

Elastic properties of steel

Modulus of elasticity (Young's modulus)

$$E = 205 \text{ kN/mm}^2$$

Poisson's ratio

$$\nu = 0.30$$

Coefficient of linear thermal expansion

$$\alpha = 12 \times 10^{-6} \text{ per } ^\circ\text{C}$$

European standards for structural steels

Introduction

As part of the exercise towards the removal of technical barriers to trade, the European Committee for Iron and Steel Standardization (ECISS) has prepared a series of European Standards (ENs) for structural steels. The first of these standards, EN 10025, was published in the UK by BSI as BS EN 10025: 1990, partly superseding BS 4360: 1986, which was re-issued as BS 4360: 1990. In 1993, a second edition of BS EN 10025 was made available together with BS EN 10113: Parts 1, 2 and 3 and BS EN 10155. In June 1994, BS EN 10210: Part 1 was published and at the same time BS 4360 was officially withdrawn. The balance of the BS 4360 steels not affected by these ENs were re-issued in new British Standards BS 7613 and BS 7668. In 1996, with the publication of BS EN 10137, BS 7613 was withdrawn. BS 7668 will remain until an EN for atmospheric corrosion resistant hollow sections is available.

Designation systems

The designation systems used in the EN are in accordance with EN 10027: Parts 1 and 2, together with ECISS Information Circular IC 10 (published by BSI as DD 214). These designations are totally different from the familiar BS 4360 designations: therefore, the following is intended to help users understand them.

Table 1 European and British Standards which have superseded BS 4360

| Standard | Superseded BS 4360 grades |
|-----------------------------------|--|
| BS EN 10025: 1993 | 40 A, B, C, D; 43 A, B, C, D; 50 A, B, C, D, DD |
| BS EN 10113: Parts 1, 2 & 3: 1993 | 40 DD, E, EE; 43 DD, E, EE; 50 E, EE; 55 C, EE |
| BS EN 10137: Parts 1, 2 & 3: 1996 | 50 F and 55 F |
| BS EN 10155: 1993 | WR 50 A, B, C |
| BS EN 10210: Part 1: 1994 | Hot-finished structural hollow section grades – excluding weather resistant grades |
| BS 7668: 1994 | Hot-finished weather resistant hollow section grades |

Table 2a Symbols used in EN 10025

| | |
|---------|--|
| S.... | Structural steel |
| E.... | Engineering steel |
| .235... | Minimum yield strength (R.) in N/mm ² @ 16 mm |
| ...JR.. | Longitudinal Charpy V-notch impacts 27J @ +20°C |
| ...J0.. | Longitudinal Charpy V-notch impacts 27J @ 0°C |
| ...J2.. | Longitudinal Charpy V-notch impacts 27J @ -20°C |
| ...K2.. | Longitudinal Charpy V-notch impacts 40J @ -20°C |
|G1 | Rimming steel (FU) |
|G2 | Rimming steel not permitted (FN) |
|G3 | FLAT products: Supply condition 'N', i.e. normalized or normalized rolled. LONG products: Supply condition at manufacturer's discretion |
|G4 | ALL products: Supply condition at manufacturer's discretion |

Examples: S235JRG1, S355K2G4

Table 2b Symbols used in EN 10155

| | |
|---------|--|
| S.... | Structural steel |
| .235... | Minimum yield strength (R.) in N/mm ² @ 16 mm |
| ...J0.. | Longitudinal Charpy V-notch impacts 27J @ 0°C |
| ...J2.. | Longitudinal Charpy V-notch impacts 27J @ -20°C |
| ...K2.. | Longitudinal Charpy V-notch impacts 40J @ -20°C |
|G1 | FLAT products: Supply condition 'N', i.e. normalized or normalized rolled. LONG products: Supply condition at manufacturer's discretion |
|G2 | All products: Supply condition at manufacturer's discretion |
|W | Weather resistant steel |
|P | High phosphorus grade |

Examples: S235J0WP, S355K2G2W

Table 2c Symbols used in EN 10113

| | |
|--------|--|
| S.... | Structural steel |
| .275.. | Minimum yield strength (R.) in N/mm ² @ 16 mm |
|N. | Normalized or normalized rolled |
|M. | Thermomechanically rolled |
|L | Charpy V-notch impacts down to -50°C |

Examples: S275N, S355ML

Table 2d Symbols used in EN 10137

| | |
|--------|--|
| S.... | Structural steel |
| .460.. | Minimum yield strength (R.) in N/mm ² @ 16 mm |
|Q. | Quenched and tempered |
|L | Charpy V-notch impacts down to -40°C |
|L1 | Charpy V-notch impacts down to -60°C |

Examples: S460QL, S620QL1

Table 3 Comparison between grades in EN 10025: 1993 and BS 4360: 1986

| Grade | EN 10025: 1993 | | | | BS 4360: 1986 | | | | | | |
|---------------|--|--|---|---------------------------------------|----------------------|-------|--|--|---|---|---------|
| | Tensile strength (R_m) at $t = 16 \text{ mm}$ (N/mm 2) | Min yield strength (R_s) at $t = 16 \text{ mm}$ (N/mm 2) | Max thickness for specified yield strength (R_e) (mm) | Charpy V-notch impacts (longitudinal) | | Grade | Tensile strength (R_m) at $t = 16 \text{ mm}$ (N/mm 2) | Min yield strength (R_s) at $t = 16 \text{ mm}$ (N/mm 2) | Max thickness for specified yield strength (R_e) (mm) | Charpy V-notch impacts (longitudinal) ≤ 100 mm (3) | |
| | | | | Temp (°C) ≤ 150 | Energy (J) mm (1) | | | | | | |
| S185 (4) | 290/510 | 185 | 25 | — | — | — | 40A | 340/500 | 235 | — | — |
| S235 (5) | 340/470 | 235 | 250 | +20 (6) | 27 | — | — | — | 150 | — | — |
| S235JR (4) | 340/470 | 235 | 25 | +20 (6) | 27 | — | — | — | — | — | — |
| S235JR/G1 (4) | 340/470 | 235 | 250 | +20 (6) | 27 | 23 | 40B | 340/500 | 235 | 150 | +20 (6) |
| S235JR/G2 | 340/470 | 235 | 250 | 0 | 27 | 23 | 40C | 340/500 | 235 | 150 | 0 |
| S235J0 | 340/470 | 235 | 250 | -20 | 27 | 23 | 40D | 340/500 | 235 | 150 | -20 |
| S235J2G3 | 340/470 | 235 | 250 | -20 | 27 | 23 | 40D | 340/500 | 235 | 150 | -20 |
| S235J2G4 | 340/470 | 235 | 250 | - | — | — | 43A | 430/580 | 275 | 150 | — |
| S275 (5) | 410/560 | 275 | 250 | +20 (6) | 27 | 23 | 43B | 430/580 | 275 | 150 | +20 (6) |
| S275JR | 410/560 | 275 | 250 | 0 | 27 | 23 | 43C | 430/580 | 275 | 150 | 0 |
| S275J0 | 410/560 | 275 | 250 | -20 | 27 | 23 | 43D | 430/580 | 275 | 150 | -20 |
| S275J2G3 | 410/560 | 275 | 250 | -20 | 27 | 23 | 43D | 430/580 | 275 | 150 | -20 |
| S275J2G4 | 410/560 | 275 | 250 | - | — | — | 50A | 490/640 | 355 | 150 | — |
| S355 (5) | 490/630 | 355 | 250 | +20 (6) | 27 | 23 | 50B | 490/640 | 355 | 150 | +20 (6) |
| S355JR | 490/630 | 355 | 250 | 0 | 27 | 23 | 50C | 490/640 | 355 | 150 | 0 |
| S355J0 | 490/630 | 355 | 250 | -20 | 27 | 23 | 50D | 490/640 | 355 | 150 | -20 |
| S355J2G3 | 490/630 | 355 | 250 | -20 | 27 | 23 | 50D | 490/640 | 355 | 150 | -20 |
| S355K2G3 | 490/630 | 355 | 250 | -20 | 40 | 33 | 50DD | 490/640 | 355 | 150 | -30 |
| S355K2G4 | 490/630 | 355 | 250 | -20 | 40 | 33 | 50DD | 490/640 | 355 | 150 | -30 |
| E295 | 470/610 | 295 | 250 | - | — | — | — | — | — | — | — |
| E335 | 570/710 | 335 | 250 | - | — | — | — | — | — | — | — |
| E360 | 650/830 | 360 | 250 | - | — | — | — | — | — | — | — |

(1) For sections up to and including 100 mm only.

(2) For wide flats and sections up to and including 63 mm and 100 mm respectively.

(3) For wide flats up to and including 63 mm and for sections no limit stated.

(4) Only available up to and including 25 mm.

(5) The steel grades S235, S275 and S355 appear only in the English language version (BS EN 10025) as non-conflicting additions, and do not appear in other European versions.

(6) Verification of the specified impact value is only carried out when agreed at the time of enquiry and order.

Table 4 Comparison between grades in EN 10113: Part 2 (Part 3); 1993 and BS 4360: 1990

| Grade | EN 10113: Part 2 (Part 3); 1993 | | | | | | BS 4360: 1990 | | | | | |
|-------------|--|-----------|------------------------------|-----------|--|-----|--|-----------|--------------------|-----|----------------------------|---------|
| | Tensile strength (R_m) | | Min yield strength (R_s) | | Max thickness for specified yield strength (R_s) | | Charpy V-notch impacts (longitudinal) – see Table 4a | | Grade | | Tensile strength (R_m) | |
| | at $t = 16 \text{ mm}$ (N/mm^2) | (1) | (mm) | (2) | (mm) | (1) | Energy (J) | (°C) | Max thickness (mm) | (1) | (mm) | (2) |
| S275N (M) | 370 (360) to | 275 | 150 (63) | 150 (150) | -20 | 40 | 150 (63) | 150 (150) | 43DD (3) | 430 | 275 | - |
| S275NL (ML) | 510 (510) 470 (450) | 275 | 150 (63) | 150 (150) | -50 | 27 | 150 (63) | 150 (150) | 43EE (4) | 580 | 275 | - |
| S355N (M) | 355 to | 355 | 150 (63) | 150 (150) | -20 | 40 | 150 (63) | 150 (150) | 50E (3) | 490 | 355 | - |
| S355NL (ML) | 630 (610) 520 (500) | 355 to | 150 (63) | 150 (150) | -50 | 27 | 150 (63) | 150 (150) | 50EE (4) | 640 | 355 | 150 (5) |
| S420N (M) | 420 to | 420 | 150 (63) | 150 (150) | -20 | 40 | 150 (63) | 150 (150) | - | - | - | - |
| S420NL (ML) | 680 (660) 550 (530) | 420 to | 150 (63) | 150 (150) | -50 | 27 | 150 (63) | 150 (150) | - | - | - | - |
| S460N (M) | 460 to | 460 | 100 (63) | 100 (150) | -20 | 40 | 100 (63) | 100 (150) | 55C (3) | 550 | 450 | 25 |
| S460NL (ML) | 720 (720) | 460 | 100 (63) | 100 (150) | -50 | 27 | 100 (63) | 100 (150) | 55EE (4) | 700 | 450 | 63 (6) |

Table 4a Longitudinal Charpy V-notch impacts

| Grade | Min ave energy (J) at test temp (°C) | | | |
|------------------------|--------------------------------------|----|-----|-----|
| | +20 | 0 | -10 | -20 |
| S ₋ N (M) | 55 | 47 | 43 | 40 |
| S ₋ NL (ML) | 63 | 55 | 51 | 47 |

(1) Applies to plate and wide flats

(2) Applies to sections

(3) Supply condition M by agreement

(4) Supply condition M not permitted

(5) For wide flats max thickness is 63 mm

(6) Not available as wide flats

(7) For wide flats max thickness is 50 mm

(8) For wide flats max thickness is 30 mm

(9) For sections no thickness limit is given

Table 5 Comparison between grades in EN 10137: Part 2: 1996 and BS 4360: 1990

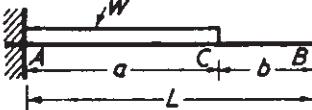
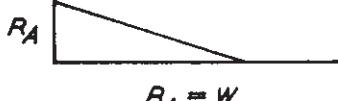
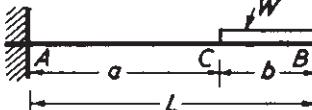
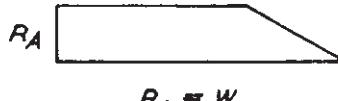
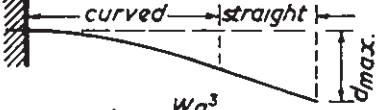
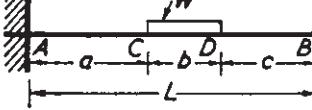
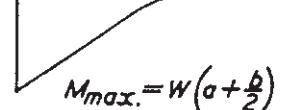
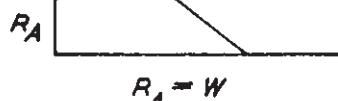
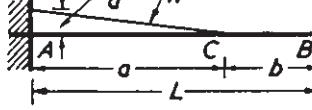
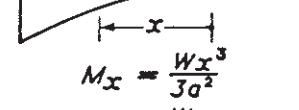
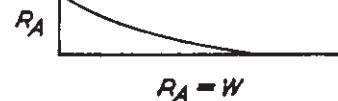
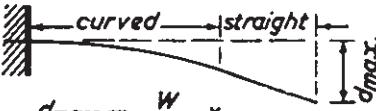
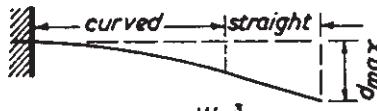
| Grade | Tensile strength (R_m) (N/mm ²) | EN 10137: Part 2: 1996 | | | | BS 4360: 1990 | | | |
|---------------------|--|--|-----|---|-----|---|---------|--|----|
| | | Min yield strength (R_e) (mm) | | Max thickness for specified yield strength (R_e) (mm) | | Charpy V-notch impacts (longitudinal) Temp (°C) Energy (J) | | Grade | |
| | | at $t = 16$ mm (N/mm ²) | | Max thickness (mm) | | at $t = 16$ mm (N/mm ²) | | Tensile strength (R_m) (N/mm ²) | |
| S460Q | 550 | 460 | 150 | -20 | 27 | 150 | - | - | - |
| 460QL ₁₀ | 460 | 150 | -40 | 27 | 150 | - | - | - | - |
| S460QL ₁ | 720 | 460 | -60 | 27 | 150 | 55F | 550-700 | 450 | 40 |
| | | | | | | | | -60 | 27 |
| | | | | | | | | -60 | 40 |

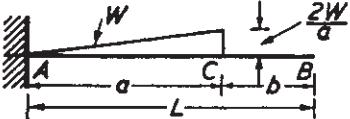
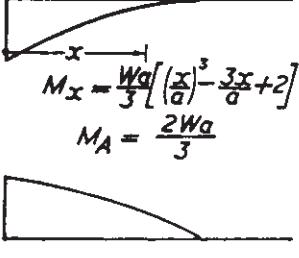
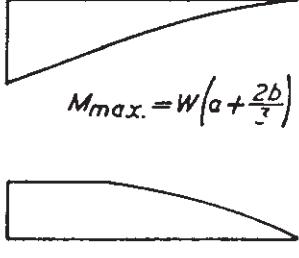
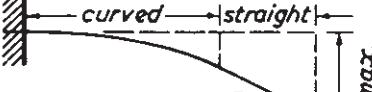
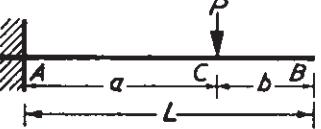
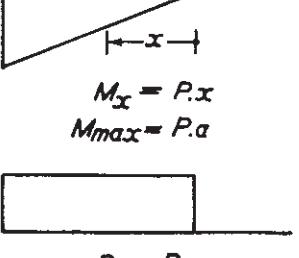
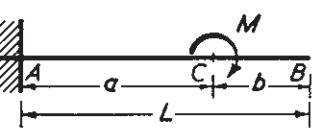
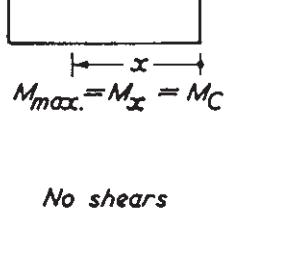
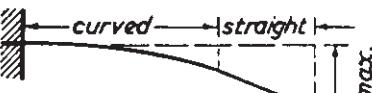
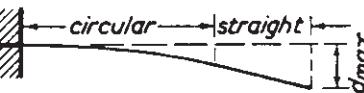
EN 10137: Part 2 also contains Grades S500Q/QL/QL1, S550Q/QL/QL1, S620Q/QL/QL1, S690Q/QL/QL1, S890Q/QL/QL1 and S960Q/QL

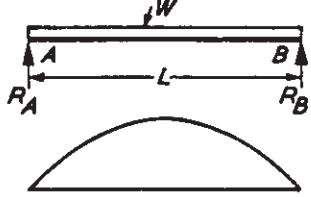
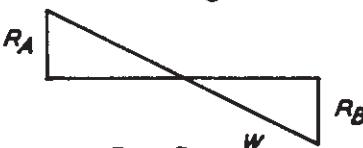
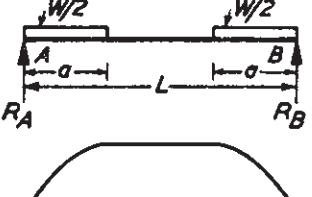
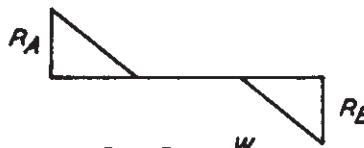
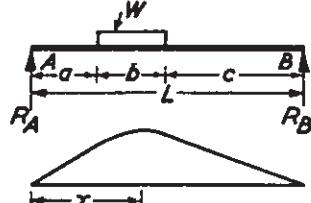
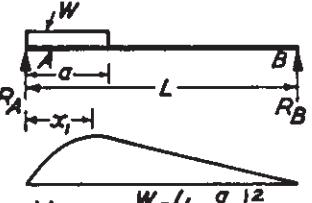
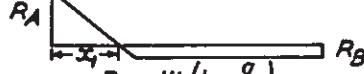
Table 6 Comparison between grades in EN 10155: 1993 and BS 4360: 1990

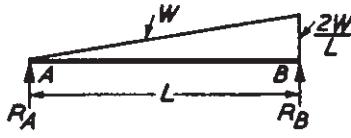
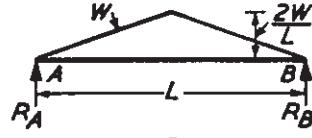
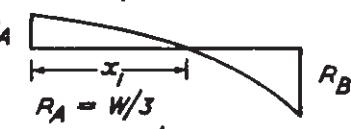
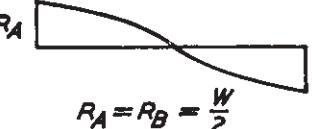
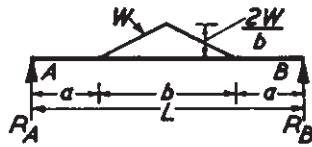
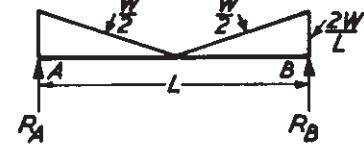
| Grade | Product nominal thickness (mm) | EN 10155: 1993 | | | | BS 4360: 1990 | | | |
|-----------|--------------------------------|--|------|--------------------------------------|-----|---|----|--|------|
| | | Tensile strength (R_m) (N/mm ²) | | Min yield strength (R_e) (mm) | | Charpy V-notch impacts (longitudinal) Temp (°C) Energy (J) | | Grade | |
| | | Flat | Long | at $t = 16$ mm | | at $t = 16$ mm (N/mm ²) | | Tensile strength (R_m) (N/mm ²) | |
| S235JOW | 100 | 40 | 100 | 340-470 | 235 | 0 | 27 | - | - |
| S235J2W | 100 | 40 | 100 | 340-470 | 285 | -20 | 27 | - | - |
| S355JOWP | 12 | 40 | - | 490-630 | 355 | 0 | 27 | WR50A | >480 |
| S355J2WP | 12 | 40 | - | 490-630 | 355 | -20 | 27 | WR50B | >480 |
| S355JOW | 100 | 40 | 100 | 490-630 | 355 | 0 | 27 | WR50C | >480 |
| S355J2G1W | 100 | 40 | 100 | 490-630 | 355 | -20 | 27 | WR50C | >480 |
| S355J2G2W | 100 | 40 | 100 | 490-630 | 355 | -20 | 27 | WR50C | >480 |
| S355K2G1W | 100 | 40 | 100 | 490-630 | 355 | -20 | 40 | - | - |
| S355K2G2W | 100 | 40 | 100 | 490-630 | 355 | -20 | 40 | - | - |

(1) Up to and incl. 12 mm thick. Over 12 mm min yield strength of 325 N/mm² applies. (2) For round and square bar max thickness is 25 mm

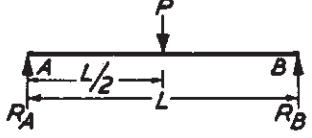
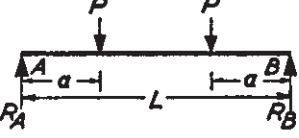
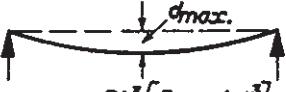
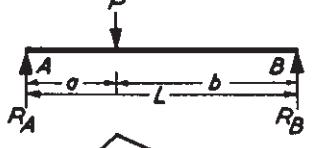
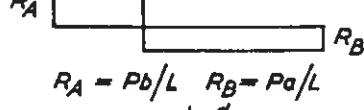
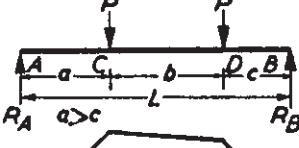
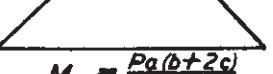
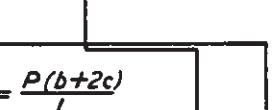
| CANTILEVERS | |
|--|---|
| LOADING | MOMENT |
|   $M_x = \frac{Wx^2}{2a}$ $M_{max} = \frac{Wa}{2}$  $R_A = W$ |   $M_{max} = W\left(a + \frac{b}{2}\right)$  $R_A = W$ |
|  $d_C = \frac{Wa^3}{8EI}$ $d_{max} = \frac{Wa^3}{8EI} \left(1 + \frac{4b}{3a}\right)$ |  $d_{max} = \frac{W(8a^3 + 18a^2b + 12ab^2 + 3b^3)}{24EI}$ |
|    $R_A = W$ |   $M_x = \frac{Wx^3}{3a^2}$ $M_A = \frac{Wa}{3}$  $R_A = W$ |
|  $d_{max} = \frac{W}{24EI} \times (8a^4 + 8a^3b + 12ab^2 + 3b^3 + 2a^2c + 2abc + 4b^2c)$ |  $d_C = \frac{Wa^3}{15EI}$ $d_{max} = \frac{Wa^3}{15EI} \left(1 + \frac{5b}{4a}\right)$ |

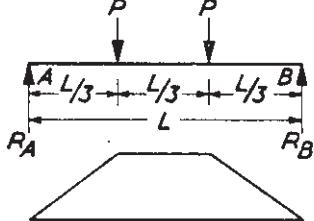
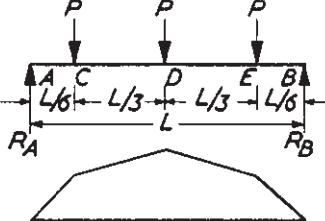
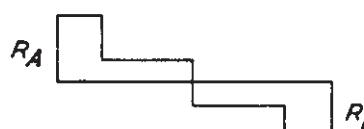
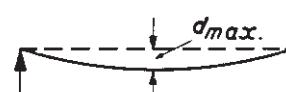
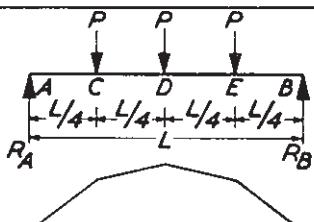
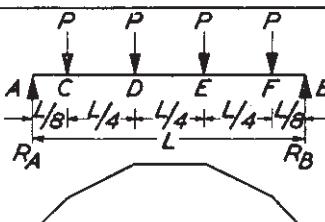
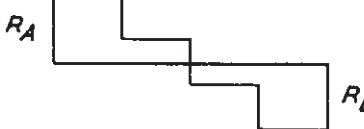
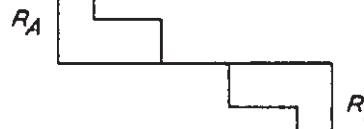
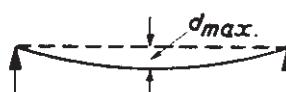
| CANTILEVERS | |
|---|--|
| LOADING | |
|   $M_x = \frac{Wx}{3} \left[\left(\frac{x}{a} \right)^3 - \frac{3x}{a} + 2 \right]$ $M_A = \frac{2Wa}{3}$ |   $M_{max.} = W \left(a + \frac{2b}{3} \right)$ |
|  $d_C = \frac{11Wa^3}{60EI}$ $d_{max.} = \frac{11Wa^3}{60EI} \left(1 + \frac{15b}{a} \right)$ |  $d_{max.} = \frac{W(20a^3 + 50a^2b + 40ab^2 + 11b^3)}{60EI}$ |
|   $M_x = P \cdot x$ $M_{max.} = P \cdot a$ |   $M_{max.} = M_x = M_C$ <p>No shears</p> |
|  $d_C = \frac{Pa^3}{3EI}$ $d_{max.} = \frac{Pa^3}{3EI} \left(1 + \frac{3b}{2a} \right)$ |  $d_C = \frac{Ma^2}{2EI}$ $d_{max.} = \frac{Ma^2}{2EI} \left(1 + \frac{2b}{a} \right)$ |

| SIMPLY SUPPORTED BEAMS | |
|------------------------|---|
| LOADING | |
| LOADING |  <p>$M_x = \frac{Wx}{2}(1 - \frac{x}{L})$ $M_{max.} = \frac{WL}{8}$</p>  <p>$R_A = R_B = \frac{W}{2}$</p>  <p>$d_{max.} = \frac{5}{384} \cdot \frac{WL^3}{EI}$</p> |
| LOADING |  <p>$M_{max.} = \frac{Wa}{4}$</p>  <p>$R_A = R_B = \frac{W}{2}$</p>  <p>$d_{max.} = \frac{Wa(3L^2 - 2a^2)}{96EI}$</p> |
| LOADING |  <p>$M_{max.} = \frac{W}{b} \left(\frac{x_1^2 - a^2}{2} \right)$ when $x_1 = a + \frac{R_{AB}}{W}$</p>  <p>$R_A = \frac{W}{L} \left(\frac{b}{2} + c \right)$ $R_B = \frac{W}{L} \left(\frac{b}{2} + a \right)$</p>  <p>When $a = c$ $d_{max.} = \frac{W}{384EI} (8L^3 - 4LB^2 + b^3)$</p> |
| LOADING |  <p>$M_{max.} = \frac{Wa}{2} \left(1 - \frac{a}{2L} \right)^2$ when $x_1 = a \left(1 - \frac{a}{2L} \right)$</p>  <p>$R_A = W \left(1 - \frac{a}{2L} \right)$ $R_B = \frac{Wa}{2L}$</p>  <p>When $x \leq a$, $d = \frac{WL^4}{24EI} [m^4 - 2n(2-n)m^3 + n^2(2-n)^2 m]$ When $x > a$, $d = \frac{WL^4}{24EI} [n^2(2m^3 - 6m^2 + m(4+n^2) - n^2)]$ where $m = x/L$ and $n = a/L$</p> |

| SIMPLY SUPPORTED BEAMS | | | | | |
|------------------------|-------|--|--|--|--|
| LOADING | | MOMENT | | DEFLECTION | |
| DEFLECTION | SHEAR |  | |  | |
| | | $M_x = \frac{Wx}{3} \left(1 - \frac{x^2}{L^2}\right)$ $M_{max.} = 0.128WL$ when $x_i = 0.5774L$ | | $M_x = Wx \left(\frac{1}{2} - \frac{2x^2}{3L^2}\right)$ $M_{max.} = WL/6$ | |
| | |  $R_A = W/3$ $R_B = 2W/3$ | |  $R_A = R_B = \frac{W}{2}$ $d_{max.} = \frac{WL^3}{6EI}$ | |
| DEFLECTION | SHEAR |  | |  | |
| | | $M_{max.} = \frac{W}{4} \left(L - \frac{4}{3}a\right)$ | | $M_x = Wx \left(\frac{L}{2} - \frac{x}{L} + \frac{2x^2}{3L^2}\right)$ $M_{max.} = WL/12$ | |
| | |  $R_A = R_B = W/2$ | |  $R_A = R_B = \frac{W}{2}$ $d_{max.} = \frac{3WL^3}{32EI}$ | |

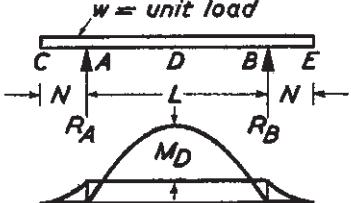
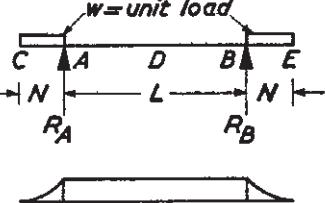
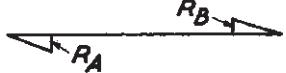
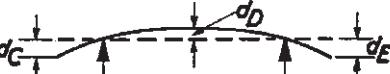
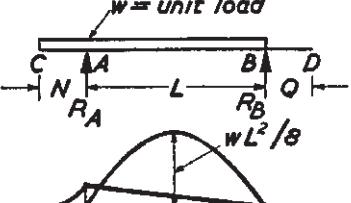
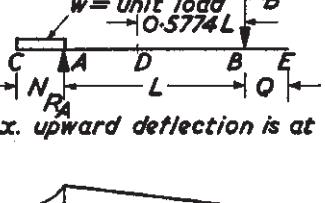
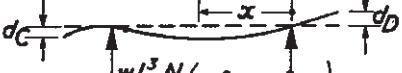
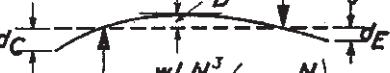
| SIMPLY SUPPORTED BEAMS | | | | | |
|------------------------|---------|--|-------|---|---|
| | LOADING | MOMENT | SHEAR | DEFLECTION | |
| | | $M_{max.} = \frac{Wa}{6}$ | | $R_A = R_B = W/2$ | $d_{max.} = \frac{Wa}{24EI}(18a^2 + 20ab + 5b^2)$ |
| | | $m = a/L$ $M_{max.} = \frac{Wa}{3}(1 - m + \frac{2m}{3}\sqrt{m})$ $\text{when } x = a(1 - \sqrt{\frac{m}{3}})$ | | $R_A = W\left(1 - \frac{m}{3}\right)$ $R_B = \frac{Wm}{3}$ | |
| | | $M_{max.} = \frac{Wa}{3}$ | | $R_A = R_B = W/2$ | $d_{max.} = \frac{Wa}{12EI}(16a^2 + 20ab + 5b^2)$ |
| | | $M_{max.} = \frac{2Wa}{3}\left(1 - \frac{2m}{3}\right)^{3/2}$ $\text{when } x = a\sqrt{1 - \frac{2m}{3}}$ | | $R_A = W\left(1 - \frac{2m}{3}\right)$ $R_B = \frac{2Wm}{3}$ | |

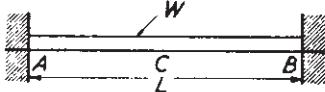
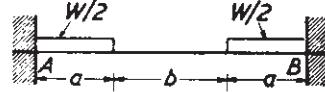
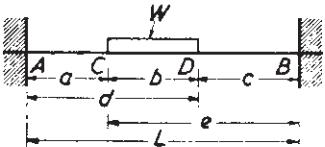
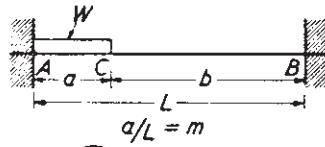
| SIMPLY SUPPORTED BEAMS | |
|--|---|
| LOADING  MOMENT  $M_{max.} = \frac{PL}{4}$ SHEAR  $R_A = R_B = \frac{P}{2}$ DEFLECTION  $d_{max.} = \frac{PL^3}{48EI}$ |  MOMENT  $M_{max.} = Pa$ SHEAR  $R_A = R_B = P$ DEFLECTION  $d_{max.} = \frac{PL^3}{6EI} \left[\frac{3a}{4L} - \left(\frac{a}{L} \right)^3 \right]$ |
| LOADING  MOMENT  $M_{max.} = \frac{Pab}{L}$ SHEAR  $R_A = Pb/L \quad R_B = Pa/L$ DEFLECTION  <p><i>d_{max.} always occurs within 0.074L of the centre of the beam. When b > a,</i></p> $d_{center} = \frac{PL^3}{48EI} \left[\frac{3a}{L} - 4 \left(\frac{a}{L} \right)^3 \right]$ <p><i>This value is always within 2.5% of the maximum value.</i></p> |  MOMENT  $M_C = \frac{Pa(b+2c)}{L}$ $M_D = \frac{Pc(b+2a)}{L}$ SHEAR  $R_A = \frac{P(b+2c)}{L}$ $R_B = \frac{P(b+2a)}{L}$ DEFLECTION <p><i>For central deflection add the values for each P derived from the formula in the adjacent diagram.</i></p> |

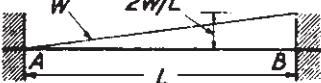
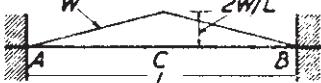
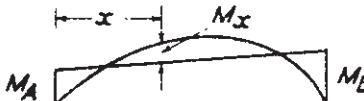
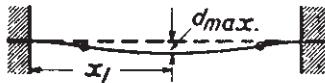
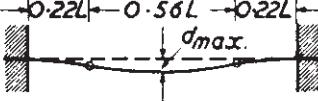
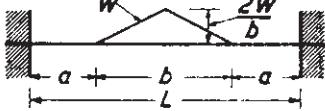
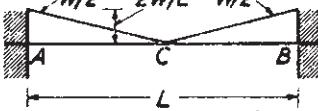
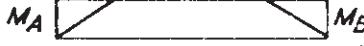
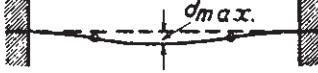
| SIMPLY SUPPORTED BEAMS | |
|---|---|
| LOADING | MOMENT |
|  |  $M_{max} = \frac{PL}{3}$ |
|  $R_A = R_B = P$ |  $R_A = R_B = \frac{3P}{2}$ |
|  $d_{max} = \frac{23PL^3}{648EI}$ |  $d_{max} = \frac{53PL^3}{1296EI}$ |
| LOADING | MOMENT |
|  |  $M_C = M_E = \frac{3PL}{8}$ $M_D = \frac{PL}{2}$ |
|  $R_A = R_B = \frac{3P}{2}$ |  $R_A = R_B = 2P$ |
|  $d_{max} = \frac{19PL^3}{384EI}$ |  $d_{max} = \frac{41PL^3}{768EI}$ |

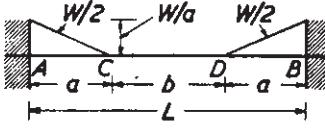
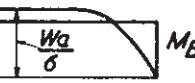
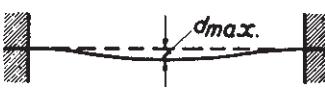
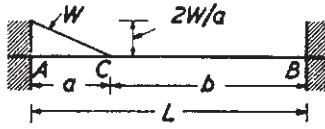
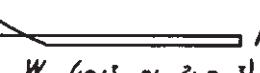
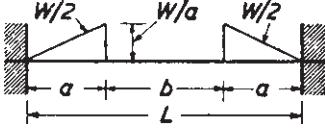
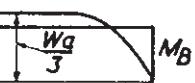
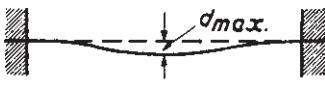
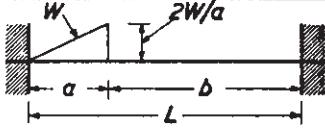
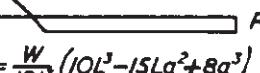
| SIMPLY SUPPORTED BEAMS | | | |
|--|---|--------------------------------|---|
| LOADING | MOMENT | SHEAR | DEFLECTION |
| | $M_C - M_F = \frac{2PL}{5}$ $M_D - M_E = \frac{3PL}{5}$ | $R_A = R_B = 2P$ | $d_{max.} = \frac{63PL^3}{1000EI}$ |
| | $\text{When } n \text{ is odd, } M_{max.} = \frac{(n^2-1)PL}{8n}$ $\text{When } n \text{ is even, } M_{max.} = \frac{nPL}{8}$ | $R_A = R_B = \frac{(n-1)P}{2}$ | $d_{max.} = \frac{PL^3}{192EI} \left[n - \frac{1}{n} \right] \left[3 - \frac{1}{2} \left(1 - \frac{1}{n^2} \right) \right]$ $\text{When } n \text{ is even, } d_{max.} = \frac{PL^3}{192EI} \cdot n \left[3 - \frac{1}{2} \left(1 + \frac{4}{n^2} \right) \right]$ |
| TOTAL LOAD = W | | | |
| | | | |
| $W/2n \quad W/n \quad W/n \quad \text{SIMPLY SUPPORTED BEAM} \quad W/2n$ $L/n + L/n + L/n + L/n + L/n + L/n$ | | | |
| <p>When $n > 10$, consider the load uniformly distributed The reaction at the supports = $W/2$, but the maximum S.F. at the ends of the beam = $\frac{W(n-1)}{2n} = A.W$</p> | | | |
| <p>The value of the maximum bending moment = $C.WL^2$ The value of the deflection at the centre of the span = $k \cdot \frac{WL^3}{EI}$</p> | | | |
| Value of n | A | C | k |
| 2 | 0.2500 | 0.1250 | 0.0105 |
| 3 | 0.3333 | 0.1111 | 0.0118 |
| 4 | 0.3750 | 0.1250 | 0.0124 |
| 5 | 0.4000 | 0.1200 | 0.0126 |
| 6 | 0.4167 | 0.1250 | 0.0127 |
| 7 | 0.4286 | 0.1224 | 0.0128 |
| 8 | 0.4375 | 0.1250 | 0.0128 |
| 9 | 0.4444 | 0.1236 | 0.0129 |
| 10 | 0.4500 | 0.1250 | 0.0129 |

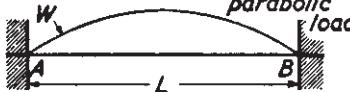
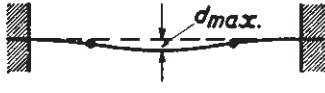
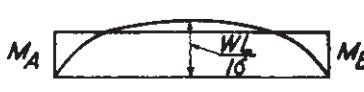
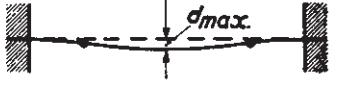
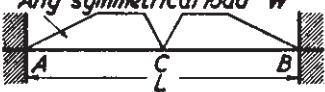
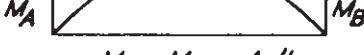
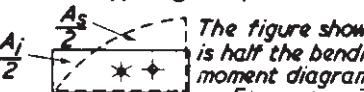
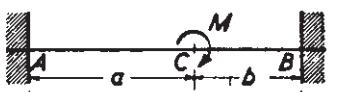
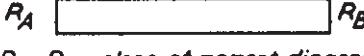
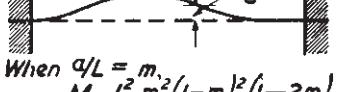
| SIMPLY SUPPORTED BEAMS | | | |
|---|---|---|---|
| LOADING | MOMENT | SHEAR | DEFLECTION |
| $M_{CA} = M \cdot a/L$ $M_{CB} = M \cdot b/L$ | $M_A = M_B$ $M_A > M_B$ $M_A > -M_B$ $(M_B \text{ anti-clockwise})$ Shear diagram when $M_A \neq M_B$ | R_A R_B $R_A = R_B = M/L$ As shown $a > b$. | $R_A = -R_B = \frac{M_A - M_B}{L}$ ① ② ③ |
| 2nd degree parabola. W $m = x/L$ $M_x = \frac{WL}{2} (m^4 - 2m^3 + m)$ $M_{max.} = \frac{5WL}{32}$ | Complement of parabola. Total load = W $m = x/L$ $M_x = \frac{WL}{2} (m - 3m^2 + 4m^3 - 2m^4)$ $M_{max.} = \frac{WL}{16}$ | R_A R_B $R_A = R_B = W/2$ $d_{max.} = \frac{6 \cdot 1 WL^3}{384EI}$ | R_A R_B $R_A = R_B = W/2$ $d_{max.} = \frac{2 \cdot 8 WL^3}{384EI}$ |

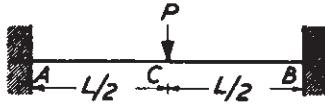
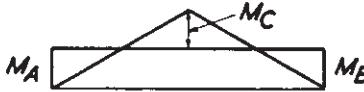
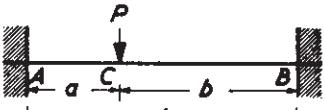
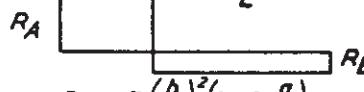
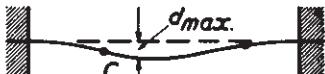
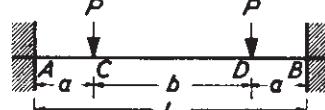
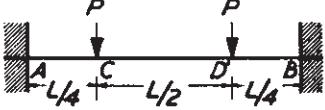
| SIMPLY SUPPORTED BEAMS | |
|---|--|
| LOADING  $M_A = M_B = -\frac{wN^2}{2}$ $M_D = \frac{wL^2}{8} + M_A$ |  $M_A = M_B = -\frac{wN^2}{2}$ |
| SHEAR MOMENT  $R_A = R_B = w(N + \frac{L}{2})$ |  $R_A = R_B = wN$ |
| DEFLECTION  $d_C = d_E = \frac{wL^3 N}{24EI} (1 - 6n^2 - 3n^3)$ $d_D = \frac{wL^4}{384EI} (5 - 24n^2)$ Where $n = N/L$ |  $d_C = d_E = \frac{wLN^3}{8EI} (2 + \frac{N}{L})$ $d_D = -\frac{wL^2 N^2}{16EI}$ |
| LOADING  $M_A = -\frac{wN^2}{2}$ |  Max. upward deflection is at D. $M_A = -\frac{wN^2}{2}$ |
| SHEAR MOMENT  $R_A = \frac{w(N+L)^2}{2L}$ $R_B = \frac{w(L+N)(L-N)}{2L}$ $m = x/L$ $n = N/L$ |  $R_A = \frac{wN(2L+N)}{2L}$ $R_B = \frac{wN^2}{2L}$ BE is straight. |
| DEFLECTION  $d_C = \frac{wL^3 N}{24EI} (3n^3 + 4n^2 - 1)$ $d_x = \frac{wL^4}{24EI} [m^4 - 2m^3(1-n^2) + m(1-2n^2)]$ $d_D = -\frac{wL^3 Q}{24EI} (2n^2 - 1)$ |  $d_C = \frac{wLN^3}{24EI} (4 + \frac{3N}{L})$ $d_D = -\frac{0.032wL^2 N^2}{EI}$ $d_E = \frac{wLN^2 Q}{12EI}$ |

| BUILT-IN BEAMS | |
|---|---|
| MOMENT LOADING | SHEAR MOMENT DEFLECTION |
|  <p>$M_A = M_B = -\frac{WL}{12}$ $M_C = \frac{WL}{24}$</p> <p>$R_A = R_B = W/2$</p> <p>$d_{max.} = \frac{WL^3}{384EI}$</p> |  <p>$M_A = M_B = -\frac{Wa}{12L}(3L-2a)$</p> <p>$R_A = R_B = W/2$</p> <p>$d_{max.} = \frac{Wa^2}{48EI}(L-a)$</p> |
|  <p>$M_A = -\frac{W}{12EJ} [e^3(4L-3e) - c^3(4L-3c)]$ $M_B = -\frac{W}{12EJ} [d^3(4L-3d) - a^3(4L-3a)]$</p> <p>$R_A = r_A + \frac{M_A - M_B}{L}$ $R_B = r_B + \frac{M_B - M_A}{L}$</p> <p>When $a = c$, $d_{max.} = \frac{W}{384EI} (L^3 + 2L^2a + 4La^2 - 8a^3)$</p> |  <p>$M_A = -\frac{WL}{12} \cdot m (3m^2 - 8m + 6)$ $M_B = -\frac{WL}{12} \cdot m^2 (4 - 3m) + M_{max.} = \frac{WL}{12} m^2 \left(-\frac{3}{2}m^5 + 6m^4 - 6m^3 + 15m^2 - 8 \right)$</p> <p>$R_A = r_A + \frac{M_A - M_B}{L}$ $R_B = \frac{W \cdot m^3 (2-m)}{2m}$</p> <p>When $a = L/2$ and $x_1 = 0.445L$, $d_{max.} = \frac{WL^3}{333EI}$, $d_C = \frac{WL^3}{384EI}$</p> |

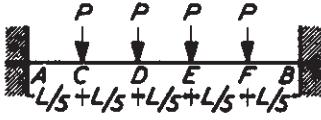
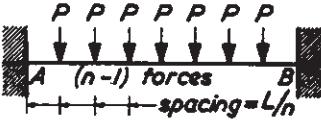
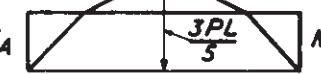
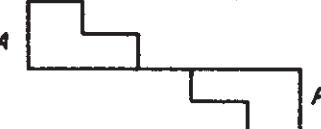
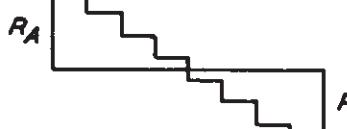
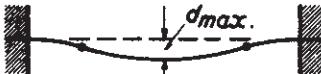
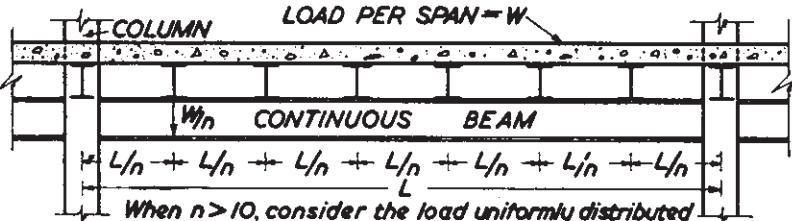
| BUILT-IN BEAMS | | | |
|----------------|---|--|--|
| LOADING | | | |
| | W | 2W/L | |
| MOMENT |  |  | |
| |  |  | |
| | $M_x = \frac{WL}{30} \left(\frac{10x^3}{L^3} - \frac{9x}{L} + 2 \right)$ | $MA = MB = -\frac{SWL}{48}$ | |
| | $+ M_{max.} = WL/23.3 \text{ when } x = 0.55L$ $MA = -WL/15 \quad MB = -WL/10$ | $MC = WL/10$ | |
| SHEAR |  |  | |
| | $R_A = 0.3W \quad R_B = 0.7W$ | $R_A = R_B = W/2$ | |
| |  |  | |
| | $d_{max.} = \frac{WL^3}{382EI}$ when $x_1 = 0.525L$ | $d_{max.} = \frac{1.4WL^3}{384EI}$ | |
| DEFLECTION |  |  | |
| |  |  | |
| | $MA = MB = -\frac{W}{48L} (5L^2 + 4aL - 4a^2)$ | $MA = MB = -WL/16$ | |
| |  |  | |
| DEFLECTION |  |  | |
| | $d_{max.} = \frac{W}{1920EI} (7L^3 + 8aL^2 + 4a^2L - 16a^3)$ | $d_{max.} = \frac{0.6WL^3}{384EI}$ | |

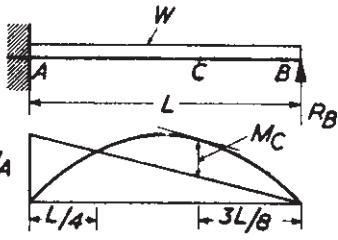
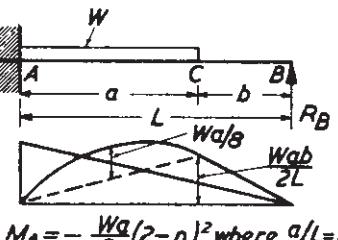
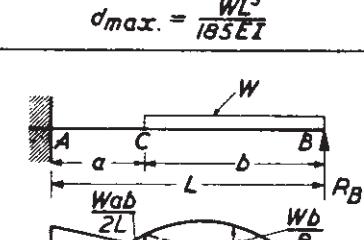
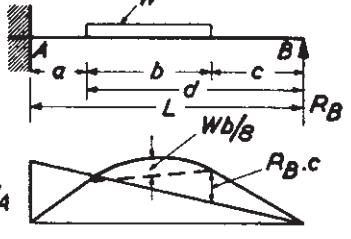
| BUILT-IN BEAMS | |
|---|---|
| LOADING | MOMENT |
|  |  $M_A = M_B = -\frac{Wq}{12L} (2L - a)$  $R_A = R_B = W/2$  $d_{max.} = \frac{Wa^2}{48EI} (SL - 4a)$ |
|  |  $M_A = M_B = -\frac{Wa}{30L^2} (3a^2 + 10bL)$ $M_B = -\frac{Wa^2}{30L^2} (5L - 3a)$ $\text{In AC, } M_x = R_B \cdot x + M_B - \frac{2W(x-b)^3}{6ab}$ $\text{In CB, } M_x = R_B \cdot x + M_B$  $R_A = R_B = 0$ |
|  |  $M_A = M_B = -\frac{Wa}{12L} (4L - 3a)$   $d_{max.} = \frac{Wa^2}{48EI} (15L - 16a)$ |
|  |  $M_A = M_B = -\frac{Wa}{15L^2} (10L^2 - 15aL + 6a^2)$ $M_B = -\frac{Wa^2}{10L^2} (5L - 4a)$  $R_A = R_B = 0$ |

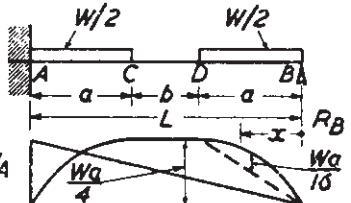
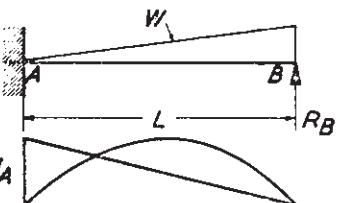
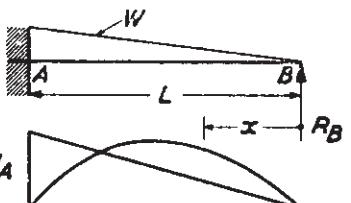
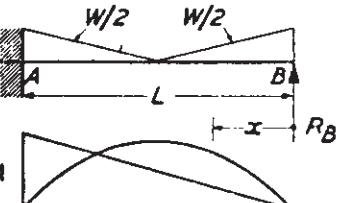
| BUILT-IN BEAMS | |
|---|--|
| LOADING   $M_A = M_B = -WL/10$ MOMENT  $R_A = R_B = W/2$ DEFLECTION  $d_{max.} = \frac{1.3 WL^3}{384 EI}$ | LOADING   $M_A = M_B = -WL/20$ MOMENT  $R_A = R_B = W/2$ DEFLECTION  $d_{max.} = \frac{0.4 WL^3}{384 EI}$ |
| LOADING  symmetrical diagram  $M_A = M_B = -A_s/L$ <p>where A_s is the area of the 'free' bending moment diagram</p>  $R_A = R_B = W/2$ SHEAR  <p>The figure shown is half the bending moment diagram</p> $d_{max. at C} = \frac{A_s x - A_s x_1}{2EI}$ <p>Where A_s is the area of the fixing moment diagram</p> | LOADING   $M_{AC} = M \cdot \frac{b}{L^2} (3a - L)$ $M_{BC} = -M \cdot \frac{a}{L^2} (3b - L)$ <p>When $a/L = m$, $M_{CA} = -M \cdot (1-m)/(1-3m+6m^2)$</p>  $R_A = R_B = \text{slope of moment diagram}$ $= \frac{M_{AC} + M_{CA}}{a} = \frac{M_{CB} + M_{BC}}{b}$  <p>When $a/L = m$, $M \cdot L^2 m^2 / (1-m)^2 (1-2m)$</p> $d_C = \frac{2C}{2EI}$ <p>For anticlockwise moments reverse the deflections</p> |

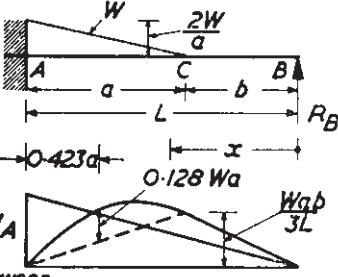
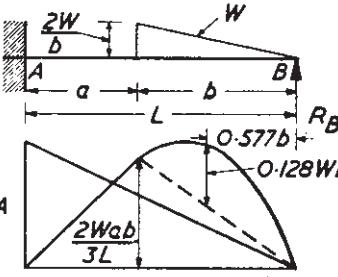
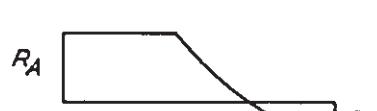
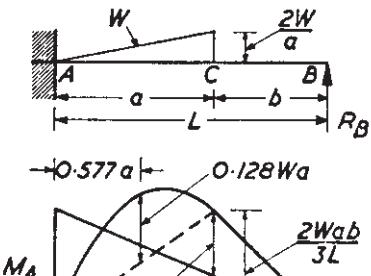
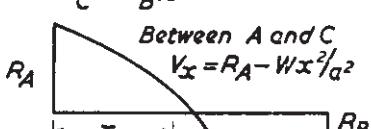
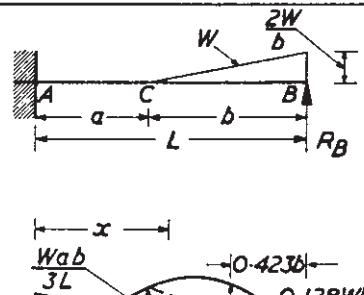
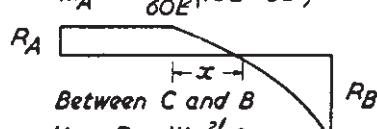
| BUILT-IN BEAMS | |
|--|--|
| MOMENT | LOADING |
|   $-M_A = -M_B = M_C = PL/8$  $R_A = R_B = P/2$  $d_{max.} = \frac{PL^3}{192EI}$ |   $M_A = -\frac{Pab^2}{L^2}$ $M_B = -\frac{Pba^2}{L^2}$ $M_C = \frac{2Pab^2b^2}{L^3}$  $R_A = P\left(\frac{b}{L}\right)^2\left(1+2\frac{a}{L}\right)$ $R_B = P\left(\frac{a}{L}\right)^2\left(1+2\frac{b}{L}\right)$  $d_C = \frac{Pa^3b^3}{3EI(L^3)}$ $d_{max.} = \frac{2Pab^2b^3}{3EI(3L-2a)^2} \text{ when } x = \frac{L^2}{3L-2a}$ |
|   $M_A = M_B = -\frac{Pa(L-a)}{L}$ $M_C = M_D = Pa^2/L$  $R_A = R_B = P$  $d_{max.} = \frac{PL^3}{6EI}\left[\frac{3a^2}{4L^2}\left(\frac{a}{L}\right)^3\right]$ |   $M_A = M_B = -\frac{3PL}{16}$ $M_C = M_D = PL/16$  $R_A = R_B = P$  $d_{max.} = \frac{PL^3}{192EI}$ |

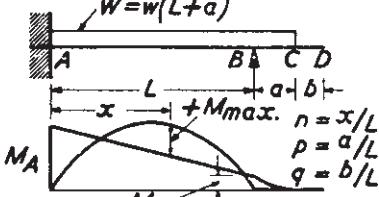
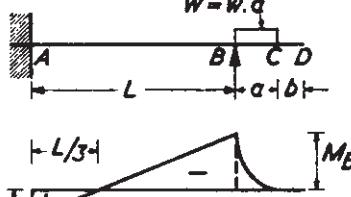
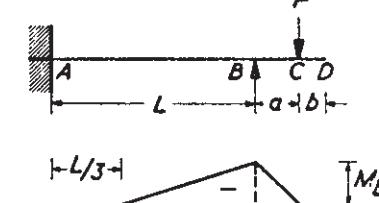
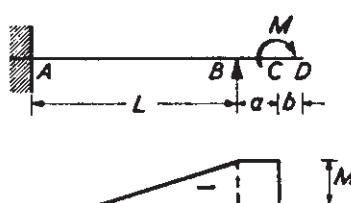
| BUILT-IN BEAMS | |
|--------------------------------------|--|
| LOADING | MOMENT |
| | |
| $R_A = R_B = P$ | $R_A = R_B = 3P/2$ |
| $d_{max.} = \frac{5PL^3}{648EI}$ | $d_{max.} = \frac{41PL^3}{5184EI}$ |
| DEFLECTION | |
| | |
| $R_A = R_B = 3P/2$ | $R_A = R_B = 2P$ |
| $d_{max.} = \frac{PL^3}{96EI}$ | $d_{max.} = \frac{PL^3}{96EI}$ |

| BUILT-IN BEAMS | | | |
|---|--|--|-------------------|
| LOADING | | | |
| | | | |
|  |  | | |
| MOMENT |  |  | |
| | $MA = MB = -2PL/5$ | $MA = MB = -PL(n^2-1)/12n$ | |
| | $MD = ME = PL/5$ | | |
| R <small>A</small> |  |  | <small>RB</small> |
| | $RA = RB = 2P$ | $RA = RB = (n-1)P/2$ | |
| SHEAR |  |  | |
| | $d_{max.} = \frac{13PL^3}{1000EI}$ | | |
| DEFLECTION | | <small>When n is odd,</small> $d_{max.} = \frac{PL^3}{192EI} \left[\frac{n-1}{n} \right] \left[\frac{1}{2} \left(1 - \frac{1}{n^2} \right) \right]$ | |
| | | <small>When n is even,</small> $d_{max.} = \frac{PL^3}{192EI} \left[\frac{3}{2} \left(1 + \frac{4}{n^2} \right) \right] n - 2 \left(n - \frac{1}{n} \right)$ | |
| 1/2 COLUMN LOAD PER SPAN = W | | | |
|  | | | |
| W_n | CONTINUOUS BEAM | | |
| $L/n + L/n + L/n + L/n + L/n + L/n + L/n$ | | | |
| When $n > 10$, consider the load uniformly distributed | | | |
| The load on the outside stringers is carried directly by the supports | | | |
| The continuous beam is assumed to be horizontal at each support | | | |
| The reaction at the supports for each span = $W/2$, but the maximum shear force in any span of the continuous beam = $\frac{W(n-1)}{2n} = A.W$ | | | |
| The value of the fixing moment at each support = $-B.WL$ | | | |
| The value of the maximum positive moment for each span = $C.WL$ | | | |
| The value of the maximum deflection for each span = $0.0026 \frac{WL^3}{EI}$ | | | |
| Value of n | A | B | C |
| 2 | 0.2500 | 0.0625 | 0.0625 |
| 3 | 0.3333 | 0.0741 | 0.0370 |
| 4 | 0.3750 | 0.0781 | 0.0469 |
| 5 | 0.4000 | 0.0800 | 0.0400 |
| 6 | 0.4167 | 0.0811 | 0.0439 |
| 7 | 0.4286 | 0.0816 | 0.0408 |
| 8 | 0.4375 | 0.0820 | 0.0430 |
| 9 | 0.4444 | 0.0823 | 0.0413 |
| 10 | 0.4500 | 0.0825 | 0.0425 |

| PROPPED CANTILEVERS | |
|---|--|
| MOMENT · LOADING  <p>$M_A = -\frac{WL}{8}$ $M_C = \frac{9WL}{128}$</p> <p>R_A [Diagram showing a linear decrease from zero at A to R_B at B] $R_A = \frac{5W}{8}$ $R_B = \frac{3W}{8}$</p> <p>$x/L = m$ x [Diagram showing a parabolic deflection curve starting from zero at A, reaching a maximum deflection d_{max} at C, and returning to zero at B].</p> <p>$d = \frac{WL^3}{48EI} (m - 3m^3 + 2m^4)$ $d_{max.} = \frac{WL^3}{185EI}$</p> |  <p>$M_A = -\frac{Wa}{8}(2-n)^2$ where $a/L = n$ $+ M_{max.} = \frac{Wa}{8} \left[\frac{(8-n)^2(4-n)}{16} + 4-n(4-n) \right]$</p> <p>$R_A$ [Diagram showing a linear decrease from zero at A to R_B at B] $R_A = \frac{W}{8} [8-n^2(4-n)]$ $R_B = \frac{Wn^2}{8} (4-n)$</p> <p>$d_C$ [Diagram showing a parabolic deflection curve starting from zero at A, reaching a maximum deflection d_C at C, and returning to zero at B].</p> <p>$d_C = \frac{Wa^3}{48EI} (8-12n+7n^2-n^3)$</p> |
| SHEAR DEFLECTION  <p>$M_A = -\frac{Wb}{8}(2-n^2)$ $M_C = \frac{Wb}{8}(6n-n^3-4)$</p> <p>$R_A$ [Diagram showing a linear increase from zero at A to R_B at B] $R_A = \frac{Wn}{8} (6-n^2)$ $R_B = \frac{W}{8} (n^3-6n+8)$</p> <p>$x/L = p$ d $x/L = m$ [Diagram showing a parabolic deflection curve starting from zero at A, reaching a maximum deflection d at C, and returning to zero at B].</p> <p>When $x \leq a$, $d = \frac{Wbl^2}{48EI} [(n^2-6)m^3 - (3n^2-6)m^2]$ When $x \geq a$, $d = \frac{WL^4}{48EI} [2p^2 p^3 n (n^3-6n+8) + pn^2 (3n^2-8n+6)]$</p> |  <p>$M_A = -\frac{W}{8L^2} (d^2 - c^2)/(2L^2 - c^2 - d^2)$</p> <p>$R_A$ [Diagram showing a linear increase from zero at A to R_B at B] $R_A = r_A + \frac{MA}{L}$ $R_B = r_B - \frac{MA}{L}$</p> <p>Where r_A and r_B are the simple support reactions for the beam (M_A being considered positive)</p> |

| PROPPED CANTILEVERS | | | | | |
|--|---|--|--|--|--|
| LOADING | MOMENT | | | | |
| | | | | | |
| | | | | | |
|  <p>$M_A = \frac{Wa}{4}$</p> <p>If $m = a/L$, then between B and D.</p> <p>$M_x = \frac{W}{8a} [-2x^2 + x(a(4-3m+2m^2))] + M_{\max}$. when $x = \frac{a}{2}(4-3m+2m^2)$</p> <p>$M_A = -\frac{Wa}{8L}(3L-2a)$</p> <p>$R_A$ (Diagram: A triangular load starting at zero at A and ending at R_A at B)</p> <p>R_B (Diagram: A triangular load starting at R_B at A and ending at zero at B)</p> <p>$R_A = \frac{W}{4L}(2L^2 + 3aL - 4a^2)$</p> <p>$R_B = \frac{W}{4L}(2L^2 - 3aL + 4a^2)$</p> |  <p>M_A (Diagram: A triangular load starting at zero at A and ending at M_A at B)</p> <p>$M_x = -\frac{WL}{60}(20m^2 - 27m + 7)$</p> <p>$M_A = -\frac{7WL}{60} + M_{\max}$. when $x = 0.67L$</p> <p>R_A (Diagram: A triangular load starting at zero at A and ending at R_A at B)</p> <p>R_B (Diagram: A triangular load starting at R_B at A and ending at zero at B)</p> <p>$V_x = \frac{W}{20}(9 - 20m^2)$</p> <p>$R_A = \frac{9W}{20}$ $R_B = \frac{11W}{20}$</p> <p>$d_{\max} = \frac{0.0061WL^3}{EI}$</p> <p>When $x = 0.598L$</p> | | | | |
|  <p>$M_A = -\frac{2WL}{15}$</p> <p>+ $M_{\max} = 0.0596WL$</p> <p>[When $x = 0.447L$]</p> <p>R_A (Diagram: A triangular load starting at zero at A and ending at R_A at B)</p> <p>R_B (Diagram: A triangular load starting at R_B at A and ending at zero at B)</p> <p>$R_A = \frac{4W}{5}$ $R_B = \frac{W}{5}$</p> <p>$d_{\max} = \frac{0.0047WL^3}{EI}$</p> <p>When $x = 0.447L$</p> |  <p>$M_A = -\frac{3WL}{32}$</p> <p>+ $M_{\max} = 0.0454WL$</p> <p>[When $x = 0.283L$]</p> <p>R_A (Diagram: A triangular load starting at zero at A and ending at R_A at B)</p> <p>R_B (Diagram: A triangular load starting at R_B at A and ending at zero at B)</p> <p>$R_A = \frac{19W}{32}$ $R_B = \frac{13W}{32}$</p> <p>$d_{\max} = \frac{0.0037WL^3}{EI}$</p> <p>When $x = 0.404L$</p> | | | | |

| PROPPED CANTILEVERS | |
|---|--|
| LOADING | MOMENT |
|  <p>Between C and A, $M_x = R_B \cdot x - \frac{W}{3a^2}(x-b)^3$</p> $M_A = -\frac{Wa}{60L^2}(3a^2-15aL+20L^2)$ $+ M_{max.} \text{ when } x = b + \frac{a^2}{2L}\sqrt{1-\frac{a}{5L}}$  $R_B = \frac{Wa^2}{20L^3}(5L-a)$ $R_A = W - R_B$ |  <p>$M_A = R_B \cdot x - \frac{Wx^3}{3b^2}$</p> $M_A = -\frac{Wb}{15L^2}(5L^2-3b^2)$  $R_A = \frac{Wb}{5L^3}(5L^2-b^2)$ $R_B = \frac{W}{5L^3}(b^3+5aL^2)$ |
|  <p>When $m = a/L$</p> $M_A = -Wa\left(\frac{m^2}{5}-\frac{3m}{4}+\frac{2}{3}\right)$ $M_C = R_B \cdot b$  $R_B = \frac{Wa^2}{20L}(15L-4a)$ $R_A = W - R_B$ |  <p>$M_x = R_A \cdot x + M_A - \frac{W}{3b^2}(x-a)^3$</p> $M_A = -\frac{Wb}{60L^2}(10L^2-3b^2)$  $R_B = \frac{W}{20b^2L}\left[L^4(11L-15a)+a^4(5L-a)\right]$ $R_A = W - R_B$ |

| PROPPED CANTILEVERS | |
|---|---|
| LOADING | MOMENT |
|  <p>$W = w(L+a)$</p> <p>M_A (moment diagram) shows a parabolic curve starting at zero at A, reaching a maximum at B, and returning to zero at D.</p> <p>$M_B = -\frac{wq^2}{2}$</p> <p>$M_{max.} = \frac{wL^2}{8}(L^2 - 2a^2)$</p> <p>$+ M_{max.} = \frac{wL^2}{128}(36p^4 - 28p^2 + 9)$</p> <p>when $x/L = \frac{5}{8} - \frac{3p^2}{4}$</p> <p>$R_A$ (reaction force) is a triangle from zero at A to R_B at B.</p> <p>$R_A = wL\left(\frac{5}{8} - \frac{3p^2}{4}\right)$</p> <p>$R_B = wL\left(\frac{3p^2}{4} + p + \frac{3}{8}\right)$</p> <p>$d_D = \frac{wL^4}{48EI} \left[(8p^4 + 6p^2 - 1)/(p+q) - 2p^4 \right]$</p> <p>$d_x = \frac{wL^4}{48EI} \left[2n^4 + (6p^2 - 5)n^3 - (6p^2 - 3)n^2 \right]$</p> <p>$d_{max.}$ when $x/L = \sqrt{15 - 18p^2}/\sqrt{324p^4 - 156p^2 + 33}$</p> |  <p>$W = w.a$</p> <p>M_A (moment diagram) shows a linear increase from zero at A to M_B at B, followed by a parabolic decrease back to zero at D.</p> <p>$M_B = -2M_A = -\frac{wa^2}{2}$</p> <p>$p = a/L$</p> <p>$q = b/L$</p> <p>$R_A$ (reaction force) is a rectangle from zero at A to R_B at B.</p> <p>$R_A = -\frac{3wap}{4}$</p> <p>$R_B = wa\left(1 + \frac{3p}{4}\right)$</p> <p>$d_D = \frac{wL^4}{48EI} \left[p^2(8p + 6)q + 6p^3(p + 1) \right]$</p> <p>$-d_{max.} = -\frac{wL^4p^2}{54EI}$</p> |
|  <p>P</p> <p>M_A (moment diagram) shows a linear increase from zero at A to M_B at B, followed by a parabolic decrease back to zero at D.</p> <p>$M_B = -2M_A = -Pa$</p> <p>$p = a/L$</p> <p>$q = b/L$</p> <p>R_A (reaction force) is a rectangle from zero at A to R_B at B.</p> <p>$R_A = -\frac{3Pd}{2}$</p> <p>$R_B = P\left(1 + \frac{3d}{2}\right)$</p> <p>$d_D = \frac{PL^3}{12EI} (4p^2 + 6pq + 3p + 3q)$</p> <p>$-d_{max.} = -\frac{PL^3p}{27EI}$</p> |  <p>M</p> <p>M_A (moment diagram) shows a linear increase from zero at A to M_B at B, followed by a parabolic decrease back to zero at D.</p> <p>$M_B = -2M_A = -M$</p> <p>R_A (reaction force) is a rectangle from zero at A to R_B at B.</p> <p>$R_A = -R_B = -\frac{3M}{2L}$</p> <p>$d_D = \frac{M}{4EI} \left[L(a+b) + a^2(2 + \frac{3b}{a}) \right]$</p> <p>$-d_{max.} = -\frac{ML^2}{27EI}$</p> |

| PROPPED CANTILEVERS | |
|---|--|
| <p>LOADING</p> <p>MOMENT</p> $M_A = -\frac{Wa}{8L}(2L-a)$ <p>SHEAR</p> $R_A = \frac{W}{8L^2}(4L^2+2aL-a^2)$ $R_B = W - R_A$ | <p>MOMENT</p> $M_A = -\frac{Wa}{8L}(4L-3a)$ <p>When $x < a$,</p> $M_x = \frac{W}{24}(9n^2x - 12nx + 12x - 4x^2)$ <p>+ M_{\max}. occurs when $q = \sqrt{\frac{3n^2}{4}} - n + 1$</p> <p>SHEAR</p> $R_A = \frac{W}{8L^2}(4L^2+4aL-3a^2)$ $R_B = W - R_A$ |
| <p>LOADING</p> <p>MOMENT</p> $M_A = -\frac{SWL}{32} + M_{\max}$ $+ M_{\max} = 0.0948WL$ <p>SHEAR</p> $R_A = \frac{2IW}{32} \quad R_B = \frac{11W}{32}$ <p>DEFLECTION</p> $d_{\max} = 0.00727 \frac{WL^3}{EI}$ | <p>LOADING</p> <p>MOMENT</p> $M_A = \frac{WL^2}{32L}(5L^2 + 4aL - 4a^2)$ <p>SHEAR</p> $R_A = \frac{W}{32L^2}(2IL^2 + 4aL - 4a^2)$ $R_B = W - R_A$ |

| PROPPED CANTILEVERS | |
|--|--|
| MOMENT LOADING | MOMENT SHEAR DEFLECTION |
| <p><i>2nd-degree parabola</i></p> <p>$M_A = -\frac{3WL}{20}$</p> <p>$M_x = \frac{WL}{20} (10m^4 - 20m^3 + 7m)$</p> <p>+ $M_{max.} = 0.0888 WL$, when $x = 0.3985L$</p> <p>R_A </p> <p>$R_A = \frac{13W}{20}, R_B = \frac{7W}{20}$</p> <p>$d_{max.} = 0.427L$</p> <p>$d_{max.} = 0.00674 \frac{WL^3}{EI}$</p> | <p><i>complement of parabola</i></p> <p>$M_A = -\frac{3WL}{40}$</p> <p>$M_x = \frac{WL}{40} (-40m^4 + 80m^3 - 60m^2 + 17m)$</p> <p>+ $M_{max.} = 0.0399 WL$, when $x = 0.2343L$</p> <p>R_A </p> <p>$R_A = \frac{23W}{40}, R_B = \frac{17W}{40}$</p> <p>$d_{max.} = 0.392L$</p> <p>$d_{max.} = 0.00278 \frac{WL^3}{EI}$</p> |
| <p><i>MOMENT LOADING</i></p> <p>$M_A = -\frac{3PL}{16}$</p> <p>$M_C = \frac{5PL}{32}$</p> <p>R_A </p> <p>$R_A = 11P/16, R_B = 5P/16$</p> <p>$d_{max.} = 0.447L$</p> <p>$d_C = \frac{7PL^3}{768EI}$</p> <p>$d_{max.} = 0.00932 \frac{PL^3}{EI}$</p> | <p><i>MOMENT LOADING</i></p> <p>$M_A = -\frac{Pb(2-b^2)}{2L^2}$ max. $M_A = -0.193PL$</p> <p>$M_C = \frac{Pb}{2}(2-\frac{3b}{L}+\frac{b^3}{L^3})$ max. $M_C = 0.174PL$</p> <p>R_A </p> <p>$R_B = \frac{Pa^2}{2L^3}(b+2L), R_A = P - R_B$</p> <p>$d_C = \frac{Pa^3b^2}{12EI(L^3)(4L-a)}$</p> |

| PROPPED CANTILEVERS | |
|---------------------|--|
| DEFLECTION | MOMENT LOADING |
| | <p>MOMENT LOADING:</p> <p>At position C ($L/3$ from A): $MC = PL/3$</p> <p>At position D ($2L/3$ from A): $MD = 2PL/9$</p> <p>At position B (L from A): RB</p> <p>SHEAR:</p> <p>R_A (constant) and R_B (constant)</p> <p>$R_A = \frac{4P}{3}$, $R_B = \frac{2P}{3}$</p> <p>Deflection curve: $d_{max.} = 0.0152 \frac{PL^3}{EI}$</p> <p>Deflection at B: $-0.423L$</p> <p>DEFLECTION:</p> <p>$d_{max.} = 0.0152 \frac{PL^3}{EI}$</p> |
| | <p>MOMENT LOADING:</p> <p>At position D ($L/4$ from A): $MD = 17PL/64$</p> <p>At position E ($3L/4$ from A): $ME = 33PL/128$</p> <p>At position B (L from A): RB</p> <p>SHEAR:</p> <p>R_A (constant) and R_B (constant)</p> <p>$R_A = \frac{63P}{32}$, $R_B = \frac{33P}{32}$</p> <p>Deflection curve: $d_{max.} = 0.0209 \frac{PL^3}{EI}$</p> <p>Deflection at B: $-0.426L$</p> <p>DEFLECTION:</p> <p>$d_{max.} = 0.0209 \frac{PL^3}{EI}$</p> |
| | <p>MOMENT LOADING:</p> <p>At position D ($2L/5$ from A): $MD = 21PL/96$</p> <p>At position E ($3L/5$ from A): $ME = 53PL/288$</p> <p>At position B (L from A): RB</p> <p>SHEAR:</p> <p>R_A (constant) and R_B (constant)</p> <p>$R_A = \frac{91P}{48}$, $R_B = \frac{53P}{48}$</p> <p>Deflection curve: $d_{max.} = 0.0169 \frac{PL^3}{EI}$</p> <p>Deflection at B: $-0.423L$</p> <p>DEFLECTION:</p> <p>$d_{max.} = 0.0169 \frac{PL^3}{EI}$</p> |
| | <p>MOMENT LOADING:</p> <p>At position E ($4L/5$ from A): $ME = 9PL/25$</p> <p>At position B (L from A): RB</p> <p>SHEAR:</p> <p>R_A (constant) and R_B (constant)</p> <p>$R_A = \frac{13P}{5}$, $R_B = \frac{7P}{5}$</p> <p>Deflection curve: $d_{max.} = 0.0265 \frac{PL^3}{EI}$</p> <p>Deflection at B: $-0.423L$</p> <p>DEFLECTION:</p> <p>$d_{max.} = 0.0265 \frac{PL^3}{EI}$</p> |

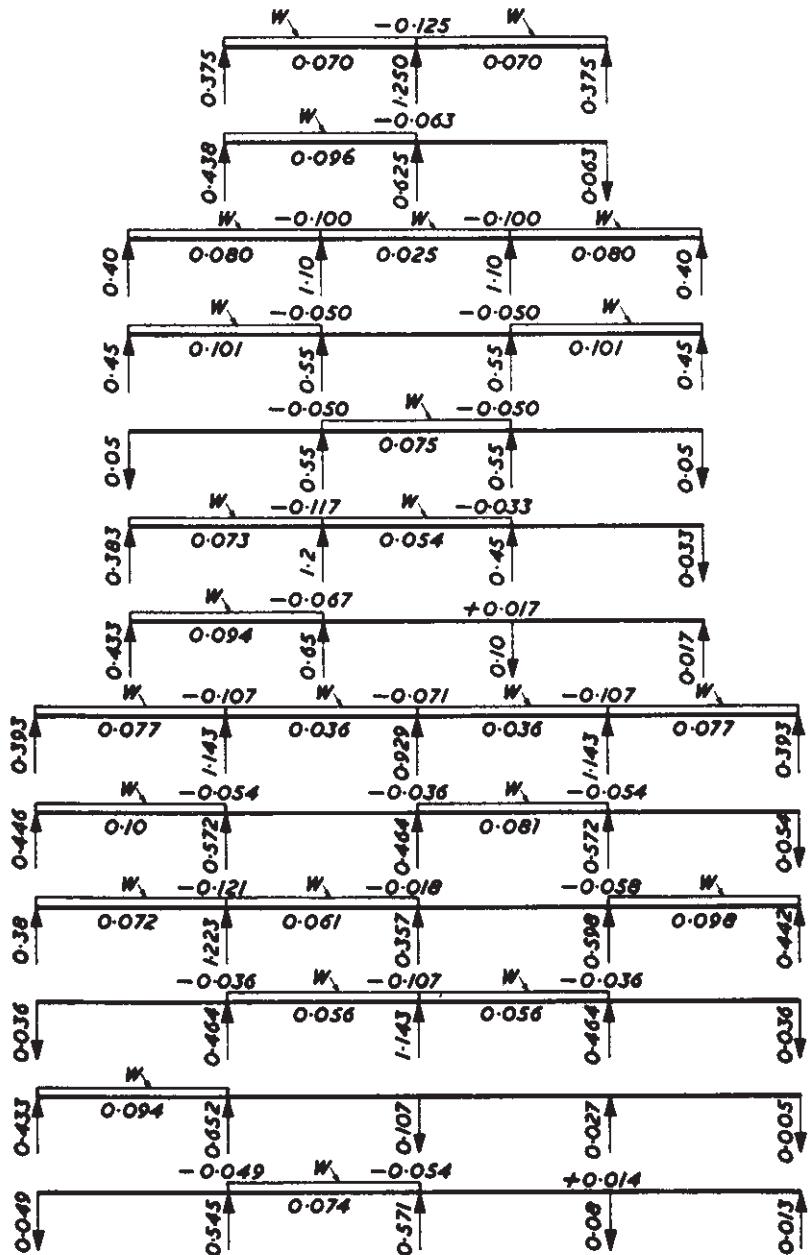
| PROPPED CANTILEVERS | |
|---|--|
| <p>LOADING</p> $MA = -\frac{33PL}{64}$ $ME = \frac{157PL}{512}$ $RA = \frac{161P}{64} \quad RB = \frac{95P}{64}$ $d_{max} = 0.0221 \frac{PL^3}{EI}$ | <p>LOADING</p> $MA = -\frac{PL(n^2-1)}{8n}$ $RA = \frac{P}{8n}(5n^2-4n-1)$ $RB = \frac{P}{8n}(3n^2-4n+1)$ <p>when n is large, $d_{max} \approx \frac{n PL^3}{185 EI}$</p> |
| <p>LOADING</p> $MA = \frac{3AS}{2L}$ $RA = \frac{W}{2} + \frac{MA}{L} \quad RB = \frac{W}{2} - \frac{MA}{L}$ $d_{max} = \frac{\text{Area } SX_x}{EI}$ | <p>LOADING</p> $a/L = n$ $(1) a=L \quad MA = -M/2 \quad M_{CB} = -M$ $(2) a > 0.423L \quad M_{CA} = -M$ $(3) a = 0.423L \quad -M$ $(4) a < 0.423L \quad M_A = \frac{M}{2}(2-6n+3n^2)$ $M_{CA} = \frac{-M}{2}(2-6n+9n^2-3n^3)$ $M_{CB} = \frac{3Mn}{2}(2-3n+n^2)$ $-RA = RB = \frac{M+MA}{L}$ <p>deflection</p> <p>In Case 1, $R = 3M/2L$ Case 3, $R = M/L$</p> |

**EQUAL SPAN CONTINUOUS BEAMS
UNIFORMLY DISTRIBUTED LOADS**

Moment = coefficient $\times W \times L$

Reaction = coefficient $\times W$

where W is the U.D.L. on one span only and L is one span

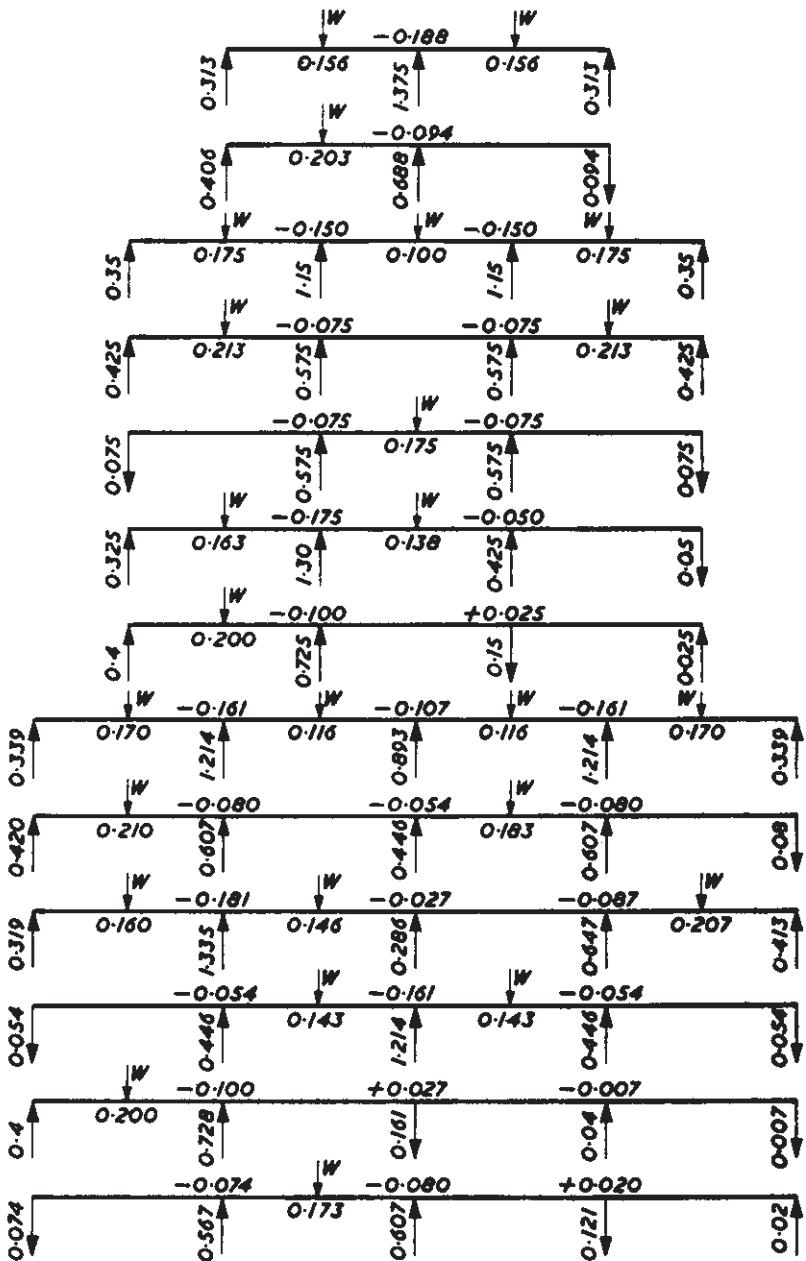


**EQUAL SPAN CONTINUOUS BEAMS
CENTRAL POINT LOADS**

Moment = coefficient $\times W \times L$

Reaction = coefficient $\times W$

where W is the Load on one span only and L is one span

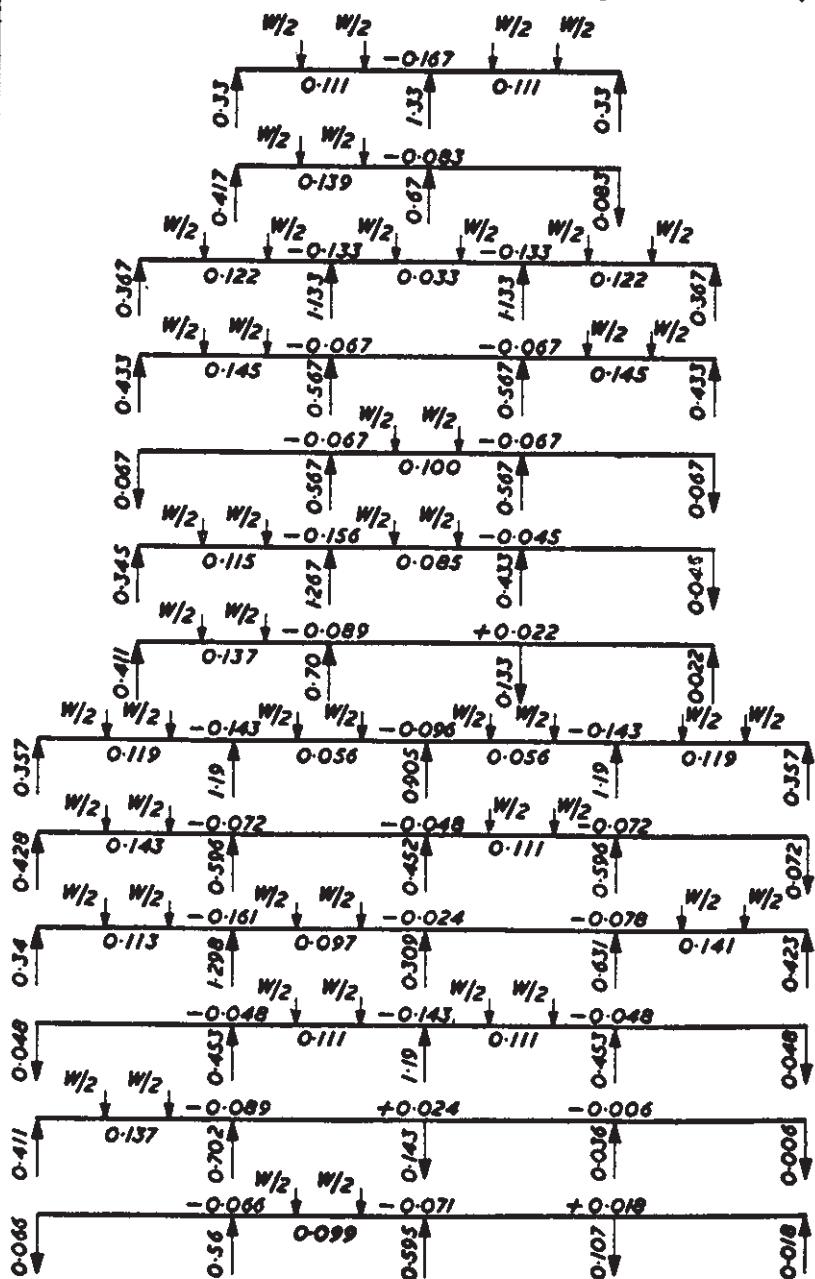


**EQUAL SPAN CONTINUOUS BEAMS
POINT LOADS AT THIRD POINTS OF SPANS**

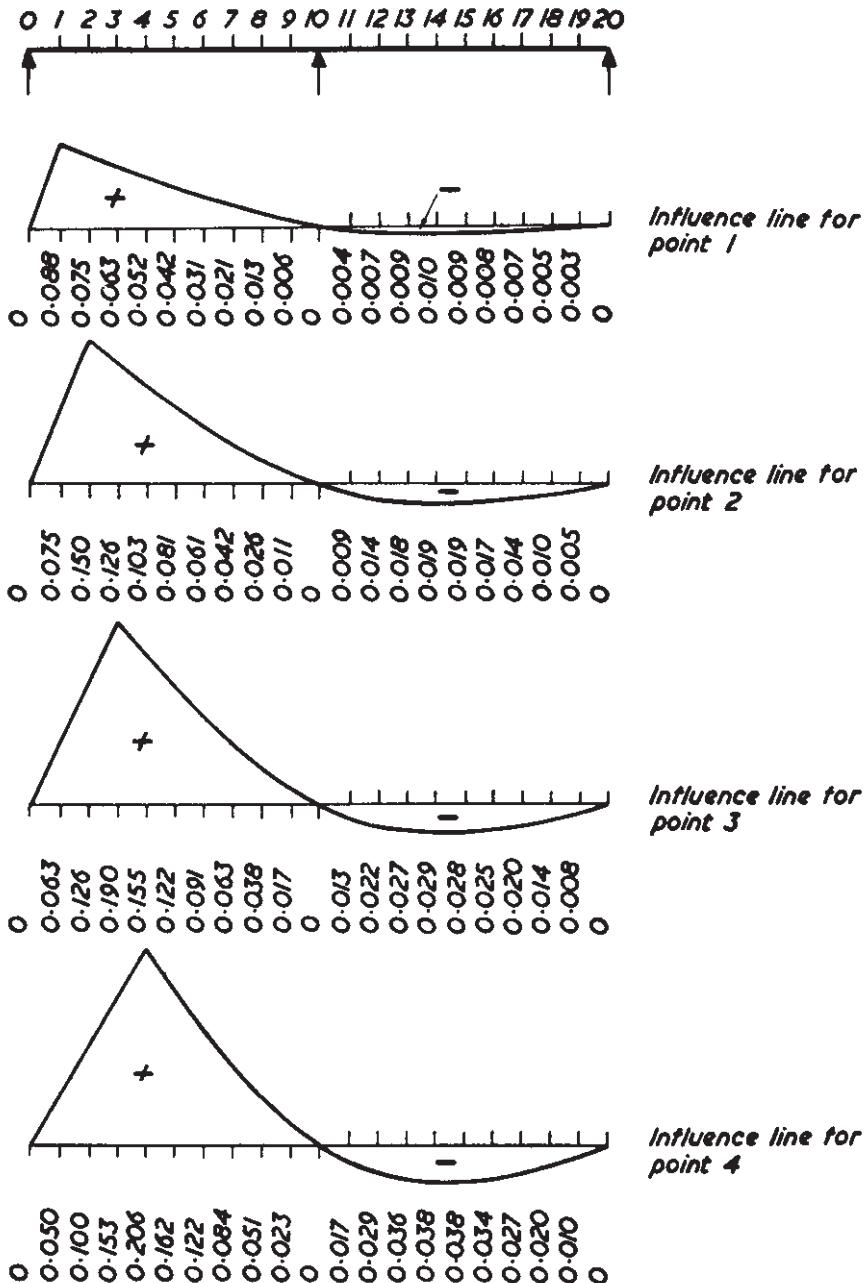
Moment = coefficient $\times W \times L$

