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|---|---|---|---|
| **FACULTY** | **AGRICULTURE, ENGINEERING, AND NATURAL SCIENCES** | | |
| **SCHOOL** | **ENGINEERING AND THE BUILT ENVIRONMENT** | | |
| **DEPARTMENT** | **CIVIL AND MINING ENGINEERING** | | |
| **SUBJECT** | **DESIGN OF STEEL AND TIMBER STRUCTURES** | | |
| **SUBJECT CODE** | **TCVS3762** | | |
| **ASSESSMENT TYPE** | **SECOND SEMESTER EXAMINATION** | | |
| **DATE** | **NOVEMBER 2023** | | |
| **TIME ALLOWED** | **2 HOURS** | **MARKS** | **100** |

# FIRST OPPORTUNITY EXAMINATION

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**Internal Moderator:** DR. PHILEMON ARITO

**External Moderator:** PROF. AKPOFURE TAIGBENU (University of the Witwatersrand)

This question paper consists of ...**21**.... pages including this front page.

## ***Instructions***

(a) **Closed** book examination.
(b) Read the questions carefully.
(c) Timber design must be carried out according to the provisions of BS 5268 and steel design according to EUROCODE 3.
(d) Fifteen (15) pages of code extracts and other relevant data are attached to this question paper for your convenient reference (please refer to pages 7 to 21).
(e) Answer questions 1 and 2, plus EITHER question 3 *OR* question 4.
(f) Marks for each question are indicated.
(g) Start each question on a new page.

**Question 1** **[20 marks]**

A timber beam with a clear span of 3.65 $m$ supports a uniformly distributed load of 3.5 $kN/m$ including self-weight of the beam. The beam is made of timber strength class $C24$ under service class 1. The bearing length is 150 $mm$ and the ends of the beam are held in position and compression edge held in line. By using the BS 5268 procedure, for this beam:

(a) Determine the minimum required section modulus $Z_{xx}$ (assume $h = 225mm$). **[6 *marks*]**

(b) By considering only the bending deflection and ignoring the deflection due to shear, find the required second moment of area, $I_{xx}$, if the permissible deflection $\delta_p$ is given as:
$\delta_p = 0.003 \times span.$ **[5 *marks*]**

(c) Using the section modulus, $Z_{xx}$, determined in (a) above and the second moment of area $I_{xx}$ determined in (b), select a section for the timber beam which is adequate for bending and deflection. **[2 *marks*]**

(d) Check the adequacy of the selected section for lateral buckling. **[3 *marks*]**

(e) Check the adequacy of the section in shear. **[4 *marks*]**

**Question 2** **[20 marks]**

The ends of a $125 \times 75 \times 10$ single unequal angle tension member are connected to gusset plates through the larger leg by a single row of three 20 $mm$ bolts in line in 22 $mm$ holes at 70 $mm$ centres. The gross cross-sectional area of the angle is $A = 19.1\,cm^2$ and its thickness is $t = 10$ $mm$. If the angle is of grade $S355$ steel and it is expected to resist a design tension force, $N_{t,Ed} = 440\,kN$:

(a) Determine the design plastic resistance of the gross cross-section **[5 *marks*]**

(b) Find the design ultimate resistance of the net cross-section **[10 *marks*]**

(c) What is the tension capacity of the angle? **[3 *marks*]**

(d) Make a statement on the sufficiency of the capacity of the angle member to resist the given design tension force **[2 *marks*]**

**Question 3** **[60 marks]**

**Fig.Q3** shows a typical floor plan of the steel framework of a multistory building. The **two-way spanning floor slab** provided is assumed **not able to provide lateral restraint to the compression flanges of the beams**. The *beams* are *simply-supported*. The load is not destabilizing. The following design data apply:

**Design Data:**

| | |
|---|---|
| Total *characteristic* permanent action on the floor (including self-weight of beam) | $4.5\ kN/m^2$ |
| Total *characteristic* variable load on the floor | $2.5\ kN/m^2$ |
| Modulus of elasticity of steel | $2.1\times10^5\ N/mm^2$ |
| Shear modulus of steel | $G=8.1\times10^4\ N/mm^2$ |

Using the above **design data**, for the simply-supported **Beam *B2-B3*:**

(a) Determine the ultimate load **[5 *marks*]**

(b) Draw the shear force and bending moment diagrams and hence, indicate the design shear force and the design bending moment **[14 *marks*]**

(c) Select a trial UB section in grade S355 steel and classify the cross-section **[10 *marks*]**

(d) Check the bending resistance of the cross-section **[4 *marks*]**

(e) Carry out lateral-torsional buckling check for the beam using either the EC 3 "**General Case**" or the "**Rolled or Equivalent Welded Section Case**" **[20 *marks*]**

(f) Make a statement on the suitability of the trial section you selected for use as beam ***B2-3***

**[2 *marks*]**

(g) If the selected section is not adequate, select one that is adequate, ensuring in all cases that the buckling resistance moment of the finally adopted beam is not greater than the design bending moment by more than 25%. **[5 *marks*]**

(b) Determine the reactions at the supports for the simply-supported primary beam **B2** (span equals 9 m) **[12 *marks*]**

(c) Determine the design axial load on the column at section **a-a** **[7 *marks*]**

(d) Determine the design axial load on the column at section **b-b** **[7 *marks*]**

(e) By using steel grade S355 and assuming that the buckling length $L_{cr} = 0.85L$, use the axial load obtained at section **b-b** to design a UC column for the first floor according to the following steps:

(i) Obtain a target area and hence select a trial UC section, listing all relevant section properties with their values. **[4 *marks*]**

(ii) Determine the relevant buckling curve and the imperfection factor $\alpha$. **[8 *marks*]**

(iii) Calculate the reduction factor $\chi$ and hence determine the buckling resistance of the section. Make a statement on the adequacy or otherwise of the selected section. **[10 *marks*]**

