined by a plastic analysis.

2.2.2 Application of AS 1250—1981. Clause 3.2 of AS 1250—1981 shall apply, except that —

- (a) connections mentioned in Clause 3.2.2(b) of AS 1250—1981 shall be designed in accordance with Section 4;
- (b) Section 10, Plastic design of AS 1250—1981, imposed by Clause 3.2.3, Method 2 thereof, shall not apply;
- (c) Clause 3.2.4, Semi-rigid design method of AS 1250—1981 shall not apply; and
- (d) Clause 3.2.5, Experimentally based design of AS 1250—1981 shall apply, but the testing procedure and load factors shall comply with Clause 6.2.

2.3 OTHER DESIGN CONSIDERATIONS. Clause 3.3 of AS 1250—1981 shall apply (with the exception of Clauses 3.3.6). However, for —

- (a) wall studs;
- (b) channels; and
- (c) zeds;

the lateral restraining systems shall comply with Section 5.

2.4 SECTION PROPERTIES.

2.4.1 Properties of stiffened and unstiffened compression elements.

2.4.1.1 General. In calculating the section properties of a flexural member, or values of Q (see Clause 3.6.3) for compression members, or where an unstiffened compression element is subject to a stress gradient, the compressive stress (f) in Clauses 2.4.1.2 and 2.4.1.3 shall be calculated as follows:

- (a) Where the compressive stress decreases toward the free edge, the average value of compressive stress shall be used (see Figure 2.1(a)).
- (b) Where the compressive stress increases toward the free edge, the value of compressive stress at the free edge shall be used (see Figure 2.1(b)).

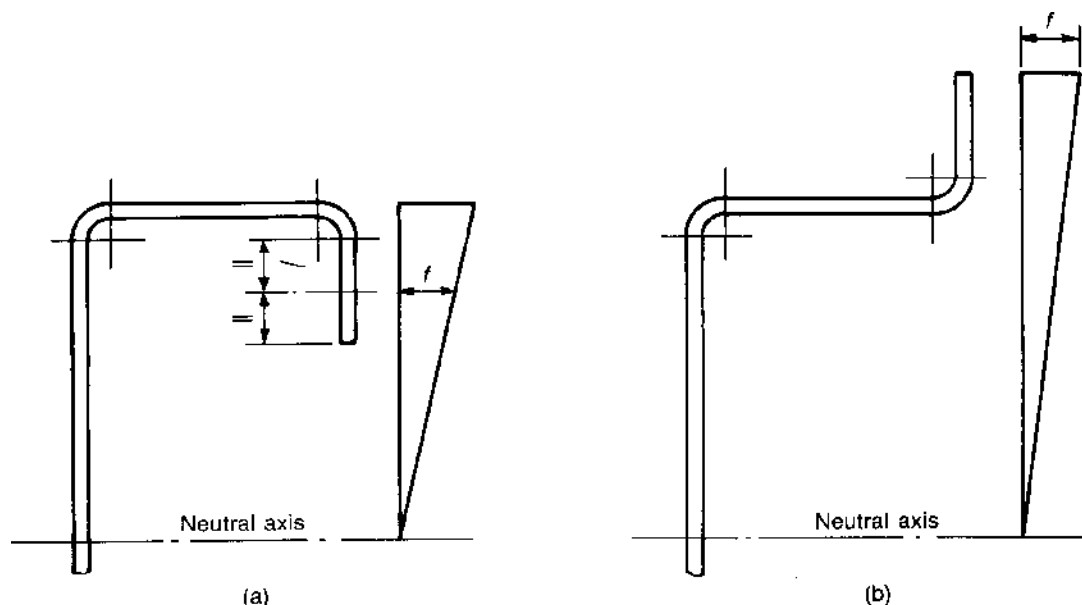


FIGURE 2.1 UNSTIFFENED COMPRESSION ELEMENTS SUBJECT TO A STRESS GRADIENT

In addition, the flat width (b) of any stiffened or unstiffened compression element shall be taken as the effective design width (b_e) determined by Clause 2.4.1.2, 2.4.1.3 or 2.4.1.4 and subject to the limitations of Clauses 2.4.3 and 2.4.5 where applicable. That portion of the total width, which is considered removed in order to determine the effective design width, shall be located at and symmetrically about the centre-line of the element in stiffened elements. In an unstiffened element, this shall be located adjacent to the free edge.

2.4.1.2 Flat elements with low b/t . For flat compression elements, where the flat-width ratio (b/t) is less than $(b/t)_{lim}$ given below, the effective design width (b_e) shall be taken as the flat width (b).

(a) For strength calculations —

$$(b/t)_{lim} = 225 \sqrt{(K/f)} \quad \dots\dots\dots 2.4.1.2(1)$$

except that for closed rectangular and square hollow sections —

$$(b/t)_{lim} = 242 \sqrt{(K/f)} \quad \dots\dots\dots 2.4.1.2(2)$$

(b) For deflection calculations —

$$(b/t)_{lim} = 290 \sqrt{(K/f)} \quad \dots\dots\dots 2.4.1.2(3)$$

except that for closed rectangular and square hollow sections —

$$(b/t)_{lim} = 311 \sqrt{(K/f)} \quad \dots\dots\dots 2.4.1.2(4)$$

where the plate buckling coefficient (K) may be assumed to be 4.0 for stiffened elements and 0.5 for unstiffened elements.