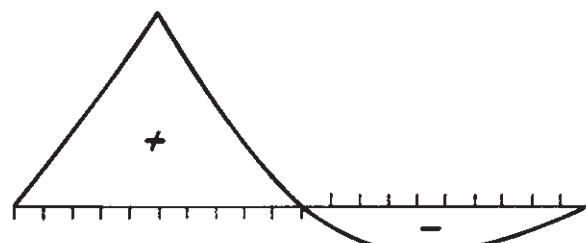
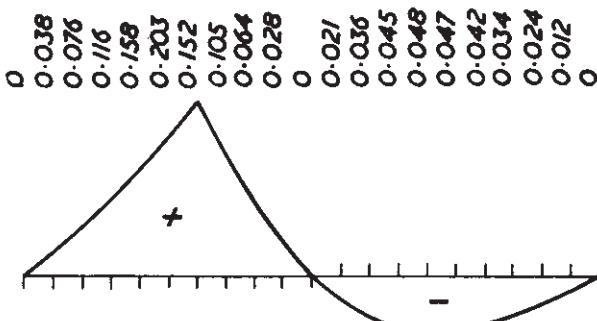
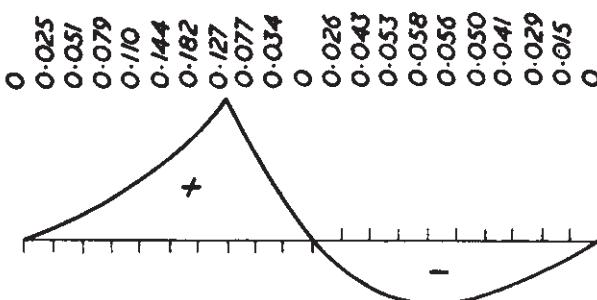
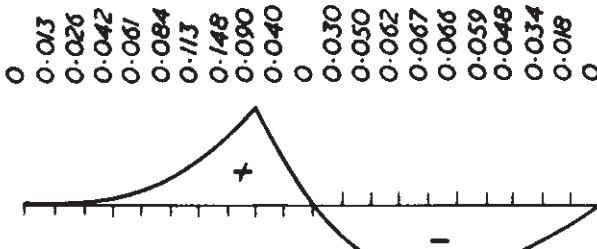
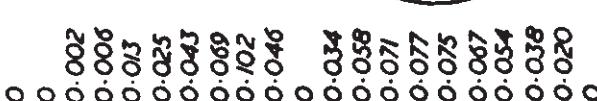
Reaction = coefficient $\times W$

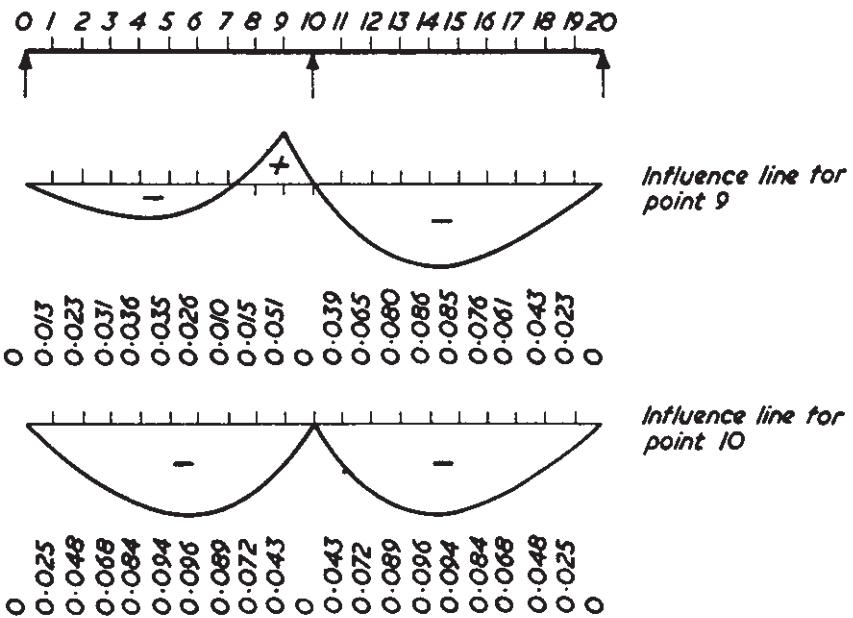
where W is the total load on one span only & L is one span



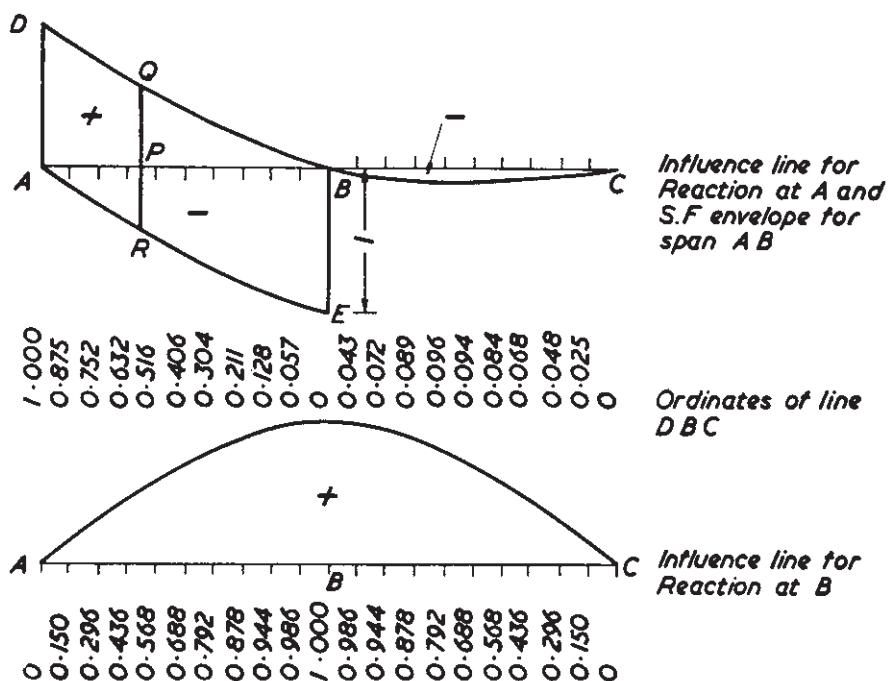
Influence lines for bending moments – two-span beam



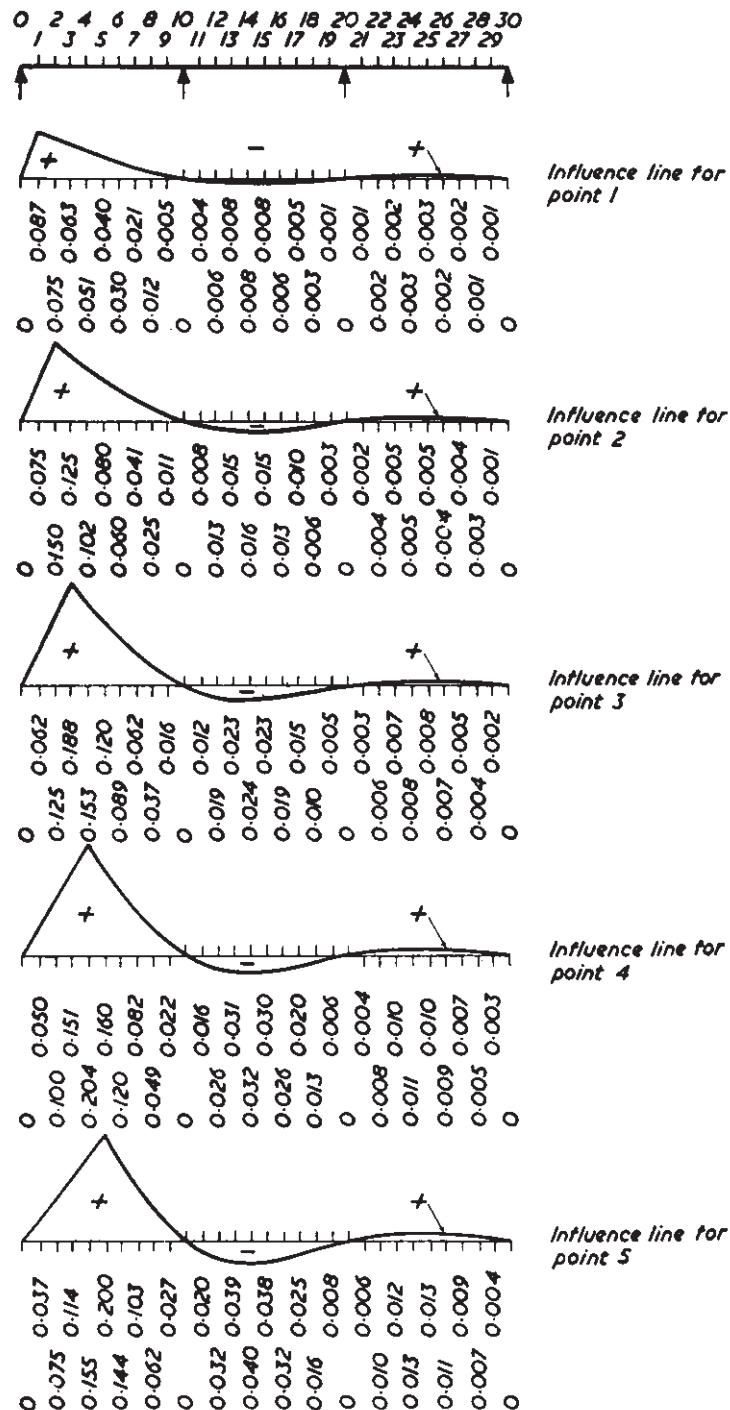
*Influence line for point 5**Influence line for point 6**Influence line for point 7**Influence line for point 8*

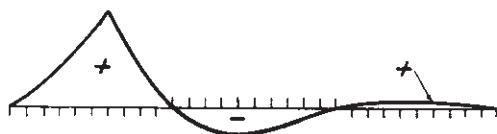
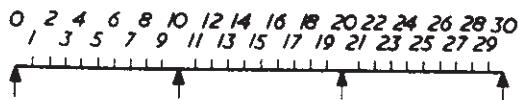


Influence lines for reactions and shear forces – two-span beam

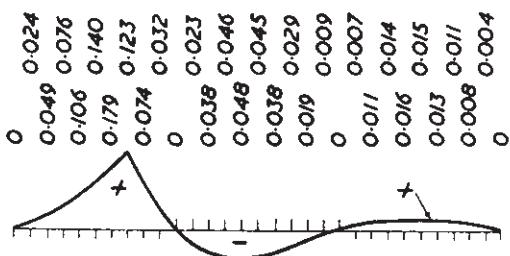


Influence lines for bending moments – three-span beam

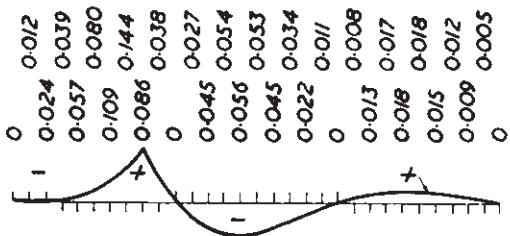




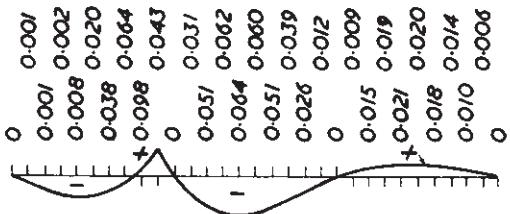
Influence line for point 6



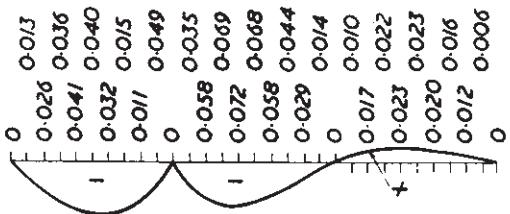
Influence line for point 7



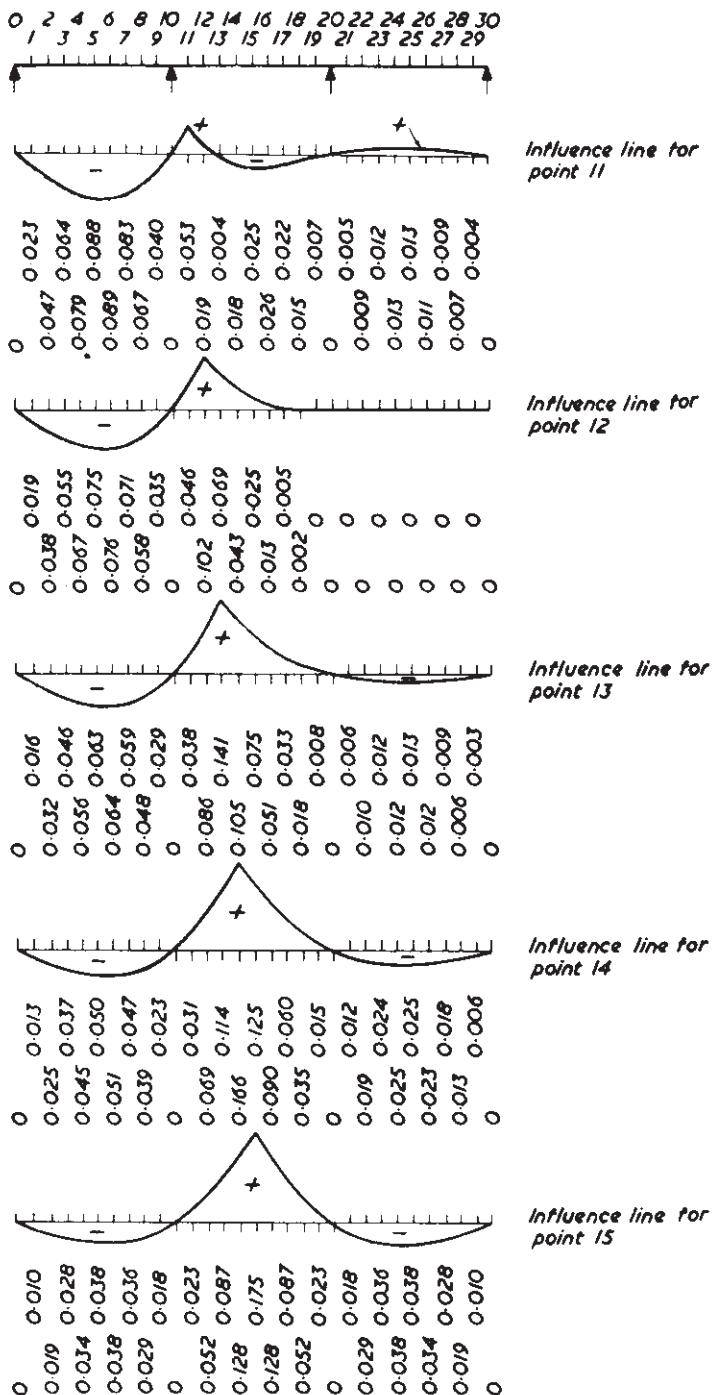
Influence line for point 8



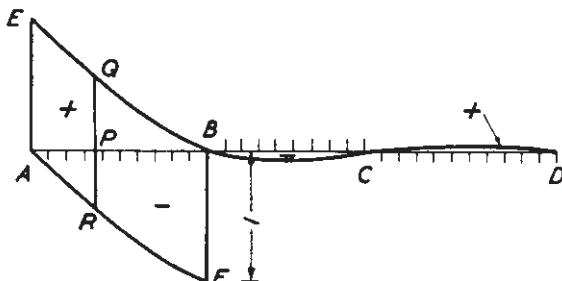
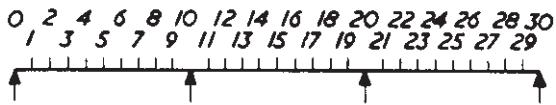
Influence line for point 9



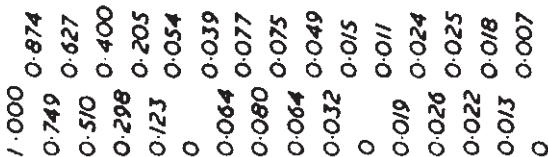
Influence line for point 10



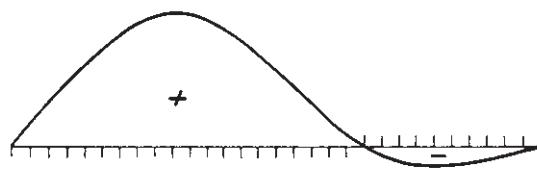
Influence lines for reactions and shear forces – three-span beam



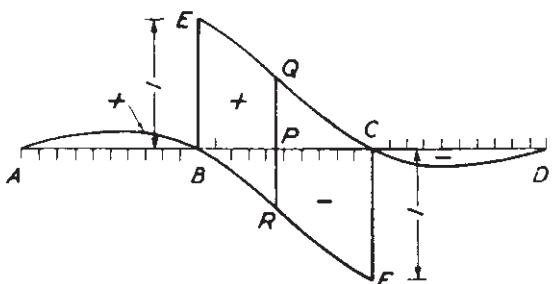
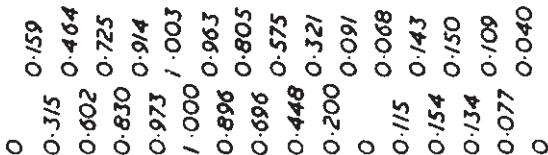
Influence line for reaction at A and S.F. envelope for span AB



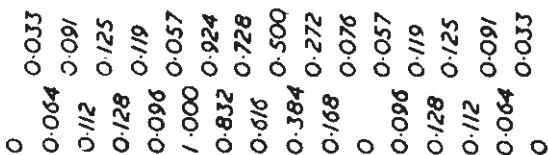
Ordinates of line EBCD



Influence line for reaction at B



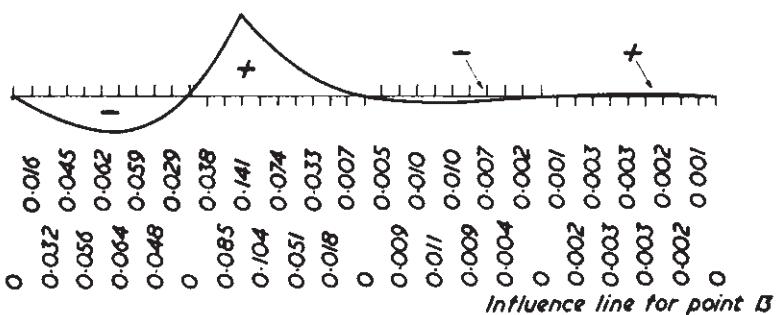
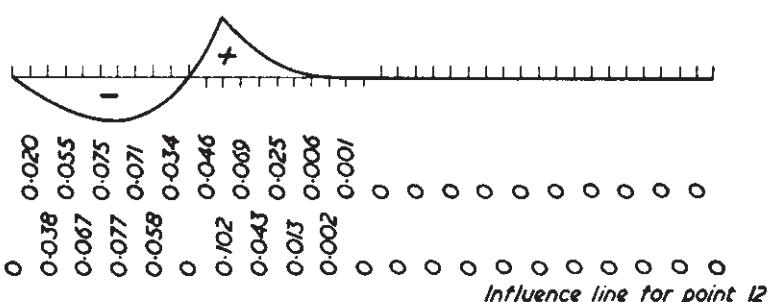
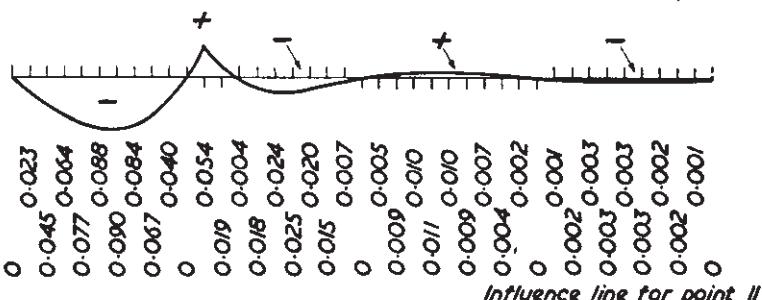
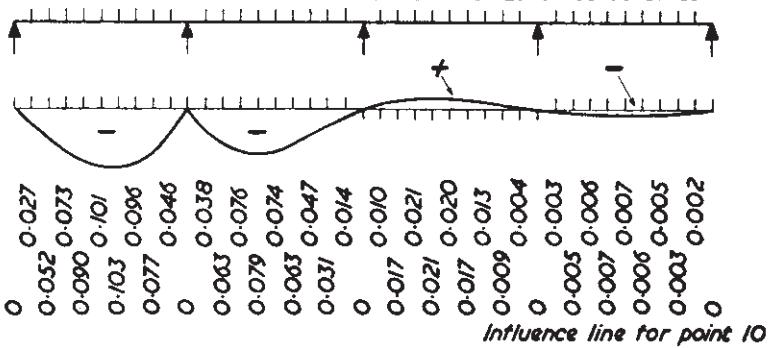
S.F. envelope for span BC



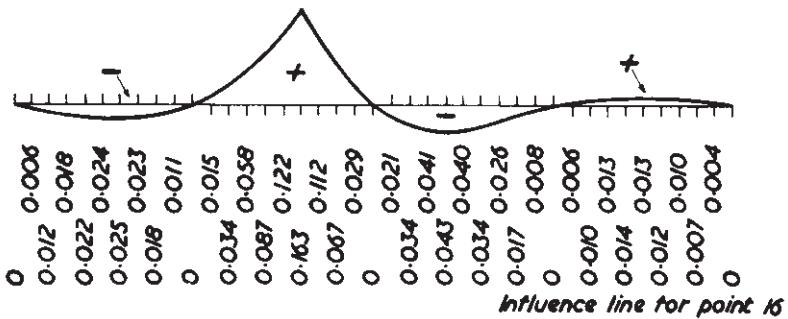
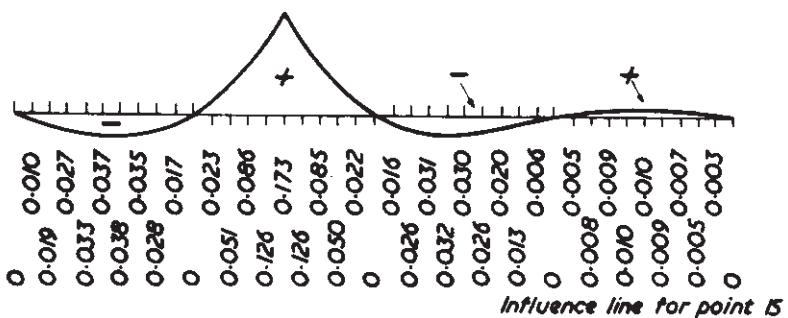
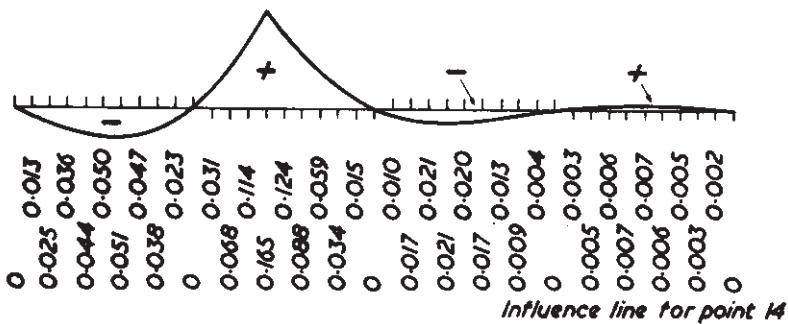
Ordinates of line ABEDC

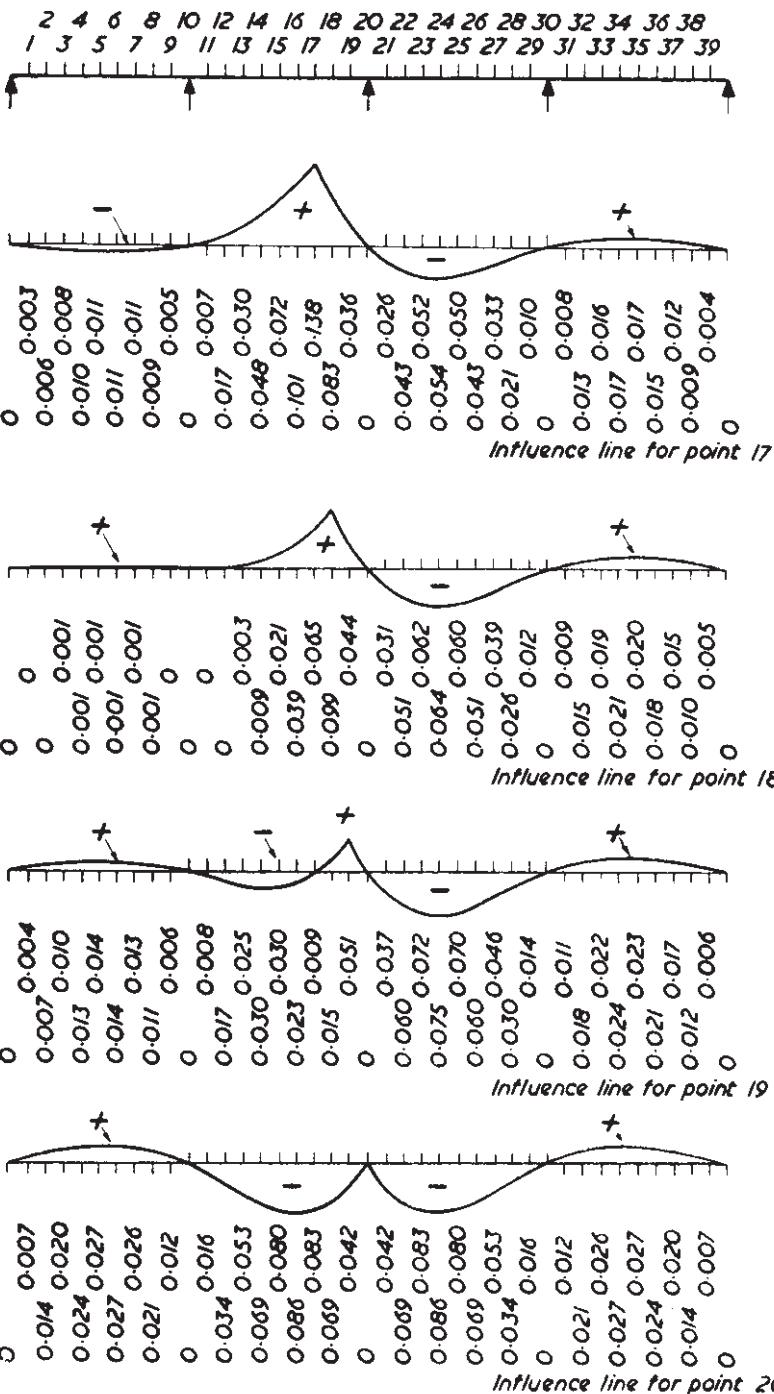
Influence lines for bending moments – four-span beam

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39

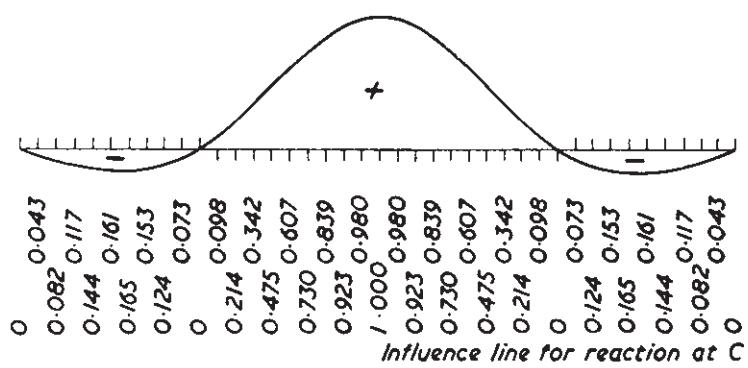
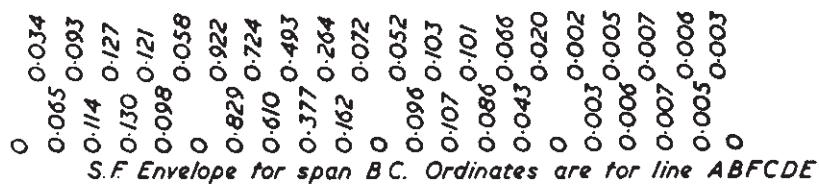
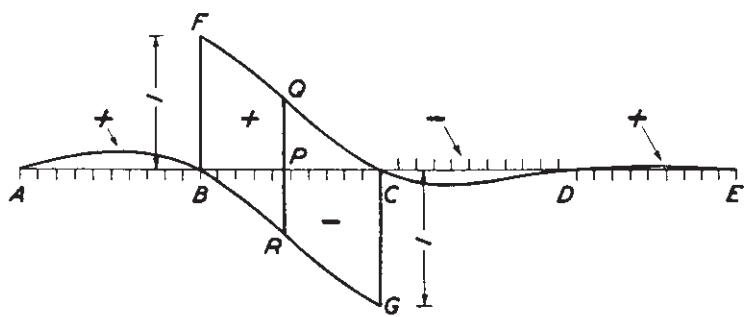
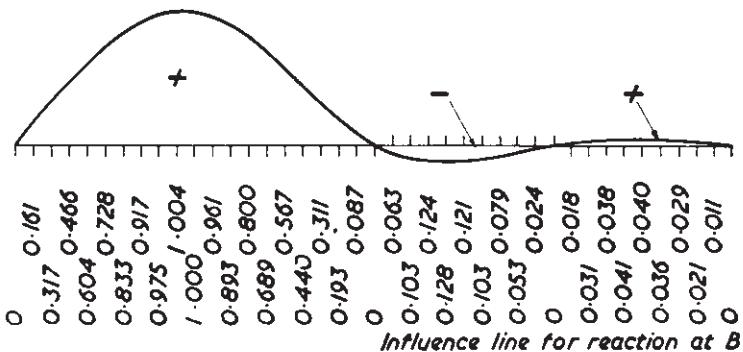
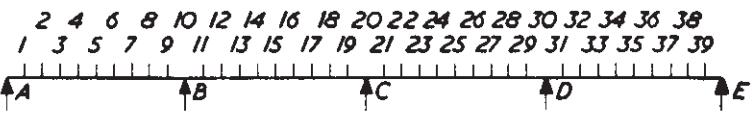


2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39





Influence lines for reactions and shear forces – four-span beam



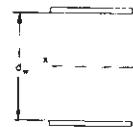
SECOND MOMENTS OF AREA (cm⁴) OF TWO FLANGES

per millimetre of width

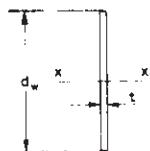
| Distance <i>d_w</i> mm | THICKNESS OF EACH FLANGE IN MILLIMETRES | | | | | | | | | |
|--|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 10 | 12 | 15 | 18 | 20 | 22 | 25 | 28 | 30 | 32 |
| 1000 | 510.1 | 614.5 | 772.7 | 932.8 | 1041 | 1149 | 1314 | 1480 | 1592 | 1705 |
| 1100 | 616.1 | 742.0 | 932.5 | 1125 | 1255 | 1385 | 1582 | 1782 | 1916 | 2051 |
| 1200 | 732.1 | 881.4 | 1107 | 1335 | 1489 | 1643 | 1876 | 2112 | 2270 | 2429 |
| 1300 | 858.1 | 1033 | 1297 | 1564 | 1743 | 1923 | 2195 | 2469 | 2654 | 2839 |
| 1400 | 994.1 | 1196 | 1502 | 1810 | 2017 | 2224 | 2539 | 2855 | 3068 | 3282 |
| 1500 | 1140 | 1372 | 1721 | 2074 | 2311 | 2548 | 2907 | 3269 | 3512 | 3756 |
| 1600 | 1296 | 1559 | 1956 | 2356 | 2625 | 2894 | 3301 | 3711 | 3986 | 4262 |
| 1700 | 1462 | 1759 | 2206 | 2656 | 2959 | 3262 | 3720 | 4181 | 4490 | 4800 |
| 1800 | 1638 | 1970 | 2471 | 2975 | 3313 | 3652 | 4164 | 4679 | 5024 | 5371 |
| 1900 | 1824 | 2193 | 2750 | 3311 | 3687 | 4064 | 4632 | 5204 | 5588 | 5973 |
| 2000 | 2020 | 2429 | 3045 | 3665 | 4081 | 4498 | 5126 | 5758 | 6182 | 6607 |
| 2100 | 2226 | 2676 | 3355 | 4037 | 4495 | 4953 | 5645 | 6340 | 6806 | 7273 |
| 2200 | 2442 | 2936 | 3680 | 4428 | 4929 | 5431 | 6189 | 6950 | 7460 | 7971 |
| 2300 | 2668 | 3207 | 4019 | 4836 | 5383 | 5931 | 6757 | 7588 | 8144 | 8702 |
| 2400 | 2904 | 3491 | 4374 | 5262 | 5857 | 6453 | 7351 | 8254 | 8858 | 9464 |
| 2500 | 3150 | 3786 | 4744 | 5706 | 6351 | 6997 | 7970 | 8947 | 9602 | 10258 |
| 2600 | 3406 | 4094 | 5129 | 6169 | 6865 | 7563 | 8614 | 9669 | 10376 | 11084 |
| 2700 | 3672 | 4413 | 5528 | 6649 | 7399 | 8150 | 9282 | 10419 | 11180 | 11943 |
| 2800 | 3948 | 4744 | 5943 | 7147 | 7953 | 8760 | 9976 | 11197 | 12014 | 12833 |
| 2900 | 4234 | 5088 | 6373 | 7663 | 8527 | 9392 | 10695 | 12003 | 12878 | 13755 |
| 3000 | 4530 | 5443 | 6818 | 8198 | 9121 | 10046 | 11439 | 12837 | 13772 | 14709 |
| 3100 | 4836 | 5811 | 7277 | 8750 | 9735 | 10722 | 12207 | 13699 | 14696 | 15696 |
| 3200 | 5152 | 6190 | 7752 | 9320 | 10369 | 11420 | 13001 | 14588 | 15650 | 16714 |
| 3300 | 5478 | 6582 | 8242 | 9908 | 11023 | 12139 | 13820 | 15506 | 16634 | 17764 |
| 3400 | 5814 | 6985 | 8747 | 10515 | 11697 | 12881 | 14664 | 16452 | 17648 | 18846 |
| 3500 | 6160 | 7401 | 9266 | 11139 | 12391 | 13645 | 15532 | 17426 | 18692 | 19961 |
| 3600 | 6516 | 7828 | 9801 | 11781 | 13105 | 14431 | 16426 | 18428 | 19766 | 21107 |
| 3700 | 6882 | 8267 | 10351 | 12441 | 13839 | 15239 | 17345 | 19458 | 20870 | 22285 |
| 3800 | 7258 | 8719 | 10916 | 13120 | 14593 | 16069 | 18289 | 20515 | 22004 | 23495 |
| 3900 | 7644 | 9182 | 11495 | 13816 | 15367 | 16920 | 19257 | 21601 | 23168 | 24738 |
| 4000 | 8040 | 9658 | 12090 | 14530 | 16161 | 17794 | 20251 | 22715 | 24362 | 26012 |
| 4100 | 8446 | 10145 | 12700 | 15262 | 16975 | 18690 | 21270 | 23857 | 25586 | 27318 |
| 4200 | 8862 | 10645 | 13325 | 16012 | 17809 | 19608 | 22314 | 25027 | 26840 | 28656 |
| 4300 | 9288 | 11156 | 13964 | 16781 | 18663 | 20548 | 23382 | 26225 | 28124 | 30027 |
| 4400 | 9724 | 11679 | 14619 | 17567 | 19537 | 21510 | 24476 | 27450 | 29438 | 31429 |
| 4500 | 10170 | 12215 | 15289 | 18371 | 20431 | 22494 | 25595 | 28704 | 30782 | 32863 |
| 4600 | 10626 | 12762 | 15974 | 19193 | 21345 | 23499 | 26739 | 29986 | 32156 | 34329 |
| 4700 | 11092 | 13322 | 16673 | 20034 | 22279 | 24527 | 27907 | 31296 | 33560 | 35827 |
| 4800 | 11568 | 13893 | 17386 | 20892 | 23233 | 25577 | 29101 | 32634 | 34994 | 37358 |
| 4900 | 12054 | 14477 | 18118 | 21768 | 24207 | 26649 | 30320 | 34000 | 36458 | 38920 |
| 5000 | 12550 | 15072 | 18863 | 22662 | 25201 | 27743 | 31564 | 35393 | 37952 | 40514 |

SECOND MOMENTS OF AREA (cm⁴) OF TWO FLANGES

per millimetre of width



| THICKNESS OF EACH FLANGE IN MILLIMETRES | | | | | | | | | | Distance <i>d</i> , mm |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|------------------------------|
| 35 | 38 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | |
| 1875 | 2048 | 2164 | 2459 | 2758 | 3064 | 3374 | 3691 | 4013 | 4341 | 1000 |
| 2255 | 2461 | 2600 | 2951 | 3308 | 3671 | 4040 | 4416 | 4797 | 5184 | 1100 |
| 2670 | 2913 | 3076 | 3489 | 3908 | 4334 | 4766 | 5205 | 5651 | 6103 | 1200 |
| 3120 | 3402 | 3592 | 4072 | 4558 | 5052 | 5552 | 6060 | 6575 | 7097 | 1300 |
| 3604 | 3930 | 4148 | 4700 | 5258 | 5825 | 6398 | 6980 | 7569 | 8166 | 1400 |
| 4124 | 4495 | 4744 | 5372 | 6008 | 6652 | 7304 | 7965 | 8633 | 9309 | 1500 |
| 4679 | 5099 | 5380 | 6090 | 6808 | 7535 | 8270 | 9014 | 9767 | 10528 | 1600 |
| 5269 | 5740 | 6056 | 6853 | 7658 | 8473 | 9296 | 10129 | 10971 | 11822 | 1700 |
| 5893 | 6420 | 6772 | 7661 | 8558 | 9466 | 10382 | 11309 | 12245 | 13191 | 1800 |
| 6553 | 7137 | 7528 | 8513 | 9508 | 10513 | 11528 | 12554 | 13589 | 14634 | 1900 |
| 7248 | 7892 | 8324 | 9411 | 10508 | 11616 | 12734 | 13863 | 15003 | 16153 | 2000 |
| 7978 | 8686 | 9160 | 10354 | 11558 | 12774 | 14009 | 15238 | 16487 | 17747 | 2100 |
| 8742 | 9517 | 10036 | 11342 | 12658 | 13987 | 15326 | 16678 | 18041 | 19416 | 2200 |
| 9542 | 10387 | 10952 | 12374 | 13808 | 15254 | 16712 | 18183 | 19665 | 21159 | 2300 |
| 10377 | 11294 | 11908 | 13452 | 15008 | 16577 | 18158 | 19752 | 21359 | 22978 | 2400 |
| 11247 | 12240 | 12904 | 14575 | 16258 | 17955 | 19664 | 21387 | 23123 | 24872 | 2500 |
| 12151 | 13223 | 13940 | 15743 | 17558 | 19388 | 21230 | 23087 | 24957 | 26841 | 2600 |
| 13091 | 14245 | 15016 | 16955 | 18908 | 20875 | 22856 | 24852 | 26861 | 28884 | 2700 |
| 14066 | 15304 | 16132 | 18213 | 20308 | 22418 | 24542 | 26681 | 28835 | 31003 | 2800 |
| 15076 | 16401 | 17288 | 19516 | 21758 | 24016 | 26288 | 28576 | 30879 | 33197 | 2900 |
| 16120 | 17537 | 18484 | 20864 | 23258 | 25669 | 28094 | 30536 | 32993 | 35466 | 3000 |
| 17200 | 18710 | 19720 | 22256 | 24808 | 27376 | 29960 | 32561 | 35177 | 37809 | 3100 |
| 18315 | 19922 | 20996 | 23694 | 26408 | 29139 | 31886 | 34650 | 37431 | 40228 | 3200 |
| 19465 | 21171 | 22312 | 25177 | 28058 | 30957 | 33872 | 36805 | 39755 | 42722 | 3300 |
| 20649 | 22459 | 23668 | 26705 | 29758 | 32830 | 35918 | 39025 | 42149 | 45291 | 3400 |
| 21869 | 23784 | 25064 | 28277 | 31508 | 34757 | 38024 | 41310 | 44613 | 47934 | 3500 |
| 23124 | 25147 | 26500 | 29895 | 33308 | 36740 | 40190 | 43659 | 47147 | 50653 | 3600 |
| 24414 | 26549 | 27976 | 31558 | 35158 | 38778 | 42416 | 46074 | 49751 | 53447 | 3700 |
| 25738 | 27988 | 29492 | 33266 | 37058 | 40871 | 44702 | 48554 | 52425 | 56316 | 3800 |
| 27098 | 29466 | 31048 | 35018 | 39008 | 43018 | 47048 | 51099 | 55169 | 59259 | 3900 |
| 28493 | 30981 | 32644 | 36816 | 41008 | 45221 | 49454 | 53708 | 57983 | 62278 | 4000 |
| 29923 | 32535 | 34280 | 38659 | 43058 | 47479 | 51920 | 56383 | 60867 | 65372 | 4100 |
| 31387 | 34126 | 35956 | 40547 | 45158 | 49792 | 54446 | 59123 | 63821 | 68541 | 4200 |
| 32887 | 35756 | 37672 | 42479 | 47308 | 52159 | 57032 | 61928 | 66845 | 71784 | 4300 |
| 34422 | 37423 | 39428 | 44457 | 49508 | 54582 | 59678 | 64797 | 69939 | 75103 | 4400 |
| 35992 | 39128 | 41224 | 46480 | 51758 | 57060 | 62384 | 67732 | 73103 | 78497 | 4500 |
| 37596 | 40872 | 43060 | 48548 | 54058 | 59593 | 65150 | 70732 | 76337 | 81966 | 4600 |
| 39236 | 42653 | 44936 | 50660 | 56408 | 62180 | 67976 | 73797 | 79641 | 85509 | 4700 |
| 40911 | 44473 | 46852 | 52818 | 58808 | 64823 | 70862 | 76926 | 83015 | 89128 | 4800 |
| 42621 | 46330 | 48808 | 55021 | 61258 | 67521 | 73808 | 80121 | 86459 | 92822 | 4900 |
| 44365 | 48226 | 50804 | 57269 | 63758 | 70274 | 76814 | 83381 | 89973 | 96591 | 5000 |



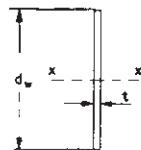
SECOND MOMENTS OF AREA (cm⁴) OF RECTANGULAR PLATES

about axis x-x

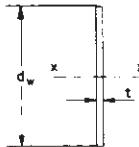
| Depth d_w mm | THICKNESS t MILLIMETRES | | | | | |
|----------------------|---------------------------|-------|-------|-------|-------|-------|
| | 3 | 4 | 5 | 6 | 8 | 10 |
| 25 | .391 | .521 | .651 | .781 | 1.04 | 1.30 |
| 50 | 3.13 | 4.17 | 5.21 | 6.25 | 8.33 | 10.4 |
| 75 | 10.5 | 14.1 | 17.6 | 21.1 | 28.1 | 35.2 |
| 100 | 25.0 | 33.3 | 41.7 | 50.0 | 66.7 | 83.3 |
| 125 | 48.8 | 65.1 | 81.4 | 97.7 | 130 | 163 |
| 150 | 84.4 | 113 | 141 | 169 | 225 | 281 |
| 175 | 134 | 179 | 223 | 268 | 357 | 447 |
| 200 | 200 | 267 | 333 | 400 | 533 | 667 |
| 225 | 285 | 380 | 475 | 570 | 759 | 949 |
| 250 | 391 | 521 | 651 | 781 | 1042 | 1302 |
| 275 | 520 | 693 | 867 | 1040 | 1386 | 1733 |
| 300 | 675 | 900 | 1125 | 1350 | 1800 | 2250 |
| 325 | 858 | 1144 | 1430 | 1716 | 2289 | 2861 |
| 350 | 1072 | 1429 | 1786 | 2144 | 2858 | 3573 |
| 375 | 1318 | 1758 | 2197 | 2637 | 3516 | 4395 |
| 400 | 1600 | 2133 | 2667 | 3200 | 4267 | 5333 |
| 425 | 1919 | 2559 | 3199 | 3838 | 5118 | 6397 |
| 450 | 2278 | 3038 | 3797 | 4556 | 6075 | 7594 |
| 475 | 2679 | 3572 | 4465 | 5359 | 7145 | 8931 |
| 500 | 3125 | 4167 | 5208 | 6250 | 8333 | 10417 |
| 525 | 3618 | 4823 | 6029 | 7235 | 9647 | 12059 |
| 550 | 4159 | 5546 | 6932 | 8319 | 11092 | 13865 |
| 575 | 4753 | 6337 | 7921 | 9505 | 12674 | 15842 |
| 600 | 5400 | 7200 | 9000 | 10800 | 14400 | 18000 |
| 625 | 6104 | 8138 | 10173 | 12207 | 16276 | 20345 |
| 650 | 6866 | 9154 | 11443 | 13731 | 18308 | 22885 |
| 675 | 7689 | 10252 | 12814 | 15377 | 20503 | 25629 |
| 700 | 8575 | 11433 | 14292 | 17150 | 22867 | 28583 |
| 725 | 9527 | 12703 | 15878 | 19054 | 25405 | 31757 |
| 750 | 10547 | 14063 | 17578 | 21094 | 29125 | 35156 |
| 775 | 11637 | 15516 | 19395 | 23274 | 31032 | 38790 |
| 800 | 12800 | 17067 | 21333 | 25600 | 34133 | 42667 |
| 825 | 14038 | 18717 | 23396 | 28076 | 37434 | 46793 |
| 850 | 15353 | 20471 | 25589 | 30706 | 40942 | 51177 |
| 875 | 16748 | 22331 | 27913 | 33496 | 44661 | 55827 |
| 900 | 18225 | 24300 | 30375 | 36450 | 48600 | 60750 |

SECOND MOMENTS OF AREA (cm⁴) OF RECTANGULAR PLATES

about axis x-x



| THICKNESS t MILLIMETRES | | | | | | Depth d mm |
|-------------------------|-------|--------|--------|--------|--------|------------------|
| 12 | 15 | 18 | 20 | 22 | 25 | |
| 1.56 | 1.95 | 2.34 | 2.60 | 2.86 | 3.26 | 25 |
| 12.5 | 15.6 | 18.8 | 20.8 | 22.9 | 26.0 | 50 |
| 42.2 | 52.7 | 63.3 | 70.3 | 77.3 | 87.9 | 75 |
| 100 | 125 | 150 | 167 | 183 | 208 | 100 |
| 195 | 244 | 293 | 326 | 358 | 407 | 125 |
| 338 | 422 | 506 | 563 | 619 | 703 | 150 |
| 536 | 670 | 804 | 893 | 983 | 1117 | 175 |
| 800 | 1000 | 1200 | 1333 | 1467 | 1667 | 200 |
| 1139 | 1424 | 1709 | 1898 | 2088 | 2373 | 225 |
| 1563 | 1953 | 2344 | 2604 | 2865 | 3255 | 250 |
| 2080 | 2600 | 3120 | 3466 | 3813 | 4333 | 275 |
| 2700 | 3375 | 4050 | 4500 | 4950 | 5625 | 300 |
| 3433 | 4291 | 5149 | 5721 | 6293 | 7152 | 325 |
| 4288 | 5359 | 6431 | 7146 | 7860 | 8932 | 350 |
| 5273 | 6592 | 7910 | 8789 | 9668 | 10986 | 375 |
| 6400 | 8000 | 9600 | 10667 | 11733 | 13333 | 400 |
| 7677 | 9596 | 11515 | 12794 | 14074 | 15993 | 425 |
| 9113 | 11391 | 13669 | 15188 | 16706 | 18984 | 450 |
| 10717 | 13396 | 16076 | 17862 | 19648 | 22327 | 475 |
| 12500 | 15625 | 18750 | 20833 | 22917 | 26042 | 500 |
| 14470 | 18088 | 21705 | 24117 | 26529 | 30146 | 525 |
| 16638 | 20797 | 24956 | 27729 | 30502 | 34661 | 550 |
| 19011 | 23764 | 28516 | 31685 | 34853 | 39606 | 575 |
| 21600 | 27000 | 32400 | 36000 | 39600 | 45000 | 600 |
| 24414 | 30518 | 36621 | 40690 | 44759 | 50863 | 625 |
| 27463 | 34328 | 41194 | 45771 | 50348 | 57214 | 650 |
| 30755 | 38443 | 46132 | 51258 | 56384 | 64072 | 675 |
| 34300 | 42875 | 51450 | 57167 | 62883 | 71458 | 700 |
| 38108 | 47635 | 57162 | 63513 | 69864 | 79391 | 725 |
| 42188 | 52734 | 63281 | 70313 | 77344 | 87891 | 750 |
| 46548 | 58186 | 69823 | 77581 | 85339 | 96976 | 775 |
| 51200 | 64000 | 76800 | 85333 | 93867 | 106667 | 800 |
| 56152 | 70189 | 84227 | 93586 | 102945 | 116982 | 825 |
| 61413 | 76766 | 92119 | 102354 | 112590 | 127943 | 850 |
| 66992 | 83740 | 100488 | 111654 | 122819 | 139567 | 875 |
| 72900 | 91125 | 109350 | 121500 | 133650 | 151875 | 900 |



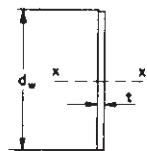
SECOND MOMENTS OF AREA (cm⁴) OF RECTANGULAR PLATES

about axis x-x

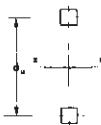
| Depth d_h mm | THICKNESS t MILLIMETRES | | | | | |
|----------------------|---------------------------|---------|---------|---------|---------|----------|
| | 3 | 4 | 5 | 6 | 8 | 10 |
| 1000 | 25000 | 33333 | 41667 | 50000 | 66667 | 83333 |
| 1100 | 33275 | 44367 | 55458 | 66550 | 88733 | 110917 |
| 1200 | 43200 | 57600 | 72000 | 86400 | 115200 | 144000 |
| 1300 | 54925 | 73233 | 91542 | 109850 | 146467 | 183083 |
| 1400 | 68600 | 91467 | 114333 | 137200 | 182933 | 228667 |
| 1500 | 84375 | 112500 | 140625 | 168750 | 225000 | 281250 |
| 1600 | 102400 | 136533 | 170667 | 204800 | 273067 | 341333 |
| 1700 | 122825 | 163767 | 204708 | 245650 | 327533 | 409417 |
| 1800 | 145800 | 194400 | 243000 | 291600 | 388800 | 486000 |
| 1900 | 171475 | 228633 | 285792 | 342950 | 457267 | 571583 |
| 2000 | 200000 | 266667 | 333333 | 400000 | 533333 | 666667 |
| 2100 | 231525 | 308700 | 385875 | 463050 | 617400 | 771750 |
| 2200 | 266200 | 354933 | 443667 | 532400 | 709867 | 887333 |
| 2300 | 304175 | 405567 | 506958 | 608350 | 811133 | 1013917 |
| 2400 | 345600 | 460800 | 576000 | 691200 | 921600 | 1152000 |
| 2500 | 390625 | 520833 | 651042 | 781250 | 1041667 | 1302083 |
| 2600 | 439400 | 585867 | 732333 | 878800 | 1171733 | 1464667 |
| 2700 | 492075 | 656100 | 820125 | 984150 | 1312200 | 1640250 |
| 2800 | 548800 | 731733 | 914667 | 1097600 | 1463467 | 1829333 |
| 2900 | 609725 | 812967 | 1016208 | 1219450 | 1625933 | 2032417 |
| 3000 | 675000 | 900000 | 1125000 | 1350000 | 1800000 | 2250000 |
| 3100 | 744775 | 993033 | 1241292 | 1489550 | 1986067 | 2482583 |
| 3200 | 819200 | 1092267 | 1365333 | 1638400 | 2184533 | 2730667 |
| 3300 | 898425 | 1197900 | 1497375 | 1796850 | 2395800 | 2994750 |
| 3400 | 982600 | 1310133 | 1637667 | 1965200 | 2620267 | 3275333 |
| 3500 | 1071875 | 1429167 | 1786458 | 2143750 | 2858333 | 3572917 |
| 3600 | 1166400 | 1555200 | 1944000 | 2332800 | 3110400 | 3888000 |
| 3700 | 1266325 | 1688433 | 2110542 | 2532650 | 3376867 | 4221083 |
| 3800 | 1371800 | 1829067 | 2286333 | 2743600 | 3658133 | 4572667 |
| 3900 | 1482975 | 1977300 | 2471625 | 2965950 | 3954600 | 4943250 |
| 4000 | 1600000 | 2133333 | 2666667 | 3200000 | 4266667 | 5333333 |
| 4100 | 1723025 | 2297367 | 2871708 | 3446050 | 4594733 | 5743417 |
| 4200 | 1852200 | 2469600 | 3087000 | 3704400 | 4939200 | 6174000 |
| 4300 | 1987675 | 2650233 | 3312792 | 3975350 | 5300467 | 6625583 |
| 4400 | 2129600 | 2839467 | 3549333 | 4259200 | 5678933 | 7098667 |
| 4500 | 2278125 | 3037500 | 3796875 | 4556250 | 6075000 | 7593750 |
| 4600 | 2433400 | 3244533 | 4055667 | 4866800 | 6489067 | 8111333 |
| 4700 | 2595575 | 3460767 | 4325958 | 5191150 | 6921533 | 8651917 |
| 4800 | 2764800 | 3686400 | 4608000 | 5529600 | 7372800 | 9216000 |
| 4900 | 2941225 | 3921633 | 4902042 | 5882450 | 7843267 | 9804083 |
| 5000 | 3125000 | 4166667 | 5208333 | 6250000 | 8333333 | 10416667 |

SECOND MOMENTS OF AREA (cm⁴) OF RECTANGULAR PLATES

about axis x-x



| THICKNESS t MILLIMETRES | | | | | | Depth d mm |
|-------------------------|----------|----------|----------|----------|----------|--------------------|
| 12 | 15 | 18 | 20 | 22 | 25 | |
| 100000 | 125000 | 150000 | 1666667 | 183333 | 208333 | 1000 |
| 133100 | 166375 | 199650 | 221833 | 244017 | 277292 | 1100 |
| 172800 | 216000 | 259200 | 288000 | 316800 | 360000 | 1200 |
| 219700 | 274625 | 329550 | 366167 | 402783 | 457708 | 1300 |
| 274400 | 343000 | 411600 | 457333 | 503067 | 571667 | 1400 |
| 337500 | 421875 | 506250 | 562500 | 618750 | 703125 | 1500 |
| 409600 | 512000 | 614400 | 682667 | 750933 | 853333 | 1600 |
| 491300 | 614125 | 736950 | 818833 | 900717 | 1023542 | 1700 |
| 583200 | 729000 | 874800 | 972000 | 1069200 | 1215000 | 1800 |
| 685900 | 857375 | 1028850 | 1143167 | 1257483 | 1428958 | 1900 |
| 800000 | 1000000 | 1200000 | 1333333 | 1466667 | 1666667 | 2000 |
| 926100 | 1157625 | 1389150 | 1543500 | 1697850 | 1929375 | 2100 |
| 1064800 | 1331000 | 1597200 | 1774667 | 1952133 | 2218333 | 2200 |
| 1216700 | 1520875 | 1825050 | 2027833 | 2230617 | 2534792 | 2300 |
| 1382400 | 1728000 | 2073600 | 2304000 | 2534400 | 2880000 | 2400 |
| 1562500 | 1953125 | 2343750 | 2604167 | 2864583 | 3255208 | 2500 |
| 1757600 | 2197000 | 2636400 | 2929333 | 3222267 | 3661667 | 2600 |
| 1968300 | 2460375 | 2952450 | 3280500 | 3608550 | 4100625 | 2700 |
| 2195200 | 2744000 | 3292800 | 3658667 | 4024533 | 4573333 | 2800 |
| 2438900 | 3048625 | 3658350 | 4064833 | 4471317 | 5081042 | 2900 |
| 2700000 | 3375000 | 4050000 | 4500000 | 4950000 | 5625000 | 3000 |
| 2979100 | 3723875 | 4468650 | 4965167 | 5461683 | 6206458 | 3100 |
| 3276800 | 4096000 | 4915200 | 5461333 | 6007467 | 6826667 | 3200 |
| 3593700 | 4492125 | 5390550 | 5989500 | 6588450 | 7486875 | 3300 |
| 3930400 | 4913000 | 5895600 | 6550667 | 7205733 | 8188333 | 3400 |
| 4287500 | 5359375 | 6431250 | 7145833 | 7860417 | 8932292 | 3500 |
| 4665600 | 5832000 | 6998400 | 7760000 | 8553600 | 9720000 | 3600 |
| 5065300 | 6331625 | 7597950 | 8442167 | 9286383 | 10552708 | 3700 |
| 5487200 | 6859000 | 8230800 | 9145333 | 10059867 | 11431667 | 3800 |
| 5931900 | 7414875 | 8897850 | 9886500 | 10875150 | 12358125 | 3900 |
| 6400000 | 8000000 | 9600000 | 10666667 | 11733333 | 13333333 | 4000 |
| 6892100 | 8615125 | 10338150 | 11486833 | 12635517 | 14358542 | 4100 |
| 7408800 | 9261000 | 11113200 | 12348000 | 13582800 | 15435000 | 4200 |
| 7950700 | 9938375 | 11926050 | 13251167 | 14576283 | 16563958 | 4300 |
| 8518400 | 10648000 | 12777600 | 14197333 | 15617067 | 17746667 | 4400 |
| 9112500 | 11390625 | 13668750 | 15187500 | 16706250 | 18984375 | 4500 |
| 9733600 | 12167000 | 14600400 | 16222667 | 17844933 | 20278333 | 4600 |
| 10382300 | 12977875 | 15573450 | 17303833 | 19034217 | 21629792 | 4700 |
| 11059200 | 13824000 | 16588800 | 18432000 | 20275200 | 23040000 | 4800 |
| 11764900 | 14706125 | 17647350 | 19608167 | 21568983 | 24510208 | 4900 |
| 12500000 | 15625000 | 18750000 | 20833333 | 22916667 | 26041667 | 5000 |



SECOND MOMENT OF A PAIR OF UNIT AREAS

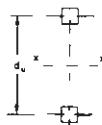
about axis x-x

| Distance d_x mm | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 500 | 1250 | 1275 | 1301 | 1326 | 1352 | 1378 | 1405 | 1431 | 1458 | 1485 |
| 550 | 1513 | 1540 | 1568 | 1596 | 1625 | 1653 | 1682 | 1711 | 1741 | 1770 |
| 600 | 1800 | 1830 | 1861 | 1891 | 1922 | 1953 | 1985 | 2016 | 2048 | 2080 |
| 650 | 2113 | 2145 | 2178 | 2211 | 2245 | 2278 | 2312 | 2346 | 2381 | 2415 |
| 700 | 2450 | 2485 | 2521 | 2556 | 2592 | 2628 | 2665 | 2701 | 2738 | 2775 |
| 750 | 2813 | 2850 | 2888 | 2926 | 2965 | 3003 | 3042 | 3081 | 3121 | 3160 |
| 800 | 3200 | 3240 | 3281 | 3321 | 3362 | 3403 | 3445 | 3486 | 3528 | 3570 |
| 850 | 3613 | 3655 | 3698 | 3741 | 3785 | 3828 | 3872 | 3916 | 3961 | 4005 |
| 900 | 4050 | 4095 | 4141 | 4186 | 4232 | 4278 | 4325 | 4371 | 4418 | 4465 |
| 950 | 4513 | 4560 | 4608 | 4656 | 4705 | 4753 | 4802 | 4851 | 4901 | 4950 |
| 1000 | 5000 | 5050 | 5101 | 5151 | 5202 | 5253 | 5305 | 5356 | 5408 | 5460 |
| 1050 | 5513 | 5565 | 5618 | 5671 | 5725 | 5778 | 5832 | 5886 | 5941 | 5995 |
| 1100 | 6050 | 6105 | 6161 | 6216 | 6272 | 6328 | 6385 | 6441 | 6498 | 6555 |
| 1150 | 6613 | 6670 | 6728 | 6786 | 6845 | 6903 | 6962 | 7021 | 7081 | 7140 |
| 1200 | 7200 | 7260 | 7321 | 7381 | 7442 | 7503 | 7565 | 7626 | 7688 | 7750 |
| 1250 | 7813 | 7875 | 7938 | 8001 | 8065 | 8128 | 8192 | 8256 | 8321 | 8385 |
| 1300 | 8450 | 8515 | 8581 | 8646 | 8712 | 8778 | 8845 | 8911 | 8978 | 9045 |
| 1350 | 9113 | 9180 | 9248 | 9316 | 9385 | 9453 | 9522 | 9591 | 9661 | 9730 |
| 1400 | 9800 | 9870 | 9941 | 10011 | 10082 | 10153 | 10225 | 10296 | 10368 | 10440 |
| 1450 | 10513 | 10585 | 10658 | 10731 | 10805 | 10878 | 10952 | 11026 | 11101 | 11175 |
| 1500 | 11250 | 11325 | 11401 | 11476 | 11552 | 11628 | 11705 | 11781 | 11858 | 11935 |
| 1550 | 12013 | 12090 | 12168 | 12246 | 12325 | 12403 | 12482 | 12561 | 12641 | 12720 |
| 1600 | 12800 | 12880 | 12961 | 13041 | 13122 | 13203 | 13285 | 13366 | 13448 | 13530 |
| 1650 | 13613 | 13695 | 13778 | 13861 | 13945 | 14028 | 14112 | 14196 | 14281 | 14365 |
| 1700 | 14450 | 14535 | 14621 | 14706 | 14792 | 14878 | 14965 | 15051 | 15138 | 15225 |
| 1750 | 15313 | 15400 | 15488 | 15576 | 15665 | 15753 | 15842 | 15931 | 16021 | 16110 |
| 1800 | 16200 | 16290 | 16381 | 16471 | 16562 | 16653 | 16745 | 16836 | 16928 | 17020 |
| 1850 | 17113 | 17205 | 17298 | 17391 | 17485 | 17578 | 17672 | 17766 | 17861 | 17955 |
| 1900 | 18050 | 18145 | 18241 | 18336 | 18432 | 18528 | 18625 | 18721 | 18818 | 18915 |
| 1950 | 19013 | 19110 | 19208 | 19306 | 19405 | 19503 | 19602 | 19701 | 19801 | 19900 |
| 2000 | 20000 | 20100 | 20201 | 20301 | 20402 | 20503 | 20605 | 20706 | 20808 | 20910 |
| 2050 | 21013 | 21115 | 21218 | 21321 | 21425 | 21528 | 21632 | 21736 | 21841 | 21945 |
| 2100 | 22050 | 22155 | 22261 | 22366 | 22472 | 22578 | 22685 | 22791 | 22898 | 23005 |
| 2150 | 23113 | 23220 | 23328 | 23436 | 23545 | 23653 | 23762 | 23871 | 23981 | 24090 |
| 2200 | 24200 | 24310 | 24421 | 24531 | 24642 | 24753 | 24865 | 24976 | 25088 | 25200 |
| 2250 | 25313 | 25425 | 25538 | 25651 | 25765 | 25878 | 25992 | 26106 | 26221 | 26335 |
| 2300 | 26450 | 26565 | 26681 | 26796 | 26912 | 27028 | 27145 | 27261 | 27378 | 27495 |
| 2350 | 27613 | 27730 | 27848 | 27966 | 28085 | 28203 | 28322 | 28441 | 28561 | 28680 |
| 2400 | 28800 | 28920 | 29041 | 29161 | 29282 | 29403 | 29525 | 29646 | 29768 | 29890 |
| 2450 | 30013 | 30135 | 30258 | 30381 | 30505 | 30628 | 30752 | 30876 | 31001 | 31125 |
| 2500 | 31250 | 31375 | 31501 | 31626 | 31752 | 31878 | 32005 | 32131 | 32258 | 32385 |
| 2550 | 32513 | 32640 | 32768 | 32896 | 33025 | 33153 | 33282 | 33411 | 33541 | 33670 |
| 2600 | 33800 | 33930 | 34061 | 34191 | 34322 | 34453 | 34585 | 34716 | 34848 | 34980 |
| 2650 | 35113 | 35245 | 35378 | 35511 | 35645 | 35778 | 35912 | 36046 | 36181 | 36315 |
| 2700 | 36450 | 36585 | 36721 | 36856 | 36992 | 37128 | 37265 | 37401 | 37538 | 37675 |

Second moments are tabulated in cm^4 and are for unit areas of 1 cm^2 each.

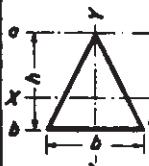
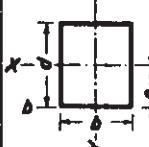
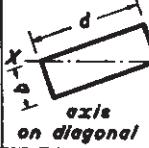
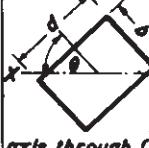
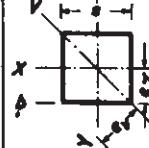
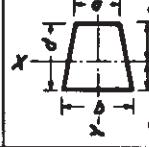
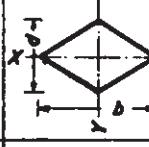
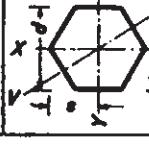
SECOND MOMENT OF A PAIR OF UNIT AREAS

about axis x—x



| Distance d , mm | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|-------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 2750 | 37813 | 37950 | 38088 | 38226 | 38365 | 38503 | 38642 | 38781 | 38921 | 39060 |
| 2800 | 39200 | 39340 | 39481 | 39621 | 39762 | 39903 | 40045 | 40186 | 40328 | 40470 |
| 2850 | 40613 | 40755 | 40898 | 41041 | 41185 | 41328 | 41472 | 41616 | 41761 | 41905 |
| 2900 | 42050 | 42195 | 42341 | 42486 | 42632 | 42778 | 42925 | 43071 | 43218 | 43365 |
| 2950 | 43513 | 43660 | 43808 | 43956 | 44105 | 44253 | 44402 | 44551 | 44701 | 44850 |
| 3000 | 45000 | 45150 | 45301 | 45451 | 45602 | 45753 | 45905 | 46056 | 46208 | 46360 |
| 3050 | 46513 | 46665 | 46818 | 46971 | 47125 | 47278 | 47432 | 47586 | 47741 | 47895 |
| 3100 | 48050 | 48205 | 48361 | 48516 | 48672 | 48828 | 48985 | 49141 | 49298 | 49455 |
| 3150 | 49613 | 49770 | 49928 | 50086 | 50245 | 50403 | 50562 | 50721 | 50881 | 51040 |
| 3200 | 51200 | 51360 | 51521 | 51681 | 51842 | 52003 | 52165 | 52326 | 52488 | 52650 |
| 3250 | 52813 | 52975 | 53138 | 53301 | 53465 | 53628 | 53792 | 53956 | 54121 | 54285 |
| 3300 | 54450 | 54615 | 54781 | 54946 | 55112 | 55278 | 55445 | 55611 | 55778 | 55945 |
| 3350 | 56113 | 56280 | 56448 | 56616 | 56785 | 56953 | 57122 | 57291 | 57461 | 57630 |
| 3400 | 57800 | 57970 | 58141 | 58311 | 58482 | 58653 | 58825 | 58996 | 59168 | 59340 |
| 3450 | 59513 | 59685 | 59858 | 60031 | 60205 | 60378 | 60552 | 60726 | 60901 | 61075 |
| 3500 | 61250 | 61425 | 61601 | 61776 | 61952 | 62128 | 62305 | 62481 | 62658 | 62835 |
| 3550 | 63013 | 63190 | 63368 | 63546 | 63725 | 63903 | 64082 | 64261 | 64441 | 64620 |
| 3600 | 64800 | 64980 | 65161 | 65341 | 65522 | 65703 | 65885 | 66066 | 66248 | 66430 |
| 3650 | 66613 | 66795 | 66978 | 67161 | 67345 | 67528 | 67712 | 67896 | 68081 | 68265 |
| 3700 | 68450 | 68635 | 68821 | 69006 | 69192 | 69378 | 69565 | 69751 | 69938 | 70125 |
| 3750 | 70313 | 70500 | 70688 | 70876 | 71065 | 71253 | 71442 | 71631 | 71821 | 72010 |
| 3800 | 72200 | 72390 | 72581 | 72771 | 72962 | 73153 | 73345 | 73536 | 73728 | 73920 |
| 3850 | 74113 | 74305 | 74498 | 74691 | 74885 | 75078 | 75272 | 75466 | 75661 | 75855 |
| 3900 | 76050 | 76245 | 76441 | 76636 | 76832 | 77028 | 77225 | 77421 | 77618 | 77815 |
| 3950 | 78013 | 78210 | 78408 | 78606 | 78805 | 79003 | 79202 | 79401 | 79601 | 79800 |
| 4000 | 80000 | 80200 | 80401 | 80601 | 80802 | 81003 | 81205 | 81406 | 81608 | 81810 |
| 4050 | 82013 | 82215 | 82418 | 82621 | 82825 | 83028 | 83232 | 83436 | 83641 | 83845 |
| 4100 | 84050 | 84255 | 84461 | 84666 | 84872 | 85078 | 85285 | 85491 | 85698 | 85905 |
| 4150 | 86113 | 86320 | 86528 | 86736 | 86945 | 87153 | 87362 | 87571 | 87781 | 87990 |
| 4200 | 88200 | 88410 | 88621 | 88831 | 89042 | 89253 | 89465 | 89676 | 89888 | 90100 |
| 4250 | 90313 | 90525 | 90738 | 90951 | 91165 | 91378 | 91592 | 91806 | 92021 | 92235 |
| 4300 | 92450 | 92665 | 92881 | 93096 | 93312 | 93528 | 93745 | 93961 | 94178 | 94395 |
| 4350 | 94613 | 94830 | 95048 | 95266 | 95485 | 95703 | 95922 | 96141 | 96361 | 96580 |
| 4400 | 96800 | 97020 | 97241 | 97461 | 97682 | 97903 | 98125 | 98346 | 98568 | 98790 |
| 4450 | 99013 | 99235 | 99458 | 99681 | 99905 | 100128 | 100352 | 100576 | 100801 | 101025 |
| 4500 | 101250 | 101475 | 101701 | 101926 | 102152 | 102378 | 102605 | 102831 | 103058 | 103285 |
| 4550 | 103513 | 103740 | 103968 | 104196 | 104425 | 104653 | 104882 | 105111 | 105341 | 105570 |
| 4600 | 105800 | 106030 | 106261 | 106491 | 106722 | 106953 | 107185 | 107416 | 107648 | 107880 |
| 4650 | 108113 | 108345 | 108578 | 108811 | 109045 | 109278 | 109512 | 109746 | 109981 | 110215 |
| 4700 | 110450 | 110685 | 110921 | 111156 | 111392 | 111628 | 111865 | 112101 | 112338 | 112575 |
| 4750 | 112813 | 113050 | 113288 | 113526 | 113765 | 114003 | 114242 | 114481 | 114721 | 114960 |
| 4800 | 115200 | 115440 | 115681 | 115921 | 116162 | 116403 | 116645 | 116886 | 117128 | 117370 |
| 4850 | 117613 | 117855 | 118098 | 118341 | 118585 | 118828 | 119072 | 119316 | 119561 | 119805 |
| 4900 | 120050 | 120295 | 120541 | 120786 | 121032 | 121278 | 121525 | 121771 | 122018 | 122265 |
| 4950 | 122513 | 122760 | 123008 | 123256 | 123505 | 123753 | 124002 | 124251 | 124501 | 124750 |

Second moments are tabulated in cm⁴ and are for unit areas of 1 cm² each.

| GEOMETRICAL PROPERTIES OF PLANE SECTIONS | | | | | |
|--|---|------------------------|--|---|--|
| | Section | Area | Position of Centroid | Moments of Inertia | Section Moduli |
| TRIANGLE |  | $A = \frac{bh}{2}$ | $c_x = \frac{h}{3}$ | $I_{XX} = bh^3/36$ $I_{YY} = hb^3/48$ $I_{zz} = bh^3/4$ $I_{bb} = bh^3/12$ | Z_{XX} $\text{base } = bh^2/12$ $\text{apex } = bh^2/24$ $Z_{YY} = bh^2/24$ |
| RECTANGLE |  | $A = bd$ | $c_x = \frac{h}{2}$ | $I_{XX} = bd^3/12$ $I_{YY} = db^3/12$ $I_{bb} = bd^3/3$ | $Z_{XX} = bd^2/6$ $Z_{YY} = db^2/6$ |
| RECTANGLE |  | $A = bd$ | $c_x = \frac{bd}{\sqrt{b^2+d^2}}$ | $I_{XX} = \frac{b^3d^3}{6(b^2+d^2)}$ | $Z_{XX} = \frac{b^2d^2}{6\sqrt{b^2+d^2}}$ |
| RECTANGLE |  | $A = bd$ | $c_x = \frac{bd(\sin\theta+d\cos\theta)}{2}$ | $I_{XX} = \frac{bd(b^2\sin^2\theta+d^2\cos^2\theta)}{12}$ | $Z_{XX} = \frac{bd(b^2\sin^2\theta+d^2\cos^2\theta)}{6(\sin\theta+d\cos\theta)}$ |
| SQUARE |  | $A = a^2$ | $c_x = \frac{a}{2}$ $c_y = \frac{a}{2}$ | $I_{XX} = I_{YY} = a^4/12$ $I_{bb} = a^4/3$ $I_{VV} = a^4/12$ | $Z_{XX} = Z_{YY} = \frac{a^3}{6}$ |
| TRAPEZIUM |  | $A = \frac{d(a+b)}{2}$ | $c_x = \frac{d(2a+b)}{3(a+b)}$ | $I_{XX} = \frac{d^3(a^2+4ab+b^2)}{36(a+b)}$ $I_{YY} = \frac{d(a^2+a^2b+ab^2+b^3)}{48}$ | $Z_{XX} = \frac{I_{XX}}{d-c_x}$ (two values) $Z_{YY} = \frac{2I_{YY}}{d}$ |
| DIAMOND |  | $A = \frac{bd}{2}$ | $c_x = \frac{d}{2}$ | $I_{XX} = \frac{bd^3}{48}$ $I_{YY} = \frac{db^3}{48}$ | $Z_{XX} = \frac{bd^2}{24}$ $Z_{YY} = \frac{db^2}{24}$ |
| HEXAGON |  | $A = 0.866a^2$ | $c_x = 0.866a = d/2$ | $I_{XX} = I_{YY} = I_{VV} = 0.0601a^4$ | $Z_{XX} = 0.1203a^3$ $Z_{YY} = Z_{VV} = 0.1042a^3$ |

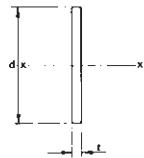
| GEOMETRICAL PROPERTIES OF PLANE SECTIONS | | | | | |
|--|---------|--|--|---|---|
| | Section | Area | Position of Centroid | Moments of Inertia | Section Moduli |
| OCTAGON | | $A = 0.8284d^2$ $= 0.4142d$ | $e_x = \frac{d}{2}$ $e_y = 0.541/d$ | $I_{XX} = I_{YY} = I_{VV} = 0.0547d^4$ | $Z_{XX} = Z_{YY} = 0.1095d^3$ $Z_{VV} = 0.1011d^3$ |
| POLYGON | | $A = \frac{n r^2 \cot \theta}{4}$ $A = n r^2 \tan \theta$ $A = \frac{n R^2 \sin 2\theta}{2}$ | $e = r \text{ or } R$ depending on the axis and value of n | $I_1 = I_2 = \frac{A(6R^2 - s^2)}{24}$ $= \frac{A(12r^2 + s^2)}{48}$ | $Z = \frac{I}{e}$ |
| CIRCLE | | $A = \pi r^2$ $A = 0.7854d^2$ | $e = r = \frac{d}{2}$ | $I = \frac{\pi d^4}{64}$ $I = 0.7854r^4$ | $Z = \frac{\pi d^3}{32}$ $Z = 0.7854r^3$ |
| SEMI-CIRCLE | | $A = 1.5708r^2$ | $e_x = 0.424r$ | $I_{XX} = 0.1098r^4$ $I_{YY} = 0.3927r^4$ | Z_{XX} base = $0.2587r^3$ crown = $0.1907r^3$ $Z_{YY} = 0.3927r^3$ |
| SEGMENT | | $A = \frac{r^2(\pi\theta/180 - \sin\theta)}{2}$ | $e_0 = \frac{c^3}{12A}$ $e_x = e_0 - r \cos \frac{\theta}{2}$ | $I_{XX} = \frac{r^4(\pi\theta/180 - \sin 2\theta)}{16} - \frac{2c^4(1 - \cos \theta)/3}{\pi\theta/180 - \sin \theta}$ $I_{YY} = \frac{r^4}{48}(\frac{\pi\theta}{30} - 8\sin\theta + \sin 2\theta)$ | Z_{XX} base = I_{XX}/e_x crown = $\frac{I_{XX}}{b - e_x}$ $Z_{YY} = \frac{2I_{YY}}{c}$ |
| SECTOR | | $A = \frac{\theta}{360^\circ} \pi r^2$ | $e_x = \frac{2}{3} r \frac{c}{a}$ $e_x = \frac{r^2 c}{3A}$ | $I_{XX} = I_0 - \frac{360^\circ}{360^\circ} \frac{\sin 2\theta}{2} \cdot \frac{4r^4}{3}$ $I_{YY} = \frac{r^4}{8}(\frac{\pi\theta}{180} - \sin\theta)$ $I_0 = \frac{r^4}{8}(\frac{\pi\theta}{180} + \sin\theta)$ | Z_{XX} centre = I_{XX}/e_x crown = $\frac{I_{XX}}{r - e_x}$ $Z_{YY} = \frac{2I_{YY}}{c}$ |
| QUADRANT | | $A = \frac{\pi r^2}{4}$ | $e_x = 0.424r$ $e_y = 0.6r$ $e_u = 0.707r$ | $I_{XX} = I_{YY} = 0.0549r^4$ $I_{DD} = 0.1963r^4$ $I_{UU} = 0.0714r^4$ $I_{VV} = 0.0384r^4$ | Minimum Values $Z_{XX} = Z_{YY} = 0.0953r^3$ $Z_{UU} = 0.1009r^3$ $Z_{VV} = 0.064r^3$ |
| COMPLEMENT | | $A = 0.2146r^2$ | $e_x = 0.777r$ $e_y = 1.098r$ $e_u = 0.707r$ $e_a = 0.316r$ $e_b = 0.391r$ | $I_{XX} = I_{YY} = 0.0075r^4$ $I_{UU} = 0.012r^4$ $I_{VV} = 0.0031r^4$ | Minimum Values $Z_{XX} = Z_{YY} = 0.0097r^3$ $Z_{UU} = 0.017r^3$ $Z_{VV} = 0.0079r^3$ |

| GEOMETRICAL PROPERTIES OF PLANE SECTIONS | | | | | |
|--|---------|------------------------|---|--|---|
| | Section | Area | Position of Centroid | Moments of Inertia | Section Moduli |
| ELLIPSE | | $A = \pi ab$ | $e_x = 0$ $e_y = b$ | $I_{XX} = 0.7854ba^3$ $I_{YY} = 0.7854ab^3$ | $Z_{XX} = 0.7854ab^2$ $Z_{YY} = 0.7854ab^2$ |
| SEMI-ELLIPSE | | $A = \frac{\pi ab}{2}$ | $e_x = 0.424a$ $e_y = b$ | $I_{XX} = 0.1098ba^3$ $I_{YY} = 0.3927ab^3$ $I_{base} = 0.3927ba^3$ | $Z_{XX - base} = 0.2587ba^2$ $Z_{XX - crown} = 0.1907ba^2$ $Z_{YY} = 0.3927b^2$ |
| 1/4 ELLIPSE | | $A = 0.7854ab$ | $e_x = 0.424a$ $e_y = 0.424b$ | $I_{XX} = 0.0549ba^3$ $I_{YY} = 0.0549ab^3$ $I_{b_1o_1} = 0.1963ba^3$ $I_{b_1c_1} = 0.1963ab^3$ | $Z_{XX - base} = 0.1293ba^2$ $Z_{XX - crown} = 0.0953ba^2$ $Z_{YY - base} = 0.1293b^2$ $Z_{YY - crown} = 0.0953ab^2$ |
| COMPLEMENT | | $A = 0.2146ab$ | $e_x = 0.777a$ $e_y = 0.777b$ | $I_{XX} = 0.0076ba^3$ $I_{YY} = 0.0076ab^3$ | $Z_{XX - base} = 0.0338ba^2$ $Z_{XX - apex} = 0.0097ba^2$ $Z_{YY - base} = 0.0338ab^2$ $Z_{YY - apex} = 0.0097ab^2$ |
| FULL PARABOLA | | $A = \frac{4ab}{3}$ | $e_x = \frac{2a}{5}$ $e_y = b$ | $I_{XX} = 0.0914ba^3$ $I_{YY} = 0.2666ab^3$ $I_{base} = 0.3048ba^3$ | $Z_{XX - base} = 0.2286ba^2$ $Z_{XX - crown} = 0.1524ba^2$ $Z_{YY} = 0.2666ab^2$ |
| SEMI-PARABOLA | | $A = \frac{2ab}{3}$ | $e_x = \frac{2a}{5}$ $e_y = \frac{3b}{8}$ | $I_{XX} = 0.0457ba^3$ $I_{YY} = 0.0396ab^3$ $I_{b_1o_1} = 0.1524ba^3$ $I_{b_1c_1} = 0.1333ab^3$ | $Z_{XX - base} = 0.1143ba^2$ $Z_{XX - crown} = 0.076ba^2$ $Z_{YY - base} = 0.1055ab^2$ $Z_{YY - crown} = 0.0633ab^2$ |
| COMPLEMENT | | $A = \frac{ab}{3}$ | $e_x = \frac{7a}{10}$ $e_y = \frac{3b}{4}$ | $I_{XX} = 0.0176ba^3$ $I_{YY} = 0.0125ab^3$ $I_{a_1b_1} = 0.181ba^3$ $I_{b_1c_1} = 0.2ab^3$ | $Z_{XX - base} = 0.0587ba^2$ $Z_{XX - apex} = 0.0252ba^2$ $Z_{YY - base} = 0.05ab^2$ $Z_{YY - apex} = 0.0167ab^2$ |
| FILLET | | $A = \frac{s^2}{6}$ | $e_u = e_v = \frac{4s}{5}$ | $I_{UU} = I_{VV} = 0.00524s^4$ $I_{ab} = 0.1119a^4$ | $Z_{UU} = Z_{VV}$ $Z_{UU - base} = 0.0262a^3$ $Z_{UU - apex} = 0.0066a^3$ |

PLASTIC MODULUS OF TWO FLANGES

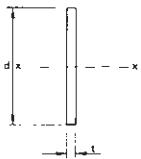


| Dist d mm | Plastic Modulus Sxx(cm ³) For Thickness t(mm) | | | | | | | | | | | | |
|-----------------|---|-------|------|------|------|------|------|------|------|------|------|------|------|
| | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 |
| 1000 | 15.2 | 20.4 | 25.6 | 30.9 | 36.2 | 41.6 | 47.0 | 52.5 | 58.0 | 63.6 | 69.2 | 74.9 | 80.6 |
| 1100 | 16.7 | 22.4 | 28.1 | 33.9 | 39.7 | 45.6 | 51.5 | 57.5 | 63.5 | 69.6 | 75.7 | 81.9 | 88.1 |
| 1200 | 18.2 | 24.4 | 30.6 | 36.9 | 43.2 | 49.6 | 56.0 | 62.5 | 69.0 | 75.6 | 82.2 | 88.9 | 95.6 |
| 1300 | 19.7 | 26.4 | 33.1 | 39.9 | 46.7 | 53.6 | 60.5 | 67.5 | 74.5 | 81.6 | 88.7 | 95.9 | 103 |
| 1400 | 21.2 | 28.4 | 35.6 | 42.9 | 50.2 | 57.6 | 65.0 | 72.5 | 80.0 | 87.6 | 95.2 | 103 | 111 |
| 1500 | 22.7 | 30.4 | 38.1 | 45.9 | 53.7 | 61.6 | 69.5 | 77.5 | 85.5 | 93.6 | 102 | 110 | 118 |
| 1600 | 24.2 | 32.4 | 40.6 | 48.9 | 57.2 | 65.6 | 74.0 | 82.5 | 91.0 | 99.6 | 108 | 117 | 126 |
| 1700 | 25.7 | 34.4 | 43.1 | 51.9 | 60.7 | 69.6 | 78.5 | 87.5 | 96.5 | 106 | 115 | 124 | 133 |
| 1800 | 27.2 | 36.4 | 45.6 | 54.9 | 64.2 | 73.6 | 83.0 | 92.5 | 102 | 112 | 121 | 131 | 141 |
| 1900 | 28.7 | 38.4 | 48.1 | 57.9 | 67.7 | 77.6 | 87.5 | 97.5 | 108 | 118 | 128 | 138 | 148 |
| 2000 | 30.2 | 40.4 | 50.6 | 60.9 | 71.2 | 81.6 | 92.0 | 102 | 113 | 124 | 134 | 145 | 156 |
| 2100 | 31.7 | 42.4 | 53.1 | 63.9 | 74.7 | 85.6 | 96.5 | 107 | 119 | 130 | 141 | 152 | 163 |
| 2200 | 33.2 | 44.4 | 55.6 | 66.9 | 78.2 | 89.6 | 101 | 112 | 124 | 136 | 147 | 159 | 171 |
| 2300 | 34.7 | 46.4 | 58.1 | 69.9 | 81.7 | 93.6 | 106 | 117 | 130 | 142 | 154 | 166 | 178 |
| 2400 | 36.2 | 48.4 | 60.6 | 72.9 | 85.2 | 97.6 | 110 | 122 | 135 | 148 | 160 | 173 | 186 |
| 2500 | 37.7 | 50.4 | 63.1 | 75.9 | 88.7 | 102 | 115 | 127 | 141 | 154 | 167 | 180 | 193 |
| 2600 | 39.2 | 52.4 | 65.6 | 78.9 | 92.2 | 106 | 119 | 132 | 146 | 160 | 173 | 187 | 201 |
| 2700 | 40.7 | 54.4 | 68.1 | 81.9 | 95.7 | 110 | 124 | 137 | 152 | 166 | 180 | 194 | 208 |
| 2800 | 42.2 | 56.4 | 70.6 | 84.9 | 99.2 | 114 | 128 | 142 | 157 | 172 | 186 | 201 | 216 |
| 2900 | 43.7 | 58.4 | 73.1 | 87.9 | 103 | 118 | 133 | 147 | 163 | 178 | 193 | 208 | 223 |
| 3000 | 45.2 | 60.4 | 75.6 | 90.9 | 106 | 122 | 137 | 152 | 168 | 184 | 199 | 215 | 231 |
| 3100 | 46.7 | 62.4 | 78.1 | 93.9 | 110 | 126 | 142 | 157 | 174 | 190 | 206 | 222 | 238 |
| 3200 | 48.2 | 64.4 | 80.6 | 96.9 | 113 | 130 | 146 | 162 | 179 | 196 | 212 | 229 | 246 |
| 3300 | 49.7 | 66.4 | 83.1 | 99.9 | 117 | 134 | 151 | 167 | 185 | 202 | 219 | 236 | 253 |
| 3400 | 51.2 | 68.4 | 85.6 | 103 | 120 | 138 | 155 | 172 | 190 | 208 | 225 | 243 | 261 |
| 3500 | 52.7 | 70.4 | 88.1 | 106 | 124 | 142 | 160 | 177 | 196 | 214 | 232 | 250 | 268 |
| 3600 | 54.2 | 72.4 | 90.6 | 109 | 127 | 146 | 164 | 182 | 201 | 220 | 238 | 257 | 276 |
| 3700 | 55.7 | 74.4 | 93.1 | 112 | 131 | 150 | 169 | 187 | 207 | 226 | 245 | 264 | 283 |
| 3800 | 57.2 | 76.4 | 95.6 | 115 | 134 | 154 | 173 | 192 | 212 | 232 | 251 | 271 | 291 |
| 3900 | 58.7 | 78.4 | 98.1 | 118 | 138 | 158 | 178 | 197 | 218 | 238 | 258 | 278 | 298 |
| 4000 | 60.2 | 80.4 | 101 | 121 | 141 | 162 | 182 | 202 | 223 | 244 | 264 | 285 | 306 |
| 4100 | 61.7 | 82.4 | 103 | 124 | 145 | 166 | 187 | 207 | 229 | 250 | 271 | 292 | 313 |
| 4200 | 63.2 | 84.4 | 106 | 127 | 148 | 170 | 191 | 212 | 234 | 256 | 277 | 299 | 321 |
| 4300 | 64.7 | 86.4 | 108 | 130 | 152 | 174 | 196 | 217 | 240 | 262 | 284 | 306 | 328 |
| 4400 | 66.2 | 88.4 | 111 | 133 | 155 | 178 | 200 | 222 | 245 | 268 | 290 | 313 | 336 |
| 4500 | 67.7 | 90.4 | 113 | 136 | 159 | 182 | 205 | 227 | 251 | 274 | 297 | 320 | 343 |
| 4600 | 69.2 | 92.4 | 116 | 139 | 162 | 186 | 209 | 232 | 256 | 280 | 303 | 327 | 351 |
| 4700 | 70.7 | 94.4 | 118 | 142 | 166 | 190 | 214 | 237 | 262 | 285 | 310 | 334 | 358 |
| 4800 | 72.2 | 96.4 | 121 | 145 | 169 | 194 | 218 | 242 | 267 | 292 | 316 | 341 | 366 |
| 4900 | 73.7 | 98.4 | 123 | 148 | 173 | 198 | 223 | 247 | 273 | 298 | 323 | 348 | 373 |
| 5000 | 75.2 | 100.0 | 126 | 151 | 176 | 202 | 227 | 252 | 278 | 304 | 329 | 355 | 381 |

