THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

EXAMINATION QUESTION PAPER MASTER

PROFORMA

Semester: 1 Academic Year: 2021

A. DEPARTMENT SECTION

I ACCEPT THAT THIS EXAMINATION PAPER SATISFACTORILY EXAMINES

Subject Code: CE311 Title: STEEL DESIGN

Number of Questions: 7 Number of Pages: 2 + APPENDICES

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   Signature: [signature] Date: 11/06/21

4. Head of Department and Chief Examiner: Checked: YES ✓ NO ____ (Please tick)
   Comments:
   – NIL –

   Signature: [signature] Date: 11/06/2021

B. EXAMINATIONS OFFICE SECTION

Examination Masters Received: YES ____ NO ____

5. Examinations Officer Signature: ____________ Date: ____________

6. Witness Signature: ____________ Date: ____________

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING -3RD YEAR DEGREE

FIRST SEMESTER EXAMINATIONS - 2021

CE 311 – STEEL DESIGN (DESIGN OF STEEL STRUCTURES)

DATE: TUESDAY, 15TH JUNE 2021 – 12:50 P.M

VENUE: STRUCTURES LECTURE THEATRE (SLT)

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read the paper before the examination starts. You must **NOT** begin writing during this time.
2. **There are SEVEN (7) Questions in this Exam Paper. Answer any FOUR (4) questions, for a total of 40 Points.**
3. Use only ink. Do not use pencils for writing except for drawings and sketches.
4. Only Calculator is allowed in the examination room. MOBILE PHONE is not allowed (Switch your Mobile Phones OFF).
5. Notes and textbooks are not allowed. All required references will be provided.
6. Start each question on a new page and show all your calculations in the answer book provided. No other material will be accepted.
7. **Write your NAME and Student NUMBER clearly on the front page. Do it now.**
8. **Marking Scheme:** All questions carry equal marks, for a total of 40 Marks.

Question One General Short Answer Questions **(10 marks)**

a) Describe what a compact steel section is and its characteristic features are.
b) Differentiate between the Limit States Design Philosophy and the Permissible Stress Design Method.
c) Briefly state the Activities in the Final Design Phase of the Design Process.
d) Briefly state what the Code of Practice AS 4100 is in design of steel structures.
e) Describe what the Strength Limit State is.
f) Describe what the Serviceability Limit State is.
g) Differentiate between Dead Load and Live/Imposed Load.
h) Differentiate between Section Capacity and Member Capacity.

Question Two Design a Tension Member **(10 marks)**

Select a single angle section from the One Steel section properties table to carry a dead load of 600 kN and a live load of 1,000 kN, in Tension. Assume all holes are filled. Length of member is 3m. Self-weight of the member is already included. Steel grade is 300 MPa.

Question Three Design a Compression Member **(10 marks)**

Select a column section (UC) to carry an axial dead load of 2000 kN and an axial live load of 3,000 kN. Column is 8 m long and is pinned at top and bottom in both directions. Steel grade is 300 MPa.

Question Four Design a Beam Member **(10 marks)**

A simply supported beam with a span of 9m is loaded by a central concentrated live load Q of 56 kN. The beam is fully restrained against lateral displacement and twist rotation only at the supports, and is free to rotate in plan (i.e. No restraint against lateral rotation exists at the supports). Design a suitable UB section of Grade 300 steel.

Question Five Beam-Column **(10 marks)**

Select a column to carry an axial dead load of 500 kN; axial live load of 1,000 kN; and, a uniform moment of 100 kN.m. Column is 8 m long and is pinned at top and bottom in both directions. Steel grade is 300 MPa.

Question Six Beams-Tie **(10 marks)**

Select a single angle section from the One Steel section properties table to carry: a dead load of 600 kN; a live load of 1,000 kN (both in Tension); and, a uniform moment of 100 kN.m. Assume all holes are filled. Length of member is 6 m. Steel grade is 300 MPa

Question Seven Joints/Connections **(10 marks)**

a) Identify and differentiate between a Butt Joint and a Fillet Joint. Use sketches to illustrate your answer.

b) Describe with illustrations the difference between a complete Butt weld and an incomplete one.

c) List and briefly state the different types of Failures for a bolted joint.

END OF EXAMINATION. ALL THE BEST!

1. **Reference:**

   One Steel Section Properties.

2. **Useful Information**

   Deflection Equations

   Central Point Load, Deflection = PL/48EI

   UDL, Deflection = $(5*w*L^4)/(384*EI)$

SECTION 8 MEMBERS SUBJECT TO COMBINED ACTIONS

8.1 GENERAL A member subject to combined axial and bending actions shall be proportioned so that its design actions specified in Clause 8.2, in combination with the nominal section and member capacities (see Sections 5, 6 and 7), satisfy Clauses 8.3 and 8.4. For plastic design (see Clause 4.5), only the requirements of Clause 8.4.3 need to be satisfied.

Eccentrically loaded double-bolted or welded angles in trusses shall be proportioned to satisfy Clause 8.3, and either Clause 8.4.5 or Clause 8.4.6.

8.2 DESIGN ACTIONS For checking the section capacity at a section, the design axial force (N^*), which may be tension or compression, shall be the force at the section, and the design bending moments (M_x^*, M_y^*) shall be the bending moments at the section about the major *x*- and minor *y*-principal axes, respectively.

For checking the member capacity, the design axial force (N^*) shall be the maximum axial force in the member, and the design bending moments (M_x^*, M_y^*) shall be the maximum bending moments in the member.

M_x^*, M_y^* are the design bending moments resulting from frame action and transverse loading on the member, and include the second order design bending moments resulting from the design loads acting on the structure and its members in their displaced and deformed configuration.

The design bending moments (M_x^*, M_y^*) shall be determined from one of the following methods of analysis:

(a) *First-order linear elastic analysis*—by modifying the first-order design bending moments, by using the appropriate moment amplification factors determined in accordance with Clause 4.4.2.

(b) *Second-order elastic analysis*—in which the design bending moments (M^*) are obtained either directly, or by modifying the second-order end moments by using the moment amplification factors determined in accordance with Appendix E.

(c) *First-order plastic analysis*—in which the design bending moments (M^*) are obtained directly for frames where the elastic buckling load factor (λ_c) satisfies $\lambda_c \geq 5$ and the requirements of Clause 4.5.4 are satisfied.

(d) *Second-order plastic analysis*—in which the design bending moments (M^*) are obtained directly for frames where the elastic buckling load factor (λ_c) satisfies $\lambda_c < 5$.

(e) *Advanced structural analysis*—in which the design bending moments (M_x^* or M_y^*) are obtained directly in accordance with Appendix D, in which case only the section capacity requirements of Clause 8.3 and the connection requirements of Section 9 need to be satisfied.

8.3 SECTION CAPACITY

8.3.1 General The member shall satisfy Clauses 8.3.2, 8.3.3 and 8.3.4, as appropriate:

(a) For bending about the major principal *x*-axis only, sections at all points along the member shall have sufficient capacity to satisfy Clause 8.3.2.

(b) For bending about the minor principal *y*-axis only, sections at all points along the member shall have sufficient capacity to satisfy Clause 8.3.3.

(c) For bending about a non-principal axis, or bending about both principal axes, sections at all points along the member shall have sufficient capacity to satisfy Clause 8.3.4.

In this Section—

M_{sx}, M_{sy} = the nominal section moment capacities about the x- and y-axes respectively, determined in accordance with Clause 5.2

N_s = the nominal section axial load capacity determined in accordance with Clause 6.2 for axial compression, or Clause 7.2 for axial tension (for which N_s equals N_t).

8.3.2 Uniaxial bending about the major principal *x*-axis Where uniaxial bending occurs about the major principal x-axis, the following shall be satisfied:

$$M_x^* \leq \phi M_{rx}$$

where

ϕ = the capacity factor (see Table 3.4)

M_{rx} = the nominal section moment capacity, reduced by axial force (tension or compression)

$$= M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right)$$

Alternatively, for doubly symmetric I-sections and rectangular and square hollow sections to AS 1163, which are compact as defined in Clause 5.2.3, M_{rx} may be calcualted by one of the following as appropriate:

(a) For compression members where k_f is equal to 1.0 and for tension members—

$$M_{rx} = 1.18 M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right) \leq M_{sx}$$

(b) For compression members where k_f is less than 1.0—

$$M_{rx} = M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right)\left[1 + 0.18\left(\frac{82 - \lambda_w}{82 - \lambda_{wy}}\right)\right] \leq M_{sx}$$

λ_w and λ_{wy} are the values of λ_e and λ_{ey} for the web (see Clause 6.2.3 and Table 6.2.4).