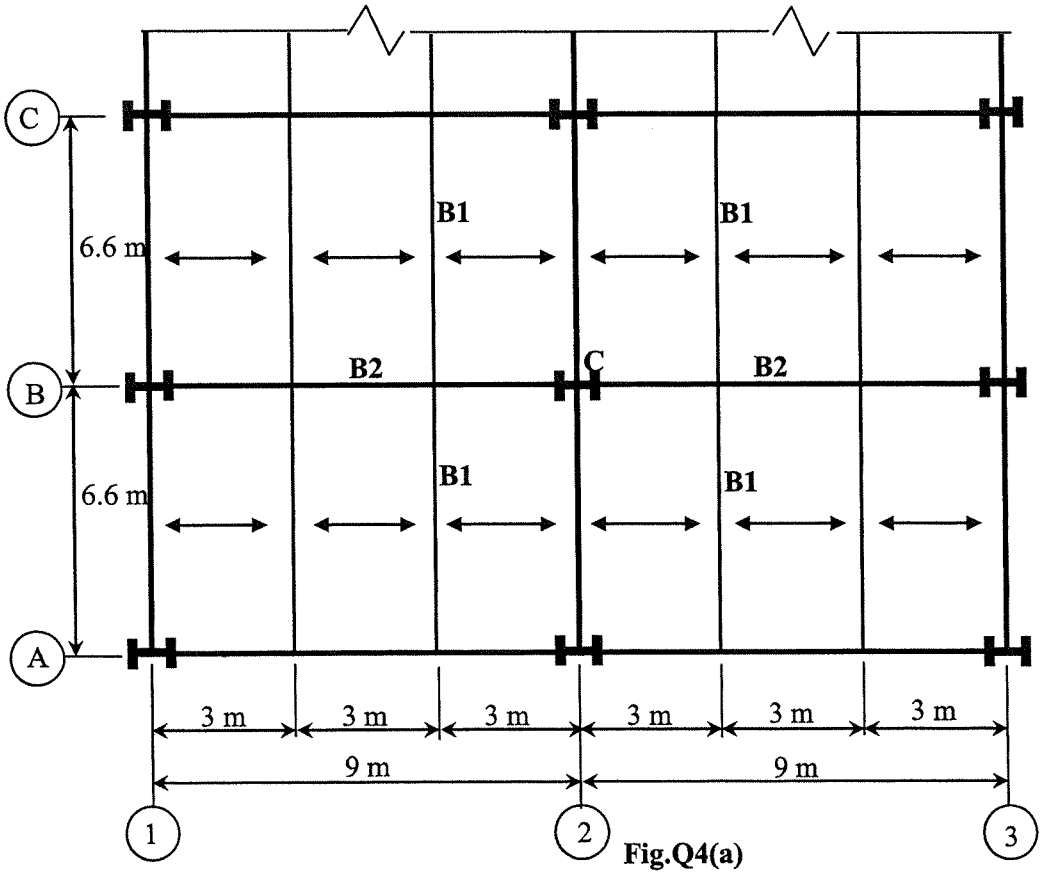



**Fig.Q4(a)**

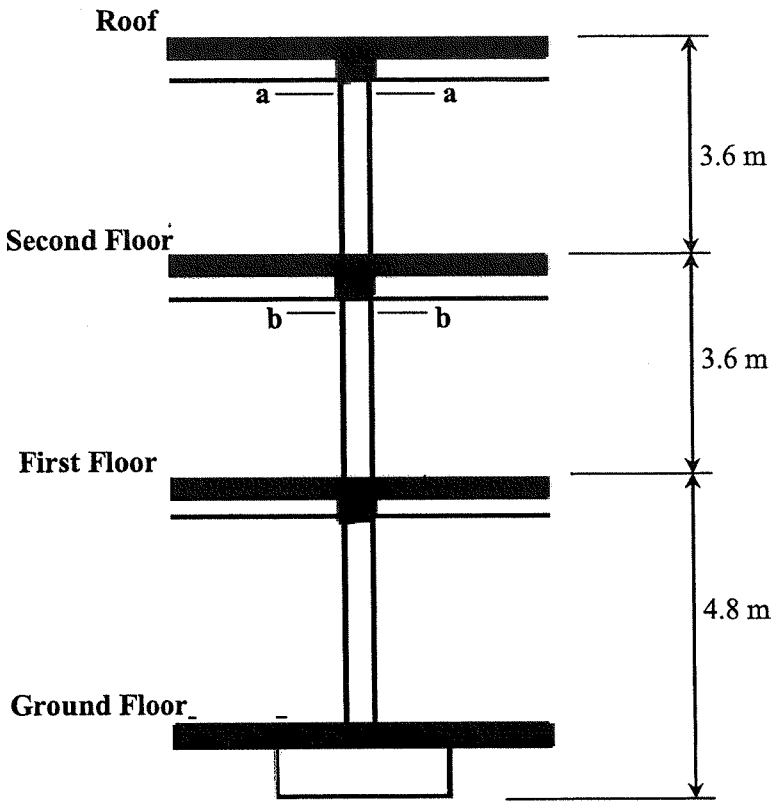



**Fig.Q4(b)**

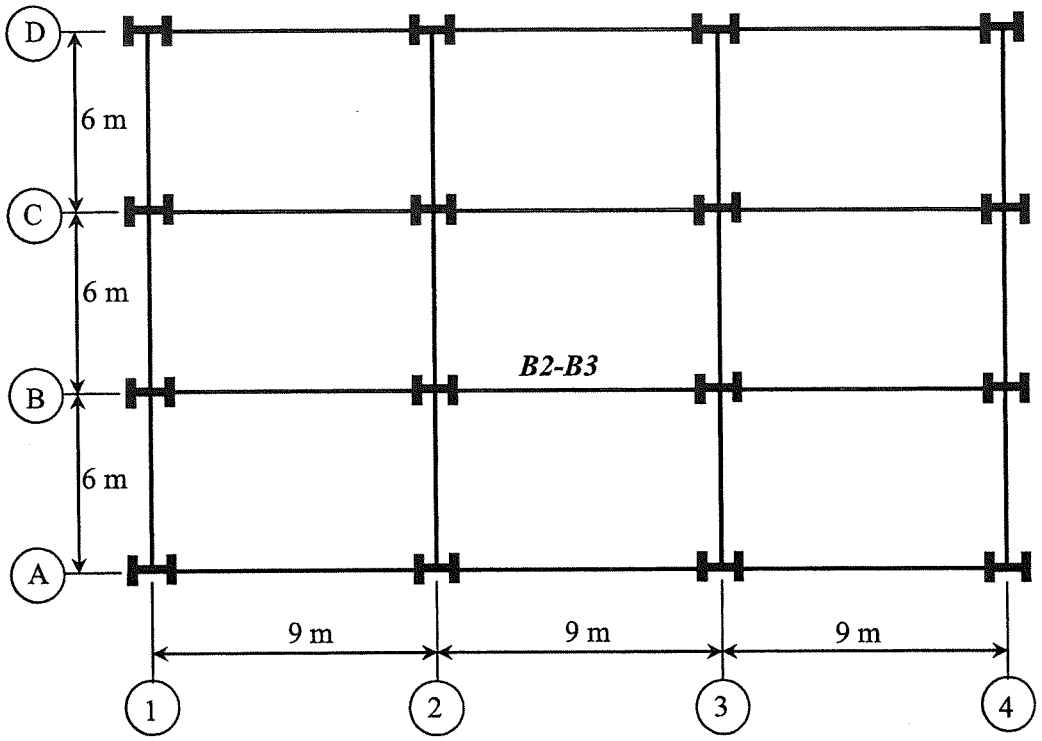



**Fig.Q3**

**Question 4** **[60 marks]**

**Fig. Q4(a)** represents the part-floor plan of an office building while **Fig.Q4(b)** is the elevation of the internal column stack C (on Grid Line B-2 on plan). The slabs for the floor and roof are prefabricated one-way spanning slabs and the roof and the floors have the same layout. The following design data apply:

**Design Data:**

| | |
|---|---|
| Total characteristic permanent load on roof | $g_k = 4.0\ kN/m^2$ |
| Total characteristic variable load on roof | $q_k = 1.5\ kN/m^2$ |
| Total characteristic permanent load on floor | $g_k = 6.4\ kN/m^2$ |
| Total characteristic variable load on floor | $q_k = 2.5\ kN/m^2$ |
| Self-weight of the columns (including fire protection) | $1.2\ kN/m$ |

**Using the above information:**

(a) Determine the reactions at the supports for the simply-supported secondary beam **B1** (span equals 6.6 m) **[12 *marks*]**

**Table 5 Maximum depth to breadth ratios (Table 19, BS 5268)**

| *Degree of lateral support* | *Maximum depth to breadth ratio* |
|---|---|
| No lateral support | 2 |
| Ends held in position | 3 |
| Ends held in position and member held in line, as by purlins or tie-rods at centres not more than 30 times the breadth of the member | 4 |
| Ends held in position and compression edge held in line, as by direct connection of sheathing, deck or joists | 5 |
| Ends held in position and compression edge held in line, as by direct connection of sheathing, deck or joists, together with adequate bridging or blocking spaced at intervals not exceeding six times the depth | 6 |
| Ends held in position and both edges held firmly in line | 7 |

**Depth factor, $K_7$:**

$K_7 = 1.17$, for solid beams having a depth $h \leq 72mm$

$K_7 = \left(\frac{300}{h}\right)^{0.11}$, for solid beams with $72mm < h < 300mm$

$K_7 = \frac{0.81\left(h^2 + 92300\right)}{\left(h^2 + 56800\right)}$, for solid beams with $h > 300mm$

$\sigma_{m,adm,//} = \sigma_{m,g,//} K_3 K_7$

$Z_{xx,req} \geq \frac{M}{\sigma_{m,adm,//}}$

$\tau_a \leq \tau_{adm}$, where:

$\tau_a$ is the applied shear stress parallel to the grain; and

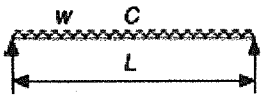
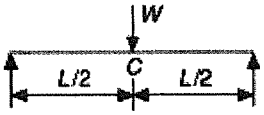
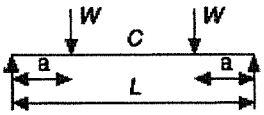
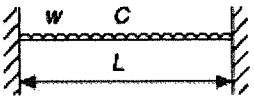
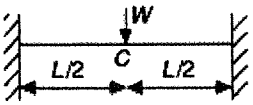
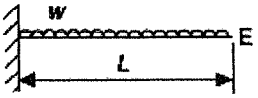
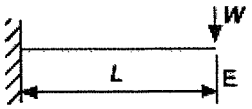
$\tau_{adm}$ is the permissible shear stress

$\tau_a = \frac{3F_v}{2A}$

$\tau_{adm} = \tau_g K_3$, where:

$\tau_g$ is the grade shear stress parallel to the grain.

**Table 4** **Bending and shear deflections assuming** $G = E/16$

| *Load distribution and supports* | *Deflection at Centre C or end E* | |
|---|---|---|
| | *Bending* | *Shear* |
|  | $\frac{5}{384} \times \frac{wL^4}{EI}$ | $\frac{12}{5} \times \frac{wL^2}{EA}$ |
|  | $\frac{WL^3}{48EI}$ | $\frac{24}{5} \times \frac{WL}{EA}$ |
|  | $\frac{Wa}{EI}\left[\frac{L^2}{8} - \frac{a^2}{6}\right]$ | $\frac{96}{5} \times \frac{Wa}{EA}$ |
|  | $\frac{wL^4}{384EI}$ | $\frac{12}{5} \times \frac{wL^2}{EA}$ |
|  | $\frac{WL^3}{192EI}$ | $\frac{24}{5} \times \frac{WL}{EA}$ |
|  | $\frac{wL^4}{8EI}$ | $\frac{48}{5} \times \frac{wL^2}{EA}$ |
|  | $\frac{WL^3}{3EI}$ | $\frac{96}{5} \times \frac{WL}{EA}$ |

## Table 3 Geometrical properties of sawn softwoods

| *Customary target size** | *Area* | *Section Modulus* | | *Second of moment area* | | *Radius of gyration* | |
|---|---|---|---|---|---|---|---|
| *mm* | $10^3 mm^2$ | *About x–x* $10^3 mm^3$ | *About y–y* $10^3 mm^3$ | *About x–x* $10^6 mm^4$ | *About y–y* $10^6 mm^4$ | *About x–x mm* | *About y–y mm* |
| 22 × 100 | 2.20 | 36.6 | 8.1 | 1.83 | 0.089 | 28.9 | 6.35 |
| 38 × 100 | 3.80 | 63.3 | 24.1 | 3.17 | 0.457 | 28.9 | 11.0 |
| 38 × 150 | 5.70 | 143 | 36.1 | 10.7 | 0.686 | 43.3 | 11.0 |
| 38 × 175 | 6.54 | 194 | 42.1 | 17.0 | 0.800 | 50.5 | 11.0 |
| 38 × 200 | 7.60 | 253 | 48.1 | 25.3 | 0.915 | 57.7 | 11.0 |
| 38 × 225 | 8.55 | 321 | 54.2 | 36.1 | 1.03 | 65.0 | 11.0 |
| 47 × 75 | 3.53 | 44.1 | 27.6 | 1.65 | 0.649 | 21.7 | 13.6 |
| 47 × 100 | 4.70 | 78.3 | 36.8 | 3.92 | 0.865 | 28.9 | 13.6 |
| 47 × 125 | 5.88 | 122 | 46.0 | 7.65 | 1.08 | 36.1 | 13.6 |
| 47 × 150 | 7.05 | 176 | 55.2 | 13.2 | 1.30 | 43.3 | 13.6 |
| 47 × 175 | 8.23 | 240 | 64.4 | 21.0 | 1.51 | 50.5 | 13.6 |
| 47 × 200 | 9.40 | 313 | 73.6 | 31.3 | 1.73 | 57.7 | 13.6 |
| 47 × 225 | 10.6 | 397 | 82.8 | 44.6 | 1.95 | 65.0 | 13.6 |
| 47 × 250 | 11.8 | 490 | 92.0 | 61.2 | 2.16 | 72.2 | 13.6 |
| 47 × 300 | 14.1 | 705 | 110 | 106 | 2.60 | 86.6 | 13.6 |
| 63 × 150 | 9.45 | 236 | 99.2 | 17.7 | 3.13 | 43.3 | 18.2 |
| 63 × 175 | 11.0 | 322 | 116 | 28.1 | 3.65 | 50.5 | 18.2 |
| 63 × 200 | 12.6 | 420 | 132 | 42.0 | 4.17 | 57.7 | 18.2 |
| 63 × 225 | 14.2 | 532 | 149 | 59.8 | 4.69 | 65.0 | 18.2 |