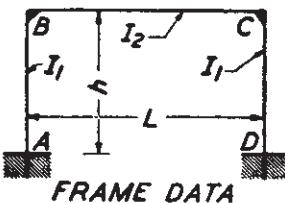
PLASTIC MODULUS OF RECTANGLES

| Depth d mm | Plastic Modulus Sxx(cm³) For Thickness t(mm) | | | | | | | | | |
|------------------|--|------|------|------|------|-------|------|------|------|------|
| | 5 | 6 | 7 | 8 | 9 | 10 | 12.5 | 15 | 20 | 25 |
| 25 | 0.78 | 0.93 | 1.09 | 1.25 | 1.41 | 1.56 | 1.95 | 2.34 | 3.13 | 3.91 |
| 50 | 3.13 | 3.75 | 4.37 | 5.00 | 5.62 | 6.25 | 7.81 | 9.37 | 12.5 | 15.6 |
| 75 | 7.03 | 8.44 | 9.84 | 11.3 | 12.7 | 14.1 | 17.6 | 21.1 | 28.1 | 35.2 |
| 100 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 31.2 | 37.5 | 50.0 | 62.5 |
| 125 | 19.5 | 23.4 | 27.3 | 31.2 | 35.2 | 39.1 | 48.8 | 58.6 | 78.1 | 97.7 |
| 150 | 28.1 | 33.8 | 39.4 | 45.0 | 50.6 | 56.2 | 70.3 | 84.4 | 112 | 141 |
| 175 | 38.3 | 45.9 | 53.6 | 61.2 | 68.9 | 76.6 | 95.7 | 115 | 153 | 191 |
| 200 | 50.0 | 60.0 | 70.0 | 80.0 | 90.0 | 100.0 | 125 | 150 | 200 | 250 |
| 225 | 63.3 | 75.9 | 88.6 | 101 | 114 | 127 | 158 | 190 | 253 | 316 |
| 250 | 78.1 | 93.7 | 109 | 125 | 141 | 156 | 195 | 234 | 312 | 391 |
| 275 | 94.5 | 113 | 132 | 151 | 170 | 189 | 236 | 284 | 378 | 473 |
| 300 | 112 | 135 | 158 | 180 | 203 | 225 | 281 | 338 | 450 | 563 |
| 325 | 132 | 158 | 185 | 211 | 238 | 264 | 330 | 396 | 528 | 650 |
| 350 | 153 | 184 | 214 | 245 | 276 | 306 | 383 | 459 | 613 | 766 |
| 375 | 176 | 211 | 246 | 281 | 316 | 352 | 439 | 527 | 703 | 879 |
| 400 | 200 | 240 | 280 | 320 | 360 | 400 | 500 | 600 | 800 | 1000 |
| 425 | 226 | 271 | 316 | 361 | 406 | 452 | 564 | 677 | 903 | 1130 |
| 450 | 253 | 304 | 354 | 405 | 456 | 506 | 633 | 759 | 1010 | 1270 |
| 475 | 282 | 338 | 395 | 451 | 508 | 564 | 705 | 846 | 1130 | 1410 |
| 500 | 312 | 375 | 437 | 500 | 562 | 625 | 781 | 937 | 1250 | 1560 |
| 525 | 345 | 413 | 482 | 551 | 620 | 689 | 861 | 1030 | 1380 | 1720 |
| 550 | 378 | 454 | 529 | 605 | 681 | 756 | 945 | 1130 | 1510 | 1890 |
| 575 | 413 | 496 | 579 | 661 | 744 | 827 | 1030 | 1240 | 1650 | 2070 |
| 600 | 450 | 540 | 630 | 720 | 810 | 900 | 1130 | 1350 | 1800 | 2250 |
| 625 | 488 | 586 | 684 | 781 | 879 | 977 | 1220 | 1460 | 1950 | 2440 |
| 650 | 528 | 634 | 739 | 845 | 951 | 1060 | 1320 | 1580 | 2110 | 2640 |
| 675 | 570 | 683 | 797 | 911 | 1030 | 1140 | 1420 | 1710 | 2280 | 2850 |
| 700 | 613 | 735 | 858 | 980 | 1100 | 1230 | 1530 | 1840 | 2450 | 3060 |
| 725 | 657 | 788 | 920 | 1050 | 1180 | 1310 | 1640 | 1970 | 2630 | 3290 |
| 750 | 703 | 844 | 984 | 1120 | 1270 | 1410 | 1760 | 2110 | 2810 | 3520 |
| 775 | 751 | 901 | 1050 | 1200 | 1350 | 1500 | 1880 | 2250 | 3000 | 3750 |
| 800 | 800 | 960 | 1120 | 1280 | 1440 | 1600 | 2000 | 2400 | 3200 | 4000 |
| 825 | 851 | 1020 | 1190 | 1360 | 1530 | 1700 | 2130 | 2550 | 3400 | 4250 |
| 850 | 903 | 1080 | 1260 | 1440 | 1630 | 1810 | 2280 | 2710 | 3610 | 4520 |
| 875 | 957 | 1150 | 1340 | 1530 | 1720 | 1910 | 2390 | 2870 | 3830 | 4790 |
| 900 | 1010 | 1210 | 1420 | 1620 | 1820 | 2020 | 2530 | 3040 | 4050 | 5060 |

PLASTIC MODULUS OF RECTANGLES



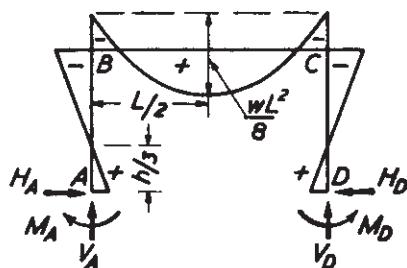
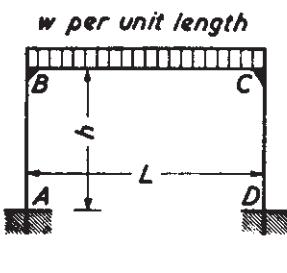
| Depth d mm | Plastic Modulus S_{xx} (cm^3) For Thickness t(mm) | | | | | | | | | |
|------------------|--|-------|-------|-------|-------|-------|-------|-------|--------|--------|
| | 5 | 6 | 7 | 8 | 9 | 10 | 12.5 | 15 | 20 | 25 |
| 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 | 3120 | 3750 | 5000 | 6250 |
| 1100 | 1510 | 1810 | 2120 | 2420 | 2720 | 3020 | 3780 | 4540 | 6050 | 7560 |
| 1200 | 1800 | 2160 | 2520 | 2880 | 3240 | 3600 | 4500 | 5400 | 7200 | 9000 |
| 1300 | 2110 | 2530 | 2960 | 3380 | 3800 | 4220 | 5280 | 6340 | 8450 | 10600 |
| 1400 | 2450 | 2940 | 3430 | 3920 | 4410 | 4900 | 6130 | 7350 | 9800 | 12300 |
| 1500 | 2810 | 3370 | 3940 | 4500 | 5060 | 5620 | 7030 | 8440 | 11200 | 14100 |
| 1600 | 3200 | 3840 | 4480 | 5120 | 5760 | 6400 | 8000 | 9600 | 12800 | 16000 |
| 1700 | 3610 | 4330 | 5060 | 5780 | 6500 | 7220 | 9030 | 10800 | 14400 | 18100 |
| 1800 | 4050 | 4860 | 5670 | 6480 | 7290 | 8100 | 10100 | 12100 | 16200 | 20200 |
| 1900 | 4510 | 5410 | 6320 | 7220 | 8120 | 9020 | 11300 | 13500 | 18000 | 22600 |
| 2000 | 5000 | 6000 | 7000 | 8000 | 9000 | 10000 | 12500 | 15000 | 20000 | 25000 |
| 2100 | 5510 | 6620 | 7720 | 8820 | 9920 | 11000 | 13800 | 16500 | 22100 | 27600 |
| 2200 | 6050 | 7260 | 8470 | 9680 | 10900 | 12100 | 15100 | 18100 | 24200 | 30200 |
| 2300 | 6610 | 7930 | 9260 | 10600 | 11900 | 13200 | 16500 | 19800 | 26500 | 33100 |
| 2400 | 7200 | 8640 | 10100 | 11500 | 13000 | 14400 | 18000 | 21600 | 28800 | 36000 |
| 2500 | 7810 | 9370 | 10900 | 12500 | 14100 | 15600 | 19500 | 23400 | 31200 | 39100 |
| 2600 | 8450 | 10100 | 11800 | 13500 | 15200 | 16900 | 21100 | 25400 | 33800 | 42200 |
| 2700 | 9110 | 10900 | 12800 | 14600 | 16400 | 18200 | 22800 | 27300 | 36400 | 45600 |
| 2800 | 9800 | 11800 | 13700 | 15700 | 17600 | 19600 | 24500 | 29400 | 39200 | 49000 |
| 2900 | 10500 | 12600 | 14700 | 16800 | 18900 | 21000 | 26300 | 31500 | 42000 | 52600 |
| 3000 | 11200 | 13500 | 15700 | 18000 | 20200 | 22500 | 28100 | 33700 | 45000 | 56200 |
| 3100 | 12000 | 14400 | 16800 | 19200 | 21600 | 24000 | 30000 | 36000 | 48000 | 60100 |
| 3200 | 12800 | 15400 | 17900 | 20500 | 23000 | 25600 | 32000 | 38400 | 51200 | 64000 |
| 3300 | 13600 | 16300 | 19100 | 21800 | 24500 | 27200 | 34000 | 40800 | 54400 | 68100 |
| 3400 | 14400 | 17300 | 20200 | 23100 | 26000 | 28900 | 36100 | 43300 | 57800 | 72200 |
| 3500 | 15300 | 18400 | 21400 | 24500 | 27600 | 30600 | 38300 | 45900 | 61200 | 76600 |
| 3600 | 16200 | 19400 | 22700 | 25900 | 29200 | 32400 | 40500 | 48600 | 64800 | 81000 |
| 3700 | 17100 | 20500 | 24000 | 27400 | 30800 | 34200 | 42800 | 51300 | 68400 | 85800 |
| 3800 | 18000 | 21700 | 25300 | 28900 | 32500 | 36100 | 45100 | 54100 | 72200 | 90200 |
| 3900 | 19000 | 22800 | 26600 | 30400 | 34200 | 38000 | 47500 | 57000 | 76000 | 95100 |
| 4000 | 20000 | 24000 | 28000 | 32000 | 36000 | 40000 | 50000 | 60000 | 80000 | 100000 |
| 4100 | 21000 | 25200 | 29400 | 33600 | 37800 | 42000 | 52500 | 63000 | 84000 | 105000 |
| 4200 | 22100 | 26500 | 30900 | 35300 | 39700 | 44100 | 55100 | 66200 | 88200 | 110000 |
| 4300 | 23100 | 27700 | 32400 | 37000 | 41600 | 46200 | 57800 | 69300 | 92400 | 116000 |
| 4400 | 24200 | 29000 | 33900 | 38700 | 43600 | 48400 | 60500 | 72600 | 96800 | 121000 |
| 4500 | 25300 | 30400 | 35400 | 40500 | 45600 | 50600 | 63300 | 75900 | 101000 | 127000 |
| 4600 | 26500 | 31700 | 37000 | 42300 | 47600 | 52900 | 66100 | 79300 | 106000 | 132000 |
| 4700 | 27600 | 33100 | 38700 | 44200 | 49700 | 55200 | 69000 | 82800 | 110000 | 138000 |
| 4800 | 28800 | 34600 | 40300 | 46100 | 51800 | 57600 | 72000 | 86400 | 115000 | 144000 |
| 4900 | 30000 | 36000 | 42000 | 48000 | 54000 | 60000 | 75000 | 90000 | 120000 | 150000 |
| 5000 | 31200 | 37500 | 43700 | 50000 | 56200 | 62500 | 78100 | 93700 | 125000 | 156000 |

Frame I

Coefficients:

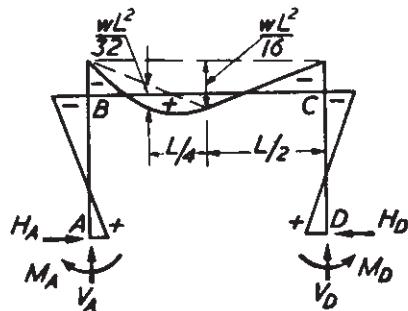
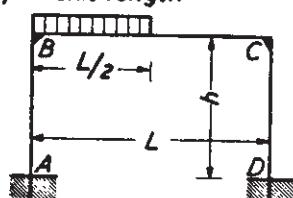
$$k = \frac{I_2}{I_1} \cdot \frac{h}{L}$$

$$N_1 = k + 2 \quad N_2 = 6k + 1$$



$$M_A = M_D = \frac{wL^2}{12N_1} \quad M_B = M_C = -\frac{wL^2}{6N_1} = -2M_A$$

$$M_{\max} = \frac{wL^2}{8} + M_B \quad V_A = V_D = \frac{wL}{2} \quad H_A = H_D = \frac{3M_A}{h}$$

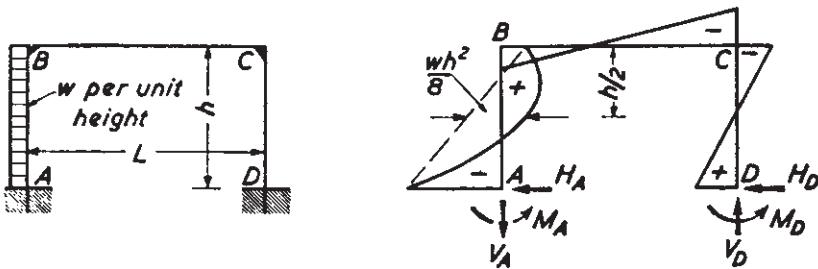
w per unit length

$$M_A = \frac{wL^2}{8} \left[\frac{1}{3N_1} - \frac{1}{8N_2} \right] \quad M_B = -\frac{wL^2}{8} \left[\frac{2}{3N_1} + \frac{1}{8N_2} \right]$$

$$M_D = \frac{wL^2}{8} \left[\frac{1}{3N_1} + \frac{1}{8N_2} \right] \quad M_C = -\frac{wL^2}{8} \left[\frac{2}{3N_1} - \frac{1}{8N_2} \right]$$

$$V_D = \frac{wL}{8} \left[1 - \frac{1}{4N_2} \right] \quad V_A = \frac{wL}{2} - V_D \quad H_A = H_D = \frac{wL^2}{8hN_1}$$

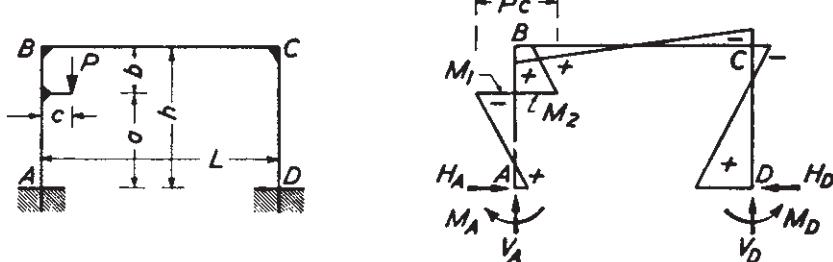
Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$M_A = \frac{wh^2}{4} \left[-\frac{k+3}{6N_1} - \frac{4k+1}{N_2} \right] \quad M_B = \frac{wh^2}{4} \left[-\frac{k}{6N_1} + \frac{2k}{N_2} \right]$$

$$M_D = \frac{wh^2}{4} \left[-\frac{k+3}{6N_1} + \frac{4k+1}{N_2} \right] \quad M_C = \frac{wh^2}{4} \left[-\frac{k}{6N_1} - \frac{2k}{N_2} \right]$$

$$H_D = \frac{wh(2k+3)}{8N_1} \quad H_A = -(wh - H_D) \quad V_A = -V_D = -\frac{wh^2 k}{LN_2}$$



Constants: $a_1 = \frac{a}{h}$ $b_1 = \frac{b}{h}$

$$X_1 = \frac{Pc}{2N_1} [1 + 2b_1 k - 3b_1^2(k+1)] \quad X_2 = \frac{Pck a_1 (3a_1 - 2)}{2N_1}$$

$$X_3 = \frac{3Pck a_1}{N_2}$$

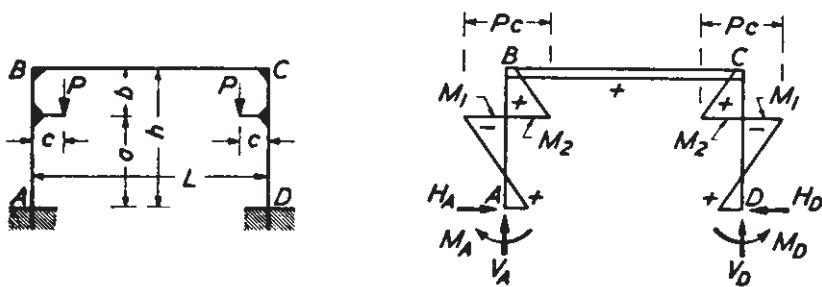
$$M_A = +X_1 - \left(\frac{Pc}{2} - X_3 \right) \quad M_B = +X_2 + X_3$$

$$M_D = +X_1 + \left(\frac{Pc}{2} - X_3 \right) \quad M_C = +X_2 - X_3$$

$$H_A = H_D = \frac{Pc}{2h} + \frac{X_1 - X_2}{h} \quad V_D = \frac{2X_3}{L} \quad V_A = P - V_D$$

$$M_1 = M_A - H_A a \quad M_2 = M_B + H_D b$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$\text{Constants: } a_1 = \frac{a}{h} \quad b_1 = \frac{b}{h}$$

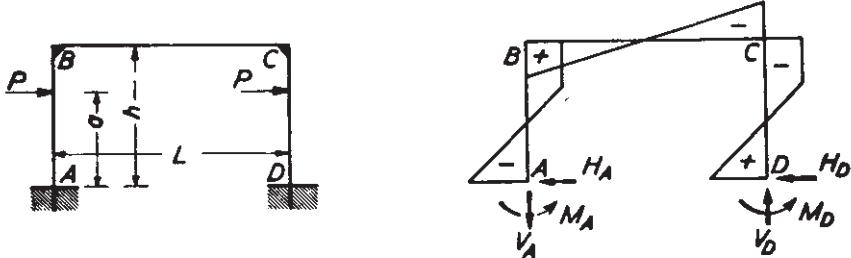
$$X_1 = \frac{Pc}{2N_1} [1 + 2b_1k - 3b_1^2(k+1)] \quad X_2 = \frac{Pck a_1 (3a_1 - 2)}{2N_1}$$

$$M_A = M_D = \frac{Pc}{N_1} [1 + 2b_1k - 3b_1^2(k+1)] = 2X_1$$

$$M_B = M_C = \frac{Pck a_1 (3a_1 - 2)}{N_1} = 2X_2$$

$$V_A = V_D = P \quad H_A = H_D = \frac{Pc + M_A - M_B}{h}$$

$$M_1 = M_A - H_A a \quad M_2 = M_B + H_D b$$



$$\text{Constants: } a_1 = \frac{a}{h} \quad X_1 = \frac{3Paa_1k}{N_2}$$

$$M_A = -Pa + X_1$$

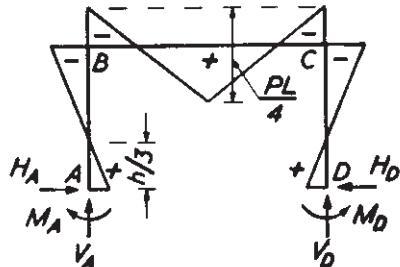
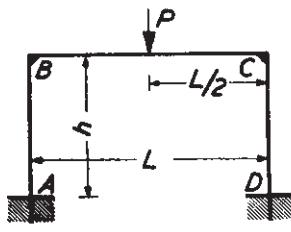
$$M_B = X_1$$

$$M_D = +Pa - X_1$$

$$M_C = -X_1$$

$$V_A = -V_D = -\frac{2X_1}{L} \quad H_A = -H_D = -P$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

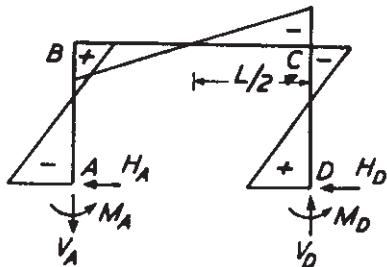
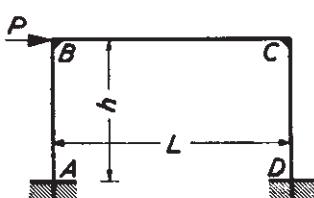


$$M_A = M_D = +\frac{PL}{8N_1}$$

$$V_A = V_D = \frac{P}{2}$$

$$M_B = M_C = -2M_A$$

$$H_A = H_D = \frac{3M_A}{h}$$



$$M_A = -\frac{Ph}{2} \cdot \frac{3k+1}{N_2}$$

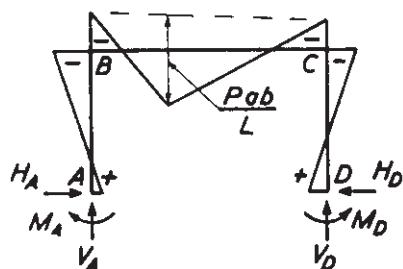
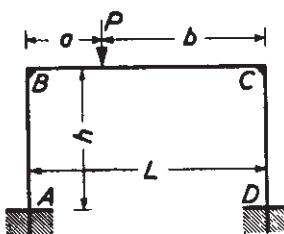
$$M_D = +\frac{Ph}{2} \cdot \frac{3k+1}{N_2}$$

$$H_A = -H_D = -\frac{P}{2}$$

$$M_B = +\frac{Ph}{2} \cdot \frac{3k}{N_2}$$

$$M_C = -\frac{Ph}{2} \cdot \frac{3k}{N_2}$$

$$V_A = -V_D = -\frac{2M_B}{L}$$



Constants: $a_1 = a/L$ $b_1 = b/L$

$$M_A = +\frac{Pab}{L} \left[\frac{1}{2N_1} - \frac{b_1 - a_1}{2N_2} \right]$$

$$M_B = -\frac{Pab}{L} \left[\frac{1}{N_1} + \frac{b_1 - a_1}{2N_2} \right]$$

$$M_D = +\frac{Pab}{L} \left[\frac{1}{2N_1} + \frac{b_1 - a_1}{2N_2} \right]$$

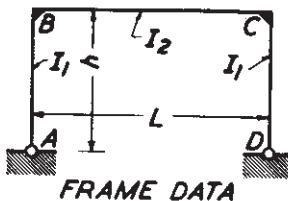
$$M_C = -\frac{Pab}{L} \left[\frac{1}{N_1} - \frac{b_1 - a_1}{2N_2} \right]$$

$$V_A = Pb_1 \left[1 + \frac{a_1(b_1 - a_1)}{N_2} \right]$$

$$V_D = P - V_A$$

$$H_A = H_D = \frac{3Pab}{2LhN_1}$$

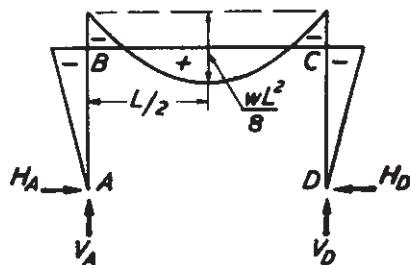
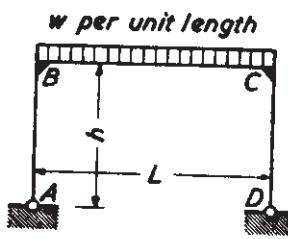
Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

Frame II

Coefficients:

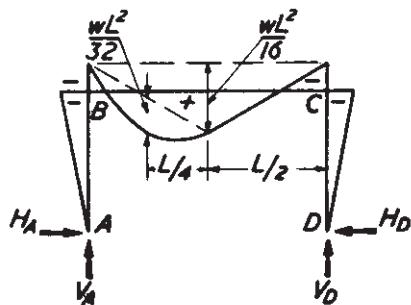
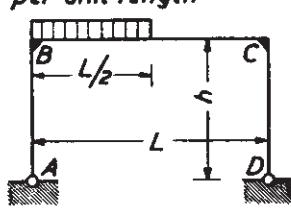
$$k = \frac{I_2}{I_1} \cdot \frac{h}{L}$$

$$N = 2k + 3$$



$$M_B = M_C = -\frac{wL^2}{4N} \quad M_{\max} = \frac{wL^2}{8} + M_B$$

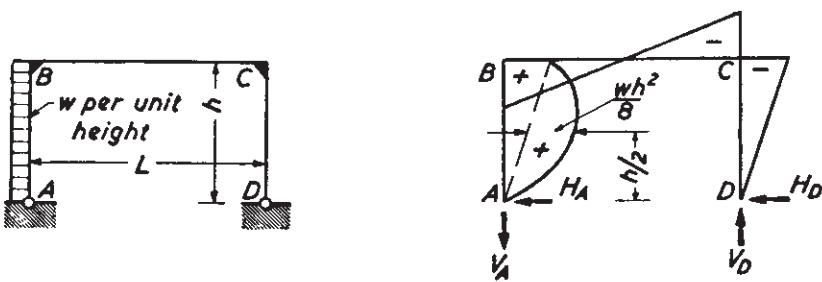
$$V_A = V_D = \frac{wL}{2} \quad H_A = H_D = -\frac{M_B}{h}$$

w per unit length

$$M_B = M_C = -\frac{wL^2}{8N}$$

$$V_A = \frac{3wL}{8} \quad V_D = \frac{wL}{8} \quad H_A = H_D = -\frac{M_B}{h}$$

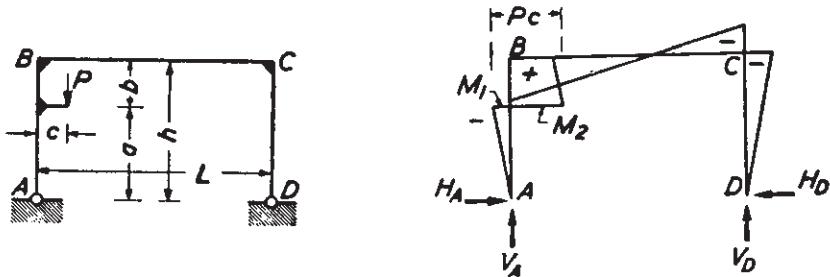
Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$M_B = \frac{wh^2}{4} \left[-\frac{k}{2N} + 1 \right] \quad H_D = -\frac{M_C}{h}$$

$$M_C = \frac{wh^2}{4} \left[-\frac{k}{2N} - 1 \right] \quad H_A = -(wh - H_D)$$

$$V_A = -V_D = -\frac{wh^2}{2L}$$



$$\text{Constant: } a_1 = \frac{a}{h}$$

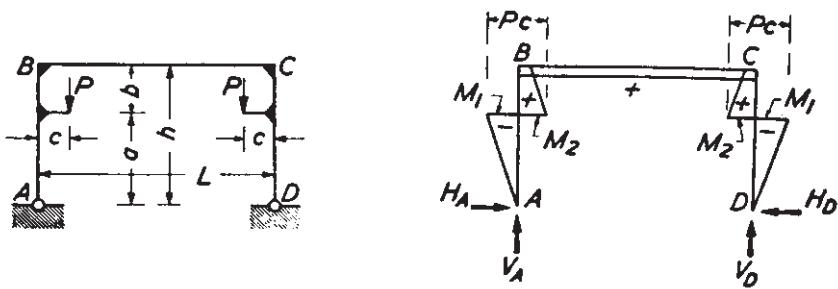
$$M_B = \frac{Pc}{2} \left[\frac{(3a_1^2 - 1)k}{N} + 1 \right]$$

$$M_C = \frac{Pc}{2} \left[\frac{(3a_1^2 - 1)k}{N} - 1 \right] \quad H_A = H_D = -\frac{M_C}{h}$$

$$V_D = \frac{Pc}{L} \quad V_A = P - V_D$$

$$M_1 = -H_A a \quad M_2 = P_c - H_A a$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

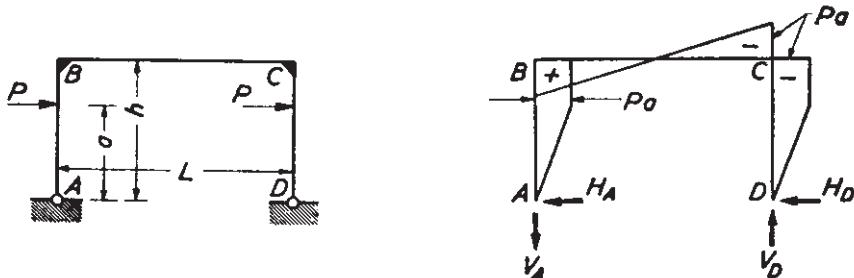


$$\text{Constant: } a_1 = \frac{a}{h}$$

$$M_B = M_C = \frac{Pc(3a_1^2 - 1)k}{N}$$

$$H_A = H_D = \frac{Pc - M_B}{h} \quad V_A = V_D = P$$

$$M_1 = -H_A a \quad M_2 = Pc - H_A a$$

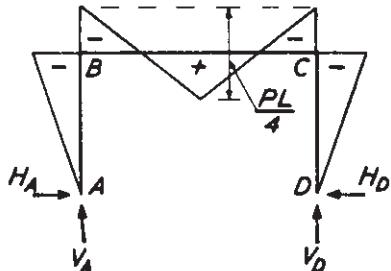
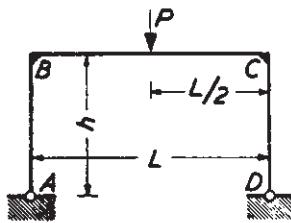


$$M_B = -M_C = Pa \quad H_A = H_D = P$$

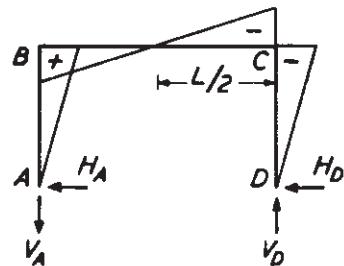
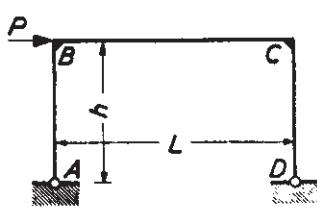
$$V_A = -V_D = -\frac{2Pa}{L}$$

Moment at loads = $\pm Pa$

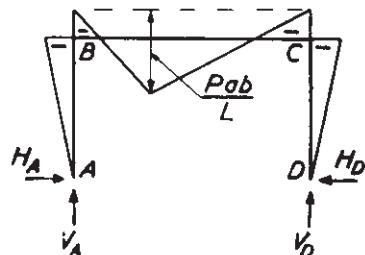
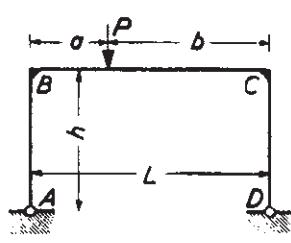
Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$M_B = M_C = -\frac{3PL}{8N} \quad V_A = V_D = \frac{P}{2} \quad H_A = H_D = -\frac{M_B}{h}$$



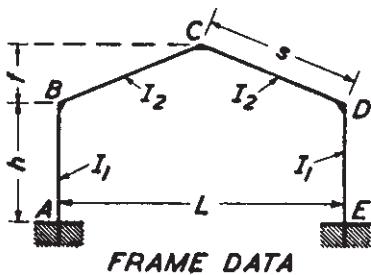
$$M_B = -M_C = +\frac{Ph}{2} \quad V_A = -V_D = -\frac{Ph}{L} \quad H_A = -H_D = -\frac{P}{2}$$



$$M_B = M_C = -\frac{Pab}{L} \cdot \frac{3}{2N}$$

$$V_A = \frac{Pb}{L} \quad V_D = \frac{Pa}{L} \quad H_A = H_D = -\frac{M_B}{h}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

Frame III

Coefficients:

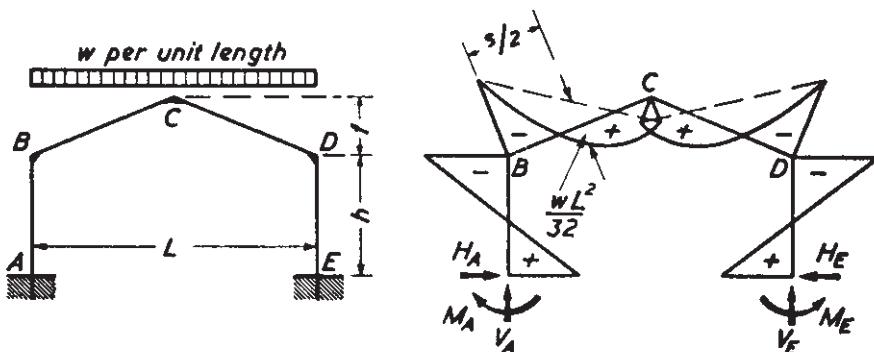
$$k = \frac{I_2}{I_1} \cdot \frac{h}{s} \quad \phi = \frac{f}{h}$$

$$m = 1 + \phi$$

$$B = 3k + 2 \quad C = 1 + 2m$$

$$K_1 = 2(k + 1 + m + m^2) \quad K_2 = 2(k + \phi^2)$$

$$R = \phi C - k \quad N_1 = K_1 K_2 - R^2 \quad N_2 = 3k + B$$



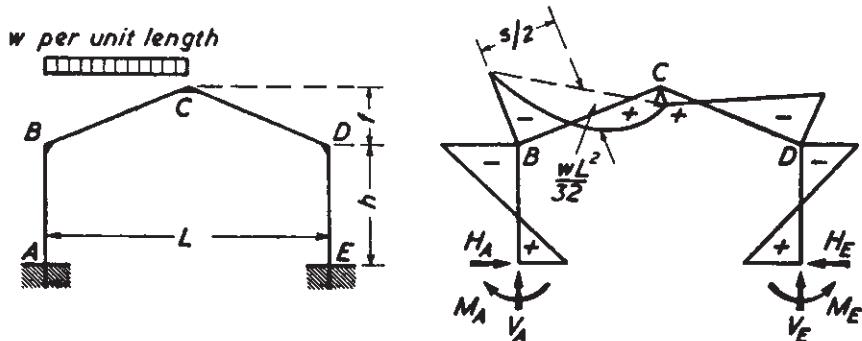
$$M_A = M_E = \frac{wL^2}{16} \cdot \frac{k(8 + 15\phi) + \phi(6 - \phi)}{N_1}$$

$$M_B = M_D = - \frac{wL^2}{16} \cdot \frac{k(16 + 15\phi) + \phi^2}{N_1}$$

$$M_C = \frac{wL^2}{8} - \phi M_A + m M_B$$

$$V_A = V_E = \frac{wL}{2} \quad H_A = H_E = \frac{M_A - M_B}{h}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$\text{Constants: } *X_1 = \frac{wL^2}{32} \cdot \frac{k(8+15\phi)+\phi(6-\phi)}{N_1}$$

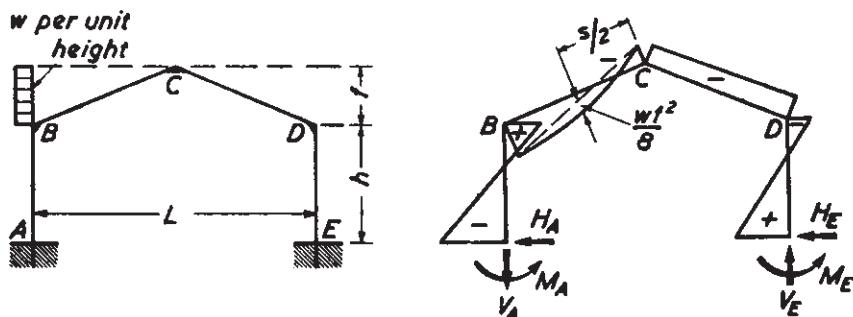
$$*X_2 = \frac{wL^2}{32} \cdot \frac{k(16+15\phi)+\phi^2}{N_1} \quad X_3 = \frac{wL^2}{32N_2}$$

$$M_A = +X_1 - X_3 \quad M_B = -X_2 - X_3 \quad M_E = +X_1 + X_3 \quad M_D = -X_2 + X_3$$

$$*M_C = \frac{wL^2}{16} - \phi X_1 - m X_2$$

$$V_E = \frac{wL}{8} - \frac{2X_3}{L} \quad V_A = \frac{wL}{2} - V_E \quad H_A = H_E = \frac{X_1 + X_2}{h}$$

* Note that X_1 , $-X_2$ and M_C are respectively half the values of M_A ($=M_E$), M_B ($=M_D$) and M_C from the previous set of formulae where the whole span was loaded.



$$\text{Constants: } X_1 = \frac{wf^2}{8} \cdot \frac{k(9\phi+4)+\phi(6+\phi)}{N_1}$$

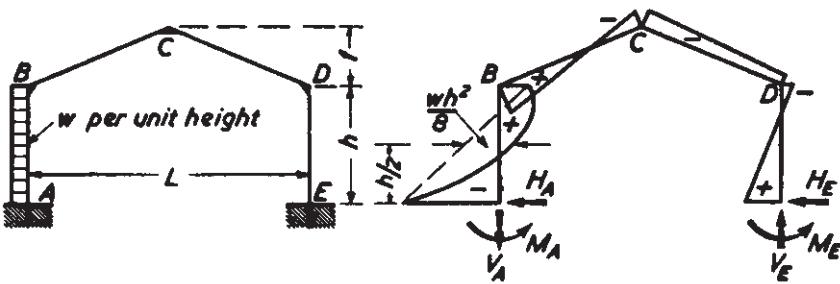
$$X_2 = \frac{wf^2}{8} \cdot \frac{k(8+9\phi)-\phi^2}{N_1} \quad X_3 = \frac{wf^2h}{8} \cdot \frac{4B+\phi}{N_2}$$

$$M_A = -X_1 - X_3 \quad M_B = +X_2 + \left(\frac{wf^2h}{2} - X_3 \right)$$

$$M_E = -X_1 + X_3 \quad M_D = +X_2 - \left(\frac{wf^2h}{2} - X_3 \right)$$

$$M_C = -\frac{wf^2}{4} + \phi X_1 + m X_2$$

$$V_A = -V_E = -\frac{wf^2h(2+\phi)}{2L} + \frac{2X_3}{L} \quad H_E = \frac{wf^2}{2} - \frac{X_1 + X_2}{h} \quad H_A = -(wf - H_E)$$



$$\text{Constants: } X_1 = \frac{wh^2}{8} \cdot \frac{k(k+6) + k\phi(15 + 16\phi) + 6\phi^2}{N_1}$$

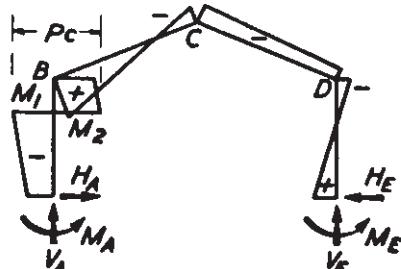
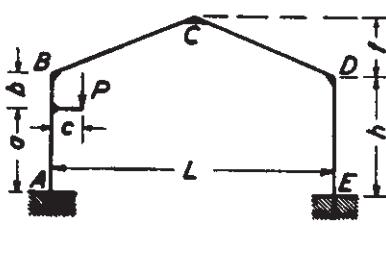
$$X_2 = \frac{wh^2k(9\phi + 8\phi^2 - k)}{8N_1} \quad X_3 = \frac{wh^2(2k + 1)}{2N_2}$$

$$M_A = -X_1 - X_3 \quad M_B = +X_2 + \left(\frac{wh^2}{4} - X_3 \right)$$

$$M_E = -X_1 + X_3 \quad M_D = +X_2 - \left(\frac{wh^2}{4} - X_3 \right)$$

$$M_C = -\frac{whf}{4} + \phi X_1 + m X_2$$

$$V_A = -V_E = -\frac{wh^2}{2L} + \frac{2X_3}{L} \quad H_E = \frac{wh}{4} - \frac{X_1 + X_2}{h} \quad H_A = -(wh - H_E)$$



$$\text{Constants: } a_1 = \frac{a}{h} \quad b_1 = \frac{b}{h}$$

$$Y_1 = P_c[2\phi^2 - (1 - 3b_1^2)k] \quad Y_2 = P_c[\phi C - (3a_1^2 - 1)k]$$

$$X_1 = \frac{Y_1 K_1 - Y_2 R}{2N_1} \quad X_2 = \frac{Y_2 K_2 - Y_1 R}{2N_1} \quad X_3 = \frac{P_c}{2} \cdot \frac{B - 3(a_1 - b_1)k}{N_2}$$

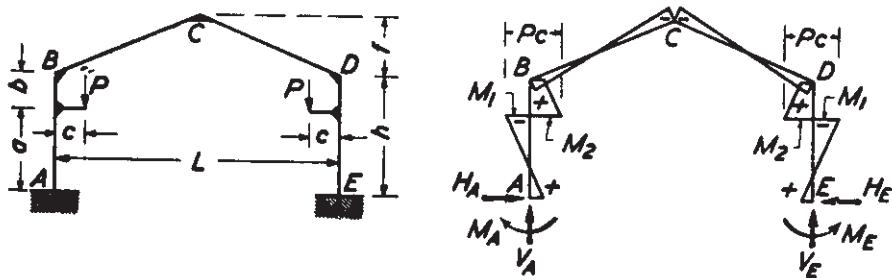
$$M_A = -X_1 - X_3 \quad M_B = +X_2 + \left(\frac{P_c}{2} - X_3 \right)$$

$$M_E = -X_1 + X_3 \quad M_D = +X_2 - \left(\frac{P_c}{2} - X_3 \right) \quad M_C = -\frac{\phi P_c}{2} + \phi X_1 + m X_2$$

$$M_1 = M_A - H_A a \quad M_2 = M_B + H_E b$$

$$V_E = \frac{P_c - 2X_3}{L} \quad V_A = P - V_E \quad H_A = H_E = \frac{P_c}{2h} - \frac{X_1 + X_2}{h}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$\text{Constants: } a_1 = \frac{a}{h} \quad b_1 = \frac{b}{h}$$

$$Y_1 = P c [2\phi^2 - (1 - 3b_1^2)k]$$

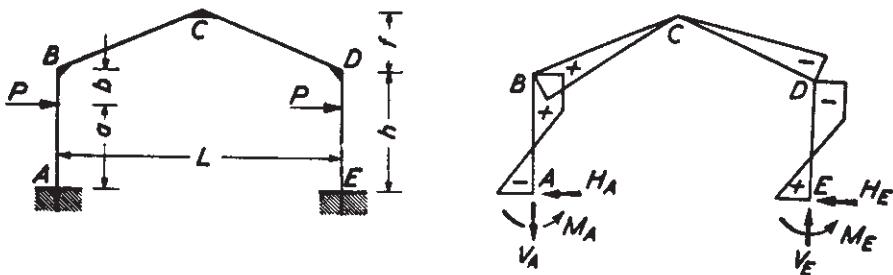
$$Y_2 = P c [\phi C + (3a_1^2 - 1)k]$$

$$M_A = M_E = \frac{Y_2 R - Y_1 K_1}{N_1} \quad M_B = M_D = \frac{Y_2 K_2 - Y_1 R}{N_1}$$

$$M_C = -\phi(Pc + M_A) + m M_B$$

$$V_A = V_D = P \quad H_A = H_E = \frac{Pc + M_A - M_B}{h}$$

$$M_1 = M_A - H_A a \quad M_2 = M_B + H_E b$$

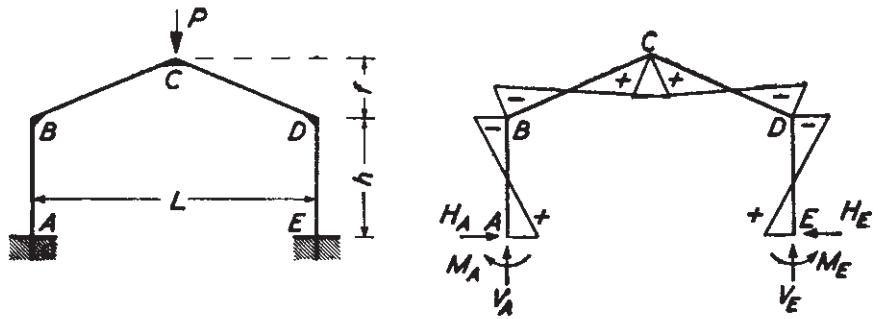


$$\text{Constant: } X_1 = \frac{Pa(B + 3b_1 k)}{N_2}$$

$$M_A = -M_E = -X_1 \quad M_B = -M_D = Pa - X_1 \quad M_C = 0$$

$$V_A = -V_E = -2 \left[\frac{Pa - X_1}{L} \right] \quad H_A = -H_E = -P$$

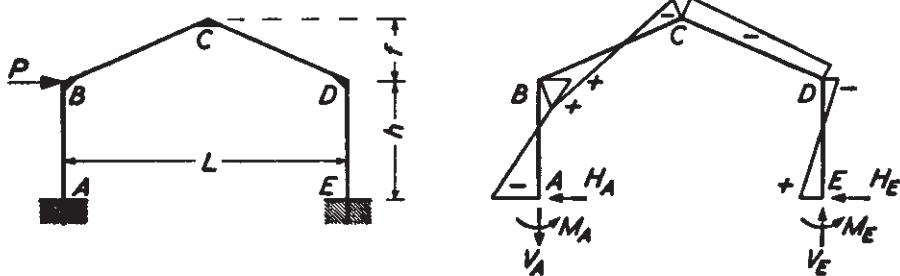
Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$M_A = M_E = \frac{3PL(k + 2k\phi + \phi)}{4N_1}$$

$$M_B = M_D = -\frac{3PLkm}{2N_1}$$

$$M_C = \frac{PL}{4} - \phi M_A + m M_B \quad V_A = V_E = P/2 \quad H_A = H_E = \frac{M_A - M_B}{h}$$

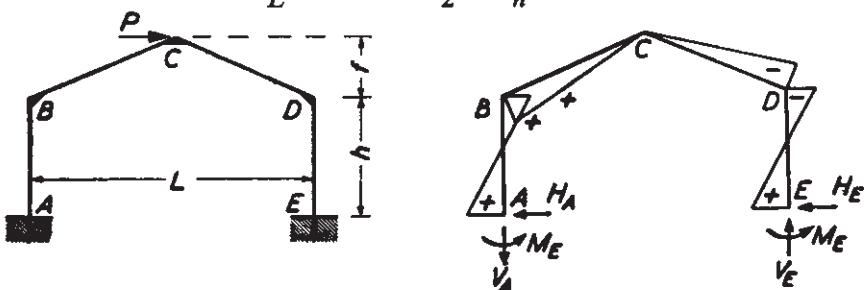


$$\text{Constants: } X_1 = \frac{3Pf(k + 2\phi k + \phi)}{2N_1} \quad X_2 = \frac{3Pfmk}{N_1} \quad X_3 = \frac{PhB}{2N_2}$$

$$M_A = -X_1 - X_3 \quad M_B = +X_2 + \left(\frac{Ph}{2} - X_3\right) \quad M_C = -\frac{Pf}{2} + \phi X_1 + m X_2$$

$$M_E = -X_1 + X_3 \quad M_D = +X_2 - \left(\frac{Ph}{2} - X_3\right)$$

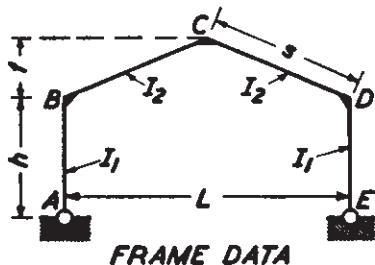
$$V_A = -V_E = -\frac{Ph - 2X_3}{L} \quad H_E = \frac{P}{2} - \frac{X_1 + X_2}{h} \quad H_A = -(P - H_E)$$



$$M_A = -M_E = -\frac{PhB}{2N_2} \quad M_B = -M_D = +\frac{3Phk}{2N_2} \quad M_C = 0$$

$$V_A = -V_E = -\frac{P(h+f) + 2M_A}{L} \quad H_A = -H_E = -\frac{P}{2}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

Frame IV

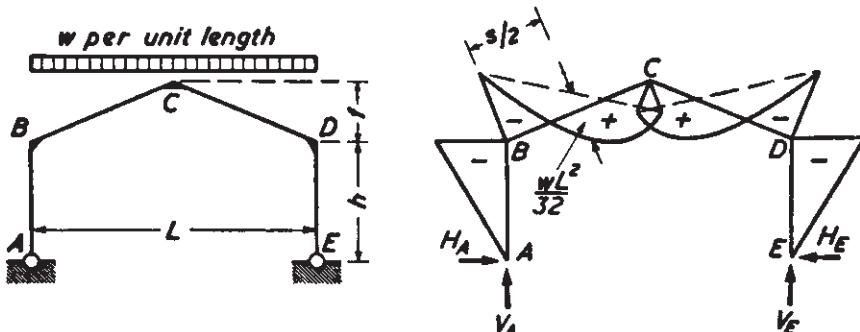
Coefficients:

$$k = \frac{I_2}{I_1} \cdot \frac{h}{s}$$

$$\phi = \frac{f}{h}$$

$$m = 1 + \phi$$

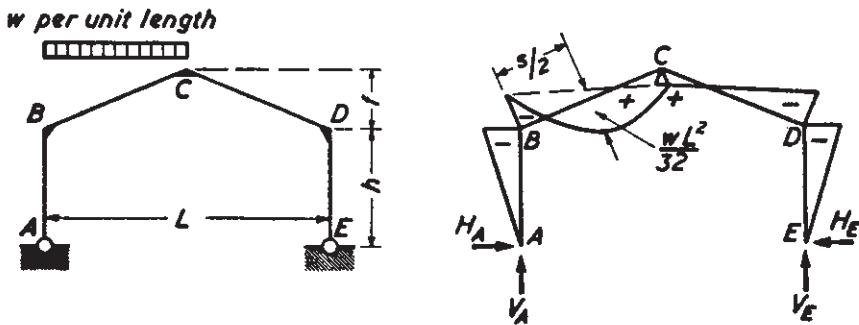
$$B = 2(k + 1) + m \quad C = 1 + 2m \quad N = B + mC$$



$$M_B = M_D = -\frac{wL^2(3 + 5m)}{16N} \quad M_C = \frac{wL^2}{8} + mM_B$$

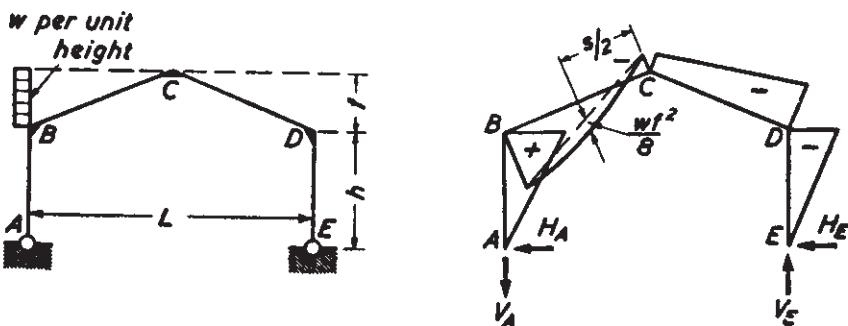
$$H_A = H_E = -\frac{M_B}{h} \quad V_A = V_E = \frac{wL}{2}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$M_B = M_D = -\frac{wL^2(3+5m)}{32N} \quad M_C = \frac{wL^2}{16} + mM_B$$

$$H_A = H_E = -\frac{M_B}{h} \quad V_A = \frac{3wL}{8} \quad V_E = \frac{wL}{8}$$



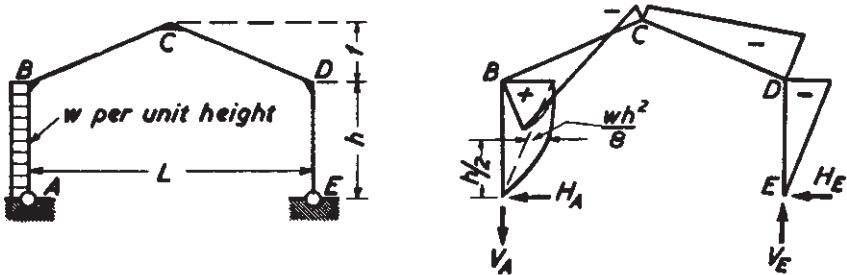
$$\text{Constant: } X = \frac{wf^2(C+m)}{8N}$$

$$M_B = +X + \frac{wfh}{2} \quad M_C = -\frac{wf^2}{4} + mX$$

$$M_D = +X - \frac{wfh}{2} \quad V_A = -V_E = -\frac{wfh(1+m)}{2L}$$

$$H_A = -\frac{X}{h} - \frac{wf}{2} \quad H_E = -\frac{X}{h} + \frac{wf}{2}$$

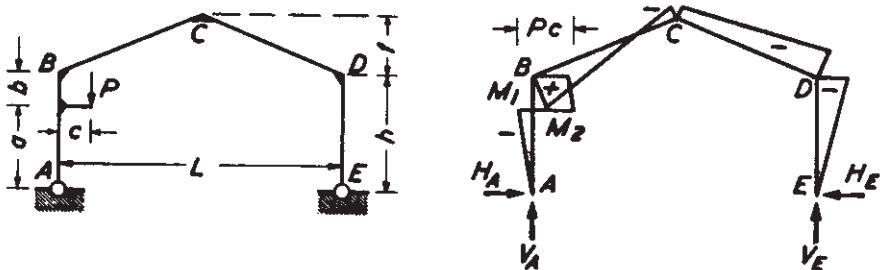
Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



$$M_D = -\frac{wh^2}{8} \cdot \frac{2(B+C)+k}{N} \quad M_B = \frac{wh^2}{2} + M_D$$

$$M_C = \frac{wh^2}{4} + mM_D$$

$$V_A = -V_E = -\frac{wh^2}{2L} \quad H_E = -\frac{M_D}{h} \quad H_A = -(wh - H_E)$$



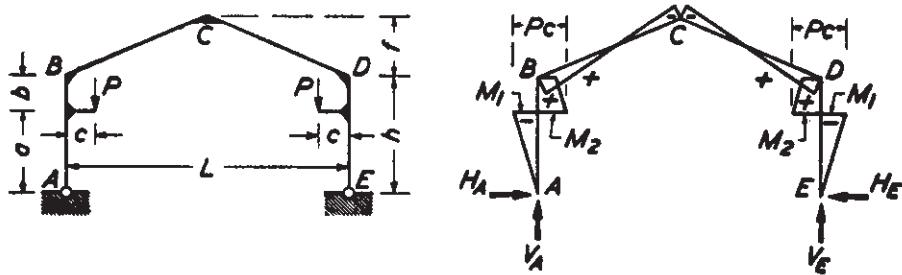
$$\text{Constants: } a_1 = \frac{a}{h} \quad X = \frac{Pc}{2} \cdot \frac{B+C-k(3a_1^2-1)}{N}$$

$$M_B = P_c - X \quad M_D = -X \quad M_C = \frac{Pc}{2} - mX$$

$$M_1 = -a_1 X \quad M_2 = P_c - a_1 X$$

$$V_E = \frac{Pc}{L} \quad V_A = P - V_E \quad H_A = H_E = \frac{X}{h}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

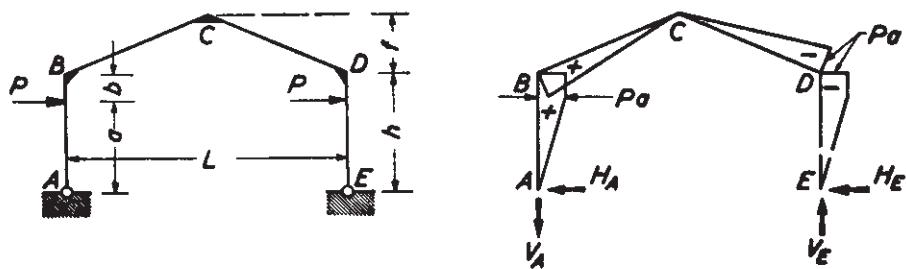


$$\text{Constant: } a_1 = \frac{a}{h}$$

$$M_B = M_D = P c \cdot \frac{\phi C + k(3a_1^2 - 1)}{N} \quad M_C = -\phi P c + m M_B$$

$$H_A = H_E = \frac{P c - M_B}{h} \quad V_A = V_E = P$$

$$M_1 = -a_1(Pc - M_B) \quad M_2 = (1 - a_1)Pc + a_1 M_B$$

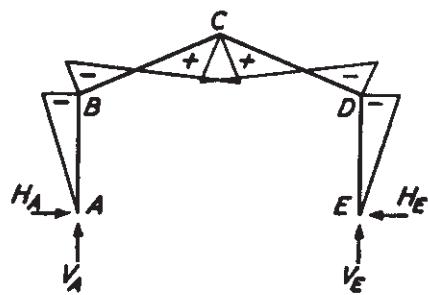
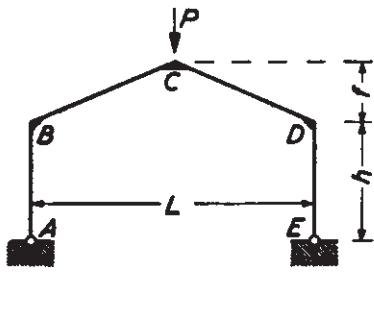


$$M_B = -M_D = Pa \quad M_C = 0$$

$$H_A = -H_E = -P \quad V_A = -V_E = -\frac{2Pa}{L}$$

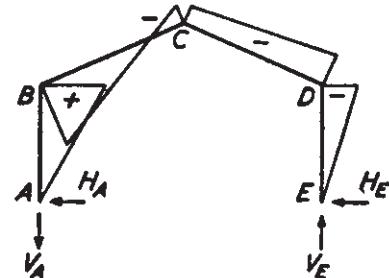
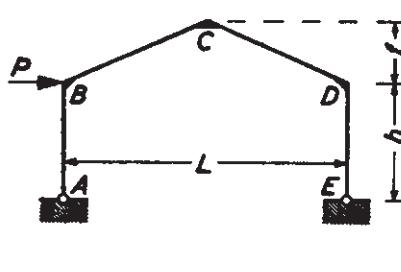
Moment at loads = $\pm Pa$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.



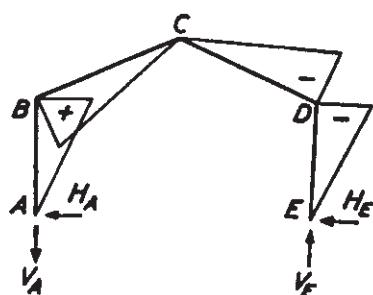
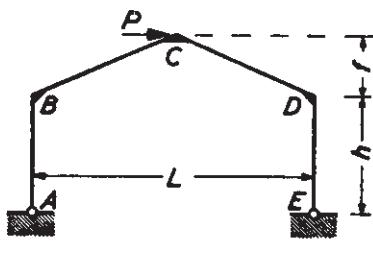
$$M_B = M_D = -\frac{PL}{4} \cdot \frac{C}{N} \quad M_C = +\frac{PL}{4} \cdot \frac{B}{N}$$

$$V_A = V_E = \frac{P}{2} \quad H_A = H_E = -\frac{M_B}{h}$$



$$M_D = -\frac{Ph(B+C)}{2N} \quad M_B = Ph + M_D \quad M_C = \frac{Ph}{2} + mM_D$$

$$V_A = -V_E = -\frac{Ph}{L} \quad H_E = -\frac{M_D}{h} \quad H_A = -(P - H_E)$$



$$M_B = -M_D = +\frac{Ph}{2} \quad M_C = 0 \quad V_A = -V_E = -\frac{Phm}{L} \quad H_A = -H_E = -\frac{P}{2}$$

Extract: 'Kleinlogel, Rahmenformeln' 11. Auflage Berlin—Verlag von Wilhelm Ernst & Sohn.

Explanatory notes on section dimensions and properties, bolts and welds

1 General

The symbols used in this section are generally the same as those in BS 5950-1:2000.^[1]

1.1 Material, section dimensions and tolerances

The structural sections referred to in this design guide are of weldable structural steels conforming to the relevant British Standards given in the table below:

Table – Structural steel products

| Product | Technical delivery requirements | | Dimensions | Tolerances | |
|--|---|------------------------------|-------------------------------|---|--|
| | Non-alloy steels | Fine grain steels | | | |
| Universal beams, universal columns, and universal bearing piles | BS EN 10025 ^[2] | BS EN 10113-1 ^[3] | BS 4-1 ^[4] | BS EN 10034 ^[5] | |
| Joists | | | BS 4-1 ^[4] | BS 4-1 ^[4] BS EN 10024 ^[6] | |
| Parallel flange channels | | | BS 4-1 ^[4] | BS EN 10279 ^[7] | |
| Angles | | | BS EN 10056-1 ^[8] | BS EN 10056-2 ^[8] | |
| Structural tees cut from universal beams and universal columns | | | Bs 4-1 ^[4] | – | |
| Castellated universal beams Castellated universal columns | | | – | – | |
| ASB (asymmetric beams) Slimdek® beam | Generally BS EN 10025 ^[2] , but see note b) | | See note a) | Generally BS EN 10034 ^[5] , but also see note b) | |
| Hot finished hollow sections | BS EN 10210-1 ^[9] | | BS EN 10210-2 ^[9] | BS EN 10210-2 ^[9] | |
| Cold formed hollow sections | BS EN 10219-1 ^[10] | | BS EN 10219-2 ^[10] | BS EN 10219-2 ^[10] | |
| Notes: For full details of the British Standards, see the reference list at the end of the Explanatory Notes. a) See Corus publication. ^[11] b) For further details consult Corus. | | | | | |

1.2 Dimensional units

The dimensions of sections are given in millimetres (mm).

1.3 Property units

Generally, the centimetre (cm) is used for the calculated properties but for surface areas and for the warping constant (H), the metre (m) and the decimetre (dm) respectively are used.

$$\begin{aligned} \text{Note: } 1 \text{ dm} &= 0.1 \text{ m} & = & 100 \text{ mm} \\ 1 \text{ dm}^6 &= 1 \times 10^{-6} \text{ m}^6 & = & 1 \times 10^{12} \text{ mm}^6 \end{aligned}$$

1.4 Mass and force units

The units used are the kilogram (kg), the newton (N) and the metre per second² (m/s²) so that $1 \text{ N} = 1 \text{ kg} \times 1 \text{ m/s}^2$. For convenience, a standard value of the acceleration due to gravity has been generally accepted as 9.80665 m/s². Thus, the force exerted by 1 kg under the action of gravity is 9.80665 N and the force exerted by 1 tonne (1000 kg) is 9.80665 kilonewtons (kN).

2 Dimensions of sections

2.1 Masses

The masses per metre have been calculated assuming that the density of steel is 7850 kg/m³.

In all cases, including compound sections, the tabulated masses are for the steel section alone and no allowance has been made for connecting material or fittings.

2.2 Ratios for local buckling

The ratios of the flange outstand to thickness (b/T) and the web depth to thickness (d/t) are given for I, H and channel sections. The ratios of the outside diameter to thickness (D/t) are given for circular hollow sections. The ratios d/t and b/t are also given for square and rectangular hollow sections. All the ratios for local buckling have been calculated using the dimensional notation given in Figure 5 of

BS 5950-1: 2000 and are for use when element and section class are being checked to the limits given in Tables 11 and 12 of BS 5950-1: 2000.

2.3 Dimensions for detailing

The dimensions C , N and n have the meanings given in the figures at the heads of the tables and have been calculated according to the formulae below. The formulae for N and C make allowance for rolling tolerances, whereas the formulae for n make no such allowance.

2.3.1 Universal beams, universal columns and bearing piles

$$N = \frac{(B-t)}{2} + 10 \text{ mm} \quad (\text{rounded to the nearest 2 mm above})$$

$$n = \frac{(D-d)}{2} \quad (\text{rounded to the nearest 2 mm above})$$

$$C = \frac{t}{2} + 2 \text{ mm} \quad (\text{rounded to the nearest mm})$$

2.3.2 Joists

$$N = \frac{(B-t)}{2} + 6 \text{ mm} \quad (\text{rounded to the nearest 2 mm above})$$

$$n = \frac{(D-d)}{2} \quad (\text{rounded to the nearest 2 mm above})$$

$$C = \frac{t}{2} + 2 \text{ mm} \quad (\text{rounded to the nearest mm})$$

Note: Flanges of BS 4-1 joists have an 8° taper.

2.3.3 Parallel flange channels

$$N = (B-t) + 6 \text{ mm} \quad (\text{rounded up to the nearest 2 mm above})$$

$$n = \frac{(D-d)}{2} \quad (\text{taken to the next higher multiple of 2 mm})$$

$$C = t + 2 \text{ mm} \quad (\text{rounded up to the nearest mm})$$

2.3.4 Castellated sections

The depth of the castellated section, D_c , is given by:

$$D_c = D + D_s/2$$

where D is the actual depth of the original section

D_s is the serial depth of the original section, except that $D_s = 381$ mm for 356×406 UCs.

3 Section properties

3.1 General

All section properties have been accurately calculated and rounded to three significant figures. They have been calculated from the metric dimensions given in the appropriate standards (see section 1.2). For angles, BS EN 10056-1 assumes that the toe radius equals half the root radius.

3.2 Sections other than hollow sections

3.2.1 Second moment of area (I)

The second moment of area of the section, often referred to as moment of inertia, has been calculated taking into account all tapers, radii and fillets of the sections.

3.2.2 Radius of gyration (r)

The radius of gyration is a parameter used in buckling calculation and is derived as follows:

$$r = \left[\frac{I}{A} \right]^{1/2}$$

where A is the cross-sectional area.

For castellated sections, the radius of gyration given is calculated at the net section as required in design to BS 5950-1: 2000.

3.2.3 Elastic modulus (Z)

The elastic modulus is used to calculate the elastic moment capacity based on the design strength of the section or the stress at the extreme fibre of the section from a known moment. It is derived as follows:

$$Z = \frac{1}{y}$$

where y is the distance to the extreme fibre of the section from the elastic neutral axis.

For castellated sections, the elastic moduli given are those at the net section. The elastic moduli of the tee are calculated at the outer face of the flange and toe of the tee formed at the net section.

For parallel flange channels, the elastic modulus about the minor ($y-y$) axis is given at the toe of the section, i.e.

$$y = B - c_y$$

where B is the width of the section

c_y is the distance from the back of the web to the centroidal axis.

For angles, the elastic moduli about both axes are given at the toes of the section, i.e.

$$y_x = A - c_x$$

$$y_y = B - c_y$$

Where A is the leg length perpendicular to the $x-x$ axis

B is the leg length perpendicular to the $y-y$ axis

C_x is the distance from the back of the angle to the centre of gravity, referred to as the $x-x$ axis

C_y is the distance from the back of the angle to the centre of gravity, referred to as the $y-y$ axis.

3.2.4 Buckling parameter (u) and torsional index (x)

The buckling parameter and torsional index used in buckling calculations are derived as follows:

- (1) For bi-symmetric flanged sections and flanged sections symmetrical about the minor axis only:

$$u = [(4S_x^2\gamma)/(A^2h^2)]^{1/4}$$

$$x = 0.566h[A/J]^{1/2}$$

- (2) For flanged sections symmetric about the major axis only:

$$u = [(I_y S_x^2\gamma)/(A^2H)]^{1/4}$$

$$x = 1.132[(A H)/(I_y J)]^{1/2}$$

where S_x is the plastic modulus about the major axis

$$\gamma = \left[1 - \frac{I_y}{I_x} \right]$$

I_x is the second moment of area about the major axis

I_y is the second moment of area about the minor axis

A is the cross-sectional area

h is the distance between shear centres of flanges (for T sections, h is the distance between the shear centre of the flange and the toe of the web)

H is the warping constant

J is the torsion constant.

3.2.5 Warping constant (H) and torsion constant (J)

(1) I and H sections

The warping constant and torsion constant for I and H sections are calculated using the formulae given in the SCI publication P057 *Design of members subject to combined bending and torsion*.^[12]

(2) Tee-sections

For tee-sections cut from UB and UC sections, the warping constant (H) and torsion constant (J) have been derived as given below.

$$H = \frac{1}{144} T^3 B^3 + \frac{1}{36} \left(d - \frac{T}{2} \right)^3 t^3$$

$$J = \frac{1}{3} BT^3 + \frac{1}{3} (d - T)t^3 + \alpha_1 D_1^4 - 0.21 T^4 - 0.105 t^3$$

$$\text{where } \alpha_1 = -0.042 + 0.2204 \frac{t}{T} + 0.1355 \frac{r}{T} - 0.0865 \frac{t r}{T^2} - 0.0725 \frac{t^2}{T^2}$$

$$D_1 = \frac{(T+r)^2 + (r+0.25t)t}{2r+T}$$

Note: These formulae do not apply to tee-sections cut from joists which have tapered flanges. For such sections, details are given in SCI publication 057.^[12]

(3) Parallel flange channels

For parallel flange channels, the warping constant (H) and torsion constant (J) are calculated as follows:

$$H = \frac{h^2}{4} \left[I_y - A \left(c_y - \frac{t}{2} \right)^2 \left(\frac{h^2 A}{4I_x} - 1 \right) \right]$$

$$J = \frac{2}{3} BT^3 + \frac{1}{3} (D - 2T)t^3 + 2\alpha_3 D_3^4 - 0.42 T^4$$

where c_y = is the distance from the back of the web to the centroidal axis

$$\alpha_3 = -0.0908 + 0.2621 \frac{t}{T} + 0.1231 \frac{r}{T} - 0.0752 \frac{t r}{T^2} - 0.0945 \left(\frac{t}{T} \right)^2$$

$$D_3 = 2[(3r+t+T) - \sqrt{2(2r+t)(2r+T)}]$$

Note: The formula for the torsion constant (J) is applicable to parallel flange channels only and does not apply to tapered flange channels.

(4) Angles

For angles, the torsion constant (J) is calculated as follows:

$$J = \frac{1}{3}bt^3 + \frac{1}{3}(d-t)t^3 + \alpha_3 D_3^4 - 0.21t^4$$

where $\alpha_3 = 0.0768 + 0.0479 \frac{r}{t}$

$$D_3 = 2[(3r+2t) - \sqrt{2(2r+t)^2}]$$

(5) ASB sections

For ASB (asymmetric beams) Slimdek® beam, the warping constant (H) and torsion constant (J) are as given in Corus brochure, *Structural sections*.^[11]

3.2.6 Plastic modulus (S)

The full plastic moduli about both principal axes are tabulated for all sections except angle sections. For angle sections, BS 5950-1: 2000 requires design using the elastic modulus.

The reduced plastic moduli under axial load are tabulated for both principal axes for all sections except asymmetric beams and angle sections. For angle sections, BS 5950-1: 2000 requires design using the elastic modulus.

When a section is loaded to full plasticity by a combination of bending and axial compression about the major axis, the plastic neutral axis shifts and may be located either in the web or in the tension flange (or in the taper part of the flange for a joist) depending on the relative values of bending and axial compression. Formulae giving the reduced plastic modulus under combined loading have to be used, which use a parameter n as follows:

$$n = \frac{F}{A p_y} \quad (\text{This is shown in the member capacity tables as } F/P_z)$$

where F is the factored axial load

A is the cross-sectional area

p_y is the design strength of the steel.

For each section, there is a ‘change’ value of n . Formulae for reduced plastic modulus and the ‘change’ value are given below.

(1) *Universal beams, universal columns and bearing piles*

If the value of n calculated is less than the change value, the plastic neutral axis is in the web and the formula for lower values of n must be used. If n is greater than the change value, the plastic neutral axis lies in the tension flange and the formula for higher values of n must be used. The same principles apply when the sections are loaded axially and bent about the minor axis, lower and higher values of n indicating that the plastic neutral axis lies inside or outside the web respectively.

Major axis bending:

Reduced plastic modulus: Change value:

$$\begin{aligned} S_{rx} &= K_1 - K_2 n^2 & \text{for } n < \frac{(D-2T)t}{A} \\ S_{rx} &= K_3(1-n)(K_4 + n) & \text{for } n \geq \frac{(D-2T)t}{A} \end{aligned}$$

$$\begin{aligned} \text{where } K_1 &= S_x & K_2 &= \frac{A^2}{4t} \\ K_3 &= \frac{A^2}{4B} & K_4 &= \frac{2DB}{A} - 1 \end{aligned}$$

Minor axis bending:

Reduced plastic modulus: Change value:

$$\begin{aligned} S_{ry} &= K_1 - K_2 n^2 & \text{for } n < \frac{tD}{A} \\ S_{ry} &= K_3(1-n)(K_4 + n) & \text{for } n \geq \frac{tD}{A} \end{aligned}$$

$$\begin{aligned} \text{where } K_1 &= S_y & K_2 &= \frac{A^2}{4D} \\ K_3 &= \frac{A^2}{8T} & K_4 &= \frac{4BT}{A} - 1 \end{aligned}$$

(2) *Joists*

Major axis bending:

If the value of n calculated is less than the lower change value (n_1), the plastic neutral axis is in the web and the formula for lower values of n must be used. If n is greater than the higher change value (n_2), the plastic neutral axis lies in

the part of the tension flange that is not tapered and the formula for higher values of n must be used. If the value of n calculated lies between the lower change value (n_1) and the higher change value (n_2), the plastic neutral axis lies in the tapered part of the flange and then a linear interpolation between the two formulae is used to calculate the reduced plastic modulus.

| Reduced plastic modulus | Change value |
|---|---|
| $S_{rx} = S_{rx1} = K_1 - K_2 n^2$ | for $n \leq n_1 = \left\{ \frac{D}{A} - \frac{2}{A} \left(T + \frac{B-t}{4} \tan(\theta) \right) \right\} t$ |
| $S_{rx} = S_{rx2} = K_3(1-n)(K_4+n)$ | for $n \geq n_2 = 1 - \frac{2B}{A} \left(T - \frac{B-t}{4} \tan(\theta) \right)$ |
| $S_{rx} = S_{rx1} + (S_{rx2} - S_{rx1}) \left(\frac{n - n_1}{n_2 - n_1} \right)$ | for $n_1 < n < n_2$ |
| where $K_1 = S_x$ | $K_2 = \frac{A^2}{4t}$ |
| $K_3 = \frac{A^2}{4B}$ | $K_4 = \frac{2DB}{A} - 1$ |
| $\theta = 8^\circ$ (flange taper) | |

Minor axis bending:

The same principles apply when the sections are loaded axially and bent about the minor axis, lower and higher values of n indicating that the plastic neutral axis lies inside or outside the web respectively.

| Reduced plastic modulus | Change value |
|-----------------------------|---------------------------|
| $S_{ry} = K_1 - K_2 n^2$ | for $n < \frac{tD}{A}$ |
| $S_{ry} = K_3(1-n)(K_4+n)$ | for $n \geq \frac{tD}{A}$ |
| where $K_1 = S_y$ | $K_2 = \frac{A^2}{4D}$ |
| $K_3 = 0.87 \frac{A^2}{8T}$ | $K_4 = \frac{4BT}{A} - 1$ |

(3) *Parallel flange channels*

Major axis bending:

If the value of n calculated is less than the change value, the plastic neutral axis is in the web and the formula for lower values of n must be used. If n is greater

than the change value, the plastic neutral axis lies in the flange and the formula for higher values of n must be used.

| | |
|----------------------------|--------------------------------|
| Reduced plastic modulus | Change value |
| $S_{rx} = K_1 - K_2 n^2$ | for $n < \frac{(D-2T)t}{A}$ |
| $S_{rx} = K_3(1-n)(K_4+n)$ | for $n \geq \frac{(D-2T)t}{A}$ |
| where $K_1 = S_x$ | $K_2 = \frac{A^2}{4t}$ |
| $K_3 = \frac{A^2}{4B}$ | $K_4 = \frac{2DB}{A} - 1$ |

Minor axis bending:

In calculating the reduced plastic modulus of a channel for axial force combined with bending about the minor axis, the axial force is considered as acting at the centroidal axis of the cross-section whereas it is considered to be resisted at the plastic neutral axis. The value of the reduced plastic modulus takes account of the resulting moment due to eccentricity relative to the net centroidal axis.

The reduced plastic modulus of a parallel flange channel bending about the minor axis depends on whether the stresses induced by the axial force and applied moment are the same or of opposite kind towards the back of the channel. Where the stresses are of the same kind, an initial increase in axial force may cause a small initial rise of the 'reduced' plastic modulus, due to the eccentricity of the axial force.

For each section there is again a change value of n . For minor axis bending the position of the plastic neutral axis when there is no axial load may be either in the web or in the flanges. When the value of n is less than the change value, the formula for lower values of n must be used. If n is greater than the change value, the formula for higher values of n must be used.

The formulae concerned are complex and are therefore not quoted here.

3.2.7 Equivalent slenderness coefficient (ϕ_a) and monosymmetry index (ψ_a)

The equivalent slenderness coefficient (ϕ_a) is tabulated for both equal and unequal angles. Two values of the equivalent slenderness coefficient are given for each unequal angle. The larger value is based on the major axis elastic modulus (Z_u) to the toe of the short leg and the lower value is based on the major axis elastic modulus to the toe of the long leg.

The equivalent slenderness coefficient (ϕ_a) is calculated as follows:

$$\phi_a = \left[\frac{Z_u^2 \gamma_a}{AJ} \right]^{0.5}$$

Definitions of all the individual terms are given in BS 5950-1^[1], clause B.2.9.

The monosymmetry index (ψ_a) is only applicable for unequal angles and is calculated as follows:

$$\psi_a = \left[2v_0 - \frac{\int v_i(u_i^2 + v_i^2)dA}{I_u} \right] \frac{1}{t}$$

Definitions of all the individual terms are given in BS 5950-1^[1], Clause B.2.9.

3.3 Hollow sections

Section properties are given for both hot-finished and cold-formed hollow sections. The ranges of hot-finished and cold-formed sections covered are different. The section ranges listed are in line with sections that are readily available from the major section manufacturers. For the same overall dimensions and wall thickness, the section properties for hot-finished and cold-formed sections are different because the corner radii are different.

3.3.1 Common properties

For comment on second moment of area, radius of gyration and elastic modulus, see sections 3.2.1, 3.2.2 and 3.2.3.

For hot-finished square and rectangular hollow sections, the sectional properties have been calculated, using corner radii of $1.5t$ externally and $1.0t$ internally, as specified by BS EN 10210-2.^[9]

For cold-formed square and rectangular hollow sections, the sectional properties have been calculated, using the external corner radii of $2t$ if $t \leq 6\text{ mm}$, $2.5t$ if $6\text{ mm} < t \leq 10\text{ mm}$ and $3t$ if $t > 10\text{ mm}$ as specified by BS EN 10219-2.^[10] The internal corner radii used are $1.0t$ if $t \leq 6\text{ mm}$, $1.5t$ if $6\text{ mm} < t \leq 10\text{ mm}$ and $2t$ if $t > 10\text{ mm}$, as specified by BS EN 10219-2.^[10]

3.3.2 Torsion constant (J)

For circular hollow sections:

$$J = 2I$$

For square and rectangular hollow sections:

$$J = \frac{4A_h^2 t}{h} + \frac{t^3 h}{3}$$

where I is the second moment of area
 t is the thickness of section
 h is the mean perimeter = $2 [(B - t) + (D - t)] - 2 R_c (4 - \pi)$
 A_h is the area enclosed by mean perimeter = $(B - t)(D - t) - R_c^2 (4 - \pi)$
 B is the breadth of section
 D is the depth of section
 R_c is the average of internal and external corner radii.

3.3.3 Torsion modulus constant (C)

For circular hollow sections

$$C = 2Z$$

For square and rectangular hollow sections

$$C = J / \left(t + \frac{2A_h}{h} \right)$$

where Z is the elastic modulus and J, t, A_h and h are as defined in section 3.3.2.

3.3.4 Plastic modulus of hollow sections (S)

The full plastic modulus (S) is given in the tables. When a member is subject to a combination of bending and axial load the plastic neutral axis shifts. Formulae giving the reduced plastic modulus under combined loading have to be used, which use the parameter n as defined below.

$$n = \frac{F}{Ap_y} \quad (\text{This is shown in the member capacity tables as } F/P_z)$$

where F is the factored axial load

A is the cross-sectional area

p_y is the design strength of the steel.

For square and rectangular hollow sections there is a ‘change’ value of n . Formulae for reduced plastic modulus and ‘change’ value are given below.

(1) Circular hollow sections

$$S_r = S \cos\left(\frac{n\pi}{2}\right)$$

(2) *Square and rectangular hollow sections*

If the value of n calculated is less than the change value, the plastic neutral axis is in the webs and the formula for lower values of n must be used. If n is greater than the change value, the plastic neutral axis lies in the flange and the formula for higher values of n must be used.

Major axis bending:

| | |
|-------------------------|--------------|
| Reduced plastic modulus | Change value |
|-------------------------|--------------|

$$S_{rx} = S_x - \frac{A^2 n^2}{8t} \quad \text{for } n \leq \frac{2t(D-2t)}{A}$$

$$S_{rx} = \frac{A^2}{4(B-t)}(1-n)\left[\frac{2D(B-t)}{A} + n - 1\right] \quad \text{for } n > \frac{2t(D-2t)}{A}$$

Minor axis bending:

| | |
|-------------------------|--------------|
| Reduced plastic modulus | Change value |
|-------------------------|--------------|

$$S_{ry} = S_y - \frac{A^2 n^2}{8t} \quad \text{for } n \leq \frac{2t(B-2t)}{A}$$

$$S_{ry} = \frac{A^2}{4(D-t)}(1-n)\left[\frac{2B(D-t)}{A} + n - 1\right] \quad \text{for } n > \frac{2t(B-2t)}{A}$$

where S, S_x, S_y are the full plastic moduli about the relevant axes

A is the gross cross-sectional area

D, B and t are as defined in section 3.3.2.

4 Bolts and welds

4.1 Bolt capacities

The types of bolts covered are:

- Grades 4.6, 8.8 and 10.9, as specified in BS 4190:^[13] *ISO metric black hexagon bolts, screws and nuts*.
- Non-preloaded and preloaded HSFG bolts as specified in BS 4395:^[14] *High strength friction grip bolts and associated nuts and washers for structural engineering*. Part 1: *General grade* and Part 2: *Higher grade*.
Preloaded HSFG bolts should be tightened to minimum shank tension (P_o) as specified in BS 4604.^[15]
- Countersunk bolts as specified in BS 4933:^[16] *ISO metric black cup and countersunk bolts and screws with hexagon nuts*.

Information on assemblies of matching bolts, nuts and washers is given in BS 5950-2.^[1]

- (1) *Non-preloaded bolts*, Ordinary (Grades 4.6, 8.8 and 10.9) and HSFG (General and Higher Grade):

- (a) The tensile stress area (A_t) is obtained from the above standards.
- (b) The tension capacity of the bolt is given by:

$$P_{\text{nom}} = 0.8p_t A_t \quad \text{Nominal} \quad 6.3.4.2$$

$$P_t = p_t A_t \quad \text{Exact} \quad 6.3.4.3$$

where p_t is the tension strength of the bolt. Table 34

- (c) The shear capacity of the bolt is given by:

$$P_s = p_s A_s \quad 6.3.2.1$$

where p_s is the shear strength of the bolt Table 30

A_s is the shear area of the bolt.

In the tables, A_s has been taken as equal to A_t .

The shear capacity given in the tables must be reduced for large packings, large grip lengths, kidney shaped slots or long joints when applicable.

6.3.2.2

6.3.2.3

6.3.2.4

6.3.2.5

- (d) The effective bearing capacity given is the lesser of the bearing capacity of the bolt given by:

$$P_{\text{bb}} = dt_p p_{\text{bb}} \quad 6.3.3.2$$

and the bearing capacity of the connected ply given by:

$$P_{\text{bs}} = k_{\text{bs}} dt_p p_{\text{bs}} \quad 6.3.3.3$$

assuming that the end distance is greater than or equal to twice the bolt diameter to meet the requirement that $P_{\text{bs}} \leq 0.5 k_{\text{bs}} e t_p p_{\text{bs}}$

where d is the nominal diameter of the bolt

t_p is the thickness of the ply.

For countersunk bolts, t_p is taken as the ply thickness minus half the depth of countersinking. Depth of countersinking is taken as half the bolt diameter based on a 90° countersink.

6.3.3.2

p_{bb} is the bearing strength of the bolt Table 31

p_{bs} is the bearing strength of the ply Table 32

e is the end distance
 k_{bs} is a coefficient to allow for hole type. 6.3.3.3

Tables assume standard clearance holes, therefore k_{bs} is taken as 1.0. For oversize holes and short slots, $k_{bs} = 0.7$. For long slots and kidney shaped slots, $k_{bs} = 0.5$.

- (2) *Preloaded HSFG bolts* (general grade and higher grade): 6.4

(a) The proof load of the bolt (P_o) is obtained from BS 4604.^[19] The same proof load is used for countersunk bolts as for non-countersunk bolts. For this to be acceptable the head dimensions must be as specified in BS 4933.^[20]

- (b) The tension capacity (P_t) of the bolt is taken as: 6.4.5

1.1 P_o for non-slip in service

0.9 P_o for non-slip under factored load

- (c) The slip resistance of the bolt is given by: 6.4.2

$P_{SL} = 1.1 K_s \mu P_o$ for non-slip in service

$P_{SL} = 0.9 K_s \mu P_o$ for non-slip under factored load

where K_s is taken as 1.0 for fasteners in standard clearance holes

6.4.2

μ is the slip factor.