8.3.3 Uniaxial bending about the minor principal *y*-axis Where uniaxial bending occurs about the minor principal y-axis, the design bending moment (M_y^*) about the minor principal y-axis shall satisfy—

$$M_y^* \leq \phi M_{ry}$$

where

ϕ = the capacity factor (see Table 3.4)

M_{ry} = the nominal section moment capacity reduced by the axial tensile or compressive force

$$= M_{sy}\left[1 - \frac{N^*}{\phi N_s}\right]$$

Alternatively, M_{ry} may be calculated by one of the following as appropriate:

(a) For doubly symmetric I-sections which are compact, as defined in Clause 5.2.3—

$$M_{ry} = 1.19 M_{sy}\left[1 - \left(\frac{N^*}{\phi N_s}\right)^2\right] \leq M_{sy}$$

(b) For rectangular or square hollow sections to AS 1163 which are compact as defined in Clause 5.2.3—

$$M_{ry} = 1.18 M_{sy}\left[1 - \left(\frac{N^*}{\phi N_s}\right)\right] \leq M_{sy}$$

8.3.4 Biaxial bending Where biaxial bending occurs, the design tensile or compressive force (N^*) and the design bending moments (M_x^*) and (M_y^*) about the major principal *x*-axis and minor principal *y*-axis shall satisfy—

$$\frac{N^*}{\phi N_s} + \frac{M_x^*}{\phi M_{sx}} + \frac{M_y^*}{\phi M_{sy}} \leq 1$$

Alternatively, for doubly symmetric I-sections and rectangular and square hollow sections to AS 1163, which are compact as defined in Clause 5.2.3, sections at all points along the member shall satisfy—

$$\left(\frac{M_x^*}{\phi M_{rx}}\right)^{\gamma} + \left(\frac{M_y^*}{\phi M_{ry}}\right)^{\gamma} \leq 1$$

where M_{rx} and M_{ry} shall be calculated in accordance with Clauses 8.3.2 and 8.3.3 respectively, and

$$\gamma = 1.4 + \left(\frac{N^*}{\phi N_s}\right) \leq 2.0$$

8.4 MEMBER CAPACITY

8.4.1 General The member shall satisfy Clauses 8.4.2, 8.4.3 and 8.4.4, as appropriate:

(a) For a member bent about the major principal *x*-axis only and where there is sufficient restraint to prevent lateral buckling, or for a member bent about the minor principal *y*-axis only, the member shall satisfy the in-plane requirements of Clause 8.4.2 for a frame analyzed elastically, or Clause 8.4.3 for a frame analyzed plastically.

(b) For a member bent about the major principal *x*-axis only and with insufficient restraint to prevent lateral buckling, the member shall satisfy both the in-plane requirements of Clause 8.4.2 and the out-of-plane requirements of Clause 8.4.4.

(c) For a member bent about a non-principal axis, or bent about both principal axes, the member shall satisfy the biaxial bending requirements of Clause 8.4.5.

8.4.2 In-plane capacity—elastic analysis

8.4.2.1 *Application* This Clause applies to a member analyzed using an elastic method in accordance with Clause 4.4, or to a member in a statically determinate structure.

8.4.2.2 *Compression members* A member bent about a principal axis shall have sufficient in-plane capacity to satisfy the following:

$$M^* \leq \phi M_i$$

where

M^* = the design bending moment about the principal axis

ϕ = the capacity factor (see Table 3.4)

M_i = the nominal in-plane member moment capacity

$$= M_s\left(1 - \frac{N^*}{\phi N_c}\right)$$

M_s = the nominal section moment capacity determined in accordance with Clause 5.2 for bending about the same principal axis as the design bending moment

N^* = the design axial compressive force

N_c = the nominal member capacity in axial compression determined in accordance with Clause 6.3 for buckling about the same principal axis, with the effective length factor (k_e) taken as 1.0 for both braced and sway members, unless a lower value is calculated for braced members from Clause 4.6.3.2, 4.6.3.3 or Clause 4.6.3.5, provided Clause 6.1 is satisfied for N_c calculated using l_e determined in accordance with Clause 4.6.3.

Alternatively, for doubly symmetric I-sections and rectangular and square hollow sections to AS 1163, which are compact as defined in Clause 5.2.3, and where the form factor (k_f) determined in accordance with Clause 6.2.2 is unity, M_i may be calculated as follows:

$$M_i = M_s\left\{\left[1 - \left(\frac{1+\beta_m}{2}\right)^3\right]\left(1 - \frac{N^*}{\phi N_c}\right) + 1.18\left(\frac{1+\beta_m}{2}\right)^3\sqrt{\left(1 - \frac{N^*}{\phi N_c}\right)}\right\}$$

$\leq M_{rx}$ or M_{ry} as appropriate

where

β_m = the ratio of the smaller to the larger end bending moment, taken as positive when the member is bent in reverse curvature for members without transverse load, or

= the value determined in accordance with Clause 4.4.2.2 for members with transverse load

M_{rx} or M_{ry} = the nominal section moment capacity about the appropriate principal axis determined in accordance with Clause 8.3.

8.4.2.3 *Tension members* A member subject to a design axial tensile force (N^*) and a design bending moment (M^*) shall satisfy Clause 8.3.

8.4.3 In-plane capacity—plastic analysis

8.4.3.1 *Application* This Clause applies only to compact doubly symmetric I-section members. When the distribution of moments in a frame is determined using a plastic method of analysis in accordance with Clause 4.5, then the design axial compressive force (N^*) in any member of the frame which is assumed to contain a plastic hinge shall satisfy the member slenderness requirements of Clause 8.4.3.2, and the web slenderness requirements of Clause 8.4.3.3.

The design plastic moment capacity reduced by axial force (tension or compression) for compact doubly symmetric I-sections shall be as specified in Clause 8.4.3.4.

8.4.3.2 *Member slenderness* The design axial compressive force (N^*) in every member assumed to contain a plastic hinge shall satisfy the following:

$$\frac{N^*}{\phi N_s} \leq \left[\frac{0.60 + 0.40\beta_m}{\sqrt{(N_s/N_{ol})}}\right]^2 \qquad \text{when } \frac{N^*}{\phi N_s} \leq 0.15,$$

and

$$\frac{N^*}{\phi N_s} \leq \frac{1 + \beta_m - \sqrt{(N_s/N_{ol})}}{1 + \beta_m + \sqrt{(N_s/N_{ol})}} \qquad \text{when } \frac{N^*}{\phi N_s} > 0.15,$$

where

β_m = the ratio of the smaller to the larger end bending moment, taken as positive when the member is bent in reverse curvature

N_s = the nominal section capacity in axial compression determined in accordance with Clause 6.2

N_{ol} = $\frac{\pi^2 EI}{l^2}$

I = the second moment of area for the axis about which the design moment acts

l = the actual length of the member.

A member for which—

$$\frac{N^*}{\phi N_s} > 0.15, \text{ and}$$

$$\frac{N^*}{\phi N_s} > \frac{1 + \beta_m - \sqrt{(N_s/N_{ol})}}{1 + \beta_m + \sqrt{(N_s/N_{ol})}}$$

shall not contain plastic hinges, although it shall be permissible to design the member as an elastic member in a plastically analyzed structure to satisfy the requirements of Clause 8.4.2.

8.4.3.3 *Web slenderness* The design axial compressive force (N^*) in every member assumed to contain a plastic hinge shall satisfy the following:

(a) For webs where $45 \leq \frac{d_1}{t}\sqrt{\left(\frac{f_y}{250}\right)} \leq 82$—

$$\frac{N^*}{\phi N_s} \leq 0.60 - \left[\frac{d_1}{t}\,\frac{\sqrt{(f_y/250)}}{137}\right]$$

(b) For webs where $25 < \frac{d_1}{t}\sqrt{\left(\frac{f_y}{250}\right)} < 45$—

$$\frac{N^*}{\phi N_s} \leq 1.91 - \left[\frac{d_1}{t}\,\frac{\sqrt{(f_y/250)}}{27.4}\right] \leq 1.0$$

(c) For webs where $0 \leq \frac{d_1}{t}\sqrt{\left(\frac{f_y}{250}\right)} \leq 25$—

$$\frac{N^*}{\phi N_s} \leq 1.0$$

Members which have webs for which $(d_1/t)\sqrt{(f_y/250)}$ exceeds 82 shall not contain plastic hinges, although it shall be permissible to design such a member as an elastic member in a plastically analyzed structure to satisfy the requirements of Clause 8.4.2.

8.4.3.4 *Plastic moment capacity* The design plastic moment capacity (ϕM_{pr}) reduced for axial force (tension or compression) shall be calculated as follows:

(a) For members bent about the major principal x-axis—

$$\phi M_{prx} = 1.18\phi M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right) \leq \phi M_{sx}$$

(b) For members bent about the minor principal y-axis—

$$\phi M_{pry} = 1.19\phi M_{sy}\left[1 - \left(\frac{N^*}{\phi N_s}\right)^2\right] \leq \phi M_{sy}$$

where M_{sx} and M_{sy} are the nominal section moment capacities determined in accordance with Clauses 5.2.1 and 5.2.3.