| *Customary target size** | *Area* | *Section Modulus* | | *Second moment of area* | | *Radius of gyration* | |
|---|---|---|---|---|---|---|---|
| *mm* | $10^3 mm^2$ | *About x–x* $10^3 mm^3$ | *About y–y* $10^3 mm^3$ | *About x–x* $10^6 mm^4$ | *About y–y* $10^6 mm^4$ | *About x–x mm* | *About y–y mm* |
| 75 × 100 | 7.50 | 125 | 93.8 | 6.25 | 3.52 | 28.9 | 21.7 |
| 75 × 150 | 11.3 | 281 | 141 | 21.1 | 5.27 | 43.3 | 21.7 |
| 75 × 175 | 13.1 | 383 | 164 | 33.5 | 6.15 | 50.5 | 21.7 |
| 75 × 200 | 15.0 | 500 | 188 | 50.0 | 7.03 | 57.7 | 21.7 |
| 75 × 225 | 16.9 | 633 | 211 | 71.2 | 7.91 | 65.0 | 21.7 |
| 75 × 250 | 18.8 | 781 | 234 | 97.7 | 8.79 | 72.2 | 21.7 |
| 75 × 300 | 22.5 | 1130 | 281 | 169 | 10.5 | 86.6 | 21.7 |
| 100 × 100 | 10.0 | 167 | 167 | 8.33 | 8.33 | 28.9 | 28.9 |
| 100 × 150 | 15.0 | 375 | 250 | 28.1 | 12.5 | 43.3 | 28.9 |
| 100 × 200 | 20.0 | 667 | 333 | 66.7 | 16.7 | 57.7 | 28.9 |
| 100 × 225 | 22.5 | 844 | 375 | 94.9 | 18.8 | 65.0 | 28.9 |
| 100 × 250 | 25.0 | 1010 | 417 | 130 | 20.8 | 72.2 | 28.9 |
| 100 × 300 | 30.0 | 1500 | 500 | 225 | 25.0 | 86.6 | 28.9 |
| 150 × 150 | 20.0 | 563 | 563 | 42.2 | 42.2 | 43.3 | 43.3 |
| 150 × 300 | 30.0 | 2250 | 1130 | 338 | 84.4 | 86.6 | 43.3 |
| 300 × 300 | 90.0 | 4500 | 4500 | 675 | 675 | 86.6 | 86.6 |

Note. * Desired size of timber measured at 20% moisture content

**TABLES AND OTHER DATA FOR DESIGN OF STEEL AND TIMBER STRUCTURES FOR "TCVS3762 DESIGN OF STEEL AND TIMBER STRUCTURES" FIRST OPPORTUNITY EXAM NOVEMBER 2023**

# I. TIMBER

**Table 1 Grade stress and modulus of elasticity for strength class $C24\,(N/mm^2)$: for service classes 1 and 2 (based on BS 5268)**

| **Bending parallel to grain** $\sigma_{m,g,//}$ | **Shear parallel to grain** $\tau_g$ | **Modulus of elasticity** $E_{\min}$ |
|---|---|---|
| 7.5 | 0.71 | 7200 |

**Table 2 Modification factors $K_3$ for duration of loading (Table 17, BS 5268)**

| *Duration of loading* | *Value of* $K_3$ |
|---|---|
| Long term (e.g. dead + permanent imposed[a]) | 1.00 |
| Medium term (e.g. dead + snow, dead + temporary imposed) | 1.25 |
| Short term (e.g. dead + imposed + wind[b], dead + imposed + snow + wind[b]) | 1.50 |
| Very short term (e.g. dead + imposed + wind[c]) | 1.75 |

Notes. [a] For uniformly distributed imposed floor loads $K_3$ = 1.00 except for type C3 occupancy (Table 1, BS 6399: Part 1: 1996) where for foot traffic on corridors, hallways, landings and stairways only, $K_3$ may be assumed to be 1.5.
[b] For wind where the largest diagonal dimension of the loaded area $a$, as defined in BS 6399: Part 2, exceeds 50 m.
[c] For wind, very short-term category applies to classes A and B (3 s or 5 s gust) as defined in CP3 : Chapter V : Part 2 or, where the largest diagonal dimension of the loaded area $a$, as defined in BS 6399: Part 2, does not exceed 50 m.

# II. STEEL

## A. CONNECTION DESIGN

The design plastic resistance of the gross cross-section is given by Eqn (1):

$$N_{pl,Rd} = \frac{Af_y}{\gamma_{M0}} \qquad (\gamma_{M0} = 1.0) \qquad (1)$$

For a single angle in tension connected by a single row of bolts in one leg, the design ultimate resistance of the net cross-section depends on the number of bolts and the pitch $p_1$, and in general it is given by Eqn (2):

$$N_{u,Rd} = \frac{\beta A_{net} f_u}{\gamma_{M2}} \qquad (\gamma_{M2} = 1.25) \qquad (2)$$

where $\beta = \beta_2$ for two bolts, and $\beta = \beta_3$ for three bolts.

**Table S1: Reduction factors $\beta_2$ and $\beta_3$ (Table 3.8 of EC3-1-8)**

| Pitch $p_1$ | $\leq 2.5d_0$ | $\geq 5.0d_0$ |
|---|---|---|
| 2 bolts $\beta_2$ | 0.4 | 0.7 |
| 3 bolts or more $\beta_3$ | 0.5 | 0.7 |

The symbols $p_1$ (pitch)and $d_0$ (hole diameter) in table S1 are defined in Fig. S1.

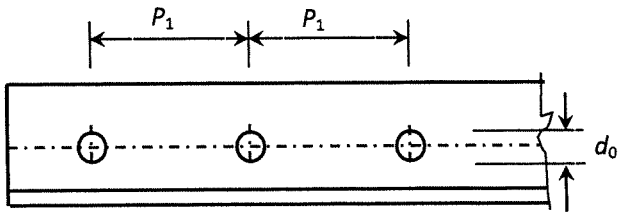



**Fig. S1: Definition of symbols for tension connections in single angles**

**Table S2: Some nominal values of yield strength for hot-rolled steel** (Table 3.1, EN 1993-1-1(2005))

| Standard and steel grade | Nominal thickness of the element t [mm] | | | |
|---|---|---|---|---|
| | $t \leq 40$ mm | | 40 mm $< t \leq 80$ mm | |
| | $f_y$ [N/mm$^2$] | $f_u$ [N/mm$^2$] | $f_y$ [N/mm$^2$] | $f_u$ [N/mm$^2$] |
| **EN 10025-2** | | | | |
| S 235 | 235 | 360 | 215 | 360 |
| S 275 | 275 | 430 | 255 | 410 |
| S 355 | 355 | 490 | 335 | 470 |
| S 450 | 440 | 550 | 410 | 550 |

## B. BEAM DESIGN

For class 1 and class 2 cross-sections:

$$M_{c,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}}$$

$$M_{cr} = C_1 \frac{\pi^2 E I_Z}{L_{cr}^2} \sqrt{\left( \frac{I_W}{I_Z} + \frac{L_{cr}^2 G I_T}{\pi^2 E I_Z} \right)}$$

where $C_1$ is obtained from Table S3.

$E = 2.10 \times 10^5 N/mm^2$; $G = 8.10 \times 10^4 N/mm^2$

$$\bar{\lambda} = \sqrt{\frac{W_y f_y}{M_{cr}}}$$

For a cross-section the buckling curve is selected from Table S4 and the imperfection factor $\alpha_{LT}$ from Table S5.

**Table S3 $C_1$ values for transverse loading**

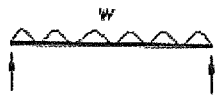
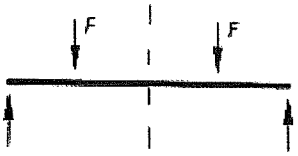
| Loading and support conditions | Bending moment diagram | Value of $C_1$ |
|---|---|---|
|  |  | 1.132 |
|  |  | 1.285 |
|  |  | 1.365 |
|  |  | 1.565 |
|  | | |
|  |  | 1.046 |

**Table S4: LTB curves for general cases**

| Cross section | Limits | Buckling curve |
|---|---|---|
| Rolled I sections | $h/b \leq 2$ | *a* |
| | $h/b > 2$ | *b* |
| Welded I sections | $h/b \leq 2$ | *c* |
| | $h/b > 2$ | *d* |
| Other cross sections | — | *d* |

**Table S5: Imperfection factors for LTB curves**

| Buckling curve | *a* | *b* | *c* | *d* |
|---|---|---|---|---|
| Imperfection factor $\alpha_{LT}$ | 0.21 | 0.34 | 0.49 | 0.76 |

$$\phi_{LT} = 0.5\left[1 + \alpha_{LT}\left(\bar{\lambda}_{LT} - 0.2\right) + \bar{\lambda}_{LT}^2\right]$$

$$\chi_{LT} = \frac{1}{\phi_{LT} + \sqrt{\phi_{LT}^2 - \bar{\lambda}_{LT}^2}} \text{ but } \chi_{LT} \leq 1.0$$

$$M_{b,y,Rd} = \chi_{LT} \frac{W_{pl,y} f_y}{\gamma_{M1}}$$

## C. COLUMN DESIGN

Target area, $A \geq \dfrac{N \times \gamma_{M1}}{\chi \times f_y}$ where $\gamma_{M1} = 1.0$

For class 3 cross-sections:

$\dfrac{c}{t} \leq 14\varepsilon$ for flanges;

$\dfrac{c}{t} \leq 42\varepsilon$ for webs, and

$$\varepsilon = \left(\frac{235}{f_y}\right)^{1/2}$$

$$\lambda = \frac{L_{cr}}{i}$$

$\bar{\lambda} = \dfrac{\lambda}{\lambda_1}$, where $\lambda_1 = 93.9\varepsilon$

Buckling curve is obtained from Table S6 and the imperfection factor $\alpha$ is obtained from Table S7.