Table 35

- (d) The bearing resistance is only applicable for non-slip in service and is taken as:

$$P_{bg} = 1.5 dt_p p_{bs} \quad 6.4.4$$

assuming that the end distance is greater than or equal to three times the bolt diameter, to meet the requirement that $P_{bg} \leq 0.5 et_p p_{bs}$.

where d is the nominal diameter of the bolt

t_p is the thickness of the ply

p_{bs} is the bearing strength of the ply.

Table 32

- (e) The shear capacity of the bolt is given by: 6.4.1(a)

$$P_s = p_s A_s \quad 6.3.2.1$$

where p_s is the shear strength of the bolt

A_s is the shear area of the bolt

Table 30

In the tables, A_s has been taken as equal to A_t .

4.2 Welds

Capacities of longitudinal and transverse fillet welds per unit length are tabulated. The weld capacities are given by:

$$\text{Longitudinal shear capacity, } P_L = p_w a \quad 6.8.7.3$$

$$\text{Transverse capacity, } P_T = K p_w a$$

where p_w is the weld design strength Table 37

a is the throat thickness, taken as $0.7 \times$ the leg length

K is the enhancement factor for transverse welds. 6.8.7.3

The plates are assumed to be at 90° and therefore $K = 1.25$. Electrode classifications of E35 and E42 are assumed for steel grade S275 and S355 respectively. Welding consumables are in accordance with BS EN 440,^[17] BS EN 449,^[18] BS EN 756,^[19] BS EN 758,^[20] or BS EN 1668^[21] as appropriate.

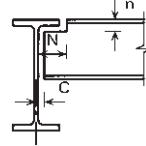
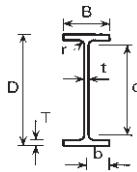
Table 37

References to explanatory notes

1. British Standards Institution
BS 5950 *Structural use of steelwork in building.*
BS 5950-1: 2000 *Code of Practice for design – Rolled and welded sections.*
BS 5950-2: 2000 *Specification for materials, fabrication and erection: Rolled and welded sections.*
2. British Standards Institution
BS EN 10025: 1993 *Hot-rolled products of non-alloy structural steels. Technical delivery conditions* (including amendment 1995).
3. British Standards Institution
BS EN 10113 *Hot-rolled products in weldable fine grain structural steels.*
BS EN 10113-1: 1993 *General delivery conditions* (replaces BS 4360: 1990).
4. British Standards Institution
BS 4 *Structural steel sections.*
BS 4-1: 1993 *Specification for hot rolled sections* (including amendment 2001).
5. British Standards Institution
BS EN 10034: 1993 *Structural steel I and H sections. Tolerances on shape and dimensions* (replaces BS 4-1: 1980).
6. British Standards Institution
BS EN 10024: 1995 *Hot rolled taper flange I sections. Tolerances on shape and dimensions.*
7. British Standards Institution
BS EN 10279: 2002 *Hot-rolled steel channels. Tolerances on shape, dimension and mass* (including amendment 1, amendment 2: 200).

8. British Standards Institution
BS EN 10056 *Specification for structural steel equal and unequal angles.*
BS EN 10056-1: 1999 *Dimensions* (replaces BS 4848-4: 1972).
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BS EN 10210 *Hot-finished structural hollow sections of non-alloy and fine grain structural steels.*
BS EN 10210-1: 1994 *Technical delivery requirements* (replaces BS 4360: 1990).
BS EN 10210-2: 1997 *Tolerances, dimensions and sectional properties* (replaces BS 4848-2: 1991).
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BS EN 10219 *Cold-formed welded structural sections of non-alloy and fine grain steels.*
BS EN 10219-1: 1997 *Technical delivery requirements.*
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The Steel Construction Institute, Ascot, Berks.
13. British Standards Institution
BS 4190: 2001 *ISO metric black hexagon bolts, screws and nuts – Specification.*
14. British Standards Institution
BS 4395 *Specification for high strength friction grip bolts and associated nuts and washers for structural engineering.*
BS 4395-1: 1969 *General grade* (including amendments 1, amendments 2: 1997).
BS 4395-2: 1969 *Higher grade bolts and nuts and general grade washers* (including amendment 1, amendment 2: 1976).
15. British Standards Institution
BS 4604 *Specification for the use of high strength friction grip bolts in structural steelwork. Metric series.*
BS 4604-1: 1970 *General grade* (including amendment 1, amendment 2, and amendment 3: 1982).
BS 4604-2: 1970 – *High grade* (parallel shank) (including amendment 1, amendment 2: 1972).
16. British Standards Institution
BS 4933: 1973 *Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts.*
17. British Standards Institution
BS EN 440: 1995 *Welding consumables. Wire electrodes and deposits for gas shielded metal arc welding of non-alloy and fine grain steels. Classification.*
18. British Standards Institution
BS EN 499: 1995 *Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain. Classification.*

19. British Standards Institution
BS EN 756: 1996 *Welding consumables. Wire electrodes and wire-flux combinations for submerged arc welding of non-alloy and fine grain steels. Classification.*
20. British Standards Institution
BS EN 758: 1997 *Welding consumables. Tubular cored electrodes for metal arc welding with and without a gas shield of non-alloy and fine grain steels. Classification.*
21. British Standards Institution
BS EN 1668: 1997 *Welding consumables. Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine grain steels. Classification.*

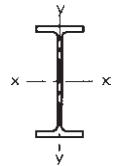
Tables of dimensions and gross section properties**UNIVERSAL BEAMS****DIMENSIONS**

| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Section B mm | Thickness | | Root Radius r mm | Depth between Fillets d mm | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|----------------------|---------------------|-----------------------|-----------------------|-----------|-------------|------------------|----------------------------|---------------------------|---------|--------------------------|------------|--------------------------|--------------------------|------|
| | | | | Web t mm | Flange T mm | | | Flange b/T | Web d/t | End Clearance C mm | Notch N mm | Per Metre m ² | Per Tonne m ² | |
| | | | | | | | | | | | n mm | | | |
| 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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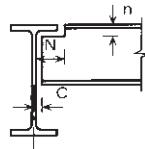
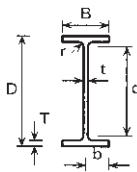


PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter u | Torsional Index x | Warping Constant H dm ⁶ | Torsional Constant J cm ⁴ | Area of Section A cm ² |
|----------------------|-----------------------------|-----------------------------|--------------------|----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------|----------------------|---------------------------------------|---|--------------------------------------|
| | 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 | | | | | |
| 1016 × 305 × 487 # † | 1020000 | 26700 | 40.6 | 6.57 | 19700 | 1730 | 23200 | 2800 | 0.867 | 21.1 | 64.4 | 4300 | 620 |
| 1016 × 305 × 437 # † | 910000 | 23500 | 40.4 | 6.49 | 17700 | 1540 | 20800 | 2470 | 0.868 | 23.1 | 55.9 | 3190 | 557 |
| 1016 × 305 × 393 # † | 808000 | 20500 | 40.2 | 6.40 | 15900 | 1350 | 18500 | 2170 | 0.868 | 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 | 9820 | 784 | 11400 | 1250 | 0.861 | 39.9 | 26.8 | 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 | 37.0 | 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 # | 325000 | 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 | 0.869 | 35.0 | 19.3 | 514 | 289 |
| 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 | 205000 | 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 | 4790 | 29.7 | 5.30 | 4020 | 362 | 4640 | 570 | 0.853 | 49.8 | 6.46 | 119 | 171 |
| 686 × 254 × 170 | 170000 | 6630 | 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 | 638 | 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 | 4590 | 937 | 0.886 | 32.7 | 8.17 | 200 | 190 |
| 610 × 229 × 140 | 112000 | 4510 | 25.0 | 5.03 | 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 | 2290 | 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 |

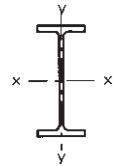
† Section is not given in BS 4-1: 1993.

Check availability.

UNIVERSAL BEAMS**DIMENSIONS**

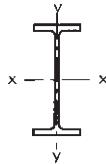
| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Section B mm | Thickness | | Root Radius r mm | Depth between Fillets d mm | Ratios for Local Buckling | | Dimensions for Detailing | | Surface Area | | | | | |
|---------------------|------------------------|--------------------------|--------------------------|-------------|----------------|---------------------|-------------------------------|---------------------------|------------|--------------------------|------|-------------------------|-------|-----------------------------|-----------------------------|--|--|
| | | | | Web t mm | Flange T mm | | | Flange b/T | Web d/t | End Clearance C mm | | Notch N mm n mm | | Per Metre m ² | Per Tonne m ² | | |
| | | | | | | | | | | N mm | n mm | | | | | | |
| 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 | | | |

UNIVERSAL BEAMS



PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter u | Torsional Index x | Warping Constant H dm ⁶ | Torsional Constant J cm ⁴ | Area of Section A cm ² |
|---------------------|--------------------------|--------------------------|--------------------|-------------|--------------------------|--------------------------|--------------------------|--------------------------|----------------------|-------------------|------------------------------------|--------------------------------------|-----------------------------------|
| | 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 | | | | | |
| 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 | 51.8 | 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 | 18.6 | 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 | 448 | 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 | 21.5 | 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 | 0.888 | 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 BEAMS**REDUCED PLASTIC MODULUS UNDER AXIAL LOAD**

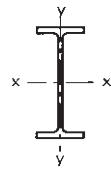
| Section Designation | Plastic Modulus Axis x-x cm ³ | Major Axis Reduced Modulus | | | | | Plastic Modulus Axis y-y cm ³ | Minor Axis Reduced Modulus | | | | | |
|----------------------|---|----------------------------|-------|-----------------------|--------------------|------|---|----------------------------|------|-----------------------|--------------------|----------|--|
| | | Lower Values of n | | Change Formula At n = | Higher Values of n | | | Lower Values of n | | Change Formula At n = | Higher Values of n | | |
| | | K1 | K2 | | K3 | K4 | | K1 | K2 | | K3 | K4 | |
| 1016 × 305 × 487 # † | 23200 | 23200 | 32000 | 0.449 | 3120 | 9.31 | 2800 | 2800 | 928 | 0.501 | 8880 | 0.0768 | |
| 1016 × 305 × 437 # † | 20800 | 20800 | 28800 | 0.448 | 2540 | 10.2 | 2470 | 2470 | 756 | 0.495 | 7910 | 0.0747 | |
| 1016 × 305 × 393 # † | 18500 | 18500 | 25600 | 0.453 | 2060 | 11.3 | 2170 | 2170 | 615 | 0.496 | 7120 | 0.0641 | |
| 1016 × 305 × 349 # † | 16600 | 16600 | 23500 | 0.440 | 1640 | 12.7 | 1940 | 1940 | 491 | 0.478 | 6190 | 0.0858 | |
| 1016 × 305 × 314 # † | 14900 | 14900 | 20900 | 0.443 | 1330 | 14.0 | 1710 | 1710 | 400 | 0.478 | 5570 | 0.0770 | |
| 1016 × 305 × 272 # † | 12800 | 12800 | 18200 | 0.441 | 1000 | 16.1 | 1470 | 1470 | 304 | 0.471 | 4860 | 0.0720 | |
| 1016 × 305 × 249 # † | 11400 | 11400 | 15200 | 0.483 | 837 | 17.6 | 1250 | 1250 | 256 | 0.510 | 4830 | -0.0158 | |
| 1016 × 305 × 222 # † | 9810 | 9810 | 12500 | 0.525 | 667 | 19.6 | 1020 | 1020 | 206 | 0.549 | 4740 | -0.105 | |
| 914 × 419 × 388 # | 17700 | 17700 | 28500 | 0.367 | 1450 | 14.7 | 3340 | 3340 | 663 | 0.399 | 8340 | 0.246 | |
| 914 × 419 × 343 # | 15500 | 15500 | 24600 | 0.376 | 1140 | 16.5 | 2890 | 2890 | 524 | 0.405 | 7470 | 0.225 | |
| 914 × 305 × 289 # | 12600 | 12600 | 17400 | 0.457 | 1100 | 14.5 | 1600 | 1600 | 366 | 0.491 | 5300 | 0.0695 | |
| 914 × 305 × 253 # | 10900 | 10900 | 15100 | 0.462 | 853 | 16.4 | 1370 | 1370 | 284 | 0.492 | 4670 | 0.0561 | |
| 914 × 305 × 224 # | 9540 | 9540 | 12800 | 0.480 | 671 | 18.4 | 1160 | 1160 | 224 | 0.507 | 4270 | 0.0178 | |
| 914 × 305 × 201 # | 8350 | 8350 | 10800 | 0.509 | 540 | 20.4 | 982 | 982 | 181 | 0.533 | 4050 | -0.0424 | |
| 838 × 292 × 226 # | 9160 | 9160 | 12900 | 0.445 | 709 | 16.3 | 1210 | 1210 | 245 | 0.475 | 3880 | 0.0915 | |
| 838 × 292 × 194 # | 7640 | 7640 | 10400 | 0.475 | 521 | 18.9 | 974 | 974 | 181 | 0.501 | 3510 | 0.0283 | |
| 838 × 292 × 176 # | 6810 | 6810 | 8960 | 0.498 | 430 | 20.7 | 842 | 842 | 150 | 0.522 | 3340 | -0.0208 | |
| 762 × 267 × 197 | 7170 | 7170 | 10100 | 0.448 | 586 | 15.5 | 959 | 959 | 204 | 0.479 | 3090 | 0.0863 | |
| 762 × 267 × 173 | 6200 | 6200 | 8490 | 0.467 | 455 | 17.4 | 807 | 807 | 159 | 0.495 | 2810 | 0.0457 | |
| 762 × 267 × 147 | 5160 | 5160 | 6840 | 0.492 | 330 | 20.4 | 647 | 647 | 116 | 0.516 | 2500 | -0.00820 | |
| 762 × 267 × 134 | 4640 | 4640 | 6060 | 0.506 | 275 | 22.2 | 570 | 570 | 97.0 | 0.528 | 2350 | -0.0390 | |
| 686 × 254 × 170 | 5630 | 5630 | 8110 | 0.432 | 459 | 15.3 | 811 | 811 | 170 | 0.463 | 2480 | 0.118 | |
| 686 × 254 × 152 | 5000 | 5000 | 7130 | 0.439 | 370 | 17.0 | 710 | 710 | 137 | 0.468 | 2240 | 0.102 | |
| 686 × 254 × 140 | 4560 | 4560 | 6420 | 0.449 | 314 | 18.4 | 638 | 638 | 116 | 0.475 | 2100 | 0.0806 | |
| 686 × 254 × 125 | 3990 | 3990 | 5440 | 0.474 | 251 | 20.5 | 542 | 542 | 93.8 | 0.497 | 1960 | 0.0280 | |
| 610 × 305 × 238 | 7490 | 7490 | 12500 | 0.348 | 739 | 12.1 | 1570 | 1570 | 362 | 0.386 | 3660 | 0.289 | |
| 610 × 305 × 179 | 5550 | 5550 | 9220 | 0.354 | 423 | 15.7 | 1140 | 1140 | 210 | 0.383 | 2760 | 0.271 | |
| 610 × 305 × 149 | 4590 | 4590 | 7650 | 0.356 | 296 | 18.6 | 937 | 937 | 147 | 0.380 | 2290 | 0.264 | |
| 610 × 229 × 140 | 4140 | 4140 | 6060 | 0.421 | 345 | 14.9 | 611 | 611 | 129 | 0.454 | 1800 | 0.142 | |
| 610 × 229 × 125 | 3680 | 3680 | 5330 | 0.428 | 277 | 16.6 | 535 | 535 | 104 | 0.457 | 1620 | 0.127 | |
| 610 × 229 × 113 | 3280 | 3280 | 4670 | 0.442 | 227 | 18.3 | 469 | 469 | 85.3 | 0.469 | 1500 | 0.0970 | |
| 610 × 229 × 101 | 2880 | 2880 | 3960 | 0.467 | 183 | 20.3 | 400 | 400 | 69.0 | 0.491 | 1400 | 0.0451 | |
| 533 × 210 × 122 | 3200 | 3200 | 4750 | 0.410 | 285 | 13.8 | 500 | 500 | 111 | 0.445 | 1420 | 0.162 | |
| 533 × 210 × 109 | 2830 | 2830 | 4160 | 0.419 | 229 | 15.4 | 436 | 436 | 89.4 | 0.451 | 1280 | 0.142 | |
| 533 × 210 × 101 | 2610 | 2610 | 3830 | 0.421 | 197 | 16.5 | 399 | 399 | 77.1 | 0.450 | 1190 | 0.136 | |
| 533 × 210 × 92 | 2360 | 2360 | 3410 | 0.432 | 165 | 18.0 | 356 | 356 | 64.6 | 0.459 | 1100 | 0.113 | |
| 533 × 210 × 82 | 2060 | 2060 | 2850 | 0.460 | 131 | 20.1 | 300 | 300 | 51.9 | 0.484 | 1040 | 0.0531 | |

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

Check availability.

n = F/(A p_y), where F is the factored axial load, A is the gross cross sectional area and p_y is the design strength of the section.For lower values of n, the reduced plastic modulus, S_r = K1 - K2.n², for both major and minor axis bending.For higher values of n, the reduced plastic modulus, S_r = K3(1 - n)(K4 + n), for both major and minor axis bending.

UNIVERSAL BEAMS

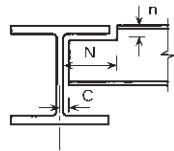
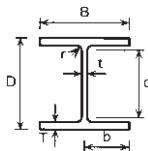


REDUCED PLASTIC MODULUS UNDER AXIAL LOAD

| Section Designation | Plastic Modulus Axis x-x cm³ | Major Axis Reduced Modulus | | | | | | Plastic Modulus Axis y-y cm³ | Minor Axis Reduced Modulus | | | | | |
|---------------------|---------------------------------|----------------------------|------|-----------------------|--------------------|------|-------------------|---------------------------------|----------------------------|--------------------|----------|--|--|--|
| | | Lower Values of n | | Change Formula At n = | Higher Values of n | | Lower Values of n | | Change Formula At n = | Higher Values of n | | | | |
| | | K1 | K2 | | K3 | K4 | K1 | K2 | | K3 | K4 | | | |
| | | | | | | | | | | | | | | |
| 457 × 191 × 98 | 2230 | 2230 | 3440 | 0.390 | 203 | 13.4 | 379 | 379 | 0.425 | 1000 | 0.207 | | | |
| 457 × 191 × 89 | 2010 | 2010 | 3080 | 0.395 | 169 | 14.6 | 338 | 338 | 0.428 | 914 | 0.194 | | | |
| 457 × 191 × 82 | 1830 | 1830 | 2760 | 0.406 | 143 | 15.8 | 304 | 304 | 0.436 | 853 | 0.172 | | | |
| 457 × 191 × 74 | 1650 | 1650 | 2490 | 0.407 | 118 | 17.4 | 272 | 272 | 0.435 | 772 | 0.167 | | | |
| 457 × 191 × 67 | 1470 | 1470 | 2150 | 0.425 | 96.3 | 19.1 | 237 | 237 | 0.451 | 720 | 0.128 | | | |
| 457 × 152 × 82 | 1810 | 1810 | 2600 | 0.430 | 176 | 12.8 | 240 | 240 | 0.468 | 723 | 0.123 | | | |
| 457 × 152 × 74 | 1630 | 1630 | 2320 | 0.435 | 145 | 14.1 | 213 | 213 | 0.469 | 656 | 0.111 | | | |
| 457 × 152 × 67 | 1450 | 1450 | 2030 | 0.450 | 119 | 15.5 | 187 | 187 | 0.482 | 610 | 0.0786 | | | |
| 457 × 152 × 60 | 1290 | 1290 | 1790 | 0.455 | 95.0 | 17.2 | 163 | 163 | 0.483 | 546 | 0.0670 | | | |
| 457 × 152 × 52 | 1100 | 1100 | 1460 | 0.488 | 72.9 | 19.6 | 133 | 133 | 0.513 | 509 | -0.00290 | | | |
| 406 × 178 × 74 | 1500 | 1500 | 2350 | 0.383 | 124 | 14.7 | 267 | 267 | 0.415 | 698 | 0.216 | | | |
| 406 × 178 × 67 | 1350 | 1350 | 2080 | 0.392 | 102 | 16.1 | 237 | 237 | 0.421 | 640 | 0.196 | | | |
| 406 × 178 × 60 | 1200 | 1200 | 1850 | 0.393 | 82.3 | 17.9 | 209 | 209 | 0.420 | 572 | 0.190 | | | |
| 406 × 178 × 54 | 1060 | 1060 | 1540 | 0.425 | 66.9 | 19.8 | 178 | 178 | 0.450 | 545 | 0.124 | | | |
| 406 × 140 × 46 | 888 | 888 | 1260 | 0.442 | 60.5 | 18.6 | 118 | 118 | 0.468 | 384 | 0.0864 | | | |
| 406 × 140 × 39 | 724 | 724 | 963 | 0.491 | 43.5 | 21.7 | 90.8 | 90.8 | 0.513 | 358 | -0.0176 | | | |
| 356 × 171 × 67 | 1210 | 1210 | 2010 | 0.353 | 105 | 13.7 | 243 | 243 | 0.387 | 582 | 0.272 | | | |
| 356 × 171 × 57 | 1010 | 1010 | 1630 | 0.371 | 76.4 | 16.0 | 199 | 199 | 0.400 | 506 | 0.234 | | | |
| 356 × 171 × 51 | 896 | 896 | 1420 | 0.379 | 61.4 | 17.8 | 174 | 174 | 0.405 | 458 | 0.215 | | | |
| 356 × 171 × 45 | 775 | 775 | 1170 | 0.405 | 48.0 | 20.0 | 147 | 147 | 0.429 | 423 | 0.158 | | | |
| 356 × 127 × 39 | 659 | 659 | 938 | 0.440 | 49.1 | 16.9 | 89.1 | 89.1 | 0.469 | 289 | 0.0836 | | | |
| 356 × 127 × 33 | 543 | 543 | 740 | 0.473 | 35.4 | 19.8 | 70.3 | 70.3 | 0.497 | 261 | 0.0120 | | | |
| 305 × 165 × 54 | 846 | 846 | 1500 | 0.325 | 70.8 | 14.1 | 196 | 196 | 0.357 | 431 | 0.330 | | | |
| 305 × 165 × 46 | 720 | 720 | 1290 | 0.323 | 52.1 | 16.3 | 166 | 166 | 0.350 | 366 | 0.331 | | | |
| 305 × 165 × 40 | 623 | 623 | 1100 | 0.331 | 39.9 | 18.5 | 142 | 142 | 0.355 | 323 | 0.312 | | | |
| 305 × 127 × 48 | 711 | 711 | 1040 | 0.416 | 74.8 | 11.7 | 116 | 116 | 0.457 | 335 | 0.146 | | | |
| 305 × 127 × 42 | 614 | 614 | 891 | 0.424 | 57.4 | 13.3 | 98.4 | 98.4 | 0.460 | 295 | 0.127 | | | |
| 305 × 127 × 37 | 539 | 539 | 784 | 0.426 | 45.1 | 14.9 | 85.4 | 85.4 | 0.458 | 260 | 0.119 | | | |
| 305 × 102 × 33 | 481 | 481 | 663 | 0.459 | 42.7 | 14.3 | 60.0 | 60.0 | 0.493 | 202 | 0.0576 | | | |
| 305 × 102 × 28 | 403 | 403 | 536 | 0.487 | 31.6 | 16.5 | 48.5 | 48.5 | 0.516 | 183 | -0.00120 | | | |
| 305 × 102 × 25 | 342 | 342 | 431 | 0.534 | 24.6 | 18.6 | 38.8 | 38.8 | 0.560 | 178 | -0.100 | | | |
| 254 × 146 × 43 | 566 | 566 | 1040 | 0.308 | 50.9 | 13.0 | 141 | 141 | 0.341 | 295 | 0.366 | | | |
| 254 × 146 × 37 | 483 | 483 | 883 | 0.313 | 38.0 | 14.9 | 119 | 119 | 0.342 | 255 | 0.353 | | | |
| 254 × 146 × 31 | 393 | 393 | 656 | 0.354 | 26.9 | 17.5 | 94.1 | 94.1 | 0.380 | 229 | 0.267 | | | |
| 254 × 102 × 28 | 353 | 353 | 517 | 0.420 | 31.8 | 13.8 | 54.8 | 54.8 | 0.455 | 163 | 0.133 | | | |
| 254 × 102 × 25 | 306 | 306 | 428 | 0.450 | 25.2 | 15.4 | 46.0 | 46.0 | 0.482 | 153 | 0.0686 | | | |
| 254 × 102 × 22 | 259 | 259 | 344 | 0.489 | 19.3 | 17.4 | 37.3 | 37.3 | 0.517 | 144 | -0.0136 | | | |
| 203 × 133 × 30 | 314 | 314 | 570 | 0.314 | 27.3 | 13.5 | 88.2 | 88.2 | 0.346 | 190 | 0.346 | | | |
| 203 × 133 × 25 | 258 | 258 | 448 | 0.334 | 19.2 | 15.9 | 70.9 | 70.9 | 0.362 | 164 | 0.300 | | | |
| 203 × 102 × 23 | 234 | 234 | 400 | 0.339 | 21.2 | 13.1 | 49.8 | 49.8 | 0.373 | 116 | 0.288 | | | |
| 178 × 102 × 19 | 171 | 171 | 307 | 0.321 | 14.5 | 13.8 | 41.6 | 41.6 | 0.352 | 93.1 | 0.318 | | | |
| 152 × 89 × 16 | 123 | 123 | 229 | 0.303 | 11.6 | 12.3 | 31.2 | 31.2 | 0.337 | 67.0 | 0.344 | | | |
| 127 × 76 × 13 | 84.2 | 84.2 | 171 | 0.271 | 8.98 | 10.7 | 22.6 | 22.6 | 0.308 | 44.9 | 0.399 | | | |

$n = F/(A p_y)$, where F is the factored axial load, A is the gross cross sectional area and p_y is the design strength of the section.
For lower values of n , the reduced plastic modulus, $S_r = K_1 - K_2 \cdot n^2$, for both major and minor axis bending.

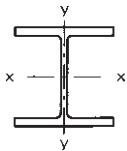
For higher values of n , the reduced plastic modulus, $S_r = K_3(1 - n)(K_4 + n)$, for both major and minor axis bending.

UNIVERSAL COLUMNS**DIMENSIONS**

| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Section B mm | Thickness | | Root Radius r mm | Depth between Fillets d mm | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|---------------------|---------------------|-----------------------|-----------------------|-----------|-------------|------------------|----------------------------|---------------------------|---------|--------------------------|------------|--------------|--------------|------|
| | | | | Web t mm | Flange T mm | | | Flange b/T | Web d/t | End Clearance C mm | Notch N mm | Per Metre m² | Per Tonne m² | |
| | | | | | | | | | | | n mm | | | |
| 356 × 406 × 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 × 406 × 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 × 406 × 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 × 406 × 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 × 406 × 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 × 406 × 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 × 406 × 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 × 368 × 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 × 368 × 177 # | 177.0 | 368.2 | 372.6 | 14.4 | 23.8 | 15.2 | 290.2 | 7.83 | 20.2 | 9 | 190 | 40 | 2.17 | 12.3 |
| 356 × 368 × 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 × 368 × 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 × 305 × 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 × 305 × 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 × 305 × 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 × 305 × 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 × 305 × 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 × 305 × 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 × 305 × 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 × 254 × 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 × 254 × 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 × 254 × 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 × 254 × 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 × 254 × 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 × 203 × 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 × 203 × 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 × 203 × 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 × 203 × 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 × 203 × 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 × 152 × 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 × 152 × 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 |
| 152 × 152 × 23 | 23.0 | 152.4 | 152.2 | 5.8 | 6.8 | 7.6 | 123.6 | 11.2 | 21.3 | 5 | 84 | 16 | 0.889 | 38.7 |

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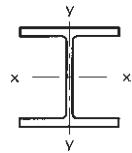


PROPERTIES

| 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 | | | | | |
| 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 | 433 |
| 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 | 4150 | 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 | 8.15 | 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 | 2050 | 692 | 2300 | 1050 | 0.852 | 14.1 | 2.39 | 249 | 174 |
| 305 × 305 × 118 | 27700 | 9060 | 13.6 | 7.77 | 1760 | 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 | 22500 | 7530 | 11.6 | 6.69 | 1630 | 576 | 1870 | 878 | 0.850 | 10.3 | 1.19 | 319 | 168 |
| 254 × 254 × 107 | 17500 | 5930 | 11.3 | 6.59 | 1310 | 458 | 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 | 6.54 | 3.70 | 164 | 52.6 | 182 | 80.2 | 0.840 | 20.7 | 0.0212 | 4.63 | 29.2 |

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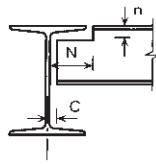
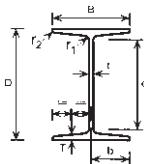
REDUCED PLASTIC MODULUS UNDER AXIAL LOAD

| Section Designation | Plastic Modulus Axis x-x cm ³ | Major Axis Reduced Modulus | | | | Plastic Modulus Axis y-y cm ³ | Minor Axis Reduced Modulus | | | | | |
|---------------------|---|----------------------------|-------|-----------------------|--------------------|---|----------------------------|-------------------|------|-----------------------|--------------------|-------|
| | | Lower Values Of n | | Change Formula At n = | Higher Values Of n | | | Lower Values Of n | | Change Formula At n = | Higher Values Of n | |
| | | K1 | K2 | | K3 | K4 | K1 | K2 | K3 | | K4 | |
| 356 × 406 × 634 # | 14200 | 14200 | 34300 | 0.189 | 3850 | 3.98 | 7110 | 7110 | 3440 | 0.280 | 10600 | 0.617 |
| 356 × 406 × 551 # | 12100 | 12100 | 29300 | 0.192 | 2940 | 4.43 | 6060 | 6060 | 2700 | 0.273 | 9120 | 0.610 |
| 356 × 406 × 467 # | 10000 | 10000 | 24700 | 0.193 | 2150 | 5.05 | 5030 | 5030 | 2030 | 0.263 | 7630 | 0.607 |
| 356 × 406 × 393 # | 8220 | 8220 | 20500 | 0.196 | 1540 | 5.81 | 4150 | 4150 | 1500 | 0.256 | 6370 | 0.600 |
| 356 × 406 × 340 # | 7000 | 7000 | 17600 | 0.197 | 1160 | 6.56 | 3540 | 3540 | 1150 | 0.250 | 5460 | 0.597 |
| 356 × 406 × 287 # | 5810 | 5810 | 14800 | 0.198 | 838 | 7.59 | 2950 | 2950 | 849 | 0.243 | 4580 | 0.593 |
| 356 × 406 × 235 # | 4690 | 4690 | 12200 | 0.197 | 568 | 9.05 | 2380 | 2380 | 588 | 0.234 | 3710 | 0.593 |
| 356 × 368 × 202 # | 3970 | 3970 | 10000 | 0.206 | 441 | 9.91 | 1920 | 1920 | 442 | 0.240 | 3060 | 0.573 |
| 356 × 368 × 177 # | 3460 | 3460 | 8830 | 0.205 | 341 | 11.2 | 1670 | 1670 | 345 | 0.235 | 2670 | 0.573 |
| 356 × 368 × 153 # | 2970 | 2970 | 7710 | 0.202 | 256 | 12.8 | 1440 | 1440 | 262 | 0.229 | 2290 | 0.575 |
| 356 × 368 × 129 # | 2480 | 2480 | 6490 | 0.203 | 183 | 15.0 | 1200 | 1200 | 190 | 0.225 | 1930 | 0.570 |
| 305 × 305 × 283 | 5110 | 5110 | 12100 | 0.206 | 1010 | 5.53 | 2340 | 2340 | 889 | 0.272 | 3680 | 0.577 |
| 305 × 305 × 240 | 4250 | 4250 | 10200 | 0.208 | 734 | 6.34 | 1950 | 1950 | 663 | 0.265 | 3100 | 0.570 |
| 305 × 305 × 198 | 3440 | 3440 | 8340 | 0.210 | 506 | 7.47 | 1580 | 1580 | 469 | 0.257 | 2540 | 0.565 |
| 305 × 305 × 158 | 2680 | 2680 | 6420 | 0.217 | 326 | 9.11 | 1230 | 1230 | 310 | 0.257 | 2030 | 0.545 |
| 305 × 305 × 137 | 2300 | 2300 | 5510 | 0.219 | 246 | 10.4 | 1050 | 1050 | 237 | 0.254 | 1750 | 0.539 |
| 305 × 305 × 118 | 1960 | 1960 | 4700 | 0.221 | 183 | 11.9 | 895 | 895 | 179 | 0.251 | 1510 | 0.531 |
| 305 × 305 × 97 | 1590 | 1590 | 3850 | 0.222 | 125 | 14.2 | 726 | 726 | 124 | 0.247 | 1240 | 0.523 |
| 254 × 254 × 167 | 2420 | 2420 | 5900 | 0.204 | 427 | 6.20 | 1140 | 1140 | 392 | 0.261 | 1790 | 0.580 |
| 254 × 254 × 132 | 1870 | 1870 | 4620 | 0.205 | 270 | 7.59 | 878 | 878 | 256 | 0.251 | 1400 | 0.573 |
| 254 × 254 × 107 | 1480 | 1480 | 3630 | 0.212 | 180 | 9.12 | 697 | 697 | 174 | 0.250 | 1130 | 0.556 |
| 254 × 254 × 89 | 1220 | 1220 | 3120 | 0.205 | 125 | 10.8 | 575 | 575 | 123 | 0.237 | 928 | 0.565 |
| 254 × 254 × 73 | 992 | 992 | 2520 | 0.208 | 85.1 | 12.9 | 465 | 465 | 85.3 | 0.235 | 763 | 0.553 |
| 203 × 203 × 86 | 977 | 977 | 2370 | 0.210 | 144 | 7.48 | 456 | 456 | 135 | 0.257 | 733 | 0.564 |
| 203 × 203 × 71 | 799 | 799 | 2040 | 0.200 | 99.0 | 8.85 | 374 | 374 | 94.7 | 0.239 | 591 | 0.579 |
| 203 × 203 × 60 | 656 | 656 | 1550 | 0.223 | 70.9 | 10.3 | 305 | 305 | 69.6 | 0.258 | 513 | 0.531 |
| 203 × 203 × 52 | 567 | 567 | 1390 | 0.216 | 53.8 | 11.7 | 264 | 264 | 53.3 | 0.246 | 439 | 0.541 |
| 203 × 203 × 46 | 497 | 497 | 1200 | 0.222 | 42.4 | 13.1 | 231 | 231 | 42.4 | 0.249 | 392 | 0.525 |
| 152 × 152 × 37 | 309 | 309 | 694 | 0.236 | 35.9 | 9.61 | 140 | 140 | 34.3 | 0.275 | 241 | 0.508 |
| 152 × 152 × 30 | 248 | 248 | 563 | 0.236 | 23.9 | 11.6 | 112 | 112 | 23.2 | 0.268 | 195 | 0.503 |
| 152 × 152 × 23 | 182 | 182 | 369 | 0.275 | 14.0 | 14.9 | 80.2 | 80.2 | 14.0 | 0.302 | 157 | 0.416 |

Check availability.

n = F/(A p_y), where F is the factored axial load, A is the gross cross sectional area and p_y is the design strength of the section.For lower values of n, the reduced plastic modulus, S_r = K1 - K2.n², for both major and minor axis bending.For higher values of n, the reduced plastic modulus, S_r = K3(1 - n)(K4 + n), for both major and minor axis bending.

JOISTS

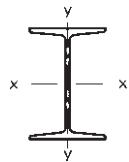


DIMENSIONS

| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Section B mm | Thickness | | Radii | | Depth between Fillets d mm | Ratios for Local Buckling | | Dimensions for Detailing | | Surface Area | | |
|---------------------|---------------------|-----------------------|-----------------------|-----------|-------------|------------------------|-----------------------|----------------------------|---------------------------|---------|--------------------------|------------|--------------------------|--------------------------|------|
| | | | | Web t mm | Flange T mm | Root r ₁ mm | Toe r ₂ mm | | Flange b/T | Web d/t | End Clearance C mm | Notch N mm | Per Metre m ² | Per Tonne m ² | |
| | | | | | | | | | | | | | | | |
| 254 × 203 × 82 # | 82.0 | 254.0 | 203.2 | 10.2 | 19.9 | 19.6 | 9.7 | 166.6 | 5.11 | 16.3 | 7 | 104 | 44 | 1.21 | |
| 254 × 114 × 37 ‡ | 37.2 | 254.0 | 114.3 | 7.6 | 12.8 | 12.4 | 6.1 | 199.3 | 4.46 | 26.2 | 6 | 60 | 28 | 0.899 | 24.2 |
| 203 × 152 × 52 # | 52.3 | 203.2 | 152.4 | 8.9 | 16.5 | 15.5 | 7.6 | 133.2 | 4.62 | 15.0 | 6 | 78 | 36 | 0.932 | 17.8 |
| 152 × 127 × 37 # | 37.3 | 152.4 | 127.0 | 10.4 | 13.2 | 13.5 | 6.6 | 94.3 | 4.81 | 9.07 | 7 | 66 | 30 | 0.737 | 19.8 |
| 127 × 114 × 29 # | 29.3 | 127.0 | 114.3 | 10.2 | 11.5 | 9.9 | 4.8 | 79.5 | 4.97 | 7.79 | 7 | 60 | 24 | 0.646 | 22.0 |
| 127 × 114 × 27 # | 26.9 | 127.0 | 114.3 | 7.4 | 11.4 | 9.9 | 5.0 | 79.5 | 5.01 | 10.7 | 6 | 60 | 24 | 0.650 | 24.2 |
| 127 × 76 × 16 ‡ | 16.5 | 127.0 | 76.2 | 5.6 | 9.6 | 9.4 | 4.6 | 86.5 | 3.97 | 15.4 | 5 | 42 | 22 | 0.512 | 31.0 |
| 114 × 114 × 27 ‡ | 27.1 | 114.3 | 114.3 | 9.5 | 10.7 | 14.2 | 3.2 | 60.8 | 5.34 | 6.40 | 7 | 60 | 28 | 0.618 | 22.8 |
| 102 × 102 × 23 # | 23.0 | 101.6 | 101.6 | 9.5 | 10.3 | 11.1 | 3.2 | 55.2 | 4.93 | 5.81 | 7 | 54 | 24 | 0.549 | 23.9 |
| 102 × 44 × 7 # | 7.5 | 101.6 | 44.5 | 4.3 | 6.1 | 6.9 | 3.3 | 74.6 | 3.65 | 17.3 | 4 | 28 | 14 | 0.350 | 46.6 |
| 89 × 89 × 19 # | 19.5 | 88.9 | 88.9 | 9.5 | 9.9 | 11.1 | 3.2 | 44.2 | 4.49 | 4.65 | 7 | 46 | 24 | 0.476 | 24.4 |
| 76 × 76 × 15 ‡ | 15.0 | 76.2 | 80.0 | 8.9 | 8.4 | 9.4 | 4.6 | 38.1 | 4.76 | 4.28 | 6 | 42 | 20 | 0.419 | 27.9 |
| 76 × 76 × 13 # | 12.8 | 76.2 | 76.2 | 5.1 | 8.4 | 9.4 | 4.6 | 38.1 | 4.54 | 7.47 | 5 | 42 | 20 | 0.411 | 32.1 |

‡ Not available from some leading producers. Check availability.

Check availability.

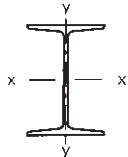
JOISTS**PROPERTIES**

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter u | Torsional Index x | Warping Constant H dm ⁶ | Torsional Constant J cm ⁴ | Area of Section A cm ² |
|---------------------|-----------------------------|-----------------------------|--------------------|----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------|----------------------|--|--|---|
| | 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 | | | | | |
| 254 × 203 × 82 # | 12000 | 2280 | 10.7 | 4.67 | 947 | 224 | 1080 | 371 | 0.888 | 11.0 | 0.312 | 152 | 105 |
| 254 × 114 × 37 ‡ | 5080 | 269 | 10.4 | 2.39 | 400 | 47.1 | 459 | 79.1 | 0.885 | 18.7 | 0.0392 | 25.2 | 47.3 |
| 203 × 152 × 52 # | 4800 | 816 | 8.49 | 3.50 | 472 | 107 | 541 | 176 | 0.890 | 10.7 | 0.0711 | 64.8 | 66.6 |
| 152 × 127 × 37 # | 1820 | 378 | 6.19 | 2.82 | 239 | 59.6 | 279 | 99.8 | 0.867 | 9.33 | 0.0183 | 33.9 | 47.5 |
| 127 × 114 × 29 # | 979 | 242 | 5.12 | 2.54 | 154 | 42.3 | 181 | 70.8 | 0.853 | 8.77 | 0.00807 | 20.8 | 37.4 |
| 127 × 114 × 27 # | 946 | 236 | 5.26 | 2.63 | 149 | 41.3 | 172 | 68.2 | 0.868 | 9.31 | 0.00788 | 16.9 | 34.2 |
| 127 × 76 × 16 ‡ | 571 | 60.8 | 5.21 | 1.70 | 90.0 | 16.0 | 104 | 26.4 | 0.891 | 11.8 | 0.00210 | 6.72 | 21.1 |
| 114 × 114 × 27 ‡ | 736 | 224 | 4.62 | 2.55 | 129 | 39.2 | 151 | 65.8 | 0.839 | 7.92 | 0.00601 | 18.9 | 34.5 |
| 102 × 102 × 23 # | 486 | 154 | 4.07 | 2.29 | 95.6 | 30.3 | 113 | 50.6 | 0.836 | 7.42 | 0.00321 | 14.2 | 29.3 |
| 102 × 44 × 7 # | 153 | 7.82 | 4.01 | 0.907 | 30.1 | 3.51 | 35.4 | 6.03 | 0.872 | 14.9 | 0.000178 | 1.25 | 9.50 |
| 89 × 89 × 19 # | 307 | 101 | 3.51 | 2.02 | 69.0 | 22.8 | 82.7 | 38.0 | 0.830 | 6.58 | 0.00158 | 11.5 | 24.9 |
| 76 × 76 × 15 ‡ | 172 | 60.9 | 3.00 | 1.78 | 45.2 | 15.2 | 54.2 | 25.8 | 0.820 | 6.42 | 0.000700 | 6.83 | 19.1 |
| 76 × 76 × 13 # | 158 | 51.8 | 3.12 | 1.79 | 41.5 | 13.6 | 48.7 | 22.4 | 0.853 | 7.21 | 0.000595 | 4.59 | 16.2 |

‡ Not available from some leading producers. Check availability.

Check availability.

JOISTS



REDUCED PLASTIC MODULUS UNDER AXIAL LOAD

| Section Designation | Plastic Modulus Axis x-x cm ³ | Major Axis Reduced Modulus | | | | | | Plastic Modulus Axis y-y cm | Minor Axis Reduced Modulus | | | | | | |
|---------------------|---|----------------------------|------|---------------------|---------------------|--------------------|------|--------------------------------|----------------------------|------|-----------------------|------|--------------------|--|--|
| | | Lower Values Of n | | Change Formula | | Higher Values Of n | | | Lower Values Of n | | Change Formula At n = | | Higher Values Of n | | |
| | | K1 | K2 | At n ₁ = | At n ₂ = | K3 | K4 | | K1 | K2 | K3 | K4 | | | |
| 254 × 203 × 82 # | 1080 | 1080 | 2680 | 0.195 | 0.504 | 134 | 8.88 | 371 | 371 | 107 | 0.248 | 597 | 0.548 | | |
| 254 × 114 × 37 ‡ | 459 | 459 | 737 | 0.354 | 0.576 | 49.0 | 11.3 | 79.1 | 79.1 | 22.1 | 0.408 | 190 | 0.236 | | |
| 203 × 152 × 52 # | 541 | 541 | 1250 | 0.213 | 0.490 | 72.7 | 8.30 | 176 | 176 | 54.5 | 0.272 | 292 | 0.511 | | |
| 152 × 127 × 37 # | 279 | 279 | 542 | 0.256 | 0.533 | 44.4 | 7.15 | 99.8 | 99.8 | 37.0 | 0.334 | 186 | 0.412 | | |
| 127 × 114 × 29 # | 181 | 181 | 342 | 0.262 | 0.542 | 30.5 | 6.77 | 70.8 | 70.8 | 27.5 | 0.347 | 132 | 0.407 | | |
| 127 × 114 × 27 # | 172 | 172 | 396 | 0.208 | 0.507 | 25.6 | 7.48 | 68.2 | 68.2 | 23.1 | 0.275 | 112 | 0.523 | | |
| 127 × 76 × 16 ‡ | 104 | 104 | 198 | 0.272 | 0.500 | 14.6 | 8.18 | 26.4 | 26.4 | 8.75 | 0.337 | 50.3 | 0.388 | | |
| 114 × 114 × 27 ‡ | 151 | 151 | 313 | 0.234 | 0.557 | 26.0 | 6.58 | 65.8 | 65.8 | 26.0 | 0.315 | 121 | 0.420 | | |
| 102 × 102 × 23 # | 113 | 113 | 226 | 0.239 | 0.534 | 21.2 | 6.04 | 50.6 | 50.6 | 21.2 | 0.329 | 90.8 | 0.428 | | |
| 102 × 44 × 7 # | 35.4 | 35.4 | 52.5 | 0.391 | 0.575 | 5.07 | 8.52 | 6.03 | 6.03 | 2.22 | 0.460 | 16.1 | 0.143 | | |
| 89 × 89 × 19 # | 82.7 | 82.7 | 163 | 0.240 | 0.515 | 17.4 | 5.36 | 38.0 | 38.0 | 17.4 | 0.340 | 67.9 | 0.416 | | |
| 76 × 76 × 15 ‡ | 54.2 | 54.2 | 103 | 0.250 | 0.533 | 11.4 | 5.37 | 25.8 | 25.8 | 12.0 | 0.354 | 47.4 | 0.404 | | |
| 76 × 76 × 13 # | 48.7 | 48.7 | 129 | 0.170 | 0.463 | 8.66 | 6.15 | 22.4 | 22.4 | 8.66 | 0.239 | 34.2 | 0.576 | | |

‡ Not available from some leading producers. Check availability.

Check availability.

n = F/(A p_y), where F is the factored axial load, A is the gross cross sectional area and p_y is the design strength of the section.

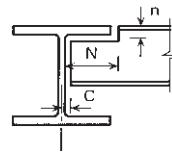
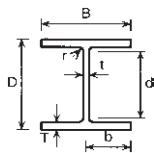
For values of n lower than n₁, the reduced plastic modulus, S_{rx} = S_{r(x1)} = K1 - K2·n², for major axis bending.

For values of n higher than n₂, the reduced plastic modulus, S_{rx} = S_{r(x2)} = K3(1 - n)(K4 + n), for major axis bending.

For values of n between n₁ and n₂, the reduced plastic modulus, S_{rx} = S_{r(x1)} + (S_{r(x2} - S_{r(x1)})(n - n₁)/(n₂ - n₁), for major axis bending.

For lower values of n, the reduced plastic modulus, S_{ry} = K1 - K2·n², for minor axis bending.

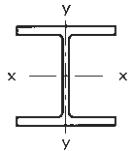
For higher values of n, the reduced plastic modulus, S_{ry} = K3(1 - n)(K4 + n), for minor axis bending.

UNIVERSAL BEARING PILES**DIMENSIONS**

| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Section B mm | Thickness | | Root Radius r mm | Depth between Fillets d mm | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|---------------------|------------------------|--------------------------|--------------------------|-------------|----------------|---------------------|-------------------------------|---------------------------|------------|--------------------------|-------|-----------------------------|-----------------------------|------|
| | | | | Web t mm | Flange T mm | | | Flange b/T | Web d/t | End Clearance C mm | Notch | Per Metre m ² | Per Tonne m ² | |
| | | | | | | | | | | N mm | n mm | | | |
| 356 × 368 × 174 # | 173.9 | 361.4 | 378.5 | 20.3 | 20.4 | 15.2 | 290.2 | 9.28 | 14.3 | 12 | 190 | 36 | 2.17 | 12.5 |
| 356 × 368 × 152 # | 152.0 | 356.4 | 376.0 | 17.8 | 17.9 | 15.2 | 290.2 | 10.5 | 16.3 | 11 | 190 | 34 | 2.16 | 14.2 |
| 356 × 368 × 133 # | 133.0 | 352.0 | 373.8 | 15.6 | 15.7 | 15.2 | 290.2 | 11.9 | 18.6 | 10 | 190 | 32 | 2.14 | 16.1 |
| 356 × 368 × 109 # | 108.9 | 346.4 | 371.0 | 12.8 | 12.9 | 15.2 | 290.2 | 14.4 | 22.7 | 8 | 190 | 30 | 2.13 | 19.5 |
| 305 × 305 × 223 # | 222.9 | 337.9 | 325.7 | 30.3 | 30.4 | 15.2 | 246.7 | 5.36 | 8.14 | 17 | 158 | 46 | 1.89 | 8.49 |
| 305 × 305 × 186 # | 186.0 | 328.3 | 320.9 | 25.5 | 25.6 | 15.2 | 246.7 | 6.27 | 9.67 | 15 | 158 | 42 | 1.86 | 10.0 |
| 305 × 305 × 149 # | 149.1 | 318.5 | 316.0 | 20.6 | 20.7 | 15.2 | 246.7 | 7.63 | 12.0 | 12 | 158 | 36 | 1.83 | 12.3 |
| 305 × 305 × 126 # | 126.1 | 312.3 | 312.9 | 17.5 | 17.6 | 15.2 | 246.7 | 8.89 | 14.1 | 11 | 158 | 34 | 1.82 | 14.4 |
| 305 × 305 × 110 # | 110.0 | 307.9 | 310.7 | 15.3 | 15.4 | 15.2 | 246.7 | 10.1 | 16.1 | 10 | 158 | 32 | 1.80 | 16.4 |
| 305 × 305 × 95 # | 94.9 | 303.7 | 308.7 | 13.3 | 13.3 | 15.2 | 246.7 | 11.6 | 18.5 | 9 | 158 | 30 | 1.79 | 18.9 |
| 305 × 305 × 88 # | 88.0 | 301.7 | 307.8 | 12.4 | 12.3 | 15.2 | 246.7 | 12.5 | 19.9 | 8 | 158 | 28 | 1.78 | 20.3 |
| 305 × 305 × 79 # | 78.9 | 299.3 | 306.4 | 11.0 | 11.1 | 15.2 | 246.7 | 13.8 | 22.4 | 8 | 158 | 28 | 1.78 | 22.5 |
| 254 × 254 × 85 # | 85.1 | 254.3 | 260.4 | 14.4 | 14.3 | 12.7 | 200.3 | 9.10 | 13.9 | 9 | 134 | 28 | 1.50 | 17.6 |
| 254 × 254 × 71 # | 71.0 | 249.7 | 258.0 | 12.0 | 12.0 | 12.7 | 200.3 | 10.8 | 16.7 | 8 | 134 | 26 | 1.49 | 20.9 |
| 254 × 254 × 63 # | 63.0 | 247.1 | 256.6 | 10.6 | 10.7 | 12.7 | 200.3 | 12.0 | 18.9 | 7 | 134 | 24 | 1.48 | 23.5 |
| 203 × 203 × 54 # | 53.9 | 204.0 | 207.7 | 11.3 | 11.4 | 10.2 | 160.8 | 9.11 | 14.2 | 8 | 110 | 22 | 1.20 | 22.2 |
| 203 × 203 × 45 # | 44.9 | 200.2 | 205.9 | 9.5 | 9.5 | 10.2 | 160.8 | 10.8 | 16.9 | 7 | 110 | 20 | 1.19 | 26.4 |

Check availability.

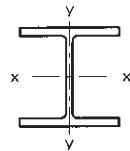
UNIVERSAL BEARING PILES



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 | | | | | |
| 356 × 368 × 174 # | 51000 | 18500 | 15.2 | 9.13 | 2820 | 976 | 3190 | 1500 | 0.822 | 15.8 | 5.37 | 330 | 221 |
| 356 × 368 × 152 # | 44000 | 15900 | 15.1 | 9.05 | 2470 | 845 | 2770 | 1290 | 0.821 | 17.9 | 4.55 | 223 | 194 |
| 356 × 368 × 133 # | 38000 | 13700 | 15.0 | 8.99 | 2160 | 732 | 2410 | 1120 | 0.823 | 20.1 | 3.87 | 151 | 169 |
| 356 × 368 × 109 # | 30600 | 11000 | 14.9 | 8.90 | 1770 | 592 | 1960 | 903 | 0.822 | 24.2 | 3.05 | 84.6 | 139 |
| 305 × 305 × 223 # | 52700 | 17600 | 13.6 | 7.87 | 3120 | 1080 | 3650 | 1680 | 0.826 | 9.55 | 4.15 | 943 | 284 |
| 305 × 305 × 186 # | 42600 | 14100 | 13.4 | 7.73 | 2600 | 881 | 3000 | 1370 | 0.827 | 11.1 | 3.24 | 560 | 237 |
| 305 × 305 × 149 # | 33100 | 10900 | 13.2 | 7.58 | 2080 | 691 | 2370 | 1070 | 0.828 | 13.5 | 2.42 | 295 | 190 |
| 305 × 305 × 126 # | 27400 | 9000 | 13.1 | 7.49 | 1760 | 575 | 1990 | 885 | 0.828 | 15.7 | 1.95 | 182 | 161 |
| 305 × 305 × 110 # | 23600 | 7710 | 13.0 | 7.42 | 1530 | 496 | 1720 | 762 | 0.830 | 17.7 | 1.65 | 122 | 140 |
| 305 × 305 × 95 # | 20000 | 6530 | 12.9 | 7.35 | 1320 | 423 | 1470 | 648 | 0.830 | 20.2 | 1.38 | 80.0 | 121 |
| 305 × 305 × 88 # | 18400 | 5980 | 12.8 | 7.31 | 1220 | 389 | 1360 | 595 | 0.830 | 21.6 | 1.25 | 64.2 | 112 |
| 305 × 305 × 79 # | 16400 | 5330 | 12.8 | 7.28 | 1100 | 348 | 1220 | 531 | 0.834 | 23.8 | 1.11 | 46.9 | 100 |
| 254 × 254 × 85 # | 12300 | 4220 | 10.6 | 6.24 | 966 | 324 | 1090 | 498 | 0.826 | 15.6 | 0.607 | 81.8 | 108 |
| 254 × 254 × 71 # | 10100 | 3440 | 10.6 | 6.17 | 807 | 267 | 904 | 409 | 0.826 | 18.4 | 0.486 | 48.4 | 90.4 |
| 254 × 254 × 63 # | 8860 | 3020 | 10.5 | 6.13 | 717 | 235 | 799 | 360 | 0.827 | 20.5 | 0.421 | 34.3 | 80.2 |
| 203 × 203 × 54 # | 5030 | 1710 | 8.55 | 4.98 | 493 | 164 | 557 | 252 | 0.827 | 15.8 | 0.158 | 32.7 | 68.7 |
| 203 × 203 × 45 # | 4100 | 1380 | 8.46 | 4.92 | 410 | 134 | 459 | 206 | 0.828 | 18.6 | 0.126 | 19.2 | 57.2 |

Check availability.

UNIVERSAL BEARING PILES**REDUCED PLASTIC MODULUS UNDER AXIAL LOAD**

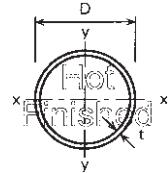
| Section Designation | Plastic Modulus Axis x-x cm ³ | Major Axis Reduced Modulus | | | | | | Plastic Modulus Axis y-y cm ³ | Minor Axis Reduced Modulus | | | | | |
|---------------------|---|----------------------------|------|-----------------------|--------------------|------|-------------------|---|----------------------------|--------------------|-------|--|--|--|
| | | Lower Values Of n | | Change Formula At n = | Higher Values Of n | | Lower Values Of n | | Change Formula At n = | Higher Values Of n | | | | |
| | | K1 | K2 | | K3 | K4 | K1 | K2 | | K3 | K4 | | | |
| 356 × 368 × 174 # | 3190 | 3190 | 6040 | 0.294 | 324 | 11.4 | 1500 | 1500 | 0.331 | 3010 | 0.394 | | | |
| 356 × 368 × 152 # | 2770 | 2770 | 5270 | 0.295 | 249 | 12.8 | 1290 | 1290 | 0.328 | 2620 | 0.390 | | | |
| 356 × 368 × 133 # | 2410 | 2410 | 4600 | 0.295 | 192 | 14.5 | 1120 | 1120 | 0.324 | 2280 | 0.386 | | | |
| 356 × 368 × 109 # | 1960 | 1960 | 3760 | 0.296 | 130 | 17.5 | 903 | 903 | 0.320 | 1870 | 0.380 | | | |
| 305 × 305 × 223 # | 3650 | 3650 | 6650 | 0.296 | 619 | 6.75 | 1680 | 1680 | 0.361 | 3320 | 0.395 | | | |
| 305 × 305 × 186 # | 3000 | 3000 | 5500 | 0.298 | 437 | 7.89 | 1370 | 1370 | 0.353 | 2740 | 0.387 | | | |
| 305 × 305 × 149 # | 2370 | 2370 | 4380 | 0.301 | 285 | 9.60 | 1070 | 1070 | 0.346 | 2180 | 0.378 | | | |
| 305 × 305 × 126 # | 1990 | 1990 | 3690 | 0.302 | 206 | 11.2 | 885 | 885 | 0.340 | 1830 | 0.371 | | | |
| 305 × 305 × 110 # | 1720 | 1720 | 3210 | 0.303 | 158 | 12.7 | 762 | 762 | 0.336 | 1590 | 0.366 | | | |
| 305 × 305 × 95 # | 1470 | 1470 | 2750 | 0.305 | 118 | 14.5 | 648 | 648 | 0.334 | 1380 | 0.358 | | | |
| 305 × 305 × 88 # | 1360 | 1360 | 2530 | 0.307 | 102 | 15.6 | 595 | 595 | 0.334 | 1280 | 0.351 | | | |
| 305 × 305 × 79 # | 1220 | 1220 | 2300 | 0.303 | 82.4 | 17.3 | 531 | 531 | 0.328 | 1140 | 0.354 | | | |
| 254 × 254 × 85 # | 1090 | 1090 | 2040 | 0.300 | 113 | 11.2 | 498 | 498 | 0.338 | 1030 | 0.375 | | | |
| 254 × 254 × 71 # | 904 | 904 | 1700 | 0.300 | 79.2 | 13.3 | 409 | 409 | 0.332 | 851 | 0.370 | | | |
| 254 × 254 × 63 # | 799 | 799 | 1520 | 0.298 | 62.7 | 14.8 | 360 | 360 | 0.327 | 752 | 0.369 | | | |
| 203 × 203 × 54 # | 557 | 557 | 1050 | 0.298 | 56.8 | 11.3 | 252 | 252 | 0.335 | 518 | 0.378 | | | |
| 203 × 203 × 45 # | 459 | 459 | 862 | 0.301 | 39.8 | 13.4 | 206 | 206 | 0.332 | 431 | 0.367 | | | |

Check availability.

n = F/(A p_y), where F is the factored axial load, A is the gross cross sectional area and p_y is the design strength of the section.For lower values of n, the reduced plastic modulus, S = K1 - K2.n², for both major and minor axis bending.

For higher values of n, the reduced plastic modulus, S = K3(1 - n) (K4 + n), for both major and minor axis bending.

**HOT-FINISHED
CIRCULAR HOLLOW SECTIONS**



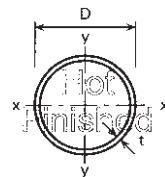
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratio for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|-----------------------|-----------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|----------------------------------|------------------------------|
| Outside Diameter D mm | Thickness t mm | | | | | | | | Per Metre m² | Per Tonne m² | | |
| 26.9 | 3.2 ~ | 1.87 | 2.38 | 8.41 | 1.70 | 0.846 | 1.27 | 1.81 | 3.41 | 2.53 | 0.0845 | 45.2 |
| 42.4 | 3.2 ~ | 3.09 | 3.94 | 13.3 | 7.62 | 1.39 | 3.59 | 4.93 | 15.2 | 7.19 | 0.133 | 43.0 |
| 48.3 | 3.2 ~ 4.0 ~ 5.0 ~ | 3.56 4.37 5.34 | 4.53 5.57 6.80 | 15.1 12.1 9.66 | 11.6 13.8 16.2 | 1.60 1.57 1.54 | 4.80 5.70 6.69 | 6.52 7.87 9.42 | 23.2 27.5 32.3 | 9.59 11.4 13.4 | 0.152 0.152 0.152 | 42.7 34.8 28.5 |
| 60.3 | 3.2 ~ 5.0 ~ | 4.51 6.82 | 5.74 8.69 | 18.8 12.1 | 23.5 33.5 | 2.02 1.96 | 7.78 11.1 | 10.4 15.3 | 46.9 67.0 | 15.6 22.2 | 0.189 0.189 | 41.9 27.7 |
| 76.1 | 2.9 ^ 3.2 ~ 4.0 ~ 5.0 ~ | 5.24 5.75 7.11 8.77 | 6.67 7.33 9.06 11.2 | 26.2 23.8 19.0 15.2 | 44.7 48.8 59.1 70.9 | 2.59 2.58 2.55 2.52 | 11.8 12.8 15.5 18.6 | 15.5 17.0 20.8 25.3 | 89.0 97.6 118 142 | 23.5 25.6 31.0 37.3 | 0.239 0.239 0.239 0.239 | 45.6 41.6 33.6 27.3 |
| 88.9 | 3.2 ~ 4.0 ~ 5.0 ~ 6.3 ~ | 6.76 8.38 10.4 12.8 | 8.62 10.7 13.2 16.3 | 27.8 22.2 17.8 14.1 | 79.2 96.3 116 140 | 3.03 3.00 2.97 2.93 | 17.8 21.7 26.2 31.5 | 23.5 28.9 35.2 43.1 | 158 193 233 280 | 35.6 43.3 52.4 63.1 | 0.279 0.279 0.279 0.279 | 41.3 33.3 27.0 21.7 |
| 114.3 | 3.2 ~ 3.6 5.0 6.3 | 8.77 9.83 13.5 16.8 | 11.2 12.5 17.2 21.4 | 35.7 31.8 22.9 18.1 | 172 192 257 313 | 3.93 3.92 3.87 3.82 | 30.2 33.6 45.0 54.7 | 39.5 44.1 59.8 73.6 | 345 384 514 625 | 60.4 67.2 89.9 109 | 0.359 0.359 0.359 0.359 | 40.9 36.5 26.6 21.4 |
| 139.7 | 5.0 6.3 8.0 10.0 ~ | 16.6 20.7 26.0 32.0 | 21.2 26.4 33.1 40.7 | 27.9 22.2 17.5 14.0 | 481 589 720 862 | 4.77 4.72 4.66 4.60 | 68.8 84.3 103 123 | 90.8 112 139 169 | 961 1180 1440 1720 | 138 169 206 247 | 0.439 0.439 0.439 0.439 | 26.4 21.2 16.9 13.7 |
| 168.3 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ | 20.1 25.2 31.6 39.0 | 25.7 32.1 40.3 49.7 | 33.7 26.7 21.0 16.8 | 856 1050 1300 1560 | 5.78 5.73 5.67 5.61 | 102 125 154 186 | 133 165 206 251 | 1710 2110 2600 3130 | 203 250 308 372 | 0.529 0.529 0.529 0.529 | 26.3 21.0 16.7 13.6 |
| 193.7 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ | 23.3 29.1 36.6 45.3 | 29.6 37.1 46.7 57.7 | 38.7 30.7 24.2 19.4 | 1320 1630 2020 2440 | 6.67 6.63 6.57 6.50 | 136 168 208 252 | 178 221 276 338 | 2640 3260 4030 4880 | 273 337 416 504 | 0.609 0.609 0.609 0.609 | 26.1 20.9 16.6 13.4 |

~ Check availability in S275.

^ Check availability in S355.

**HOT-FINISHED
CIRCULAR HOLLOW SECTIONS**

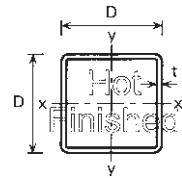


DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratio for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|-----------------------|----------------|----------------|-----------------|--------------------------|-----------------------|--------------------|-----------------|-----------------|---------------------|-------|--------------|--------------|
| Outside Diameter D mm | Thickness t mm | | | | | | | | S cm³ | J cm⁴ | C cm³ | Per Metre m² |
| 219.1 | 5.0 ~ | 26.4 | 33.6 | 43.8 | 1930 | 7.57 | 176 | 229 | 3860 | 352 | 0.688 | 26.1 |
| | 6.3 ~ | 33.1 | 42.1 | 34.8 | 2390 | 7.53 | 218 | 285 | 4770 | 436 | 0.688 | 20.8 |
| | 8.0 ~ | 41.6 | 53.1 | 27.4 | 2960 | 7.47 | 270 | 357 | 5920 | 540 | 0.688 | 16.5 |
| | 10.0 ~ | 51.6 | 65.7 | 21.9 | 3600 | 7.40 | 328 | 438 | 7200 | 657 | 0.688 | 13.3 |
| | 12.5 ~ | 63.7 | 81.1 | 17.5 | 4350 | 7.32 | 397 | 534 | 8690 | 793 | 0.688 | 10.8 |
| 244.5 | 12.0 ~ | 68.8 | 87.7 | 20.4 | 5940 | 8.23 | 486 | 649 | 11900 | 972 | 0.768 | 11.2 |
| 273.0 | 5.0 ~ | 33.0 | 42.1 | 54.6 | 3780 | 9.48 | 277 | 359 | 7560 | 554 | 0.858 | 26.0 |
| | 6.3 ~ | 41.4 | 52.8 | 43.3 | 4700 | 9.43 | 344 | 448 | 9390 | 688 | 0.858 | 20.1 |
| | 8.0 ~ | 52.3 | 66.6 | 34.1 | 5850 | 9.37 | 429 | 562 | 11700 | 857 | 0.858 | 16.4 |
| | 10.0 ~ | 64.9 | 82.6 | 27.3 | 7150 | 9.31 | 524 | 692 | 14300 | 1050 | 0.858 | 13.2 |
| | 12.5 ~ | 80.3 | 102 | 21.8 | 8700 | 9.22 | 637 | 849 | 17400 | 1270 | 0.858 | 10.1 |
| | 16.0 ~ | 101 | 129 | 17.1 | 10700 | 9.10 | 784 | 1060 | 21400 | 1570 | 0.858 | 8.46 |
| 323.9 | 6.3 ~ | 49.3 | 62.9 | 51.4 | 7930 | 11.2 | 490 | 636 | 15900 | 979 | 1.02 | 20.7 |
| | 8.0 ~ | 62.3 | 79.4 | 40.5 | 9910 | 11.2 | 612 | 799 | 19800 | 1220 | 1.02 | 16.4 |
| | 10.0 ~ | 77.4 | 98.6 | 32.4 | 12200 | 11.1 | 751 | 986 | 24300 | 1500 | 1.02 | 13.2 |
| | 12.5 ~ | 96.0 | 122 | 25.9 | 14800 | 11.0 | 917 | 1210 | 29700 | 1830 | 1.02 | 10.6 |
| | 16.0 ~ | 122 | 155 | 20.2 | 18400 | 10.9 | 1140 | 1520 | 36800 | 2270 | 1.02 | 8.40 |
| 406.4 | 6.3 ~ | 62.2 | 79.2 | 64.5 | 15900 | 14.1 | 780 | 1010 | 31700 | 1560 | 1.28 | 20.6 |
| | 8.0 ~ | 78.6 | 100 | 50.8 | 19900 | 14.1 | 978 | 1270 | 39700 | 1960 | 1.28 | 16.3 |
| | 10.0 ~ | 97.8 | 125 | 40.6 | 24500 | 14.0 | 1210 | 1570 | 49000 | 2410 | 1.28 | 13.1 |
| | 12.5 ~ | 121 | 155 | 32.5 | 30000 | 13.9 | 1480 | 1940 | 60100 | 2960 | 1.28 | 10.5 |
| | 16.0 ~ | 154 | 196 | 25.4 | 37500 | 13.8 | 1840 | 2440 | 74900 | 3690 | 1.28 | 8.31 |
| 457.0 | 8.0 ~ | 88.6 | 113 | 57.1 | 28500 | 15.9 | 1250 | 1610 | 56900 | 2490 | 1.44 | 16.3 |
| | 10.0 ~ | 110 | 140 | 45.7 | 35100 | 15.8 | 1540 | 2000 | 70200 | 3070 | 1.44 | 13.1 |
| | 12.5 ~ | 137 | 175 | 36.6 | 43100 | 15.7 | 1890 | 2470 | 86300 | 3780 | 1.44 | 10.5 |
| | 16.0 ~ | 174 | 222 | 28.6 | 54000 | 15.6 | 2360 | 3110 | 108000 | 4730 | 1.44 | 8.28 |
| 508.0 | 8.0 ~ | 98.6 | 126 | 63.5 | 39300 | 17.7 | 1550 | 2000 | 78600 | 3090 | 1.60 | 16.2 |
| | 10.0 ~ | 123 | 156 | 50.8 | 48500 | 17.6 | 1910 | 2480 | 97000 | 3820 | 1.60 | 13.0 |
| | 12.5 ~ | 153 | 195 | 40.6 | 59800 | 17.5 | 2350 | 3070 | 120000 | 4710 | 1.60 | 10.5 |
| | 16.0 ~ | 194 | 247 | 31.8 | 74900 | 17.4 | 2950 | 3870 | 150000 | 5900 | 1.60 | 8.25 |
| | 20.0 ~ | 241 | 307 | 25.4 | 91400 | 17.3 | 3600 | 4770 | 183000 | 7200 | 1.60 | 6.64 |

~ Check availability in S275.

HOT-FINISHED SQUARE HOLLOW SECTIONS



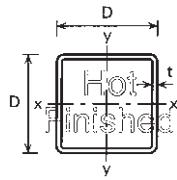
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre kg/m | Area of Section A cm² | Ratio for Local Buckling d/t ⁽¹⁾ | Second Moment of Area I cm⁴ | Radius of Gyration r cm | Elastic Modulus Z cm³ | Plastic Modulus S cm³ | Torsional Constants | | Surface Area | |
|---------------------|--------|---------------------|-----------------------|---|-----------------------------|-------------------------|-----------------------|-----------------------|---------------------|-------|--------------|--------------|
| | | | | | | | | | J cm⁴ | C cm³ | Per Metre m² | Per Tonne m² |
| 40 × 40 | 3.0 ~ | 3.41 | 4.34 | 10.3 | 9.78 | 1.50 | 4.89 | 5.97 | 15.7 | 7.10 | 0.152 | 44.6 |
| | 3.2 ~ | 3.61 | 4.60 | 9.50 | 10.2 | 1.49 | 5.11 | 6.28 | 16.5 | 7.42 | 0.152 | 42.1 |
| | 4.0 | 4.39 | 5.59 | 7.00 | 11.8 | 1.45 | 5.91 | 7.44 | 19.5 | 8.54 | 0.150 | 34.2 |
| | 5.0 ~ | 5.28 | 6.73 | 5.00 | 13.4 | 1.41 | 6.68 | 8.66 | 22.5 | 9.60 | 0.147 | 27.8 |
| 50 × 50 | 3.0 ~ | 4.35 | 5.54 | 13.7 | 20.2 | 1.91 | 8.08 | 9.70 | 32.1 | 11.8 | 0.192 | 44.1 |
| | 3.2 ~ | 4.62 | 5.88 | 12.6 | 21.2 | 1.90 | 8.49 | 10.2 | 33.8 | 12.4 | 0.192 | 41.6 |
| | 4.0 | 5.64 | 7.19 | 9.50 | 25.0 | 1.86 | 9.99 | 12.3 | 40.4 | 14.5 | 0.190 | 33.7 |
| | 5.0 | 6.85 | 8.73 | 7.00 | 28.9 | 1.82 | 11.6 | 14.5 | 47.6 | 16.7 | 0.187 | 27.3 |
| | 6.3 ~ | 8.31 | 10.6 | 4.94 | 32.8 | 1.76 | 13.1 | 17.0 | 55.2 | 18.8 | 0.184 | 22.1 |
| 60 × 60 | 3.0 ~ | 5.29 | 6.74 | 17.0 | 36.2 | 2.32 | 12.1 | 14.3 | 56.9 | 17.7 | 0.232 | 43.9 |
| | 3.2 ~ | 5.62 | 7.16 | 15.8 | 38.2 | 2.31 | 12.7 | 15.2 | 60.2 | 18.6 | 0.232 | 41.3 |
| | 4.0 ~ | 6.90 | 8.79 | 12.0 | 45.4 | 2.27 | 15.1 | 18.3 | 72.5 | 22.0 | 0.230 | 33.3 |
| | 5.0 | 8.42 | 10.7 | 9.00 | 53.3 | 2.23 | 17.8 | 21.9 | 86.4 | 25.7 | 0.227 | 27.0 |
| | 6.3 ~ | 10.3 | 13.1 | 6.52 | 61.6 | 2.17 | 20.5 | 26.0 | 102 | 29.6 | 0.224 | 21.7 |
| | 8.0 ~ | 12.5 | 16.0 | 4.50 | 69.7 | 2.09 | 23.2 | 30.4 | 118 | 33.4 | 0.219 | 17.5 |
| 70 × 70 | 3.6 ~ | 7.40 | 9.42 | 16.4 | 68.6 | 2.70 | 19.6 | 23.3 | 108 | 28.7 | 0.271 | 36.6 |
| | 5.0 ~ | 9.99 | 12.7 | 11.0 | 88.5 | 2.64 | 25.3 | 30.8 | 142 | 36.8 | 0.267 | 26.7 |
| | 6.3 ~ | 12.3 | 15.6 | 8.11 | 104 | 2.58 | 29.7 | 36.9 | 169 | 42.9 | 0.264 | 21.5 |
| | 8.0 ~ | 15.0 | 19.2 | 5.75 | 120 | 2.50 | 34.2 | 43.8 | 200 | 49.2 | 0.259 | 17.3 |
| 80 × 80 | 3.6 ~ | 8.53 | 10.9 | 19.2 | 105 | 3.11 | 26.2 | 31.0 | 164 | 38.5 | 0.311 | 36.5 |
| | 4.0 ~ | 9.41 | 12.0 | 17.0 | 114 | 3.09 | 28.6 | 34.0 | 180 | 41.9 | 0.310 | 32.9 |
| | 5.0 ~ | 11.6 | 14.7 | 13.0 | 137 | 3.05 | 34.2 | 41.1 | 217 | 49.8 | 0.307 | 26.6 |
| | 6.3 ~ | 14.2 | 18.1 | 9.70 | 162 | 2.99 | 40.5 | 49.7 | 262 | 58.7 | 0.304 | 21.4 |
| | 8.0 ~ | 17.5 | 22.4 | 7.00 | 189 | 2.91 | 47.3 | 59.5 | 312 | 68.3 | 0.299 | 17.1 |
| 90 × 90 | 3.6 ~ | 9.66 | 12.3 | 22.0 | 152 | 3.52 | 33.8 | 39.7 | 237 | 49.7 | 0.351 | 36.3 |
| | 4.0 ~ | 10.7 | 13.6 | 19.5 | 166 | 3.50 | 37.0 | 43.6 | 260 | 54.2 | 0.350 | 32.7 |
| | 5.0 ~ | 13.1 | 16.7 | 15.0 | 200 | 3.45 | 44.4 | 53.0 | 316 | 64.8 | 0.347 | 26.5 |
| | 6.3 ~ | 16.2 | 20.7 | 11.3 | 238 | 3.40 | 53.0 | 64.3 | 382 | 77.0 | 0.344 | 21.2 |
| | 8.0 ~ | 20.1 | 25.6 | 8.25 | 281 | 3.32 | 62.6 | 77.6 | 459 | 90.5 | 0.339 | 16.9 |
| 100 × 100 | 4.0 | 11.9 | 15.2 | 22.0 | 232 | 3.91 | 46.4 | 54.4 | 361 | 68.2 | 0.390 | 32.8 |
| | 5.0 | 14.7 | 18.7 | 17.0 | 279 | 3.86 | 55.9 | 66.4 | 439 | 81.8 | 0.387 | 26.3 |
| | 6.3 | 18.2 | 23.2 | 12.9 | 336 | 3.80 | 67.1 | 80.9 | 534 | 97.8 | 0.384 | 21.1 |
| | 8.0 ~ | 22.6 | 28.8 | 9.50 | 400 | 3.73 | 79.9 | 98.2 | 646 | 116 | 0.379 | 16.8 |
| | 10.0 | 27.4 | 34.9 | 7.00 | 462 | 3.64 | 92.4 | 116 | 761 | 133 | 0.374 | 13.6 |
| 120 × 120 | 5.0 ~ | 17.8 | 22.7 | 21.0 | 498 | 4.68 | 83.0 | 97.6 | 777 | 122 | 0.467 | 26.2 |
| | 6.3 | 22.2 | 28.2 | 16.0 | 603 | 4.62 | 100 | 120 | 950 | 147 | 0.464 | 20.9 |
| | 8.0 ~ | 27.6 | 35.2 | 12.0 | 726 | 4.55 | 121 | 147 | 1160 | 176 | 0.459 | 16.6 |
| | 10.0 ~ | 33.7 | 42.9 | 9.00 | 852 | 4.46 | 142 | 175 | 1380 | 206 | 0.454 | 13.5 |
| | 12.5 ~ | 40.9 | 52.1 | 6.60 | 982 | 4.34 | 164 | 207 | 1620 | 236 | 0.448 | 11.0 |

~ Check availability in S275.

⁽¹⁾For local buckling calculation $d = D - 3t$.

HOT-FINISHED SQUARE HOLLOW SECTIONS



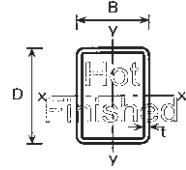
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section A cm² | Ratio for Local Buckling d/l ⁽¹⁾ | Second Moment of Area I cm⁴ | Radius of Gyration r cm | Elastic Modulus Z cm³ | Plastic Modulus S cm³ | Torsional Constants | | Surface Area | |
|---------------------|--------|----------------|-----------------------|---|-----------------------------|-------------------------|-----------------------|-----------------------|---------------------|-------|--------------|--------------|
| | | | | | | | | | J cm⁴ | C cm³ | Per Metre m² | Per Tonne m² |
| 140 × 140 | 5.0 ~ | 21.0 | 26.7 | 25.0 | 807 | 5.50 | 115 | 135 | 1250 | 170 | 0.547 | 26.0 |
| | 6.3 ~ | 26.1 | 33.3 | 19.2 | 984 | 5.44 | 141 | 166 | 1540 | 206 | 0.544 | 20.8 |
| | 8.0 ~ | 32.6 | 41.6 | 14.5 | 1200 | 5.36 | 171 | 204 | 1890 | 249 | 0.539 | 16.5 |
| | 10.0 ~ | 40.0 | 50.9 | 11.0 | 1420 | 5.27 | 202 | 246 | 2270 | 294 | 0.534 | 13.4 |
| | 12.5 ~ | 48.7 | 62.1 | 8.20 | 1650 | 5.16 | 236 | 293 | 2700 | 342 | 0.528 | 10.8 |
| 150 × 150 | 5.0 ~ | 22.6 | 28.7 | 27.0 | 1000 | 5.90 | 134 | 156 | 1550 | 197 | 0.587 | 26.0 |
| | 6.3 ~ | 28.1 | 35.8 | 20.8 | 1220 | 5.85 | 163 | 192 | 1910 | 240 | 0.584 | 20.8 |
| | 8.0 ~ | 35.1 | 44.8 | 15.8 | 1490 | 5.77 | 199 | 237 | 2350 | 291 | 0.579 | 16.5 |
| | 10.0 ~ | 43.1 | 54.9 | 12.0 | 1770 | 5.68 | 236 | 286 | 2830 | 344 | 0.574 | 13.3 |
| | 12.5 ~ | 52.7 | 67.1 | 9.00 | 2080 | 5.57 | 277 | 342 | 3370 | 402 | 0.568 | 10.8 |
| 160 × 160 | 5.0 ~ | 24.1 | 30.7 | 29.0 | 1230 | 6.31 | 153 | 178 | 1890 | 226 | 0.627 | 26.0 |
| | 6.3 ~ | 30.1 | 38.3 | 22.4 | 1500 | 6.26 | 187 | 220 | 2330 | 275 | 0.624 | 20.7 |
| | 8.0 ~ | 37.6 | 48.0 | 17.0 | 1830 | 6.18 | 229 | 272 | 2880 | 335 | 0.619 | 16.5 |
| | 10.0 ~ | 46.3 | 58.9 | 13.0 | 2190 | 6.09 | 273 | 329 | 3480 | 398 | 0.614 | 13.3 |
| | 12.5 ~ | 56.6 | 72.1 | 9.80 | 2580 | 5.98 | 322 | 395 | 4160 | 467 | 0.608 | 10.7 |
| 180 × 180 | 6.3 ~ | 34.0 | 43.3 | 25.6 | 2170 | 7.07 | 241 | 281 | 3360 | 355 | 0.704 | 20.7 |
| | 8.0 ~ | 42.7 | 54.4 | 19.5 | 2660 | 7.00 | 296 | 349 | 4160 | 434 | 0.699 | 16.4 |
| | 10.0 ~ | 52.5 | 66.9 | 15.0 | 3190 | 6.91 | 355 | 424 | 5050 | 518 | 0.694 | 13.2 |
| | 12.5 ~ | 64.4 | 82.1 | 11.4 | 3790 | 6.80 | 421 | 511 | 6070 | 613 | 0.688 | 10.7 |
| | 16.0 ~ | 80.2 | 102 | 8.25 | 4500 | 6.64 | 500 | 621 | 7340 | 724 | 0.679 | 8.47 |
| 200 × 200 | 5.0 ~ | 30.4 | 38.7 | 37.0 | 2450 | 7.95 | 245 | 283 | 3760 | 362 | 0.787 | 25.9 |
| | 6.3 ~ | 38.0 | 48.4 | 28.7 | 3010 | 7.89 | 301 | 350 | 4650 | 444 | 0.784 | 20.6 |
| | 8.0 ~ | 47.7 | 60.8 | 22.0 | 3710 | 7.81 | 371 | 436 | 5780 | 545 | 0.779 | 16.3 |
| | 10.0 ~ | 58.8 | 74.9 | 17.0 | 4470 | 7.72 | 447 | 531 | 7030 | 655 | 0.774 | 13.2 |
| | 12.5 ~ | 72.3 | 92.1 | 13.0 | 5340 | 7.61 | 534 | 643 | 8490 | 778 | 0.768 | 10.6 |
| 250 × 250 | 5.0 ~ | 47.9 | 61.0 | 36.7 | 6010 | 9.93 | 481 | 556 | 9240 | 712 | 0.984 | 20.5 |
| | 8.0 ~ | 60.3 | 76.8 | 28.3 | 7460 | 9.86 | 596 | 694 | 11500 | 880 | 0.979 | 16.2 |
| | 10.0 ~ | 74.5 | 94.9 | 22.0 | 9060 | 9.77 | 724 | 851 | 14100 | 1070 | 0.974 | 13.1 |
| | 12.5 ~ | 91.9 | 117 | 17.0 | 10900 | 9.66 | 873 | 1040 | 17200 | 1280 | 0.968 | 10.5 |
| | 16.0 ~ | 115 | 147 | 12.6 | 13300 | 9.50 | 1060 | 1280 | 21100 | 1550 | 0.959 | 8.31 |
| 300 × 300 | 6.3 ~ | 57.8 | 73.6 | 44.6 | 10500 | 12.0 | 703 | 809 | 16100 | 1040 | 1.18 | 20.4 |
| | 8.0 ~ | 72.8 | 92.8 | 34.5 | 13100 | 11.9 | 875 | 1010 | 20200 | 1290 | 1.18 | 16.2 |
| | 10.0 ~ | 90.2 | 115 | 27.0 | 16000 | 11.8 | 1070 | 1250 | 24800 | 1580 | 1.17 | 13.0 |
| | 12.5 ~ | 112 | 142 | 21.0 | 19400 | 11.7 | 1300 | 1530 | 30300 | 1900 | 1.17 | 10.5 |
| | 16.0 ~ | 141 | 179 | 15.8 | 23900 | 11.5 | 1590 | 1900 | 37600 | 2330 | 1.16 | 8.26 |
| 350 × 350 | 8.0 ~ | 85.4 | 109 | 40.8 | 21100 | 13.9 | 1210 | 1390 | 32400 | 1790 | 1.38 | 16.2 |
| | 10.0 ~ | 106 | 135 | 32.0 | 25900 | 13.9 | 1480 | 1720 | 39900 | 2190 | 1.37 | 12.9 |
| | 12.5 ~ | 131 | 167 | 25.0 | 31500 | 13.7 | 1800 | 2110 | 48900 | 2650 | 1.37 | 10.5 |
| | 16.0 ~ | 166 | 211 | 18.9 | 38900 | 13.6 | 2230 | 2630 | 61000 | 3260 | 1.36 | 8.19 |
| 400 × 400 | 10.0 ~ | 122 | 155 | 37.0 | 39100 | 15.9 | 1960 | 2260 | 60100 | 2900 | 1.57 | 12.9 |
| | 12.5 ~ | 151 | 192 | 29.0 | 48700 | 15.8 | 2390 | 2780 | 73900 | 3530 | 1.57 | 10.4 |
| | 16.0 ~ | 191 | 243 | 22.0 | 59300 | 15.6 | 2970 | 3480 | 92400 | 4360 | 1.56 | 8.17 |
| | 20.0 ~ | 235 | 300 | 17.0 | 71500 | 15.4 | 3580 | 4250 | 113000 | 5240 | 1.55 | 6.60 |

~ Check availability in S275.

⁽¹⁾ For local buckling calculation $d = D - 3t$.