8.4.4 Out-of-plane capacity

8.4.4.1 *Compression members* A member subject to a design axial compressive force (N^*) and a design bending moment (M_x^*) about its major principal x-axis, and which may buckle laterally, shall satisfy Clause 8.4.2 and also the following:

$$M_x^* \leq \phi M_{ox}$$

where

ϕ = the capacity factor (see Table 3.4)

M_{ox} = the nominal out-of-plane member moment capacity

$$= M_{bx}\left(1 - \frac{N^*}{\phi N_{cy}}\right)$$

M_{bx} = the nominal member moment capacity of the member without full lateral restraint and bent about the major principal x-axis, determined in accordance with Clause 5.6 using a moment modification factor (α_m) appropriate to the distribution of design bending moments along the member

N_{cy} = the nominal member capacity in axial compression, determined in accordance with Clause 6.3 for buckling about the minor principal y-axis.

Alternatively, for members without transverse loads which are of compact doubly symmetric I-section (see Clause 5.2.3), are fully or partially restrained at both ends, and have a form factor (k_f) of unity determined in accordance with Clause 6.2.2, M_{ox} may be calculated as follows:

$$M_{ox} = \alpha_{bc} M_{bxo} \sqrt{\left[\left(1 - \frac{N^*}{\phi N_{cy}}\right)\left(1 - \frac{N^*}{\phi N_{oz}}\right)\right]} \leq M_{rx}$$

where

$$\frac{1}{\alpha_{bc}} = \frac{1 - \beta_m}{2} + \left(\frac{1 + \beta_m}{2}\right)^3 \left(0.4 - 0.23 \frac{N^*}{\phi N_{cy}}\right)$$

M_{bxo} = the nominal member moment capacity without full lateral restraint and with a uniform distribution of design bending moment so that α_m is unity, determined in accordance with Clause 5.6

N_{cy} = the nominal member capacity in axial compression, determined in accordance with Clause 6.3 for buckling about the minor principal y-axis

β_m = the ratio of the smaller to the larger end bending moment, taken as positive when the member is bent in reverse curvature

N_{oz} = the nominal elastic torsional buckling capacity of the member, calculated as follows:

$$N_{oz} = \frac{GJ + (\pi^2 E I_w / l_z^2)}{(I_x + I_y)/A}$$

E, G = the elastic moduli

A, I_w, I_x, I_y, and J = the section constants

l_z = the distance between partial or full torsional restraints

NOTE: Values of E and G, and expressions for I_w and J are given in Appendix H.

8.4.4.2 *Tension members* A member subject to a design axial tensile force (N^*) and a design bending moment (M_x^*) about its major principal x-axis, and which may buckle laterally, shall satisfy the following:

$$M_x^* \leq \phi M_{ox}$$

where

ϕ = the capacity factor (see Table 3.4)

M_{ox} = the nominal out-of-plane member moment capacity

$$= M_{bx}\left(1 + \frac{N^*}{\phi_{N_t}}\right) \leq M_{rx}$$

M_{bx} = the nominal member moment capacity defined in Clause 8.4.4.1

N_t = the nominal section capacity in axial tension determined in accordance with Clause 7.2

M_{rx} = the nominal section moment capacity reduced by axial force determined in accordance with Clause 8.3.2.

8.4.5 Biaxial bending capacity

8.4.5.1 *Compression members* A member subject to a design axial compressive force (N^*) and design bending moments (M_x^*) and (M_y^*) about the major x- and minor y- principal axes respectively shall satisfy the following:

$$\left(\frac{M_x^*}{\phi M_{cx}}\right)^{1.4} + \left(\frac{M_y^*}{\phi M_{iy}}\right)^{1.4} \leq 1$$

where

ϕ = the capacity factor (see Table 3.4)

M_{cx} = the lesser of the nominal in-plane member moment capacity (M_{ix}) and the nominal out-of-plane member moment capacity (M_{ox}) for bending about the major principal x-axis, determined in accordance with Clauses 8.4.2 and 8.4.4 respectively

M_{iy} = the nominal in-plane member moment capacity, determined in accordance with Clause 8.4.2, for bending about the minor principal y-axis.

8.4.5.2 *Tension members* A member subject to a design axial tensile force (N^*) and design bending moments (M_x^*) and (M_y^*) about the major x- and minor y- principal axes respectively shall satisfy the following:

$$\left(\frac{M_x^*}{\phi M_{tx}}\right)^{1.4} + \left(\frac{M_y^*}{\phi M_{ry}}\right)^{1.4} \leq 1$$

where

ϕ = the capacity factor (see Table 3.4)

M_{tx} = the lesser of the nominal section moment capacity (M_{rx}) reduced by axial tension and the nominal out-of-plane member moment capacity (M_{ox}) determined in accordance with Clauses 8.3.2 and 8.4.4.2 respectively

M_{ry} = the nominal section moment capacity reduced by axial tension, determined in accordance with Clause 8.3.3.

8.4.6 Eccentrically loaded double bolted or welded single angles in trusses Single angle web compression members in trusses which are connected with at least two bolts or welded at their ends and loaded through one leg (see Figure 8.4.6) shall be designed to satisfy Clause 8.3 and either Clause 8.4.5 or the following:

$$\frac{N^*}{\phi N_{ch}} + \frac{M_h^*}{\phi M_{bx} \cos \alpha} \leq 1$$

where

N^* = the design axial compression force in the member

M_h^* = the design bending moment acting about the rectangular h-axis parallel to the loaded leg

ϕ = the capacity factor (see Table 3.4)

N_{ch} = the nominal member capacity in axial compression, determined in accordance with Clause 6.3, of a single angle compression member buckling with l_e equals l about the rectangular h-axis parallel to the loaded leg

M_{bx} = the nominal member moment capacity, determined in accordance with Clause 5.6, for an angle without full lateral support, bent about the major principal x-axis using a factor α_m appropriate to the distribution of design bending moment along the member

α = the angle between x- and h- axes.

For equal leg angles, where $l/t \leq (210 + 175\beta_m)(250/f_y)$, M_{bx} may be taken as M_{sx},

where

M_{sx} = the nominal section moment capacity about the x-principal axis, determined in accordance with Clause 5.2.

l = the member length

t = the thickness of the angle.

For other equal leg angles, M_{bx} may be determined by using Clause 5.6.1.1 with—

$$M_o = \left(\frac{525t}{l}\right)\left(\frac{250}{f_y}\right)M_s$$

The design end bending moment (M_h^*) shall be calculated from a rational elastic analysis of the truss, or shall be taken as not less than N^*e, resulting from the out-of-plane eccentricity (e) of the design axial force (N^*) in the member,

where

$e = \left(c_h - \frac{t}{2}\right)$, for angles on the same side of the truss chord

$= (e_c + e_t)$, for angles on opposite sides of the truss chord.

(see Figure 8.4.6).

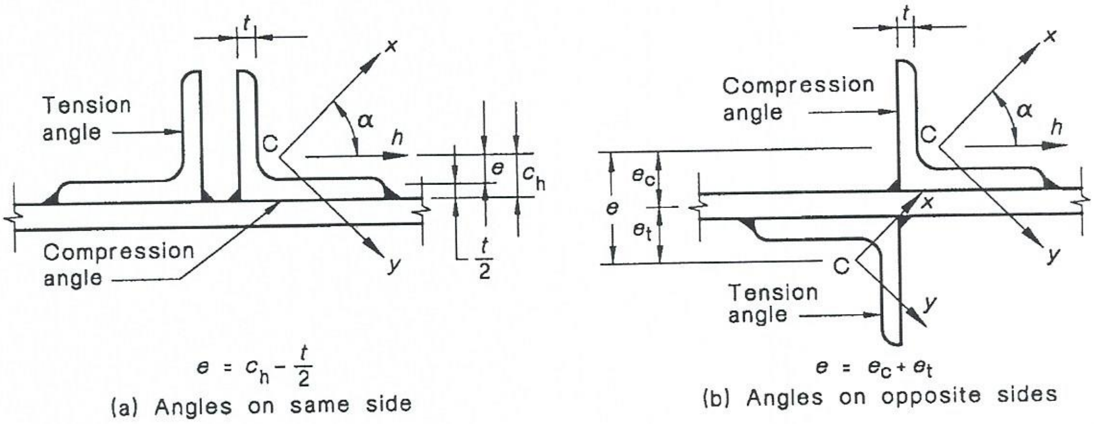
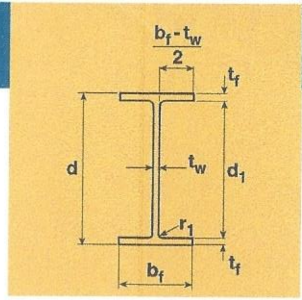
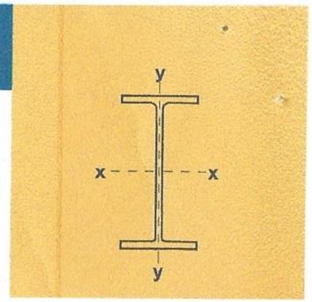