$$\phi = 0.5\left[1 + \alpha\left(\bar{\lambda} - 0.2\right) + \bar{\lambda}^2\right]$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}}$$

$$N_{b,y,Rd} = \frac{\chi \times A f_y}{\gamma_{M1}}$$

**Table S6 Selection of buckling curve for a cross-section**

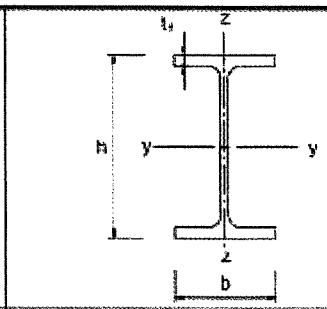
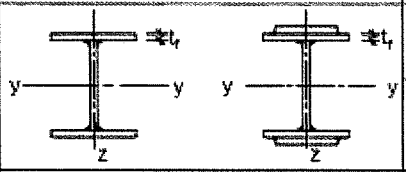
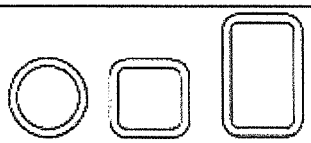
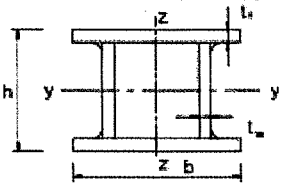
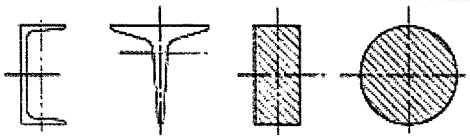
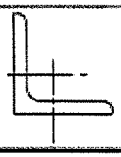
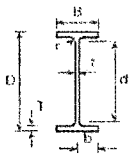
| Cross section | | Limits | | Buckling about axis | Buckling curve: S 235 S 275 S 355 S 420 | Buckling curve: S 460 |
|---|---|---|---|---|---|---|
| Rolled sections |  | $h/b > 1.2$ | $t_f \le 40$ mm | y–y<br>z–z | a<br>b | $a_0$<br>$a_0$ |
| | | | 40 mm < $t_f \le 100$ | y–y<br>z–z | b<br>c | a<br>a |
| | | $h/b \le 1.2$ | $t_f \le 100$ mm | y–y<br>z–z | b<br>c | a<br>a |
| | | | $t_f > 100$ mm | y–y<br>z–z | d<br>d | c<br>c |
| Welded I-sections |  | $t_f \le 40$ mm | | y–y<br>z–z | b<br>c | b<br>c |
| | | $t_f > 40$ mm | | y–y<br>z–z | c<br>d | c<br>d |
| Hollow sections |  | hot finished | | any | a | $a_0$ |
| | | cold formed | | any | c | c |
| Welded box sections |  | generally (except as below) | | any | b | b |
| | | thick welds: $a > 0.5t_f$<br>$b/t_f < 30$<br>$h/t_w < 30$ | | any | c | c |
| U-, T- and solid sections |  | | | any | c | c |
| L-sections |  | | | any | b | b |

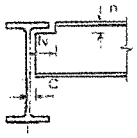
**Table S7 Imperfection factors for buckling curves (Table 6.1 of EN 1993-1-1)**

| Buckling curve | $a_0$ | $a$ | $b$ | $c$ | $d$ |
|---|---|---|---|---|---|
| Imperfection factor $\alpha$ | 0.13 | 0.21 | 0.34 | 0.49 | 0.76 |

# Tables of dimensions and gross section properties

## UNIVERSAL BEAMS




### DIMENSIONS

| Section Designation | Mass per Metre | Depth of Section | Width of Section | Thickness | | Root Radius | Depth between Fillets | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Web | Flange | | | Flange | Web | End Clearance | Notch | | Per Metre | Per Tonne |
| | kg/m | D mm | B mm | t mm | T mm | r mm | d mm | b/T | d/t | C mm | N mm | n mm | $m^2$ | $m^2$ |
| 1016 × 305 × 487 # † | 486.6 | 1036.1 | 308.5 | 30.0 | 54.1 | 30.0 | 867.9 | 2.85 | 28.9 | 17 | 150 | 86 | 3.19 | 6.57 |
| 1016 × 305 × 437 # † | 436.9 | 1025.9 | 305.4 | 26.9 | 49.0 | 30.0 | 867.9 | 3.12 | 32.3 | 16 | 150 | 80 | 3.17 | 7.25 |
| 1016 × 305 × 393 # † | 392.7 | 1016.0 | 303.0 | 24.4 | 43.9 | 30.0 | 868.2 | 3.45 | 35.6 | 14 | 150 | 74 | 3.14 | 8.01 |
| 1016 × 305 × 349 # † | 349.4 | 1008.1 | 302.0 | 21.1 | 40.0 | 30.0 | 868.1 | 3.77 | 41.1 | 13 | 150 | 70 | 3.13 | 8.96 |
| 1016 × 305 × 314 # † | 314.3 | 1000.0 | 300.0 | 19.1 | 35.9 | 30.0 | 868.2 | 4.18 | 45.5 | 12 | 150 | 66 | 3.11 | 9.90 |
| 1016 × 305 × 272 # † | 272.3 | 990.1 | 300.0 | 16.5 | 31.0 | 30.0 | 868.1 | 4.84 | 52.6 | 10 | 152 | 63 | 3.10 | 11.4 |
| 1016 × 305 × 249 # † | 248.7 | 980.2 | 300.0 | 16.5 | 26.0 | 30.0 | 868.2 | 5.77 | 52.6 | 10 | 152 | 56 | 3.08 | 12.4 |
| 1016 × 305 × 222 # † | 222.0 | 970.3 | 300.0 | 16.0 | 21.1 | 30.0 | 868.1 | 7.11 | 54.3 | 10 | 152 | 52 | 3.06 | 13.8 |
| 914 × 419 × 388 # | 388.0 | 921.0 | 420.5 | 21.4 | 36.6 | 24.1 | 799.6 | 5.74 | 37.4 | 13 | 210 | 62 | 3.44 | 8.87 |
| 914 × 419 × 343 # | 343.3 | 911.8 | 418.5 | 19.4 | 32.0 | 24.1 | 799.6 | 6.54 | 41.2 | 12 | 210 | 58 | 3.42 | 9.95 |
| 914 × 305 × 289 # | 289.1 | 926.6 | 307.7 | 19.5 | 32.0 | 19.1 | 824.4 | 4.81 | 42.3 | 12 | 156 | 52 | 3.01 | 10.4 |
| 914 × 305 × 253 # | 253.4 | 918.4 | 305.5 | 17.3 | 27.9 | 19.1 | 824.4 | 5.47 | 47.7 | 11 | 156 | 48 | 2.99 | 11.8 |
| 914 × 305 × 224 # | 224.2 | 910.4 | 304.1 | 15.9 | 23.9 | 19.1 | 824.4 | 6.36 | 51.8 | 10 | 156 | 44 | 2.97 | 13.3 |
| 914 × 305 × 201 # | 200.9 | 903.0 | 303.3 | 15.1 | 20.2 | 19.1 | 824.4 | 7.51 | 54.6 | 10 | 156 | 40 | 2.96 | 14.7 |
| 838 × 292 × 226 # | 226.5 | 850.9 | 293.8 | 16.1 | 26.8 | 17.8 | 761.7 | 5.48 | 47.3 | 10 | 150 | 46 | 2.81 | 12.4 |
| 838 × 292 × 194 # | 193.8 | 840.7 | 292.4 | 14.7 | 21.7 | 17.8 | 761.7 | 6.74 | 51.8 | 9 | 150 | 40 | 2.79 | 14.4 |
| 838 × 292 × 176 # | 175.9 | 834.9 | 291.7 | 14.0 | 18.8 | 17.8 | 761.7 | 7.76 | 54.4 | 9 | 150 | 38 | 2.78 | 15.8 |
| 762 × 267 × 197 | 196.8 | 769.8 | 268.0 | 15.6 | 25.4 | 16.5 | 686.0 | 5.28 | 44.0 | 10 | 138 | 42 | 2.55 | 13.0 |
| 762 × 267 × 173 | 173.0 | 762.2 | 266.7 | 14.3 | 21.6 | 16.5 | 686.0 | 6.17 | 48.0 | 9 | 138 | 40 | 2.53 | 14.6 |
| 762 × 267 × 147 | 146.9 | 754.0 | 265.2 | 12.8 | 17.5 | 16.5 | 686.0 | 7.58 | 53.6 | 8 | 138 | 34 | 2.51 | 17.1 |
| 762 × 267 × 134 | 133.9 | 750.0 | 264.4 | 12.0 | 15.5 | 16.5 | 686.0 | 8.53 | 57.2 | 8 | 138 | 32 | 2.51 | 18.7 |
| 686 × 254 × 170 | 170.2 | 692.9 | 255.8 | 14.5 | 23.7 | 15.2 | 615.1 | 5.40 | 42.4 | 9 | 132 | 40 | 2.35 | 13.8 |
| 686 × 254 × 152 | 152.4 | 687.5 | 254.5 | 13.2 | 21.0 | 15.2 | 615.1 | 6.06 | 46.6 | 9 | 132 | 38 | 2.34 | 15.4 |
| 686 × 254 × 140 | 140.1 | 683.5 | 253.7 | 12.4 | 19.0 | 15.2 | 615.1 | 6.68 | 49.6 | 8 | 132 | 36 | 2.33 | 16.6 |
| 686 × 254 × 125 | 125.2 | 677.9 | 253.0 | 11.7 | 16.2 | 15.2 | 615.1 | 7.81 | 52.6 | 8 | 132 | 32 | 2.32 | 18.5 |
| 610 × 305 × 238 | 238.1 | 635.8 | 311.4 | 18.4 | 31.4 | 16.5 | 540.0 | 4.96 | 29.3 | 11 | 158 | 48 | 2.45 | 10.3 |
| 610 × 305 × 179 | 179.0 | 620.2 | 307.1 | 14.1 | 23.6 | 16.5 | 540.0 | 6.51 | 38.3 | 9 | 158 | 42 | 2.41 | 13.5 |
| 610 × 305 × 149 | 149.2 | 612.4 | 304.8 | 11.8 | 19.7 | 16.5 | 540.0 | 7.74 | 45.8 | 8 | 158 | 38 | 2.39 | 16.0 |
| 610 × 229 × 140 | 139.9 | 617.2 | 230.2 | 13.1 | 22.1 | 12.7 | 547.6 | 5.21 | 41.8 | 9 | 120 | 36 | 2.11 | 15.1 |
| 610 × 229 × 125 | 125.1 | 612.2 | 229.0 | 11.9 | 19.6 | 12.7 | 547.6 | 5.84 | 46.0 | 8 | 120 | 34 | 2.09 | 16.7 |
| 610 × 229 × 113 | 113.0 | 607.6 | 228.2 | 11.1 | 17.3 | 12.7 | 547.6 | 6.60 | 49.3 | 8 | 120 | 30 | 2.08 | 18.4 |
| 610 × 229 × 101 | 101.2 | 602.6 | 227.6 | 10.5 | 14.8 | 12.7 | 547.6 | 7.69 | 52.2 | 7 | 120 | 28 | 2.07 | 20.5 |
| 533 × 210 × 122 | 122.0 | 544.5 | 211.9 | 12.7 | 21.3 | 12.7 | 476.5 | 4.97 | 37.5 | 8 | 110 | 34 | 1.89 | 15.5 |
| 533 × 210 × 109 | 109.0 | 539.5 | 210.8 | 11.6 | 18.8 | 12.7 | 476.5 | 5.61 | 41.1 | 8 | 110 | 32 | 1.88 | 17.2 |
| 533 × 210 × 101 | 101.0 | 536.7 | 210.0 | 10.8 | 17.4 | 12.7 | 476.5 | 6.03 | 44.1 | 7 | 110 | 32 | 1.87 | 18.5 |
| 533 × 210 × 92 | 92.1 | 533.1 | 209.3 | 10.1 | 15.6 | 12.7 | 476.5 | 6.71 | 47.2 | 7 | 110 | 30 | 1.86 | 20.2 |
| 533 × 210 × 82 | 82.2 | 528.3 | 208.8 | 9.6 | 13.2 | 12.7 | 476.5 | 7.91 | 49.6 | 7 | 110 | 26 | 1.85 | 22.5 |