HOT-FINISHED RECTANGULAR HOLLOW SECTIONS



DIMENSIONS AND PROPERTIES

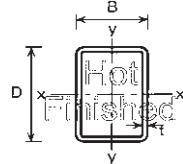
| Section Designation | | Mass per Metre kg/m | Area of Section cm ² | Ratios for Local Buckling | | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Torsional Constants | | Surface Area | | | | |
|---------------------|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--------------------------|--|--|
| Size D × B mm | Thickness t mm | | | A | d/t ⁽¹⁾ | b/t ⁽¹⁾ | 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 | J cm ⁴ | C cm ³ | Per Metre m ² | Per Tonne m ² | | |
| | | | | | | | | | | | | | | | | | | | | |
| 50 × 30 | 3.2 ~ | 3.61 | 4.60 | 12.6 | 6.38 | 14.2 | 6.20 | 1.76 | 1.16 | 5.68 | 4.13 | 7.25 | 5.00 | 14.2 | 6.80 | 0.152 | 42.1 | | | |
| 60 × 40 | 3.0 ~ 4.0 ~ 5.0 ~ | 4.35 5.64 6.85 | 5.54 7.19 8.73 | 17.0 12.0 9.00 | 10.3 7.00 5.00 | 26.5 32.8 38.1 | 13.9 17.0 19.5 | 2.18 2.14 2.09 | 1.58 1.54 1.50 | 8.82 10.9 12.7 | 6.95 8.52 9.77 | 10.9 13.8 16.4 | 8.19 10.3 12.2 | 29.2 36.7 43.0 | 11.2 13.7 15.7 | 0.192 0.190 0.187 | 44.1 33.7 27.3 | | | |
| 80 × 40 | 3.2 ~ 4.0 ~ 5.0 ~ 6.3 ~ 8.0 ~ | 5.62 6.90 8.42 10.3 12.5 | 7.16 8.79 10.7 13.1 16.0 | 22.0 17.0 13.0 9.70 7.00 | 9.50 7.00 5.00 3.35 2.00 | 57.2 68.2 80.3 93.3 106 | 18.9 22.2 25.7 29.2 32.1 | 2.83 2.79 2.74 2.67 2.58 | 1.63 1.59 1.55 1.49 1.42 | 14.3 17.1 20.1 23.3 26.5 | 9.46 11.1 12.9 14.6 16.1 | 18.0 21.8 26.1 31.1 36.5 | 11.0 13.2 15.7 18.4 21.2 | 46.2 55.2 65.1 75.6 85.8 | 16.1 18.9 21.9 24.8 27.4 | 0.232 0.230 0.227 0.224 0.219 | 41.3 33.3 27.0 21.7 17.5 | | | |
| 90 × 50 | 3.6 ~ 5.0 ~ 6.3 ~ | 7.40 9.99 12.3 | 9.42 12.7 15.6 | 22.0 15.0 11.3 | 10.9 7.00 4.94 | 98.3 127 150 | 38.7 49.2 57.0 | 3.23 3.16 3.10 | 2.03 1.97 1.91 | 21.8 28.3 33.3 | 15.5 19.7 22.8 | 27.2 36.0 43.2 | 18.0 23.5 28.0 | 89.4 116 138 | 25.9 32.9 38.1 | 0.271 0.267 0.264 | 36.6 26.7 21.5 | | | |
| 100 × 50 | 3.0 ~ 3.2 ~ 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ^ | 6.71 7.13 10.8 13.3 16.3 19.6 | 8.54 9.08 13.7 16.9 20.8 24.9 | 30.3 28.3 17.0 12.9 9.50 7.00 | 13.7 12.6 7.00 4.94 3.25 2.00 | 110 116 167 197 230 259 | 36.8 38.8 54.3 63.0 71.7 78.4 | 3.58 3.57 3.48 3.42 3.33 3.22 | 2.08 2.07 1.99 1.93 1.86 1.77 | 21.9 23.2 33.3 39.4 46.0 51.8 | 14.7 15.5 21.7 25.2 30.8 31.4 | 27.3 28.9 42.6 51.3 61.4 71.2 | 16.8 17.7 25.8 30.8 42.9 53.6 | 88.4 93.4 135 160 186 209 | 25.0 26.4 36.9 42.9 48.9 53.6 | 0.292 0.292 0.287 0.284 0.279 0.274 | 43.5 41.0 26.6 21.4 17.1 14.0 | | | |
| 100 × 60 | 3.6 ~ 5.0 ~ 6.3 ~ 8.0 ~ | 8.53 11.6 14.2 17.5 | 10.9 14.7 18.1 22.4 | 24.8 17.0 12.9 9.50 | 13.7 7.00 6.52 4.50 | 145 189 225 264 | 64.8 83.6 98.1 113 | 3.65 3.58 3.52 3.44 | 2.44 2.38 2.33 2.25 | 28.9 37.8 45.0 52.8 | 21.6 27.9 32.7 37.8 | 35.6 47.4 57.3 68.7 | 24.9 32.9 39.5 47.1 | 142 188 224 265 | 35.6 45.9 53.8 62.2 | 0.311 0.307 0.304 0.299 | 36.5 26.5 21.4 17.1 | | | |
| 120 × 60 | 3.6 ~ 5.0 ~ 6.3 ~ 8.0 ~ | 9.70 13.1 16.2 20.1 | 12.3 16.7 20.7 25.6 | 30.3 21.0 16.0 12.0 | 13.7 9.00 6.52 4.50 | 227 299 358 425 | 76.3 98.8 116 135 | 4.30 4.23 4.16 4.08 | 2.49 2.43 2.37 2.30 | 37.9 42.9 59.7 70.8 | 25.4 32.9 38.8 45.0 | 47.2 53.1 76.7 92.7 | 28.9 38.4 46.3 55.4 | 183 242 290 344 | 43.3 56.0 65.9 76.6 | 0.351 0.347 0.344 0.339 | 36.2 26.5 21.2 16.9 | | | |
| 120 × 80 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ | 14.7 18.2 22.6 27.4 | 18.7 23.2 28.8 34.9 | 21.0 16.0 12.0 9.00 | 13.0 9.70 7.00 5.00 | 365 440 525 609 | 193 230 273 313 | 4.42 4.36 4.27 4.18 | 3.21 3.15 3.08 2.99 | 60.9 73.3 87.5 102 | 48.2 57.6 68.1 78.1 | 74.6 91.0 111 131 | 56.1 68.2 82.6 97.3 | 401 487 587 688 | 77.9 92.9 110 126 | 0.387 0.384 0.379 0.374 | 26.3 21.1 16.8 13.6 | | | |
| 150 × 100 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ 12.5 ~ | 18.6 23.1 28.9 35.3 42.8 | 23.7 29.5 36.8 44.9 54.6 | 27.0 20.8 15.8 12.0 9.00 | 17.0 12.9 9.50 7.00 5.00 | 739 898 569 1280 1490 | 392 474 544 665 763 | 5.58 5.52 3.94 5.34 5.22 | 4.07 4.01 3.94 3.85 3.74 | 98.5 120 145 171 198 | 78.5 94.8 114 133 153 | 119 147 180 216 256 | 90.1 110 135 161 190 | 807 986 1200 1430 1680 | 127 153 183 214 246 | 0.487 0.484 0.479 0.474 0.468 | 26.2 21.0 16.6 13.4 10.9 | | | |
| 160 × 80 | 4.0 ~ 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ | 14.4 17.8 22.2 27.6 33.7 | 18.4 22.7 28.2 35.2 42.9 | 37.0 29.0 22.4 17.0 13.0 | 17.0 13.0 9.70 7.00 5.00 | 612 744 903 1090 1280 | 207 249 299 356 411 | 5.77 5.72 5.66 5.57 5.47 | 3.35 3.31 3.26 3.18 3.10 | 76.5 93.0 113 136 161 | 51.7 62.3 74.8 89.0 103 | 94.7 116 142 175 209 | 58.3 71.1 86.8 106 125 | 493 600 730 883 1040 | 88.0 106 127 151 175 | 0.470 0.467 0.464 0.459 0.454 | 32.6 26.2 20.9 16.6 13.5 | | | |

~ Check availability in S275.

^ Check availability in S355.

⁽¹⁾ For local buckling calculation $d = D - 3t$ and $b = B - 3t$.

HOT-FINISHED RECTANGULAR HOLLOW SECTIONS



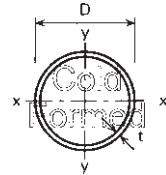
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratios for Local Buckling | | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Torsional Constants | | Surface Area | | | | |
|---------------------|---|--|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|-------------------|-----------|-----------|
| Size | Thickness | | | d/t ⁽¹⁾ | b/t ⁽¹⁾ | Axis x-x | Axis y-y | cm | cm | Axis x-x | Axis y-y | cm | cm | Axis x-x | Axis y-y | cm | J cm ⁴ | C cm ³ | Per Metre | Per Tonne |
| | D × B mm | t mm | A cm ² | kg/m | cm ⁴ | cm ⁴ | cm | cm | cm ³ | cm ³ | cm | cm | cm ³ | cm ³ | cm ³ | m ² | m ² | | | |
| 200 × 100 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ 12.5 | 22.6 28.1 35.1 43.1 52.7 | 28.7 35.8 44.8 54.9 67.1 | 37.0 28.7 22.0 17.0 13.0 | 17.0 12.9 9.50 7.00 5.00 | 1500 1830 2230 2660 3140 | 505 613 739 869 1000 | 7.21 7.15 7.06 6.96 6.84 | 4.19 4.14 4.06 3.98 3.87 | 149 183 223 266 314 | 101 123 148 174 201 | 185 228 282 341 408 | 114 140 172 206 245 | 1200 1470 1800 2160 2540 | 172 208 251 295 341 | 0.587 0.584 0.579 0.574 0.568 | 26.0 20.8 16.5 13.3 10.8 | | | |
| 200 × 120 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ | 24.1 30.1 37.6 46.3 | 30.7 38.3 48.0 58.9 | 37.0 28.7 22.0 17.0 | 21.0 16.0 12.0 9.00 | 1690 2070 2530 3030 | 762 929 1130 1340 | 7.40 7.34 7.26 7.17 | 4.98 4.92 4.85 4.76 | 168 207 253 303 | 127 155 188 223 | 205 253 313 379 | 144 177 218 263 | 1650 2030 2490 3000 | 210 255 310 367 | 0.627 0.624 0.619 0.614 | 26.0 20.7 16.5 13.3 | | | |
| 200 × 150 | 8.0 ~ 10.0 ~ | 41.4 51.0 | 52.8 64.9 | 22.0 17.0 | 15.8 12.0 | 2970 3570 | 1890 2260 | 7.50 7.41 | 5.99 5.91 | 297 357 | 253 302 | 359 436 | 294 356 | 3640 4410 | 398 475 | 0.679 0.674 | 16.4 13.2 | | | |
| 250 × 100 | 10.0 ~ 12.5 ~ | 51.0 62.5 | 64.9 79.6 | 22.0 17.0 | 7.00 5.00 | 4730 5620 | 1070 1250 | 8.54 8.41 | 4.06 3.96 | 379 450 | 214 249 | 491 592 | 251 299 | 2910 3440 | 376 438 | 0.674 0.668 | 13.2 10.7 | | | |
| 250 × 150 | 5.0 ~ 6.3 ~ 8.0 ~ 10.0 ~ 12.5 ~ 16.0 ~ | 30.4 38.0 47.7 58.8 72.3 90.3 | 38.7 48.4 60.8 74.9 92.1 115 | 47.0 36.7 20.8 22.0 12.0 12.6 | 27.0 36.7 2300 12.0 9.00 6.38 | 3360 4140 5110 6170 7390 8880 | 1530 1870 2300 2760 3270 3870 | 9.31 9.25 9.17 9.08 8.96 8.79 | 6.28 6.22 6.15 6.06 5.96 5.80 | 269 331 409 494 591 710 | 204 250 306 367 435 516 | 324 402 501 611 740 906 | 228 300 350 426 514 625 | 3280 4050 5020 6090 7330 8870 | 337 413 506 605 717 849 | 0.787 0.784 0.779 0.774 0.768 0.759 | 25.9 20.6 16.3 13.2 10.6 8.41 | | | |
| 300 × 100 | 8.0 ~ 10.0 ~ | 47.7 58.8 | 60.8 74.9 | 34.5 27.0 | 9.50 7.00 | 6310 7610 | 1080 1280 | 10.2 10.1 | 4.21 4.13 | 420 508 | 216 255 | 546 666 | 245 296 | 3070 3680 | 387 458 | 0.779 0.774 | 16.3 13.2 | | | |
| 300 × 200 | 6.3 ~ 8.0 ~ 10.0 ~ 12.5 ~ 16.0 ~ | 47.9 60.3 74.5 91.9 115 | 61.0 76.8 94.9 117 147 | 44.6 34.5 27.0 21.0 15.8 | 28.7 22.0 17.0 13.0 9.50 | 7830 9720 11800 14300 17400 | 4190 5180 6280 7540 9110 | 11.3 11.3 11.2 11.0 10.9 | 8.29 8.22 8.13 8.02 7.87 | 522 648 788 952 1160 | 419 518 628 754 911 | 624 779 956 1170 1440 | 472 589 721 877 1080 | 8480 10600 12900 15700 19300 | 681 840 1020 1220 1470 | 0.984 0.979 0.974 0.968 0.959 | 20.5 16.2 13.1 10.5 8.34 | | | |
| 400 × 200 | 8.0 ~ 10.0 ~ 12.5 ~ 16.0 ~ | 72.8 90.2 112 141 | 92.8 115 142 179 | 47.0 37.0 29.0 22.0 | 22.0 17.0 13.0 9.50 | 19600 23900 29100 35700 | 6660 8080 9740 11800 | 14.5 14.4 14.3 14.1 | 8.47 8.39 8.28 8.13 | 978 1200 1450 1790 | 666 808 974 1180 | 1200 1480 1810 2260 | 743 911 1110 1370 | 15700 19300 23400 28900 | 1140 1380 1660 2010 | 1.18 1.17 1.17 1.16 | 16.2 13.0 10.5 8.26 | | | |
| 450 × 250 | 8.0 ~ 10.0 ~ 12.5 ~ 16.0 ~ | 85.4 106 131 166 | 109 135 167 211 | 53.3 42.0 33.0 25.1 | 28.3 22.0 17.0 12.6 | 30100 36900 45000 55700 | 12100 14800 18000 22000 | 16.6 16.5 16.4 16.2 | 10.6 10.5 10.4 10.2 | 1340 1640 2000 2480 | 971 1190 1440 1760 | 1620 2000 2460 3070 | 1080 1330 1630 2030 | 27100 33300 40700 50500 | 1630 1990 2410 2950 | 1.38 1.37 1.37 1.36 | 16.2 12.9 10.5 8.19 | | | |
| 500 × 300 | 8.0 ~ 10.0 ~ 12.5 ~ 16.0 ~ 20.0 ~ | 98.0 122 151 191 235 | 125 155 192 243 300 | 59.5 47.0 37.0 28.3 22.0 | 34.5 27.0 21.0 15.8 12.0 | 43700 53800 65800 81800 98800 | 20000 24400 29800 36800 44100 | 18.7 18.6 18.5 18.3 18.2 | 12.6 12.6 12.5 12.3 12.1 | 1750 2150 2630 3270 3950 | 1330 1630 1990 2450 2940 | 2100 2600 3200 4010 4890 | 1480 1830 2240 2800 3410 | 42600 52400 64400 80300 97400 | 2200 2700 3280 4040 4840 | 1.58 1.57 1.57 1.56 1.55 | 16.1 12.9 10.4 8.17 6.60 | | | |

~ Check availability in S275.

⁽¹⁾ For local buckling calculation $d = D - 3t$ and $b = B - 3t$.

**COLD-FORMED
CIRCULAR HOLLOW SECTIONS**

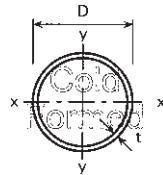


DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratio for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|-----------------------|----------------|----------------|-----------------|--------------------------|-----------------------|--------------------|-----------------|-----------------|---------------------|-------|--------------|--------------|
| Outside Diameter D mm | Thickness t mm | | | | | | | | J cm⁴ | C cm³ | Per Metre m² | Per Tonne m² |
| 26.9 | 2.0 ‡ | 1.23 | 1.56 | 13.5 | 1.22 | 0.883 | 0.907 | 1.24 | 2.44 | 1.81 | 0.0845 | 68.7 |
| | 2.5 ‡ | 1.50 | 1.92 | 10.8 | 1.44 | 0.867 | 1.07 | 1.49 | 2.88 | 2.14 | 0.0845 | 56.3 |
| | 3.0 ‡ | 1.77 | 2.25 | 8.97 | 1.63 | 0.852 | 1.21 | 1.72 | 3.27 | 2.43 | 0.0845 | 47.7 |
| 33.7 | 2.0 ‡ | 1.56 | 1.99 | 16.9 | 2.51 | 1.12 | 1.49 | 2.01 | 5.02 | 2.98 | 0.106 | 67.9 |
| | 2.5 ‡ | 1.92 | 2.45 | 13.5 | 3.00 | 1.11 | 1.78 | 2.44 | 6.00 | 3.56 | 0.106 | 55.2 |
| | 3.0 ‡ | 2.27 | 2.89 | 11.2 | 3.44 | 1.09 | 2.04 | 2.84 | 6.88 | 4.08 | 0.106 | 46.7 |
| | 4.0 ‡ | 2.93 | 3.73 | 8.43 | 4.19 | 1.06 | 2.49 | 3.55 | 8.38 | 4.97 | 0.106 | 36.2 |
| | 4.5 ‡ | 3.24 | 4.13 | 7.49 | 4.50 | 1.04 | 2.67 | 3.87 | 9.01 | 5.35 | 0.106 | 32.7 |
| 42.4 | 2.5 ‡ | 2.46 | 3.13 | 17.0 | 6.26 | 1.41 | 2.95 | 3.99 | 12.5 | 5.91 | 0.133 | 54.1 |
| | 3.0 ‡ | 2.91 | 3.71 | 14.1 | 7.25 | 1.40 | 3.42 | 4.67 | 14.5 | 6.84 | 0.133 | 45.7 |
| | 3.5 ‡ | 3.36 | 4.28 | 12.1 | 8.16 | 1.38 | 3.85 | 5.31 | 16.3 | 7.69 | 0.133 | 39.6 |
| | 4.0 ‡ | 3.79 | 4.83 | 10.6 | 8.99 | 1.36 | 4.24 | 5.92 | 18.0 | 8.48 | 0.133 | 35.1 |
| 48.3 | 2.5 ‡ | 2.82 | 3.60 | 19.3 | 9.46 | 1.62 | 3.92 | 5.25 | 18.9 | 7.83 | 0.152 | 53.9 |
| | 3.0 ‡ | 3.35 | 4.27 | 16.1 | 11.0 | 1.61 | 4.55 | 6.17 | 22.0 | 9.11 | 0.152 | 45.4 |
| | 3.5 ‡ | 3.87 | 4.93 | 13.8 | 12.4 | 1.59 | 5.15 | 7.04 | 24.9 | 10.3 | 0.152 | 39.3 |
| | 4.0 ‡ | 4.37 | 5.57 | 12.1 | 13.8 | 1.57 | 5.70 | 7.87 | 27.5 | 11.4 | 0.152 | 34.8 |
| | 5.0 ‡ | 5.34 | 6.80 | 9.66 | 16.2 | 1.54 | 6.69 | 9.42 | 32.3 | 13.4 | 0.152 | 28.5 |
| 60.3 | 2.5 ‡ | 3.56 | 4.54 | 24.1 | 19.0 | 2.05 | 6.30 | 8.36 | 38.0 | 12.6 | 0.189 | 53.1 |
| | 3.0 ‡ | 4.24 | 5.40 | 20.1 | 22.2 | 2.03 | 7.37 | 9.86 | 44.4 | 14.7 | 0.189 | 44.6 |
| | 3.5 ‡ | 4.90 | 6.25 | 17.2 | 25.3 | 2.01 | 8.39 | 11.3 | 50.6 | 16.8 | 0.189 | 38.6 |
| | 4.0 ‡ | 5.55 | 7.07 | 15.1 | 28.2 | 2.00 | 9.34 | 12.7 | 56.3 | 18.7 | 0.189 | 34.1 |
| | 5.0 ‡ | 6.82 | 8.69 | 12.1 | 33.5 | 1.96 | 11.1 | 15.3 | 67.0 | 22.2 | 0.189 | 27.7 |
| 76.1 | 2.5 ‡ | 4.54 | 5.78 | 30.4 | 39.2 | 2.60 | 10.3 | 13.5 | 78.4 | 20.6 | 0.239 | 52.6 |
| | 3.0 ‡ | 5.41 | 6.89 | 25.4 | 46.1 | 2.59 | 12.1 | 16.0 | 92.2 | 24.2 | 0.239 | 44.2 |
| | 3.5 ‡ | 6.27 | 7.98 | 21.7 | 52.7 | 2.57 | 13.9 | 18.5 | 105 | 27.7 | 0.239 | 38.1 |
| | 4.0 ‡ | 7.11 | 9.06 | 19.0 | 59.1 | 2.55 | 15.5 | 20.8 | 118 | 31.0 | 0.239 | 33.6 |
| | 5.0 ‡ | 8.77 | 11.2 | 15.2 | 70.9 | 2.52 | 18.6 | 25.3 | 142 | 37.3 | 0.239 | 27.3 |
| 88.9 | 3.0 ‡ | 6.36 | 8.10 | 29.6 | 74.8 | 3.04 | 16.8 | 22.1 | 150 | 33.6 | 0.279 | 43.9 |
| | 3.5 ‡ | 7.37 | 9.39 | 25.4 | 85.7 | 3.02 | 19.3 | 25.5 | 171 | 38.6 | 0.279 | 37.9 |
| | 4.0 ‡ | 8.38 | 10.7 | 22.2 | 96.3 | 3.00 | 21.7 | 28.9 | 193 | 43.3 | 0.279 | 33.1 |
| | 5.0 ‡ | 10.3 | 13.2 | 17.8 | 116 | 2.97 | 26.2 | 35.2 | 233 | 52.4 | 0.279 | 27.1 |
| 114.3 | 3.0 ‡ | 8.23 | 10.5 | 38.1 | 163 | 3.94 | 28.4 | 37.2 | 325 | 56.9 | 0.359 | 43.6 |
| | 3.5 ‡ | 9.56 | 12.2 | 32.7 | 187 | 3.92 | 32.7 | 43.0 | 374 | 65.5 | 0.359 | 37.6 |
| | 4.0 ‡ | 10.9 | 13.9 | 28.6 | 211 | 3.90 | 36.9 | 48.7 | 422 | 73.9 | 0.359 | 32.9 |
| | 5.0 ‡ | 13.5 | 17.2 | 22.9 | 257 | 3.87 | 45.0 | 59.8 | 514 | 89.9 | 0.359 | 26.6 |
| | 6.0 ‡ | 16.0 | 20.4 | 19.1 | 300 | 3.83 | 52.5 | 70.4 | 600 | 105 | 0.359 | 22.4 |
| 139.7 | 4.0 ‡ | 13.4 | 17.1 | 34.9 | 393 | 4.80 | 56.2 | 73.7 | 786 | 112 | 0.439 | 32.8 |
| | 5.0 ‡ | 16.6 | 21.2 | 27.9 | 481 | 4.77 | 68.8 | 90.8 | 961 | 138 | 0.439 | 26.4 |
| | 6.0 ‡ | 19.8 | 25.2 | 23.3 | 564 | 4.73 | 80.8 | 107 | 1130 | 162 | 0.439 | 22.2 |
| | 8.0 ‡ | 26.0 | 33.1 | 17.5 | 720 | 4.66 | 103 | 139 | 1440 | 206 | 0.439 | 16.9 |
| | 10.0 ‡ | 32.0 | 40.7 | 14.0 | 862 | 4.60 | 123 | 169 | 1720 | 247 | 0.439 | 13.7 |
| | 12.5 ‡ | 39.2 | 50.0 | 11.2 | 1020 | 4.52 | 146 | 203 | 2040 | 292 | 0.439 | 11.2 |

‡ Grade S275 not available from some leading producers. Check availability.

**COLD-FORMED
CIRCULAR HOLLOW SECTIONS**

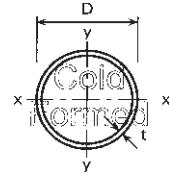


DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratio for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|-----------------------|----------------|----------------|-----------------|--------------------------|-----------------------|--------------------|-----------------|-----------------|---------------------|-------------------|--------------------------|--------------------------|
| Outside Diameter D mm | Thickness t mm | | | | | | | | J cm ⁴ | C cm ³ | Per Metre m ² | Per Tonne m ² |
| 168.3 | 4.0 ‡ | 16.2 | 20.6 | 42.1 | 697 | 5.81 | 82.8 | 108 | 1390 | 166 | 0.529 | 32.7 |
| | 5.0 ‡ | 20.1 | 25.7 | 33.7 | 856 | 5.78 | 102 | 133 | 1710 | 203 | 0.529 | 26.3 |
| | 6.0 ‡ | 24.0 | 30.6 | 28.1 | 1010 | 5.74 | 120 | 158 | 2020 | 240 | 0.529 | 22.0 |
| | 8.0 ‡ | 31.6 | 40.3 | 21.0 | 1300 | 5.67 | 154 | 206 | 2600 | 308 | 0.529 | 16.7 |
| | 10.0 ‡ | 39.0 | 49.7 | 16.8 | 1560 | 5.61 | 186 | 251 | 3130 | 372 | 0.529 | 13.6 |
| | 12.5 ‡ | 48.0 | 61.2 | 13.5 | 1870 | 5.53 | 222 | 304 | 3740 | 444 | 0.529 | 11.0 |
| 193.7 | 4.0 ‡ | 18.7 | 23.8 | 48.4 | 1070 | 6.71 | 111 | 144 | 2150 | 222 | 0.609 | 32.6 |
| | 4.5 ‡ | 21.0 | 26.7 | 43.0 | 1200 | 6.69 | 124 | 161 | 2400 | 247 | 0.609 | 29.0 |
| | 5.0 ‡ | 23.3 | 29.6 | 38.7 | 1320 | 6.67 | 136 | 178 | 2640 | 273 | 0.609 | 26.1 |
| | 6.0 ‡ | 27.8 | 35.4 | 32.3 | 1560 | 6.64 | 161 | 211 | 3120 | 322 | 0.609 | 21.9 |
| | 8.0 ‡ | 36.6 | 46.7 | 24.2 | 2020 | 6.57 | 208 | 276 | 4030 | 416 | 0.609 | 16.6 |
| | 10.0 ‡ | 45.3 | 57.7 | 19.4 | 2440 | 6.50 | 252 | 338 | 4880 | 504 | 0.609 | 13.4 |
| 219.1 | 4.0 ‡ | 21.2 | 27.0 | 54.8 | 1560 | 7.61 | 143 | 185 | 3130 | 286 | 0.688 | 32.5 |
| | 4.5 ‡ | 23.8 | 30.3 | 48.7 | 1750 | 7.59 | 159 | 207 | 3490 | 319 | 0.688 | 28.9 |
| | 5.0 ‡ | 26.4 | 33.6 | 43.8 | 1930 | 7.57 | 176 | 229 | 3860 | 352 | 0.688 | 26.1 |
| | 6.0 ‡ | 31.5 | 40.2 | 36.5 | 2280 | 7.54 | 208 | 273 | 4560 | 417 | 0.688 | 21.8 |
| | 8.0 ‡ | 41.6 | 53.1 | 27.4 | 2960 | 7.47 | 270 | 357 | 5920 | 540 | 0.688 | 16.5 |
| | 10.0 ‡ | 51.6 | 65.7 | 21.9 | 3600 | 7.40 | 328 | 438 | 7200 | 657 | 0.688 | 13.3 |
| 244.5 | 12.0 ‡ | 61.3 | 78.1 | 18.3 | 4200 | 7.33 | 383 | 515 | 8400 | 767 | 0.688 | 11.2 |
| | 12.5 ‡ | 63.7 | 81.1 | 17.5 | 4350 | 7.32 | 397 | 534 | 8690 | 793 | 0.688 | 10.8 |
| | 16.0 ‡ | 80.1 | 102 | 13.7 | 5300 | 7.20 | 483 | 661 | 10600 | 967 | 0.688 | 8.59 |
| | 4.5 ‡ | 26.6 | 33.9 | 54.3 | 2440 | 8.49 | 200 | 259 | 4890 | 400 | 0.768 | 28.9 |
| | 5.0 ‡ | 29.5 | 37.6 | 48.9 | 2700 | 8.47 | 221 | 287 | 5400 | 441 | 0.768 | 26.0 |
| | 6.0 ‡ | 35.3 | 45.0 | 40.8 | 3200 | 8.43 | 262 | 341 | 6400 | 523 | 0.768 | 21.8 |
| 273.0 | 8.0 ‡ | 46.7 | 59.4 | 30.6 | 4160 | 8.37 | 340 | 448 | 8320 | 681 | 0.768 | 16.4 |
| | 10.0 ‡ | 57.8 | 73.7 | 24.5 | 5070 | 8.30 | 415 | 550 | 10200 | 830 | 0.768 | 13.3 |
| | 12.0 ‡ | 68.8 | 87.7 | 20.4 | 5940 | 8.23 | 486 | 649 | 11900 | 972 | 0.768 | 11.2 |
| | 12.5 ‡ | 71.5 | 91.1 | 19.6 | 6150 | 8.21 | 503 | 673 | 12300 | 1010 | 0.768 | 10.7 |
| | 16.0 ‡ | 90.2 | 115 | 15.3 | 7530 | 8.10 | 616 | 837 | 15100 | 1230 | 0.768 | 8.51 |
| | 4.0 ‡ | 26.5 | 33.8 | 68.3 | 3060 | 9.51 | 224 | 289 | 6120 | 448 | 0.858 | 32.4 |
| 273.0 | 4.5 ‡ | 29.8 | 38.0 | 60.7 | 3420 | 9.49 | 251 | 324 | 6840 | 501 | 0.858 | 28.8 |
| | 5.0 ‡ | 33.0 | 42.1 | 54.6 | 3780 | 9.48 | 277 | 359 | 7560 | 554 | 0.858 | 26.0 |
| | 6.0 ‡ | 39.5 | 50.3 | 45.5 | 4490 | 9.44 | 329 | 428 | 8970 | 657 | 0.858 | 21.7 |
| | 8.0 ‡ | 52.3 | 66.6 | 34.1 | 5850 | 9.37 | 429 | 562 | 11700 | 857 | 0.858 | 16.4 |
| | 10.0 ‡ | 64.9 | 82.6 | 27.3 | 7150 | 9.31 | 524 | 692 | 14300 | 1050 | 0.858 | 13.2 |
| | 12.0 ‡ | 77.2 | 98.4 | 22.8 | 8400 | 9.24 | 615 | 818 | 16800 | 1230 | 0.858 | 11.1 |
| 273.0 | 12.5 ‡ | 80.3 | 102 | 21.8 | 8700 | 9.22 | 637 | 849 | 17400 | 1270 | 0.858 | 10.7 |
| | 16.0 ‡ | 101 | 129 | 17.1 | 10700 | 9.10 | 784 | 1060 | 21400 | 1570 | 0.858 | 8.50 |

‡ Grade S275 not available from some leading producers. Check availability.

**COLD-FORMED
CIRCULAR HOLLOW SECTIONS**

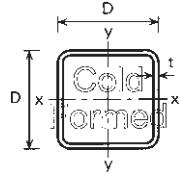


DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre kg/m | Area of Section A cm ² | Ratio for Local Buckling D/t | Second Moment of Area I cm ⁴ | Radius of Gyration r cm | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|--------------------------|-------------------|------------------------|--------------------------------------|---------------------------------|--|----------------------------|-----------------|-----------------|---------------------|-------------------|-----------------------------|-----------------------------|
| Outside Diameter D mm | Thickness t mm | | | | | | | | J cm ⁴ | C cm ³ | Per Metre m ² | Per Tonne m ² |
| 323.9 | 5.0 ‡ | 39.3 | 50.1 | 64.8 | 6370 | 11.3 | 393 | 509 | 12700 | 787 | 1.02 | 26.0 |
| | 6.0 ‡ | 47.0 | 59.9 | 54.0 | 7570 | 11.2 | 468 | 606 | 15100 | 935 | 1.02 | 21.7 |
| | 8.0 ‡ | 62.3 | 79.4 | 40.5 | 9910 | 11.2 | 612 | 799 | 19800 | 1220 | 1.02 | 16.4 |
| | 10.0 ‡ | 77.4 | 98.6 | 32.4 | 12200 | 11.1 | 751 | 986 | 24300 | 1500 | 1.02 | 13.2 |
| | 12.0 ‡ | 92.3 | 118 | 27.0 | 14300 | 11.0 | 884 | 1170 | 28600 | 1770 | 1.02 | 11.1 |
| | 12.5 ‡ | 96.0 | 122 | 25.9 | 14800 | 11.0 | 917 | 1210 | 29700 | 1830 | 1.02 | 10.6 |
| | 16.0 ‡ | 121 | 155 | 20.2 | 18400 | 10.9 | 1140 | 1520 | 36800 | 2270 | 1.02 | 8.43 |
| 355.6 | 5.0 ‡ | 43.2 | 55.1 | 71.1 | 8460 | 12.4 | 476 | 615 | 16900 | 952 | 1.12 | 25.9 |
| | 6.0 ‡ | 51.7 | 65.9 | 59.3 | 10100 | 12.4 | 566 | 733 | 20100 | 1130 | 1.12 | 21.7 |
| | 8.0 ‡ | 68.6 | 87.4 | 44.5 | 13200 | 12.3 | 742 | 967 | 26400 | 1490 | 1.12 | 16.3 |
| | 10.0 ‡ | 85.2 | 109 | 35.6 | 16200 | 12.2 | 912 | 1200 | 32400 | 1830 | 1.12 | 13.1 |
| | 12.0 ‡ | 102 | 130 | 29.6 | 19100 | 12.2 | 1080 | 1420 | 38300 | 2150 | 1.12 | 11.0 |
| | 12.5 ‡ | 106 | 135 | 28.4 | 19900 | 12.1 | 1120 | 1470 | 39700 | 2230 | 1.12 | 10.6 |
| | 16.0 ‡ | 134 | 171 | 22.2 | 24700 | 12.0 | 1390 | 1850 | 49300 | 2770 | 1.12 | 8.36 |
| 406.4 | 6.0 ‡ | 59.2 | 75.5 | 67.7 | 15100 | 14.2 | 745 | 962 | 30300 | 1490 | 1.28 | 21.6 |
| | 8.0 ‡ | 78.6 | 100 | 50.8 | 19900 | 14.1 | 978 | 1270 | 39700 | 1960 | 1.28 | 16.3 |
| | 10.0 ‡ | 97.8 | 125 | 40.6 | 24500 | 14.0 | 1210 | 1570 | 49000 | 2410 | 1.28 | 13.1 |
| | 12.0 ‡ | 117 | 149 | 33.9 | 28900 | 14.0 | 1420 | 1870 | 57900 | 2850 | 1.28 | 10.9 |
| | 12.5 ‡ | 121 | 155 | 32.5 | 30000 | 13.9 | 1480 | 1940 | 60100 | 2960 | 1.28 | 10.6 |
| | 16.0 ‡ | 154 | 196 | 25.4 | 37400 | 13.8 | 1840 | 2440 | 74900 | 3690 | 1.28 | 8.31 |
| 457.0 | 8.0 ‡ | 88.6 | 113 | 57.1 | 28400 | 15.9 | 1250 | 1610 | 56900 | 2490 | 1.44 | 16.3 |
| | 10.0 ‡ | 110 | 140 | 45.7 | 35100 | 15.8 | 1540 | 2000 | 70200 | 3070 | 1.44 | 13.1 |
| | 12.0 ‡ | 132 | 168 | 38.1 | 41600 | 15.7 | 1820 | 2380 | 83100 | 3640 | 1.44 | 10.9 |
| | 12.5 ‡ | 137 | 175 | 36.6 | 43100 | 15.7 | 1890 | 2470 | 86300 | 3780 | 1.44 | 10.5 |
| | 16.0 ‡ | 174 | 222 | 28.6 | 54000 | 15.6 | 2360 | 3110 | 108000 | 4720 | 1.44 | 8.28 |
| 508.0 | 8.0 ‡ | 98.6 | 126 | 63.5 | 39300 | 17.7 | 1550 | 2000 | 78600 | 3090 | 1.60 | 16.2 |
| | 10.0 ‡ | 123 | 156 | 50.8 | 48500 | 17.6 | 1910 | 2480 | 97000 | 3820 | 1.60 | 13.0 |
| | 12.0 ‡ | 147 | 187 | 42.3 | 57500 | 17.5 | 2270 | 2950 | 115000 | 4530 | 1.60 | 10.9 |
| | 12.5 ‡ | 153 | 195 | 40.6 | 59800 | 17.5 | 2350 | 3070 | 120000 | 4710 | 1.60 | 10.5 |
| | 16.0 ‡ | 194 | 247 | 31.8 | 74900 | 17.4 | 2950 | 3870 | 150000 | 5900 | 1.60 | 8.25 |

‡ Grade S275 not available from some leading producers. Check availability.

**COLD-FORMED
SQUARE HOLLOW SECTIONS**



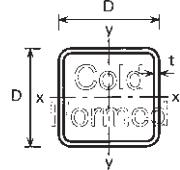
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratio for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | | | | | | | | | |
|---------------------|-----------|----------------|-----------------|--------------------------|-----------------------|--------------------|-----------------|-----------------|---------------------|-------|--------------------|-------|-------|-------|-------|-------|-------|--------------|--------------|--|
| Size | Thickness | | | | | | | | t mm | A cm² | d/t ⁽¹⁾ | I cm⁴ | r cm | Z cm³ | S cm³ | J cm⁴ | C cm³ | Per Metre m² | Per Tonne m² | |
| 25 × 25 | 2.0 ‡ | 1.36 | 1.74 | 7.50 | 1.48 | 0.924 | 1.19 | 1.47 | 2.53 | 1.80 | 0.0931 | 68.5 | | | | | | | | |
| | 2.5 ‡ | 1.64 | 2.09 | | 1.69 | 0.899 | | | 2.97 | 2.07 | 0.0914 | 55.7 | | | | | | | | |
| | 3.0 ‡ | 1.89 | 2.41 | | 1.84 | 0.874 | | | 3.33 | 2.27 | 0.0897 | 47.5 | | | | | | | | |
| 30 × 30 | 2.0 ‡ | 1.68 | 2.14 | 10.0 | 2.72 | 1.13 | 1.81 | 2.21 | 4.54 | 2.75 | 0.113 | 67.3 | | | | | | | | |
| | 2.5 ‡ | 2.03 | 2.59 | | 3.16 | 1.10 | | | 5.40 | 3.20 | 0.111 | 54.7 | | | | | | | | |
| | 3.0 ‡ | 2.36 | 3.01 | | 3.50 | 1.08 | | | 6.15 | 3.58 | 0.110 | 46.6 | | | | | | | | |
| 40 × 40 | 2.0 ‡ | 2.31 | 2.94 | 15.0 | 6.94 | 1.54 | 3.47 | 4.13 | 11.3 | 5.23 | 0.153 | 66.2 | | | | | | | | |
| | 2.5 ‡ | 2.82 | 3.59 | | 8.22 | 1.51 | | | 4.97 | 13.6 | 6.21 | 0.151 | 53.5 | | | | | | | |
| | 3.0 ‡ | 3.30 | 4.21 | | 9.32 | 1.49 | | | 5.72 | 15.8 | 7.07 | 0.150 | 45.5 | | | | | | | |
| | 4.0 ‡ | 4.20 | 5.35 | | 11.1 | 1.44 | | | 7.01 | 19.4 | 8.48 | 0.146 | 34.8 | | | | | | | |
| 50 × 50 | 2.0 ‡ | 2.93 | 3.74 | 20.0 | 14.1 | 1.95 | 5.66 | 6.66 | 22.6 | 8.51 | 0.193 | 65.9 | | | | | | | | |
| | 2.5 ‡ | 3.60 | 4.59 | | 16.9 | 1.92 | | | 6.78 | 27.5 | 10.2 | 0.191 | 53.1 | | | | | | | |
| | 3.0 ‡ | 4.25 | 5.41 | | 19.5 | 1.90 | | | 7.79 | 32.1 | 11.8 | 0.190 | 44.7 | | | | | | | |
| | 4.0 ‡ | 5.45 | 6.95 | | 23.7 | 1.85 | | | 9.49 | 40.4 | 14.4 | 0.186 | 34.1 | | | | | | | |
| | 5.0 ‡ | 6.56 | 8.36 | | 27.0 | 1.80 | | | 10.8 | 47.5 | 16.6 | 0.183 | 27.9 | | | | | | | |
| 60 × 60 | 3.0 ‡ | 5.19 | 6.61 | 15.0 | 35.1 | 2.31 | 11.7 | 14.0 | 57.1 | 17.7 | 0.230 | 44.3 | | | | | | | | |
| | 4.0 ‡ | 6.71 | 8.55 | | 43.6 | 2.26 | | | 14.5 | 72.6 | 22.0 | 0.226 | 33.7 | | | | | | | |
| | 5.0 ‡ | 8.13 | 10.4 | | 50.5 | 2.21 | | | 16.8 | 86.4 | 25.6 | 0.223 | 27.4 | | | | | | | |
| 70 × 70 | 2.5 ‡ | 5.17 | 6.59 | 23.0 | 49.4 | 2.74 | 14.1 | 16.5 | 78.5 | 21.2 | 0.271 | 52.4 | | | | | | | | |
| | 3.0 ‡ | 6.13 | 7.81 | | 57.5 | 2.71 | | | 19.4 | 92.4 | 24.7 | 0.270 | 44.0 | | | | | | | |
| | 3.5 ‡ | 7.06 | 8.99 | | 65.1 | 2.69 | | | 18.6 | 22.2 | 106 | 28.0 | 0.268 | 38.0 | | | | | | |
| | 4.0 ‡ | 7.97 | 10.1 | | 72.1 | 2.67 | | | 20.6 | 24.8 | 119 | 31.1 | 0.266 | 33.4 | | | | | | |
| | 5.0 ‡ | 9.70 | 12.4 | | 84.6 | 2.62 | | | 24.2 | 142 | 36.7 | 0.263 | 27.1 | | | | | | | |
| 80 × 80 | 3.0 ‡ | 7.07 | 9.01 | 21.7 | 87.8 | 3.12 | 22.0 | 25.8 | 140 | 33.0 | 0.310 | 43.8 | | | | | | | | |
| | 3.5 ‡ | 8.16 | 10.4 | | 99.8 | 3.10 | | | 25.0 | 161 | 37.6 | 0.308 | 37.7 | | | | | | | |
| | 4.0 ‡ | 9.22 | 11.7 | | 111 | 3.07 | | | 27.8 | 180 | 41.8 | 0.306 | 33.2 | | | | | | | |
| | 5.0 ‡ | 11.3 | 14.4 | | 131 | 3.03 | | | 32.9 | 218 | 49.7 | 0.303 | 26.8 | | | | | | | |
| | 6.0 ‡ | 13.2 | 16.8 | | 149 | 2.98 | | | 37.3 | 252 | 56.6 | 0.299 | 22.7 | | | | | | | |
| 90 × 90 | 3.0 ‡ | 8.01 | 10.2 | 25.0 | 127 | 3.53 | 28.3 | 33.0 | 201 | 42.5 | 0.350 | 43.7 | | | | | | | | |
| | 3.5 ‡ | 9.26 | 11.8 | | 145 | 3.51 | | | 32.2 | 232 | 48.5 | 0.348 | 37.6 | | | | | | | |
| | 4.0 ‡ | 10.5 | 13.3 | | 162 | 3.48 | | | 36.0 | 261 | 54.2 | 0.346 | 33.0 | | | | | | | |
| | 5.0 ‡ | 12.8 | 16.4 | | 193 | 3.43 | | | 42.9 | 316 | 64.7 | 0.343 | 26.8 | | | | | | | |
| | 6.0 ‡ | 15.1 | 19.2 | | 220 | 3.39 | | | 49.0 | 368 | 74.2 | 0.339 | 22.5 | | | | | | | |
| 100 × 100 | 3.0 ‡ | 8.96 | 11.4 | 28.3 | 177 | 3.94 | 35.4 | 41.2 | 279 | 53.2 | 0.390 | 43.5 | | | | | | | | |
| | 4.0 ‡ | 11.7 | 14.9 | | 226 | 3.89 | | | 45.3 | 362 | 68.1 | 0.386 | 33.0 | | | | | | | |
| | 5.0 ‡ | 14.4 | 18.4 | | 271 | 3.84 | | | 54.2 | 441 | 81.7 | 0.383 | 26.6 | | | | | | | |
| | 6.0 ‡ | 17.0 | 21.6 | | 311 | 3.79 | | | 62.3 | 75.1 | 94.1 | 0.379 | 22.3 | | | | | | | |
| | 8.0 ‡ | 21.4 | 27.2 | | 366 | 3.67 | | | 73.2 | 91.1 | 114 | 0.366 | 17.1 | | | | | | | |
| 120 × 120 | 4.0 ‡ | 14.2 | 18.1 | 25.0 | 402 | 4.71 | 67.0 | 78.3 | 637 | 101 | 0.466 | 32.8 | | | | | | | | |
| | 5.0 ‡ | 17.5 | 22.4 | | 485 | 4.66 | | | 80.9 | 778 | 122 | 0.463 | 26.5 | | | | | | | |
| | 6.0 ‡ | 20.7 | 26.4 | | 562 | 4.61 | | | 93.7 | 112 | 913 | 141 | 0.459 | 22.2 | | | | | | |
| | 8.0 ‡ | 26.4 | 33.6 | | 677 | 4.49 | | | 113 | 138 | 1160 | 175 | 0.446 | 16.9 | | | | | | |
| | 10.0 ‡ | 31.8 | 40.6 | | 777 | 4.38 | | | 129 | 162 | 1380 | 203 | 0.437 | 13.7 | | | | | | |

‡ Grade S275 not available from some leading producers. Check availability.

⁽¹⁾ For local buckling calculation $d = D - 5t$.

COLD-FORMED SQUARE HOLLOW SECTIONS



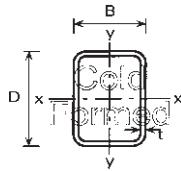
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratio for Local Buckling | Second Moment of Area | Radius of Gyration | Elastic Modulus | Plastic Modulus | Torsional Constants | | Surface Area | |
|---------------------|-----------|----------------|-----------------|--------------------------|-----------------------|--------------------|-----------------|-----------------|---------------------|-------|--------------------|-------|
| Size | Thickness | | | | | | | | t mm | A cm² | d/t ⁽¹⁾ | I cm⁴ |
| 140 × 140 | 4.0 ‡ | 16.8 | 21.3 | 30.0 | 652 | 5.52 | 93.1 | 108 | 1020 | 140 | 0.546 | 32.5 |
| | 5.0 ‡ | 20.7 | 26.4 | 23.0 | 791 | 5.48 | 113 | 132 | 1260 | 170 | 0.543 | 26.2 |
| | 6.0 ‡ | 24.5 | 31.2 | 18.3 | 920 | 5.43 | 131 | 155 | 1480 | 198 | 0.539 | 22.0 |
| | 8.0 ‡ | 31.4 | 40.0 | 12.5 | 1130 | 5.30 | 161 | 194 | 1900 | 248 | 0.526 | 16.8 |
| | 10.0 ‡ | 38.1 | 48.6 | 9.00 | 1310 | 5.20 | 187 | 230 | 2270 | 291 | 0.517 | 13.6 |
| 150 × 150 | 4.0 ‡ | 18.0 | 22.9 | 32.5 | 808 | 5.93 | 108 | 125 | 1260 | 162 | 0.586 | 32.6 |
| | 5.0 ‡ | 22.3 | 28.4 | 25.0 | 982 | 5.89 | 131 | 153 | 1550 | 197 | 0.583 | 26.1 |
| | 6.0 ‡ | 26.4 | 33.6 | 20.0 | 1150 | 5.84 | 153 | 180 | 1830 | 230 | 0.579 | 21.9 |
| | 8.0 ‡ | 33.9 | 43.2 | 13.8 | 1410 | 5.71 | 188 | 226 | 2360 | 289 | 0.566 | 16.7 |
| | 10.0 ‡ | 41.3 | 52.6 | 10.0 | 1650 | 5.61 | 220 | 269 | 2840 | 341 | 0.557 | 13.5 |
| 160 × 160 | 4.0 ‡ | 19.3 | 24.5 | 35.0 | 987 | 6.34 | 123 | 143 | 1540 | 185 | 0.626 | 32.4 |
| | 5.0 ‡ | 23.8 | 30.4 | 27.0 | 1200 | 6.29 | 150 | 175 | 1900 | 226 | 0.623 | 26.2 |
| | 6.0 ‡ | 28.3 | 36.0 | 21.7 | 1410 | 6.25 | 176 | 206 | 2240 | 264 | 0.619 | 21.9 |
| | 8.0 ‡ | 36.5 | 46.4 | 15.0 | 1740 | 6.12 | 218 | 260 | 2900 | 334 | 0.606 | 16.6 |
| | 10.0 ‡ | 44.4 | 56.6 | 11.0 | 2050 | 6.02 | 256 | 311 | 3490 | 395 | 0.597 | 13.4 |
| 180 × 180 | 5.0 ‡ | 27.0 | 34.4 | 31.0 | 1740 | 7.11 | 193 | 224 | 2720 | 290 | 0.703 | 26.0 |
| | 6.0 ‡ | 32.1 | 40.8 | 25.0 | 2040 | 7.06 | 226 | 264 | 3220 | 340 | 0.699 | 21.8 |
| | 8.0 ‡ | 41.5 | 52.8 | 17.5 | 2550 | 6.94 | 283 | 336 | 4190 | 432 | 0.686 | 16.5 |
| | 10.0 ‡ | 50.7 | 64.6 | 13.0 | 3020 | 6.84 | 335 | 404 | 5070 | 515 | 0.677 | 13.4 |
| | 12.0 ‡ | 58.5 | 74.5 | 10.0 | 3320 | 6.68 | 369 | 454 | 5870 | 584 | 0.658 | 11.2 |
| | 12.5 ‡ | 60.5 | 77.0 | 9.40 | 3410 | 6.65 | 378 | 467 | 6050 | 600 | 0.656 | 10.8 |
| 200 × 200 | 5.0 ‡ | 30.1 | 38.4 | 35.0 | 2410 | 7.93 | 241 | 279 | 3760 | 362 | 0.783 | 26.0 |
| | 6.0 ‡ | 35.8 | 45.6 | 28.3 | 2830 | 7.88 | 283 | 330 | 4460 | 426 | 0.779 | 21.8 |
| | 8.0 ‡ | 46.5 | 59.2 | 20.0 | 3570 | 7.76 | 357 | 421 | 5820 | 544 | 0.766 | 16.5 |
| | 10.0 ‡ | 57.0 | 72.6 | 15.0 | 4250 | 7.65 | 425 | 508 | 7070 | 651 | 0.757 | 13.3 |
| | 12.0 ‡ | 66.0 | 84.1 | 11.7 | 4730 | 7.50 | 473 | 576 | 8230 | 743 | 0.738 | 11.2 |
| | 12.5 ‡ | 68.3 | 87.0 | 11.0 | 4860 | 7.47 | 486 | 594 | 8500 | 765 | 0.736 | 10.8 |
| 250 × 250 | 6.0 ‡ | 45.2 | 57.6 | 36.7 | 5670 | 9.92 | 454 | 524 | 8840 | 681 | 0.979 | 21.7 |
| | 8.0 ‡ | 59.1 | 75.2 | 26.3 | 7230 | 9.80 | 578 | 676 | 11600 | 878 | 0.966 | 16.3 |
| | 10.0 ‡ | 72.7 | 92.6 | 20.0 | 8710 | 9.70 | 697 | 822 | 14200 | 1060 | 0.957 | 13.2 |
| | 12.0 ‡ | 84.8 | 108 | 15.8 | 9860 | 9.55 | 789 | 944 | 16700 | 1230 | 0.938 | 11.1 |
| | 12.5 ‡ | 88.0 | 112 | 15.0 | 10200 | 9.52 | 813 | 975 | 17300 | 1270 | 0.936 | 10.6 |
| 300 × 300 | 8.0 ‡ | 71.6 | 91.2 | 32.5 | 12800 | 11.8 | 853 | 991 | 20300 | 1290 | 1.17 | 16.3 |
| | 10.0 ‡ | 88.4 | 113 | 25.0 | 15500 | 11.7 | 1030 | 1210 | 25000 | 1570 | 1.16 | 13.1 |
| | 12.0 ‡ | 104 | 132 | 20.0 | 17800 | 11.6 | 1180 | 1400 | 29500 | 1830 | 1.14 | 11.0 |
| | 12.5 ‡ | 108 | 137 | 19.0 | 18300 | 11.6 | 1220 | 1450 | 30600 | 1890 | 1.14 | 10.6 |

‡ Grade S275 not available from some leading producers. Check availability.

⁽¹⁾ For local buckling calculation $d = D - 5t$.

**COLD-FORMED
RECTANGULAR HOLLOW SECTIONS**



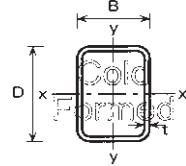
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratios for Local Buckling | | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Torsional Constants | | Surface Area | |
|---------------------|-----------|----------------|-------------------|---------------------------|--------------------|-----------------------|-----------------|--------------------|----------|-----------------|-----------------|-----------------|-----------------|---------------------|-------------------|----------------|----------------|
| Size | Thickness | | | d/t ⁽¹⁾ | b/t ⁽¹⁾ | Axis x-x | Axis y-y | Axis x-x | Axis y-y | Axis x-x | Axis y-y | Axis x-x | Axis y-y | J cm ⁴ | C cm ³ | Per Metre | Per Tonne |
| D × B mm | t mm | kg/m | A cm ² | | | cm ⁴ | cm ⁴ | cm | cm | cm ³ | cm ³ | cm ³ | cm ³ | | | m ² | m ² |
| 50 × 25 | 2.0 ‡ | 2.15 | 2.74 | 20.0 | 7.50 | 8.38 | 2.81 | 1.75 | 1.01 | 3.35 | 2.25 | 4.26 | 2.62 | 7.06 | 3.92 | 0.143 | 66.5 |
| | 2.5 ‡ | 2.62 | 3.34 | 15.0 | 5.00 | 9.89 | 3.28 | 1.72 | 0.991 | 3.95 | 2.62 | 5.11 | 3.12 | 8.43 | 4.60 | 0.141 | 53.8 |
| | 3.0 ‡ | 3.07 | 3.91 | 11.7 | 3.33 | 11.2 | 3.67 | 1.69 | 0.869 | 4.47 | 2.93 | 5.86 | 3.56 | 9.64 | 5.18 | 0.140 | 45.6 |
| 50 × 30 | 2.0 ‡ | 2.31 | 2.94 | 20.0 | 10.0 | 9.54 | 4.29 | 1.80 | 1.21 | 3.81 | 2.86 | 4.74 | 3.33 | 9.77 | 4.84 | 0.153 | 66.2 |
| | 2.5 ‡ | 2.82 | 3.59 | 15.0 | 7.00 | 11.3 | 5.05 | 1.77 | 1.19 | 4.52 | 3.37 | 5.70 | 3.98 | 11.7 | 5.72 | 0.151 | 53.5 |
| | 3.0 ‡ | 3.30 | 4.21 | 11.7 | 5.00 | 12.8 | 5.70 | 1.75 | 1.16 | 5.13 | 3.80 | 6.57 | 4.58 | 13.5 | 6.49 | 0.150 | 45.5 |
| | 4.0 ‡ | 4.20 | 5.35 | 7.50 | 2.50 | 15.3 | 6.69 | 1.69 | 1.12 | 6.10 | 4.46 | 8.05 | 5.58 | 16.5 | 7.71 | 0.146 | 34.8 |
| 60 × 30 | 3.0 ‡ | 3.77 | 4.81 | 15.0 | 5.00 | 20.5 | 6.80 | 2.06 | 1.19 | 6.83 | 4.53 | 8.82 | 5.39 | 17.5 | 7.95 | 0.170 | 45.1 |
| | 4.0 ‡ | 4.83 | 6.15 | 10.0 | 2.50 | 24.7 | 8.06 | 2.00 | 1.14 | 8.23 | 5.37 | 10.9 | 6.62 | 21.5 | 9.52 | 0.166 | 34.4 |
| 60 × 40 | 2.5 ‡ | 3.60 | 4.59 | 19.0 | 11.0 | 22.1 | 11.7 | 2.19 | 1.60 | 7.36 | 5.87 | 9.06 | 6.84 | 25.1 | 9.72 | 0.191 | 53.1 |
| | 3.0 ‡ | 4.25 | 5.41 | 15.0 | 8.33 | 25.4 | 13.4 | 2.17 | 1.58 | 8.46 | 6.72 | 10.5 | 7.94 | 29.3 | 11.2 | 0.190 | 44.7 |
| | 4.0 ‡ | 5.45 | 6.95 | 10.0 | 5.00 | 31.0 | 16.3 | 2.11 | 1.53 | 10.3 | 8.14 | 13.2 | 9.89 | 36.7 | 13.7 | 0.186 | 34.1 |
| | 5.0 ‡ | 6.56 | 8.36 | 7.00 | 3.00 | 35.3 | 18.4 | 2.06 | 1.48 | 11.8 | 9.21 | 15.4 | 11.5 | 42.8 | 15.6 | 0.183 | 27.9 |
| | 7.0 × 40 | 3.0 ‡ | 4.72 | 6.01 | 18.3 | 8.33 | 37.3 | 15.5 | 2.49 | 1.61 | 10.7 | 7.75 | 13.4 | 9.05 | 36.5 | 13.2 | 0.210 |
| 7.0 × 40 | 4.0 ‡ | 6.08 | 7.75 | 12.5 | 5.00 | 46.0 | 18.9 | 2.44 | 1.56 | 13.1 | 9.44 | 16.8 | 11.3 | 45.8 | 16.2 | 0.206 | 33.9 |
| | 7.0 × 50 | 3.0 ‡ | 5.19 | 6.61 | 18.3 | 11.7 | 44.1 | 26.1 | 2.58 | 1.99 | 12.6 | 10.4 | 15.4 | 12.2 | 53.6 | 17.1 | 0.230 |
| 7.0 × 50 | 4.0 ‡ | 6.71 | 8.55 | 12.5 | 7.50 | 54.7 | 32.2 | 2.53 | 1.94 | 15.6 | 12.9 | 19.5 | 15.4 | 68.1 | 21.2 | 0.226 | 33.7 |
| | 8.0 × 40 | 3.0 ‡ | 5.19 | 6.61 | 21.7 | 8.33 | 52.3 | 17.6 | 2.81 | 1.63 | 13.1 | 8.78 | 16.5 | 10.2 | 43.9 | 15.3 | 0.230 |
| 8.0 × 40 | 4.0 ‡ | 6.71 | 8.55 | 15.0 | 5.00 | 64.8 | 21.5 | 2.75 | 1.59 | 16.2 | 10.7 | 20.9 | 12.8 | 55.2 | 18.8 | 0.226 | 33.7 |
| | 5.0 ‡ | 8.13 | 10.4 | 11.0 | 3.00 | 75.1 | 24.6 | 2.69 | 1.54 | 18.8 | 12.3 | 24.7 | 15.0 | 65.0 | 21.7 | 0.223 | 27.4 |
| 8.0 × 50 | 3.0 ‡ | 5.66 | 7.21 | 21.7 | 11.7 | 61.1 | 29.4 | 2.91 | 2.02 | 15.3 | 11.8 | 18.8 | 13.6 | 65.0 | 19.7 | 0.250 | 44.2 |
| | 4.0 ‡ | 7.34 | 9.35 | 15.0 | 7.50 | 76.4 | 36.5 | 2.86 | 1.98 | 19.1 | 14.6 | 24.0 | 17.2 | 82.7 | 24.6 | 0.246 | 33.5 |
| | 5.0 ‡ | 8.91 | 11.4 | 11.0 | 5.00 | 89.2 | 42.3 | 2.80 | 1.93 | 22.3 | 16.9 | 28.5 | 20.5 | 98.4 | 28.7 | 0.243 | 27.3 |
| 8.0 × 60 | 3.0 ‡ | 6.13 | 7.81 | 21.7 | 15.0 | 70.0 | 44.9 | 3.00 | 2.40 | 17.5 | 15.0 | 21.2 | 17.4 | 88.3 | 24.1 | 0.270 | 44.0 |
| | 4.0 ‡ | 7.97 | 10.1 | 15.0 | 10.0 | 87.9 | 56.1 | 2.94 | 2.35 | 22.0 | 18.7 | 27.0 | 22.1 | 113 | 30.3 | 0.266 | 33.4 |
| | 5.0 ‡ | 9.70 | 12.4 | 11.0 | 7.00 | 103 | 65.7 | 2.89 | 2.31 | 25.8 | 21.9 | 32.2 | 26.4 | 136 | 35.7 | 0.263 | 27.1 |
| 9.0 × 50 | 3.0 ‡ | 6.13 | 7.81 | 25.0 | 11.7 | 81.9 | 32.7 | 3.24 | 2.05 | 18.2 | 13.1 | 22.6 | 15.0 | 76.7 | 22.4 | 0.270 | 44.0 |
| | 3.5 ‡ | 7.06 | 8.99 | 20.7 | 9.29 | 92.7 | 36.9 | 3.21 | 2.03 | 20.6 | 14.8 | 25.8 | 17.1 | 87.5 | 25.3 | 0.268 | 38.0 |
| | 4.0 ‡ | 7.97 | 10.1 | 17.5 | 7.50 | 103 | 40.7 | 3.18 | 2.00 | 22.8 | 16.3 | 28.8 | 19.1 | 97.7 | 28.0 | 0.266 | 33.4 |
| | 5.0 ‡ | 9.70 | 12.4 | 13.0 | 5.00 | 121 | 47.4 | 3.12 | 1.96 | 26.8 | 18.9 | 34.4 | 22.7 | 116 | 32.7 | 0.263 | 27.1 |
| 100 × 40 | 3.0 ‡ | 6.13 | 7.81 | 28.3 | 8.33 | 92.3 | 21.7 | 3.44 | 1.67 | 18.5 | 10.8 | 23.7 | 12.4 | 59.0 | 19.4 | 0.270 | 44.0 |
| | 4.0 ‡ | 7.97 | 10.1 | 20.0 | 5.00 | 116 | 26.7 | 3.38 | 1.62 | 23.1 | 13.3 | 30.3 | 15.7 | 74.5 | 24.0 | 0.266 | 33.4 |
| | 5.0 ‡ | 9.70 | 12.4 | 15.0 | 3.00 | 136 | 30.8 | 3.31 | 1.58 | 27.1 | 15.4 | 36.1 | 18.5 | 87.9 | 27.9 | 0.263 | 27.1 |
| 100 × 50 | 3.0 ‡ | 6.60 | 8.41 | 28.3 | 11.7 | 106 | 36.1 | 3.56 | 2.07 | 21.3 | 14.4 | 26.7 | 16.4 | 88.6 | 25.0 | 0.290 | 43.9 |
| | 4.0 ‡ | 8.59 | 10.9 | 20.0 | 7.50 | 134 | 44.9 | 3.50 | 2.03 | 26.8 | 18.0 | 34.1 | 20.9 | 113 | 31.3 | 0.286 | 33.3 |
| | 5.0 ‡ | 10.5 | 13.4 | 15.0 | 5.00 | 158 | 52.5 | 3.44 | 1.98 | 31.6 | 21.0 | 40.8 | 25.0 | 135 | 36.8 | 0.283 | 27.0 |
| | 6.0 ‡ | 12.3 | 15.6 | 11.7 | 3.33 | 179 | 58.7 | 3.38 | 1.94 | 35.8 | 23.5 | 46.9 | 28.5 | 154 | 41.4 | 0.279 | 22.7 |
| 100 × 60 | 3.0 ‡ | 7.07 | 9.01 | 28.3 | 15.0 | 121 | 54.6 | 3.66 | 2.46 | 24.1 | 18.2 | 29.6 | 20.8 | 122 | 30.6 | 0.310 | 43.8 |
| | 3.5 ‡ | 8.16 | 10.4 | 23.6 | 12.1 | 137 | 61.9 | 3.63 | 2.44 | 27.4 | 20.6 | 33.8 | 23.8 | 139 | 34.8 | 0.308 | 37.7 |
| | 4.0 ‡ | 9.22 | 11.7 | 20.0 | 10.0 | 153 | 68.7 | 3.60 | 2.42 | 30.5 | 22.9 | 37.9 | 26.6 | 156 | 38.7 | 0.306 | 33.2 |
| | 5.0 ‡ | 11.3 | 14.4 | 15.0 | 7.00 | 181 | 80.8 | 3.55 | 2.37 | 36.2 | 26.9 | 45.6 | 31.9 | 188 | 45.8 | 0.303 | 26.8 |
| | 6.0 ‡ | 13.2 | 16.8 | 11.7 | 5.00 | 205 | 91.2 | 3.49 | 2.33 | 41.1 | 30.4 | 52.5 | 36.6 | 216 | 51.9 | 0.299 | 22.7 |

‡ Grade S275 not available from some leading producers. Check availability.

⁽¹⁾ For local buckling calculation $d = D - 5t$ and $b = B - 5t$.

**COLD-FORMED
RECTANGULAR HOLLOW SECTIONS**



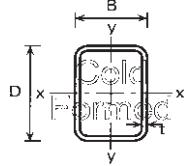
DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre | Area of Section | Ratios for Local Buckling | | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Torsional Constants | | Surface Area | |
|---------------------|----------------|----------------|-----------------|---------------------------|--------------------|--------------------------|--------------------------|--------------------|-------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------|-------------------|--------------------------|--------------------------|
| Size | Thickness t mm | | | d/t ⁽¹⁾ | b/t ⁽¹⁾ | 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 | J cm ⁴ | C cm ³ | Per Metre m ² | Per Tonne m ² |
| 100 × 80 | 3.0 ‡ | 8.01 | 10.2 | 28.3 | 21.7 | 149 | 106 | 3.82 | 3.22 | 29.8 | 26.4 | 35.4 | 30.4 | 196 | 41.9 | 0.350 | 43.7 |
| | 4.0 ‡ | 10.5 | 13.3 | 20.0 | 15.0 | 189 | 134 | 3.77 | 3.17 | 37.9 | 33.5 | 45.6 | 39.2 | 254 | 53.4 | 0.346 | 33.0 |
| | 5.0 ‡ | 12.8 | 16.4 | 15.0 | 11.0 | 226 | 160 | 3.72 | 3.12 | 45.2 | 39.9 | 55.1 | 47.2 | 308 | 63.7 | 0.343 | 26.8 |
| 120 × 40 | 3.0 ‡ | 7.07 | 9.01 | 35.0 | 8.33 | 148 | 25.8 | 4.05 | 1.69 | 24.7 | 12.9 | 32.2 | 14.6 | 74.6 | 23.5 | 0.310 | 43.8 |
| | 4.0 ‡ | 9.22 | 11.7 | 25.0 | 5.00 | 187 | 31.9 | 3.99 | 1.65 | 31.1 | 15.9 | 41.2 | 18.5 | 94.2 | 29.2 | 0.306 | 33.2 |
| | 5.0 ‡ | 11.3 | 14.4 | 19.0 | 3.00 | 221 | 36.9 | 3.92 | 1.60 | 36.8 | 18.5 | 49.4 | 22.0 | 111 | 34.1 | 0.303 | 26.8 |
| 120 × 60 | 3.0 ‡ | 8.01 | 10.2 | 35.0 | 15.0 | 189 | 64.4 | 4.30 | 2.51 | 31.5 | 21.5 | 39.2 | 24.2 | 156 | 37.1 | 0.350 | 43.7 |
| | 3.5 ‡ | 9.26 | 11.8 | 29.3 | 12.1 | 216 | 73.1 | 4.28 | 2.49 | 35.9 | 24.4 | 44.9 | 27.7 | 179 | 42.2 | 0.348 | 37.6 |
| | 4.0 ‡ | 10.5 | 13.3 | 25.0 | 10.0 | 241 | 81.2 | 4.25 | 2.47 | 40.1 | 27.1 | 50.5 | 31.1 | 201 | 47.0 | 0.346 | 33.0 |
| | 5.0 ‡ | 12.8 | 16.4 | 19.0 | 7.00 | 287 | 96.0 | 4.19 | 2.42 | 47.8 | 32.0 | 60.9 | 37.4 | 242 | 55.8 | 0.343 | 26.8 |
| | 6.0 ‡ | 15.1 | 19.2 | 15.0 | 5.00 | 328 | 109 | 4.13 | 2.38 | 54.7 | 36.3 | 70.6 | 43.1 | 280 | 63.6 | 0.339 | 22.5 |
| 120 × 80 | 3.0 ‡ | 8.96 | 11.4 | 35.0 | 21.7 | 230 | 123 | 4.49 | 3.29 | 38.4 | 30.9 | 46.2 | 35.0 | 255 | 50.8 | 0.390 | 43.5 |
| | 4.0 ‡ | 11.7 | 14.9 | 25.0 | 15.0 | 295 | 157 | 4.44 | 3.24 | 49.1 | 39.3 | 59.8 | 45.2 | 331 | 64.9 | 0.386 | 33.0 |
| | 5.0 ‡ | 14.4 | 18.4 | 19.0 | 11.0 | 353 | 188 | 4.39 | 3.20 | 58.9 | 46.9 | 72.4 | 54.7 | 402 | 77.8 | 0.383 | 26.6 |
| | 6.0 ‡ | 17.0 | 21.6 | 15.0 | 8.33 | 406 | 215 | 4.33 | 3.15 | 67.7 | 53.8 | 84.3 | 63.5 | 469 | 89.4 | 0.379 | 22.3 |
| | 8.0 ‡ | 21.4 | 27.2 | 10.0 | 5.00 | 476 | 252 | 4.18 | 3.04 | 79.3 | 62.9 | 102 | 76.9 | 584 | 108 | 0.366 | 17.1 |
| 140 × 80 | 3.0 ‡ | 9.90 | 12.6 | 41.7 | 21.7 | 334 | 141 | 5.15 | 3.35 | 47.8 | 35.3 | 58.2 | 39.6 | 317 | 59.7 | 0.430 | 43.4 |
| | 4.0 ‡ | 13.0 | 16.5 | 30.0 | 15.0 | 430 | 180 | 5.10 | 3.30 | 61.4 | 45.1 | 75.5 | 51.3 | 412 | 76.5 | 0.426 | 32.8 |
| | 5.0 ‡ | 16.0 | 20.4 | 23.0 | 11.0 | 517 | 216 | 5.04 | 3.26 | 73.9 | 54.0 | 91.8 | 62.2 | 501 | 91.8 | 0.423 | 26.4 |
| | 6.0 ‡ | 18.9 | 24.0 | 18.3 | 8.33 | 597 | 248 | 4.98 | 3.21 | 85.3 | 62.0 | 107 | 72.4 | 584 | 106 | 0.419 | 22.2 |
| | 8.0 ‡ | 23.9 | 30.4 | 12.5 | 5.00 | 708 | 293 | 4.82 | 3.10 | 101 | 73.3 | 131 | 88.4 | 731 | 129 | 0.406 | 17.0 |
| 150 × 100 | 3.0 ‡ | 10.86 | 14.6 | 41.7 | 21.7 | 334 | 141 | 5.15 | 3.35 | 47.8 | 35.3 | 58.2 | 39.6 | 317 | 59.7 | 0.430 | 43.4 |
| | 4.0 ‡ | 14.9 | 18.9 | 32.5 | 20.0 | 595 | 319 | 5.60 | 4.10 | 79.3 | 63.7 | 95.7 | 72.5 | 662 | 105 | 0.486 | 32.6 |
| | 5.0 ‡ | 18.3 | 23.4 | 25.0 | 15.0 | 719 | 384 | 5.55 | 4.05 | 95.9 | 76.8 | 117 | 88.3 | 809 | 127 | 0.483 | 26.4 |
| | 6.0 ‡ | 21.7 | 27.6 | 20.0 | 11.7 | 835 | 444 | 5.50 | 4.01 | 111 | 88.8 | 137 | 103 | 948 | 147 | 0.479 | 22.1 |
| | 8.0 ‡ | 27.7 | 35.2 | 13.8 | 7.50 | 1010 | 536 | 5.35 | 3.90 | 134 | 107 | 169 | 128 | 1210 | 182 | 0.466 | 16.8 |
| 160 × 80 | 5.0 ‡ | 17.5 | 22.4 | 27.0 | 11.0 | 722 | 244 | 5.68 | 3.30 | 90.2 | 61.0 | 113 | 69.7 | 601 | 106 | 0.463 | 26.5 |
| | 6.0 ‡ | 20.7 | 26.4 | 21.7 | 8.33 | 836 | 281 | 5.62 | 3.26 | 105 | 70.2 | 132 | 81.3 | 702 | 122 | 0.459 | 22.2 |
| | 8.0 ‡ | 26.4 | 33.6 | 15.0 | 5.00 | 1000 | 335 | 5.46 | 3.16 | 125 | 83.7 | 163 | 100 | 882 | 150 | 0.446 | 16.9 |
| 180 × 80 | 4.0 ‡ | 15.5 | 19.7 | 40.0 | 15.0 | 802 | 227 | 6.37 | 3.39 | 89.1 | 56.7 | 112 | 63.5 | 578 | 99.6 | 0.506 | 32.6 |
| | 5.0 ‡ | 19.1 | 24.4 | 31.0 | 11.0 | 971 | 272 | 6.31 | 3.34 | 108 | 68.1 | 137 | 77.2 | 704 | 120 | 0.503 | 26.3 |
| | 6.0 ‡ | 22.6 | 28.8 | 25.0 | 8.33 | 1130 | 314 | 6.25 | 3.30 | 125 | 78.5 | 160 | 90.2 | 823 | 139 | 0.499 | 22.1 |
| | 8.0 ‡ | 28.9 | 36.8 | 17.5 | 5.00 | 1360 | 377 | 6.08 | 3.20 | 151 | 94.1 | 198 | 111 | 1040 | 170 | 0.486 | 16.8 |
| | 10.0 ‡ | 35.0 | 44.6 | 13.0 | 3.00 | 1570 | 429 | 5.94 | 3.10 | 174 | 107 | 234 | 131 | 1210 | 196 | 0.477 | 13.6 |
| 180 × 100 | 4.0 ‡ | 16.8 | 21.3 | 40.0 | 20.0 | 926 | 374 | 6.59 | 4.18 | 103 | 74.8 | 126 | 84.0 | 854 | 127 | 0.546 | 32.5 |
| | 5.0 ‡ | 20.7 | 26.4 | 31.0 | 15.0 | 1120 | 452 | 6.53 | 4.14 | 125 | 90.4 | 154 | 103 | 1040 | 154 | 0.543 | 26.2 |
| | 6.0 ‡ | 24.5 | 31.2 | 25.0 | 11.7 | 1310 | 524 | 6.48 | 4.10 | 146 | 105 | 181 | 120 | 1230 | 179 | 0.539 | 22.0 |
| | 8.0 ‡ | 31.4 | 40.0 | 17.5 | 7.50 | 1600 | 637 | 6.32 | 3.99 | 178 | 127 | 226 | 150 | 1570 | 222 | 0.526 | 16.8 |
| | 10.0 ‡ | 38.1 | 48.6 | 13.0 | 5.00 | 1860 | 736 | 6.19 | 3.89 | 207 | 147 | 268 | 177 | 1860 | 260 | 0.517 | 13.6 |

‡ Grade S275 not available from some leading producers. Check availability.

⁽¹⁾ For local buckling calculation $d = D - 5t$ and $b = B - 5t$.

**COLD-FORMED
RECTANGULAR HOLLOW SECTIONS**

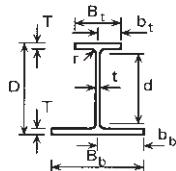


DIMENSIONS AND PROPERTIES

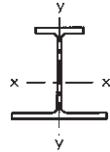
| Section Designation | | Mass per Metre kg/m | Area of Section A cm² | Ratios for Local Buckling | | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Torsional Constants | | Surface Area | |
|---------------------|----------------|---------------------|-----------------------|---------------------------|--------------------|-----------------------|--------------|--------------------|-------------|-----------------|--------------|-----------------|--------------|---------------------|-------|--------------|--------------|
| Size D x B mm | Thickness t mm | | | d/t ⁽¹⁾ | b/t ⁽¹⁾ | Axis x-x cm⁴ | Axis y-y cm⁴ | Axis x-x cm | Axis y-y cm | Axis x-x cm³ | Axis y-y cm³ | Axis x-x cm³ | Axis y-y cm³ | J cm⁴ | C cm³ | Per Metre m² | Per Tonne m² |
| 200 x 100 | 4.0 ‡ | 18.0 | 22.9 | 45.0 | 20.0 | 1200 | 411 | 7.23 | 4.23 | 120 | 82.2 | 148 | 91.7 | 985 | 142 | 0.586 | 32.6 |
| | 5.0 ‡ | 22.3 | 28.4 | 35.0 | 15.0 | 1460 | 497 | 7.17 | 4.19 | 146 | 99.4 | 181 | 112 | 1210 | 172 | 0.583 | 26.1 |
| | 6.0 ‡ | 26.4 | 33.6 | 28.3 | 11.7 | 1700 | 577 | 7.12 | 4.14 | 170 | 115 | 213 | 132 | 1420 | 200 | 0.579 | 21.9 |
| | 8.0 ‡ | 33.9 | 43.2 | 20.0 | 7.50 | 2090 | 705 | 6.95 | 4.04 | 209 | 141 | 267 | 165 | 1810 | 250 | 0.566 | 16.7 |
| | 10.0 ‡ | 41.3 | 52.6 | 15.0 | 5.00 | 2440 | 818 | 6.82 | 3.94 | 244 | 164 | 318 | 195 | 2150 | 292 | 0.557 | 13.5 |
| 200 x 120 | 4.0 ‡ | 19.3 | 24.5 | 45.0 | 25.0 | 1350 | 618 | 7.43 | 5.02 | 135 | 103 | 164 | 115 | 1350 | 172 | 0.626 | 32.4 |
| | 5.0 ‡ | 23.8 | 30.4 | 35.0 | 19.0 | 1650 | 750 | 7.37 | 4.97 | 165 | 125 | 201 | 141 | 1650 | 210 | 0.623 | 26.2 |
| | 6.0 ‡ | 28.3 | 36.0 | 28.3 | 15.0 | 1930 | 874 | 7.32 | 4.93 | 193 | 146 | 237 | 166 | 1950 | 245 | 0.619 | 21.9 |
| | 8.0 ‡ | 36.5 | 46.4 | 20.0 | 10.0 | 2390 | 1080 | 7.17 | 4.82 | 239 | 180 | 298 | 209 | 2510 | 308 | 0.606 | 16.6 |
| | 10.0 ‡ | 44.4 | 56.6 | 15.0 | 7.00 | 2810 | 1260 | 7.04 | 4.72 | 281 | 210 | 356 | 250 | 3010 | 364 | 0.597 | 13.4 |
| 200 x 150 | 4.0 ‡ | 21.2 | 26.9 | 45.0 | 32.5 | 1580 | 1020 | 7.67 | 6.16 | 158 | 136 | 187 | 154 | 1940 | 219 | 0.686 | 32.4 |
| | 5.0 ‡ | 26.2 | 33.4 | 35.0 | 25.0 | 1930 | 1250 | 7.62 | 6.11 | 193 | 166 | 230 | 189 | 2390 | 267 | 0.683 | 26.1 |
| | 6.0 ‡ | 31.1 | 39.6 | 28.3 | 20.0 | 2270 | 1460 | 7.56 | 6.06 | 227 | 194 | 271 | 223 | 2830 | 313 | 0.679 | 21.8 |
| | 8.0 ‡ | 40.2 | 51.2 | 20.0 | 13.8 | 2830 | 1820 | 7.43 | 5.95 | 283 | 242 | 344 | 283 | 3660 | 396 | 0.666 | 16.6 |
| | 10.0 ‡ | 49.1 | 62.6 | 15.0 | 10.0 | 3350 | 2140 | 7.31 | 5.85 | 335 | 286 | 413 | 339 | 4430 | 471 | 0.657 | 13.4 |
| 250 x 150 | 5.0 ‡ | 30.1 | 38.4 | 45.0 | 25.0 | 3300 | 1510 | 9.28 | 6.27 | 264 | 201 | 320 | 225 | 3280 | 337 | 0.783 | 26.0 |
| | 6.0 ‡ | 35.8 | 45.6 | 36.7 | 20.0 | 3890 | 1770 | 9.23 | 6.23 | 311 | 236 | 378 | 266 | 3890 | 396 | 0.779 | 21.8 |
| | 8.0 ‡ | 46.5 | 59.2 | 26.3 | 13.8 | 4890 | 2220 | 9.08 | 6.12 | 391 | 296 | 482 | 340 | 5050 | 504 | 0.766 | 16.5 |
| | 10.0 ‡ | 57.0 | 72.6 | 20.0 | 10.0 | 5830 | 2630 | 8.96 | 6.02 | 466 | 351 | 582 | 409 | 6120 | 602 | 0.757 | 13.3 |
| | 12.0 ‡ | 66.0 | 84.1 | 15.8 | 7.50 | 6460 | 2930 | 8.77 | 5.90 | 517 | 390 | 658 | 463 | 7090 | 684 | 0.738 | 11.2 |
| 300 x 100 | 6.0 ‡ | 35.8 | 45.6 | 45.0 | 11.7 | 4780 | 842 | 10.2 | 4.30 | 318 | 168 | 411 | 188 | 2400 | 306 | 0.779 | 21.8 |
| | 8.0 ‡ | 46.5 | 59.2 | 32.5 | 7.50 | 5980 | 1040 | 10.0 | 4.20 | 399 | 209 | 523 | 238 | 3080 | 385 | 0.766 | 16.5 |
| | 10.0 ‡ | 57.0 | 72.6 | 25.0 | 5.00 | 7110 | 1220 | 9.90 | 4.11 | 474 | 245 | 631 | 285 | 3680 | 455 | 0.757 | 13.3 |
| | 12.0 ‡ | 66.0 | 84.1 | 20.0 | 3.33 | 7810 | 1340 | 9.64 | 4.00 | 521 | 269 | 710 | 321 | 4180 | 508 | 0.738 | 11.2 |
| | 12.5 ‡ | 68.3 | 87.0 | 19.0 | 3.00 | 8010 | 1370 | 9.59 | 3.97 | 534 | 275 | 732 | 330 | 4290 | 521 | 0.736 | 10.8 |
| 300 x 200 | 6.0 ‡ | 45.2 | 57.6 | 45.0 | 28.3 | 7370 | 3960 | 11.3 | 8.29 | 491 | 396 | 588 | 446 | 8120 | 651 | 0.979 | 21.7 |
| | 8.0 ‡ | 59.1 | 75.2 | 32.5 | 20.0 | 9390 | 5040 | 11.2 | 8.19 | 626 | 504 | 757 | 574 | 10600 | 838 | 0.966 | 16.3 |
| | 10.0 ‡ | 72.7 | 92.6 | 25.0 | 15.0 | 11300 | 6060 | 11.1 | 8.09 | 754 | 606 | 921 | 698 | 13000 | 1010 | 0.957 | 13.2 |
| | 12.0 ‡ | 84.8 | 108 | 20.0 | 11.7 | 12800 | 6850 | 10.9 | 7.96 | 853 | 685 | 1060 | 801 | 15200 | 1170 | 0.938 | 11.1 |
| | 12.5 ‡ | 88.0 | 112 | 19.0 | 11.0 | 13200 | 7060 | 10.8 | 7.94 | 879 | 706 | 1090 | 828 | 15800 | 1200 | 0.936 | 10.6 |
| 400 x 200 | 8.0 ‡ | 71.6 | 91.2 | 45.0 | 20.0 | 19000 | 6520 | 14.4 | 8.45 | 949 | 652 | 1170 | 728 | 15800 | 1130 | 1.17 | 16.3 |
| | 10.0 ‡ | 88.4 | 113 | 35.0 | 15.0 | 23000 | 7860 | 14.3 | 8.36 | 1150 | 786 | 1430 | 888 | 19400 | 1370 | 1.16 | 13.1 |
| | 12.0 ‡ | 104 | 132 | 28.3 | 11.7 | 26200 | 8980 | 14.1 | 8.24 | 1310 | 898 | 1660 | 1030 | 22800 | 1590 | 1.14 | 11.0 |
| | 12.5 ‡ | 108 | 137 | 27.0 | 11.0 | 27100 | 9260 | 14.1 | 8.22 | 1360 | 926 | 1710 | 1060 | 23600 | 1640 | 1.14 | 10.6 |

‡ Grade S275 not available from some leading producers. Check availability.

⁽¹⁾ For local buckling calculation $d = D - 5t$ and $b = B - 5t$.



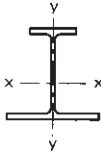
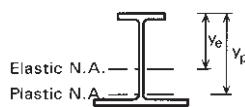
ASB (ASYMMETRIC BEAMS)



DIMENSIONS AND PROPERTIES

| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Flange | | Thickness | | Root Radius r mm | Depth between Fillets d mm | Ratios for Local Buckling | | | Second Moment of Area | | Surface Area | | | |
|---------------------|---------------------|-----------------------|-----------------------|--------------------------|-----------|-------------|------------------|----------------------------|---------------------------|-------------------|---------|--------------------------|--------------------------|--------------------------|--------------------------|--|--|
| | | | Top B _t mm | Bottom B _b mm | Web t mm | Flange T mm | | | Flanges | | Web d/t | Axis x-x cm ⁴ | Axis y-y cm ⁴ | Per Metre m ² | Per Tonne m ² | | |
| | | | | | | | | | b _t /T | b _b /T | | | | | | | |
| 300 ASB 249† | 249 | 342 | 203 | 313 | 40.0 | 40.0 | 27.0 | 208 | 2.54 | 3.91 | 5.20 | 52900 | 13200 | 1.59 | 6.38 | | |
| 300 ASB 196 | 196 | 342 | 183 | 293 | 20.0 | 40.0 | 27.0 | 208 | 2.29 | 3.66 | 10.4 | 45900 | 10500 | 1.55 | 7.93 | | |
| 300 ASB 185† | 185 | 320 | 195 | 305 | 32.0 | 29.0 | 27.0 | 208 | 3.36 | 5.26 | 6.50 | 35700 | 8750 | 1.53 | 8.29 | | |
| 300 ASB 155 | 155 | 326 | 179 | 289 | 16.0 | 32.0 | 27.0 | 208 | 2.80 | 4.52 | 13.0 | 34500 | 7990 | 1.51 | 9.71 | | |
| 300 ASB 153† | 153 | 310 | 190 | 300 | 27.0 | 24.0 | 27.0 | 208 | 3.96 | 6.25 | 7.70 | 28400 | 6840 | 1.50 | 9.81 | | |
| 280 ASB 136† | 136 | 288 | 190 | 300 | 25.0 | 22.0 | 24.0 | 196 | 4.32 | 6.82 | 7.84 | 22200 | 6260 | 1.46 | 10.7 | | |
| 280 ASB 124 | 124 | 296 | 178 | 288 | 13.0 | 26.0 | 24.0 | 196 | 3.42 | 5.54 | 15.1 | 23500 | 6410 | 1.46 | 11.8 | | |
| 280 ASB 105 | 105 | 288 | 176 | 286 | 11.0 | 22.0 | 24.0 | 196 | 4.00 | 6.50 | 17.8 | 19200 | 5300 | 1.44 | 13.7 | | |
| 280 ASB 100† | 100 | 276 | 184 | 294 | 19.0 | 16.0 | 24.0 | 196 | 5.75 | 9.19 | 10.3 | 15500 | 4250 | 1.43 | 14.2 | | |
| 280 ASB 74 | 73.6 | 272 | 175 | 285 | 10.0 | 14.0 | 24.0 | 196 | 6.25 | 10.2 | 19.6 | 12200 | 3330 | 1.40 | 19.1 | | |

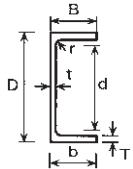
† Sections are fire engineered with thick webs.
ASB sections are only available in S355.

ASB (ASYMMETRIC BEAMS)**PROPERTIES (CONTINUED)**

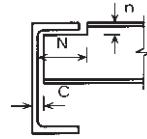
| Section Designation | Radius of Gyration | | Elastic Modulus | | | Neutral Axis Position | | Plastic Modulus | | Buckling Parameter | Torsional Index | Warping Constant | Torsional Constant | Area of Section |
|---------------------|--------------------|----------------|------------------------------------|---------------------------------------|-----------------------------|---------------------------------|---------------------------------|-----------------------------|-----------------------------|--------------------|-----------------|------------------|--------------------|-----------------|
| | Axis x-x cm | Axis y-y cm | Axis x-x Top cm ³ | Axis x-x Bottom cm ³ | Axis y-y cm ³ | Elastic y _e cm | Plastic y _p cm | Axis x-x cm ³ | Axis y-y cm ³ | | | | | |
| 300 ASB 249† | 12.9 | 6.40 | 2760 | 3530 | 843 | 19.2 | 22.6 | 3760 | 1510 | 0.820 | 6.80 | 2.00 | 2000 | 318 |
| 300 ASB 196 | 13.6 | 6.48 | 2320 | 3180 | 714 | 19.8 | 28.1 | 3060 | 1230 | 0.840 | 7.86 | 1.50 | 1180 | 249 |
| 300 ASB 185† | 12.3 | 6.10 | 1980 | 2540 | 574 | 18.0 | 21.0 | 2660 | 1030 | 0.820 | 8.56 | 1.20 | 871 | 235 |
| 300 ASB 155 | 13.2 | 6.35 | 1830 | 2520 | 553 | 18.9 | 27.3 | 2360 | 950 | 0.840 | 9.40 | 1.07 | 620 | 198 |
| 300 ASB 153† | 12.1 | 5.93 | 1630 | 2090 | 456 | 17.4 | 20.4 | 2160 | 817 | 0.820 | 9.97 | 0.895 | 513 | 195 |
| 280 ASB 136† | 11.3 | 6.00 | 1370 | 1770 | 417 | 16.3 | 19.2 | 1810 | 741 | 0.810 | 10.2 | 0.710 | 379 | 174 |
| 280 ASB 124 | 12.2 | 6.37 | 1360 | 1900 | 445 | 17.3 | 25.7 | 1730 | 761 | 0.830 | 10.5 | 0.721 | 332 | 158 |
| 280 ASB 105 | 12.0 | 6.30 | 1150 | 1610 | 370 | 16.8 | 25.3 | 1440 | 633 | 0.830 | 12.1 | 0.574 | 207 | 133 |
| 280 ASB 100† | 11.0 | 5.76 | 995 | 1290 | 289 | 15.6 | 18.4 | 1290 | 511 | 0.810 | 13.2 | 0.451 | 160 | 128 |
| 280 ASB 74 | 11.4 | 5.96 | 776 | 1060 | 234 | 15.7 | 21.3 | 978 | 403 | 0.830 | 16.7 | 0.338 | 72.0 | 93.7 |

† Sections are fire engineered with thick webs.

ASB sections are only available in S355.