FIGURE 8.4.6 SINGLE ANGLES LOADED THROUGH ONE LEG

onesteel market mills





Universal Beams

Table 15 Universal Beams — Dimensions and Properties

Designation	Depth of Section d	Flange Width b_f	Flange Thickness t_f	Web Thickness t_w	Root Radius r_1	Depth Between Flanges d_1	$\frac{d_1}{t_w}$	$\frac{(b_f - t_w)}{2t_f}$	Gross Area of Cross-Section A_g	About x-axis I_x	Z_x	S_x	r_x	About y-axis I_y	Z_y	S_y	r_y	Torsion Constant J	Warping Constant I_w	Designation
kg/m	mm	mm	mm	mm	mm	mm			mm^2	10^6mm^4	10^3mm^3	10^3mm^3	mm	10^6mm^4	10^3mm^3	10^3mm^3	mm	10^3mm^4	10^9mm^6	
610 UB 125	612	229	19.6	11.9	14.0	572	48.1	5.54	16000	986	3230	3680	249	39.3	343	536	49.6	1560	3450	610 UB 125
113	607	228	17.3	11.2	14.0	572	51.1	6.27	14500	875	2880	3290	246	34.3	300	469	48.7	1140	2980	113
101	602	228	14.8	10.6	14.0	572	54.0	7.34	13000	761	2530	2900	242	29.3	257	402	47.5	790	2530	101
530 UB 92.4	533	209	15.6	10.2	14.0	502	49.2	6.37	11800	554	2080	2370	217	23.8	228	355	44.9	775	1590	530 UB 92.4
82.0	528	209	13.2	9.6	14.0	502	52.3	7.55	10500	477	1810	2070	213	20.1	193	301	43.8	526	1330	82.0
460 UB 82.1	460	191	16.0	9.9	11.4	428	43.3	5.66	10500	372	1610	1840	188	18.6	195	303	42.2	701	919	460 UB 82.1
74.6	457	190	14.5	9.1	11.4	428	47.1	6.24	9520	335	1460	1660	188	16.6	175	271	41.8	530	815	74.6
67.1	454	190	12.7	8.5	11.4	428	50.4	7.15	8580	296	1300	1480	186	14.5	153	238	41.2	378	708	67.1
410 UB 59.7	406	178	12.8	7.8	11.4	381	48.8	6.65	7640	216	1060	1200	168	12.1	135	209	39.7	337	467	410 UB 59.7
53.7	403	178	10.9	7.6	11.4	381	50.1	7.82	6890	188	933	1060	165	10.3	115	179	38.6	234	394	53.7
360 UB 56.7	359	172	13.0	8.0	11.4	333	41.6	6.31	7240	161	899	1010	149	11.0	128	198	39.0	338	330	360 UB 56.7
50.7	356	171	11.5	7.3	11.4	333	45.6	7.12	6470	142	798	897	148	9.60	112	173	38.5	241	284	50.7
44.7	352	171	9.7	6.9	11.4	333	48.2	8.46	5720	121	689	777	146	8.10	94.7	146	37.6	161	237	44.7
310 UB 46.2	307	166	11.8	6.7	11.4	284	42.3	6.75	5930	100	654	729	130	9.01	109	166	39.0	233	197	310 UB 46.2
40.4	304	165	10.2	6.1	11.4	284	46.5	7.79	5210	86.4	569	633	129	7.65	92.7	142	38.3	157	165	40.4
32.0	298	149	8.0	5.5	13.0	282	51.3	8.97	4080	63.2	424	475	124	4.42	59.3	91.8	32.9	86.5	92.9	32.0
250 UB 37.3	256	146	10.9	6.4	8.9	234	36.6	6.40	4750	55.7	435	486	108	5.66	77.5	119	34.5	158	85.2	250 UB 37.3
31.4	252	146	8.6	6.1	8.9	234	38.4	8.13	4010	44.5	354	397	105	4.47	61.2	94.2	33.4	89.3	65.9	31.4
25.7	248	124	8.0	5.0	12.0	232	46.4	7.44	3270	35.4	285	319	104	2.55	41.1	63.6	27.9	67.4	36.7	25.7
200 UB 29.8	207	134	9.6	6.3	8.9	188	29.8	6.65	3820	29.1	281	316	87.3	3.86	57.5	88.4	31.8	105	37.6	200 UB 29.8
25.4	203	133	7.8	5.8	8.9	188	32.3	8.15	3230	23.6	232	260	85.4	3.06	46.1	70.9	30.8	62.7	29.2	25.4
22.3	202	133	7.0	5.0	8.9	188	37.5	9.14	2870	21.0	208	231	85.5	2.75	41.3	63.4	31.0	45.0	26.0	22.3
18.2	198	99	7.0	4.5	11.0	184	40.9	6.75	2320	15.8	160	180	82.6	1.14	23.0	35.7	22.1	38.6	10.4	18.2
180 UB 22.2	179	90	10.0	6.0	8.9	159	26.5	4.20	2820	15.3	171	195	73.6	1.22	27.1	42.3	20.8	81.6	8.71	180 UB 22.2
18.1	175	90	8.0	5.0	8.9	159	31.8	5.31	2300	12.1	139	157	72.6	0.975	21.7	33.7	20.6	44.8	6.80	18.1
16.1	173	90	7.0	4.5	8.9	159	35.3	6.11	2040	10.6	123	138	72.0	0.853	19.0	29.4	20.4	31.5	5.88	16.1
150 UB 18.0	155	75	9.5	6.0	8.0	136	22.7	3.63	2300	9.05	117	135	62.8	0.672	17.9	28.2	17.1	60.5	3.56	150 UB 18.0
14.0	150	75	7.0	5.0	8.0	136	27.2	5.00	1780	6.66	88.8	102	61.1	0.495	13.2	20.8	16.6	28.1	2.53	14.0

Universal Beams

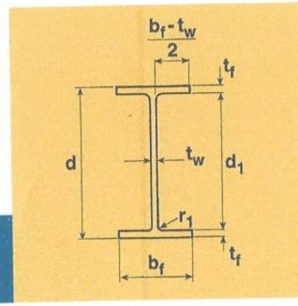
Table 16 Universal Beams — Properties for Assessing Section Capacity