† Section is not given in BS 4-1: 1993.
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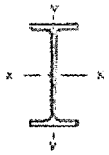
## UNIVERSAL BEAMS

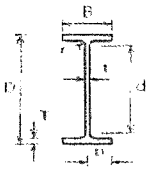


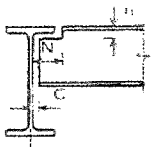

### PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter | Torsional Index | Warping Constant | Torsional Constant | Area of Section |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Axis x-x $cm^4$ | Axis y-y $cm^4$ | Axis x-x cm | Axis y-y cm | Axis x-x $cm^3$ | Axis y-y $cm^3$ | Axis x-x $cm^3$ | Axis y-y $cm^3$ | u | x | H $dm^6$ | J $cm^4$ | A $cm^2$ |
| 1016 × 305 × 487 # † | 1020000 | 26700 | 40.6 | 6.57 | 19700 | 1730 | 22200 | 2800 | 0.867 | 21.1 | 64.4 | 4300 | 620 |
| 1016 × 305 × 437 # † | 910000 | 23500 | 40.4 | 6.49 | 17700 | 1540 | 20000 | 2470 | 0.866 | 23.1 | 55.9 | 3190 | 557 |
| 1016 × 305 × 393 # † | 808000 | 20500 | 40.2 | 6.40 | 15900 | 1350 | 18000 | 2170 | 0.865 | 25.5 | 48.4 | 2330 | 500 |
| 1016 × 305 × 349 # † | 723000 | 18500 | 40.3 | 6.44 | 14400 | 1220 | 16600 | 1940 | 0.872 | 27.9 | 43.3 | 1720 | 445 |
| 1016 × 305 × 314 # † | 644000 | 16200 | 40.1 | 6.37 | 12900 | 1080 | 14900 | 1710 | 0.872 | 30.7 | 37.7 | 1260 | 400 |
| 1016 × 305 × 272 # † | 554000 | 14000 | 40.0 | 6.35 | 11200 | 934 | 12800 | 1470 | 0.872 | 35.0 | 32.2 | 835 | 347 |
| 1016 × 305 × 249 # † | 481000 | 11800 | 39.0 | 6.09 | 9520 | 784 | 11400 | 1250 | 0.861 | 39.9 | 26.2 | 582 | 317 |
| 1016 × 305 × 222 # † | 408000 | 9550 | 38.0 | 5.81 | 8410 | 636 | 9810 | 1020 | 0.849 | 45.8 | 21.5 | 390 | 283 |
| 914 × 419 × 388 # | 720000 | 45400 | 38.2 | 9.59 | 15600 | 2160 | 17700 | 3340 | 0.885 | 26.7 | 88.9 | 1730 | 494 |
| 914 × 419 × 343 # | 626000 | 39200 | 37.8 | 9.46 | 13700 | 1870 | 15500 | 2890 | 0.883 | 30.1 | 75.8 | 1190 | 437 |
| 914 × 305 × 289 # | 504000 | 15600 | 37.6 | 6.51 | 10900 | 1010 | 12600 | 1600 | 0.867 | 31.9 | 31.2 | 926 | 368 |
| 914 × 305 × 253 # | 436000 | 13300 | 36.8 | 6.42 | 9500 | 871 | 10900 | 1370 | 0.865 | 36.2 | 26.4 | 626 | 323 |
| 914 × 305 × 224 # | 376000 | 11200 | 36.3 | 6.27 | 8270 | 739 | 9540 | 1160 | 0.861 | 41.3 | 22.1 | 422 | 286 |
| 914 × 305 × 201 # | 335000 | 9420 | 35.7 | 6.07 | 7200 | 621 | 8350 | 982 | 0.853 | 46.9 | 18.4 | 291 | 256 |
| 838 × 292 × 226 # | 340000 | 11400 | 34.3 | 6.27 | 7990 | 773 | 9160 | 1210 | 0.859 | 35.0 | 19.3 | 514 | 269 |
| 838 × 292 × 194 # | 279000 | 9070 | 33.6 | 6.06 | 6640 | 620 | 7640 | 974 | 0.862 | 41.6 | 15.2 | 306 | 247 |
| 838 × 292 × 176 # | 246000 | 7800 | 33.1 | 5.90 | 5890 | 535 | 6810 | 842 | 0.856 | 46.5 | 13.0 | 221 | 224 |
| 762 × 267 × 197 | 240000 | 8180 | 30.9 | 5.71 | 6230 | 610 | 7170 | 959 | 0.868 | 33.2 | 11.3 | 404 | 251 |
| 762 × 267 × 173 | 209000 | 6850 | 30.5 | 5.58 | 5390 | 514 | 6200 | 807 | 0.865 | 38.1 | 9.39 | 267 | 220 |
| 762 × 267 × 147 | 169000 | 5460 | 30.0 | 5.40 | 4470 | 411 | 5160 | 647 | 0.858 | 45.2 | 7.40 | 159 | 187 |
| 762 × 267 × 134 | 151000 | 4780 | 29.7 | 5.30 | 4020 | 362 | 4640 | 570 | 0.853 | 49.8 | 6.46 | 119 | 171 |
| 686 × 254 × 170 | 170000 | 8630 | 28.0 | 5.53 | 4920 | 518 | 5630 | 811 | 0.872 | 31.8 | 7.42 | 308 | 217 |
| 686 × 254 × 152 | 150000 | 5780 | 27.8 | 5.46 | 4370 | 455 | 5000 | 710 | 0.871 | 35.4 | 6.42 | 220 | 194 |
| 686 × 254 × 140 | 136000 | 5180 | 27.6 | 5.39 | 3990 | 409 | 4560 | 636 | 0.869 | 38.6 | 5.72 | 169 | 178 |
| 686 × 254 × 125 | 118000 | 4380 | 27.2 | 5.24 | 3480 | 346 | 3990 | 542 | 0.863 | 43.8 | 4.80 | 116 | 159 |
| 610 × 305 × 238 | 210000 | 15800 | 26.3 | 7.23 | 6590 | 1020 | 7490 | 1570 | 0.887 | 21.3 | 14.5 | 785 | 303 |
| 610 × 305 × 179 | 153000 | 11400 | 25.9 | 7.07 | 4940 | 743 | 5550 | 1140 | 0.886 | 27.7 | 10.2 | 340 | 228 |
| 610 × 305 × 149 | 126000 | 9310 | 25.7 | 7.00 | 4110 | 611 | 4580 | 937 | 0.886 | 32.7 | 8.17 | 200 | 190 |
| 610 × 229 × 140 | 112000 | 4510 | 25.0 | 5.09 | 3620 | 391 | 4140 | 611 | 0.875 | 30.6 | 3.99 | 216 | 178 |
| 610 × 229 × 125 | 98600 | 3930 | 24.9 | 4.97 | 3220 | 343 | 3680 | 535 | 0.874 | 34.1 | 3.45 | 154 | 159 |
| 610 × 229 × 113 | 87300 | 3430 | 24.6 | 4.88 | 2870 | 301 | 3280 | 469 | 0.870 | 38.1 | 2.99 | 111 | 144 |
| 610 × 229 × 101 | 75800 | 2920 | 24.2 | 4.75 | 2520 | 256 | 2880 | 400 | 0.863 | 43.1 | 2.52 | 77.0 | 129 |
| 533 × 210 × 122 | 76000 | 3390 | 22.1 | 4.67 | 2790 | 320 | 3200 | 500 | 0.878 | 27.6 | 2.32 | 178 | 155 |
| 533 × 210 × 109 | 66800 | 2940 | 21.9 | 4.60 | 2480 | 279 | 2830 | 436 | 0.874 | 31.0 | 1.99 | 126 | 139 |
| 533 × 210 × 101 | 61500 | 2690 | 21.9 | 4.57 | 2280 | 256 | 2610 | 399 | 0.873 | 33.2 | 1.81 | 101 | 129 |
| 533 × 210 × 92 | 55200 | 2390 | 21.7 | 4.51 | 2070 | 228 | 2360 | 356 | 0.873 | 36.4 | 1.60 | 75.7 | 117 |
| 533 × 210 × 82 | 47500 | 2010 | 21.3 | 4.38 | 1800 | 192 | 2060 | 300 | 0.863 | 41.6 | 1.33 | 51.5 | 105 |

† Section is not given in BS 4-1: 1993.
# Check availability.