Alternatively, the plate buckling coefficient (K) for each flat element shall be determined from a rational elastic buckling analysis of the whole section as a plate assemblage subjected to the longitudinal stress distribution in the section prior to buckling.

NOTE: Guidance on the determination of the elastic critical stress for local buckling may be found in the references in Appendix D.

2.4.1.3 Flat elements with medium b/t . For flat elements, where b/t exceeds the appropriate value of $(b/t)_{lim}$ given in Clause 2.4.1.2, but is less than or equal to 60, b_e shall be calculated as follows:

(a) For strength calculations —

$$\frac{b_e}{t} = \frac{332\sqrt{K}}{\sqrt{f}} \left[1 - \frac{72.5\sqrt{K}}{(b/t)\sqrt{f}} \right] \quad \dots\dots\dots 2.4.1.3(1)$$

except that for closed rectangular and square hollow sections —

$$\frac{b_e}{t} = \frac{332\sqrt{K}}{\sqrt{f}} \left[1 - \frac{66.0\sqrt{K}}{(b/t)\sqrt{f}} \right] \quad \dots\dots\dots 2.4.1.3(2)$$

(b) For deflection calculations —

$$\frac{b_e}{t} = \frac{428\sqrt{K}}{\sqrt{f}} \left[1 - \frac{93.5\sqrt{K}}{(b/t)\sqrt{f}} \right] \quad \dots\dots\dots 2.4.1.3(3)$$

except that for closed rectangular and square hollow sections —

$$\frac{b_e}{t} = \frac{428\sqrt{K}}{\sqrt{f}} \left[1 - \frac{85\sqrt{K}}{(b/t)\sqrt{f}} \right] \quad \dots\dots\dots 2.4.1.3(4)$$

where K is as defined in Clause 2.4.1.2.

NOTES:

1. If the flat-width ratio exceeds $(b/t)_{lim}$, it may be necessary to determine the properties of the section by successive approximations or other appropriate methods, since the calculated stress (f) and the effective design width (b_e) (used for determining section properties), are interdependent.

2. Upper limits on b/t for flat compression elements connected to various edge stiffeners are given in Clause 2.4.3.

3. For sections composed entirely of unstiffened elements, such as angles, tees and cruciforms, the compression stress is automatically limited by Clause 3.6, when the elastic critical stress is calculated using the torsional buckling stress defined in Clause 3.6.4.1(c).

4. Unstiffened compression elements that have flat-width ratios exceeding 30 may show noticeable distortion of the free edges under maximum permissible compressive stress without detriment to the ability of the member to support the load. However, for flat width ratios exceeding 60, distortion of the flanges is likely to be so pronounced as to render the section structurally unacceptable, unless applied load and stress are limited to such a degree that the section may become uneconomical.

2.4.1.4 Stiffened compression elements with high b/t .

Stiffened compression elements with high b/t shall comply with the following requirements, as appropriate:

- (a) For stiffened compression elements with $b/t > 60$, and with one longitudinal edge connected to a web or flange, the other edge being connected to—

- (i) another type of edge stiffener, but significantly stiffer than a simple lip; or

- (ii) an intermediate stiffener;

b_e shall be taken as the value obtained from Clause 2.4.1.3 reduced by $(b - 60t)/10$.

- (b) For stiffened compression elements with $b/t > 60$, and with both edges connected to webs or flanges, the provisions of Clause 2.4.1.3 shall be used without reduction.

- (c) To determine the effective section properties of a member having stiffened compression elements subjected to the above reduction in effective width, the area of stiffeners (A_{st}) shall be considered reduced to an effective area (A_{ef}) as follows:

- (i) For b/t between 60 and 90 —

$$A_{ef} = \alpha A_{st} \quad \dots\dots\dots 2.4.1.4(1)$$

where

$$\alpha = \left(3 - \frac{2b_e}{b} \right) - \frac{1}{30} \left(1 - \frac{b_e}{b} \right) \left(\frac{b}{t} \right) \quad 2.4.1.4(2)$$

- (ii) For b/t greater than 90 —

$$A_{ef} = \left(\frac{b_e}{b} \right) A_{st} \quad \dots\dots\dots 2.4.1.4(3)$$

In the above equations, A_{ef} and A_{st} refer only to the area of the stiffener section or the column section inclusive of bends but exclusive of any portion of adjacent elements.

The centroid of the stiffener shall be considered located at the centroid of the full area of the stiffener, and the second moment of area of the stiffener about its own centroidal axis shall be that of the full section of the stiffener.

NOTE: For limitations on the number of intermediate stiffeners which may be considered effective and their minimum second moment of area, see Clause 2.4.3(a).

2.4.2 Stiffeners for compression elements.

2.4.2.1 Edge stiffeners. Edge stiffeners shall comply with the following requirements, as appropriate:

- (a) If a flat compression element is to be considered as a stiffened compression element, it shall be stiffened along each longitudinal edge parallel to the direction of stress, by an edge stiffener having