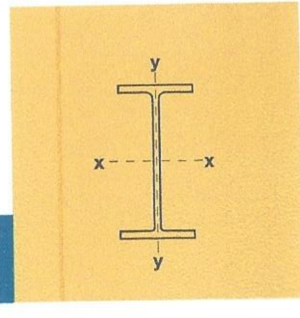
Designation	Yield Stress Flange f_y MPa	Yield Stress Web f_y MPa	Form Factor k_f	About x-axis Compactness	About x-axis Z_{ex} 10^3mm^3	About y-axis Compactness	About y-axis Z_{ey} 10^3mm^3	Yield Stress Flange f_y MPa	Yield Stress Web f_y MPa	Form Factor k_f	About x-axis Compactness	About x-axis Z_{ex} 10^3mm^3	About y-axis Compactness	About y-axis Z_{ey} 10^3mm^3	Designation
			300PLUS*								**AS/NZS 3679.1-350**				
610 UB 125	280	300	0.950	C	3680	C	515	340	340	0.916	C	3680	C	515	610 UB 125
113	280	300	0.926	C	3290	C	451	340	340	0.891	C	3290	C	451	113
101	300	320	0.888	C	2900	C	386	340	360	0.867	C	2900	C	386	101
530 UB 92.4	300	320	0.928	C	2370	C	342	340	360	0.907	C	2370	C	342	530 UB 92.4
82.0	300	320	0.902	C	2070	C	289	340	360	0.880	C	2070	C	289	82.0
460 UB 82.1	300	320	0.979	C	1840	C	292	340	360	0.956	C	1840	C	292	460 UB 82.1
74.6	300	320	0.948	C	1660	C	262	340	360	0.926	C	1660	C	262	74.6
67.1	300	320	0.922	C	1480	C	230	340	360	0.901	C	1480	C	230	67.1
410 UB 59.7	300	320	0.938	C	1200	C	203	340	360	0.918	C	1200	C	203	410 UB 59.7
53.7	320	320	0.913	C	1060	C	173	360	360	0.894	N	1050	N	172	53.7
360 UB 56.7	300	320	0.996	C	1010	C	193	340	360	0.974	C	1010	C	193	360 UB 56.7
50.7	300	320	0.963	C	897	C	168	340	360	0.943	C	897	C	168	50.7
44.7	320	320	0.930	N	770	N	140	360	360	0.911	N	762	N	139	44.7
310 UB 46.2	300	320	0.991	C	729	C	163	340	360	0.972	C	729	C	163	310 UB 46.2
40.4	320	320	0.952	C	633	C	139	360	360	0.936	N	629	N	138	40.4
32.0	320	320	0.915	N	467	N	86.9	360	360	0.898	N	462	N	85.7	32.0
250 UB 37.3	320	320	1.00	C	486	C	116	360	360	1.00	C	486	C	116	250 UB 37.3
31.4	320	320	1.00	N	395	N	91.4	360	360	0.991	N	392	N	90.3	31.4
25.7	320	320	0.949	C	319	C	61.7	360	360	0.932	C	319	C	61.7	25.7
200 UB 29.8	320	320	1.00	C	316	C	86.3	360	360	1.00	C	316	C	86.3	200 UB 29.8
25.4	320	320	1.00	N	259	N	68.8	360	360	1.00	N	257	N	68.0	25.4
22.3	320	320	1.00	N	227	N	60.3	360	360	1.00	N	225	N	59.4	22.3
18.2	320	320	0.990	C	180	C	34.4	360	360	0.970	C	180	C	34.4	18.2
180 UB 22.2	320	320	1.00	C	195	C	40.7	360	360	1.00	C	195	C	40.7	180 UB 22.2
18.1	320	320	1.00	C	157	C	32.5	360	360	1.00	C	157	C	32.5	18.1
16.1	320	320	1.00	C	138	C	28.4	360	360	1.00	C	138	C	28.4	16.1
150 UB 18.0	320	320	1.00	C	135	C	26.9	360	360	1.00	C	135	C	26.9	150 UB 18.0
14.0	320	320	1.00	C	102	C	19.8	360	360	1.00	C	102	C	19.8	14.0

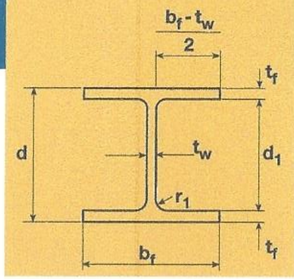
* 300PLUS replaced Grade 250 as the base grade for these sections in 1994.
300PLUS hot rolled sections are produced to exceed the minimum requirements of AS/NZS 3679.1-300.

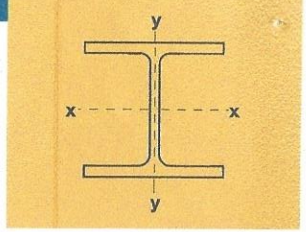
Notes

1. For 300PLUS sections the tensile strength (f_u) is 440 MPa.
2. For Grade 350 sections the tensile strength (f_u) is 480 MPa.
3. C: Compact Section; N: Non-compact Section; S: Slender Section.









Universal Columns

Table 17 Universal Columns — Dimensions and Properties

Designation	Depth of Section d	Flange Width b_f	Flange Thickness t_f	Web Thickness t_w	Root Radius r_1	Depth Between Flanges d_1	$\frac{d_1}{t_w}$	$\frac{(b_f-t_w)}{2t_f}$	Gross Area of Cross-Section A_g	About x-axis I_x	Z_x	S_x	r_x	About y-axis I_y	Z_y	S_y	r_y	Torsion Constant J	Warping Constant I_w	Designation
kg/m	mm	mm	mm	mm	mm	mm			mm^2	$10^6 mm^4$	$10^3 mm^3$	$10^3 mm^3$	mm	$10^6 mm^4$	$10^3 mm^3$	$10^3 mm^3$	mm	$10^3 mm^4$	$10^9 mm^6$	
310 UC 158	327	311	25.0	15.7	16.5	277	17.7	5.91	20100	388	2370	2680	139	125	807	1230	78.9	3810	2860	310 UC 158
137	321	309	21.7	13.8	16.5	277	20.1	6.80	17500	329	2050	2300	137	107	691	1050	78.2	2520	2390	137
118	315	307	18.7	11.9	16.5	277	23.3	7.89	15000	277	1760	1960	136	90.2	588	893	77.5	1630	1980	118
96.8	308	305	15.4	9.9	16.5	277	28.0	9.58	12400	223	1450	1600	134	72.9	478	725	76.7	928	1560	96.8
250 UC 89.5	260	256	17.3	10.5	14.0	225	21.5	7.10	11400	143	1100	1230	112	48.4	378	575	65.2	1040	713	250 UC 89.5
72.9	254	254	14.2	8.6	14.0	225	26.2	8.64	9320	114	897	992	111	38.8	306	463	64.5	586	557	72.9
200 UC 59.5	210	205	14.2	9.3	11.4	181	19.5	6.89	7620	61.3	584	656	89.7	20.4	199	303	51.7	477	195	200 UC 59.5
52.2	206	204	12.5	8.0	11.4	181	22.7	7.84	6660	52.8	512	570	89.1	17.7	174	264	51.5	325	166	52.2
46.2	203	203	11.0	7.3	11.4	181	24.8	8.90	5900	45.9	451	500	88.2	15.3	151	230	51.0	228	142	46.2
150 UC 37.2	162	154	11.5	8.1	8.9	139	17.1	6.34	4730	22.2	274	310	68.4	7.01	91.0	139	38.5	197	39.6	150 UC 37.2
30.0	158	153	9.4	6.6	8.9	139	21.0	7.79	3860	17.6	223	250	67.5	5.62	73.4	112	38.1	109	30.8	30.0
23.4	152	152	6.8	6.1	8.9	139	22.8	10.7	2980	12.6	166	184	65.1	3.98	52.4	80.2	36.6	50.2	21.1	23.4
100 UC 14.8	97	99	7.0	5.0	10.0	83.0	16.6	6.71	1890	3.18	65.6	74.4	41.1	1.14	22.9	35.2	24.5	34.9	2.30	100 UC 14.8

Universal Columns

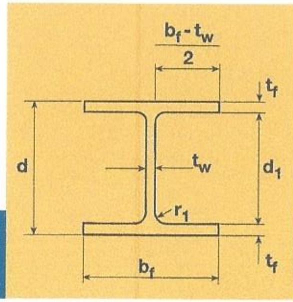
Table 18 Universal Columns — Properties for Assessing Section Capacity

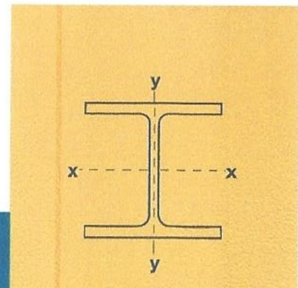
Designation	Yield Stress Flange f_y	Yield Stress Web f_y	Form Factor k_f	About x-axis Compactness	About x-axis Z_{ex}	About y-axis Compactness	About y-axis Z_{ey}	Yield Stress Flange f_y	Yield Stress Web f_y	Form Factor k_f	About x-axis Compactness	About x-axis Z_{ex}	About y-axis Compactness	About y-axis Z_{ey}	Designation
	MPa	MPa			10^3mm^3		10^3mm^3	MPa	MPa			10^3mm^3		10^3mm^3	
			300PLUS*								**AS/NZS 3679.1-350**				
310 UC 158	280	300	1.00	C	2680	C	1210	340	340	1.00	C	2680	C	1210	310 UC 158
137	280	300	1.00	C	2300	C	1040	340	340	1.00	C	2300	C	1040	137
118	280	300	1.00	C	1960	C	882	340	340	1.00	N	1950	N	878	118
96.8	300	320	1.00	N	1560	N	694	340	360	1.00	N	1550	N	684	96.8
250 UC 89.5	280	320	1.00	C	1230	C	567	340	360	1.00	C	1230	C	567	250 UC 89.5
72.9	300	320	1.00	N	986	N	454	340	360	1.00	N	977	N	448	72.9
200 UC 59.5	300	320	1.00	C	656	C	299	340	360	1.00	C	656	C	299	200 UC 59.5
52.2	300	320	1.00	C	570	C	260	340	360	1.00	N	569	N	260	52.2
46.2	300	320	1.00	N	494	N	223	340	360	1.00	N	490	N	219	46.2
150 UC 37.2	300	320	1.00	C	310	C	137	340	360	1.00	C	310	C	137	150 UC 37.2
30.0	320	320	1.00	C	250	C	110	360	360	1.00	N	248	N	109	30.0
23.4	320	320	1.00	N	176	N	73.5	360	360	1.00	N	174	N	72.3	23.4
100 UC 14.8	320	320	1.00	C	74.4	C	34.4	360	360	1.00	C	74.4	C	34.4	100 UC 14.8

* 300PLUS replaced Grade 250 as the base grade for these sections in 1994.
300PLUS hot rolled sections are produced to exceed the minimum requirements of AS/NZS 3679.1-300.