## UNIVERSAL BEAMS




### DIMENSIONS

| Section Designation | Mass per Metre | Depth of Section | Width of Section | Thickness | | Root Radius | Depth between Fillets | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Web | Flange | | | Flange | Web | End Clearance | Notch | | Per Metre | Per Tonne |
| | | D | B | t | T | r | d | b/T | d/t | C | N | n | | |
| | kg/m | mm | mm | mm | mm | mm | mm | | | mm | mm | mm | $m^2$ | $m^2$ |
| 457 × 191 × 98 | 98.3 | 467.2 | 192.8 | 11.4 | 19.6 | 10.2 | 407.6 | 4.92 | 35.8 | 8 | 102 | 30 | 1.67 | 16.9 |
| 457 × 191 × 89 | 89.3 | 463.4 | 191.9 | 10.5 | 17.7 | 10.2 | 407.6 | 5.42 | 38.8 | 7 | 102 | 28 | 1.66 | 18.5 |
| 457 × 191 × 82 | 82.0 | 460.0 | 191.3 | 9.9 | 16.0 | 10.2 | 407.6 | 5.98 | 41.2 | 7 | 102 | 28 | 1.65 | 20.1 |
| 457 × 191 × 74 | 74.3 | 457.0 | 190.4 | 9.0 | 14.5 | 10.2 | 407.6 | 6.57 | 45.3 | 7 | 102 | 26 | 1.64 | 22.1 |
| 457 × 191 × 67 | 67.1 | 453.4 | 189.9 | 8.5 | 12.7 | 10.2 | 407.6 | 7.48 | 48.0 | 6 | 102 | 24 | 1.63 | 24.3 |
| 457 × 152 × 82 | 82.1 | 465.8 | 155.3 | 10.5 | 18.9 | 10.2 | 407.6 | 4.11 | 38.8 | 7 | 84 | 30 | 1.51 | 18.4 |
| 457 × 152 × 74 | 74.2 | 462.0 | 154.4 | 9.6 | 17.0 | 10.2 | 407.6 | 4.54 | 42.5 | 7 | 84 | 28 | 1.50 | 20.3 |
| 457 × 152 × 67 | 67.2 | 458.0 | 153.8 | 9.0 | 15.0 | 10.2 | 407.6 | 5.13 | 45.3 | 7 | 84 | 26 | 1.50 | 22.3 |
| 457 × 152 × 60 | 59.8 | 454.6 | 152.9 | 8.1 | 13.3 | 10.2 | 407.6 | 5.75 | 50.3 | 6 | 84 | 24 | 1.49 | 24.9 |
| 457 × 152 × 52 | 52.3 | 449.8 | 152.4 | 7.6 | 10.9 | 10.2 | 407.6 | 6.99 | 53.6 | 6 | 84 | 22 | 1.48 | 28.2 |
| 406 × 178 × 74 | 74.2 | 412.8 | 179.5 | 9.5 | 16.0 | 10.2 | 360.4 | 5.61 | 37.9 | 7 | 96 | 28 | 1.51 | 20.3 |
| 406 × 178 × 67 | 67.1 | 409.4 | 178.8 | 8.8 | 14.3 | 10.2 | 360.4 | 6.25 | 41.0 | 6 | 96 | 26 | 1.50 | 22.3 |
| 406 × 178 × 60 | 60.1 | 406.4 | 177.9 | 7.9 | 12.8 | 10.2 | 360.4 | 6.95 | 45.6 | 6 | 96 | 24 | 1.49 | 24.8 |
| 406 × 178 × 54 | 54.1 | 402.6 | 177.7 | 7.7 | 10.9 | 10.2 | 360.4 | 8.15 | 46.8 | 6 | 96 | 22 | 1.48 | 27.4 |
| 406 × 140 × 46 | 46.0 | 403.2 | 142.2 | 6.8 | 11.2 | 10.2 | 360.4 | 6.35 | 53.0 | 5 | 78 | 22 | 1.34 | 29.2 |
| 406 × 140 × 39 | 39.0 | 398.0 | 141.8 | 6.4 | 8.6 | 10.2 | 360.4 | 8.24 | 56.3 | 5 | 78 | 20 | 1.33 | 34.2 |
| 356 × 171 × 67 | 67.1 | 363.4 | 173.2 | 9.1 | 15.7 | 10.2 | 311.6 | 5.52 | 34.2 | 7 | 94 | 26 | 1.38 | 20.6 |
| 356 × 171 × 57 | 57.0 | 358.0 | 172.2 | 8.1 | 13.0 | 10.2 | 311.6 | 6.62 | 38.5 | 6 | 94 | 24 | 1.37 | 24.1 |
| 356 × 171 × 51 | 51.0 | 355.0 | 171.5 | 7.4 | 11.5 | 10.2 | 311.6 | 7.46 | 42.1 | 6 | 94 | 22 | 1.36 | 26.7 |
| 356 × 171 × 45 | 45.0 | 351.4 | 171.1 | 7.0 | 9.7 | 10.2 | 311.6 | 8.82 | 44.5 | 6 | 94 | 20 | 1.36 | 30.1 |
| 356 × 127 × 39 | 39.1 | 353.4 | 126.0 | 6.6 | 10.7 | 10.2 | 311.6 | 5.89 | 47.2 | 5 | 70 | 22 | 1.18 | 30.2 |
| 356 × 127 × 33 | 33.1 | 349.0 | 125.4 | 6.0 | 8.5 | 10.2 | 311.6 | 7.38 | 51.9 | 5 | 70 | 20 | 1.17 | 35.4 |
| 305 × 165 × 54 | 54.0 | 310.4 | 166.9 | 7.9 | 13.7 | 8.9 | 265.2 | 6.09 | 33.6 | 6 | 90 | 24 | 1.26 | 23.3 |
| 305 × 165 × 46 | 46.1 | 306.6 | 165.7 | 6.7 | 11.8 | 8.9 | 265.2 | 7.02 | 39.6 | 5 | 90 | 22 | 1.25 | 27.1 |
| 305 × 165 × 40 | 40.3 | 303.4 | 165.0 | 6.0 | 10.2 | 8.9 | 265.2 | 8.09 | 44.2 | 5 | 90 | 20 | 1.24 | 30.8 |
| 305 × 127 × 48 | 48.1 | 311.0 | 125.3 | 9.0 | 14.0 | 8.9 | 265.2 | 4.47 | 29.5 | 7 | 70 | 24 | 1.09 | 22.7 |
| 305 × 127 × 42 | 41.9 | 307.2 | 124.3 | 8.0 | 12.1 | 8.9 | 265.2 | 5.14 | 33.1 | 6 | 70 | 22 | 1.08 | 25.8 |
| 305 × 127 × 37 | 37.0 | 304.4 | 123.4 | 7.1 | 10.7 | 8.9 | 265.2 | 5.77 | 37.4 | 6 | 70 | 20 | 1.07 | 29.0 |
| 305 × 102 × 33 | 32.8 | 312.7 | 102.4 | 6.6 | 10.8 | 7.6 | 275.9 | 4.74 | 41.8 | 5 | 58 | 20 | 1.01 | 30.8 |
| 305 × 102 × 28 | 28.2 | 308.7 | 101.8 | 6.0 | 8.8 | 7.6 | 275.9 | 5.78 | 46.0 | 5 | 58 | 18 | 1.00 | 35.4 |
| 305 × 102 × 25 | 24.8 | 305.1 | 101.6 | 5.8 | 7.0 | 7.6 | 275.9 | 7.26 | 47.6 | 5 | 58 | 16 | 0.992 | 40.0 |
| 254 × 146 × 43 | 43.0 | 259.6 | 147.3 | 7.2 | 12.7 | 7.6 | 219.0 | 5.80 | 30.4 | 6 | 82 | 22 | 1.08 | 25.1 |
| 254 × 146 × 37 | 37.0 | 256.0 | 146.4 | 6.3 | 10.9 | 7.6 | 219.0 | 6.72 | 34.8 | 5 | 82 | 20 | 1.07 | 29.0 |
| 254 × 146 × 31 | 31.1 | 251.4 | 146.1 | 6.0 | 8.6 | 7.6 | 219.0 | 8.49 | 36.5 | 5 | 82 | 18 | 1.06 | 34.2 |
| 254 × 102 × 28 | 28.3 | 260.4 | 102.2 | 6.3 | 10.0 | 7.6 | 225.2 | 5.11 | 35.7 | 5 | 58 | 18 | 0.904 | 31.9 |
| 254 × 102 × 25 | 25.2 | 257.2 | 101.9 | 6.0 | 8.4 | 7.6 | 225.2 | 6.07 | 37.5 | 5 | 58 | 16 | 0.897 | 35.6 |
| 254 × 102 × 22 | 22.0 | 254.0 | 101.6 | 5.7 | 6.8 | 7.6 | 225.2 | 7.47 | 39.5 | 5 | 58 | 16 | 0.890 | 40.5 |
| 203 × 133 × 30 | 30.0 | 206.8 | 133.9 | 6.4 | 9.6 | 7.6 | 172.4 | 6.97 | 26.9 | 5 | 74 | 18 | 0.923 | 30.8 |
| 203 × 133 × 25 | 25.1 | 203.2 | 133.2 | 5.7 | 7.8 | 7.6 | 172.4 | 8.54 | 30.2 | 5 | 74 | 16 | 0.915 | 36.4 |
| 203 × 102 × 23 | 23.1 | 203.2 | 101.8 | 5.4 | 9.3 | 7.6 | 169.4 | 5.47 | 31.4 | 5 | 60 | 18 | 0.790 | 34.2 |
| 178 × 102 × 19 | 19.0 | 177.8 | 101.2 | 4.8 | 7.9 | 7.6 | 146.8 | 6.41 | 30.6 | 4 | 60 | 16 | 0.738 | 38.8 |
| 152 × 89 × 16 | 16.0 | 152.4 | 88.7 | 4.5 | 7.7 | 7.6 | 121.8 | 5.76 | 27.1 | 4 | 54 | 16 | 0.638 | 39.8 |
| 127 × 76 × 13 | 13.0 | 127.0 | 76.0 | 4.0 | 7.6 | 7.6 | 96.6 | 5.00 | 24.1 | 4 | 46 | 16 | 0.537 | 41.3 |

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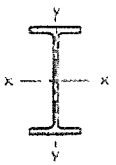
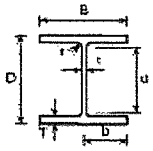
## UNIVERSAL BEAMS