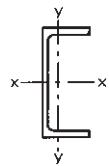
PARALLEL FLANGE CHANNELS



DIMENSIONS

| Section Designation | Mass per Metre kg/m | Depth of Section D mm | Width of Section B mm | Thickness | | Root Radius r mm | Depth between Fillets d mm | Ratios for Local Buckling | | Dimensions for Detailing | | | Surface Area | |
|---------------------------------|---------------------|-----------------------|-----------------------|------------|--------------|------------------|----------------------------|---------------------------|--------------|--------------------------|------------|----------|--------------------------|--------------------------|
| | | | | Web t mm | Flange T mm | | | Flange b/T | Web d/t | End Clearance C mm | Notch N mm | n mm | Per Metre m ² | Per Tonne m ² |
| 430 × 100 × 64 | 64.4 | 430 | 100 | 11.0 | 19.0 | 15 | 362 | 5.26 | 32.9 | 13 | 96 | 36 | 1.23 | 19.0 |
| 380 × 100 × 54 | 54.0 | 380 | 100 | 9.5 | 17.5 | 15 | 315 | 5.71 | 33.2 | 12 | 98 | 34 | 1.13 | 20.9 |
| 300 × 100 × 46 300 × 90 × 41 | 45.5 41.4 | 300 300 | 100 90 | 9.0 9.0 | 16.5 15.5 | 15 12 | 237 245 | 6.06 5.81 | 26.3 27.2 | 11 11 | 98 88 | 32 28 | 0.969 0.932 | 21.3 22.5 |
| 260 × 90 × 35 260 × 75 × 28 | 34.8 27.6 | 260 260 | 90 75 | 8.0 7.0 | 14.0 12.0 | 12 12 | 208 212 | 6.43 6.25 | 26.0 30.3 | 10 9 | 88 74 | 28 26 | 0.854 0.796 | 24.5 28.8 |
| 230 × 90 × 32 230 × 75 × 26 | 32.2 25.7 | 230 230 | 90 75 | 7.5 6.5 | 14.0 12.5 | 12 12 | 178 181 | 6.43 6.00 | 23.7 27.8 | 10 9 | 90 76 | 28 26 | 0.795 0.737 | 24.7 28.7 |
| 200 × 90 × 30 200 × 75 × 23 | 29.7 23.4 | 200 200 | 90 75 | 7.0 6.0 | 14.0 12.5 | 12 12 | 148 151 | 6.43 6.00 | 21.1 25.2 | 9 8 | 90 76 | 28 26 | 0.736 0.678 | 24.8 28.9 |
| 180 × 90 × 26 180 × 75 × 20 | 26.1 20.3 | 180 180 | 90 75 | 6.5 6.0 | 12.5 10.5 | 12 12 | 131 135 | 7.20 7.14 | 20.2 22.5 | 9 8 | 90 76 | 26 24 | 0.697 0.638 | 26.7 31.4 |
| 150 × 90 × 24 150 × 75 × 18 | 23.9 17.9 | 150 150 | 90 75 | 6.5 5.5 | 12.0 10.0 | 12 12 | 102 106 | 7.50 7.50 | 15.7 19.3 | 9 8 | 90 76 | 26 24 | 0.637 0.579 | 26.7 32.4 |
| 125 × 65 × 15 # | 14.8 | 125 | 65 | 5.5 | 9.5 | 12 | 82.0 | 6.84 | 14.9 | 8 | 66 | 22 | 0.489 | 33.1 |
| 100 × 50 × 10 # | 10.2 | 100 | 50 | 5.0 | 8.5 | 9 | 65.0 | 5.88 | 13.0 | 7 | 52 | 18 | 0.382 | 37.5 |

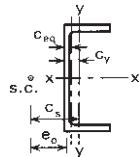
Check availability.

PARALLEL FLANGE CHANNELS**PROPERTIES**

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter u | Torsional Index x | Warping Constant H dm ⁶ | Torsional Constant J cm ⁴ | Area of Section A cm ² |
|---------------------------------|-----------------------------|-----------------------------|--------------------|----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------|----------------------|--|--|---|
| | 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 | | | | | |
| 430 × 100 × 64 | 21900 | 722 | 16.3 | 2.97 | 1020 | 97.9 | 1220 | 176 | 0.917 | 22.5 | 0.219 | 63.0 | 82.1 |
| 380 × 100 × 54 | 15000 | 643 | 14.8 | 3.06 | 791 | 89.2 | 933 | 161 | 0.933 | 21.2 | 0.150 | 45.7 | 68.7 |
| 300 × 100 × 46 300 × 90 × 41 | 8230 7220 | 568 404 | 11.9 11.7 | 3.13 2.77 | 549 481 | 81.7 63.1 | 641 568 | 148 114 | 0.944 0.934 | 17.0 18.4 | 0.0813 0.0581 | 36.8 28.8 | 58.0 52.7 |
| 260 × 90 × 35 260 × 75 × 28 | 4730 3620 | 353 185 | 10.3 10.1 | 2.82 2.30 | 364 278 | 56.3 34.4 | 425 328 | 102 62.0 | 0.943 0.932 | 17.2 20.5 | 0.0379 0.0203 | 20.6 11.7 | 44.4 35.1 |
| 230 × 90 × 32 230 × 75 × 26 | 3520 2750 | 334 181 | 9.27 9.17 | 2.86 2.35 | 306 239 | 55.0 34.8 | 355 278 | 98.9 63.2 | 0.949 0.945 | 15.1 17.3 | 0.0279 0.0153 | 19.3 11.8 | 41.0 32.7 |
| 200 × 90 × 30 200 × 75 × 23 | 2520 1960 | 314 170 | 8.16 8.11 | 2.88 2.39 | 252 196 | 53.4 33.8 | 291 227 | 94.5 60.6 | 0.952 0.956 | 12.9 14.7 | 0.0197 0.0107 | 18.3 11.1 | 37.9 29.9 |
| 180 × 90 × 26 180 × 75 × 20 | 1820 1370 | 277 146 | 7.40 7.27 | 2.89 2.38 | 202 152 | 47.4 28.8 | 232 176 | 83.5 51.8 | 0.950 0.945 | 12.8 15.3 | 0.0141 0.00754 | 13.3 7.34 | 33.2 25.9 |
| 150 × 90 × 24 150 × 75 × 18 | 1160 861 | 253 131 | 6.18 6.15 | 2.89 2.40 | 155 115 | 44.4 26.6 | 179 132 | 76.9 47.2 | 0.937 0.945 | 10.8 13.1 | 0.00890 0.00467 | 11.8 6.10 | 30.4 22.8 |
| 125 × 65 × 15 # | 483 | 80.0 | 5.07 | 2.06 | 77.3 | 18.8 | 89.9 | 33.2 | 0.942 | 11.1 | 0.00194 | 4.72 | 18.8 |
| 100 × 50 × 10 # | 208 | 32.3 | 4.00 | 1.58 | 41.5 | 9.89 | 48.9 | 17.5 | 0.942 | 10.0 | 0.000491 | 2.53 | 13.0 |

Check availability.

PARALLEL FLANGE CHANNELS

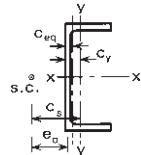


MAJOR AXIS REDUCED PLASTIC MODULUS UNDER AXIAL LOAD

| Section Designation | Area of Section A cm ² | Dimension | | | | Plastic Modulus Axis x-x cm ³ | Major Axis Reduced Modulus | | | | | |
|---------------------------------|---|----------------------|----------------------|----------------------|-----------------------|--|----------------------------|------------|-----------------------|--------------------|--------------|--|
| | | e _o cm | C _s cm | C _y cm | C _{eq} cm | | Lower Values of n | | Change Formula at n = | Higher Values of n | | |
| | | | | | | | K1 | K2 | | K3 | K4 | |
| 430 × 100 × 64 | 82.1 | 3.27 | 5.34 | 2.62 | 0.954 | 1220 | 1220 | 1530 | 0.525 | 168 | 9.48 | |
| 380 × 100 × 54 | 68.7 | 3.48 | 5.79 | 2.79 | 0.904 | 933 | 933 | 1240 | 0.477 | 118 | 10.1 | |
| 300 × 100 × 46 300 × 90 × 41 | 58.0 52.7 | 3.68 3.18 | 6.29 5.33 | 3.05 2.60 | 1.31 0.879 | 641 568 | 641 568 | 934 772 | 0.414 0.459 | 84.1 77.2 | 9.35 9.24 | |
| 260 × 90 × 35 260 × 75 × 28 | 44.4 35.1 | 3.32 2.62 | 5.66 4.37 | 2.74 2.10 | 1.14 0.676 | 425 328 | 425 328 | 615 441 | 0.418 0.470 | 54.7 41.2 | 9.55 10.1 | |
| 230 × 90 × 32 230 × 75 × 26 | 41.0 32.7 | 3.46 2.78 | 6.01 4.75 | 2.92 2.30 | 1.69 1.03 | 355 278 | 355 278 | 559 411 | 0.370 0.408 | 46.6 35.6 | 9.11 9.55 | |
| 200 × 90 × 30 200 × 75 × 23 | 37.9 29.9 | 3.60 2.91 | 6.37 5.09 | 3.12 2.48 | 2.24 1.53 | 291 227 | 291 227 | 512 372 | 0.318 0.352 | 39.8 29.7 | 8.51 9.04 | |
| 180 × 90 × 26 180 × 75 × 20 | 33.2 25.9 | 3.64 2.87 | 6.48 4.98 | 3.17 2.41 | 2.36 1.34 | 232 176 | 232 176 | 424 280 | 0.304 0.368 | 30.6 22.4 | 8.76 9.42 | |
| 150 × 90 × 24 150 × 75 × 18 | 30.4 22.8 | 3.71 2.99 | 6.69 5.29 | 3.30 2.58 | 2.66 1.81 | 179 132 | 179 132 | 356 236 | 0.269 0.314 | 25.7 17.3 | 7.88 8.88 | |
| 125 × 65 × 15 # | 18.8 | 2.56 | 4.53 | 2.25 | 1.55 | 89.9 | 89.9 | 161 | 0.310 | 13.6 | 7.64 | |
| 100 × 50 × 10 # | 13.0 | 1.94 | 3.43 | 1.73 | 1.18 | 48.9 | 48.9 | 84.5 | 0.319 | 8.45 | 6.69 | |

Check availability.

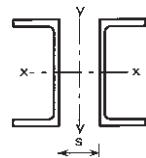
e_o is the distance from the centre of the web to the shear centre.C_s is the distance from the centroidal axis to the shear centre.C_y is the distance from the back of the web to the centroidal axis.C_{eq} is the distance from the back of the web to the equal area axis.n = F/(A_g · p_y), where F is the factored axial load, A_g is the gross cross sectional area and p_y is the design strength of the section.For lower values of n, the reduced plastic modulus, S_r = K1 - K2 · n²For higher values of n, the reduced plastic modulus, S_r = K3(1 - n)(K4 + n)

PARALLEL FLANGE CHANNELS**MINOR AXIS REDUCED PLASTIC MODULUS UNDER AXIAL LOAD**

| Section Designation | Dimension C_y cm | Plastic Modulus Axis y-y cm^3 | Minor Axis reduced Modulus under axial load about centroidal axis | | | | | | | | | | | | | |
|---------------------------------|--------------------------|--|--|--------------|----------------|--------------------|--------------|----------------|-------------------------|--|--------------|----------------|--------------------|--------------|--------------|--|
| | | | Axial load and moment inducing stresses of the same kind towards back of web | | | | | | Change Formula at $n =$ | Axial load and moment inducing stresses of the opposite kind towards back of web | | | | | | |
| | | | Lower Values of n | | | Higher Values of n | | | | Lower Values of n | | | Higher Values of n | | | |
| | | | K1 | K2 | K3 | K1 | K2 | K3 | | K1 | K2 | K3 | K1 | K2 | K3 | |
| 430 × 100 × 64 | 2.62 | 176 | 176 | 39.2 | 3.49 | 162 | 443 | 0.634 | 0.152 | 176 | 39.2 | 3.49 | 176 | 39.2 | 3.49 | |
| 380 × 100 × 54 | 2.79 | 161 | 161 | 31.1 | 4.17 | 158 | 338 | 0.532 | 0.0503 | 161 | 31.1 | 4.17 | 161 | 31.1 | 4.17 | |
| 300 × 100 × 46 300 × 90 × 41 | 3.05 2.60 | 148 114 | 148 114 | 255 23.2 | 0.419 3.92 | 148 113 | 255 224 | 0.419 0.495 | 0.0689 0.0241 | 148 114 | 255 23.2 | 0.419 3.92 | 149 114 | 28.0 23.2 | 4.32 3.92 | |
| 260 × 90 × 35 260 × 75 × 28 | 2.74 2.10 | 102 62.0 | 102 62.0 | 176 11.9 | 0.419 4.22 | 102 61.0 | 176 129 | 0.419 0.525 | 0.0626 0.0359 | 102 62.0 | 176 11.9 | 0.419 4.22 | 103 62.0 | 18.9 11.9 | 4.42 4.22 | |
| 230 × 90 × 32 230 × 75 × 26 | 2.92 2.30 | 98.9 63.2 | 98.9 63.2 | 150 107 | 0.338 0.410 | 99.1 63.1 | 150 107 | 0.338 0.410 | 0.158 0.0854 | 98.9 63.2 | 150 107 | 0.338 0.410 | 101 63.6 | 18.2 11.6 | 4.56 4.47 | |
| 200 × 90 × 30 200 × 75 × 23 | 3.12 2.48 | 94.5 60.6 | 94.5 60.6 | 128 89.2 | 0.261 0.318 | 94.5 60.6 | 128 89.2 | 0.261 0.318 | 0.260 0.196 | 94.5 60.6 | 128 89.2 | 0.261 0.318 | 100 62.8 | 17.9 11.2 | 4.60 4.64 | |
| 180 × 90 × 26 180 × 75 × 20 | 3.17 2.41 | 83.5 51.8 | 83.5 51.8 | 110 79.9 | 0.242 0.350 | 83.5 51.9 | 110 79.9 | 0.242 0.350 | 0.295 0.166 | 83.5 51.8 | 110 79.9 | 0.242 0.350 | 89.8 53.1 | 15.3 9.32 | 4.87 4.70 | |
| 150 × 90 × 24 150 × 75 × 18 | 3.30 2.58 | 76.9 47.2 | 76.9 47.2 | 96.3 64.8 | 0.201 0.271 | 76.9 47.2 | 96.3 64.8 | 0.201 0.271 | 0.359 0.275 | 76.9 47.2 | 96.3 64.8 | 0.201 0.271 | 85.0 50.1 | 15.4 8.64 | 4.52 4.80 | |
| 125 × 65 × 15 # | 2.25 | 33.2 | 33.2 | 46.5 | 0.281 | 33.4 | 46.5 | 0.281 | 0.269 | 33.2 | 46.5 | 0.281 | 35.2 | 7.07 | 3.98 | |
| 100 × 50 × 10 # | 1.73 | 17.5 | 17.5 | 24.8 | 0.291 | 17.6 | 24.8 | 0.291 | 0.231 | 17.5 | 24.8 | 0.291 | 18.3 | 4.22 | 3.33 | |

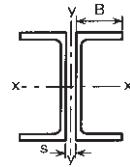
Check availability.

 C_y is the distance from the back of the web to the centroidal axis. $n = F/(A_g \cdot p_y)$, where F is the factored axial load, A_g is the gross cross sectional area and p_y is the design strength of the section.For axial load and moment inducing stresses of the same kind towards back of web, the reduced plastic modulus, $S_r = K1 + K2 \cdot n \cdot (K3 - n)$ For axial load and moment inducing stresses of the opposite kind towards back of web, the reduced plastic modulus, $S_r = K1 - K2 \cdot n \cdot (K3 + n)$

TWO PARALLEL FLANGE CHANNELS LACED**DIMENSIONS AND PROPERTIES**

| Composed of Two Channels | Total Mass per Metre kg/m | Total Area cm ² | Space between Webs s mm | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | |
|---------------------------------|---------------------------------------|----------------------------------|-------------------------------------|--------------------------------|--------------------------------|-----------------------|-------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| | | | | 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 |
| 430 × 100 × 64 | 129 | 164 | 270 | 43900 | 44100 | 16.3 | 16.4 | 2040 | 1880 | 2440 | 2650 |
| 380 × 100 × 54 | 108 | 137 | 235 | 30100 | 30400 | 14.8 | 14.9 | 1580 | 1400 | 1870 | 2000 |
| 300 × 100 × 46 300 × 90 × 41 | 91.1 82.8 | 116 105 | 170 175 | 16500 14400 | 16600 14400 | 11.9 11.7 | 12.0 11.7 | 1100 962 | 898 811 | 1280 1140 | 1340 1200 |
| 260 × 90 × 35 260 × 75 × 28 | 69.7 55.2 | 88.8 70.3 | 145 155 | 9460 7240 | 9560 7190 | 10.3 10.1 | 10.4 10.1 | 727 557 | 588 472 | 849 656 | 886 692 |
| 230 × 90 × 32 230 × 75 × 26 | 64.3 51.3 | 81.9 65.4 | 120 135 | 7040 5500 | 7190 5720 | 9.27 9.17 | 9.37 9.35 | 612 478 | 479 401 | 709 557 | 731 592 |
| 200 × 90 × 30 200 × 75 × 23 | 59.4 46.9 | 75.7 59.7 | 90.0 105 | 5050 3930 | 5030 3910 | 8.16 8.11 | 8.15 8.09 | 505 393 | 372 306 | 583 454 | 577 462 |
| 180 × 90 × 26 180 × 75 × 20 | 52.1 40.7 | 66.4 51.8 | 75.0 90.0 | 3640 2740 | 3730 2770 | 7.40 7.27 | 7.49 7.31 | 404 304 | 292 231 | 464 352 | 459 358 |
| 150 × 90 × 24 150 × 75 × 18 | 47.7 35.7 | 60.8 45.5 | 45.0 65.0 | 2320 1720 | 2380 1810 | 6.18 6.15 | 6.26 6.30 | 310 230 | 212 168 | 357 264 | 338 265 |
| 125 × 65 × 15 # | 29.5 | 37.6 | 50.0 | 966 | 1010 | 5.07 | 5.18 | 155 | 112 | 180 | 178 |
| 100 × 50 × 10 # | 20.4 | 26.0 | 40.0 | 415 | 427 | 4.00 | 4.05 | 83.1 | 61.0 | 97.7 | 97.1 |

Check availability.

TWO PARALLEL FLANGE CHANNELS BACK TO BACK**DIMENSIONS AND PROPERTIES**

| Composed of Two Channels | Total Mass per Metre kg/m | Total Area cm ² | Properties about Axis x-x | | | | Radius of Gyration r_y about Axis y-y (cm) | | | | |
|---------------------------------|---------------------------------------|----------------------------------|---------------------------|--------------|--------------------------|--------------------------|--|--------------|--------------|--------------|--------------|
| | | | I_x cm ⁴ | r_x cm | Z_x cm ³ | S_x cm ³ | Space between webs, s (mm) | | | | |
| | | | | | | | 0 | 8 | 10 | 12 | 15 |
| 430 × 100 × 64 | 129 | 164 | 43900 | 16.3 | 2040 | 2440 | 3.96 | 4.23 | 4.31 | 4.38 | 4.49 |
| 380 × 100 × 54 | 108 | 137 | 30100 | 14.8 | 1580 | 1870 | 4.14 | 4.42 | 4.49 | 4.57 | 4.68 |
| 300 × 100 × 46 300 × 90 × 41 | 91.1 82.8 | 116 105 | 16500 14400 | 11.9 11.7 | 1100 962 | 1280 1140 | 4.37 3.80 | 4.66 4.08 | 4.73 4.16 | 4.81 4.23 | 4.92 4.35 |
| 260 × 90 × 35 260 × 75 × 28 | 69.7 55.2 | 88.8 70.3 | 9460 7240 | 10.3 10.1 | 727 557 | 849 656 | 3.93 3.11 | 4.22 3.40 | 4.29 3.47 | 4.37 3.55 | 4.48 3.66 |
| 230 × 90 × 32 230 × 75 × 26 | 64.3 51.3 | 81.9 65.4 | 7040 5500 | 9.27 9.17 | 612 478 | 709 557 | 4.09 3.29 | 4.38 3.58 | 4.46 3.66 | 4.53 3.73 | 4.65 3.85 |
| 200 × 90 × 30 200 × 75 × 23 | 59.4 46.9 | 75.7 59.7 | 5050 3930 | 8.16 8.11 | 505 393 | 583 454 | 4.25 3.44 | 4.55 3.74 | 4.63 3.82 | 4.71 3.89 | 4.83 4.01 |
| 180 × 90 × 26 180 × 75 × 20 | 52.1 40.7 | 66.4 51.8 | 3640 2740 | 7.40 7.27 | 404 304 | 464 352 | 4.29 3.39 | 4.59 3.68 | 4.67 3.76 | 4.75 3.84 | 4.87 3.95 |
| 150 × 90 × 24 150 × 75 × 18 | 47.7 35.7 | 60.8 45.5 | 2320 1720 | 6.18 6.15 | 310 230 | 357 264 | 4.39 3.52 | 4.69 3.82 | 4.77 3.90 | 4.85 3.98 | 4.98 4.10 |
| 125 × 65 × 15 # | 29.5 | 37.6 | 966 | 5.07 | 155 | 180 | 3.05 | 3.36 | 3.44 | 3.52 | 3.64 |
| 100 × 50 × 10 # | 20.4 | 26.0 | 415 | 4.00 | 83.1 | 97.7 | 2.34 | 2.65 | 2.73 | 2.82 | 2.94 |

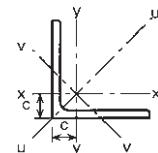
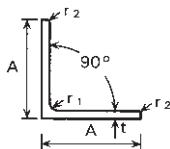
Check availability.

Properties about y axis

$$I_y = (\text{Total Area}) \cdot (r_y)^2$$

$$Z_y = I_y / (B + 0.5s)$$

where s is the space between webs.

EQUAL ANGLES**DIMENSIONS AND PROPERTIES**

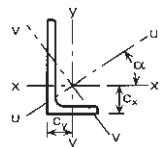
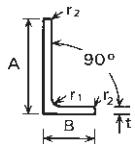
| Section Designation | | Mass per Metre kg/m | Radius | | Area of Section cm ² | Dimension c cm | Second Moment of Area | | | Radius of Gyration | | | Elastic Modulus | Torsional Constant J cm ⁴ | Equivalent Slenderness Coefficient ϕ_a |
|---------------------|----------------------|------------------------|------------------------------|-----------------------------|------------------------------------|----------------------|-------------------------------------|--------------------------------|--------------------------------|------------------------|-------------------|-------------------|-----------------|--|--|
| Size A × A mm | Thickness t mm | | Root r ₁ mm | Toe r ₂ mm | | | Axis x-x, y-y cm ⁴ | Axis u-u cm ⁴ | Axis v-v cm ⁴ | Axis x-x, y-y cm | Axis u-u cm | Axis v-v cm | | | |
| 200 × 200 | 24 # | 71.1 | 18.0 | 9.00 | 90.6 | 5.84 | 3330 | 5280 | 1380 | 6.06 | 7.64 | 3.90 | 235 | 182 | 2.50 |
| | 20 | 59.9 | 18.0 | 9.00 | 76.3 | 5.68 | 2850 | 4530 | 1170 | 6.11 | 7.70 | 3.92 | 199 | 107 | 3.05 |
| | 18 | 54.3 | 18.0 | 9.00 | 69.1 | 5.60 | 2600 | 4150 | 1050 | 6.13 | 7.75 | 3.90 | 181 | 78.9 | 3.43 |
| | 16 | 48.5 | 18.0 | 9.00 | 61.8 | 5.52 | 2340 | 3720 | 960 | 6.16 | 7.76 | 3.94 | 162 | 56.1 | 3.85 |
| 150 × 150 | 18 # | 40.1 | 16.0 | 8.00 | 51.2 | 4.38 | 1060 | 1680 | 440 | 4.55 | 5.73 | 2.93 | 99.8 | 58.6 | 2.48 |
| | 15 | 33.8 | 16.0 | 8.00 | 43.0 | 4.25 | 898 | 1430 | 370 | 4.57 | 5.76 | 2.93 | 83.5 | 34.6 | 3.01 |
| | 12 | 27.3 | 16.0 | 8.00 | 34.8 | 4.12 | 737 | 1170 | 303 | 4.60 | 5.80 | 2.95 | 67.7 | 18.2 | 3.77 |
| | 10 | 23.0 | 16.0 | 8.00 | 29.3 | 4.03 | 624 | 990 | 258 | 4.62 | 5.82 | 2.97 | 56.9 | 10.80 | 4.51 |
| 120 × 120 | 15 # | 26.6 | 13.0 | 6.50 | 34.0 | 3.52 | 448 | 710 | 186 | 3.63 | 4.57 | 2.34 | 52.8 | 27.0 | 2.37 |
| | 12 | 21.6 | 13.0 | 6.50 | 27.5 | 3.40 | 368 | 584 | 152 | 3.65 | 4.60 | 2.35 | 42.7 | 14.2 | 2.99 |
| | 10 | 18.2 | 13.0 | 6.50 | 23.2 | 3.31 | 313 | 497 | 129 | 3.67 | 4.63 | 2.36 | 36.0 | 8.41 | 3.61 |
| | 8 # | 14.7 | 13.0 | 6.50 | 18.8 | 3.24 | 259 | 411 | 107 | 3.71 | 4.67 | 2.38 | 29.5 | 4.44 | 4.56 |
| 100 × 100 | 15 # | 21.9 | 12.0 | 6.00 | 28.0 | 3.02 | 250 | 395 | 105 | 2.99 | 3.76 | 1.94 | 35.8 | 22.3 | 1.92 |
| | 12 | 17.8 | 12.0 | 6.00 | 22.7 | 2.90 | 207 | 328 | 85.7 | 3.02 | 3.80 | 1.94 | 29.1 | 11.8 | 2.44 |
| | 10 | 15.0 | 12.0 | 6.00 | 19.2 | 2.82 | 177 | 280 | 73.0 | 3.04 | 3.83 | 1.95 | 24.6 | 6.97 | 2.94 |
| | 8 | 12.2 | 12.0 | 6.00 | 15.5 | 2.74 | 145 | 230 | 59.9 | 3.06 | 3.85 | 1.96 | 19.9 | 3.68 | 3.70 |
| 90 × 90 | 12 # | 15.9 | 11.0 | 5.50 | 20.3 | 2.66 | 149 | 235 | 62.0 | 2.71 | 3.40 | 1.75 | 23.5 | 10.46 | 2.17 |
| | 10 | 13.4 | 11.0 | 5.50 | 17.1 | 2.58 | 127 | 201 | 52.6 | 2.72 | 3.42 | 1.75 | 19.8 | 6.20 | 2.64 |
| | 8 | 10.9 | 11.0 | 5.50 | 13.9 | 2.50 | 104 | 166 | 43.1 | 2.74 | 3.45 | 1.76 | 16.1 | 3.28 | 3.33 |
| | 7 # | 9.61 | 11.0 | 5.50 | 12.2 | 2.45 | 92.6 | 147 | 38.3 | 2.75 | 3.46 | 1.77 | 14.1 | 2.24 | 3.80 |
| 80 × 80 | 10 # | 11.9 | 10.0 | 5.00 | 15.1 | 2.34 | 87.5 | 139 | 36.4 | 2.41 | 3.03 | 1.55 | 15.4 | 5.45 | 2.33 |
| | 8 # | 9.63 | 10.0 | 5.00 | 12.3 | 2.26 | 72.2 | 115 | 29.9 | 2.43 | 3.06 | 1.56 | 12.6 | 2.88 | 2.94 |
| 75 × 75 | 8 # | 8.99 | 9.00 | 4.50 | 11.4 | 2.14 | 59.1 | 93.8 | 24.5 | 2.27 | 2.86 | 1.46 | 11.0 | 2.65 | 2.76 |
| | 6 # | 6.85 | 9.00 | 4.50 | 8.73 | 2.05 | 45.8 | 72.7 | 18.9 | 2.29 | 2.89 | 1.47 | 8.41 | 1.17 | 3.70 |
| 70 × 70 | 7 # | 7.38 | 9.00 | 4.50 | 9.40 | 1.97 | 42.3 | 67.1 | 17.5 | 2.12 | 2.67 | 1.36 | 8.41 | 1.69 | 2.92 |
| | 6 # | 6.38 | 9.00 | 4.50 | 8.13 | 1.93 | 36.9 | 58.5 | 15.3 | 2.13 | 2.68 | 1.37 | 7.27 | 1.093 | 3.41 |
| 65 × 65 | 7 # | 6.83 | 9.00 | 4.50 | 8.73 | 2.05 | 33.4 | 53.0 | 13.8 | 1.96 | 2.47 | 1.26 | 7.18 | 1.58 | 2.67 |
| | 6 # | 5.70 | 8.00 | 4.00 | 9.03 | 1.77 | 29.2 | 46.1 | 12.2 | 1.80 | 2.26 | 1.16 | 6.89 | 2.09 | 2.14 |
| 60 × 60 | 6 # | 5.42 | 8.00 | 4.00 | 6.91 | 1.69 | 22.8 | 36.1 | 9.44 | 1.82 | 2.29 | 1.17 | 5.29 | 0.922 | 2.90 |
| | 5 # | 4.57 | 8.00 | 4.00 | 5.82 | 1.64 | 19.4 | 30.7 | 8.03 | 1.82 | 2.30 | 1.17 | 4.45 | 0.550 | 3.48 |
| 50 × 50 | 6 # | 4.47 | 7.00 | 3.50 | 5.69 | 1.45 | 12.8 | 20.3 | 5.34 | 1.50 | 1.89 | 0.968 | 3.61 | 0.755 | 2.38 |
| | 5 # | 3.77 | 7.00 | 3.50 | 4.80 | 1.40 | 11.0 | 17.4 | 4.55 | 1.51 | 1.90 | 0.973 | 3.05 | 0.450 | 2.88 |
| | 4 # | 3.06 | 7.00 | 3.50 | 3.89 | 1.36 | 8.97 | 14.2 | 3.73 | 1.52 | 1.91 | 0.979 | 2.46 | 0.240 | 3.57 |
| 45 × 45 | 4.5 # | 3.06 | 7.00 | 3.50 | 3.90 | 1.25 | 7.14 | 11.4 | 2.94 | 1.35 | 1.71 | 0.870 | 2.20 | 0.304 | 2.84 |
| | 4 # | 2.97 | 6.00 | 3.00 | 3.79 | 1.16 | 5.43 | 8.60 | 2.26 | 1.20 | 1.51 | 0.773 | 1.91 | 0.352 | 2.26 |
| 40 × 40 | 5 # | 2.42 | 6.00 | 3.00 | 3.08 | 1.12 | 4.47 | 7.09 | 1.86 | 1.21 | 1.52 | 0.777 | 1.55 | 0.188 | 2.83 |
| | 4 # | 2.09 | 5.00 | 2.50 | 2.67 | 1.00 | 2.95 | 4.68 | 1.23 | 1.05 | 1.32 | 0.678 | 1.18 | 0.158 | 2.50 |
| 30 × 30 | 4 # | 1.78 | 5.00 | 2.50 | 2.27 | 0.878 | 1.80 | 2.85 | 0.754 | 0.892 | 1.12 | 0.577 | 0.850 | 0.137 | 2.07 |
| | 3 # | 1.36 | 5.00 | 2.50 | 1.74 | 0.835 | 1.40 | 2.22 | 0.585 | 0.899 | 1.13 | 0.581 | 0.649 | 0.0613 | 2.75 |
| 25 × 25 | 4 # | 1.45 | 3.50 | 1.75 | 1.85 | 0.762 | 1.02 | 1.61 | 0.430 | 0.741 | 0.931 | 0.482 | 0.586 | 0.1070 | 1.75 |
| | 3 # | 1.12 | 3.50 | 1.75 | 1.42 | 0.723 | 0.803 | 1.27 | 0.334 | 0.751 | 0.945 | 0.484 | 0.452 | 0.0472 | 2.38 |
| 20 × 20 | 3 # | 0.882 | 3.50 | 1.75 | 1.12 | 0.598 | 0.392 | 0.618 | 0.165 | 0.590 | 0.742 | 0.383 | 0.279 | 0.0382 | 1.81 |

‡ Not available from some leading producers. Check availability.

Check availability.

c is the distance from the back of the leg to the centre of gravity.

UNEQUAL ANGLES



DIMENSIONS AND PROPERTIES

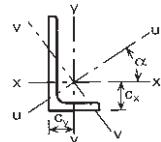
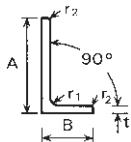
| Section Designation | | Mass per Metre kg/m | Radius | | Dimension | | Second Moment of Area | | | | Radius of Gyration | | | |
|---------------------|------|---------------------|------------------------|-----------------------|-------------------|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------|-------------|-------------|-------------|
| | | | Root r ₁ mm | Toe r ₂ mm | c _x cm | c _y cm | Axis x-x cm ⁴ | Axis y-y cm ⁴ | Axis u-u cm ⁴ | Axis v-v cm ⁴ | Axis x-x cm | Axis y-y cm | Axis u-u cm | Axis v-v cm |
| 200 × 150 | 18 # | 47.1 | 15.0 | 7.50 | 6.34 | 3.86 | 2390 | 1160 | 2920 | 623 | 6.30 | 4.38 | 6.97 | 3.22 |
| | 15 | 39.6 | 15.0 | 7.50 | 6.21 | 3.73 | 2020 | 979 | 2480 | 526 | 6.33 | 4.40 | 7.00 | 3.23 |
| | 12 | 32.0 | 15.0 | 7.50 | 6.08 | 3.61 | 1650 | 803 | 2030 | 430 | 6.36 | 4.44 | 7.04 | 3.25 |
| 200 × 100 | 15 | 33.8 | 15.0 | 7.50 | 7.16 | 2.22 | 1760 | 299 | 1860 | 193 | 6.40 | 2.64 | 6.59 | 2.12 |
| | 12 | 27.3 | 15.0 | 7.50 | 7.03 | 2.10 | 1440 | 247 | 1530 | 159 | 6.43 | 2.67 | 6.63 | 2.14 |
| | 10 | 23.0 | 15.0 | 7.50 | 6.93 | 2.01 | 1220 | 210 | 1290 | 135 | 6.46 | 2.68 | 6.65 | 2.15 |
| 150 × 90 | 15 | 33.9 | 12.0 | 6.00 | 5.21 | 2.23 | 761 | 205 | 841 | 126 | 4.74 | 2.46 | 4.98 | 1.93 |
| | 12 | 21.6 | 12.0 | 6.00 | 5.08 | 2.12 | 627 | 171 | 694 | 104 | 4.77 | 2.49 | 5.02 | 1.94 |
| | 10 | 18.2 | 12.0 | 6.00 | 5.00 | 2.04 | 533 | 146 | 591 | 88.3 | 4.80 | 2.51 | 5.05 | 1.95 |
| 150 × 75 | 15 | 24.8 | 12.0 | 6.00 | 5.52 | 1.81 | 713 | 119 | 753 | 78.6 | 4.75 | 1.94 | 4.88 | 1.58 |
| | 12 | 20.2 | 12.0 | 6.00 | 5.40 | 1.69 | 588 | 99.6 | 623 | 64.7 | 4.78 | 1.97 | 4.92 | 1.59 |
| | 10 | 17.0 | 12.0 | 6.00 | 5.31 | 1.61 | 501 | 85.6 | 531 | 55.1 | 4.81 | 1.99 | 4.95 | 1.60 |
| 125 × 75 | 12 | 17.8 | 11.0 | 5.50 | 4.31 | 1.84 | 354 | 95.5 | 391 | 58.5 | 3.95 | 2.05 | 4.15 | 1.61 |
| | 10 | 15.0 | 11.0 | 5.50 | 4.23 | 1.76 | 302 | 82.1 | 334 | 49.9 | 3.97 | 2.07 | 4.18 | 1.61 |
| | 8 | 12.2 | 11.0 | 5.50 | 4.14 | 1.68 | 247 | 67.6 | 274 | 40.9 | 4.00 | 2.09 | 4.21 | 1.63 |
| 100 × 75 | 12 | 15.4 | 10.0 | 5.00 | 3.27 | 2.03 | 189 | 90.2 | 230 | 49.5 | 3.10 | 2.14 | 3.42 | 1.59 |
| | 10 | 13.0 | 10.0 | 5.00 | 3.19 | 1.95 | 162 | 77.6 | 197 | 42.2 | 3.12 | 2.16 | 3.45 | 1.59 |
| | 8 | 10.6 | 10.0 | 5.00 | 3.10 | 1.87 | 133 | 64.1 | 162 | 34.6 | 3.14 | 2.18 | 3.47 | 1.60 |
| 100 × 65 | 10 # | 12.3 | 10.0 | 5.00 | 3.36 | 1.63 | 154 | 51.0 | 175 | 30.1 | 3.14 | 1.81 | 3.35 | 1.39 |
| | 8 # | 9.94 | 10.0 | 5.00 | 3.27 | 1.55 | 127 | 42.2 | 144 | 24.8 | 3.16 | 1.83 | 3.37 | 1.40 |
| | 7 # | 8.77 | 10.0 | 5.00 | 3.23 | 1.51 | 113 | 37.6 | 128 | 22.0 | 3.17 | 1.83 | 3.39 | 1.40 |
| 100 × 50 | 8 ‡ | 8.97 | 8.00 | 4.00 | 3.60 | 1.13 | 116 | 19.7 | 123 | 12.8 | 3.19 | 1.31 | 3.28 | 1.06 |
| | 6 ‡ | 6.84 | 8.00 | 4.00 | 3.51 | 1.05 | 89.9 | 15.4 | 95.4 | 9.92 | 3.21 | 1.33 | 3.31 | 1.07 |
| 80 × 60 | 7 ‡ | 7.36 | 8.00 | 4.00 | 2.51 | 1.52 | 59.0 | 28.4 | 72.0 | 15.4 | 2.51 | 1.74 | 2.77 | 1.28 |
| 80 × 40 | 8 ‡ | 7.07 | 7.00 | 3.50 | 2.94 | 0.963 | 57.6 | 9.61 | 60.9 | 6.34 | 2.53 | 1.03 | 2.60 | 0.838 |
| | 6 ‡ | 5.41 | 7.00 | 3.50 | 2.85 | 0.884 | 44.9 | 7.59 | 47.6 | 4.93 | 2.55 | 1.05 | 2.63 | 0.845 |
| 75 × 50 | 8 ‡ | 7.39 | 7.00 | 3.50 | 2.52 | 1.29 | 52.0 | 18.4 | 59.6 | 10.8 | 2.35 | 1.40 | 2.52 | 1.07 |
| | 6 ‡ | 5.65 | 7.00 | 3.50 | 2.44 | 1.21 | 40.5 | 14.4 | 46.6 | 8.36 | 2.37 | 1.42 | 2.55 | 1.08 |
| 70 × 50 | 6 ‡ | 5.41 | 7.00 | 3.50 | 2.23 | 1.25 | 33.4 | 14.2 | 39.7 | 7.92 | 2.20 | 1.43 | 2.40 | 1.07 |
| 65 × 50 | 5 ‡ | 4.35 | 6.00 | 3.00 | 1.99 | 1.25 | 23.2 | 11.9 | 28.8 | 6.32 | 2.05 | 1.47 | 2.28 | 1.07 |
| 60 × 40 | 6 ‡ | 4.46 | 6.00 | 3.00 | 2.00 | 1.01 | 20.1 | 7.12 | 23.1 | 4.16 | 1.88 | 1.12 | 2.02 | 0.855 |
| | 5 ‡ | 3.76 | 6.00 | 3.00 | 1.96 | 0.972 | 17.2 | 6.11 | 19.7 | 3.54 | 1.89 | 1.13 | 2.03 | 0.860 |
| 60 × 30 | 5 ‡ | 3.36 | 5.00 | 2.50 | 2.17 | 0.684 | 15.6 | 2.63 | 16.5 | 1.71 | 1.91 | 0.784 | 1.97 | 0.633 |
| 50 × 30 | 5 ‡ | 2.96 | 5.00 | 2.50 | 1.73 | 0.741 | 9.36 | 2.51 | 10.3 | 1.54 | 1.57 | 0.816 | 1.65 | 0.639 |
| 45 × 30 | 4 ‡ | 2.25 | 4.50 | 2.25 | 1.48 | 0.740 | 5.78 | 2.05 | 6.65 | 1.18 | 1.42 | 0.850 | 1.52 | 0.640 |
| 40 × 25 | 4 ‡ | 1.93 | 4.00 | 2.00 | 1.36 | 0.623 | 3.89 | 1.16 | 4.35 | 0.700 | 1.26 | 0.687 | 1.33 | 0.534 |
| 40 × 20 | 4 ‡ | 1.77 | 4.00 | 2.00 | 1.47 | 0.480 | 3.59 | 0.600 | 3.80 | 0.393 | 1.26 | 0.514 | 1.30 | 0.417 |
| 30 × 20 | 4 ‡ | 1.46 | 4.00 | 2.00 | 1.03 | 0.541 | 1.59 | 0.553 | 1.81 | 0.330 | 0.925 | 0.546 | 0.988 | 0.421 |
| | 3 ‡ | 1.12 | 4.00 | 2.00 | 0.990 | 0.502 | 1.25 | 0.437 | 1.43 | 0.256 | 0.935 | 0.553 | 1.00 | 0.424 |

‡ Not available from some leading producers. Check availability.

Check availability.

c_x is the distance from the back of the short leg to the centre of gravity.c_y is the distance from the back of the long leg to the centre of gravity.

UNEQUAL ANGLES

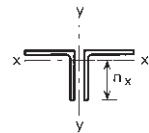
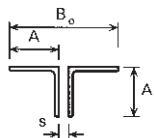


DIMENSIONS AND PROPERTIES (CONTINUED)

| Section Designation | | Elastic Modulus | | Angle Axis x-x to Axis u-u Tan α | Torsional Constant J cm ⁴ | Equivalent Slenderness Coefficient | | Mono-symmetry index ψ _a | Area of Section cm ² |
|---------------------|----------------|--------------------------|--------------------------|-------------------------------------|--|------------------------------------|--------------------|---------------------------------------|------------------------------------|
| Size A × B mm | Thickness t mm | Axis x-x cm ³ | Axis y-y cm ³ | | | Min φ _a | Max φ _a | | |
| 200 × 150 | 18 # | 175 | 104 | 0.549 | 67.9 | 2.93 | 3.72 | 4.60 | 60.1 |
| | 15 | 147 | 86.9 | 0.551 | 39.9 | 3.53 | 4.50 | 5.55 | 50.5 |
| | 12 | 119 | 70.5 | 0.552 | 20.9 | 4.43 | 5.70 | 6.97 | 40.8 |
| 200 × 100 | 15 | 137 | 38.5 | 0.260 | 34.3 | 3.54 | 5.17 | 9.19 | 43.0 |
| | 12 | 111 | 31.3 | 0.262 | 18.0 | 4.42 | 6.57 | 11.5 | 34.8 |
| | 10 | 93.2 | 26.3 | 0.263 | 10.66 | 5.26 | 7.92 | 13.9 | 29.2 |
| 150 × 90 | 15 | 77.7 | 30.4 | 0.354 | 26.8 | 2.58 | 3.59 | 5.96 | 33.9 |
| | 12 | 63.3 | 24.8 | 0.358 | 14.1 | 3.24 | 4.58 | 7.50 | 27.5 |
| | 10 | 53.3 | 21.0 | 0.360 | 8.30 | 3.89 | 5.56 | 9.03 | 23.2 |
| 150 × 75 | 15 | 75.2 | 21.0 | 0.253 | 25.1 | 2.62 | 3.74 | 6.84 | 31.7 |
| | 12 | 61.3 | 17.1 | 0.258 | 13.2 | 3.30 | 4.79 | 8.60 | 25.7 |
| | 10 | 51.6 | 14.5 | 0.261 | 7.80 | 3.95 | 5.83 | 10.4 | 21.7 |
| 125 × 75 | 12 | 43.2 | 16.9 | 0.354 | 11.6 | 2.66 | 3.73 | 6.23 | 22.7 |
| | 10 | 36.5 | 14.3 | 0.357 | 6.87 | 3.21 | 4.55 | 7.50 | 19.1 |
| | 8 | 29.6 | 11.6 | 0.360 | 3.62 | 4.00 | 5.75 | 9.43 | 15.5 |
| 100 × 75 | 12 | 28.0 | 16.5 | 0.540 | 10.05 | 2.10 | 2.64 | 3.46 | 19.7 |
| | 10 | 23.8 | 14.0 | 0.544 | 5.95 | 2.54 | 3.22 | 4.17 | 16.6 |
| | 8 | 19.3 | 11.4 | 0.547 | 3.13 | 3.18 | 4.08 | 5.24 | 13.5 |
| 100 × 65 | 10 # | 23.2 | 10.5 | 0.410 | 5.61 | 2.52 | 3.43 | 5.45 | 15.6 |
| | 8 # | 18.9 | 8.54 | 0.413 | 2.96 | 3.14 | 4.35 | 6.86 | 12.7 |
| | 7 # | 16.6 | 7.53 | 0.415 | 2.02 | 3.58 | 5.00 | 7.85 | 11.2 |
| 100 × 50 | 8 ‡ | 18.2 | 5.08 | 0.258 | 2.61 | 3.30 | 4.80 | 8.61 | 11.4 |
| | 6 ‡ | 13.8 | 3.89 | 0.262 | 1.14 | 4.38 | 6.52 | 11.6 | 8.71 |
| 80 × 60 | 7 ‡ | 10.7 | 6.34 | 0.546 | 1.66 | 2.92 | 3.72 | 4.78 | 9.38 |
| 80 × 40 | 8 ‡ | 11.4 | 3.16 | 0.253 | 2.05 | 2.61 | 3.73 | 6.85 | 9.01 |
| | 6 ‡ | 8.73 | 2.44 | 0.258 | 0.899 | 3.48 | 5.12 | 9.22 | 6.89 |
| 75 × 50 | 8 ‡ | 10.4 | 4.95 | 0.430 | 2.14 | 2.36 | 3.18 | 4.92 | 9.41 |
| | 6 ‡ | 8.01 | 3.81 | 0.435 | 0.935 | 3.18 | 4.34 | 6.60 | 7.19 |
| 70 × 50 | 6 ‡ | 7.01 | 3.78 | 0.500 | 0.899 | 2.96 | 3.89 | 5.44 | 6.89 |
| 65 × 50 | 5 ‡ | 5.14 | 3.19 | 0.577 | 0.498 | 3.38 | 4.26 | 5.08 | 5.54 |
| 60 × 40 | 6 ‡ | 5.03 | 2.38 | 0.431 | 0.735 | 2.51 | 3.39 | 5.26 | 5.68 |
| | 5 ‡ | 4.25 | 2.02 | 0.434 | 0.435 | 3.02 | 4.11 | 6.34 | 4.79 |
| 60 × 30 | 5 ‡ | 4.07 | 1.14 | 0.257 | 0.382 | 3.15 | 4.56 | 8.26 | 4.28 |
| 50 × 30 | 5 ‡ | 2.86 | 1.11 | 0.352 | 0.340 | 2.51 | 3.52 | 5.99 | 3.78 |
| 45 × 30 | 4 ‡ | 1.91 | 0.910 | 0.436 | 0.166 | 2.85 | 3.87 | 5.92 | 2.87 |
| 40 × 25 | 4 ‡ | 1.47 | 0.619 | 0.380 | 0.142 | 2.51 | 3.48 | 5.75 | 2.46 |
| 40 × 20 | 4 ‡ | 1.42 | 0.393 | 0.252 | 0.131 | 2.57 | 3.68 | 6.86 | 2.26 |
| 30 × 20 | 4 ‡ | 0.807 | 0.379 | 0.421 | 0.1096 | 1.79 | 2.39 | 3.95 | 1.86 |
| | 3 ‡ | 0.621 | 0.292 | 0.427 | 0.0486 | 2.40 | 3.28 | 5.31 | 1.43 |

‡ Not available from some leading producers. Check availability.

Check availability.



DIMENSIONS AND PROPERTIES

| Composed of Two Angles | | Total Mass per Metre kg/m | Distance n _x cm | Total Area cm ² | Properties about Axis x-x | | | Radius of Gyration r _x about Axis y-y (cm) | | | | |
|------------------------|------|---------------------------|----------------------------|----------------------------|--------------------------------|-------------------|--------------------------------|---|------|------|------|------|
| | | | | | I _x cm ⁴ | r _x cm | Z _x cm ³ | 0 | 8 | 10 | 12 | 15 |
| 200 × 200 | 24 # | 142 | 14.2 | 181 | 6660 | 6.06 | 470 | 8.42 | 8.70 | 8.77 | 8.84 | 8.95 |
| | 20 | 120 | 14.3 | 153 | 5700 | 6.11 | 398 | 8.34 | 8.62 | 8.69 | 8.76 | 8.87 |
| | 18 | 109 | 14.4 | 138 | 5200 | 6.13 | 362 | 8.31 | 8.58 | 8.65 | 8.72 | 8.83 |
| | 16 | 97.0 | 14.5 | 124 | 4680 | 6.16 | 324 | 8.27 | 8.54 | 8.61 | 8.68 | 8.79 |
| 150 × 150 | 18 # | 80.2 | 10.6 | 102 | 2120 | 4.55 | 200 | 6.32 | 6.60 | 6.67 | 6.75 | 6.86 |
| | 15 | 67.6 | 10.8 | 86.0 | 1800 | 4.57 | 167 | 6.24 | 6.52 | 6.59 | 6.66 | 6.77 |
| | 12 | 54.6 | 10.9 | 69.6 | 1470 | 4.60 | 135 | 6.18 | 6.45 | 6.52 | 6.59 | 6.70 |
| | 10 | 46.0 | 11.0 | 58.6 | 1250 | 4.62 | 114 | 6.13 | 6.40 | 6.47 | 6.54 | 6.64 |
| 120 × 120 | 15 # | 53.2 | 8.48 | 68.0 | 896 | 3.63 | 106 | 5.06 | 5.34 | 5.42 | 5.49 | 5.60 |
| | 12 | 43.2 | 8.60 | 55.0 | 736 | 3.65 | 85.4 | 4.99 | 5.27 | 5.35 | 5.42 | 5.53 |
| | 10 | 36.4 | 8.69 | 46.4 | 626 | 3.67 | 72.0 | 4.94 | 5.22 | 5.29 | 5.36 | 5.47 |
| | 8 # | 29.4 | 8.76 | 37.6 | 518 | 3.71 | 59.0 | 4.93 | 5.20 | 5.27 | 5.34 | 5.45 |
| 100 × 100 | 15 # | 43.8 | 6.98 | 56.0 | 500 | 2.99 | 71.6 | 4.25 | 4.54 | 4.62 | 4.69 | 4.81 |
| | 12 | 35.6 | 7.10 | 45.4 | 414 | 3.02 | 58.2 | 4.19 | 4.47 | 4.55 | 4.62 | 4.74 |
| | 10 | 30.0 | 7.18 | 38.4 | 354 | 3.04 | 49.2 | 4.14 | 4.43 | 4.50 | 4.57 | 4.69 |
| | 8 | 24.4 | 7.26 | 31.0 | 290 | 3.06 | 39.8 | 4.11 | 4.38 | 4.46 | 4.53 | 4.64 |
| 90 × 90 | 12 # | 31.8 | 6.34 | 40.6 | 298 | 2.71 | 47.0 | 3.80 | 4.09 | 4.16 | 4.24 | 4.36 |
| | 10 | 26.8 | 6.42 | 34.2 | 254 | 2.72 | 39.6 | 3.75 | 4.04 | 4.11 | 4.19 | 4.30 |
| | 8 | 21.8 | 6.50 | 27.8 | 208 | 2.74 | 32.2 | 3.71 | 3.99 | 4.06 | 4.13 | 4.25 |
| | 7 # | 19.2 | 6.55 | 24.4 | 185 | 2.75 | 28.2 | 3.69 | 3.96 | 4.04 | 4.11 | 4.22 |
| 80 × 80 | 10 ‡ | 23.8 | 5.66 | 30.2 | 175 | 2.41 | 30.8 | 3.36 | 3.65 | 3.72 | 3.80 | 3.92 |
| | 8 ‡ | 19.3 | 5.74 | 24.6 | 144 | 2.43 | 25.2 | 3.31 | 3.60 | 3.67 | 3.75 | 3.86 |
| 75 × 75 | 8 ‡ | 18.0 | 5.36 | 22.8 | 118 | 2.27 | 22.0 | 3.12 | 3.41 | 3.49 | 3.56 | 3.68 |
| | 6 ‡ | 13.7 | 5.45 | 17.5 | 91.6 | 2.29 | 16.8 | 3.07 | 3.35 | 3.43 | 3.50 | 3.62 |
| 70 × 70 | 7 ‡ | 14.8 | 5.03 | 18.8 | 84.6 | 2.12 | 16.8 | 2.89 | 3.18 | 3.26 | 3.33 | 3.45 |
| | 6 ‡ | 12.8 | 5.07 | 16.3 | 73.8 | 2.13 | 14.5 | 2.87 | 3.16 | 3.23 | 3.31 | 3.42 |
| 65 × 65 | 7 ‡ | 13.7 | 4.45 | 17.5 | 66.8 | 1.96 | 14.4 | 2.83 | 3.14 | 3.21 | 3.29 | 3.42 |
| | 6 ‡ | 14.2 | 4.23 | 18.1 | 58.4 | 1.80 | 13.8 | 2.52 | 2.82 | 2.90 | 2.97 | 3.10 |
| 60 × 60 | 6 ‡ | 10.8 | 4.31 | 13.8 | 45.6 | 1.82 | 10.6 | 2.48 | 2.77 | 2.85 | 2.92 | 3.04 |
| | 5 ‡ | 9.14 | 4.36 | 11.6 | 38.8 | 1.82 | 8.90 | 2.45 | 2.74 | 2.81 | 2.89 | 3.01 |
| 50 × 50 | 6 ‡ | 8.94 | 3.55 | 11.4 | 25.6 | 1.50 | 7.22 | 2.09 | 2.38 | 2.46 | 2.54 | 2.66 |
| | 5 ‡ | 7.54 | 3.60 | 9.60 | 22.0 | 1.51 | 6.10 | 2.06 | 2.35 | 2.43 | 2.51 | 2.63 |
| | 4 ‡ | 6.12 | 3.64 | 7.78 | 17.9 | 1.52 | 4.92 | 2.04 | 2.32 | 2.40 | 2.48 | 2.60 |

‡ Not available from some leading producers. Check availability.

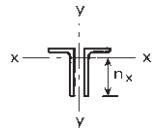
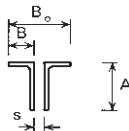
Check availability.

Properties about y-y axis:

$$I_y = (\text{Total Area}) \cdot (r_y)^2$$

$$Z_y = I_y / (0.5B_o)$$

UNEQUAL ANGLES LONG LEGS BACK TO BACK



DIMENSIONS AND PROPERTIES

| Composed of Two Angles | | Total Mass per Metre kg/m | Distance n_x cm | Total Area cm ² | Properties about Axis x-x | | | Radius of Gyration r_y about Axis y-y (cm) | | | | |
|---------------------------|---------|---------------------------------------|-------------------------|----------------------------------|---------------------------|-------------|--------------------------|--|------|------|------|------|
| | | | | | I_x cm ⁴ | r_x cm | Z_x cm ³ | Space between angles, s, (mm) | | | | |
| A × B mm | t mm | | | | 0 | 8 | 10 | 12 | 15 | | | |
| 200 × 150 | 18 # | 94.2 | 13.7 | 120 | 4780 | 6.30 | 350 | 5.84 | 6.11 | 6.18 | 6.25 | 6.36 |
| | 15 | 79.2 | 13.8 | 101 | 4040 | 6.33 | 294 | 5.77 | 6.04 | 6.11 | 6.18 | 6.28 |
| | 12 | 64.0 | 13.9 | 81.6 | 3300 | 6.36 | 238 | 5.72 | 5.98 | 6.05 | 6.12 | 6.22 |
| 200 × 100 | 15 | 67.5 | 12.8 | 86.0 | 3520 | 6.40 | 274 | 3.45 | 3.72 | 3.79 | 3.86 | 3.97 |
| | 12 | 54.6 | 13.0 | 69.6 | 2880 | 6.43 | 222 | 3.39 | 3.65 | 3.72 | 3.79 | 3.90 |
| | 10 | 46.0 | 13.1 | 58.4 | 2440 | 6.46 | 186 | 3.35 | 3.61 | 3.67 | 3.74 | 3.85 |
| 150 × 90 | 15 | 53.2 | 9.79 | 67.8 | 1522 | 4.74 | 155 | 3.32 | 3.60 | 3.67 | 3.75 | 3.86 |
| | 12 | 43.2 | 9.92 | 55.0 | 1250 | 4.77 | 127 | 3.27 | 3.55 | 3.62 | 3.69 | 3.80 |
| | 10 | 36.4 | 10.0 | 46.4 | 1070 | 4.80 | 107 | 3.23 | 3.50 | 3.57 | 3.64 | 3.75 |
| 150 × 75 | 15 | 49.6 | 9.48 | 63.4 | 1430 | 4.75 | 150 | 2.65 | 2.94 | 3.01 | 3.09 | 3.21 |
| | 12 | 40.4 | 9.60 | 51.4 | 1180 | 4.78 | 123 | 2.59 | 2.87 | 2.94 | 3.02 | 3.14 |
| | 10 | 34.0 | 9.69 | 43.4 | 1000 | 4.81 | 103 | 2.56 | 2.83 | 2.90 | 2.97 | 3.08 |
| 125 × 75 | 12 | 35.6 | 8.19 | 45.4 | 708 | 3.95 | 86.4 | 2.76 | 3.04 | 3.11 | 3.19 | 3.30 |
| | 10 | 30.0 | 8.27 | 38.2 | 604 | 3.97 | 73.0 | 2.72 | 2.99 | 3.07 | 3.14 | 3.26 |
| | 8 | 24.4 | 8.36 | 31.0 | 494 | 4.00 | 59.2 | 2.68 | 2.95 | 3.02 | 3.09 | 3.20 |
| 100 × 75 | 12 | 30.8 | 6.73 | 39.4 | 378 | 3.10 | 56.0 | 2.95 | 3.24 | 3.31 | 3.39 | 3.51 |
| | 10 | 26.0 | 6.81 | 33.2 | 324 | 3.12 | 47.6 | 2.91 | 3.19 | 3.27 | 3.34 | 3.46 |
| | 8 | 21.2 | 6.90 | 27.0 | 266 | 3.14 | 38.6 | 2.87 | 3.15 | 3.22 | 3.29 | 3.41 |
| 100 × 65 | 10 # | 24.6 | 6.64 | 31.2 | 308 | 3.14 | 46.4 | 2.43 | 2.72 | 2.79 | 2.87 | 2.99 |
| | 8 # | 19.9 | 6.73 | 25.4 | 254 | 3.16 | 37.8 | 2.39 | 2.67 | 2.74 | 2.82 | 2.93 |
| | 7 # | 17.5 | 6.77 | 22.4 | 226 | 3.17 | 33.2 | 2.37 | 2.65 | 2.72 | 2.79 | 2.91 |
| 100 × 50 | 8 ‡ | 17.9 | 6.40 | 22.8 | 232 | 3.19 | 36.4 | 1.73 | 2.02 | 2.09 | 2.17 | 2.29 |
| | 6 ‡ | 13.7 | 6.49 | 17.4 | 180 | 3.21 | 27.6 | 1.69 | 1.97 | 2.04 | 2.12 | 2.24 |
| 80 × 60 | 7 ‡ | 14.7 | 5.49 | 18.8 | 118 | 2.51 | 21.4 | 2.31 | 2.59 | 2.67 | 2.74 | 2.86 |
| 80 × 40 | 8 ‡ | 14.1 | 5.06 | 18.0 | 115 | 2.53 | 22.8 | 1.41 | 1.71 | 1.79 | 1.87 | 2.00 |
| | 6 ‡ | 10.8 | 5.15 | 13.8 | 89.8 | 2.55 | 17.5 | 1.37 | 1.66 | 1.74 | 1.82 | 1.97 |
| 75 × 50 | 8 ‡ | 14.8 | 4.98 | 18.8 | 104 | 2.35 | 20.8 | 1.90 | 2.19 | 2.27 | 2.35 | 2.47 |
| | 6 ‡ | 11.3 | 5.06 | 14.4 | 81.0 | 2.37 | 16.0 | 1.86 | 2.14 | 2.22 | 2.30 | 2.42 |
| 70 × 50 | 6 ‡ | 10.8 | 4.77 | 13.8 | 66.8 | 2.20 | 14.0 | 1.90 | 2.19 | 2.26 | 2.34 | 2.46 |
| 65 × 50 | 5 ‡ | 8.70 | 4.51 | 11.1 | 46.4 | 2.05 | 10.3 | 1.93 | 2.21 | 2.28 | 2.36 | 2.48 |
| 60 × 40 | 6 ‡ | 8.92 | 4.00 | 11.4 | 40.2 | 1.88 | 10.1 | 1.51 | 1.80 | 1.88 | 1.96 | 2.09 |
| | 5 ‡ | 7.52 | 4.04 | 9.58 | 34.4 | 1.89 | 8.50 | 1.49 | 1.78 | 1.86 | 1.94 | 2.06 |

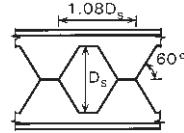
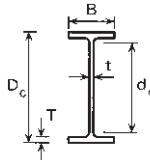
‡ Not available from some leading producers. Check availability.

Check availability.

Properties about y-y axis:

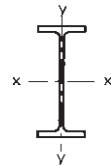
$$I_y = (\text{Total Area}) \cdot (r_y)^2$$

$$Z_y = I_y / (0.5B_o)$$

CASTELLATED UNIVERSAL BEAMS**DIMENSIONS AND PROPERTIES**

| Section Designation | | Mass per Metre kg/m | Depth of Section D _c mm | Width of Section B mm | Thickness | | Depth between Fillets d _c mm | Pitch 1.08 × D _s mm | Net Second Moment of Area | | Net Radius of Gyration | |
|---------------------|------------------|------------------------|--|-----------------------------|----------------|-------------------|---|--------------------------------------|-----------------------------|-----------------------------|------------------------|----------------|
| Original | Castellated | | | | Web t mm | Flange T mm | | | Axis x-x cm ⁴ | Axis y-y cm ⁴ | Axis x-x cm | Axis y-y cm |
| 914 × 419 × 388 | 1371 × 419 × 388 | 388.0 | 1378.0 | 420.5 | 21.4 | 36.6 | 1256.6 | 987.1 | 1670000 | 45400 | 64.8 | 10.7 |
| 914 × 419 × 343 | 1371 × 419 × 343 | 343.3 | 1368.8 | 418.5 | 19.4 | 32.0 | 1256.6 | 987.1 | 1450000 | 39100 | 64.6 | 10.6 |
| 914 × 305 × 289 | 1371 × 305 × 289 | 289.1 | 1383.6 | 307.7 | 19.5 | 32.0 | 1281.4 | 987.1 | 1160000 | 15600 | 64.5 | 7.47 |
| 914 × 305 × 253 | 1371 × 305 × 253 | 253.4 | 1375.4 | 305.5 | 17.3 | 27.9 | 1281.4 | 987.1 | 1010000 | 13300 | 64.3 | 7.38 |
| 914 × 305 × 224 | 1371 × 305 × 224 | 224.2 | 1367.4 | 304.1 | 15.9 | 23.9 | 1281.4 | 987.1 | 873000 | 11200 | 64.0 | 7.26 |
| 914 × 305 × 201 | 1371 × 305 × 201 | 200.9 | 1360.0 | 303.3 | 15.1 | 20.2 | 1281.4 | 987.1 | 757000 | 9410 | 63.6 | 7.10 |
| 838 × 292 × 226 | 1257 × 292 × 226 | 226.5 | 1269.9 | 293.8 | 16.1 | 26.8 | 1180.7 | 905.0 | 781000 | 11400 | 59.4 | 7.16 |
| 838 × 292 × 194 | 1257 × 292 × 194 | 193.8 | 1259.7 | 292.4 | 14.7 | 21.7 | 1180.7 | 905.0 | 645000 | 9060 | 59.0 | 6.99 |
| 838 × 292 × 176 | 1257 × 292 × 176 | 175.9 | 1253.9 | 291.7 | 14.0 | 18.8 | 1180.7 | 905.0 | 570000 | 7790 | 58.7 | 6.86 |
| 762 × 267 × 197 | 1143 × 267 × 197 | 196.8 | 1150.8 | 268.0 | 15.6 | 25.4 | 1067.0 | 823.0 | 554000 | 8160 | 53.8 | 6.53 |
| 762 × 267 × 173 | 1143 × 267 × 173 | 173.0 | 1143.2 | 266.7 | 14.3 | 21.6 | 1067.0 | 823.0 | 475000 | 6840 | 53.5 | 6.42 |
| 762 × 267 × 147 | 1143 × 267 × 147 | 146.9 | 1135.0 | 265.2 | 12.8 | 17.5 | 1067.0 | 823.0 | 392000 | 5450 | 53.2 | 6.27 |
| 762 × 267 × 134 | 1143 × 267 × 134 | 133.9 | 1131.0 | 264.4 | 12.0 | 15.5 | 1067.0 | 823.0 | 351000 | 4780 | 53.0 | 6.19 |
| 686 × 254 × 170 | 1029 × 254 × 170 | 170.2 | 1035.9 | 255.8 | 14.5 | 23.7 | 958.1 | 740.9 | 393000 | 6620 | 48.5 | 6.30 |
| 686 × 254 × 152 | 1029 × 254 × 152 | 152.4 | 1030.5 | 254.5 | 13.2 | 21.0 | 958.1 | 740.9 | 348000 | 5780 | 48.4 | 6.23 |
| 686 × 254 × 140 | 1029 × 254 × 140 | 140.1 | 1026.5 | 253.7 | 12.4 | 19.0 | 958.1 | 740.9 | 316000 | 5180 | 48.2 | 6.17 |
| 686 × 254 × 125 | 1029 × 254 × 125 | 125.2 | 1020.9 | 253.0 | 11.7 | 16.2 | 958.1 | 740.9 | 274000 | 4380 | 47.9 | 6.06 |
| 610 × 305 × 238 | 915 × 305 × 238 | 238.1 | 940.8 | 311.4 | 18.4 | 31.4 | 845.0 | 658.8 | 478000 | 15800 | 44.0 | 8.00 |
| 610 × 305 × 179 | 915 × 305 × 179 | 179.0 | 925.2 | 307.1 | 14.1 | 23.6 | 845.0 | 658.8 | 352000 | 11400 | 43.6 | 7.85 |
| 610 × 305 × 149 | 915 × 305 × 149 | 149.2 | 917.4 | 304.8 | 11.8 | 19.7 | 845.0 | 658.8 | 291000 | 9300 | 43.4 | 7.77 |
| 610 × 229 × 140 | 915 × 229 × 140 | 139.9 | 922.2 | 230.2 | 13.1 | 22.1 | 852.6 | 658.8 | 258000 | 4500 | 43.2 | 5.71 |
| 610 × 229 × 125 | 915 × 229 × 125 | 125.1 | 917.2 | 229.0 | 11.9 | 19.6 | 852.6 | 658.8 | 228000 | 3930 | 43.1 | 5.65 |
| 610 × 229 × 113 | 915 × 229 × 113 | 113.0 | 912.6 | 228.2 | 11.1 | 17.3 | 852.6 | 658.8 | 203000 | 3430 | 42.9 | 5.58 |
| 610 × 229 × 101 | 915 × 229 × 101 | 101.2 | 907.6 | 227.6 | 10.5 | 14.8 | 852.6 | 658.8 | 176000 | 2910 | 42.7 | 5.48 |
| 533 × 210 × 122 | 800 × 210 × 122 | 122.0 | 811.0 | 211.9 | 12.7 | 21.3 | 743.0 | 575.6 | 175000 | 3380 | 37.9 | 5.28 |
| 533 × 210 × 109 | 800 × 210 × 109 | 109.0 | 806.0 | 210.8 | 11.6 | 18.8 | 743.0 | 575.6 | 154000 | 2940 | 37.8 | 5.22 |
| 533 × 210 × 101 | 800 × 210 × 101 | 101.0 | 803.2 | 210.0 | 10.8 | 17.4 | 743.0 | 575.6 | 142000 | 2690 | 37.7 | 5.19 |
| 533 × 210 × 92 | 800 × 210 × 92 | 92.1 | 799.6 | 209.3 | 10.1 | 15.3 | 743.0 | 575.6 | 128000 | 2390 | 37.6 | 5.14 |
| 533 × 210 × 82 | 800 × 210 × 82 | 82.2 | 794.8 | 208.8 | 9.6 | 13.2 | 743.0 | 575.6 | 110000 | 2010 | 37.4 | 5.03 |
| 457 × 191 × 98 | 686 × 191 × 98 | 98.3 | 695.7 | 192.8 | 11.4 | 19.6 | 636.1 | 493.6 | 105000 | 2340 | 32.6 | 4.86 |
| 457 × 191 × 89 | 686 × 191 × 89 | 89.3 | 691.9 | 191.9 | 10.5 | 17.7 | 636.1 | 493.6 | 94600 | 2090 | 32.5 | 4.82 |
| 457 × 191 × 82 | 686 × 191 × 82 | 82.0 | 688.5 | 191.3 | 9.9 | 16.0 | 636.1 | 493.6 | 85600 | 1870 | 32.3 | 4.78 |
| 457 × 191 × 74 | 686 × 191 × 74 | 74.3 | 685.5 | 190.4 | 9.0 | 14.5 | 636.1 | 493.6 | 77200 | 1670 | 32.3 | 4.75 |
| 457 × 191 × 67 | 686 × 191 × 67 | 67.1 | 681.9 | 189.9 | 8.5 | 12.7 | 636.1 | 493.6 | 68200 | 1450 | 32.1 | 4.69 |
| 457 × 152 × 82 | 686 × 152 × 82 | 82.1 | 694.3 | 155.3 | 10.5 | 18.9 | 636.1 | 493.6 | 84300 | 1180 | 32.4 | 3.83 |
| 457 × 152 × 74 | 686 × 152 × 74 | 74.2 | 690.5 | 154.4 | 9.6 | 17.0 | 636.1 | 493.6 | 75500 | 1050 | 32.3 | 3.80 |
| 457 × 152 × 67 | 686 × 152 × 67 | 67.2 | 686.5 | 153.8 | 9.0 | 15.0 | 636.1 | 493.6 | 67000 | 911 | 32.1 | 3.74 |
| 457 × 152 × 60 | 686 × 152 × 60 | 59.8 | 683.1 | 152.9 | 8.1 | 13.3 | 636.1 | 493.6 | 59200 | 794 | 32.0 | 3.71 |
| 457 × 152 × 52 | 686 × 152 × 52 | 52.3 | 678.3 | 152.4 | 7.6 | 10.9 | 636.1 | 493.6 | 49800 | 644 | 31.8 | 3.62 |

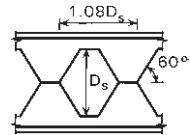
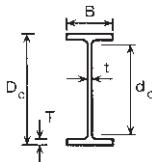
CASTELLATED UNIVERSAL BEAMS



PROPERTIES (CONTINUED)

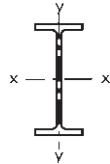
| Section Designation | | Net Elastic Modulus | | Elastic Modulus of Tee | | Net Plastic Modulus | | Net Buckling Parameter u | Net Torsional Index x | Net Warping Constant H dm ⁶ | Net Torsional Constant J cm ⁴ | Net Area A _n cm ² |
|---------------------|------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------|--|--|---|
| Original | Castellated | Axis x-x cm ³ | Axis y-y cm ³ | Flange x-x cm ³ | Toe x-x cm ³ | Axis x-x cm ³ | Axis y-y cm ³ | | | | | |
| 914 × 419 × 388 | 1371 × 419 × 388 | 24200 | 2160 | 1380 | 314 | 25600 | 3290 | 0.975 | 37.9 | 204 | 1590 | 396 |
| 914 × 419 × 343 | 1371 × 419 × 343 | 21200 | 1870 | 1250 | 276 | 22400 | 2850 | 0.974 | 43.0 | 175 | 1080 | 349 |
| 914 × 305 × 289 | 1371 × 305 × 289 | 16800 | 1010 | 1080 | 288 | 17900 | 1560 | 0.972 | 44.8 | 71.1 | 813 | 279 |
| 914 × 305 × 253 | 1371 × 305 × 253 | 14700 | 869 | 964 | 249 | 15600 | 1340 | 0.971 | 50.9 | 60.3 | 547 | 244 |
| 914 × 305 × 224 | 1371 × 305 × 224 | 12800 | 738 | 863 | 223 | 13600 | 1140 | 0.971 | 58.4 | 50.6 | 361 | 213 |
| 914 × 305 × 201 | 1371 × 305 × 201 | 11100 | 620 | 772 | 205 | 11800 | 956 | 0.969 | 67.1 | 42.2 | 239 | 187 |
| 838 × 292 × 226 | 1257 × 292 × 226 | 12300 | 772 | 811 | 204 | 13100 | 1180 | 0.972 | 49.0 | 43.8 | 455 | 221 |
| 838 × 292 × 194 | 1257 × 292 × 194 | 10200 | 619 | 704 | 179 | 10900 | 951 | 0.971 | 59.0 | 34.7 | 261 | 185 |
| 838 × 292 × 176 | 1257 × 292 × 176 | 9080 | 534 | 639 | 166 | 9660 | 821 | 0.970 | 66.4 | 29.7 | 183 | 165 |
| 762 × 267 × 197 | 1143 × 267 × 197 | 9620 | 609 | 620 | 159 | 10200 | 935 | 0.972 | 46.7 | 25.8 | 356 | 191 |
| 762 × 267 × 173 | 1143 × 267 × 173 | 8310 | 513 | 554 | 141 | 8840 | 788 | 0.971 | 53.9 | 21.5 | 230 | 166 |
| 762 × 267 × 147 | 1143 × 267 × 147 | 6900 | 411 | 476 | 122 | 7330 | 632 | 0.971 | 64.7 | 17.0 | 132 | 138 |
| 762 × 267 × 134 | 1143 × 267 × 134 | 6200 | 362 | 435 | 113 | 6590 | 556 | 0.969 | 71.7 | 14.9 | 97.0 | 125 |
| 686 × 254 × 170 | 1029 × 254 × 170 | 7590 | 518 | 480 | 120 | 8070 | 793 | 0.973 | 44.8 | 17.0 | 273 | 167 |
| 686 × 254 × 152 | 1029 × 254 × 152 | 6750 | 454 | 438 | 107 | 7160 | 695 | 0.972 | 50.2 | 14.7 | 193 | 149 |
| 686 × 254 × 140 | 1029 × 254 × 140 | 6160 | 408 | 407 | 98.6 | 6520 | 625 | 0.972 | 54.8 | 13.1 | 147 | 136 |
| 686 × 254 × 125 | 1029 × 254 × 125 | 5380 | 346 | 367 | 90.4 | 5700 | 531 | 0.972 | 62.7 | 11.0 | 97.9 | 119 |
| 610 × 305 × 238 | 915 × 305 × 238 | 10200 | 1020 | 555 | 135 | 10800 | 1550 | 0.974 | 30.1 | 32.7 | 722 | 247 |
| 610 × 305 × 179 | 915 × 305 × 179 | 7610 | 743 | 444 | 96.3 | 8040 | 1130 | 0.974 | 39.3 | 23.2 | 312 | 185 |
| 610 × 305 × 149 | 915 × 305 × 149 | 6340 | 610 | 385 | 77.8 | 6670 | 927 | 0.974 | 46.6 | 18.7 | 183 | 154 |
| 610 × 229 × 140 | 915 × 229 × 140 | 5590 | 391 | 348 | 86.2 | 5950 | 598 | 0.974 | 43.0 | 9.11 | 194 | 138 |
| 610 × 229 × 125 | 915 × 229 × 125 | 4970 | 343 | 317 | 76.6 | 5280 | 525 | 0.973 | 48.1 | 7.91 | 137 | 123 |
| 610 × 229 × 113 | 915 × 229 × 113 | 4440 | 301 | 291 | 69.7 | 4700 | 460 | 0.973 | 53.9 | 6.87 | 97.4 | 110 |
| 610 × 229 × 101 | 915 × 229 × 101 | 3880 | 256 | 263 | 64.1 | 4120 | 392 | 0.971 | 61.6 | 5.80 | 65.2 | 96.9 |
| 533 × 210 × 122 | 800 × 210 × 122 | 4310 | 319 | 262 | 65.9 | 4590 | 489 | 0.971 | 39.0 | 5.27 | 160 | 122 |
| 533 × 210 × 109 | 800 × 210 × 109 | 3820 | 279 | 240 | 58.6 | 4060 | 427 | 0.973 | 43.8 | 4.55 | 112 | 108 |
| 533 × 210 × 101 | 800 × 210 × 101 | 3540 | 256 | 225 | 53.8 | 3750 | 392 | 0.973 | 46.9 | 4.15 | 89.8 | 99.9 |
| 533 × 210 × 92 | 800 × 210 × 92 | 3200 | 228 | 209 | 49.3 | 3390 | 349 | 0.972 | 51.8 | 3.67 | 66.5 | 90.5 |
| 533 × 210 × 82 | 800 × 210 × 82 | 2780 | 192 | 188 | 45.4 | 2940 | 294 | 0.971 | 59.5 | 3.06 | 43.7 | 79.1 |
| 457 × 191 × 98 | 686 × 191 × 98 | 3020 | 243 | 177 | 43.6 | 3220 | 371 | 0.974 | 36.3 | 2.68 | 110 | 99.2 |
| 457 × 191 × 89 | 686 × 191 × 89 | 2730 | 218 | 164 | 39.2 | 2900 | 332 | 0.974 | 40.0 | 2.37 | 81.9 | 89.8 |
| 457 × 191 × 82 | 686 × 191 × 82 | 2490 | 195 | 153 | 36.1 | 2640 | 298 | 0.973 | 43.8 | 2.11 | 61.8 | 81.9 |
| 457 × 191 × 74 | 686 × 191 × 74 | 2250 | 175 | 142 | 32.3 | 2380 | 267 | 0.973 | 48.1 | 1.88 | 46.2 | 74.1 |
| 457 × 191 × 67 | 686 × 191 × 67 | 2000 | 153 | 130 | 29.7 | 2120 | 233 | 0.973 | 54.0 | 1.62 | 32.5 | 66.1 |
| 457 × 152 × 82 | 686 × 152 × 82 | 2430 | 152 | 147 | 39.2 | 2600 | 234 | 0.974 | 38.3 | 1.35 | 80.4 | 80.5 |
| 457 × 152 × 74 | 686 × 152 × 74 | 2190 | 135 | 135 | 35.0 | 2330 | 208 | 0.974 | 42.2 | 1.18 | 59.2 | 72.5 |
| 457 × 152 × 67 | 686 × 152 × 67 | 1950 | 118 | 124 | 32.0 | 2080 | 182 | 0.972 | 47.2 | 1.03 | 42.1 | 65.0 |
| 457 × 152 × 60 | 686 × 152 × 60 | 1730 | 104 | 113 | 28.2 | 1840 | 159 | 0.973 | 52.8 | 0.890 | 29.8 | 57.7 |
| 457 × 152 × 52 | 686 × 152 × 52 | 1470 | 84.5 | 99.2 | 25.5 | 1560 | 130 | 0.971 | 62.5 | 0.717 | 18.0 | 49.3 |

The values of the elastic modulus of the Tee are the elastic modulus at the flange and at the toe of the Tee formed at the net section.

CASTELLATED UNIVERSAL BEAMS**DIMENSIONS AND PROPERTIES**

| Section Designation | | Mass per Metre kg/m | Depth of Section D _c mm | Width of Section B mm | Thickness | | Depth between Fillets d _c mm | Pitch 1.08 × D _s mm | Net Second Moment of Area | | Net Radius of Gyration | |
|---------------------|----------------|------------------------|--|-----------------------------|----------------|-------------------|---|--------------------------------------|-----------------------------|-----------------------------|------------------------|----------------|
| Original | Castellated | | | | Web t mm | Flange T mm | | | Axis x-x cm ⁴ | Axis y-y cm ⁴ | Axis x-x cm | Axis y-y cm |
| 406 × 178 × 74 | 609 × 178 × 74 | 74.2 | 615.8 | 179.5 | 9.5 | 16.0 | 563.4 | 438.5 | 62900 | 1540 | 28.9 | 4.53 |
| 406 × 178 × 67 | 609 × 178 × 67 | 67.1 | 612.4 | 178.8 | 8.8 | 14.3 | 563.4 | 438.5 | 56200 | 1360 | 28.8 | 4.49 |
| 406 × 178 × 60 | 609 × 178 × 60 | 60.1 | 609.4 | 177.9 | 7.9 | 12.8 | 563.4 | 438.5 | 50000 | 1200 | 28.7 | 4.46 |
| 406 × 178 × 54 | 609 × 178 × 54 | 54.1 | 605.6 | 177.7 | 7.7 | 10.9 | 563.4 | 438.5 | 43500 | 1020 | 28.6 | 4.37 |
| 406 × 140 × 46 | 609 × 140 × 46 | 46.0 | 606.2 | 142.2 | 6.8 | 11.2 | 563.4 | 438.5 | 36400 | 538 | 28.5 | 3.46 |
| 406 × 140 × 39 | 609 × 140 × 39 | 39.0 | 601.0 | 141.8 | 6.4 | 8.6 | 563.4 | 438.5 | 29200 | 409 | 28.2 | 3.34 |
| 356 × 171 × 67 | 534 × 171 × 67 | 67.1 | 541.4 | 173.2 | 9.1 | 15.7 | 489.6 | 384.5 | 44800 | 1360 | 25.4 | 4.43 |
| 356 × 171 × 57 | 534 × 171 × 57 | 57.0 | 536.0 | 172.2 | 8.1 | 13.0 | 489.6 | 384.5 | 37100 | 1110 | 25.3 | 4.36 |
| 356 × 171 × 51 | 534 × 171 × 51 | 51.0 | 533.0 | 171.5 | 7.4 | 11.5 | 489.6 | 384.5 | 32800 | 968 | 25.2 | 4.32 |
| 356 × 171 × 45 | 534 × 171 × 45 | 45.0 | 529.4 | 171.1 | 7.0 | 9.7 | 489.6 | 384.5 | 28100 | 811 | 25.0 | 4.25 |
| 356 × 127 × 39 | 534 × 127 × 39 | 39.1 | 531.4 | 126.0 | 6.6 | 10.7 | 489.6 | 384.5 | 23700 | 357 | 24.9 | 3.07 |
| 356 × 127 × 33 | 534 × 127 × 33 | 33.1 | 527.0 | 125.4 | 6.0 | 8.5 | 489.6 | 384.5 | 19300 | 280 | 24.8 | 2.98 |
| 305 × 165 × 54 | 458 × 165 × 54 | 54.0 | 462.9 | 166.9 | 7.9 | 13.7 | 417.7 | 329.4 | 27000 | 1060 | 21.8 | 4.33 |
| 305 × 165 × 46 | 458 × 165 × 46 | 46.1 | 459.1 | 165.7 | 6.7 | 11.8 | 417.7 | 329.4 | 22900 | 895 | 21.7 | 4.30 |
| 305 × 165 × 40 | 458 × 165 × 40 | 40.3 | 455.9 | 165.0 | 6.0 | 10.2 | 417.7 | 329.4 | 19800 | 764 | 21.6 | 4.26 |
| 305 × 127 × 48 | 458 × 127 × 48 | 48.1 | 463.5 | 125.3 | 9.0 | 14.0 | 417.7 | 329.4 | 22100 | 460 | 21.6 | 3.11 |
| 305 × 127 × 42 | 458 × 127 × 42 | 41.9 | 459.7 | 124.3 | 8.0 | 12.1 | 417.7 | 329.4 | 19000 | 388 | 21.5 | 3.07 |
| 305 × 127 × 37 | 458 × 127 × 37 | 37.0 | 456.9 | 123.4 | 7.1 | 10.7 | 417.7 | 329.4 | 16700 | 336 | 21.4 | 3.04 |
| 305 × 102 × 33 | 458 × 102 × 33 | 32.8 | 465.2 | 102.4 | 6.6 | 10.8 | 428.4 | 329.4 | 14900 | 194 | 21.7 | 2.47 |
| 305 × 102 × 28 | 458 × 102 × 28 | 28.2 | 461.2 | 101.8 | 6.0 | 8.8 | 428.4 | 329.4 | 12400 | 155 | 21.5 | 2.41 |
| 305 × 102 × 25 | 458 × 102 × 25 | 24.8 | 457.6 | 101.6 | 5.8 | 7.0 | 428.4 | 329.4 | 10300 | 123 | 21.3 | 2.32 |
| 254 × 146 × 43 | 381 × 146 × 43 | 43.0 | 386.6 | 147.3 | 7.2 | 12.7 | 346.0 | 274.3 | 15100 | 677 | 18.2 | 3.85 |
| 254 × 146 × 37 | 381 × 146 × 37 | 37.0 | 383.0 | 146.4 | 6.3 | 10.9 | 346.0 | 274.3 | 12800 | 570 | 18.1 | 3.82 |
| 254 × 146 × 31 | 381 × 146 × 31 | 31.1 | 378.4 | 146.1 | 6.0 | 8.6 | 346.0 | 274.3 | 10300 | 447 | 17.9 | 3.74 |
| 254 × 102 × 28 | 381 × 102 × 28 | 28.3 | 387.4 | 102.2 | 6.3 | 10.0 | 352.2 | 274.3 | 9190 | 178 | 18.1 | 2.52 |
| 254 × 102 × 25 | 381 × 102 × 27 | 25.2 | 384.2 | 101.9 | 6.0 | 8.4 | 352.2 | 274.3 | 7870 | 148 | 18.0 | 2.47 |
| 254 × 102 × 22 | 381 × 102 × 22 | 22.0 | 381.0 | 101.6 | 5.7 | 6.8 | 352.2 | 274.3 | 6580 | 119 | 17.8 | 2.39 |
| 203 × 133 × 30 | 305 × 133 × 30 | 30.0 | 308.3 | 133.9 | 6.4 | 9.6 | 273.9 | 219.2 | 6680 | 384 | 14.5 | 3.48 |
| 203 × 133 × 25 | 305 × 133 × 25 | 25.1 | 304.7 | 133.2 | 5.7 | 7.8 | 273.9 | 219.2 | 5430 | 307 | 14.4 | 3.43 |
| 203 × 102 × 23 | 305 × 102 × 23 | 23.1 | 304.7 | 101.8 | 5.4 | 9.3 | 270.9 | 219.2 | 4910 | 164 | 14.3 | 2.62 |
| 178 × 102 × 19 | 267 × 102 × 19 | 19.0 | 266.8 | 101.2 | 4.8 | 7.9 | 235.8 | 192.2 | 3160 | 137 | 12.6 | 2.61 |
| 152 × 89 × 16 | 228 × 89 × 16 | 16.0 | 228.4 | 88.7 | 4.5 | 7.7 | 197.8 | 164.2 | 1950 | 89.7 | 10.7 | 2.30 |
| 127 × 76 × 13 | 191 × 76 × 13 | 13.0 | 190.5 | 76.0 | 4.0 | 7.6 | 160.1 | 137.2 | 1120 | 55.7 | 8.93 | 2.00 |

CASTELLATED UNIVERSAL BEAMS

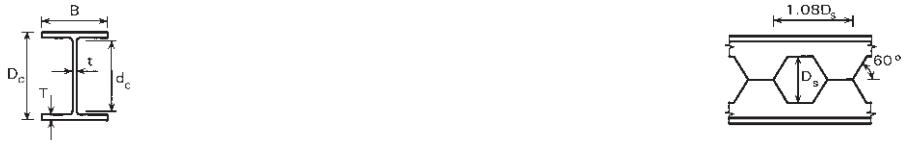


PROPERTIES (CONTINUED)

| Section Designation | | Net Elastic Modulus | | Elastic Modulus of Tee | | Net Plastic Modulus | | Net Buckling Parameter u | Net Torsional Index x | Net Warping Constant H dm ⁶ | Net Torsional Constant J cm ⁴ | Net Area A _n cm ² |
|---------------------|----------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------|--|--|---|
| Original | Castellated | Axis x-x cm ³ | Axis y-y cm ³ | Flange x-x cm ³ | Toe x-x cm ³ | Axis x-x cm ³ | Axis y-y cm ³ | | | | | |
| 406 × 178 × 74 | 609 × 178 × 74 | 2040 | 172 | 121 | 28.4 | 2170 | 262 | 0.974 | 39.0 | 1.39 | 57.0 | 75.2 |
| 406 × 178 × 67 | 609 × 178 × 67 | 1840 | 153 | 112 | 25.6 | 1940 | 233 | 0.973 | 43.2 | 1.22 | 41.5 | 67.7 |
| 406 × 178 × 60 | 609 × 178 × 60 | 1640 | 135 | 103 | 22.6 | 1730 | 206 | 0.974 | 48.0 | 1.07 | 30.0 | 60.5 |
| 406 × 178 × 54 | 609 × 178 × 54 | 1440 | 115 | 94.1 | 21.3 | 1520 | 175 | 0.973 | 54.9 | 0.902 | 20.0 | 53.3 |
| 406 × 140 × 46 | 609 × 140 × 46 | 1200 | 75.6 | 78.6 | 18.7 | 1270 | 116 | 0.974 | 54.8 | 0.476 | 16.9 | 44.8 |
| 406 × 140 × 39 | 609 × 140 × 39 | 971 | 57.7 | 66.8 | 16.8 | 1030 | 88.8 | 0.970 | 68.0 | 0.359 | 8.93 | 36.7 |
| 356 × 171 × 67 | 534 × 171 × 67 | 1660 | 157 | 92.1 | 21.2 | 1760 | 239 | 0.974 | 34.6 | 0.940 | 51.2 | 69.3 |
| 356 × 171 × 57 | 534 × 171 × 57 | 1380 | 129 | 81.5 | 18.0 | 1460 | 196 | 0.974 | 41.1 | 0.757 | 30.2 | 58.1 |
| 356 × 171 × 51 | 534 × 171 × 51 | 1230 | 113 | 74.8 | 16.0 | 1300 | 172 | 0.974 | 45.9 | 0.658 | 21.4 | 51.7 |
| 356 × 171 × 45 | 534 × 171 × 45 | 1060 | 94.7 | 67.8 | 14.7 | 1120 | 144 | 0.972 | 53.1 | 0.547 | 13.8 | 44.9 |
| 356 × 127 × 39 | 534 × 127 × 39 | 891 | 56.7 | 56.5 | 13.8 | 945 | 87.1 | 0.974 | 49.6 | 0.242 | 13.4 | 38.0 |
| 356 × 127 × 33 | 534 × 127 × 33 | 732 | 44.6 | 48.6 | 12.1 | 775 | 68.7 | 0.971 | 60.1 | 0.188 | 7.51 | 31.5 |
| 305 × 165 × 54 | 458 × 165 × 54 | 1170 | 127 | 61.9 | 13.5 | 1230 | 193 | 0.974 | 33.7 | 0.536 | 32.3 | 56.7 |
| 305 × 165 × 46 | 458 × 165 × 46 | 998 | 108 | 54.7 | 11.0 | 1050 | 164 | 0.975 | 38.8 | 0.448 | 20.7 | 48.5 |
| 305 × 165 × 40 | 458 × 165 × 40 | 866 | 92.6 | 49.6 | 9.58 | 910 | 140 | 0.974 | 44.4 | 0.379 | 13.6 | 42.2 |
| 305 × 127 × 48 | 458 × 127 × 48 | 954 | 73.4 | 54.8 | 14.9 | 1020 | 113 | 0.973 | 33.1 | 0.232 | 28.1 | 47.5 |
| 305 × 127 × 42 | 458 × 127 × 42 | 827 | 62.4 | 49.0 | 12.8 | 881 | 96.0 | 0.972 | 37.8 | 0.194 | 18.5 | 41.2 |
| 305 × 127 × 37 | 458 × 127 × 37 | 730 | 54.4 | 44.3 | 11.1 | 775 | 83.5 | 0.972 | 42.4 | 0.167 | 12.9 | 36.4 |
| 305 × 102 × 33 | 458 × 102 × 33 | 641 | 37.8 | 41.9 | 11.3 | 685 | 58.4 | 0.971 | 44.3 | 0.100 | 10.7 | 31.8 |
| 305 × 102 × 28 | 458 × 102 × 28 | 536 | 30.5 | 36.4 | 9.87 | 572 | 47.1 | 0.970 | 52.7 | 0.0794 | 6.30 | 26.7 |
| 305 × 102 × 25 | 458 × 102 × 25 | 451 | 24.2 | 31.6 | 9.11 | 482 | 37.5 | 0.966 | 62.6 | 0.0623 | 3.78 | 22.8 |
| 254 × 146 × 43 | 381 × 146 × 43 | 780 | 91.9 | 39.0 | 8.65 | 827 | 139 | 0.974 | 30.3 | 0.237 | 22.3 | 45.6 |
| 254 × 146 × 37 | 381 × 146 × 37 | 670 | 77.9 | 34.8 | 7.24 | 707 | 118 | 0.973 | 34.9 | 0.197 | 14.3 | 39.2 |
| 254 × 146 × 31 | 381 × 146 × 31 | 544 | 61.2 | 31.3 | 6.45 | 572 | 93.0 | 0.971 | 42.9 | 0.153 | 7.64 | 32.1 |
| 254 × 102 × 28 | 381 × 102 × 28 | 474 | 34.9 | 29.3 | 7.51 | 506 | 53.6 | 0.972 | 38.8 | 0.0635 | 8.51 | 28.1 |
| 254 × 102 × 25 | 381 × 102 × 25 | 410 | 29.1 | 26.5 | 6.85 | 436 | 44.9 | 0.971 | 44.8 | 0.0524 | 5.50 | 24.4 |
| 254 × 102 × 22 | 381 × 102 × 22 | 345 | 23.5 | 23.3 | 6.22 | 368 | 36.2 | 0.968 | 52.7 | 0.0417 | 3.36 | 20.8 |
| 203 × 133 × 30 | 305 × 133 × 30 | 433 | 57.4 | 22.1 | 4.86 | 459 | 87.2 | 0.970 | 31.0 | 0.0857 | 9.42 | 31.7 |
| 203 × 133 × 25 | 305 × 133 × 25 | 357 | 46.2 | 19.6 | 4.08 | 376 | 70.1 | 0.969 | 37.2 | 0.0678 | 5.34 | 26.2 |
| 203 × 102 × 23 | 305 × 102 × 23 | 322 | 32.2 | 16.4 | 3.79 | 342 | 49.0 | 0.976 | 32.1 | 0.0357 | 6.49 | 23.9 |
| 178 × 102 × 19 | 267 × 102 × 19 | 237 | 27.0 | 11.8 | 2.60 | 251 | 41.1 | 0.974 | 32.4 | 0.0229 | 4.08 | 20.0 |
| 152 × 89 × 16 | 228 × 89 × 16 | 171 | 20.2 | 7.86 | 1.80 | 181 | 30.8 | 0.974 | 28.1 | 0.0109 | 3.33 | 16.9 |
| 127 × 76 × 13 | 191 × 76 × 13 | 117 | 14.7 | 4.63 | 1.12 | 125 | 22.3 | 0.976 | 23.5 | 0.00466 | 2.72 | 14.0 |

The values of the elastic modulus of the Tee are the elastic modulus at the flange and at the toe of the Tee formed at the net section.