Notes

1. For 300PLUS sections the tensile strength (f_u) is 440 MPa.
2. For Grade 350 sections the tensile strength (f_u) is 480 MPa.
3. C: Compact Section; N: Non-compact Section; S: Slender Section.

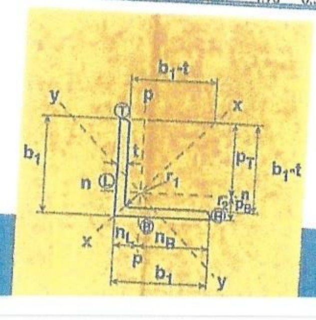


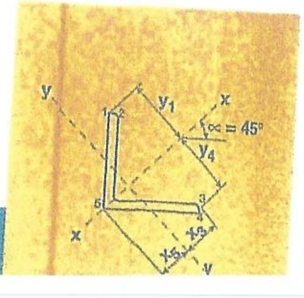


Equal Angles

Table 25 Equal Angles — x-axis and y-axis — Dimensions and Properties

Designation: Leg-size $b_1 \times b_1$ (mm mm)	Designation: Nominal Thickness (mm)	Mass per metre (kg/m)	Actual Thickness t (mm)	Radii: Root r_1 (mm)	Radii: Toe r_2 (mm)	$(b_1-t)/t$	Gross Area of Cross-Section A_g (mm²)	Coordinate of Centroid: $n_L = p_B$ (mm)	Coordinate of Centroid: $n_R = p_T$ (mm)	About x-axis: I_x (10⁶mm⁴)	About x-axis: $y_1 = y_4$ (mm)	About x-axis: $Z_{x1} = Z_{x4}$ (10³mm³)	About x-axis: S_x (10³mm³)	About x-axis: r_x (mm)	About y-axis: I_y (10⁶mm⁴)	About y-axis: x_3 (mm)	About y-axis: Z_{y3} (10³mm³)	About y-axis: x_5 (mm)	About y-axis: Z_{y5} (10³mm³)	About y-axis: S_y (10³mm³)	About y-axis: r_y (mm)	Torsion Constant J (10³mm⁴)	Designation
200 x 200	26 EA	76.8	26.0	18.0	5.0	6.69	9780	59.3	141	56.8	141	402	643	76.2	14.9	73.9	202	83.8	178	329	39.0	2250	200 x 200 x 26 EA
	20 EA	60.1	20.0	18.0	5.0	9.00	7660	57.0	143	45.7	141	323	511	77.2	11.8	72.9	162	80.6	147	260	39.3	1060	20 EA
	18 EA	54.4	18.0	18.0	5.0	10.1	6930	56.2	144	41.7	141	295	464	77.6	10.8	72.6	149	79.5	136	236	39.4	778	18 EA
	16 EA	48.7	16.0	18.0	5.0	11.5	6200	55.4	145	37.6	141	266	417	77.9	9.72	72.3	135	78.4	124	212	39.6	554	16 EA
	13 EA	40.0	13.0	18.0	5.0	14.4	5090	54.2	146	31.2	141	221	344	78.3	8.08	71.9	112	76.6	105	176	39.8	304	13 EA
150 x 150	19 EA	42.1	19.0	13.0	5.0	6.89	5360	44.2	106	17.6	106	166	265	57.2	4.60	54.9	83.8	62.6	73.5	135	29.3	657	150 x 150 x 19 EA
	16 EA	35.4	15.8	13.0	5.0	8.49	4520	43.0	107	15.1	106	142	225	57.8	3.91	54.3	71.9	60.8	64.2	115	29.4	386	16 EA
	12 EA	27.3	12.0	13.0	5.0	11.5	3480	41.5	108	11.9	106	112	175	58.4	3.06	53.7	56.9	58.7	52.1	89.3	29.6	174	12 EA
	10 EA	21.9	9.5	13.0	5.0	14.8	2790	40.5	109	9.61	106	90.6	141	58.7	2.48	53.4	46.4	57.3	43.3	72.0	29.8	88.9	10 EA
125 x 125	16 EA	29.1	15.8	10.0	5.0	6.91	3710	36.8	88.2	8.43	88.4	95.4	153	47.7	2.20	45.4	48.5	52.1	42.3	77.8	24.4	313	125 x 125 x 16 EA
	12 EA	22.5	12.0	10.0	5.0	9.42	2870	35.4	89.6	6.69	88.4	75.7	120	48.3	1.73	44.7	38.6	50.1	34.5	60.8	24.5	141	12 EA
	10 EA	18.0	9.5	10.0	5.0	12.2	2300	34.4	90.6	5.44	88.4	61.6	96.5	48.7	1.40	44.4	31.5	48.7	28.8	49.0	24.7	71.9	10 EA
	8 EA	14.9	7.8	10.0	5.0	15.0	1900	33.7	91.3	4.55	88.4	51.5	80.2	48.9	1.17	44.2	26.5	47.7	24.5	40.8	24.8	40.6	8 EA
100 x 100	12 EA	17.7	12.0	8.0	5.0	7.33	2260	29.2	70.8	3.29	70.7	46.6	74.5	38.2	0.857	35.8	23.9	41.3	20.8	37.9	19.5	110	100 x 100 x 12 EA
	10 EA	14.2	9.5	8.0	5.0	9.53	1810	28.2	71.8	2.70	70.7	38.2	60.4	38.6	0.695	35.4	19.6	39.9	17.4	30.7	19.6	56.2	10 EA
	8 EA	11.8	7.8	8.0	5.0	11.8	1500	27.5	72.5	2.27	70.7	32.0	50.3	38.8	0.582	35.2	16.5	38.9	14.9	25.6	19.7	31.7	8 EA
	6 EA	9.16	6.0	8.0	5.0	15.7	1170	26.8	73.2	1.78	70.7	25.2	39.3	39.1	0.458	35.0	13.1	37.9	12.1	20.0	19.8	14.8	6 EA
90 x 90	10 EA	12.7	9.5	8.0	5.0	8.47	1620	25.7	64.3	1.93	63.6	30.4	48.3	34.5	0.500	31.9	15.7	36.4	13.8	24.6	17.6	50.5	90 x 90 x 10 EA
	8 EA	10.6	7.8	8.0	5.0	10.5	1350	25.0	65.0	1.63	63.6	25.6	40.4	34.8	0.419	31.7	13.2	35.4	11.8	20.5	17.6	28.6	8 EA
	6 EA	8.22	6.0	8.0	5.0	14.0	1050	24.3	65.7	1.28	63.6	20.1	31.6	35.0	0.330	31.5	10.5	34.3	9.62	16.1	17.8	13.4	6 EA
75 x 75	10 EA	10.5	9.5	8.0	5.0	6.89	1340	22.0	53.0	1.08	53.0	20.4	32.8	28.4	0.282	26.6	10.6	31.1	9.09	16.8	14.5	41.9	75 x 75 x 10 EA
	8 EA	8.73	7.8	8.0	5.0	8.62	1110	21.3	53.7	0.913	53.0	17.2	27.5	28.7	0.237	26.4	8.99	30.1	7.87	14.0	14.6	23.8	8 EA
	6 EA	6.81	6.0	8.0	5.0	11.5	867	20.5	54.5	0.722	53.0	13.6	21.6	28.9	0.187	26.2	7.15	29.0	6.44	11.0	14.7	11.2	6 EA
	5 EA	5.27	4.6	8.0	5.0	15.3	672	19.9	55.1	0.563	53.0	10.6	16.7	29.0	0.147	26.1	5.62	28.1	5.22	8.61	14.8	5.28	5 EA
65 x 65	10 EA	9.02	9.5	6.0	3.0	5.84	1150	19.6	45.4	0.691	46.0	15.0	24.3	24.5	0.183	23.7	7.71	27.7	6.60	12.5	12.6	35.1	65 x 65 x 10 EA
	8 EA	7.51	7.8	6.0	3.0	7.33	957	19.0	46.0	0.589	46.0	12.8	20.5	24.8	0.154	23.4	6.56	26.8	5.73	10.5	12.7	20.0	8 EA
	6 EA	5.87	6.0	6.0	3.0	9.83	748	18.3	46.7	0.471	46.0	10.2	16.2	25.1	0.122	23.1	5.26	25.8	4.71	8.25	12.8	9.37	6 EA
	5 EA	4.56	4.6	6.0	3.0	13.1	581	17.7	47.3	0.371	46.0	8.08	12.7	25.3	0.0959	23.0	4.18	25.0	3.83	6.46	12.9	4.36	5 EA
55 x 55	6 EA	4.93	6.0	6.0	3.0	8.17	628	15.8	39.2	0.278	38.9	7.14	11.4	21.0	0.0723	19.6	3.69	22.3	3.24	5.82	10.7	7.93	55 x 55 x 6 EA
	5 EA	3.84	4.6	6.0	3.0	11.0	489	15.2	39.8	0.220	38.9	5.66	8.93	21.2	0.0571	19.4	2.94	21.5	2.66	4.57	10.8	3.71	5 EA
50 x 50	8 EA	5.68	7.8	6.0	3.0	5.41	723	15.2	34.8	0.253	35.4	7.16	11.7	18.7	0.0675	18.1	3.73	21.5	3.14	6.00	9.66	15.2	50 x 50 x 8 EA
	6 EA	4.46	6.0	6.0	3.0	7.33	568	14.5	35.5	0.205	35.4	5.79	9.30	19.0	0.0536	17.8	3.01	20.5	2.61	4.76	9.71	7.21	6 EA
	5 EA	3.48	4.6	6.0	3.0	9.87	443	13.9	36.1	0.163	35.4	4.61	7.32	19.2	0.0424	17.6	2.40	19.7	2.15	3.75	9.78	3.38	5 EA
	3 EA	2.31	3.0	6.0	3.0	15.7	295	13.2	36.8	0.110	35.4	3.11	4.90	19.3	0.0289	17.6	1.65	18.7	1.55	2.53	9.90	1.01	3 EA
45 x 45	6 EA	3.97	6.0	5.0	3.0	6.50	506	13.3	31.7	0.146	31.8	4.59	7.41	17.0	0.0383	16.0	2.39	18.8	2.04	3.79	8.71	6.32	45 x 45 x 6 EA
	5 EA	3.10	4.6	5.0	3.0	8.78	394	12.7	32.3	0.117	31.8	3.66	5.84	17.2	0.0303	15.8	1.91	18.0	1.68	2.99	8.76	2.96	5 EA
	3 EA	2.06	3.0	5.0	3.0	14.0	263	12.0	33.0	0.0790	31.8	2.48	3.92	17.3	0.0206	15.7	1.31	17.0	1.21	2.02	8.85	0.875	3 EA
40 x 40	6 EA	3.50	6.0	5.0	3.0	5.67	446	12.0	28.0	0.0997	28.3	3.53	5.75	15.0	0.0265	14.3	1.86	17.0	1.55	2.95	7.71	5.60	40 x 40 x 6 EA
	5 EA	2.73	4.6	5.0	3.0	7.70	348	11.5	28.5	0.0801	28.3	2.83	4.55	15.2	0.0209	14.0	1.49	16.2	1.29	2.33	7.75	2.63	5 EA
	3 EA	1.83	3.0	5.0	3.0	12.3	233	10.8	29.2	0.0545	28.3	1.93	3.06	15.3	0.0142	13.9	1.02	15.3	0.930	1.58	7.82	0.785	3 EA
30 x 30	6 EA	2.56	6.0	5.0	3.0	4.00	326	9.53	20.5	0.0387	21.2	1.83	3.06	10.9	0.0107	10.7	0.993	13.5	0.790	1.59	5.72	4.16	30 x 30 x 6 EA
	5 EA	2.01	4.6	5.0	3.0	5.52	256	8.99	21.0	0.0316	21.2	1.49	2.45	11.1	0.00839	10.5	0.799	12.7	0.660	1.26	5.72	1.98	5 EA
	3 EA	1.35	3.0	5.0	3.0	9.00	173	8.30	21.7	0.0218	21.2	1.03	1.67	11.2	0.00573	10.3	0.554	11.7	0.488	0.862	5.76	0.605	3 EA
25 x 25	6 EA	2.08	6.0	5.0	3.0	3.17	266	8.28	16.7	0.0210	17.7	1.19	2.03	8.89	0.00600	8.97	0.669	11.7	0.513	1.07	4.75	3.44	25 x 25 x 6 EA
	5 EA	1.65	4.6	5.0	3.0	4.43	210	7.75	17.3	0.0173	17.7	0.980	1.65	9.07	0.00469	8.73	0.537	11.0	0.428	0.849	4.72	1.66	5 EA
	3 EA	1.12	3.0	5.0	3.0	7.33	143	7.07	17.9	0.0121	17.7	0.685	1.13	9.22	0.00319	8.56	0.373	9.99	0.319	0.583	4.73	0.515	3 EA