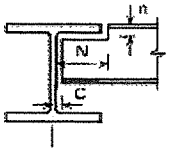



### PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter | Torsional Index | Warping Constant | Torsional Constant | Area of Section |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Axis x-x $cm^4$ | Axis y-y $cm^4$ | Axis x-x cm | Axis y-y cm | Axis x-x $cm^3$ | Axis y-y $cm^3$ | Axis x-x $cm^3$ | Axis y-y $cm^3$ | u | x | H $dm^6$ | J $cm^4$ | A $cm^2$ |
| 457 × 191 × 98 | 45700 | 2350 | 19.1 | 4.33 | 1960 | 243 | 2230 | 379 | 0.882 | 25.7 | 1.18 | 121 | 125 |
| 457 × 191 × 89 | 41000 | 2090 | 19.0 | 4.29 | 1770 | 218 | 2010 | 338 | 0.879 | 28.3 | 1.04 | 90.7 | 114 |
| 457 × 191 × 82 | 37100 | 1870 | 18.8 | 4.23 | 1610 | 196 | 1830 | 304 | 0.879 | 30.8 | 0.922 | 69.2 | 104 |
| 457 × 191 × 74 | 33300 | 1670 | 18.8 | 4.20 | 1460 | 176 | 1650 | 272 | 0.877 | 33.8 | 0.818 | 51.6 | 94.6 |
| 457 × 191 × 67 | 29400 | 1450 | 18.5 | 4.12 | 1300 | 153 | 1470 | 237 | 0.872 | 37.9 | 0.705 | 37.1 | 85.5 |
| 457 × 152 × 82 | 36600 | 1190 | 18.7 | 3.37 | 1570 | 153 | 1810 | 240 | 0.871 | 27.4 | 0.591 | 89.2 | 105 |
| 457 × 152 × 74 | 32700 | 1050 | 18.5 | 3.33 | 1410 | 136 | 1630 | 213 | 0.873 | 30.2 | 0.518 | 65.9 | 94.5 |
| 457 × 152 × 67 | 28900 | 913 | 18.4 | 3.27 | 1260 | 119 | 1450 | 187 | 0.868 | 33.6 | 0.448 | 47.7 | 85.6 |
| 457 × 152 × 60 | 25500 | 795 | 18.3 | 3.23 | 1120 | 104 | 1290 | 163 | 0.868 | 37.5 | 0.387 | 33.8 | 76.2 |
| 457 × 152 × 52 | 21400 | 645 | 17.9 | 3.11 | 950 | 84.6 | 1100 | 133 | 0.859 | 43.8 | 0.311 | 21.4 | 66.6 |
| 406 × 178 × 74 | 27300 | 1550 | 17.0 | 4.04 | 1320 | 172 | 1500 | 267 | 0.882 | 27.6 | 0.608 | 62.8 | 94.5 |
| 406 × 178 × 67 | 24300 | 1370 | 16.9 | 3.99 | 1190 | 153 | 1350 | 237 | 0.880 | 30.5 | 0.533 | 46.1 | 85.5 |
| 406 × 178 × 60 | 21600 | 1200 | 16.8 | 3.97 | 1060 | 135 | 1200 | 209 | 0.880 | 33.8 | 0.466 | 33.3 | 76.5 |
| 406 × 178 × 54 | 18700 | 1020 | 16.5 | 3.85 | 930 | 115 | 1060 | 178 | 0.871 | 38.3 | 0.392 | 23.1 | 69.0 |
| 406 × 140 × 46 | 15700 | 538 | 16.4 | 3.03 | 778 | 75.7 | 888 | 118 | 0.872 | 39.0 | 0.207 | 19.0 | 58.6 |
| 406 × 140 × 39 | 12500 | 410 | 15.9 | 2.87 | 629 | 57.8 | 724 | 90.8 | 0.858 | 47.5 | 0.155 | 10.7 | 49.7 |
| 356 × 171 × 67 | 19500 | 1360 | 15.1 | 3.99 | 1070 | 157 | 1210 | 243 | 0.886 | 24.4 | 0.412 | 55.7 | 85.5 |
| 356 × 171 × 57 | 16000 | 1110 | 14.9 | 3.91 | 896 | 129 | 1010 | 199 | 0.882 | 28.8 | 0.330 | 33.4 | 72.6 |
| 356 × 171 × 51 | 14100 | 968 | 14.8 | 3.86 | 796 | 113 | 896 | 174 | 0.881 | 32.1 | 0.286 | 23.8 | 64.9 |
| 356 × 171 × 45 | 12100 | 811 | 14.5 | 3.76 | 687 | 94.8 | 775 | 147 | 0.874 | 36.8 | 0.237 | 15.8 | 57.3 |
| 356 × 127 × 39 | 10200 | 358 | 14.3 | 2.68 | 576 | 56.8 | 659 | 89.1 | 0.871 | 35.2 | 0.105 | 15.1 | 49.8 |
| 356 × 127 × 33 | 8250 | 280 | 14.0 | 2.58 | 473 | 44.7 | 543 | 70.3 | 0.863 | 42.2 | 0.081 | 8.79 | 42.1 |
| 305 × 165 × 54 | 11700 | 1060 | 13.0 | 3.93 | 754 | 127 | 846 | 196 | 0.889 | 23.6 | 0.234 | 34.8 | 68.8 |
| 305 × 165 × 46 | 9900 | 896 | 13.0 | 3.90 | 646 | 108 | 720 | 166 | 0.891 | 27.1 | 0.195 | 22.2 | 58.7 |
| 305 × 165 × 40 | 8500 | 764 | 12.9 | 3.86 | 560 | 92.6 | 623 | 142 | 0.889 | 31.0 | 0.164 | 14.7 | 51.3 |
| 305 × 127 × 48 | 9580 | 461 | 12.5 | 2.74 | 616 | 73.6 | 711 | 116 | 0.874 | 23.3 | 0.102 | 31.8 | 61.2 |
| 305 × 127 × 42 | 8200 | 389 | 12.4 | 2.70 | 534 | 62.6 | 614 | 98.4 | 0.872 | 26.6 | 0.0846 | 21.1 | 53.4 |
| 305 × 127 × 37 | 7170 | 336 | 12.3 | 2.67 | 471 | 54.5 | 539 | 85.4 | 0.871 | 29.7 | 0.0725 | 14.8 | 47.2 |
| 305 × 102 × 33 | 6500 | 194 | 12.5 | 2.15 | 416 | 37.9 | 481 | 60.0 | 0.867 | 31.6 | 0.0442 | 12.2 | 41.8 |
| 305 × 102 × 28 | 5370 | 155 | 12.2 | 2.08 | 348 | 30.5 | 403 | 48.5 | 0.859 | 37.4 | 0.0349 | 7.40 | 35.9 |
| 305 × 102 × 25 | 4460 | 123 | 11.9 | 1.97 | 292 | 24.2 | 342 | 38.8 | 0.846 | 43.4 | 0.0273 | 4.77 | 31.6 |
| 254 × 146 × 43 | 6540 | 677 | 10.9 | 3.52 | 504 | 92.0 | 566 | 141 | 0.890 | 21.2 | 0.103 | 23.9 | 54.8 |
| 254 × 146 × 37 | 5540 | 571 | 10.8 | 3.48 | 433 | 78.0 | 483 | 119 | 0.889 | 24.4 | 0.0857 | 15.3 | 47.2 |
| 254 × 146 × 31 | 4410 | 446 | 10.5 | 3.36 | 351 | 61.3 | 393 | 94.1 | 0.879 | 29.6 | 0.0660 | 8.55 | 39.7 |
| 254 × 102 × 28 | 4010 | 179 | 10.5 | 2.22 | 308 | 34.9 | 353 | 54.8 | 0.874 | 27.5 | 0.0280 | 9.57 | 36.1 |
| 254 × 102 × 25 | 3420 | 149 | 10.3 | 2.15 | 266 | 29.2 | 306 | 46.0 | 0.867 | 31.4 | 0.0230 | 6.42 | 32.0 |
| 254 × 102 × 22 | 2840 | 119 | 10.1 | 2.06 | 224 | 23.5 | 259 | 37.3 | 0.856 | 36.3 | 0.0182 | 4.15 | 28.0 |
| 203 × 133 × 30 | 2900 | 385 | 8.71 | 3.17 | 280 | 57.5 | 314 | 88.2 | 0.881 | 21.6 | 0.0374 | 10.3 | 38.2 |
| 203 × 133 × 25 | 2340 | 308 | 8.56 | 3.10 | 230 | 46.2 | 258 | 70.9 | 0.877 | 25.6 | 0.0294 | 5.96 | 32.0 |
| 203 × 102 × 23 | 2110 | 164 | 8.46 | 2.36 | 207 | 32.2 | 234 | 49.8 | 0.868 | 22.5 | 0.0154 | 7.02 | 29.4 |
| 178 × 102 × 19 | 1360 | 137 | 7.48 | 2.37 | 153 | 27.0 | 171 | 41.6 | 0.886 | 22.6 | 0.00987 | 4.41 | 24.3 |
| 152 × 89 × 16 | 834 | 89.8 | 6.41 | 2.10 | 109 | 20.2 | 123 | 31.2 | 0.889 | 19.6 | 0.00470 | 3.56 | 20.3 |
| 127 × 76 × 13 | 473 | 55.7 | 5.35 | 1.84 | 74.6 | 14.7 | 84.2 | 22.6 | 0.896 | 16.3 | 0.00199 | 2.85 | 16.5 |