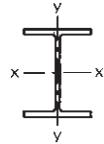
CASTELLATED UNIVERSAL BEAMS



DIMENSIONS AND PROPERTIES

| Section Designation | | Mass per Metre kg/m | Depth of Section D_c mm | Width of Section B mm | Thickness | | Depth between Fillets d_c mm | Pitch 1.08 × D_s mm | Net Second Moment of Area | | Net Radius of Gyration | |
|---------------------|-----------------|---------------------|-------------------------|-----------------------|-----------|-------------|------------------------------|---------------------|---------------------------|---------------|------------------------|-------------|
| | | | | | Web t mm | Flange T mm | | | Axis x-x cm^4 | Axis Y-Y cm^4 | Axis x-x cm | Axis Y-Y cm |
| 356 × 406 × 634 | 534 × 406 × 634 | 633.9 | 665.1 | 424.0 | 47.6 | 77.0 | 480.7 | 411.5 | 600000 | 98000 | 28.9 | 11.7 |
| 356 × 406 × 551 | 534 × 406 × 551 | 551.0 | 646.1 | 418.5 | 42.1 | 67.5 | 480.7 | 411.5 | 504000 | 82600 | 28.5 | 11.5 |
| 356 × 406 × 467 | 534 × 406 × 467 | 467.0 | 627.1 | 412.2 | 35.8 | 58.0 | 480.7 | 411.5 | 413000 | 67800 | 28.0 | 11.3 |
| 356 × 406 × 393 | 534 × 406 × 393 | 393.0 | 609.5 | 407.0 | 30.6 | 49.2 | 480.7 | 411.5 | 336000 | 55300 | 27.6 | 11.2 |
| 356 × 406 × 340 | 534 × 406 × 340 | 339.9 | 596.9 | 403.0 | 26.6 | 42.9 | 480.7 | 411.5 | 284000 | 46800 | 27.3 | 11.1 |
| 356 × 406 × 287 | 534 × 406 × 287 | 287.1 | 584.1 | 399.0 | 22.6 | 36.5 | 480.7 | 411.5 | 235000 | 38700 | 27.0 | 10.9 |
| 356 × 406 × 235 | 534 × 406 × 235 | 235.1 | 571.5 | 394.8 | 18.4 | 30.2 | 480.7 | 411.5 | 188000 | 31000 | 26.7 | 10.8 |
| 356 × 368 × 202 | 534 × 368 × 202 | 201.9 | 552.6 | 374.7 | 16.5 | 27.0 | 468.2 | 384.5 | 152000 | 23700 | 25.8 | 10.2 |
| 356 × 368 × 177 | 534 × 368 × 177 | 177.0 | 546.2 | 372.6 | 14.4 | 23.8 | 468.2 | 384.5 | 132000 | 20500 | 25.7 | 10.1 |
| 356 × 368 × 153 | 534 × 368 × 153 | 152.9 | 540.0 | 370.5 | 12.3 | 20.7 | 468.2 | 384.5 | 113000 | 17600 | 25.5 | 10.1 |
| 356 × 368 × 129 | 534 × 368 × 129 | 129.0 | 533.6 | 368.6 | 10.4 | 17.5 | 468.2 | 384.5 | 94000 | 14600 | 25.4 | 10.0 |
| 305 × 305 × 283 | 458 × 305 × 283 | 282.9 | 517.8 | 322.2 | 26.8 | 44.1 | 399.2 | 329.4 | 172000 | 24600 | 23.2 | 8.78 |
| 305 × 305 × 240 | 458 × 305 × 240 | 240.0 | 505.0 | 318.4 | 23.0 | 37.7 | 399.2 | 329.4 | 142000 | 20300 | 22.9 | 8.66 |
| 305 × 305 × 198 | 458 × 305 × 198 | 198.1 | 492.4 | 314.5 | 19.1 | 31.4 | 399.2 | 329.4 | 114000 | 16300 | 22.6 | 8.54 |
| 305 × 305 × 158 | 458 × 305 × 158 | 158.1 | 479.6 | 311.2 | 15.8 | 25.0 | 399.2 | 329.4 | 88100 | 12600 | 22.3 | 8.42 |
| 305 × 305 × 137 | 458 × 305 × 137 | 136.9 | 473.0 | 309.2 | 13.8 | 21.7 | 399.2 | 329.4 | 75100 | 10700 | 22.1 | 8.35 |
| 305 × 305 × 118 | 458 × 305 × 118 | 117.9 | 467.0 | 307.4 | 12.0 | 18.7 | 399.2 | 329.4 | 63800 | 9060 | 22.0 | 8.29 |
| 305 × 305 × 97 | 458 × 305 × 97 | 96.9 | 460.4 | 305.3 | 9.9 | 15.4 | 399.2 | 329.4 | 51700 | 7310 | 21.8 | 8.21 |
| 254 × 254 × 167 | 381 × 254 × 167 | 167.1 | 416.1 | 265.2 | 19.2 | 31.7 | 327.3 | 274.3 | 67100 | 9860 | 18.9 | 7.23 |
| 254 × 254 × 132 | 381 × 254 × 132 | 132.0 | 403.3 | 261.3 | 15.3 | 25.3 | 327.3 | 274.3 | 51200 | 7530 | 18.6 | 7.11 |
| 254 × 254 × 107 | 381 × 254 × 107 | 107.1 | 393.7 | 258.8 | 12.8 | 20.5 | 327.3 | 274.3 | 40300 | 5930 | 18.3 | 7.02 |
| 254 × 254 × 89 | 381 × 254 × 89 | 88.9 | 387.3 | 256.3 | 10.3 | 17.3 | 327.3 | 274.3 | 33200 | 4860 | 18.2 | 6.96 |
| 254 × 254 × 73 | 381 × 254 × 73 | 73.1 | 381.1 | 254.6 | 8.6 | 14.2 | 327.3 | 274.3 | 26700 | 3910 | 18.0 | 6.90 |
| 203 × 203 × 86 | 305 × 203 × 86 | 86.1 | 323.7 | 209.1 | 12.7 | 20.5 | 262.3 | 219.2 | 21400 | 3130 | 14.9 | 5.68 |
| 203 × 203 × 71 | 305 × 203 × 71 | 71.0 | 317.3 | 206.4 | 10.0 | 17.3 | 262.3 | 219.2 | 17400 | 2540 | 14.7 | 5.62 |
| 203 × 203 × 60 | 305 × 203 × 60 | 60.0 | 311.1 | 205.8 | 9.4 | 14.2 | 262.3 | 219.2 | 14200 | 2060 | 14.6 | 5.56 |
| 203 × 203 × 52 | 305 × 203 × 52 | 52.0 | 307.7 | 204.3 | 7.9 | 12.5 | 262.3 | 219.2 | 12200 | 1780 | 14.5 | 5.52 |
| 203 × 203 × 46 | 305 × 203 × 46 | 46.1 | 304.7 | 203.6 | 7.2 | 11.0 | 262.3 | 219.2 | 10700 | 1550 | 14.4 | 5.49 |
| 152 × 152 × 37 | 228 × 152 × 37 | 37.0 | 237.8 | 154.4 | 8.0 | 11.5 | 199.6 | 164.2 | 5030 | 706 | 11.1 | 4.15 |
| 152 × 152 × 30 | 228 × 152 × 30 | 30.0 | 233.6 | 152.9 | 6.5 | 9.4 | 199.6 | 164.2 | 4020 | 560 | 11.0 | 4.10 |
| 152 × 152 × 23 | 228 × 152 × 23 | 23.0 | 228.4 | 152.2 | 5.8 | 6.8 | 199.6 | 164.2 | 2910 | 400 | 10.8 | 4.01 |

CASTELLATED UNIVERSAL BEAMS

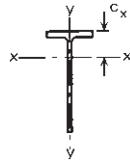
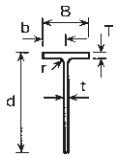


PROPERTIES (CONTINUED)

| Section Designation | | Net Elastic Modulus | | Elastic Modulus of Tee | | Net Plastic Modulus | | Net Buckling Parameter u | Net Torsional Index x | Net Warping Constant H dm ⁶ | Net Torsional Constant J cm ⁴ | Net Area A _n cm ² |
|---------------------|-----------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------|--|--|---|
| Original | Castellated | Axis x-x cm ³ | Axis y-y cm ³ | Flange x-x cm ³ | Toe x-x cm ³ | Axis x-x cm ³ | Axis y-y cm ³ | | | | | |
| 356 × 406 × 634 | 534 × 406 × 634 | 18100 | 4620 | 706 | 325 | 20600 | 7000 | 0.946 | 7.81 | 84.7 | 13000 | 717 |
| 356 × 406 × 551 | 534 × 406 × 551 | 15600 | 3950 | 573 | 245 | 17600 | 5970 | 0.946 | 8.72 | 69.1 | 8770 | 622 |
| 356 × 406 × 467 | 534 × 406 × 467 | 13200 | 3290 | 452 | 177 | 14700 | 4970 | 0.946 | 9.96 | 54.9 | 5520 | 527 |
| 356 × 406 × 393 | 534 × 406 × 393 | 11000 | 2720 | 358 | 127 | 12200 | 4110 | 0.947 | 11.5 | 43.4 | 3360 | 442 |
| 356 × 406 × 340 | 534 × 406 × 340 | 9530 | 2320 | 298 | 96.8 | 10400 | 3510 | 0.948 | 13.0 | 35.9 | 2220 | 382 |
| 356 × 406 × 287 | 534 × 406 × 287 | 8040 | 1940 | 244 | 71.4 | 8680 | 2930 | 0.947 | 15.1 | 29.0 | 1370 | 323 |
| 356 × 406 × 235 | 534 × 406 × 235 | 6580 | 1570 | 195 | 50.4 | 7040 | 2370 | 0.949 | 17.9 | 22.7 | 772 | 264 |
| 356 × 368 × 202 | 534 × 368 × 202 | 5500 | 1260 | 196 | 46.2 | 5870 | 1910 | 0.949 | 19.5 | 16.4 | 531 | 228 |
| 356 × 368 × 177 | 534 × 368 × 177 | 4820 | 1100 | 174 | 37.7 | 5120 | 1660 | 0.949 | 21.9 | 14.0 | 364 | 200 |
| 356 × 368 × 153 | 534 × 368 × 153 | 4180 | 947 | 153 | 30.2 | 4410 | 1430 | 0.949 | 25.0 | 11.8 | 239 | 173 |
| 356 × 368 × 129 | 534 × 368 × 129 | 3520 | 793 | 134 | 23.8 | 3700 | 1190 | 0.949 | 29.2 | 9.73 | 146 | 146 |
| 305 × 305 × 283 | 458 × 305 × 283 | 6650 | 1530 | 256 | 90.4 | 7390 | 2320 | 0.950 | 10.9 | 13.8 | 1940 | 320 |
| 305 × 305 × 240 | 458 × 305 × 240 | 5620 | 1280 | 210 | 67.6 | 6180 | 1930 | 0.950 | 12.5 | 11.1 | 1210 | 271 |
| 305 × 305 × 198 | 458 × 305 × 198 | 4630 | 1040 | 170 | 48.7 | 5030 | 1570 | 0.952 | 14.7 | 8.66 | 699 | 223 |
| 305 × 305 × 158 | 458 × 305 × 158 | 3670 | 807 | 137 | 34.4 | 3940 | 1220 | 0.952 | 18.1 | 6.49 | 358 | 177 |
| 305 × 305 × 137 | 458 × 305 × 137 | 3180 | 692 | 120 | 27.8 | 3390 | 1050 | 0.953 | 20.6 | 5.45 | 236 | 153 |
| 305 × 305 × 118 | 458 × 305 × 118 | 2730 | 589 | 106 | 22.5 | 2890 | 890 | 0.952 | 23.6 | 4.55 | 152 | 132 |
| 305 × 305 × 97 | 458 × 305 × 97 | 2240 | 479 | 90.9 | 17.1 | 2360 | 722 | 0.954 | 28.2 | 3.62 | 86.3 | 108 |
| 254 × 254 × 167 | 381 × 254 × 167 | 3220 | 744 | 115 | 37.9 | 3540 | 1130 | 0.952 | 12.2 | 3.64 | 596 | 188 |
| 254 × 254 × 132 | 381 × 254 × 132 | 2540 | 576 | 88.0 | 25.1 | 2750 | 871 | 0.950 | 15.0 | 2.69 | 303 | 149 |
| 254 × 254 × 107 | 381 × 254 × 107 | 2050 | 458 | 71.7 | 18.1 | 2200 | 692 | 0.952 | 18.1 | 2.06 | 164 | 120 |
| 254 × 254 × 89 | 381 × 254 × 89 | 1710 | 379 | 59.5 | 13.3 | 1820 | 572 | 0.953 | 21.2 | 1.66 | 97.7 | 100 |
| 254 × 254 × 73 | 381 × 254 × 73 | 1400 | 307 | 50.6 | 10.1 | 1480 | 463 | 0.952 | 25.4 | 1.31 | 54.9 | 82.2 |
| 203 × 203 × 86 | 305 × 203 × 86 | 1320 | 299 | 46.8 | 13.5 | 1440 | 452 | 0.951 | 14.8 | 0.718 | 130 | 96.7 |
| 203 × 203 × 71 | 305 × 203 × 71 | 1100 | 246 | 37.7 | 9.61 | 1180 | 371 | 0.952 | 17.4 | 0.571 | 76.9 | 80.3 |
| 203 × 203 × 60 | 305 × 203 × 60 | 911 | 201 | 33.5 | 7.83 | 971 | 303 | 0.951 | 20.6 | 0.455 | 44.4 | 66.8 |
| 203 × 203 × 52 | 305 × 203 × 52 | 796 | 174 | 29.2 | 6.22 | 843 | 263 | 0.952 | 23.3 | 0.387 | 30.1 | 58.3 |
| 203 × 203 × 46 | 305 × 203 × 46 | 702 | 152 | 26.7 | 5.34 | 740 | 230 | 0.952 | 26.1 | 0.334 | 20.9 | 51.4 |
| 152 × 152 × 37 | 228 × 152 × 37 | 423 | 91.4 | 16.8 | 4.13 | 453 | 138 | 0.952 | 19.4 | 0.0904 | 17.9 | 41.0 |
| 152 × 152 × 30 | 228 × 152 × 30 | 344 | 73.3 | 14.0 | 3.05 | 365 | 111 | 0.952 | 23.4 | 0.0704 | 9.82 | 33.3 |
| 152 × 152 × 23 | 228 × 152 × 23 | 255 | 52.5 | 12.0 | 2.37 | 268 | 79.5 | 0.952 | 30.7 | 0.0491 | 4.14 | 24.8 |

The values of the elastic modulus of the Tee are the elastic modulus at the flange and at the toe of the Tee formed at the net section.

STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS

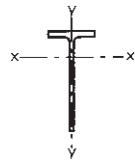


DIMENSIONS AND PROPERTIES

| Section Designation | Cut from Universal Beam Section Designation | Mass per Metre kg/m | Width of Section mm | Depth of Section mm | Thickness | | Root Radius mm | Ratios for Local Buckling | | Dimension c _x cm | Second Moment of Area | |
|---------------------|--|------------------------|------------------------|------------------------|-----------|--------------|-------------------|---------------------------|------------|-----------------------------------|-----------------------------|-----------------------------|
| | | | | | Web mm | Flange mm | | Flange b/T | Web d/t | | Axis x-x cm ⁴ | Axis y-y cm ⁴ |
| | | | | | t mm | T mm | | b/T | d/t | | | |
| 305 × 457 × 127 | 914 × 305 × 253 | 126.7 | 305.5 | 459.1 | 17.3 | 27.9 | 19.1 | 5.47 | 26.5 | 12.0 | 32700 | 6650 |
| 305 × 457 × 112 | 914 × 305 × 224 | 112.1 | 304.1 | 455.1 | 15.9 | 23.9 | 19.1 | 6.36 | 28.6 | 12.1 | 29100 | 5620 |
| 305 × 457 × 101 | 914 × 305 × 201 | 100.4 | 303.3 | 451.4 | 15.1 | 20.2 | 19.1 | 7.51 | 29.9 | 12.5 | 26400 | 4710 |
| 292 × 419 × 113 | 838 × 292 × 226 | 113.3 | 293.8 | 425.4 | 16.1 | 26.8 | 17.8 | 5.48 | 26.4 | 10.8 | 24600 | 5680 |
| 292 × 419 × 97 | 838 × 292 × 194 | 96.9 | 292.4 | 420.3 | 14.7 | 21.7 | 17.8 | 6.74 | 28.6 | 11.1 | 21300 | 4530 |
| 292 × 419 × 88 | 838 × 292 × 176 | 87.9 | 291.7 | 417.4 | 14.0 | 18.8 | 17.8 | 7.76 | 29.8 | 11.4 | 19600 | 3900 |
| 267 × 381 × 99 | 762 × 267 × 197 | 98.4 | 268.0 | 384.8 | 15.6 | 25.4 | 16.5 | 5.28 | 24.7 | 9.89 | 17500 | 4090 |
| 267 × 381 × 87 | 762 × 267 × 173 | 86.5 | 266.7 | 381.0 | 14.3 | 21.6 | 16.5 | 6.17 | 26.6 | 9.98 | 15500 | 3430 |
| 267 × 381 × 74 | 762 × 267 × 147 | 73.5 | 265.2 | 376.9 | 12.8 | 17.5 | 16.5 | 7.58 | 29.4 | 10.2 | 13200 | 2730 |
| 267 × 381 × 67 | 762 × 267 × 134 | 66.9 | 264.4 | 374.9 | 12.0 | 15.5 | 16.5 | 8.53 | 31.2 | 10.3 | 12100 | 2390 |
| 254 × 343 × 85 | 686 × 254 × 170 | 85.1 | 255.8 | 346.4 | 14.5 | 23.7 | 15.2 | 5.40 | 23.9 | 8.67 | 12100 | 3320 |
| 254 × 343 × 76 | 686 × 254 × 152 | 76.2 | 254.5 | 343.7 | 13.2 | 21.0 | 15.2 | 6.06 | 26.0 | 8.61 | 10800 | 2890 |
| 254 × 343 × 70 | 686 × 254 × 140 | 70.0 | 253.7 | 341.7 | 12.4 | 19.0 | 15.2 | 6.68 | 27.6 | 8.63 | 9910 | 2590 |
| 254 × 343 × 63 | 686 × 254 × 125 | 62.6 | 253.0 | 338.9 | 11.7 | 16.2 | 15.2 | 7.81 | 29.0 | 8.85 | 8980 | 2190 |
| 305 × 305 × 119 | 610 × 305 × 238 | 119.0 | 311.4 | 317.8 | 18.4 | 31.4 | 16.5 | 4.96 | 17.3 | 7.11 | 12300 | 7920 |
| 305 × 305 × 90 | 610 × 305 × 179 | 89.5 | 307.1 | 310.0 | 14.1 | 23.6 | 16.5 | 6.51 | 22.0 | 6.69 | 9040 | 5700 |
| 305 × 305 × 75 | 610 × 305 × 149 | 74.6 | 304.8 | 306.1 | 11.8 | 19.7 | 16.5 | 7.74 | 25.9 | 6.45 | 7420 | 4650 |
| 229 × 305 × 70 | 610 × 229 × 140 | 69.9 | 230.2 | 308.5 | 13.1 | 22.1 | 12.7 | 5.21 | 23.5 | 7.61 | 7740 | 2250 |
| 229 × 305 × 63 | 610 × 229 × 125 | 62.5 | 229.0 | 306.0 | 11.9 | 19.6 | 12.7 | 5.84 | 25.7 | 7.54 | 6900 | 1970 |
| 229 × 305 × 57 | 610 × 229 × 113 | 56.5 | 228.2 | 303.7 | 11.1 | 17.3 | 12.7 | 6.60 | 27.4 | 7.58 | 6270 | 1720 |
| 229 × 305 × 51 | 610 × 229 × 101 | 50.6 | 227.6 | 301.2 | 10.5 | 14.8 | 12.7 | 7.69 | 28.7 | 7.78 | 5690 | 1460 |
| 210 × 267 × 61 | 533 × 210 × 122 | 61.0 | 211.9 | 272.2 | 12.7 | 21.3 | 12.7 | 4.97 | 21.4 | 6.66 | 5160 | 1690 |
| 210 × 267 × 55 | 533 × 210 × 109 | 54.5 | 210.8 | 269.7 | 11.6 | 18.8 | 12.7 | 5.61 | 23.3 | 6.61 | 4600 | 1470 |
| 210 × 267 × 51 | 533 × 210 × 101 | 50.5 | 210.0 | 268.3 | 10.8 | 17.4 | 12.7 | 6.03 | 24.8 | 6.53 | 4250 | 1350 |
| 210 × 267 × 46 | 533 × 210 × 92 | 46.1 | 209.3 | 266.5 | 10.1 | 15.6 | 12.7 | 6.71 | 26.4 | 6.55 | 3890 | 1200 |
| 210 × 267 × 41 | 533 × 210 × 82 | 41.1 | 208.8 | 264.1 | 9.6 | 13.2 | 12.7 | 7.91 | 27.5 | 6.75 | 3530 | 1000 |
| 191 × 229 × 49 | 457 × 191 × 98 | 49.2 | 192.8 | 233.5 | 11.4 | 19.6 | 10.2 | 4.92 | 20.5 | 5.53 | 2970 | 1170 |
| 191 × 229 × 45 | 457 × 191 × 89 | 44.6 | 191.9 | 231.6 | 10.5 | 17.7 | 10.2 | 5.42 | 22.1 | 5.47 | 2680 | 1050 |
| 191 × 229 × 41 | 457 × 191 × 82 | 41.0 | 191.3 | 229.9 | 9.9 | 16.0 | 10.2 | 5.98 | 23.2 | 5.47 | 2470 | 935 |
| 191 × 229 × 37 | 457 × 191 × 74 | 37.1 | 190.4 | 228.4 | 9.0 | 14.5 | 10.2 | 6.57 | 25.4 | 5.38 | 2220 | 836 |
| 191 × 229 × 34 | 457 × 191 × 67 | 33.6 | 189.9 | 226.6 | 8.5 | 12.7 | 10.2 | 7.48 | 26.7 | 5.46 | 2030 | 726 |
| 152 × 229 × 41 | 457 × 152 × 82 | 41.0 | 155.3 | 232.8 | 10.5 | 18.9 | 10.2 | 4.11 | 22.2 | 5.96 | 2600 | 592 |
| 152 × 229 × 37 | 457 × 152 × 74 | 37.1 | 154.4 | 230.9 | 9.6 | 17.0 | 10.2 | 4.54 | 24.1 | 5.88 | 2330 | 523 |
| 152 × 229 × 34 | 457 × 152 × 67 | 33.6 | 153.8 | 228.9 | 9.0 | 15.0 | 10.2 | 5.13 | 25.4 | 5.91 | 2120 | 456 |
| 152 × 229 × 30 | 457 × 152 × 60 | 29.9 | 152.9 | 227.2 | 8.1 | 13.3 | 10.2 | 5.75 | 28.0 | 5.84 | 1880 | 397 |
| 152 × 229 × 26 | 457 × 152 × 52 | 26.2 | 152.4 | 224.8 | 7.6 | 10.9 | 10.2 | 6.99 | 29.6 | 6.04 | 1670 | 322 |

STRUCTURAL TEES

CUT FROM UNIVERSAL BEAMS

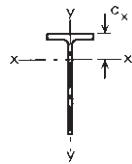
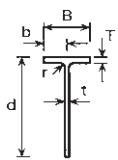


PROPERTIES (CONTINUED)

| Section Designation | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter u | Torsional Index x | Mono-symmetry Index ψ | Warping Constant (*) H cm ⁶ | Torsional Constant J cm ⁴ | Area of Section A cm ² | | | | | | |
|---------------------|--------------------|----------------|---------------------------|------------------------|-----------------------------|-----------------------------|-------------------------|----------------------|-------------------------------|---|---|--------------------------------------|------|--|--|--|--|--|
| | Axis x-x cm | Axis y-y cm | Axis x-x | | Axis y-y cm ³ | Axis x-x cm ³ | | | | | | | | | | | | |
| | | | Flange cm ³ | Toe cm ³ | | | | | | | | | | | | | | |
| 305 × 457 × 127 | 14.2 | 6.42 | 2720 | 965 | 435 | 1730 | 685 | 0.656 | 18.1 | 0.749 | 17000 | 313 | 161 | | | | | |
| 305 × 457 × 112 | 14.3 | 6.27 | 2400 | 871 | 369 | 1570 | 582 | 0.666 | 20.6 | 0.753 | 12400 | 211 | 143 | | | | | |
| 305 × 457 × 101 | 14.4 | 6.07 | 2110 | 808 | 311 | 1460 | 491 | 0.685 | 23.4 | 0.759 | 9820 | 146 | 128 | | | | | |
| 292 × 419 × 113 | 13.1 | 6.27 | 2280 | 776 | 387 | 1380 | 606 | 0.640 | 17.5 | 0.742 | 11500 | 257 | 144 | | | | | |
| 292 × 419 × 97 | 13.1 | 6.06 | 1930 | 689 | 310 | 1240 | 487 | 0.660 | 20.8 | 0.747 | 7830 | 153 | 123 | | | | | |
| 292 × 419 × 88 | 13.2 | 5.90 | 1720 | 644 | 267 | 1160 | 421 | 0.675 | 23.2 | 0.751 | 6320 | 111 | 112 | | | | | |
| 267 × 381 × 99 | 11.8 | 5.71 | 1770 | 613 | 305 | 1090 | 479 | 0.641 | 16.6 | 0.741 | 7620 | 202 | 125 | | | | | |
| 267 × 381 × 87 | 11.9 | 5.58 | 1550 | 550 | 257 | 986 | 404 | 0.654 | 19.0 | 0.745 | 5450 | 134 | 110 | | | | | |
| 267 × 381 × 74 | 11.9 | 5.40 | 1300 | 481 | 206 | 867 | 324 | 0.670 | 22.6 | 0.749 | 3600 | 79.5 | 93.6 | | | | | |
| 267 × 381 × 67 | 11.9 | 5.30 | 1180 | 445 | 181 | 806 | 285 | 0.679 | 24.9 | 0.753 | 2850 | 59.2 | 85.3 | | | | | |
| 254 × 343 × 85 | 10.5 | 5.53 | 1390 | 464 | 259 | 826 | 406 | 0.624 | 15.9 | 0.731 | 4720 | 154 | 108 | | | | | |
| 254 × 343 × 76 | 10.5 | 5.46 | 1250 | 417 | 227 | 743 | 355 | 0.627 | 17.7 | 0.732 | 3420 | 110 | 97.0 | | | | | |
| 254 × 343 × 70 | 10.5 | 5.39 | 1150 | 388 | 204 | 691 | 319 | 0.633 | 19.3 | 0.734 | 2720 | 84.3 | 89.2 | | | | | |
| 254 × 343 × 63 | 10.6 | 5.24 | 1010 | 358 | 173 | 643 | 271 | 0.651 | 21.9 | 0.740 | 2090 | 58.1 | 79.7 | | | | | |
| 305 × 305 × 119 | 9.02 | 7.23 | 1740 | 500 | 509 | 894 | 787 | 0.483 | 10.6 | 0.661 | 11300 | 393 | 152 | | | | | |
| 305 × 305 × 90 | 8.91 | 7.07 | 1350 | 372 | 371 | 657 | 572 | 0.485 | 13.8 | 0.664 | 4710 | 170 | 114 | | | | | |
| 305 × 305 × 75 | 8.83 | 7.00 | 1150 | 307 | 305 | 539 | 469 | 0.483 | 16.3 | 0.666 | 2690 | 100 | 95.0 | | | | | |
| 229 × 305 × 70 | 9.32 | 5.03 | 1020 | 333 | 196 | 592 | 306 | 0.613 | 15.3 | 0.727 | 2560 | 108 | 89.1 | | | | | |
| 229 × 305 × 63 | 9.31 | 4.97 | 915 | 299 | 172 | 531 | 268 | 0.617 | 17.0 | 0.728 | 1840 | 77.1 | 79.7 | | | | | |
| 229 × 305 × 57 | 9.33 | 4.88 | 826 | 275 | 150 | 489 | 235 | 0.626 | 19.0 | 0.731 | 1400 | 55.7 | 72.0 | | | | | |
| 229 × 305 × 51 | 9.40 | 4.76 | 732 | 255 | 128 | 456 | 200 | 0.645 | 21.5 | 0.736 | 1080 | 38.5 | 64.4 | | | | | |
| 210 × 267 × 61 | 8.15 | 4.67 | 775 | 251 | 160 | 446 | 250 | 0.600 | 13.8 | 0.719 | 1660 | 89.2 | 77.7 | | | | | |
| 210 × 267 × 55 | 8.14 | 4.60 | 697 | 226 | 140 | 401 | 218 | 0.605 | 15.4 | 0.721 | 1200 | 63.2 | 69.4 | | | | | |
| 210 × 267 × 51 | 8.12 | 4.57 | 650 | 209 | 128 | 371 | 200 | 0.606 | 16.6 | 0.722 | 951 | 50.5 | 64.3 | | | | | |
| 210 × 267 × 46 | 8.14 | 4.51 | 593 | 193 | 114 | 343 | 178 | 0.613 | 18.2 | 0.724 | 737 | 37.8 | 58.7 | | | | | |
| 210 × 267 × 41 | 8.21 | 4.38 | 523 | 179 | 96.1 | 320 | 150 | 0.634 | 20.8 | 0.730 | 565 | 25.8 | 52.3 | | | | | |
| 191 × 229 × 49 | 6.88 | 4.33 | 536 | 167 | 122 | 296 | 189 | 0.573 | 12.9 | 0.705 | 835 | 60.6 | 62.6 | | | | | |
| 191 × 229 × 45 | 6.87 | 4.29 | 491 | 152 | 109 | 269 | 169 | 0.576 | 14.1 | 0.706 | 628 | 45.3 | 56.9 | | | | | |
| 191 × 229 × 41 | 6.88 | 4.23 | 452 | 141 | 97.8 | 250 | 152 | 0.583 | 15.4 | 0.708 | 494 | 34.6 | 52.2 | | | | | |
| 191 × 229 × 37 | 6.86 | 4.20 | 413 | 127 | 87.8 | 225 | 136 | 0.583 | 16.9 | 0.709 | 365 | 25.9 | 47.3 | | | | | |
| 191 × 229 × 34 | 6.90 | 4.12 | 372 | 118 | 76.5 | 209 | 119 | 0.597 | 18.9 | 0.713 | 280 | 18.6 | 42.7 | | | | | |
| 152 × 229 × 41 | 7.05 | 3.37 | 436 | 150 | 76.3 | 267 | 120 | 0.634 | 13.7 | 0.740 | 534 | 44.6 | 52.3 | | | | | |
| 152 × 229 × 37 | 7.03 | 3.33 | 397 | 135 | 67.8 | 242 | 107 | 0.637 | 15.1 | 0.742 | 396 | 33.0 | 47.2 | | | | | |
| 152 × 229 × 34 | 7.04 | 3.27 | 359 | 125 | 59.3 | 223 | 93.3 | 0.646 | 16.8 | 0.745 | 305 | 23.8 | 42.8 | | | | | |
| 152 × 229 × 30 | 7.02 | 3.23 | 322 | 111 | 52.0 | 199 | 81.5 | 0.649 | 18.7 | 0.746 | 217 | 16.9 | 38.1 | | | | | |
| 152 × 229 × 26 | 7.08 | 3.11 | 276 | 102 | 42.3 | 183 | 66.7 | 0.671 | 21.9 | 0.753 | 161 | 10.7 | 33.3 | | | | | |

(*) Note units are cm⁶ and not dm⁶.

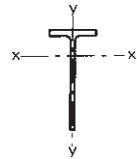
STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS



DIMENSIONS AND PROPERTIES

| Section Designation | Cut from Universal Beam Section Designation | Mass per Metre kg/m | Width of Section B mm | Depth of Section d mm | Thickness | | Root Radius r mm | Ratios for Local Buckling | | Dimension c _x cm | Second Moment of Area | |
|---------------------|---|---------------------|-----------------------|-----------------------|-----------|-------------|------------------|---------------------------|---------|-----------------------------|--------------------------|--------------------------|
| | | | | | Web t mm | Flange T mm | | Flange b/T | Web d/t | | Axis x-x cm ⁴ | Axis y-y cm ⁴ |
| | | | | | | | | | | | | |
| 178 × 203 × 37 | 406 × 178 × 74 | 37.1 | 179.5 | 206.3 | 9.5 | 16.0 | 10.2 | 5.61 | 21.7 | 4.76 | 1740 | 773 |
| 178 × 203 × 34 | 406 × 178 × 67 | 33.6 | 178.8 | 204.6 | 8.8 | 14.3 | 10.2 | 6.25 | 23.2 | 4.73 | 1570 | 682 |
| 178 × 203 × 30 | 406 × 178 × 60 | 30.0 | 177.9 | 203.1 | 7.9 | 12.8 | 10.2 | 6.95 | 25.7 | 4.64 | 1400 | 602 |
| 178 × 203 × 27 | 406 × 178 × 54 | 27.1 | 177.7 | 201.2 | 7.7 | 10.9 | 10.2 | 8.15 | 26.1 | 4.83 | 1290 | 511 |
| 140 × 203 × 23 | 406 × 140 × 46 | 23.0 | 142.2 | 201.5 | 6.8 | 11.2 | 10.2 | 6.35 | 29.6 | 5.02 | 1120 | 269 |
| 140 × 203 × 20 | 406 × 140 × 39 | 19.5 | 141.8 | 198.9 | 6.4 | 8.6 | 10.2 | 8.24 | 31.1 | 5.32 | 979 | 205 |
| 171 × 178 × 34 | 356 × 171 × 67 | 33.5 | 173.2 | 181.6 | 9.1 | 15.7 | 10.2 | 5.52 | 20.0 | 4.00 | 1150 | 681 |
| 171 × 178 × 29 | 356 × 171 × 57 | 28.5 | 172.2 | 178.9 | 8.1 | 13.0 | 10.2 | 6.62 | 22.1 | 3.97 | 986 | 554 |
| 171 × 178 × 26 | 356 × 171 × 51 | 25.5 | 171.5 | 177.4 | 7.4 | 11.5 | 10.2 | 7.46 | 24.0 | 3.94 | 882 | 484 |
| 171 × 178 × 23 | 356 × 171 × 45 | 22.5 | 171.1 | 175.6 | 7.0 | 9.7 | 10.2 | 8.82 | 25.1 | 4.05 | 798 | 406 |
| 127 × 178 × 20 | 356 × 127 × 39 | 19.5 | 126.0 | 176.6 | 6.6 | 10.7 | 10.2 | 5.89 | 26.8 | 4.43 | 728 | 179 |
| 127 × 178 × 17 | 356 × 127 × 33 | 16.5 | 125.4 | 174.4 | 6.0 | 8.5 | 10.2 | 7.38 | 29.1 | 4.56 | 626 | 140 |
| 165 × 152 × 27 | 305 × 165 × 54 | 27.0 | 166.9 | 155.1 | 7.9 | 13.7 | 8.9 | 6.09 | 19.6 | 3.21 | 642 | 531 |
| 165 × 152 × 23 | 305 × 165 × 46 | 23.1 | 165.7 | 153.2 | 6.7 | 11.8 | 8.9 | 7.02 | 22.9 | 3.07 | 536 | 448 |
| 165 × 152 × 20 | 305 × 165 × 40 | 20.1 | 165.0 | 151.6 | 6.0 | 10.2 | 8.9 | 8.09 | 25.3 | 3.03 | 468 | 382 |
| 127 × 152 × 24 | 305 × 127 × 48 | 24.0 | 125.3 | 155.4 | 9.0 | 14.0 | 8.9 | 4.47 | 17.3 | 3.94 | 662 | 231 |
| 127 × 152 × 21 | 305 × 127 × 42 | 21.0 | 124.3 | 153.5 | 8.0 | 12.1 | 8.9 | 5.14 | 19.2 | 3.87 | 573 | 194 |
| 127 × 152 × 19 | 305 × 127 × 37 | 18.5 | 123.4 | 152.1 | 7.1 | 10.7 | 8.9 | 5.77 | 21.4 | 3.78 | 501 | 168 |
| 102 × 152 × 17 | 305 × 102 × 33 | 16.4 | 102.4 | 156.3 | 6.6 | 10.8 | 7.6 | 4.74 | 23.7 | 4.14 | 487 | 97.0 |
| 102 × 152 × 14 | 305 × 102 × 28 | 14.1 | 101.8 | 154.3 | 6.0 | 8.8 | 7.6 | 5.78 | 25.7 | 4.20 | 420 | 77.7 |
| 102 × 152 × 13 | 305 × 102 × 25 | 12.4 | 101.6 | 152.5 | 5.8 | 7.0 | 7.6 | 7.26 | 26.3 | 4.43 | 377 | 61.5 |
| 146 × 127 × 22 | 254 × 146 × 43 | 21.5 | 147.3 | 129.7 | 7.2 | 12.7 | 7.6 | 5.80 | 18.0 | 2.64 | 343 | 339 |
| 146 × 127 × 19 | 254 × 146 × 37 | 18.5 | 146.4 | 127.9 | 6.3 | 10.9 | 7.6 | 6.72 | 20.3 | 2.55 | 292 | 285 |
| 146 × 127 × 16 | 254 × 146 × 31 | 15.6 | 146.1 | 125.6 | 6.0 | 8.6 | 7.6 | 8.49 | 20.9 | 2.66 | 259 | 224 |
| 102 × 127 × 14 | 254 × 102 × 28 | 14.2 | 102.2 | 130.1 | 6.3 | 10.0 | 7.6 | 5.11 | 20.7 | 3.24 | 277 | 89.3 |
| 102 × 127 × 13 | 254 × 102 × 25 | 12.6 | 101.9 | 128.5 | 6.0 | 8.4 | 7.6 | 6.07 | 21.4 | 3.32 | 250 | 74.3 |
| 102 × 127 × 11 | 254 × 102 × 22 | 11.0 | 101.6 | 126.9 | 5.7 | 6.8 | 7.6 | 7.47 | 22.3 | 3.45 | 223 | 59.7 |
| 133 × 102 × 15 | 203 × 133 × 30 | 15.0 | 133.9 | 103.3 | 6.4 | 9.6 | 7.6 | 6.97 | 16.1 | 2.11 | 154 | 192 |
| 133 × 102 × 13 | 203 × 133 × 25 | 12.5 | 133.2 | 101.5 | 5.7 | 7.8 | 7.6 | 8.54 | 17.8 | 2.10 | 131 | 154 |

STRUCTURAL TEES CUT FROM UNIVERSAL BEAMS



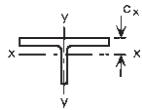
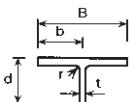
PROPERTIES (CONTINUED)

| Section Designation | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Buckling Parameter | Torsional Index | Mono-symmetry Index | Warping Constant (*) | Torsional Constant | Area of Section | | | | | | |
|---------------------|--------------------|----------|-----------------|------|-----------------|----------|--------------------|-----------------|---------------------|----------------------|--------------------|-----------------|--|--|--|--|--|--|
| | Axis x-x | Axis y-y | Axis x-x | | Axis y-y | Axis x-x | | | | | | | | | | | | |
| | | | cm | cm | | | | | | | | | | | | | | |
| 178 × 203 × 37 | 6.06 | 4.04 | 365 | 109 | 86.1 | 194 | 133 | 0.556 | 13.8 | 0.696 | 350 | 31.4 | | | | | | |
| 178 × 203 × 34 | 6.07 | 3.99 | 332 | 100 | 76.3 | 177 | 118 | 0.561 | 15.2 | 0.698 | 262 | 23.1 | | | | | | |
| 178 × 203 × 30 | 6.04 | 3.97 | 301 | 89.0 | 67.6 | 157 | 105 | 0.561 | 16.9 | 0.699 | 186 | 16.7 | | | | | | |
| 178 × 203 × 27 | 6.13 | 3.85 | 268 | 84.6 | 57.5 | 150 | 89.1 | 0.588 | 19.1 | 0.705 | 146 | 11.6 | | | | | | |
| 140 × 203 × 23 | 6.19 | 3.03 | 224 | 74.2 | 37.8 | 132 | 59.1 | 0.633 | 19.5 | 0.740 | 93.7 | 9.51 | | | | | | |
| 140 × 203 × 20 | 6.28 | 2.87 | 184 | 67.2 | 28.9 | 121 | 45.4 | 0.668 | 23.7 | 0.750 | 66.3 | 5.35 | | | | | | |
| 171 × 178 × 34 | 5.20 | 3.99 | 288 | 81.5 | 78.6 | 145 | 121 | 0.500 | 12.2 | 0.672 | 249 | 27.8 | | | | | | |
| 171 × 178 × 29 | 5.21 | 3.91 | 248 | 70.9 | 64.4 | 125 | 99.4 | 0.514 | 14.4 | 0.676 | 154 | 16.7 | | | | | | |
| 171 × 178 × 26 | 5.21 | 3.86 | 224 | 63.9 | 56.5 | 113 | 87.1 | 0.522 | 16.0 | 0.677 | 110 | 11.9 | | | | | | |
| 171 × 178 × 23 | 5.28 | 3.76 | 197 | 59.1 | 47.4 | 104 | 73.3 | 0.545 | 18.4 | 0.683 | 79.2 | 7.92 | | | | | | |
| 127 × 178 × 20 | 5.41 | 2.68 | 164 | 55.0 | 28.4 | 98.1 | 44.5 | 0.632 | 17.6 | 0.739 | 57.1 | 7.55 | | | | | | |
| 127 × 178 × 17 | 5.45 | 2.58 | 137 | 48.6 | 22.3 | 87.2 | 35.1 | 0.654 | 21.1 | 0.746 | 38.0 | 4.40 | | | | | | |
| 165 × 152 × 27 | 4.32 | 3.93 | 200 | 52.2 | 63.7 | 92.9 | 97.8 | 0.389 | 11.8 | 0.636 | 128 | 17.4 | | | | | | |
| 165 × 152 × 23 | 4.27 | 3.91 | 174 | 43.7 | 54.1 | 77.2 | 82.8 | 0.380 | 13.6 | 0.636 | 78.6 | 11.1 | | | | | | |
| 165 × 152 × 20 | 4.27 | 3.86 | 155 | 38.6 | 46.3 | 67.7 | 70.9 | 0.393 | 15.5 | 0.638 | 52.0 | 7.37 | | | | | | |
| 127 × 152 × 24 | 4.65 | 2.74 | 168 | 57.1 | 36.8 | 102 | 58.0 | 0.602 | 11.7 | 0.714 | 104 | 15.9 | | | | | | |
| 127 × 152 × 21 | 4.63 | 2.70 | 148 | 49.9 | 31.3 | 88.9 | 49.2 | 0.606 | 13.2 | 0.716 | 69.2 | 10.6 | | | | | | |
| 127 × 152 × 19 | 4.61 | 2.67 | 132 | 43.8 | 27.2 | 78.0 | 42.7 | 0.606 | 14.9 | 0.718 | 47.4 | 7.38 | | | | | | |
| 102 × 152 × 17 | 4.82 | 2.15 | 118 | 42.3 | 19.0 | 75.8 | 30.0 | 0.656 | 15.8 | 0.749 | 36.8 | 6.10 | | | | | | |
| 102 × 152 × 14 | 4.84 | 2.08 | 100 | 37.4 | 15.3 | 67.4 | 24.2 | 0.673 | 18.7 | 0.756 | 25.2 | 3.70 | | | | | | |
| 102 × 152 × 13 | 4.88 | 1.97 | 85.0 | 34.8 | 12.1 | 63.4 | 19.4 | 0.702 | 21.7 | 0.766 | 20.4 | 2.39 | | | | | | |
| 146 × 127 × 22 | 3.54 | 3.52 | 130 | 33.2 | 46.0 | 59.6 | 70.5 | 0.195 | 10.6 | 0.613 | 64.9 | 11.9 | | | | | | |
| 146 × 127 × 19 | 3.52 | 3.48 | 115 | 28.5 | 39.0 | 50.7 | 59.7 | 0.233 | 12.2 | 0.616 | 41.0 | 7.67 | | | | | | |
| 146 × 127 × 16 | 3.61 | 3.36 | 97.4 | 26.2 | 30.6 | 46.1 | 47.1 | 0.376 | 14.8 | 0.623 | 24.5 | 4.28 | | | | | | |
| 102 × 127 × 14 | 3.92 | 2.22 | 85.5 | 28.3 | 17.5 | 50.5 | 27.4 | 0.608 | 13.7 | 0.720 | 21.0 | 4.78 | | | | | | |
| 102 × 127 × 13 | 3.95 | 2.15 | 75.3 | 26.2 | 14.6 | 46.9 | 23.0 | 0.629 | 15.7 | 0.727 | 15.9 | 3.21 | | | | | | |
| 102 × 127 × 11 | 3.99 | 2.06 | 64.5 | 24.1 | 11.7 | 43.4 | 18.6 | 0.655 | 18.2 | 0.735 | 12.0 | 2.07 | | | | | | |
| 133 × 102 × 15 | 2.84 | 3.17 | 73.1 | 18.8 | 28.7 | 33.5 | 44.1 | — | 10.7 | 0.569 | 21.7 | 5.15 | | | | | | |
| 133 × 102 × 13 | 2.86 | 3.10 | 62.4 | 16.2 | 23.1 | 28.7 | 35.5 | — | 12.8 | 0.572 | 12.6 | 2.98 | | | | | | |

(*) Note units are cm⁶ and not dm⁶.

— Indicates that no values of u and x are given, as lateral torsional buckling due to bending about the x-x axis is not possible, because the second moment of area about the y-y axis exceeds the second moment of area about the x-x axis.

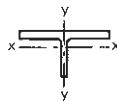
STRUCTURAL TEES CUT FROM UNIVERSAL COLUMNS



DIMENSIONS

| Section Designation | Cut from Universal Column | Mass per Metre kg/m | Width of Section B mm | Depth of Section d mm | Thickness | | Root Radius r mm | Ratios for Local Buckling | | Dimension c _x cm |
|---------------------|---------------------------|---------------------|-----------------------|-----------------------|-----------|-------------|------------------|---------------------------|---------|-----------------------------|
| | | | | | Web t mm | Flange T mm | | Flange b/T | Web d/t | |
| | | | | | | | | | | |
| 406 × 178 × 118 | 356 × 406 × 235 | 117.5 | 394.8 | 190.4 | 18.4 | 30.2 | 15.2 | 6.54 | 10.3 | 3.40 |
| 368 × 178 × 101 | 356 × 368 × 202 | 100.9 | 374.7 | 187.2 | 16.5 | 27.0 | 15.2 | 6.94 | 11.3 | 3.29 |
| 368 × 178 × 89 | 356 × 368 × 177 | 88.5 | 372.6 | 184.0 | 14.4 | 23.8 | 15.2 | 7.83 | 12.8 | 3.09 |
| 368 × 178 × 77 | 356 × 368 × 153 | 76.5 | 370.5 | 180.9 | 12.3 | 20.7 | 15.2 | 8.95 | 14.7 | 2.88 |
| 368 × 178 × 65 | 356 × 368 × 129 | 64.5 | 368.6 | 177.7 | 10.4 | 17.5 | 15.2 | 10.5 | 17.1 | 2.69 |
| 305 × 152 × 79 | 305 × 305 × 158 | 79.0 | 311.2 | 163.5 | 15.8 | 25.0 | 15.2 | 6.22 | 10.3 | 3.04 |
| 305 × 152 × 69 | 305 × 305 × 137 | 68.5 | 309.2 | 160.2 | 13.8 | 21.7 | 15.2 | 7.12 | 11.6 | 2.86 |
| 305 × 152 × 59 | 305 × 305 × 118 | 58.9 | 307.4 | 157.2 | 12.0 | 18.7 | 15.2 | 8.22 | 13.1 | 2.69 |
| 305 × 152 × 49 | 305 × 305 × 97 | 48.4 | 305.3 | 153.9 | 9.9 | 15.4 | 15.2 | 9.91 | 15.5 | 2.50 |
| 254 × 127 × 66 | 254 × 254 × 132 | 66.0 | 261.3 | 138.1 | 15.3 | 25.3 | 12.7 | 5.16 | 9.03 | 2.70 |
| 254 × 127 × 54 | 254 × 254 × 107 | 53.5 | 258.8 | 133.3 | 12.8 | 20.5 | 12.7 | 6.31 | 10.4 | 2.45 |
| 254 × 127 × 45 | 254 × 254 × 89 | 44.5 | 256.3 | 130.1 | 10.3 | 17.3 | 12.7 | 7.41 | 12.6 | 2.21 |
| 254 × 127 × 37 | 254 × 254 × 73 | 36.5 | 254.6 | 127.0 | 8.6 | 14.2 | 12.7 | 8.96 | 14.8 | 2.05 |
| 203 × 102 × 43 | 203 × 203 × 86 | 43.0 | 209.1 | 111.0 | 12.7 | 20.5 | 10.2 | 5.10 | 8.74 | 2.20 |
| 203 × 102 × 36 | 203 × 203 × 71 | 35.5 | 206.4 | 107.8 | 10.0 | 17.3 | 10.2 | 5.97 | 10.8 | 1.95 |
| 203 × 102 × 30 | 203 × 203 × 60 | 30.0 | 205.8 | 104.7 | 9.4 | 14.2 | 10.2 | 7.25 | 11.1 | 1.89 |
| 203 × 102 × 26 | 203 × 203 × 52 | 26.0 | 204.3 | 103.0 | 7.9 | 12.5 | 10.2 | 8.17 | 13.0 | 1.75 |
| 203 × 102 × 23 | 203 × 203 × 46 | 23.0 | 203.6 | 101.5 | 7.2 | 11.0 | 10.2 | 9.25 | 14.1 | 1.69 |
| 152 × 76 × 19 | 152 × 152 × 37 | 18.5 | 154.4 | 80.8 | 8.0 | 11.5 | 7.6 | 6.71 | 10.1 | 1.53 |
| 152 × 76 × 15 | 152 × 152 × 30 | 15.0 | 152.9 | 78.7 | 6.5 | 9.4 | 7.6 | 8.13 | 12.1 | 1.41 |
| 152 × 76 × 12 | 152 × 152 × 23 | 11.5 | 152.2 | 76.1 | 5.8 | 6.8 | 7.6 | 11.2 | 13.1 | 1.39 |

STRUCTURAL TEES CUT FROM UNIVERSAL COLUMNS



PROPERTIES

| Section Designation | Second Moment of Area | | Radius of Gyration | | Elastic Modulus | | Plastic Modulus | | Mono-symmetry Index | Warping Constant (*) | Torsional Constant | Area of Section | | | | |
|---------------------|-----------------------|----------|--------------------|----------|-----------------|-----------------|-----------------|----------|---------------------|----------------------|--------------------|-----------------|------|--|--|--|
| | Axis x-x | Axis y-y | Axis x-x | Axis y-y | Axis x-x | | Axis x-x | Axis y-y | | | | | | | | |
| | | | | | cm ⁴ | cm ⁴ | cm | cm | | | | | | | | |
| 406 × 178 × 118 | 2860 | 15500 | 4.37 | 10.2 | 843 | 183 | 785 | 367 | 1190 | 0.165 | 12700 | 405 | 150 | | | |
| 368 × 178 × 101 | 2460 | 11800 | 4.38 | 9.60 | 749 | 160 | 632 | 312 | 960 | 0.216 | 7840 | 278 | 129 | | | |
| 368 × 178 × 89 | 2090 | 10300 | 4.30 | 9.54 | 676 | 136 | 551 | 263 | 835 | 0.212 | 5270 | 190 | 113 | | | |
| 368 × 178 × 77 | 1730 | 8780 | 4.22 | 9.49 | 601 | 114 | 474 | 216 | 717 | 0.209 | 3390 | 125 | 97.4 | | | |
| 368 × 178 × 65 | 1420 | 7310 | 4.16 | 9.43 | 527 | 94.1 | 396 | 175 | 600 | 0.207 | 2010 | 76.2 | 82.2 | | | |
| 305 × 152 × 79 | 1530 | 6290 | 3.90 | 7.90 | 503 | 115 | 404 | 225 | 615 | 0.268 | 3650 | 188 | 101 | | | |
| 305 × 152 × 69 | 1290 | 5350 | 3.84 | 7.83 | 450 | 97.7 | 346 | 188 | 526 | 0.263 | 2340 | 124 | 87.2 | | | |
| 305 × 152 × 59 | 1080 | 4530 | 3.79 | 7.77 | 401 | 82.8 | 295 | 156 | 448 | 0.262 | 1470 | 80.3 | 75.1 | | | |
| 305 × 152 × 49 | 858 | 3650 | 3.73 | 7.69 | 343 | 66.5 | 239 | 123 | 363 | 0.258 | 806 | 45.5 | 61.7 | | | |
| 254 × 127 × 66 | 871 | 3770 | 3.22 | 6.69 | 323 | 78.3 | 288 | 159 | 439 | 0.250 | 2200 | 159 | 84.1 | | | |
| 254 × 127 × 54 | 676 | 2960 | 3.15 | 6.59 | 276 | 62.1 | 229 | 122 | 349 | 0.245 | 1150 | 85.9 | 68.2 | | | |
| 254 × 127 × 45 | 524 | 2430 | 3.04 | 6.55 | 237 | 48.5 | 190 | 94.1 | 288 | 0.242 | 660 | 51.1 | 56.7 | | | |
| 254 × 127 × 37 | 417 | 1950 | 2.99 | 6.48 | 204 | 39.2 | 153 | 74.1 | 233 | 0.236 | 359 | 28.8 | 46.5 | | | |
| 203 × 102 × 43 | 373 | 1560 | 2.61 | 5.34 | 169 | 41.9 | 150 | 84.6 | 228 | 0.257 | 605 | 68.1 | 54.8 | | | |
| 203 × 102 × 36 | 280 | 1270 | 2.49 | 5.30 | 143 | 31.8 | 123 | 63.6 | 187 | 0.254 | 343 | 40.0 | 45.2 | | | |
| 203 × 102 × 30 | 244 | 1030 | 2.53 | 5.20 | 129 | 28.4 | 100 | 54.4 | 153 | 0.245 | 195 | 23.5 | 38.2 | | | |
| 203 × 102 × 26 | 200 | 889 | 2.46 | 5.18 | 115 | 23.4 | 87.0 | 44.5 | 132 | 0.243 | 128 | 15.8 | 33.1 | | | |
| 203 × 102 × 23 | 177 | 774 | 2.45 | 5.13 | 105 | 20.9 | 76.0 | 39.0 | 115 | 0.242 | 87.2 | 11.0 | 29.4 | | | |
| 152 × 76 × 19 | 93.1 | 353 | 1.99 | 3.87 | 60.7 | 14.2 | 45.7 | 27.1 | 69.8 | 0.277 | 44.9 | 9.54 | 23.5 | | | |
| 152 × 76 × 15 | 72.2 | 280 | 1.94 | 3.83 | 51.4 | 11.2 | 36.7 | 20.9 | 55.8 | 0.269 | 23.7 | 5.24 | 19.1 | | | |
| 152 × 76 × 12 | 58.5 | 200 | 2.00 | 3.70 | 41.9 | 9.41 | 26.3 | 16.9 | 40.1 | 0.278 | 9.78 | 2.30 | 14.6 | | | |

(*) Note units are cm⁶ and not dm⁶.

Values of u and x are not given, as lateral torsional buckling due to bending about the x-x axis is not possible, because the second moment of area about the y-y axis exceeds the second moment of area about the x-x axis.

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(Tel + 44 (0) 20 8996 9001).

BS 5950: Part 1: 2000: Section two**Table 8.** Suggested limits for calculated deflections(a) *Vertical deflection of beams due to imposed load*

| | |
|---|-------------------|
| Cantilevers | Length/180 |
| Beams carrying plaster or other brittle finish | Span/360 |
| Other beams (except purlins and sheeting rails) | Span/200 |
| Purlins and sheeting rails | See clause 4.12.2 |

(b) *Horizontal deflection of columns due to imposed load and wind load*

| | |
|--|---------------------------|
| Tops of columns in single-storey buildings, except portal frames | Height/300 |
| Columns in portal frame buildings, not supporting crane runways | To suit cladding |
| Columns supporting crane runways | To suit crane runway |
| In each storey of a building with more than one storey | Height of that storey/300 |

(c) *Crane girders*

| | |
|--|----------|
| Vertical deflection due to static vertical wheel loads from overhead travelling cranes | Span/600 |
| Horizontal deflection (calculated on the top flange properties alone) due to horizontal crane loads | Span/500 |

BS 5950: Part 1: 2000: Section three**Table 9.** Design strength p_y

| Steel grade | Thickness ^a less than or equal to mm | Design strength p_y N/mm ² |
|-------------|---|---|
| S 275 | 16 | 275 |
| | 40 | 265 |
| | 63 | 255 |
| | 80 | 245 |
| | 100 | 235 |
| | 150 | 225 |
| S 355 | 16 | 355 |
| | 40 | 345 |
| | 63 | 335 |
| | 80 | 325 |
| | 100 | 315 |
| | 150 | 295 |
| S 460 | 16 | 460 |
| | 40 | 440 |
| | 63 | 430 |
| | 80 | 410 |
| | 100 | 400 |

^aFor rolled sections, use the specified thickness of the thickest element of the cross-section.

BS 5950: Part 1: 2000: Section three**Table 11.** Limiting width-to-thickness ratios for sections other than CHS and RHS

| Compression element | | Ratio ^a | Limiting value ^b | | |
|---|--|--------------------|---|---|---|
| | | | Class 1 plastic | Class 2 compact | Class 3 semi-compact |
| Outstand element of compression flange | Rolled section | b/T | 9ε | 10ε | 15ε |
| Internal element of compression flange | Welded section | b/T | 8ε | 9ε | 13ε |
| | Compression due to bending | b/T | 28ε | 32ε | 40ε |
| | Axial compression | b/T | Not applicable | | |
| Web of an I-, H- or box section ^c | Neutral axis at mid-depth | d/t | 80ε | 100ε | 120ε |
| | Generally ^d If r_1 is negative: | d/t | $\frac{100\varepsilon}{1+r_1}$ | | |
| | If r_1 is positive: | d/t | $\frac{80\varepsilon}{1+r_1}$ but $\geq 40\varepsilon$ | $\frac{100\varepsilon}{1+1.5r_1}$ but $\geq 40\varepsilon$ | $\frac{120\varepsilon}{1+2r_2}$ but $\geq 40\varepsilon$ |
| | Axial compression ^d | d/t | Not applicable | | |
| Web of a channel | | d/t | 40ε | 40ε | 40ε |
| Angle, compression due to bending (Both criteria should be satisfied) | | b/t | 9ε | 10ε | 15ε |
| | | d/t | 9ε | 10ε | 15ε |
| Single angle, or double angles with the components separated, axial compression (All three criteria should be satisfied) | | b/t | 15ε | | |
| | | d/t | 15ε | | |
| | | $(b+d)/t$ | 24ε | | |
| Outstand leg of an angle in contact back-to-back in a double angle member | | b/t | 9ε | 10ε | 15ε |
| Outstand leg of an angle with its back in continuous contact with another component | | | | | |
| Stem of a T-section, rolled or cut from a rolled I- or H-section | | D/t | 8ε | 9ε | 18ε |

^aDimensions b , D , d , T and t are as defined in Figure 5 of BS 5950-1. For a box section b and T are flange dimensions and d and t are web dimensions, where the distinction between webs and flanges depends upon whether the box section is bent about its major axis or its minor axis: see clause 3.5.1.

^bThe parameter $\varepsilon = (275/p_y)^{0.5}$.

^cFor the web of a hybrid section ε should be based on the design strength p_{y1} of the flanges.

^dThe stress ratios r_1 and r_2 are defined in clause 3.5.5.

BS 5950: Part 1: 2000: Section three**Table 12.** Limiting width-to-thickness ratios for CHS and RHS

| Compression element | | | Ratio ^a | Limiting value ^b | | |
|---------------------|--------------------------------|--------------------------------|--------------------|--|---|---|
| | | | | Class 1 plastic | Class 2 compact | Class 3 semi-compact |
| CHS | Compression due to bending | | D/t | $40\epsilon^2$ | $50\epsilon^2$ | $140\epsilon^2$ |
| HF RHS | Axial compression | | D/t | Not applicable | Not applicable | $80\epsilon^2$ |
| | Flange | Compression due to bending | b/t | 28ϵ but $\leq 80\epsilon - d/t$ | 32ϵ but $\leq 62\epsilon - 0.5d/t$ | 40ϵ |
| | Web | Axial compression | b/t | Not applicable | Not applicable | |
| | | Neutral axis at mid-depth | d/t | 64ϵ | 80ϵ but $\geq 40\epsilon$ | 120ϵ |
| CF RHS | Generally ^{c/d} | | d/t | $\frac{64\epsilon}{1+0.6r_1}$ but $\geq 40\epsilon$ | $\frac{80\epsilon}{1+r_1}$ but $\geq 40\epsilon$ | $\frac{120\epsilon}{1+2r_2}$ but $\geq 40\epsilon$ |
| | | Axial compression ^d | d/t | Not applicable | Not applicable | |
| | | Flange | b/t | 26ϵ but $\leq 72\epsilon - d/t$ | 28ϵ but $\leq 54\epsilon - 0.5d/t$ | 35ϵ |
| | | Axial compression ^d | b/t | Not applicable | Not applicable | |
| | Neutral axis at mid-depth | | d/t | 56ϵ | 70ϵ | 105ϵ |
| | Generally ^{c/d} | | d/t | $\frac{56\epsilon}{1+0.6r_1}$ but $\geq 35\epsilon$ | $\frac{70\epsilon}{1+r_1}$ but $\geq 35\epsilon$ | $\frac{105\epsilon}{1+2r_2}$ but $\geq 35\epsilon$ |
| | Axial compression ^d | | d/t | Not applicable | Not applicable | |

Abbreviations

CF Cold-formed;

CHS Circular hollow section – including welded tube;

HF Hot-finished;

RHS Rectangular hollow section – including square hollow section.

^aFor an RHS, the dimensions b and d should be taken as follows:– for HF RHS to BS EN 10210: $b = B - 3t$; $d = D - 3t$ – for CF RHS to BS EN 10219: $b = B - 5t$; $d = D - 5t$ and B , D and t are as defined in Figure 5 of BS 5950-1. For an RHS subject to bending B and b are always flange dimensions and D and d are always web dimensions, but the definition of which sides of the RHS are webs and which are flanges changes according to the axis of bending: see clause 3.5.1.^bThe parameter $\epsilon = (275/p_0)^{0.5}$.^cFor RHS subject to moments about both axes see H.3.^dThe stress ratios r_1 and r_2 are defined in clause 3.5.5.

BS 5950: Part 1: 2000: Section four**Table 16.** Bending strength p_b (N/mm²) for rolled sections

| λ_{LT} | Steel grade and design strength p_y (N/mm ²) | | | | | | | | | | | | | | | | | |
|----------------|--|------|------|------|------|-------|------|------|------|------|-------|------|------|------|------|--|--|--|
| | S 275 | | | | | S 355 | | | | | S 460 | | | | | | | |
| | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 400 | 410 | 430 | 440 | 460 | | | |
| 25 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 400 | 410 | 430 | 440 | 460 | | | |
| 30 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 395 | 403 | 421 | 429 | 446 | | | |
| 35 | 235 | 245 | 255 | 265 | 273 | 307 | 316 | 324 | 332 | 341 | 378 | 386 | 402 | 410 | 426 | | | |
| 40 | 229 | 238 | 246 | 254 | 262 | 294 | 302 | 309 | 317 | 325 | 359 | 367 | 382 | 389 | 404 | | | |
| 45 | 219 | 227 | 235 | 242 | 250 | 280 | 287 | 294 | 302 | 309 | 340 | 347 | 361 | 367 | 381 | | | |
| 50 | 210 | 217 | 224 | 231 | 238 | 265 | 272 | 279 | 285 | 292 | 320 | 326 | 338 | 344 | 356 | | | |
| 55 | 199 | 206 | 213 | 219 | 226 | 251 | 257 | 263 | 268 | 274 | 299 | 305 | 315 | 320 | 330 | | | |
| 60 | 189 | 195 | 201 | 207 | 213 | 236 | 241 | 246 | 251 | 257 | 278 | 283 | 292 | 296 | 304 | | | |
| 65 | 179 | 185 | 190 | 196 | 201 | 221 | 225 | 230 | 234 | 239 | 257 | 261 | 269 | 272 | 279 | | | |
| 70 | 169 | 174 | 179 | 184 | 188 | 206 | 210 | 214 | 218 | 222 | 237 | 241 | 247 | 250 | 256 | | | |
| 75 | 159 | 164 | 168 | 172 | 176 | 192 | 195 | 199 | 202 | 205 | 219 | 221 | 226 | 229 | 234 | | | |
| 80 | 150 | 154 | 158 | 161 | 165 | 178 | 181 | 184 | 187 | 190 | 201 | 203 | 208 | 210 | 214 | | | |
| 85 | 140 | 144 | 147 | 151 | 154 | 165 | 168 | 170 | 173 | 175 | 185 | 187 | 190 | 192 | 195 | | | |
| 90 | 132 | 135 | 138 | 141 | 144 | 153 | 156 | 158 | 160 | 162 | 170 | 172 | 175 | 176 | 179 | | | |
| 95 | 124 | 126 | 129 | 131 | 134 | 143 | 144 | 146 | 148 | 150 | 157 | 158 | 161 | 162 | 164 | | | |
| 100 | 116 | 118 | 121 | 123 | 125 | 132 | 134 | 136 | 137 | 139 | 145 | 146 | 148 | 149 | 151 | | | |
| 105 | 109 | 111 | 113 | 115 | 117 | 123 | 125 | 126 | 128 | 129 | 134 | 135 | 137 | 138 | 140 | | | |
| 110 | 102 | 104 | 106 | 107 | 109 | 115 | 116 | 117 | 119 | 120 | 124 | 125 | 127 | 128 | 129 | | | |
| 115 | 96 | 97 | 99 | 101 | 102 | 107 | 108 | 109 | 110 | 111 | 115 | 116 | 118 | 118 | 120 | | | |
| 120 | 90 | 91 | 93 | 94 | 96 | 100 | 101 | 102 | 103 | 104 | 107 | 108 | 109 | 110 | 111 | | | |
| 125 | 85 | 86 | 87 | 89 | 90 | 94 | 95 | 96 | 96 | 97 | 100 | 101 | 102 | 103 | 104 | | | |
| 130 | 80 | 81 | 82 | 83 | 84 | 88 | 89 | 90 | 90 | 91 | 94 | 94 | 95 | 96 | 97 | | | |
| 135 | 75 | 76 | 77 | 78 | 79 | 83 | 83 | 84 | 85 | 85 | 88 | 88 | 89 | 90 | 90 | | | |
| 140 | 71 | 72 | 73 | 74 | 75 | 78 | 78 | 79 | 80 | 80 | 82 | 83 | 84 | 84 | 85 | | | |
| 145 | 67 | 68 | 69 | 70 | 71 | 73 | 74 | 74 | 75 | 75 | 77 | 78 | 79 | 79 | 80 | | | |
| 150 | 64 | 64 | 65 | 66 | 67 | 69 | 70 | 70 | 71 | 71 | 73 | 73 | 74 | 74 | 75 | | | |
| 155 | 60 | 61 | 62 | 62 | 63 | 65 | 66 | 66 | 67 | 67 | 69 | 69 | 70 | 70 | 71 | | | |
| 160 | 57 | 58 | 59 | 59 | 60 | 62 | 62 | 63 | 63 | 63 | 65 | 65 | 66 | 66 | 67 | | | |
| 165 | 54 | 55 | 56 | 56 | 57 | 59 | 59 | 59 | 60 | 60 | 61 | 62 | 62 | 62 | 63 | | | |
| 170 | 52 | 52 | 53 | 53 | 54 | 56 | 56 | 56 | 57 | 57 | 58 | 58 | 59 | 59 | 60 | | | |
| 175 | 49 | 50 | 50 | 51 | 51 | 53 | 53 | 53 | 54 | 54 | 55 | 55 | 56 | 56 | 56 | | | |
| 180 | 47 | 47 | 48 | 48 | 49 | 50 | 51 | 51 | 51 | 51 | 52 | 53 | 53 | 53 | 54 | | | |
| 185 | 45 | 45 | 46 | 46 | 46 | 48 | 48 | 48 | 49 | 49 | 50 | 50 | 50 | 51 | 51 | | | |
| 190 | 43 | 43 | 44 | 44 | 44 | 46 | 46 | 46 | 46 | 47 | 48 | 48 | 48 | 48 | 48 | | | |
| 195 | 41 | 41 | 42 | 42 | 42 | 43 | 44 | 44 | 44 | 45 | 45 | 46 | 46 | 46 | 46 | | | |
| 200 | 39 | 39 | 40 | 40 | 40 | 42 | 42 | 42 | 42 | 42 | 43 | 43 | 44 | 44 | 44 | | | |
| 210 | 36 | 36 | 37 | 37 | 37 | 38 | 38 | 38 | 39 | 39 | 39 | 40 | 40 | 40 | 40 | | | |
| 220 | 33 | 33 | 34 | 34 | 34 | 35 | 35 | 35 | 35 | 36 | 36 | 36 | 37 | 37 | 37 | | | |
| 230 | 31 | 31 | 31 | 31 | 31 | 32 | 32 | 33 | 33 | 33 | 33 | 33 | 34 | 34 | 34 | | | |
| 240 | 28 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 31 | 31 | 31 | 31 | 31 | 31 | | | |
| 250 | 26 | 27 | 27 | 27 | 27 | 28 | 28 | 28 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | | | |
| λ_{L0} | 37.1 | 36.3 | 35.6 | 35.0 | 34.3 | 32.1 | 31.6 | 31.1 | 30.6 | 30.2 | 28.4 | 28.1 | 27.4 | 27.1 | 26.5 | | | |

Table 17. Bending strength p_b (N/mm²) for welded sections

| λ_{LT} | Steel grade and design strength p_y (N/mm ²) | | | | | | | | | | | | | | | |
|----------------|--|------|------|------|------|-------|------|------|------|------|-------|------|------|------|------|--|
| | S 275 | | | | | S 355 | | | | | S 460 | | | | | |
| | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 400 | 410 | 430 | 440 | 460 | |
| 25 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 400 | 410 | 430 | 440 | 460 | |
| 30 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 390 | 397 | 412 | 419 | 434 | |
| 35 | 235 | 245 | 255 | 265 | 272 | 300 | 307 | 314 | 321 | 328 | 358 | 365 | 378 | 385 | 398 | |
| 40 | 224 | 231 | 237 | 244 | 250 | 276 | 282 | 288 | 295 | 301 | 328 | 334 | 346 | 352 | 364 | |
| 45 | 206 | 212 | 218 | 224 | 230 | 253 | 259 | 265 | 270 | 276 | 300 | 306 | 316 | 321 | 332 | |
| 50 | 190 | 196 | 201 | 207 | 212 | 233 | 238 | 243 | 248 | 253 | 275 | 279 | 288 | 293 | 302 | |
| 55 | 175 | 180 | 185 | 190 | 195 | 214 | 219 | 223 | 227 | 232 | 251 | 255 | 263 | 269 | 281 | |
| 60 | 162 | 167 | 171 | 176 | 180 | 197 | 201 | 205 | 209 | 212 | 237 | 242 | 253 | 258 | 269 | |
| 65 | 150 | 154 | 158 | 162 | 166 | 183 | 188 | 194 | 199 | 204 | 227 | 232 | 242 | 247 | 256 | |
| 70 | 139 | 142 | 146 | 150 | 155 | 177 | 182 | 187 | 192 | 196 | 217 | 222 | 230 | 234 | 242 | |
| 75 | 130 | 135 | 140 | 145 | 151 | 170 | 175 | 179 | 184 | 188 | 207 | 210 | 218 | 221 | 228 | |
| 80 | 126 | 131 | 136 | 141 | 146 | 163 | 168 | 172 | 176 | 179 | 196 | 199 | 205 | 208 | 214 | |
| 85 | 122 | 127 | 131 | 136 | 140 | 156 | 160 | 164 | 167 | 171 | 185 | 187 | 190 | 192 | 195 | |
| 90 | 118 | 123 | 127 | 131 | 135 | 149 | 152 | 156 | 159 | 162 | 170 | 172 | 175 | 176 | 179 | |
| 95 | 114 | 118 | 122 | 125 | 129 | 142 | 144 | 146 | 148 | 150 | 157 | 158 | 161 | 162 | 164 | |
| 100 | 110 | 113 | 117 | 120 | 123 | 132 | 134 | 136 | 137 | 139 | 145 | 146 | 148 | 149 | 151 | |
| 105 | 106 | 109 | 112 | 115 | 117 | 123 | 125 | 126 | 128 | 129 | 134 | 135 | 137 | 138 | 140 | |
| 110 | 101 | 104 | 106 | 107 | 109 | 115 | 116 | 117 | 119 | 120 | 124 | 125 | 127 | 128 | 129 | |
| 115 | 96 | 97 | 99 | 101 | 102 | 107 | 108 | 109 | 110 | 111 | 115 | 116 | 118 | 118 | 120 | |
| 120 | 90 | 91 | 93 | 94 | 96 | 100 | 101 | 102 | 103 | 104 | 107 | 108 | 109 | 110 | 111 | |
| 125 | 85 | 86 | 87 | 89 | 90 | 94 | 95 | 96 | 96 | 97 | 100 | 101 | 102 | 103 | 104 | |
| 130 | 80 | 81 | 82 | 83 | 84 | 88 | 89 | 90 | 90 | 91 | 94 | 94 | 95 | 96 | 97 | |
| 135 | 75 | 76 | 77 | 78 | 79 | 83 | 83 | 84 | 85 | 85 | 88 | 88 | 89 | 90 | 90 | |
| 140 | 71 | 72 | 73 | 74 | 75 | 78 | 78 | 79 | 80 | 80 | 82 | 83 | 84 | 84 | 85 | |
| 145 | 67 | 68 | 69 | 70 | 71 | 73 | 74 | 74 | 75 | 75 | 77 | 78 | 79 | 79 | 80 | |
| 150 | 64 | 64 | 65 | 66 | 67 | 69 | 70 | 70 | 71 | 71 | 73 | 73 | 74 | 74 | 75 | |
| 155 | 60 | 61 | 62 | 62 | 63 | 65 | 66 | 66 | 67 | 67 | 69 | 69 | 70 | 70 | 71 | |
| 160 | 57 | 58 | 59 | 59 | 60 | 62 | 62 | 63 | 63 | 63 | 65 | 65 | 66 | 66 | 67 | |
| 165 | 54 | 55 | 56 | 56 | 57 | 59 | 59 | 59 | 60 | 60 | 61 | 62 | 62 | 62 | 63 | |
| 170 | 52 | 52 | 53 | 53 | 54 | 56 | 56 | 56 | 57 | 57 | 58 | 58 | 59 | 59 | 60 | |
| 175 | 49 | 50 | 50 | 51 | 51 | 53 | 53 | 53 | 54 | 54 | 55 | 55 | 56 | 56 | 56 | |
| 180 | 47 | 47 | 48 | 48 | 49 | 50 | 51 | 51 | 51 | 51 | 52 | 53 | 53 | 53 | 54 | |
| 185 | 45 | 45 | 46 | 46 | 46 | 48 | 48 | 48 | 49 | 49 | 50 | 50 | 50 | 51 | 51 | |
| 190 | 43 | 43 | 44 | 44 | 44 | 46 | 46 | 46 | 46 | 47 | 48 | 48 | 48 | 48 | 48 | |
| 195 | 41 | 41 | 42 | 42 | 42 | 43 | 44 | 44 | 44 | 44 | 45 | 45 | 46 | 46 | 46 | |
| 200 | 39 | 39 | 40 | 40 | 40 | 42 | 42 | 42 | 42 | 42 | 43 | 43 | 44 | 44 | 44 | |
| 210 | 36 | 36 | 37 | 37 | 37 | 38 | 38 | 38 | 39 | 39 | 39 | 40 | 40 | 40 | 40 | |
| 220 | 33 | 33 | 34 | 34 | 34 | 35 | 35 | 35 | 35 | 36 | 36 | 36 | 37 | 37 | 37 | |
| 230 | 31 | 31 | 31 | 31 | 31 | 32 | 32 | 33 | 33 | 33 | 33 | 33 | 34 | 34 | 34 | |
| 240 | 28 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 31 | 31 | 31 | 31 | 31 | |
| 250 | 26 | 27 | 27 | 27 | 27 | 28 | 28 | 28 | 28 | 28 | 29 | 29 | 29 | 29 | 29 | |
| λ_{L0} | 37.1 | 36.3 | 35.6 | 35.0 | 34.3 | 32.1 | 31.6 | 31.1 | 30.6 | 30.2 | 28.4 | 28.1 | 27.4 | 27.1 | 26.5 | |

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BS 5950: Part 1: 2000: Section four**Table 23.** Allocation of strut curve

| Type of section | Maximum thickness (see note 1) | Axis of buckling | |
|---|-----------------------------------|------------------|-----|
| | | x-x | y-y |
| Hot-finished structural hollow section | | (a) | (a) |
| Cold-formed structural hollow section | | (c) | (c) |
| Rolled I-section | ≤40 mm | (a) | (b) |
| | >40 mm | (b) | (c) |
| Rolled H-section | ≤40 mm | (b) | (c) |
| | >40 mm | (c) | (d) |
| Welded I- or H-section (see note 2 and clause 4.7.5) | ≤40 mm | (b) | (c) |
| | >40 mm | (b) | (d) |
| Rolled I-section with welded flange cover plates with $0.25 < U/B < 0.8$ as shown in Figure 14(a) of BS 5950-1 | ≤40 mm | (a) | (b) |
| | >40 mm | (b) | (c) |
| Rolled H-section with welded flange cover plates with $0.25 < U/B < 0.8$ as shown in Figure 14(a) of BS 5950-1 | ≤40 mm | (b) | (c) |
| | >40 mm | (c) | (d) |
| Rolled I- or H-section with welded flange cover plates with $U/B \geq 0.8$ as shown in Figure 14(b) of BS 5950-1 | ≤40 mm | (b) | (a) |
| | >40 mm | (c) | (b) |
| Rolled I- or H-section with welded flange cover plates with $U/B \leq 0.25$ as shown in Figure 14(c) of BS 5950-1 | ≤40 mm | (b) | (c) |
| | >40 mm | (b) | (d) |
| Welded box section (see note 3 and clause 4.7.5) | ≤40 mm | (b) | (b) |
| | >40 mm | (c) | (c) |
| Round, square or flat bar | ≤40 mm | (b) | (b) |
| | >40 mm | (c) | (c) |
| Rolled angle, channel or T-section | | Any axis: (c) | |
| Two rolled sections laced, battened or back-to-back | | | |
| Compound rolled sections | | | |

NOTE 1 For thicknesses between 40 mm and 50 mm the value of p_c may be taken as the average of the values for thicknesses up to 40 mm and over 40 mm for the relevant value of p_y .

NOTE 2 For welded I- or H-sections with their flanges thermally cut by machine without subsequent edge grinding or machining, for buckling about the y-y axis, strut curve (b) may be used for flanges up to 40 mm thick and strut curve (c) for flanges over 40 mm thick. Table 24 gives values for p_c for strut curves (a)-(d).

NOTE 3 The category 'welded box section' includes any box section fabricated from plates or rolled sections, provided that all of the longitudinal welds are near the corners of the cross-section. Box sections with longitudinal stiffeners are not included in this category.