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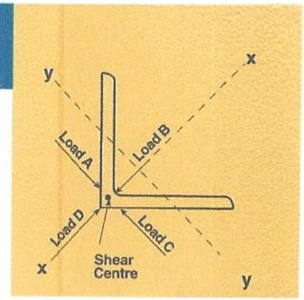

Equal Angles

Table 26 Equal Angles — x-axis and y-axis — Properties for Assessing Section Capacity

Designation	Yield Stress	Form Factor	About x-axis	About y-axis		Yield Stress	Form Factor	About x-axis	About y-axis		Designation
			Load A or C	Load B	Load D			Load A or C	Load B	Load D	
	f_y	k_f	Z_{ex}	Z_{ey}	Z_{ey}	f_y	k_f	Z_{ex}	Z_{ey}	Z_{ey}	
mm mm mm	MPa		$10^3 mm^3$	$10^3 mm^3$	$10^3 mm^3$	MPa		$10^3 mm^3$	$10^3 mm^3$	$10^3 mm^3$	
			300PLUS*					***AS/NZS 3679.1-350***			
200 x 200 x 26 EA	280	1.00	602	267	267	340	1.00	602	267	267	200 x 200 x 26 EA
20 EA	280	1.00	479	218	220	340	1.00	469	214	220	20 EA
18 EA	280	1.00	427	196	204	340	1.00	417	192	204	18 EA
16 EA	300	1.00	369	172	186	340	1.00	362	169	186	16 EA
13 EA	300	1.00	285	136	158	340	0.956	278	132	158	13 EA
150 x 150 x 19 EA	280	1.00	248	110	110	340	1.00	248	110	110	150 x 150 x 19 EA
16 EA	300	1.00	212	95.7	96.3	340	1.00	209	94.5	96.3	16 EA
12 EA	300	1.00	155	72.3	78.1	340	1.00	152	70.9	78.1	12 EA
10 EA	320	0.958	114	54.5	64.9	360	0.906	111	53.1	64.9	10 EA
125 x 125 x 16 EA	300	1.00	143	63.4	63.4	340	1.00	143	63.4	63.4	125 x 125 x 16 EA
12 EA	300	1.00	110	50.3	51.7	340	1.00	109	49.6	51.7	12 EA
10 EA	320	1.00	83.2	38.9	43.1	360	1.00	81.6	38.1	43.1	10 EA
8 EA	320	0.943	64.3	30.7	36.8	360	0.892	62.7	29.9	36.8	8 EA
100 x 100 x 12 EA	300	1.00	69.9	31.1	31.1	340	1.00	69.9	31.1	31.1	100 x 100 x 12 EA
10 EA	320	1.00	55.1	25.2	26.1	360	1.00	54.4	24.8	26.1	10 EA
8 EA	320	1.00	43.7	20.4	22.4	360	1.00	42.9	20.0	22.4	8 EA
6 EA	320	0.906	30.9	14.8	18.1	360	0.856	30.0	14.4	18.1	6 EA
90 x 90 x 10 EA	320	1.00	45.0	20.4	20.6	360	1.00	44.5	20.1	20.6	90 x 90 x 10 EA
8 EA	320	1.00	36.0	16.7	17.8	360	1.00	35.4	16.4	17.8	8 EA
6 EA	320	1.00	25.9	12.4	14.4	360	0.954	25.3	12.1	14.4	6 EA
75 x 75 x 10 EA	320	1.00	30.5	13.6	13.6	360	1.00	30.5	13.6	13.6	75 x 75 x 10 EA
8 EA	320	1.00	25.4	11.6	11.8	360	1.00	25.1	11.5	11.8	8 EA
6 EA	320	1.00	18.7	8.85	9.66	360	1.00	18.4	8.70	9.66	6 EA
5 EA	320	0.927	13.2	6.47	7.82	360	0.876	12.8	6.30	7.82	5 EA
65 x 65 x 10 EA	320	1.00	22.5	9.90	9.90	360	1.00	22.5	9.90	9.90	65 x 65 x 10 EA
8 EA	320	1.00	19.2	8.59	8.59	360	1.00	19.2	8.59	8.59	8 EA
6 EA	320	1.00	14.7	6.76	7.07	360	1.00	14.5	6.66	7.07	6 EA
5 EA	320	1.00	10.6	5.05	5.75	360	1.00	10.4	4.94	5.75	5 EA
55 x 55 x 6 EA	320	1.00	10.7	4.84	4.86	360	1.00	10.5	4.78	4.86	55 x 55 x 6 EA
5 EA	320	1.00	7.88	3.70	3.98	360	1.00	7.75	3.64	3.98	5 EA
50 x 50 x 8 EA	320	1.00	10.7	4.71	4.71	360	1.00	10.7	4.71	4.71	50 x 50 x 8 EA
6 EA	320	1.00	8.69	3.92	3.92	360	1.00	8.69	3.92	3.92	6 EA
5 EA	320	1.00	6.60	3.08	3.22	360	1.00	6.50	3.03	3.22	5 EA
3 EA	320	0.907	3.82	1.90	2.32	360	0.858	3.71	1.85	2.32	3 EA
45 x 45 x 6 EA	320	1.00	6.88	3.06	3.06	360	1.00	6.88	3.06	3.06	45 x 45 x 6 EA
5 EA	320	1.00	5.39	2.47	2.52	360	1.00	5.32	2.44	2.52	5 EA
3 EA	320	1.00	3.19	1.55	1.81	360	0.954	3.12	1.52	1.81	3 EA
40 x 40 x 6 EA	320	1.00	5.29	2.33	2.33	360	1.00	5.29	2.33	2.33	40 x 40 x 6 EA
5 EA	320	1.00	4.25	1.93	1.93	360	1.00	4.22	1.92	1.93	5 EA
3 EA	320	1.00	2.59	1.25	1.40	360	1.00	2.54	1.23	1.40	3 EA
30 x 30 x 6 EA	320	1.00	2.74	1.19	1.19	360	1.00	2.74	1.19	1.19	30 x 30 x 6 EA
5 EA	320	1.00	2.23	0.990	0.990	360	1.00	2.23	0.990	0.990	5 EA
3 EA	320	1.00	1.50	0.714	0.732	360	1.00	1.48	0.705	0.732	3 EA
25 x 25 x 6 EA	320	1.00	1.78	0.769	0.769	360	1.00	1.78	0.769	0.769	25 x 25 x 6 EA
5 EA	320	1.00	1.47	0.642	0.642	360	1.00	1.47	0.642	0.642	5 EA
3 EA	320	1.00	1.03	0.479	0.479	360	1.00	1.03	0.479	0.479	3 EA