# UNIVERSAL COLUMNS




## DIMENSIONS

| Section Designation | Mass per Metre | Depth of Section | Width of Section | Thickness | | Root Radius | Depth between Fillets | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Web | Flange | | | Flange | Web | End Clearance | Notch | | Per Metre | Per Tonne |
| | kg/m | D mm | B mm | t mm | T mm | r mm | d mm | b/T | d/t | C mm | N mm | n mm | m² | m² |
| 356 x 406 x 634 # | 633.9 | 474.6 | 424.0 | 47.6 | 77.0 | 15.2 | 290.2 | 2.75 | 6.10 | 26 | 200 | 94 | 2.52 | 3.98 |
| 356 x 406 x 551 # | 551.0 | 455.6 | 418.5 | 42.1 | 67.5 | 15.2 | 290.2 | 3.10 | 6.89 | 23 | 200 | 84 | 2.47 | 4.49 |
| 356 x 406 x 467 # | 467.0 | 436.6 | 412.2 | 35.8 | 58.0 | 15.2 | 290.2 | 3.55 | 8.11 | 20 | 200 | 74 | 2.42 | 5.19 |
| 356 x 406 x 393 # | 393.0 | 419.0 | 407.0 | 30.6 | 49.2 | 15.2 | 290.2 | 4.14 | 9.48 | 17 | 200 | 66 | 2.38 | 6.05 |
| 356 x 406 x 340 # | 339.9 | 406.4 | 403.0 | 26.6 | 42.9 | 15.2 | 290.2 | 4.70 | 10.9 | 15 | 200 | 60 | 2.35 | 6.90 |
| 356 x 406 x 287 # | 287.1 | 393.6 | 399.0 | 22.6 | 36.5 | 15.2 | 290.2 | 5.47 | 12.8 | 13 | 200 | 52 | 2.31 | 8.05 |
| 356 x 406 x 235 # | 235.1 | 381.0 | 394.8 | 18.4 | 30.2 | 15.2 | 290.2 | 6.54 | 15.8 | 11 | 200 | 46 | 2.28 | 9.69 |
| 356 x 368 x 202 # | 201.9 | 374.6 | 374.7 | 16.5 | 27.0 | 15.2 | 290.2 | 6.94 | 17.6 | 10 | 190 | 44 | 2.19 | 10.8 |
| 356 x 368 x 177 # | 177.0 | 368.2 | 372.6 | 14.4 | 23.8 | 15.2 | 290.2 | 7.89 | 20.2 | 9 | 190 | 40 | 2.17 | 12.3 |
| 356 x 368 x 153 # | 152.9 | 362.0 | 370.5 | 12.3 | 20.7 | 15.2 | 290.2 | 8.95 | 23.6 | 8 | 190 | 36 | 2.16 | 14.1 |
| 356 x 368 x 129 # | 129.0 | 355.6 | 368.6 | 10.4 | 17.5 | 15.2 | 290.2 | 10.50 | 27.9 | 7 | 190 | 34 | 2.14 | 16.6 |
| 305 x 305 x 283 | 282.9 | 365.3 | 322.2 | 26.8 | 44.1 | 15.2 | 246.7 | 3.65 | 9.21 | 15 | 158 | 60 | 1.94 | 6.86 |
| 305 x 305 x 240 | 240.0 | 352.5 | 318.4 | 23.0 | 37.7 | 15.2 | 246.7 | 4.22 | 10.7 | 14 | 158 | 54 | 1.91 | 7.94 |
| 305 x 305 x 198 | 198.1 | 339.9 | 314.5 | 19.1 | 31.4 | 15.2 | 246.7 | 5.01 | 12.9 | 12 | 158 | 48 | 1.87 | 9.46 |
| 305 x 305 x 158 | 158.1 | 327.1 | 311.2 | 15.8 | 25.0 | 15.2 | 246.7 | 6.22 | 15.6 | 10 | 158 | 42 | 1.84 | 11.6 |
| 305 x 305 x 137 | 136.9 | 320.5 | 309.2 | 13.8 | 21.7 | 15.2 | 246.7 | 7.12 | 17.9 | 9 | 158 | 38 | 1.82 | 13.3 |
| 305 x 305 x 118 | 117.9 | 314.5 | 307.4 | 12.0 | 18.7 | 15.2 | 246.7 | 8.22 | 20.6 | 8 | 158 | 34 | 1.81 | 15.3 |
| 305 x 305 x 97 | 96.9 | 307.9 | 305.3 | 9.9 | 15.4 | 15.2 | 246.7 | 9.91 | 24.9 | 7 | 158 | 32 | 1.79 | 18.5 |
| 254 x 254 x 167 | 167.1 | 289.1 | 265.2 | 19.2 | 31.7 | 12.7 | 200.3 | 4.18 | 10.4 | 12 | 134 | 46 | 1.58 | 9.45 |
| 254 x 254 x 132 | 132.0 | 276.3 | 261.3 | 15.3 | 25.3 | 12.7 | 200.3 | 5.16 | 13.1 | 10 | 134 | 38 | 1.55 | 11.7 |
| 254 x 254 x 107 | 107.1 | 266.7 | 258.8 | 12.8 | 20.5 | 12.7 | 200.3 | 6.31 | 15.6 | 8 | 134 | 34 | 1.52 | 14.2 |
| 254 x 254 x 89 | 88.9 | 260.3 | 256.3 | 10.3 | 17.3 | 12.7 | 200.3 | 7.41 | 19.4 | 7 | 134 | 30 | 1.50 | 16.9 |
| 254 x 254 x 73 | 73.1 | 254.1 | 254.6 | 8.6 | 14.2 | 12.7 | 200.3 | 8.96 | 23.3 | 6 | 134 | 28 | 1.49 | 20.4 |
| 203 x 203 x 86 | 86.1 | 222.2 | 209.1 | 12.7 | 20.5 | 10.2 | 160.8 | 5.10 | 12.7 | 8 | 110 | 32 | 1.24 | 14.4 |
| 203 x 203 x 71 | 71.0 | 215.8 | 206.4 | 10.0 | 17.3 | 10.2 | 160.8 | 5.97 | 16.1 | 7 | 110 | 28 | 1.22 | 17.2 |
| 203 x 203 x 60 | 60.0 | 209.6 | 205.8 | 9.4 | 14.2 | 10.2 | 160.8 | 7.25 | 17.1 | 7 | 110 | 26 | 1.21 | 20.1 |
| 203 x 203 x 52 | 52.0 | 206.2 | 204.3 | 7.9 | 12.5 | 10.2 | 160.8 | 8.17 | 20.4 | 6 | 110 | 24 | 1.20 | 23.0 |
| 203 x 203 x 46 | 46.1 | 203.2 | 203.6 | 7.2 | 11.0 | 10.2 | 160.8 | 9.25 | 22.3 | 6 | 110 | 22 | 1.19 | 25.8 |
| 152 x 152 x 37 | 37.0 | 161.8 | 154.4 | 8.0 | 11.5 | 7.6 | 123.6 | 6.71 | 15.5 | 6 | 84 | 20 | 0.912 | 24.7 |
| 152 x 152 x 30 | 30.0 | 157.6 | 152.9 | 6.5 | 9.4 | 7.6 | 123.6 | 8.13 | 19.0 | 5 | 84 | 18 | 0.901 | 30.0 |

# PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter | Torsional Index | Warping Constant | Torsional Constant | Area of Section |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Axis x-x $cm^4$ | Axis y-y $cm^4$ | Axis x-x cm | Axis y-y cm | Axis x-x $cm^3$ | Axis y-y $cm^3$ | Axis x-x $cm^3$ | Axis y-y $cm^3$ | u | x | H $dm^6$ | J $cm^4$ | A $cm^2$ |
| 356 × 406 × 634 # | 275000 | 98100 | 18.4 | 11.0 | 11600 | 4630 | 14200 | 7110 | 0.843 | 5.46 | 38.8 | 13700 | 808 |
| 356 × 406 × 551 # | 227000 | 82700 | 18.0 | 10.9 | 9960 | 3950 | 12100 | 6060 | 0.841 | 6.05 | 31.1 | 9240 | 702 |
| 356 × 406 × 467 # | 183000 | 67800 | 17.5 | 10.7 | 8380 | 3290 | 10000 | 5030 | 0.839 | 6.86 | 24.3 | 5810 | 595 |
| 356 × 406 × 393 # | 147000 | 55400 | 17.1 | 10.5 | 7000 | 2720 | 8220 | 4150 | 0.837 | 7.87 | 18.9 | 3550 | 501 |
| 356 × 406 × 340 # | 123000 | 46900 | 16.8 | 10.4 | 6030 | 2330 | 7000 | 3540 | 0.836 | 8.84 | 15.5 | 2340 | 439 |
| 356 × 406 × 287 # | 99900 | 38700 | 16.5 | 10.3 | 5080 | 1940 | 5810 | 2950 | 0.834 | 10.2 | 12.3 | 1440 | 366 |
| 356 × 406 × 235 # | 79100 | 31000 | 16.3 | 10.2 | 4160 | 1570 | 4690 | 2380 | 0.835 | 12.0 | 9.54 | 812 | 299 |
| 356 × 368 × 202 # | 66300 | 23700 | 16.1 | 9.60 | 3540 | 1260 | 3970 | 1920 | 0.844 | 13.4 | 7.16 | 558 | 257 |
| 356 × 368 × 177 # | 57100 | 20500 | 15.9 | 9.54 | 3100 | 1100 | 3460 | 1670 | 0.843 | 15.0 | 6.09 | 381 | 226 |
| 356 × 368 × 153 # | 48600 | 17600 | 15.8 | 9.49 | 2680 | 948 | 2970 | 1440 | 0.844 | 17.0 | 5.11 | 251 | 195 |
| 356 × 368 × 129 # | 40300 | 14600 | 15.6 | 9.43 | 2260 | 793 | 2480 | 1200 | 0.845 | 19.8 | 4.18 | 153 | 164 |
| 305 × 305 × 283 | 78900 | 24600 | 14.8 | 8.27 | 4320 | 1530 | 5110 | 2340 | 0.856 | 7.65 | 6.35 | 2030 | 360 |
| 305 × 305 × 240 | 64200 | 20300 | 14.5 | 8.16 | 3640 | 1280 | 4250 | 1950 | 0.854 | 8.74 | 5.03 | 1270 | 306 |
| 305 × 305 × 198 | 50900 | 16300 | 14.2 | 8.04 | 3000 | 1040 | 3440 | 1580 | 0.854 | 10.2 | 3.88 | 734 | 252 |
| 305 × 305 × 158 | 38800 | 12600 | 13.9 | 7.90 | 2370 | 808 | 2680 | 1230 | 0.852 | 12.5 | 2.87 | 378 | 201 |
| 305 × 305 × 137 | 32800 | 10700 | 13.7 | 7.83 | 2060 | 692 | 2300 | 1060 | 0.852 | 14.1 | 2.39 | 249 | 174 |
| 305 × 305 × 118 | 27700 | 9060 | 13.6 | 7.77 | 1780 | 589 | 1960 | 895 | 0.851 | 16.2 | 1.98 | 161 | 150 |
| 305 × 305 × 97 | 22300 | 7310 | 13.4 | 7.69 | 1450 | 479 | 1590 | 726 | 0.852 | 19.2 | 1.56 | 91.2 | 123 |
| 254 × 254 × 167 | 30000 | 9870 | 11.9 | 6.81 | 2080 | 744 | 2420 | 1140 | 0.851 | 8.50 | 1.63 | 626 | 213 |
| 254 × 254 × 132 | 22600 | 7530 | 11.6 | 6.69 | 1630 | 576 | 1870 | 876 | 0.850 | 10.3 | 1.19 | 319 | 168 |
| 254 × 254 × 107 | 17500 | 5930 | 11.3 | 6.59 | 1310 | 456 | 1480 | 697 | 0.849 | 12.4 | 0.898 | 172 | 136 |
| 254 × 254 × 89 | 14300 | 4860 | 11.2 | 6.55 | 1100 | 379 | 1220 | 575 | 0.851 | 14.5 | 0.717 | 102 | 113 |
| 254 × 254 × 73 | 11400 | 3910 | 11.1 | 6.48 | 898 | 307 | 992 | 465 | 0.849 | 17.3 | 0.562 | 57.6 | 93.1 |
| 203 × 203 × 86 | 9450 | 3130 | 9.28 | 5.34 | 850 | 299 | 977 | 456 | 0.849 | 10.2 | 0.318 | 137 | 110 |
| 203 × 203 × 71 | 7620 | 2540 | 9.18 | 5.30 | 706 | 246 | 799 | 374 | 0.853 | 11.9 | 0.250 | 80.2 | 90.4 |
| 203 × 203 × 60 | 6130 | 2070 | 8.96 | 5.20 | 584 | 201 | 656 | 305 | 0.846 | 14.1 | 0.197 | 47.2 | 76.4 |
| 203 × 203 × 52 | 5260 | 1780 | 8.91 | 5.18 | 510 | 174 | 567 | 264 | 0.848 | 15.8 | 0.167 | 31.8 | 66.3 |
| 203 × 203 × 46 | 4570 | 1550 | 8.82 | 5.13 | 450 | 152 | 497 | 231 | 0.846 | 17.7 | 0.143 | 22.2 | 58.7 |
| 152 × 152 × 37 | 2210 | 706 | 6.85 | 3.87 | 273 | 91.5 | 309 | 140 | 0.849 | 13.3 | 0.0399 | 19.2 | 47.1 |
| 152 × 152 × 30 | 1750 | 560 | 6.76 | 3.83 | 222 | 73.3 | 248 | 112 | 0.849 | 16.0 | 0.0308 | 10.5 | 38.3 |
| 152 × 152 × 23 | 1250 | 400 | 6.64 | 3.70 | 164 | 52.6 | 182 | 80.2 | 0.840 | 20.7 | 0.0212 | 4.63 | 29.2 |