*300PLUS replaced Grade 250 as the base grade for 125x125x8 equal angles and larger in 1994.
300PLUS replaced Grade 250 as the base grade for 100x100x12 equal angles and smaller in 1997.
300PLUS hot rolled sections are produced to exceed the minimum requirements of AS/NZS 3679.1-300.

Notes 1. For 300PLUS sections the tensile strength (f_u) is 440 MPa.
2. For Grade 350 sections the tensile strength (f_u) is 480 MPa.

Table 27 Equal Angles — n-axis and p-axis — Propert.

Designation	About n-axis and p-axis							Product of 2nd Moment of Area	Designation
	$I_n = I_p$	$n_L = p_B$	$Z_{nB} = Z_{pL}$	$n_R = p_T$	$Z_{nT} = Z_{pR}$	$S_n = S_p$	$r_n = r_p$	I_{np}	
mm mm mm	$10^6 mm^4$	mm	$10^3 mm^3$	mm	$10^3 mm^3$	$10^3 mm^3$	mm	$10^6 mm^4$	
200 x 200 x 26 EA	35.8	59.3	605	141	255	460	60.5	-20.9	200 x 200 x 26 EA
20 EA	28.8	57.0	505	143	201	363	61.3	-16.9	20 EA
18 EA	26.3	56.2	467	144	183	330	61.5	-15.5	18 EA
16 EA	23.7	55.4	427	145	164	296	61.8	-14.0	16 EA
13 EA	19.7	54.2	363	146	135	243	62.2	-11.6	13 EA
150 x 150 x 19 EA	11.1	44.2	250	106	105	189	45.4	-6.48	150 x 150 x 19 EA
16 EA	9.48	43.0	220	107	88.7	160	45.8	-5.58	16 EA
12 EA	7.46	41.5	180	108	68.8	124	46.3	-4.40	12 EA
10 EA	6.04	40.5	149	109	55.2	99.9	46.6	-3.56	10 EA
125 x 125 x 16 EA	5.32	36.8	144	88.2	60.3	109	37.9	-3.11	125 x 125 x 16 EA
12 EA	4.21	35.4	119	89.6	47.0	85.0	38.3	-2.48	12 EA
10 EA	3.42	34.4	99.4	90.6	37.8	68.4	38.6	-2.02	10 EA
8 EA	2.86	33.7	84.9	91.3	31.3	56.8	38.8	-1.69	8 EA
100 x 100 x 12 EA	2.08	29.2	71.1	70.8	29.3	53.2	30.3	-1.22	100 x 100 x 12 EA
10 EA	1.70	28.2	60.1	71.8	23.6	42.9	30.6	-1.00	10 EA
8 EA	1.42	27.5	51.7	72.5	19.6	35.7	30.8	-0.842	8 EA
6 EA	1.12	26.8	41.8	73.2	15.3	27.8	31.0	-0.661	6 EA
90 x 90 x 10 EA	1.22	25.7	47.3	64.3	18.9	34.4	27.4	-0.716	90 x 90 x 10 EA
8 EA	1.02	25.0	40.9	65.0	15.7	28.7	27.6	-0.604	8 EA
6 EA	0.805	24.3	33.2	65.7	12.3	22.4	27.7	-0.475	6 EA
75 x 75 x 10 EA	0.681	22.0	31.0	53.0	12.8	23.4	22.6	-0.399	75 x 75 x 10 EA
8 EA	0.575	21.3	27.0	53.7	10.7	19.6	22.7	-0.338	8 EA
6 EA	0.455	20.5	22.1	54.5	8.35	15.3	22.9	-0.268	6 EA
5 EA	0.355	19.9	17.9	55.1	6.44	11.8	23.0	-0.208	5 EA
65 x 65 x 10 EA	0.437	19.6	22.3	45.4	9.62	17.4	19.5	-0.254	65 x 65 x 10 EA
8 EA	0.371	19.0	19.6	46.0	8.07	14.6	19.7	-0.218	8 EA
6 EA	0.296	18.3	16.2	46.7	6.34	11.5	19.9	-0.175	6 EA
5 EA	0.234	17.7	13.2	47.3	4.94	8.97	20.1	-0.138	5 EA
55 x 55 x 6 EA	0.175	15.8	11.1	39.2	4.46	8.11	16.7	-0.103	55 x 55 x 6 EA
5 EA	0.139	15.2	9.12	39.8	3.48	6.34	16.8	-0.0814	5 EA
50 x 50 x 8 EA	0.160	15.2	10.5	34.8	4.61	8.38	14.9	-0.0928	50 x 50 x 8 EA
6 EA	0.129	14.5	8.90	35.5	3.64	6.63	15.1	-0.0756	6 EA
5 EA	0.103	13.9	7.36	36.1	2.85	5.19	15.2	-0.0602	5 EA
3 EA	0.0694	13.2	5.25	36.8	1.89	3.46	15.3	-0.0405	3 EA
45 x 45 x 6 EA	0.0922	13.3	6.93	31.7	2.91	5.30	13.5	-0.0538	45 x 45 x 6 EA
5 EA	0.0734	12.7	5.76	32.3	2.28	4.16	13.6	-0.0432	5 EA
3 EA	0.0498	12.0	4.14	33.0	1.51	2.77	13.8	-0.0292	3 EA
40 x 40 x 6 EA	0.0631	12.0	5.24	28.0	2.26	4.12	11.9	-0.0366	40 x 40 x 6 EA
5 EA	0.0505	11.5	4.39	28.5	1.77	3.24	12.0	-0.0296	5 EA
3 EA	0.0344	10.8	3.19	29.2	1.18	2.17	12.2	-0.0201	3 EA
30 x 30 x 6 EA	0.0247	9.53	2.59	20.5	1.21	2.22	8.71	-0.0140	30 x 30 x 6 EA
5 EA	0.0200	8.99	2.22	21.0	0.951	1.76	8.83	-0.0116	5 EA
3 EA	0.0138	8.30	1.66	21.7	0.635	1.18	8.93	-0.00804	3 EA
25 x 25 x 6 EA	0.0135	8.28	1.63	16.7	0.807	1.49	7.13	-0.00750	25 x 25 x 6 EA
5 EA	0.0110	7.75	1.42	17.3	0.638	1.19	7.23	-0.00632	5 EA
3 EA	0.00765	7.07	1.08	17.9	0.426	0.802	7.33	-0.00446	3 EA