BS 5950: Part 1: 2000: Section four**Table 24.** Compressive strength p_c (N/mm²)(1) Values of p_c in N/mm² with $\lambda < 110$ for strut curve a

| λ | Steel grade and design strength p_y (N/mm ²) | | | | | | | | | | | | | | | | | | |
|-----------|--|-----|-----|-----|-----|-------|-----|-----|-----|-----|-------|-----|-----|-----|-----|-----|-----|-----|-----|
| | S 275 | | | | | S 355 | | | | | S 460 | | | | | | | | |
| | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 399 | 409 | 429 | 439 | 458 | 400 | 410 | 430 | 440 |
| 15 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 399 | 409 | 429 | 439 | 458 | | | | |
| 20 | 234 | 244 | 254 | 264 | 273 | 312 | 322 | 332 | 342 | 351 | 395 | 405 | 424 | 434 | 453 | | | | |
| 25 | 232 | 241 | 251 | 261 | 270 | 309 | 318 | 328 | 338 | 347 | 390 | 400 | 419 | 429 | 448 | | | | |
| 30 | 229 | 239 | 248 | 258 | 267 | 305 | 315 | 324 | 333 | 343 | 385 | 395 | 414 | 423 | 442 | | | | |
| 35 | 226 | 236 | 245 | 254 | 264 | 301 | 310 | 320 | 329 | 338 | 380 | 389 | 407 | 416 | 434 | | | | |
| 40 | 223 | 233 | 242 | 251 | 260 | 296 | 305 | 315 | 324 | 333 | 373 | 382 | 399 | 408 | 426 | | | | |
| 42 | 222 | 231 | 240 | 249 | 258 | 294 | 303 | 312 | 321 | 330 | 370 | 378 | 396 | 404 | 422 | | | | |
| 44 | 221 | 230 | 239 | 248 | 257 | 292 | 301 | 310 | 319 | 327 | 366 | 375 | 392 | 400 | 417 | | | | |
| 46 | 219 | 228 | 237 | 246 | 255 | 290 | 299 | 307 | 316 | 325 | 363 | 371 | 388 | 396 | 413 | | | | |
| 48 | 218 | 227 | 236 | 244 | 253 | 288 | 296 | 305 | 313 | 322 | 359 | 367 | 383 | 391 | 407 | | | | |
| 50 | 216 | 225 | 234 | 242 | 251 | 285 | 293 | 302 | 310 | 318 | 355 | 363 | 378 | 386 | 401 | | | | |
| 52 | 215 | 223 | 232 | 241 | 249 | 282 | 291 | 299 | 307 | 315 | 350 | 358 | 373 | 380 | 395 | | | | |
| 54 | 213 | 222 | 230 | 238 | 247 | 279 | 287 | 295 | 303 | 311 | 345 | 353 | 367 | 374 | 388 | | | | |
| 56 | 211 | 220 | 228 | 236 | 244 | 276 | 284 | 292 | 300 | 307 | 340 | 347 | 361 | 368 | 381 | | | | |
| 58 | 210 | 218 | 226 | 234 | 242 | 273 | 281 | 288 | 295 | 303 | 334 | 341 | 354 | 360 | 372 | | | | |
| 60 | 208 | 216 | 224 | 232 | 239 | 269 | 277 | 284 | 291 | 298 | 328 | 334 | 346 | 352 | 364 | | | | |
| 62 | 206 | 214 | 221 | 229 | 236 | 266 | 273 | 280 | 286 | 293 | 321 | 327 | 338 | 344 | 354 | | | | |
| 64 | 204 | 211 | 219 | 226 | 234 | 262 | 268 | 275 | 281 | 288 | 314 | 320 | 330 | 335 | 344 | | | | |
| 66 | 201 | 209 | 216 | 223 | 230 | 257 | 264 | 270 | 276 | 282 | 307 | 312 | 321 | 326 | 334 | | | | |
| 68 | 199 | 206 | 213 | 220 | 227 | 253 | 259 | 265 | 270 | 276 | 299 | 303 | 312 | 316 | 324 | | | | |
| 70 | 196 | 203 | 210 | 217 | 224 | 248 | 254 | 259 | 265 | 270 | 291 | 295 | 303 | 306 | 313 | | | | |
| 72 | 194 | 201 | 207 | 214 | 220 | 243 | 248 | 253 | 258 | 263 | 282 | 286 | 293 | 296 | 302 | | | | |
| 74 | 191 | 198 | 204 | 210 | 216 | 238 | 243 | 247 | 252 | 256 | 274 | 277 | 283 | 286 | 292 | | | | |
| 76 | 188 | 194 | 200 | 206 | 212 | 232 | 237 | 241 | 245 | 249 | 265 | 268 | 274 | 276 | 281 | | | | |
| 78 | 185 | 191 | 197 | 202 | 208 | 227 | 231 | 235 | 239 | 242 | 257 | 259 | 264 | 267 | 271 | | | | |
| 80 | 182 | 188 | 193 | 198 | 203 | 221 | 225 | 229 | 232 | 235 | 248 | 251 | 255 | 257 | 261 | | | | |
| 82 | 179 | 184 | 189 | 194 | 199 | 215 | 219 | 222 | 225 | 228 | 240 | 242 | 246 | 248 | 251 | | | | |
| 84 | 176 | 181 | 185 | 190 | 194 | 209 | 213 | 216 | 219 | 221 | 232 | 234 | 237 | 239 | 242 | | | | |
| 86 | 172 | 177 | 181 | 186 | 190 | 204 | 207 | 209 | 212 | 214 | 224 | 225 | 229 | 230 | 233 | | | | |
| 88 | 169 | 173 | 177 | 181 | 185 | 198 | 200 | 203 | 205 | 208 | 216 | 218 | 220 | 222 | 224 | | | | |
| 90 | 165 | 169 | 173 | 177 | 180 | 192 | 195 | 197 | 199 | 201 | 209 | 210 | 213 | 214 | 216 | | | | |
| 92 | 162 | 166 | 169 | 173 | 176 | 186 | 189 | 191 | 193 | 194 | 201 | 203 | 205 | 206 | 208 | | | | |
| 94 | 158 | 162 | 165 | 168 | 171 | 181 | 183 | 185 | 187 | 188 | 194 | 196 | 198 | 199 | 200 | | | | |
| 96 | 154 | 158 | 161 | 164 | 166 | 175 | 177 | 179 | 181 | 182 | 188 | 189 | 191 | 192 | 193 | | | | |
| 98 | 151 | 154 | 157 | 159 | 162 | 170 | 172 | 173 | 175 | 176 | 181 | 182 | 184 | 185 | 186 | | | | |
| 100 | 147 | 150 | 153 | 155 | 157 | 165 | 167 | 168 | 169 | 171 | 175 | 176 | 178 | 178 | 180 | | | | |
| 102 | 144 | 146 | 149 | 151 | 153 | 160 | 161 | 163 | 164 | 165 | 169 | 170 | 172 | 172 | 174 | | | | |
| 104 | 140 | 142 | 145 | 147 | 149 | 155 | 156 | 158 | 159 | 160 | 164 | 165 | 166 | 166 | 168 | | | | |
| 106 | 136 | 139 | 141 | 143 | 145 | 150 | 152 | 153 | 154 | 155 | 158 | 159 | 160 | 161 | 162 | | | | |
| 108 | 133 | 135 | 137 | 139 | 141 | 146 | 147 | 148 | 149 | 150 | 153 | 154 | 155 | 156 | 157 | | | | |

Table 24. Compressive strength p_c (N/mm²) (*continued*)

Table 24. Compressive strength p_c (N/mm²) (continued)(3) Values of p_c (N/mm²) with $\lambda < 110$ for strut curve b

| λ | Steel grade and design strength p_y (N/mm ²) | | | | | | | | | | | | | | | | | |
|-----------|--|-----|-----|-----|-----|-------|-----|-----|-----|-----|-------|-----|-----|-----|-----|--|--|--|
| | S 275 | | | | | S 355 | | | | | S 460 | | | | | | | |
| | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 399 | 409 | 428 | 438 | 457 | | | |
| 15 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 399 | 409 | 428 | 438 | 457 | | | |
| 20 | 234 | 243 | 253 | 263 | 272 | 310 | 320 | 330 | 339 | 349 | 391 | 401 | 420 | 429 | 448 | | | |
| 25 | 229 | 239 | 248 | 258 | 267 | 304 | 314 | 323 | 332 | 342 | 384 | 393 | 411 | 421 | 439 | | | |
| 30 | 225 | 234 | 243 | 253 | 262 | 298 | 307 | 316 | 325 | 335 | 375 | 384 | 402 | 411 | 429 | | | |
| 35 | 220 | 229 | 238 | 247 | 256 | 291 | 300 | 309 | 318 | 327 | 366 | 374 | 392 | 400 | 417 | | | |
| 40 | 216 | 224 | 233 | 241 | 250 | 284 | 293 | 301 | 310 | 318 | 355 | 364 | 380 | 388 | 404 | | | |
| 42 | 213 | 222 | 231 | 239 | 248 | 281 | 289 | 298 | 306 | 314 | 351 | 359 | 375 | 383 | 399 | | | |
| 44 | 211 | 220 | 228 | 237 | 245 | 278 | 286 | 294 | 302 | 310 | 346 | 354 | 369 | 377 | 392 | | | |
| 46 | 209 | 218 | 226 | 234 | 242 | 275 | 283 | 291 | 298 | 306 | 341 | 349 | 364 | 371 | 386 | | | |
| 48 | 207 | 215 | 223 | 231 | 239 | 271 | 279 | 287 | 294 | 302 | 336 | 343 | 358 | 365 | 379 | | | |
| 50 | 205 | 213 | 221 | 229 | 237 | 267 | 275 | 283 | 290 | 298 | 330 | 337 | 351 | 358 | 372 | | | |
| 52 | 203 | 210 | 218 | 226 | 234 | 264 | 271 | 278 | 286 | 293 | 324 | 331 | 344 | 351 | 364 | | | |
| 54 | 200 | 208 | 215 | 223 | 230 | 260 | 267 | 274 | 281 | 288 | 318 | 325 | 337 | 344 | 356 | | | |
| 56 | 198 | 205 | 213 | 220 | 227 | 256 | 263 | 269 | 276 | 283 | 312 | 318 | 330 | 336 | 347 | | | |
| 58 | 195 | 202 | 210 | 217 | 224 | 252 | 258 | 265 | 271 | 278 | 305 | 311 | 322 | 328 | 339 | | | |
| 60 | 193 | 200 | 207 | 214 | 221 | 247 | 254 | 260 | 266 | 272 | 298 | 304 | 314 | 320 | 330 | | | |
| 62 | 190 | 197 | 204 | 210 | 217 | 243 | 249 | 255 | 261 | 266 | 291 | 296 | 306 | 311 | 320 | | | |
| 64 | 187 | 194 | 200 | 207 | 213 | 238 | 244 | 249 | 255 | 261 | 284 | 289 | 298 | 302 | 311 | | | |
| 66 | 184 | 191 | 197 | 203 | 210 | 233 | 239 | 244 | 249 | 255 | 276 | 281 | 289 | 294 | 301 | | | |
| 68 | 181 | 188 | 194 | 200 | 206 | 228 | 233 | 239 | 244 | 249 | 269 | 273 | 281 | 285 | 292 | | | |
| 70 | 178 | 185 | 190 | 196 | 202 | 223 | 228 | 233 | 238 | 242 | 261 | 265 | 272 | 276 | 282 | | | |
| 72 | 175 | 181 | 187 | 193 | 198 | 218 | 223 | 227 | 232 | 236 | 254 | 257 | 264 | 267 | 273 | | | |
| 74 | 172 | 178 | 183 | 189 | 194 | 213 | 217 | 222 | 226 | 230 | 246 | 249 | 255 | 258 | 264 | | | |
| 76 | 169 | 175 | 180 | 185 | 190 | 208 | 212 | 216 | 220 | 223 | 238 | 241 | 247 | 250 | 255 | | | |
| 78 | 166 | 171 | 176 | 181 | 186 | 203 | 206 | 210 | 214 | 217 | 231 | 234 | 239 | 241 | 246 | | | |
| 80 | 163 | 168 | 172 | 177 | 181 | 197 | 201 | 204 | 208 | 211 | 224 | 226 | 231 | 233 | 237 | | | |
| 82 | 160 | 164 | 169 | 173 | 177 | 192 | 196 | 199 | 202 | 205 | 217 | 219 | 223 | 225 | 229 | | | |
| 84 | 156 | 161 | 165 | 169 | 173 | 187 | 190 | 193 | 196 | 199 | 210 | 212 | 216 | 218 | 221 | | | |
| 86 | 153 | 157 | 161 | 165 | 169 | 182 | 185 | 188 | 190 | 193 | 203 | 205 | 208 | 210 | 213 | | | |
| 88 | 150 | 154 | 158 | 161 | 165 | 177 | 180 | 182 | 185 | 187 | 196 | 198 | 201 | 203 | 206 | | | |
| 90 | 146 | 150 | 154 | 157 | 161 | 172 | 175 | 177 | 179 | 181 | 190 | 192 | 195 | 196 | 199 | | | |
| 92 | 143 | 147 | 150 | 153 | 156 | 167 | 170 | 172 | 174 | 176 | 184 | 185 | 188 | 189 | 192 | | | |
| 94 | 140 | 143 | 147 | 150 | 152 | 162 | 165 | 167 | 169 | 171 | 178 | 179 | 182 | 183 | 185 | | | |
| 96 | 137 | 140 | 143 | 146 | 148 | 158 | 160 | 162 | 164 | 165 | 172 | 173 | 176 | 177 | 179 | | | |
| 98 | 134 | 137 | 139 | 142 | 145 | 153 | 155 | 157 | 159 | 160 | 167 | 168 | 170 | 171 | 173 | | | |
| 100 | 130 | 133 | 136 | 138 | 141 | 149 | 151 | 152 | 154 | 155 | 161 | 162 | 164 | 165 | 167 | | | |
| 102 | 127 | 130 | 132 | 135 | 137 | 145 | 146 | 148 | 149 | 151 | 156 | 157 | 159 | 160 | 162 | | | |
| 104 | 124 | 127 | 129 | 131 | 133 | 141 | 142 | 144 | 145 | 146 | 151 | 152 | 154 | 155 | 156 | | | |
| 106 | 121 | 124 | 126 | 128 | 130 | 137 | 138 | 139 | 141 | 142 | 147 | 148 | 149 | 150 | 151 | | | |
| 108 | 118 | 121 | 123 | 125 | 126 | 133 | 134 | 135 | 137 | 138 | 142 | 143 | 144 | 145 | 147 | | | |

Table 24. Compressive strength p_c (N/mm²) (continued)

Table 24. Compressive strength p_c (N/mm²) (continued)(5) Values of p_c (N/mm²) with $\lambda < 110$ for strut curve c

| λ | Steel grade and design strength p_y (N/mm ²) | | | | | | | | | | | | | | | | | |
|-----------|--|-----|-----|-----|-----|-------|-----|-----|-----|-----|-------|-----|-----|-----|-----|--|--|--|
| | S 275 | | | | | S 355 | | | | | S 460 | | | | | | | |
| | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 398 | 408 | 427 | 436 | 455 | | | |
| 15 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 398 | 408 | 427 | 436 | 455 | | | |
| 20 | 233 | 242 | 252 | 261 | 271 | 308 | 317 | 326 | 336 | 345 | 387 | 396 | 414 | 424 | 442 | | | |
| 25 | 226 | 235 | 245 | 254 | 263 | 299 | 308 | 317 | 326 | 335 | 375 | 384 | 402 | 410 | 428 | | | |
| 30 | 220 | 228 | 237 | 246 | 255 | 289 | 298 | 307 | 315 | 324 | 363 | 371 | 388 | 396 | 413 | | | |
| 35 | 213 | 221 | 230 | 238 | 247 | 280 | 288 | 296 | 305 | 313 | 349 | 357 | 374 | 382 | 397 | | | |
| 40 | 206 | 214 | 222 | 230 | 238 | 270 | 278 | 285 | 293 | 301 | 335 | 343 | 358 | 365 | 380 | | | |
| 42 | 203 | 211 | 219 | 227 | 235 | 266 | 273 | 281 | 288 | 296 | 329 | 337 | 351 | 358 | 373 | | | |
| 44 | 200 | 208 | 216 | 224 | 231 | 261 | 269 | 276 | 284 | 291 | 323 | 330 | 344 | 351 | 365 | | | |
| 46 | 197 | 205 | 213 | 220 | 228 | 257 | 264 | 271 | 279 | 286 | 317 | 324 | 337 | 344 | 357 | | | |
| 48 | 195 | 202 | 209 | 217 | 224 | 253 | 260 | 267 | 274 | 280 | 311 | 317 | 330 | 337 | 349 | | | |
| 50 | 192 | 199 | 206 | 213 | 220 | 248 | 255 | 262 | 268 | 275 | 304 | 310 | 323 | 329 | 341 | | | |
| 52 | 189 | 196 | 203 | 210 | 217 | 244 | 250 | 257 | 263 | 270 | 297 | 303 | 315 | 321 | 333 | | | |
| 54 | 186 | 193 | 199 | 206 | 213 | 239 | 245 | 252 | 258 | 264 | 291 | 296 | 308 | 313 | 324 | | | |
| 56 | 183 | 189 | 196 | 202 | 209 | 234 | 240 | 246 | 252 | 258 | 284 | 289 | 300 | 305 | 315 | | | |
| 58 | 179 | 186 | 192 | 199 | 205 | 229 | 235 | 241 | 247 | 252 | 277 | 282 | 292 | 297 | 306 | | | |
| 60 | 176 | 183 | 189 | 195 | 201 | 225 | 230 | 236 | 241 | 247 | 270 | 274 | 284 | 289 | 298 | | | |
| 62 | 173 | 179 | 185 | 191 | 197 | 220 | 225 | 230 | 236 | 241 | 262 | 267 | 276 | 280 | 289 | | | |
| 64 | 170 | 176 | 182 | 188 | 193 | 215 | 220 | 225 | 230 | 235 | 255 | 260 | 268 | 272 | 280 | | | |
| 66 | 167 | 173 | 178 | 184 | 189 | 210 | 215 | 220 | 224 | 229 | 248 | 252 | 260 | 264 | 271 | | | |
| 68 | 164 | 169 | 175 | 180 | 185 | 205 | 210 | 214 | 219 | 223 | 241 | 245 | 252 | 256 | 262 | | | |
| 70 | 161 | 166 | 171 | 176 | 181 | 200 | 204 | 209 | 213 | 217 | 234 | 238 | 244 | 248 | 254 | | | |
| 72 | 157 | 163 | 168 | 172 | 177 | 195 | 199 | 203 | 207 | 211 | 227 | 231 | 237 | 240 | 246 | | | |
| 74 | 154 | 159 | 164 | 169 | 173 | 190 | 194 | 198 | 202 | 205 | 220 | 223 | 229 | 232 | 238 | | | |
| 76 | 151 | 156 | 160 | 165 | 169 | 185 | 189 | 193 | 196 | 200 | 214 | 217 | 222 | 225 | 230 | | | |
| 78 | 148 | 152 | 157 | 161 | 165 | 180 | 184 | 187 | 191 | 194 | 207 | 210 | 215 | 217 | 222 | | | |
| 80 | 145 | 149 | 153 | 157 | 161 | 176 | 179 | 182 | 185 | 188 | 201 | 203 | 208 | 210 | 215 | | | |
| 82 | 142 | 146 | 150 | 154 | 157 | 171 | 174 | 177 | 180 | 183 | 195 | 197 | 201 | 203 | 207 | | | |
| 84 | 139 | 142 | 146 | 150 | 154 | 167 | 169 | 172 | 175 | 178 | 189 | 191 | 195 | 197 | 201 | | | |
| 86 | 135 | 139 | 143 | 146 | 150 | 162 | 165 | 168 | 170 | 173 | 183 | 185 | 189 | 190 | 194 | | | |
| 88 | 132 | 136 | 139 | 143 | 146 | 158 | 160 | 163 | 165 | 168 | 177 | 179 | 183 | 184 | 187 | | | |
| 90 | 129 | 133 | 136 | 139 | 142 | 153 | 156 | 158 | 161 | 163 | 172 | 173 | 177 | 178 | 181 | | | |
| 92 | 126 | 130 | 133 | 136 | 139 | 149 | 152 | 154 | 156 | 158 | 166 | 168 | 171 | 173 | 175 | | | |
| 94 | 124 | 127 | 130 | 133 | 135 | 145 | 147 | 149 | 151 | 153 | 161 | 163 | 166 | 167 | 170 | | | |
| 96 | 121 | 124 | 127 | 129 | 132 | 141 | 143 | 145 | 147 | 149 | 156 | 158 | 160 | 162 | 164 | | | |
| 98 | 118 | 121 | 123 | 126 | 129 | 137 | 139 | 141 | 143 | 145 | 151 | 153 | 155 | 157 | 159 | | | |
| 100 | 115 | 118 | 120 | 123 | 125 | 134 | 135 | 137 | 139 | 140 | 147 | 148 | 151 | 152 | 154 | | | |
| 102 | 113 | 115 | 118 | 120 | 122 | 130 | 132 | 133 | 135 | 136 | 143 | 144 | 146 | 147 | 149 | | | |
| 104 | 110 | 112 | 115 | 117 | 119 | 126 | 128 | 130 | 131 | 133 | 138 | 139 | 142 | 142 | 144 | | | |
| 106 | 107 | 110 | 112 | 114 | 116 | 123 | 125 | 126 | 127 | 129 | 134 | 135 | 137 | 138 | 140 | | | |
| 108 | 105 | 107 | 109 | 111 | 113 | 120 | 121 | 123 | 124 | 125 | 130 | 131 | 133 | 134 | 136 | | | |

Table 24. Compressive strength p_c (N/mm²) (continued)

Table 24. Compressive strength p_c (N/mm²) (*continued*)(7) Values of p_c (N/mm²) with $\lambda < 110$ for strut curve d

| λ | Steel grade and design strength p_y (N/mm ²) | | | | | | | | | | | | | | | | | |
|-----------|--|-----|-----|-----|-----|-------|-----|-----|-----|-----|-------|-----|-----|-----|-----|--|--|--|
| | S 275 | | | | | S 355 | | | | | S 460 | | | | | | | |
| | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 400 | 410 | 430 | 440 | 460 | | | |
| 15 | 235 | 245 | 255 | 265 | 275 | 315 | 325 | 335 | 345 | 355 | 397 | 407 | 425 | 435 | 453 | | | |
| 20 | 232 | 241 | 250 | 259 | 269 | 305 | 314 | 323 | 332 | 341 | 381 | 390 | 408 | 417 | 434 | | | |
| 25 | 223 | 231 | 240 | 249 | 257 | 292 | 301 | 309 | 318 | 326 | 365 | 373 | 390 | 398 | 415 | | | |
| 30 | 213 | 222 | 230 | 238 | 247 | 279 | 287 | 296 | 304 | 312 | 348 | 356 | 372 | 380 | 396 | | | |
| 35 | 204 | 212 | 220 | 228 | 236 | 267 | 274 | 282 | 290 | 297 | 331 | 339 | 353 | 361 | 375 | | | |
| 40 | 195 | 203 | 210 | 218 | 225 | 254 | 261 | 268 | 275 | 283 | 314 | 321 | 334 | 341 | 355 | | | |
| 42 | 192 | 199 | 206 | 214 | 221 | 249 | 256 | 263 | 270 | 277 | 307 | 314 | 327 | 333 | 346 | | | |
| 44 | 188 | 195 | 202 | 209 | 216 | 244 | 251 | 257 | 264 | 271 | 300 | 306 | 319 | 325 | 337 | | | |
| 46 | 185 | 192 | 199 | 205 | 212 | 239 | 245 | 252 | 258 | 265 | 293 | 299 | 311 | 317 | 329 | | | |
| 48 | 181 | 188 | 195 | 201 | 208 | 234 | 240 | 246 | 252 | 259 | 286 | 291 | 303 | 309 | 320 | | | |
| 50 | 178 | 184 | 191 | 197 | 204 | 228 | 235 | 241 | 247 | 253 | 278 | 284 | 295 | 301 | 311 | | | |
| 52 | 174 | 181 | 187 | 193 | 199 | 223 | 229 | 235 | 241 | 246 | 271 | 277 | 287 | 292 | 303 | | | |
| 54 | 171 | 177 | 183 | 189 | 195 | 218 | 224 | 229 | 235 | 240 | 264 | 269 | 279 | 284 | 294 | | | |
| 56 | 167 | 173 | 179 | 185 | 191 | 213 | 219 | 224 | 229 | 234 | 257 | 262 | 271 | 276 | 285 | | | |
| 58 | 164 | 170 | 175 | 181 | 187 | 208 | 213 | 218 | 224 | 229 | 250 | 255 | 264 | 268 | 277 | | | |
| 60 | 161 | 166 | 172 | 177 | 182 | 203 | 208 | 213 | 218 | 223 | 243 | 247 | 256 | 260 | 268 | | | |
| 62 | 157 | 163 | 168 | 173 | 178 | 198 | 203 | 208 | 212 | 217 | 236 | 240 | 248 | 252 | 260 | | | |
| 64 | 154 | 159 | 164 | 169 | 174 | 193 | 198 | 202 | 207 | 211 | 229 | 233 | 241 | 245 | 252 | | | |
| 66 | 150 | 156 | 160 | 165 | 170 | 188 | 193 | 197 | 201 | 205 | 223 | 226 | 234 | 237 | 244 | | | |
| 68 | 147 | 152 | 157 | 162 | 166 | 184 | 188 | 192 | 196 | 200 | 216 | 220 | 226 | 230 | 236 | | | |
| 70 | 144 | 149 | 153 | 158 | 162 | 179 | 183 | 187 | 190 | 194 | 210 | 213 | 219 | 222 | 228 | | | |
| 72 | 141 | 145 | 150 | 154 | 158 | 174 | 178 | 182 | 185 | 189 | 203 | 207 | 213 | 215 | 221 | | | |
| 74 | 138 | 142 | 146 | 150 | 154 | 170 | 173 | 177 | 180 | 183 | 197 | 200 | 206 | 209 | 214 | | | |
| 76 | 135 | 139 | 143 | 147 | 151 | 165 | 169 | 172 | 175 | 178 | 191 | 194 | 199 | 202 | 207 | | | |
| 78 | 132 | 136 | 139 | 143 | 147 | 161 | 164 | 167 | 170 | 173 | 186 | 188 | 193 | 195 | 200 | | | |
| 80 | 129 | 132 | 136 | 140 | 143 | 156 | 160 | 163 | 165 | 168 | 180 | 182 | 187 | 189 | 194 | | | |
| 82 | 126 | 129 | 133 | 136 | 140 | 152 | 155 | 158 | 161 | 163 | 175 | 177 | 181 | 183 | 187 | | | |
| 84 | 123 | 126 | 130 | 133 | 136 | 148 | 151 | 154 | 156 | 159 | 169 | 171 | 176 | 177 | 181 | | | |
| 86 | 120 | 123 | 127 | 130 | 133 | 144 | 147 | 149 | 152 | 154 | 164 | 166 | 170 | 172 | 175 | | | |
| 88 | 117 | 120 | 123 | 127 | 129 | 140 | 143 | 145 | 148 | 150 | 159 | 161 | 165 | 167 | 170 | | | |
| 90 | 114 | 118 | 121 | 123 | 126 | 137 | 139 | 141 | 144 | 146 | 154 | 156 | 160 | 161 | 164 | | | |
| 92 | 112 | 115 | 118 | 120 | 123 | 133 | 135 | 137 | 139 | 142 | 150 | 152 | 155 | 156 | 159 | | | |
| 94 | 109 | 112 | 115 | 117 | 120 | 129 | 132 | 134 | 136 | 138 | 145 | 147 | 150 | 152 | 154 | | | |
| 96 | 107 | 109 | 112 | 115 | 117 | 126 | 128 | 130 | 132 | 134 | 141 | 143 | 146 | 147 | 150 | | | |
| 98 | 104 | 107 | 109 | 112 | 114 | 123 | 125 | 126 | 128 | 130 | 137 | 138 | 141 | 143 | 145 | | | |
| 100 | 102 | 104 | 107 | 109 | 111 | 119 | 121 | 123 | 125 | 126 | 133 | 134 | 137 | 138 | 141 | | | |
| 102 | 99 | 102 | 104 | 106 | 108 | 116 | 118 | 120 | 121 | 123 | 129 | 131 | 133 | 134 | 136 | | | |
| 104 | 97 | 99 | 102 | 104 | 106 | 113 | 115 | 116 | 118 | 120 | 126 | 127 | 129 | 130 | 132 | | | |
| 106 | 95 | 97 | 99 | 101 | 103 | 110 | 112 | 113 | 115 | 116 | 122 | 123 | 125 | 126 | 128 | | | |
| 108 | 93 | 95 | 97 | 99 | 101 | 107 | 109 | 110 | 112 | 113 | 119 | 120 | 122 | 123 | 125 | | | |

Bolt data

Hole sizes – for ordinary bolts and friction grip connections

| Nominal diameter (mm) | Clearance hole diameter ^b (mm) | Oversize hole diameter ^a (mm) | Short slotted holes ^a (mm) | | Long slotted holes ^a (mm) | |
|-----------------------|---|--|---------------------------------------|----------------|--------------------------------------|-------------------|
| | | | Narrow dimension | Slot dimension | Narrow dimension | Maximum dimension |
| M12 ^a | 14 | 17 | 14 | 18 | 14 | 30 |
| M16 | 18 | 21 | 18 | 22 | 18 | 40 |
| M20 | 22 | 25 | 22 | 26 | 22 | 50 |
| M22 | 24 | 27 | 24 | 28 | 24 | 55 |
| M24 | 26 | 30 | 26 | 32 | 26 | 60 |
| M27 | 30 | 35 | 30 | 37 | 30 | 67 |
| M30 | 33 | 38 | 33 | 40 | 33 | 75 |

^aHardened washers to be used^bIn cases where there are more than three plies in joint the holes in the inner plies should be one millimetre larger than those in the outer plies

Bolt strengths

| | Bolt grade | | Steel grade | | |
|---|------------|-------------------|-------------|------|------|
| | 4.6 | 8.8 | S275 | S355 | S460 |
| Shear strength, p_s (N/mm ²) | 160 | 375 | | | |
| Bearing strength, p_{bb} (N/mm ²) | 460 | 1000 ^a | 460 | 550 | 670 |
| Tension strength, p_t (N/mm ²) | 240 | 560 | | | |

^aThe bearing value of the connected part is critical

Spacing, end and edge distances – minimum values (see Fig. 23.1)

| Nominal diameter of fastener (mm) | Diameter of clearance hole (mm) | Minimum spacing (mm) | Edge distance to rolled, sawn, planed, or machine flame cut edge (mm) | Edge distance to sheared edge or hand flame cut edge and end distance (mm) |
|-----------------------------------|---------------------------------|----------------------|---|--|
| M12 | 14 | 30 | 18 | 20 |
| M16 | 18 | 40 | 23 | 26 |
| M20 | 22 | 50 | 28 | 31 |
| M22 ^a | 24 | 55 | 30 | 34 |
| M24 | 26 | 60 | 33 | 37 |
| M27 ^a | 30 | 68 | 38 | 42 |
| M30 | 33 | 75 | 42 | 47 |

^aNon-preferred size

Maximum centres of fasteners

| Thickness of element (mm) | Spacing in the direction of stress (mm) | Spacing in any direction in corrosive environments (mm) |
|---------------------------|---|---|
| 5 | 70 | 80 |
| 6 | 84 | 96 |
| 7 | 98 | 112 |
| 8 | 112 | 128 |
| 9 | 126 | 144 |
| 10 | 140 | 160 |
| 11 | 154 | 176 |
| 12 | 168 | 192 |
| 13 | 182 | 200 |
| 14 | 196 | 200 |
| 15 | 210 | 200 |

Maximum edge distances (1)

| BS 4360 grade | Thickness less than or equal to (mm) | p_y (N/mm ²) | $\varepsilon = \left(\frac{275}{p_y} \right)^{1/2}$ | $11t\varepsilon^a$ |
|------------------|--|----------------------------|--|--------------------|
| S275 | 16 | 275 | 1.0 | $11t$ |
| | 40 | 265 | 1.02 | $11.21t$ |
| | 63 | 255 | 1.04 | $11.44t$ |
| | 80 | 245 | 1.06 | $11.65t$ |
| | 100 | 235 | 1.08 | $11.90t$ |
| S355 | 16 | 355 | 0.88 | $9.68t$ |
| | 40 | 345 | 0.89 | $9.79t$ |
| | 63 | 335 | 0.91 | $10.0t$ |
| | 80 | 325 | 0.92 | $10.12t$ |
| | 100 | 315 | 0.93 | $10.28t$ |
| S460 | 16 | 460 | 0.77 | $8.47t$ |
| | 40 | 440 | 0.79 | $8.69t$ |
| | 63 | 430 | 0.80 | $8.80t$ |
| | 80 | 410 | 0.82 | $9.02t$ |
| | 100 | 400 | 0.83 | $9.13t$ |

^aThis rule does not apply to fasteners interconnecting the components of back-to-back tension members
This table is expanded in the next table (Maximum edge distances (2))

Maximum edge distances (2)

| Thickness of element t (mm) | Corrosive environment $40\text{ mm} + 4t$ (mm) | Steel grade S275 $\varepsilon = 11t\varepsilon$ (mm) | Steel grade S355 $\varepsilon = 11t\varepsilon$ (mm) | Steel grade S460 $\varepsilon = 11t\varepsilon$ (mm) |
|-------------------------------------|---|---|---|---|
| 5 | 60 ^a | 55 ^a | 48 ^a | 42 ^a |
| 6 | 64 ^a | 66 | 58 ^a | 51 ^a |
| 7 | 68 ^a | 77 | 67 ^a | 59 |
| 8 | 72 ^a | 88 | 77 | 68 ^a |
| 9 | 76 | 99 | 87 | 76 |
| 10 | 80 | 110 | 96 | 85 |
| 11 | 84 | 121 | 106 | 93 |
| 12 | 88 | 132 | 116 | 102 |
| 13 | 92 | 143 | 125 | 110 |
| 14 | 96 | 154 | 135 | 119 |
| 15 | 100 | 165 | 145 | 127 |
| 16 | 104 | 176 | 154 | 136 |
| 20 | 120 | 224 | 196 | 174 |
| 25 | 140 | 280 | 245 | 217 |
| 30 | 160 | 336 | 294 | 261 |
| 35 | 180 | 392 | 343 | 304 |
| 40 | 200 | 448 | 392 | 347 |
| 45 | 220 | 515 | 445 | 396 |
| 50 | 240 | 572 | 501 | 440 |
| 55 | 260 | 629 | 551 | 484 |
| 60 | 280 | 686 | 601 | 528 |
| 65 | 300 | 757 | 657 | 586 |
| 70 | 320 | 816 | 708 | 631 |
| 75 | 340 | 874 | 759 | 677 |

^aUse the lesser values for the appropriate grade of steel

Back marks in channel flanges

| RSC | Nominal flange width (mm) | Back mark (mm) | Edge dist. (mm) | Recommended diameter (mm) |
|-----|---------------------------|----------------|-----------------|---------------------------|
| | 102 | 55 | 47 | 24 |
| | 89 | 55 | 34 | 20 |
| | 76 | 45 | 31 | 20 |
| | 64 | 35 | 29 | 16 |
| | 51 | 30 | 21 | 10 |
| | 38 | 22 | — | — |

Back marks in angles

| Nominal leg (mm) | S_1 (mm) | S_2 (mm) | S_3 (mm) | S_4 (mm) | S_5 (mm) | S_6 (mm) | Nominal leg (mm) | S_1 (mm) |
|------------------|------------|------------|------------|------------|------------|------------|------------------|------------|
| 250 | | | | | | | 75 | 45 (20) |
| 200 | | | | | | | 70 | 40 (20) |
| 150 | | | | | | | 65 | 35 (20) |
| 125 | | | | | | | 60 | 35 (16) |
| 120 | | | | | | | 50 | 28 (12) |
| 100 | 55 (24) | | | | | | 45 | 25 |
| 90 | 50 (24) | | | | | | 40 | 23 |
| 80 | 45 (20) | | | | | | 30 | 20 |
| | | S_1 | S_2 | S_3 | S_4 | S_5 | 25 | 15 |
| | | | | | | S_6 | | |

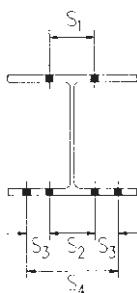
Maximum recommended bolt sizes are given in brackets

This table is reproduced from BCSA Publication No. 5/79, *Metric Practice for Structural Steelworks*, 3rd edn, 1979.

Cross centres through flanges

| Flange width (mm) | Minimum for accessibility (mm) | Maximum for edge dist. (mm) | S_1 (mm) | S_2 (mm) | S_3 (mm) | S_4 (mm) |
|-------------------|--------------------------------|-----------------------------|------------|------------|------------|------------|
| <i>Joists</i> | | | | | | |
| 44 | 27 (5) | 30 | 30 | | | |
| 64 | 38 (10) | 39 | 40 | | | |
| 76 | 48 (10) | 51 | 48 | | | |
| 89 | 54 (12) | 59 | 56 | | | |
| 102 | 60 (16) | 62 | 60 | | | |
| 114 | 66 (16) | 74 | 70 | | | |
| 127 | 72 (20) | 77 | 75 | | | |
| 152 | 75 (20) | 102 | 90 | | | |
| 203 | 91 (24) | 143 | 140 | | | |
| <i>UCs</i> | | | | | | |
| 152 | 65 (24) | 92 | 90 | | | |
| 203 | 75 (24) | 143 | 140 | | | |
| 254 | 87 (24) | 194 | 140 | | | |
| 305 | 100 (24) | 245 | 140 | 120 (24) | 60 (24) | 240 (24) |
| 368 | 88 (24) | 308 | 140 | 140 (24) | 75 (24) | 290 (24) |
| 406 | 120 (24) | 346 | 140 | 140 (24) | 75 (24) | 290 (24) |
| <i>UBs</i> | | | | | | |
| 102 | 50 (16) | 62 | 54 | | | |
| 127 | 62 (20) | 77 | 70 | | | |
| 133 | 57 (20) | 83 | 70 | | | |
| 140 | 69 (24) | 80 | 70 | | | |
| 146 | 64 (24) | 86 | 70 | | | |
| 152 | 73 (24) | 92 | 90 | | | |
| 165 | 67 (24) | 105 | 90 | | | |
| 171 | 72 (24) | 111 | 90 | | | |
| 178 | 72 (24) | 118 | 90 | | | |
| 191 | 74 (24) | 131 | 90 | | | |
| 210 | 80 (24) | 150 | 140 | | | |
| 229 | 80 (24) | 169 | 140 | | | |
| 254 | 87 (24) | 194 | 140 | | | |
| 267 | 91 (24) | 207 | 140 | 90 (20) | 50 (20) | 190 (20) |
| 292 | 94 (24) | 232 | 140 | 100 (24) | 60 (24) | 220 (24) |
| 305 | 100 (24) | 245 | 140 | 120 (24) | 60 (24) | 240 (24) |
| 419 | 112 (24) | 359 | 140 | 140 (24) | 75 (24) | 290 (24) |

Maximum bolt diameters for dimensions shown are given in brackets



BS 5950-1: 2000
BS 4190: 2001

BOLT CAPACITIES

NON-PRELOADED ORDINARY BOLTS

GRADE 4.6 BOLTS IN S275

| Diameter of Bolt mm | Tensile Stress Area A_t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | | |
|------------------------|---|---|----------------------------------|-----------------------------|------------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|--|
| | | Nominal $0.8A_tP_t$ P_{nom} kN | Exact A_tP_t P_t kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | | |
| | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | | | | | |
| 12 | 84.3 | 16.2 | 20.2 | 13.5 | 27.0 | 27.6 | 33.1 | 38.6 | 44.2 | 49.7 | 55.2 | 66.2 | 82.8 | 110 | 138 | 166 | |
| 16 | 157 | 30.1 | 37.7 | 25.1 | 50.2 | 36.8 | 44.2 | 51.5 | 58.9 | 66.2 | 73.6 | 88.3 | 110 | 147 | 184 | 221 | |
| 20 | 245 | 47.0 | 58.8 | 39.2 | 78.4 | 46.0 | 55.2 | 64.4 | 73.6 | 82.8 | 92.0 | 110 | 138 | 184 | 230 | 276 | |
| 22 | 303 | 58.2 | 72.7 | 48.5 | 97.0 | 50.6 | 60.7 | 70.8 | 81.0 | 91.1 | 101 | 121 | 152 | 202 | 253 | 304 | |
| 24 | 353 | 67.8 | 84.7 | 56.5 | 113 | 55.2 | 66.2 | 77.3 | 86.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 | |
| 27 | 459 | 88.1 | 110 | 73.4 | 147 | 62.1 | 74.5 | 86.9 | 99.4 | 112 | 124 | 149 | 186 | 248 | 311 | 373 | |
| 30 | 561 | 108 | 135 | 89.8 | 180 | 69.0 | 82.8 | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 | |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

GRADE 8.8 BOLTS IN S275

| Diameter of Bolt mm | Tensile Stress Area A_t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | | |
|------------------------|---|---|----------------------------------|-----------------------------|------------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|--|
| | | Nominal $0.8A_tP_t$ P_{nom} kN | Exact A_tP_t P_t kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | | |
| | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | | | | | |
| 12 | 84.3 | 37.8 | 47.2 | 31.6 | 63.2 | 27.6 | 33.1 | 38.6 | 44.2 | 49.7 | 55.2 | 66.2 | 82.8 | 110 | 138 | 166 | |
| 16 | 157 | 70.3 | 87.9 | 58.9 | 118 | 36.8 | 44.2 | 51.5 | 58.9 | 66.2 | 73.6 | 88.3 | 110 | 147 | 184 | 221 | |
| 20 | 245 | 110 | 137 | 91.9 | 184 | 46.0 | 55.2 | 64.4 | 73.6 | 82.8 | 92.0 | 110 | 138 | 184 | 230 | 276 | |
| 22 | 303 | 136 | 170 | 114 | 227 | 50.6 | 60.7 | 70.8 | 81.0 | 91.1 | 101 | 121 | 152 | 202 | 253 | 304 | |
| 24 | 353 | 158 | 198 | 132 | 265 | 55.2 | 66.2 | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 | |
| 27 | 459 | 206 | 257 | 172 | 344 | 62.1 | 74.5 | 86.9 | 99.4 | 112 | 124 | 149 | 186 | 248 | 311 | 373 | |
| 30 | 561 | 251 | 314 | 210 | 421 | 69.0 | 82.8 | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 | |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

BS 5950-1: 2000
BS 4190: 2001

BOLT CAPACITIES

NON-PRELOADED ORDINARY BOLTS

GRADE 10.9 BOLTS IN S275

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|-------------------------------|--------------------------|-----------------------|------------------------|--|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|
| | | Nominal $0.8A_t p_t$ kN | Exact $A_t p_t$ kN | Single P_s kN | Double $2P_s$ kN | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 47.2 | 59.0 | 33.7 | 67.4 | 27.6 | 33.1 | 38.6 | 44.2 | 49.7 | 55.2 | 66.2 | 82.8 | 110 | 138 | 166 |
| 16 | 157 | 87.9 | 110 | 62.8 | 126 | 36.8 | 44.2 | 51.5 | 58.9 | 66.2 | 73.6 | 88.3 | 110 | 147 | 184 | 221 |
| 20 | 245 | 137 | 172 | 98.0 | 196 | 46.0 | 55.2 | 64.4 | 73.6 | 82.8 | 92.0 | 110 | 138 | 184 | 230 | 276 |
| 22 | 303 | 170 | 212 | 121 | 242 | 50.6 | 60.7 | 70.8 | 81.0 | 91.1 | 101 | 121 | 152 | 202 | 253 | 304 |
| 24 | 353 | 198 | 247 | 141 | 282 | 55.2 | 66.2 | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 337 |
| 27 | 459 | 257 | 321 | 184 | 367 | 62.1 | 74.5 | 86.9 | 99.4 | 112 | 124 | 149 | 186 | 248 | 311 | 373 |
| 30 | 561 | 314 | 393 | 224 | 449 | 69.0 | 82.8 | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

BS 5950-1: 2000
BS 4190: 2001
BS 4933: 1973

BOLT CAPACITIES**NON-PRELOADED COUNTERSUNK BOLTS****GRADE 4.6 COUNTERSUNK BOLTS IN S275**

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|--|-------------------------|--------------------------------|---------------------------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|
| | | Nominal $0.8A_tP_t$ kN | Exact A_tP_t kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | Thickness in mm of ply passed through. | | | | | | | | | | | | | | |
| | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 16.2 | 20.2 | 13.5 | 27.0 | 11.0 | 16.6 | 22.1 | 27.6 | 33.1 | 38.6 | 49.7 | 66.2 | 93.8 | 121 | 149 |
| 16 | 157 | 30.1 | 37.7 | 25.1 | 50.2 | 7.36 | 14.7 | 22.1 | 29.4 | 36.8 | 44.2 | 58.9 | 81.0 | 118 | 155 | 191 |
| 20 | 245 | 47.0 | 58.8 | 39.2 | 78.4 | 0 | 9.20 | 18.4 | 27.6 | 36.8 | 46.0 | 64.4 | 92.0 | 138 | 184 | 230 |
| 22 | 303 | 58.2 | 72.7 | 48.5 | 97.0 | 0 | 5.06 | 15.2 | 25.3 | 35.4 | 45.5 | 65.8 | 96.1 | 147 | 197 | 248 |
| 24 | 353 | 67.8 | 84.7 | 56.5 | 113 | 0 | 0 | 11.0 | 22.1 | 33.1 | 44.2 | 66.2 | 99.4 | 155 | 210 | 265 |
| 27 | 459 | 88.1 | 110 | 73.4 | 147 | 0 | 0 | 3.11 | 15.5 | 27.9 | 40.4 | 65.2 | 102 | 165 | 227 | 289 |
| 30 | 561 | 108 | 135 | 89.8 | 180 | 0 | 0 | 0 | 6.90 | 20.7 | 34.5 | 62.1 | 104 | 173 | 242 | 311 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

Depth of countersink is taken as half the bolt diameter.

GRADE 8.8 COUNTERSUNK BOLTS IN S 275

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|--|-------------------------|--------------------------------|---------------------------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|
| | | Nominal $0.8A_tP_t$ kN | Exact A_tP_t kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | Thickness in mm of ply passed through. | | | | | | | | | | | | | | |
| | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 37.8 | 47.2 | 31.6 | 63.2 | 11.0 | 16.6 | 22.1 | 27.6 | 33.1 | 38.6 | 49.7 | 66.2 | 93.8 | 121 | 149 |
| 16 | 157 | 70.3 | 87.9 | 58.9 | 118 | 7.36 | 14.7 | 22.1 | 29.4 | 36.8 | 44.2 | 58.9 | 81.0 | 118 | 155 | 191 |
| 20 | 245 | 110 | 137 | 91.9 | 184 | 0 | 9.20 | 18.4 | 27.6 | 36.8 | 46.0 | 64.4 | 92.0 | 138 | 184 | 230 |
| 22 | 303 | 136 | 170 | 114 | 227 | 0 | 5.06 | 15.2 | 25.3 | 35.4 | 45.5 | 65.8 | 96.1 | 147 | 197 | 248 |
| 24 | 353 | 158 | 198 | 132 | 265 | 0 | 0 | 11.0 | 22.1 | 33.1 | 44.2 | 66.2 | 99.4 | 155 | 210 | 265 |
| 27 | 459 | 206 | 257 | 172 | 344 | 0 | 0 | 3.11 | 15.5 | 27.9 | 40.4 | 65.2 | 102 | 165 | 227 | 289 |
| 30 | 561 | 251 | 314 | 210 | 421 | 0 | 0 | 0 | 6.90 | 20.7 | 34.5 | 62.1 | 104 | 173 | 242 | 311 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

Depth of countersink is taken as half the bolt diameter.

BS 5950-1: 2000
BS 4190: 2001
BS 4933: 1973

BOLT CAPACITIES

NON-PRELOADED COUNTERSUNK BOLTS

GRADE 10.9 COUNTERSUNK BOLTS IN S 275

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{tb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|-------------------------|--------------------|-------------------|------------------|--|-------------|------|------|------|-------------|-------------|-------------|------|-----|-----|
| | | Nominal $0.8A_t p_i$ | Exact $A_t p_i$ | Single P_s | Double $2P_s$ | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | p_i kN | p_i kN | P_s kN | $2P_s$ kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 47.2 | 59.0 | 33.7 | 67.4 | 11.0 | 16.6 | 22.1 | 27.6 | 33.1 | 38.6 | 49.7 | 66.2 | 93.8 | 121 | 149 |
| 16 | 157 | 87.9 | 110 | 62.8 | 126 | 7.36 | 14.7 | 22.1 | 29.4 | 36.8 | 44.2 | 58.9 | 81.0 | 118 | 155 | 191 |
| 20 | 245 | 137 | 172 | 98.0 | 196 | 0 | 9.20 | 18.4 | 27.6 | 36.8 | 46.0 | 64.4 | 92.0 | 138 | 184 | 230 |
| 22 | 303 | 170 | 212 | 121 | 242 | 0 | 5.06 | 15.2 | 25.3 | 35.4 | 45.5 | 65.8 | 96.1 | 147 | 197 | 248 |
| 24 | 353 | 198 | 247 | 141 | 282 | 0 | 0 | 11.0 | 22.1 | 33.1 | 44.2 | 66.2 | 99.4 | 155 | 210 | 265 |
| 27 | 459 | 257 | 321 | 184 | 367 | 0 | 0 | 3.11 | 15.5 | 27.9 | 40.4 | 65.2 | 102 | 165 | 227 | 289 |
| 30 | 561 | 314 | 393 | 224 | 449 | 0 | 0 | 0 | 6.90 | 20.7 | 34.5 | 62.1 | 104 | 173 | 242 | 311 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

Depth of countersink is taken as half the bolt diameter.

BS 5950-1: 2000
BS 4395: 1969

BOLT CAPACITIES

NON-PRELOADED HSFG BOLTS

GENERAL GRADE HSFG BOLTS IN S275

| Diameter of Bolt mm | Tensile Stress Area A_t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | | |
|------------------------|---|-------------------------------|--------------------------|-----------------------------|------------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|--|
| | | Nominal $0.8A_t p_t$ kN | Exact $A_t p_t$ kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | | |
| | | P_{nom} kN | P_t kN | P_s kN | $2P_s$ kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | |
| 12 | 84.3 | 39.8 | 49.7 | 33.7 | 67.4 | 27.6 | 33.1 | 38.6 | 44.2 | 49.7 | 55.2 | 66.2 | 82.8 | 110 | 138 | 166 | |
| 16 | 157 | 74.1 | 92.6 | 62.8 | 126 | 36.8 | 44.2 | 51.5 | 58.9 | 66.2 | 73.6 | 88.3 | 110 | 147 | 184 | 221 | |
| 20 | 245 | 116 | 145 | 98.0 | 196 | 46.0 | 55.2 | 64.4 | 73.6 | 82.8 | 92.0 | 110 | 138 | 184 | 230 | 276 | |
| 22 | 303 | 143 | 179 | 121 | 242 | 50.6 | 60.7 | 70.8 | 81.0 | 91.1 | 101 | 121 | 152 | 202 | 253 | 304 | |
| 24 | 353 | 167 | 208 | 141 | 282 | 55.2 | 66.2 | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 | |
| 27 | 459 | 189 | 236 | 161 | 321 | 62.1 | 74.5 | 86.9 | 99.4 | 112 | 124 | 149 | 186 | 248 | 311 | 373 | |
| 30 | 561 | 231 | 289 | 196 | 393 | 69.0 | 82.8 | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 | |

Values in bold are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

HIGHER GRADE HSFG BOLTS IN S 275

| Diameter of Bolt mm | Tensile Stress Area A_t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | | |
|------------------------|---|-------------------------------|--------------------------|-----------------------------|------------------------------|--|------|------|------|------|------|------|-----|-----|-----|-----|--|
| | | Nominal $0.8A_t p_t$ kN | Exact $A_t p_t$ kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | | |
| | | P_{nom} kN | P_t kN | P_s kN | $2P_s$ kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | |
| 16 | 157 | 87.9 | 110 | 62.8 | 126 | 36.8 | 44.2 | 51.5 | 58.9 | 66.2 | 73.6 | 88.3 | 110 | 147 | 184 | 221 | |
| 20 | 245 | 137 | 172 | 98.0 | 196 | 46.0 | 55.2 | 64.4 | 73.6 | 82.8 | 92.0 | 110 | 138 | 184 | 230 | 276 | |
| 22 | 303 | 170 | 212 | 121 | 242 | 50.6 | 60.7 | 70.8 | 81.0 | 91.1 | 101 | 121 | 152 | 202 | 253 | 304 | |
| 24 | 353 | 198 | 247 | 141 | 282 | 55.2 | 66.2 | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 | |
| 27 | 459 | 257 | 321 | 184 | 367 | 62.1 | 74.5 | 86.9 | 99.4 | 112 | 124 | 149 | 186 | 248 | 311 | 373 | |
| 30 | 561 | 314 | 393 | 224 | 449 | 69.0 | 82.8 | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 | |

Values in bold are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

BS 5950-1: 2000

BS 4395: 1969

BS 4604: 1970

BOLT CAPACITIES**PRELOADED HSFG BOLTS: NON-SLIP IN SERVICE****GENERAL GRADE HSFG BOLTS IN S275**

| Diameter of Bolt mm | Min. Shank Tension P_s kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P_{bg} in kN End distance equal to 3 x bolt diameter. | | | | | | | | | | | |
|------------------------------|---|-----------------|-----------------|-------------------|-----------------|------------------------------------|-----------------|--|-------------|-------------|------------|------------|------|------|-----|-----|-----|-----|--|
| | | 1.1 P_s kN | $A_p P_s$ kN | Single Shear | Double Shear | Single Shear | Double Shear | Thickness in mm of ply passed through. | | | | | | | | | | | |
| | | | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | |
| 12 | 49.4 | 54.3 | 49.7 | 33.7 | 67.4 | 27.2 | 54.3 | 41.4 | 49.7 | 58.0 | 66.2 | 74.5 | 82.8 | 99.4 | 124 | 166 | 207 | 248 | |
| 16 | 92.1 | 101 | 92.6 | 62.8 | 126 | 50.7 | 101 | 55.2 | <i>66.2</i> | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 | |
| 20 | 144 | 158 | 145 | 98.0 | 195 | 79.2 | 158 | 89.0 | <i>82.8</i> | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 | |
| 22 | 177 | 195 | 179 | 121 | 242 | 97.4 | 195 | 75.9 | <i>91.1</i> | 106 | 121 | 137 | 152 | 182 | 228 | 304 | 380 | 455 | |
| 24 | 207 | 228 | 208 | 141 | 282 | 114 | 228 | 82.8 | <i>99.4</i> | 116 | <i>132</i> | 149 | 166 | 199 | 248 | 331 | 414 | 497 | |
| 27 | 234 | 257 | 236 | 161 | 321 | 129 | 257 | 93.2 | <i>112</i> | 130 | <i>149</i> | 168 | 186 | 224 | 279 | 373 | 466 | 559 | |
| 30 | 286 | 315 | 289 | 195 | 393 | 157 | 315 | 104 | <i>124</i> | 145 | <i>166</i> | 186 | 207 | 248 | 311 | 414 | 518 | 621 | |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

HIGHER GRADE HSFG BOLTS IN S275

| Diameter of Bolt mm | Min. Shank Tension P_s kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P_{bg} in kN End distance equal to 3 x bolt diameter. | | | | | | | | | | | |
|------------------------------|---|-----------------|-----------------|-------------------|-----------------|------------------------------------|-----------------|--|-------------|-------------|------------|------------|-----|-----|-----|-----|-----|-----|--|
| | | 1.1 P_s kN | $A_p P_s$ kN | Single Shear | Double Shear | Single Shear | Double Shear | Thickness in mm of ply passed through. | | | | | | | | | | | |
| | | | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | |
| 16 | 104 | 114 | 110 | 62.8 | 126 | 57.1 | 114 | 55.2 | <i>66.2</i> | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 | |
| 20 | 162 | 178 | 172 | 98.0 | 196 | 89.0 | 178 | 69.0 | <i>82.8</i> | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 | |
| 22 | 200 | 220 | 212 | 121 | 242 | 110 | 220 | 75.9 | <i>91.1</i> | 106 | 121 | 137 | 152 | 182 | 228 | 304 | 380 | 455 | |
| 24 | 233 | 257 | 247 | 141 | 282 | 128 | 257 | 82.8 | <i>99.4</i> | 116 | <i>132</i> | 149 | 166 | 199 | 248 | 331 | 414 | 497 | |
| 27 | 303 | 333 | 321 | 184 | 367 | 167 | 333 | 93.2 | <i>112</i> | 130 | <i>149</i> | 168 | 186 | 224 | 279 | 373 | 466 | 559 | |
| 30 | 370 | 407 | 393 | 224 | 449 | 204 | 407 | 104 | <i>124</i> | 145 | <i>166</i> | 186 | 207 | 248 | 311 | 414 | 518 | 621 | |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

BS 5950-1: 2000

BS 4395: 1969

BS 4604: 1970

BOLT CAPACITIES**PRELOADED HSFG BOLTS: NON-SLIP UNDER FACTORED LOADS****GENERAL GRADE HSFG BOLTS IN S275**

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{SL} | | | | | | | |
|------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 12 | 49.4 | 44.5 | 8.89 | 17.8 | 13.3 | 26.7 | 17.8 | 35.6 | 22.2 | 44.5 |
| 16 | 92.1 | 82.9 | 16.6 | 33.2 | 24.9 | 49.7 | 33.2 | 66.3 | 41.4 | 82.9 |
| 20 | 144 | 130 | 25.9 | 51.8 | 38.9 | 77.8 | 51.8 | 104 | 64.8 | 130 |
| 22 | 177 | 159 | 31.9 | 63.7 | 47.8 | 95.6 | 63.7 | 127 | 79.7 | 159 |
| 24 | 207 | 186 | 37.3 | 74.5 | 55.9 | 112 | 74.5 | 149 | 93.2 | 186 |
| 27 | 234 | 211 | 42.1 | 84.2 | 63.2 | 126 | 84.2 | 168 | 105 | 211 |
| 30 | 286 | 257 | 51.5 | 103 | 77.2 | 154 | 103 | 206 | 129 | 257 |

HIGHER GRADE HSFG BOLTS IN S 275

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{SL} | | | | | | | |
|------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 16 | 104 | 93.5 | 18.7 | 37.4 | 28.1 | 56.1 | 37.4 | 74.8 | 46.8 | 93.5 |
| 20 | 162 | 146 | 29.1 | 58.2 | 43.7 | 87.4 | 58.2 | 116 | 72.8 | 146 |
| 22 | 200 | 180 | 36.0 | 72.1 | 54.1 | 108 | 72.1 | 144 | 90.1 | 180 |
| 24 | 233 | 210 | 42.0 | 84.0 | 63.0 | 126 | 84.0 | 168 | 105 | 210 |
| 27 | 303 | 273 | 54.5 | 109 | 81.8 | 164 | 109 | 218 | 136 | 273 |
| 30 | 370 | 333 | 66.6 | 133 | 99.9 | 200 | 133 | 266 | 167 | 333 |

BS 5950-1: 2000

BS 4395: 1969

BS 4604: 1970

BS 4933: 1973

BOLT CAPACITIES**PRELOADED HSFG BOLTS: NON-SLIP IN SERVICE****GENERAL GRADE COUNTERSUNK HSFG BOLTS IN S275**

| Diameter of Bolt mm | Min. Shank Tension P_s kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P_{bg} in kN End distance equal to $3 \times$ bolt diameter. | | | | | | | | | | | | |
|------------------------------|---|-----------------|-------------|-----------------------|-----------------------|------------------------------------|-----------------------|---|-------------|-------------|-------------|-------------|-------------|-------------|------------|-----|-----|-----|--|--|
| | | 1.1 P_s kN | A_p kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Thickness in mm of ply passed through. | | | | | | | | | | | | |
| | | | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | | |
| 12 | 49.4 | 54.3 | 49.7 | 33.7 | 67.4 | 27.2 | 54.3 | 16.6 | 24.8 | 33.1 | 41.4 | 49.7 | 58.0 | 74.5 | 99.4 | 141 | 182 | 224 | | |
| 16 | 92.1 | 101 | 92.6 | 62.8 | 126 | 50.7 | 101 | 11.0 | 22.1 | 33.1 | 44.2 | 55.2 | 66.2 | 88.3 | 121 | 177 | 232 | 287 | | |
| 20 | 144 | 158 | 145 | 98.0 | 196 | 79.2 | 158 | 0 | 13.8 | 27.6 | 41.4 | 55.2 | 69.0 | 96.6 | 138 | 207 | 276 | 345 | | |
| 22 | 177 | 195 | 179 | 121 | 242 | 97.4 | 195 | 0 | 7.59 | 22.8 | 38.0 | 53.1 | 68.3 | 98.7 | 144 | 220 | 296 | 372 | | |
| 24 | 207 | 228 | 208 | 141 | 282 | 114 | 228 | 0 | 0 | 16.6 | 33.1 | 49.7 | 66.2 | 99.4 | 149 | 232 | 315 | 397 | | |
| 27 | 234 | 257 | 236 | 161 | 321 | 129 | 257 | 0 | 0 | 4.66 | 23.3 | 41.9 | 60.5 | 97.8 | 154 | 247 | 340 | 433 | | |
| 30 | 286 | 315 | 289 | 196 | 393 | 157 | 315 | 0 | 0 | 0 | 10.4 | 31.1 | 51.8 | 93.2 | 155 | 259 | 362 | 466 | | |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

HIGHER GRADE COUNTERSUNK HSFG BOLTS IN S275

| Diameter of Bolt mm | Min. Shank Tension P_s kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P_{bg} in kN End distance equal to $3 \times$ bolt diameter. | | | | | | | | | | | | |
|------------------------------|---|-----------------|-------------|-----------------------|-----------------------|------------------------------------|-----------------------|---|-------------|-------------|-------------|-------------|-------------|-------------|------------|-----|-----|-----|--|--|
| | | 1.1 P_s kN | A_p kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Thickness in mm of ply passed through. | | | | | | | | | | | | |
| | | | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | | |
| 16 | 104 | 114 | 110 | 62.8 | 126 | 57.1 | 114 | 11.0 | 22.1 | 33.1 | 44.2 | 55.2 | 66.2 | 88.3 | 121 | 177 | 232 | 287 | | |
| 20 | 162 | 178 | 172 | 98.0 | 196 | 89.0 | 178 | 0 | 13.8 | 27.6 | 41.4 | 55.2 | 69.0 | 96.6 | 138 | 207 | 276 | 345 | | |
| 22 | 200 | 220 | 212 | 121 | 242 | 110 | 220 | 0 | 7.59 | 22.8 | 38.0 | 53.1 | 68.3 | 98.7 | 144 | 220 | 296 | 372 | | |
| 24 | 233 | 257 | 247 | 141 | 282 | 128 | 257 | 0 | 0 | 16.6 | 33.1 | 49.7 | 66.2 | 99.4 | 149 | 232 | 315 | 397 | | |
| 27 | 303 | 333 | 321 | 184 | 367 | 167 | 333 | 0 | 0 | 4.66 | 23.3 | 41.9 | 60.5 | 97.8 | 154 | 247 | 340 | 433 | | |
| 30 | 370 | 407 | 393 | 224 | 449 | 204 | 407 | 0 | 0 | 0 | 10.4 | 31.1 | 51.8 | 93.2 | 155 | 259 | 362 | 466 | | |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

BS 5950-1: 2000
 BS 4395: 1969
 BS 4604: 1970
 BS 4933: 1973

BOLT CAPACITIES**PRELOADED HSFG BOLTS: NON-SLIP UNDER FACTORED LOADS****GENERAL GRADE COUNTERSUNK HSFG BOLTS IN S275**

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{SL} | | | | | | | |
|----------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 12 | 49.4 | 44.5 | 8.89 | 17.8 | 13.3 | 26.7 | 17.8 | 35.6 | 22.2 | 44.5 |
| 16 | 92.1 | 82.9 | 16.6 | 33.2 | 24.9 | 49.7 | 33.2 | 66.3 | 41.4 | 82.9 |
| 20 | 144 | 130 | 25.9 | 51.8 | 38.9 | 77.8 | 51.8 | 104 | 64.8 | 130 |
| 22 | 177 | 159 | 31.9 | 63.7 | 47.8 | 95.6 | 63.7 | 127 | 79.7 | 159 |
| 24 | 207 | 186 | 37.3 | 74.5 | 55.9 | 112 | 74.5 | 149 | 93.2 | 186 |
| 27 | 234 | 211 | 42.1 | 84.2 | 63.2 | 126 | 84.2 | 168 | 105 | 211 |
| 30 | 286 | 257 | 51.5 | 103 | 77.2 | 154 | 103 | 206 | 129 | 257 |

HIGHER GRADE COUNTERSUNK HSFG BOLTS IN S 275

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{SL} | | | | | | | |
|----------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 16 | 104 | 93.5 | 18.7 | 37.4 | 28.1 | 56.1 | 37.4 | 74.8 | 46.8 | 93.5 |
| 20 | 162 | 146 | 29.1 | 58.2 | 43.7 | 87.4 | 58.2 | 116 | 72.8 | 146 |
| 22 | 200 | 180 | 36.0 | 72.1 | 54.1 | 108 | 72.1 | 144 | 90.1 | 180 |
| 24 | 233 | 210 | 42.0 | 84.0 | 63.0 | 126 | 84.0 | 168 | 105 | 210 |
| 27 | 303 | 273 | 54.5 | 109 | 81.8 | 164 | 109 | 218 | 136 | 273 |
| 30 | 370 | 333 | 66.6 | 133 | 99.9 | 200 | 133 | 266 | 167 | 333 |

BS 5950-1: 2000
BS 4190: 2001

BOLT CAPACITIES

NON-PRELOADED ORDINARY BOLTS

GRADE 4.6 BOLTS IN S355

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|-------------------------|--------------------|-------------------|------------------|--|------|------|------|------|------|------|------|-----|-----|-----|
| | | Nominal $0.8A_t p_i$ | Exact $A_t p_i$ | Single P_s | Double $2P_s$ | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | p_i kN | p_i kN | P_s kN | $2P_s$ kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 16.2 | 20.2 | 13.5 | 27.0 | 27.6 | 33.1 | 38.6 | 44.2 | 49.7 | 55.2 | 66.2 | 82.8 | 110 | 138 | 166 |
| 16 | 157 | 30.1 | 37.7 | 25.1 | 50.2 | 36.8 | 44.2 | 51.5 | 58.9 | 66.2 | 73.6 | 88.3 | 110 | 147 | 184 | 221 |
| 20 | 245 | 47.0 | 58.8 | 39.2 | 78.4 | 46.0 | 55.2 | 64.4 | 73.6 | 82.8 | 92.0 | 110 | 138 | 184 | 230 | 276 |
| 22 | 303 | 58.2 | 72.7 | 48.5 | 97.0 | 50.6 | 60.7 | 70.8 | 81.0 | 91.1 | 101 | 121 | 152 | 202 | 253 | 304 |
| 24 | 353 | 67.8 | 84.7 | 56.5 | 113 | 55.2 | 66.2 | 77.3 | 88.3 | 99.4 | 110 | 132 | 166 | 221 | 276 | 331 |
| 27 | 459 | 88.1 | 110 | 73.4 | 147 | 62.1 | 74.5 | 86.9 | 99.4 | 112 | 124 | 149 | 186 | 248 | 311 | 373 |
| 30 | 561 | 108 | 135 | 89.8 | 180 | 69.0 | 82.8 | 96.6 | 110 | 124 | 138 | 166 | 207 | 276 | 345 | 414 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

GRADE 8.8 BOLTS IN S355

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|-------------------------|--------------------|-------------------|------------------|--|------|------|------|------|------|------|------|-----|-----|-----|
| | | Nominal $0.8A_t p_i$ | Exact $A_t p_i$ | Single P_s | Double $2P_s$ | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | p_i kN | p_i kN | P_s kN | $2P_s$ kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 37.8 | 47.2 | 31.6 | 63.2 | 33.0 | 39.6 | 46.2 | 52.8 | 59.4 | 66.0 | 79.2 | 99.0 | 132 | 165 | 198 |
| 16 | 157 | 70.3 | 87.9 | 58.9 | 118 | 44.0 | 52.8 | 61.6 | 70.4 | 79.2 | 88.0 | 106 | 132 | 176 | 220 | 264 |
| 20 | 245 | 110 | 137 | 91.9 | 184 | 55.0 | 66.0 | 77.0 | 88.0 | 99.0 | 110 | 132 | 165 | 220 | 275 | 330 |
| 22 | 303 | 136 | 170 | 114 | 227 | 60.5 | 72.6 | 84.7 | 96.8 | 109 | 121 | 145 | 182 | 242 | 303 | 363 |
| 24 | 353 | 158 | 198 | 132 | 265 | 66.0 | 79.2 | 92.4 | 106 | 119 | 132 | 158 | 198 | 264 | 330 | 396 |
| 27 | 459 | 206 | 257 | 172 | 344 | 74.3 | 89.1 | 104 | 119 | 134 | 149 | 178 | 223 | 297 | 371 | 446 |
| 30 | 561 | 251 | 314 | 210 | 421 | 82.5 | 99.0 | 116 | 132 | 149 | 165 | 198 | 248 | 330 | 413 | 495 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

BS 5950-1: 2000
BS 4190: 2001

BOLT CAPACITIES

NON-PRELOADED ORDINARY BOLTS

GRADE 10.9 BOLTS IN S355

| Diameter of Bolt mm | Tensile Stress Area A _t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P _{bb} and P _{bs}) | | | | | | | | | | |
|----------------------------------|--|---|--|--------------------------------|---------------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|
| | | Nominal 0.8A _t P _t kN | Exact A _t P _t kN | Single P _s kN | Double 2P _s kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | |
| | | Thickness in mm of ply passed through. | | | | | | | | | | | | | | |
| 12 | 84.3 | 47.2 | 59.0 | 33.7 | 67.4 | 33.0 | 39.6 | 46.2 | 52.8 | 59.4 | 66.0 | 79.2 | 99.0 | 132 | 165 | 198 |
| 16 | 157 | 87.9 | 110 | 62.8 | 126 | 44.0 | 52.8 | 61.6 | 70.4 | 79.2 | 88.0 | 106 | 132 | 176 | 220 | 264 |
| 20 | 245 | 137 | 172 | 98.0 | 196 | 55.0 | 66.0 | 77.0 | 88.0 | 99.0 | 110 | 132 | 165 | 220 | 275 | 330 |
| 22 | 303 | 170 | 212 | 121 | 242 | 60.5 | 72.6 | 84.7 | 96.8 | 109 | 121 | 145 | 182 | 242 | 303 | 363 |
| 24 | 353 | 198 | 247 | 141 | 282 | 66.0 | 79.2 | 92.4 | 106 | 119 | 132 | 158 | 198 | 264 | 330 | 396 |
| 27 | 459 | 257 | 321 | 184 | 367 | 74.3 | 89.1 | 104 | 119 | 134 | 149 | 178 | 223 | 297 | 371 | 446 |
| 30 | 561 | 314 | 393 | 224 | 449 | 82.5 | 99.0 | 116 | 132 | 149 | 165 | 198 | 248 | 330 | 413 | 495 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

BS 5950-1: 2000
BS 4190: 2001
BS 4933: 1973

BOLT CAPACITIES

NON-PRELOADED COUNTERSUNK BOLTS

GRADE 4.6 COUNTERSUNK BOLTS IN S355

| Diameter of Bolt mm | Tensile Stress Area A _t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P _{bb} and P _{bs}) | | | | | | | | | | | |
|---------------------|--|--------------------------------|---|--------------------------------|---------------------------------|--|------|------|------|------|------|------|------|------|-----|-----|--|
| | | Nominal P _{nom} kN | Exact 0.8A _t P _t kN | Single Shear P _s kN | Double Shear 2P _s kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | | |
| | | A _t mm ² | P _t kN | P _s kN | 2P _s kN | Thickness in mm of ply passed through. | | | | | | | | | | | |
| | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | | | | | |
| 12 | 84.3 | 16.2 | 20.2 | 13.5 | 27.0 | 11.0 | 16.6 | 22.1 | 27.6 | 33.1 | 38.6 | 49.7 | 66.2 | 93.8 | 121 | 149 | |
| 16 | 157 | 30.1 | 37.7 | 25.1 | 50.2 | 7.36 | 14.7 | 22.1 | 29.4 | 36.8 | 44.2 | 58.9 | 81.0 | 118 | 155 | 191 | |
| 20 | 245 | 47.0 | 58.8 | 39.2 | 78.4 | 0 | 9.20 | 18.4 | 27.6 | 36.8 | 46.0 | 64.4 | 92.0 | 138 | 184 | 230 | |
| 22 | 303 | 58.2 | 72.7 | 48.5 | 97.0 | 0 | 5.06 | 15.2 | 25.3 | 35.4 | 45.5 | 65.8 | 96.1 | 147 | 197 | 248 | |
| 24 | 353 | 67.8 | 84.7 | 56.5 | 113 | 0 | 0 | 11.0 | 22.1 | 33.1 | 44.2 | 66.2 | 99.4 | 155 | 210 | 265 | |
| 27 | 459 | 88.1 | 110 | 73.4 | 147 | 0 | 0 | 3.11 | 15.5 | 27.9 | 40.4 | 65.2 | 102 | 165 | 227 | 289 | |
| 30 | 561 | 108 | 135 | 89.8 | 180 | 0 | 0 | 0 | 6.90 | 20.7 | 34.5 | 62.1 | 104 | 173 | 242 | 311 | |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

Depth of countersink is taken as half the bolt diameter.

GRADE 8.8 COUNTERSUNK BOLTS IN S 355

| Diameter of Bolt mm | Tensile Stress Area A _t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P _{bb} and P _{bs}) | | | | | | | | | | | |
|---------------------|--|--------------------------------|---|--------------------------------|---------------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|--|
| | | Nominal P _{nom} kN | Exact 0.8A _t P _t kN | Single Shear P _s kN | Double Shear 2P _s kN | End distance equal to 2 x bolt diameter. | | | | | | | | | | | |
| | | A _t mm ² | P _t kN | P _s kN | 2P _s kN | Thickness in mm of ply passed through. | | | | | | | | | | | |
| | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | | | | | |
| 12 | 84.3 | 37.8 | 47.2 | 31.6 | 63.2 | 13.2 | 19.8 | 26.4 | 33.0 | 39.6 | 46.2 | 59.4 | 79.2 | 112 | 145 | 178 | |
| 16 | 157 | 70.3 | 87.9 | 58.9 | 118 | 8.80 | 17.6 | 26.4 | 35.2 | 44.0 | 52.8 | 70.4 | 96.8 | 141 | 185 | 229 | |
| 20 | 245 | 110 | 137 | 91.9 | 184 | 0 | 11.0 | 22.0 | 33.0 | 44.0 | 55.0 | 77.0 | 110 | 165 | 220 | 275 | |
| 22 | 303 | 136 | 170 | 114 | 227 | 0 | 6.05 | 18.2 | 30.3 | 42.4 | 54.5 | 78.7 | 115 | 175 | 236 | 296 | |
| 24 | 353 | 158 | 198 | 132 | 265 | 0 | 0 | 13.2 | 26.4 | 39.6 | 52.8 | 79.2 | 119 | 185 | 251 | 317 | |
| 27 | 459 | 206 | 257 | 172 | 344 | 0 | 0 | 3.71 | 18.6 | 33.4 | 48.3 | 78.0 | 123 | 197 | 271 | 345 | |
| 30 | 561 | 251 | 314 | 210 | 421 | 0 | 0 | 0 | 8.25 | 24.8 | 41.3 | 74.3 | 124 | 206 | 289 | 371 | |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

Depth of countersink is taken as half the bolt diameter.

BS 5950-1: 2000
BS 4190: 2001
BS 4933: 1973

BOLT CAPACITIES**NON-PRELOADED COUNTERSUNK BOLTS**

GRADE 10.9 COUNTERSUNK BOLTS IN S355

| Diameter of Bolt mm | Tensile Stress Area A_t mm^2 | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|------------------------------|---|--|-----------------------------------|-----------------------|------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|
| | | Nominal $0.8A_t p_t$ P_{nom} kN | Exact $A_t p_t$ P_t kN | Single P_s kN | Double $2P_s$ kN | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | Thickness in mm of ply passed through. | | | | | | | | | | | | | | |
| | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 47.2 | 59.0 | 33.7 | 67.4 | 13.2 | 19.8 | 26.4 | 33.0 | 39.6 | 46.2 | 59.4 | 79.2 | 112 | 145 | 178 |
| 16 | 157 | 87.9 | 110 | 62.8 | 126 | 8.80 | 17.6 | 26.4 | 35.2 | 44.0 | 52.8 | 70.4 | 96.8 | 141 | 185 | 229 |
| 20 | 245 | 137 | 172 | 98.0 | 196 | 0 | 11.0 | 22.0 | 33.0 | 44.0 | 55.0 | 77.0 | 110 | 165 | 220 | 275 |
| 22 | 303 | 170 | 212 | 121 | 242 | 0 | 6.05 | 18.2 | 30.3 | 42.4 | 54.5 | 78.7 | 115 | 175 | 236 | 296 |
| 24 | 353 | 198 | 247 | 141 | 282 | 0 | 0 | 13.2 | 26.4 | 39.6 | 52.8 | 79.2 | 119 | 185 | 251 | 317 |
| 27 | 459 | 257 | 321 | 184 | 367 | 0 | 0 | 3.71 | 18.6 | 33.4 | 48.3 | 78.0 | 123 | 197 | 271 | 345 |
| 30 | 561 | 314 | 393 | 224 | 449 | 0 | 0 | 0 | 8.25 | 24.8 | 41.3 | 74.3 | 124 | 206 | 289 | 371 |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

Depth of countersink is taken as half the bolt diameter.

BS 5950-1: 2000
BS 4395: 1969

BOLT CAPACITIES

NON-PRELOADED HSFG BOLTS

GENERAL GRADE HSFG BOLTS IN S355

| Diameter of Bolt mm | Tensile Stress Area A_t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|---------------------|---|-------------------------|--------------------|-----------------------|------------------------|--|------|------|------|------|------|------|------|-----|-----|-----|
| | | Nominal $0.8A_t p_i$ kN | Exact $A_t p_i$ kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 84.3 | 39.8 | 49.7 | 33.7 | 67.4 | 33.0 | 39.6 | 46.2 | 52.8 | 59.4 | 66.0 | 79.2 | 99.0 | 132 | 165 | 198 |
| 16 | 157 | 74.1 | 92.6 | 62.8 | 126 | 44.0 | 52.8 | 61.6 | 70.4 | 79.2 | 88.0 | 106 | 132 | 176 | 220 | 264 |
| 20 | 245 | 116 | 145 | 98.0 | 196 | 55.0 | 66.0 | 77.0 | 88.0 | 99.0 | 110 | 132 | 165 | 220 | 275 | 330 |
| 22 | 303 | 143 | 179 | 121 | 242 | 60.5 | 72.6 | 84.7 | 96.8 | 109 | 121 | 145 | 182 | 242 | 303 | 363 |
| 24 | 353 | 167 | 208 | 141 | 282 | 66.0 | 79.2 | 92.4 | 106 | 119 | 132 | 158 | 198 | 254 | 330 | 396 |
| 27 | 459 | 189 | 236 | 161 | 321 | 74.3 | 89.1 | 104 | 119 | 134 | 149 | 178 | 223 | 297 | 371 | 446 |
| 30 | 561 | 231 | 289 | 196 | 393 | 82.5 | 99.0 | 116 | 132 | 149 | 165 | 198 | 248 | 330 | 413 | 495 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

HIGHER GRADE HSFG BOLTS IN S 355

| Diameter of Bolt mm | Tensile Stress Area A_t mm ² | Tension Capacity | | Shear Capacity | | Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) | | | | | | | | | | |
|---------------------|---|-------------------------|--------------------|-----------------------|------------------------|--|------|------|------|------|------|-----|-----|-----|-----|-----|
| | | Nominal $0.8A_t p_i$ kN | Exact $A_t p_i$ kN | Single Shear P_s kN | Double Shear $2P_s$ kN | End distance equal to $2 \times$ bolt diameter. | | | | | | | | | | |
| | | | | | | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 16 | 157 | 87.9 | 110 | 62.8 | 126 | 44.0 | 52.8 | 61.6 | 70.4 | 79.2 | 88.0 | 106 | 132 | 176 | 220 | 264 |
| 20 | 245 | 137 | 172 | 98.0 | 196 | 55.0 | 66.0 | 77.0 | 88.0 | 99.0 | 110 | 132 | 165 | 220 | 275 | 330 |
| 22 | 303 | 170 | 212 | 121 | 242 | 60.5 | 72.6 | 84.7 | 96.8 | 109 | 121 | 145 | 182 | 242 | 303 | 363 |
| 24 | 353 | 198 | 247 | 141 | 282 | 66.0 | 79.2 | 92.4 | 106 | 119 | 132 | 158 | 198 | 264 | 330 | 396 |
| 27 | 459 | 257 | 321 | 184 | 367 | 74.3 | 89.1 | 104 | 119 | 134 | 149 | 178 | 223 | 297 | 371 | 446 |
| 30 | 561 | 314 | 393 | 224 | 449 | 82.5 | 99.0 | 116 | 132 | 149 | 165 | 198 | 248 | 330 | 413 | 495 |

Values in **bold** are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

BS 6950-1: 2000
BS 4395: 1969
BS 4604: 1970

BOLT CAPACITIES**PRELOADED HSFG BOLTS: NON-SLIP IN SERVICE****GENERAL GRADE HSFG BOLTS IN S355**

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P_{bg} in kN | | | | | | | | | | | |
|------------------------------|---|-----------------|---------------|-------------------|-----------------|------------------------------------|-----------------|---|------|------|------|------|------|-----|-----|-----|-----|-----|--|
| | | 1.1 P_o kN | A_p , kN | Single Shear | Double Shear | Single Shear | Double Shear | End distance equal to $3 \times$ bolt diameter. | | | | | | | | | | | |
| | | | | kN | kN | kN | kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | |
| 12 | 49.4 | 54.3 | 49.7 | 33.7 | 67.4 | 27.2 | 54.3 | 49.5 | 59.4 | 69.3 | 79.2 | 89.1 | 99.0 | 119 | 149 | 198 | 248 | 297 | |
| 16 | 92.1 | 101 | 92.6 | 62.8 | 126 | 50.7 | 101 | 66.0 | 79.2 | 92.4 | 106 | 119 | 132 | 158 | 198 | 264 | 330 | 396 | |
| 20 | 144 | 158 | 145 | 98.0 | 196 | 79.2 | 158 | 82.5 | 99.0 | 116 | 132 | 149 | 165 | 198 | 248 | 330 | 413 | 495 | |
| 22 | 177 | 195 | 179 | 121 | 242 | 97.4 | 195 | 90.8 | 109 | 127 | 145 | 163 | 182 | 218 | 272 | 363 | 454 | 545 | |
| 24 | 207 | 228 | 208 | 141 | 282 | 114 | 228 | 99.0 | 119 | 139 | 158 | 178 | 198 | 238 | 297 | 396 | 495 | 594 | |
| 27 | 234 | 257 | 236 | 161 | 321 | 129 | 257 | 111 | 134 | 156 | 178 | 200 | 223 | 267 | 334 | 446 | 557 | 668 | |
| 30 | 286 | 315 | 289 | 196 | 393 | 157 | 315 | 124 | 149 | 173 | 198 | 223 | 248 | 297 | 371 | 495 | 619 | 743 | |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

HIGHER GRADE HSFG BOLTS IN S355

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P_{bg} in kN | | | | | | | | | | | |
|------------------------------|---|-----------------|---------------|-------------------|-----------------|------------------------------------|-----------------|---|------|------|-----|-----|-----|-----|-----|-----|-----|-----|--|
| | | 1.1 P_o kN | A_p , kN | Single Shear | Double Shear | Single Shear | Double Shear | End distance equal to $3 \times$ bolt diameter. | | | | | | | | | | | |
| | | | | kN | kN | kN | kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 | |
| 16 | 104 | 114 | 110 | 62.8 | 126 | 57.1 | 114 | 66.0 | 79.2 | 92.4 | 106 | 119 | 132 | 158 | 198 | 264 | 330 | 396 | |
| 20 | 162 | 178 | 172 | 98.0 | 196 | 89.0 | 178 | 82.5 | 99.0 | 116 | 132 | 149 | 165 | 198 | 248 | 330 | 413 | 495 | |
| 22 | 200 | 220 | 212 | 121 | 242 | 110 | 220 | 90.8 | 109 | 127 | 145 | 163 | 182 | 218 | 272 | 363 | 454 | 545 | |
| 24 | 233 | 257 | 247 | 141 | 282 | 128 | 257 | 99.0 | 119 | 139 | 158 | 178 | 198 | 238 | 297 | 396 | 495 | 594 | |
| 27 | 303 | 333 | 321 | 184 | 367 | 167 | 333 | 111 | 134 | 156 | 178 | 200 | 223 | 267 | 334 | 446 | 557 | 668 | |
| 30 | 370 | 407 | 393 | 224 | 449 | 204 | 407 | 124 | 149 | 173 | 198 | 223 | 248 | 297 | 371 | 495 | 619 | 743 | |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

BS 5950-1: 2000
BS 4395: 1969
BS 4604: 1970

BOLT CAPACITIES

PRELOADED HSFG BOLTS: NON-SLIP UNDER FACTORED LOADS

GENERAL GRADE HSFG BOLTS IN S355

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{sl} | | | | | | | |
|----------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 12 | 49.4 | 44.5 | 8.89 | 17.8 | 13.3 | 26.7 | 17.8 | 35.6 | 22.2 | 44.5 |
| 16 | 92.1 | 82.9 | 16.6 | 33.2 | 24.9 | 49.7 | 33.2 | 66.3 | 41.4 | 82.9 |
| 20 | 144 | 130 | 25.9 | 51.8 | 38.9 | 77.8 | 51.8 | 104 | 64.8 | 130 |
| 22 | 177 | 159 | 31.9 | 63.7 | 47.8 | 95.6 | 63.7 | 127 | 79.7 | 159 |
| 24 | 207 | 186 | 37.3 | 74.5 | 55.9 | 112 | 74.5 | 149 | 93.2 | 186 |
| 27 | 234 | 211 | 42.1 | 84.2 | 63.2 | 126 | 84.2 | 168 | 105 | 211 |
| 30 | 286 | 257 | 51.5 | 103 | 77.2 | 154 | 103 | 206 | 129 | 257 |

HIGHER GRADE HSFG BOLTS IN S355

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{sl} | | | | | | | |
|----------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 16 | 104 | 93.5 | 18.7 | 37.4 | 28.1 | 56.1 | 37.4 | 74.8 | 46.8 | 93.5 |
| 20 | 162 | 146 | 29.1 | 58.2 | 43.7 | 87.4 | 58.2 | 116 | 72.8 | 146 |
| 22 | 200 | 180 | 36.0 | 72.1 | 54.1 | 108 | 72.1 | 144 | 90.1 | 180 |
| 24 | 233 | 210 | 42.0 | 84.0 | 63.0 | 126 | 84.0 | 168 | 105 | 210 |
| 27 | 303 | 273 | 54.5 | 109 | 81.8 | 164 | 109 | 218 | 136 | 273 |
| 30 | 370 | 333 | 66.6 | 133 | 99.9 | 200 | 133 | 266 | 167 | 333 |

BS 5950-1: 2000
BS 4395: 1969
BS 4604: 1970
BS 4933: 1973

BOLT CAPACITIES**PRELOADED HSFG BOLTS: NON-SLIP IN SERVICE****GENERAL GRADE COUNTERSUNK HSFG BOLTS IN S355**

| Diameter of Bolt mm | Min. Shank Tension P _s kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P _{bg} in kN | | | | | | | | | | |
|---------------------|--------------------------------------|----------------------------------|-------------------------------|----------------|--------------|---------------------------------|--------------|--|-------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|
| | | P _s 1.1P _s | A _b P _s | Single Shear | Double Shear | Single Shear | Double Shear | End distance equal to 3 x bolt diameter. | | | | | | | | | | |
| | | kN | kN | kN | kN | kN | kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 12 | 49.4 | 54.3 | 49.7 | 33.7 | 67.4 | 27.2 | 54.3 | 19.8 | 29.7 | 39.6 | 49.5 | 59.4 | 69.3 | 89.1 | 119 | 168 | 218 | 267 |
| 16 | 92.1 | 101 | 92.6 | 62.8 | 126 | 50.7 | 101 | 13.2 | 26.4 | 39.6 | 52.8 | 66.0 | 79.2 | 106 | 145 | 211 | 277 | 343 |
| 20 | 144 | 158 | 145 | 98.0 | 196 | 79.2 | 158 | 0 | 16.5 | 33.0 | 49.5 | 66.0 | 82.5 | 116 | 165 | 248 | 330 | 413 |
| 22 | 177 | 195 | 179 | 121 | 242 | 97.4 | 195 | 0 | 9.08 | 27.2 | 45.4 | 63.5 | 81.7 | 118 | 172 | 263 | 354 | 445 |
| 24 | 207 | 228 | 208 | 141 | 282 | 114 | 228 | 0 | 0 | 19.8 | 39.6 | 59.4 | 79.2 | 119 | 178 | 277 | 376 | 475 |
| 27 | 234 | 257 | 236 | 161 | 321 | 129 | 257 | 0 | 0 | 5.57 | 27.8 | 50.1 | 72.4 | 117 | 184 | 295 | 407 | 518 |
| 30 | 266 | 315 | 289 | 196 | 393 | 157 | 315 | 0 | 0 | 0 | 12.4 | 37.1 | 61.9 | 111 | 186 | 309 | 433 | 557 |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

HIGHER GRADE COUNTERSUNK HSFG BOLTS IN S355

| Diameter of Bolt mm | Min. Shank Tension P _s kN | Tension | | Shear Capacity | | Slip Resistance for $\mu = 0.5$ | | Bearing Capacity, P _{bg} in kN | | | | | | | | | | |
|---------------------|--------------------------------------|----------------------------------|-------------------------------|----------------|--------------|---------------------------------|--------------|--|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|
| | | P _s 1.1P _s | A _b P _s | Single Shear | Double Shear | Single Shear | Double Shear | End distance equal to 3 x bolt diameter. | | | | | | | | | | |
| | | kN | kN | kN | kN | kN | kN | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 | 20 | 25 | 30 |
| 16 | 104 | 114 | 110 | 62.8 | 126 | 57.1 | 114 | 13.2 | 26.4 | 39.6 | 52.8 | 66.0 | 79.2 | 106 | 145 | 211 | 277 | 343 |
| 20 | 162 | 178 | 172 | 98.0 | 196 | 89.0 | 178 | 0 | 16.5 | 33.0 | 49.5 | 66.0 | 82.5 | 116 | 165 | 248 | 330 | 413 |
| 22 | 200 | 220 | 212 | 121 | 242 | 110 | 220 | 0 | 9.08 | 27.2 | 45.4 | 63.5 | 81.7 | 118 | 172 | 263 | 354 | 445 |
| 24 | 233 | 257 | 247 | 141 | 282 | 128 | 257 | 0 | 0 | 19.8 | 39.6 | 59.4 | 79.2 | 119 | 178 | 277 | 376 | 475 |
| 27 | 303 | 333 | 321 | 184 | 367 | 167 | 333 | 0 | 0 | 5.57 | 27.8 | 50.1 | 72.4 | 117 | 184 | 295 | 407 | 518 |
| 30 | 370 | 407 | 393 | 224 | 449 | 204 | 407 | 0 | 0 | 0 | 12.4 | 37.1 | 61.9 | 111 | 186 | 309 | 433 | 557 |

Values in **bold** are less than the single shear capacity of the bolt.Values in *italic* are greater than the double shear capacity of the bolt.

Shading indicates that the ply thickness is not suitable for an outer ply.

BS 5950-1: 2000
 BS 4395: 1969
 BS 4604: 1970
 BS 4933: 1973

BOLT CAPACITIES

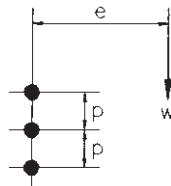
PRELOADED HSFG BOLTS: NON-SLIP UNDER FACTORED LOADS

GENERAL GRADE COUNTERSUNK HSFG BOLTS IN S355

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{sl} | | | | | | | |
|------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 12 | 49.4 | 44.5 | 8.89 | 17.8 | 13.3 | 26.7 | 17.8 | 35.6 | 22.2 | 44.5 |
| 16 | 92.1 | 82.9 | 16.6 | 33.2 | 24.9 | 49.7 | 33.2 | 66.3 | 41.4 | 82.9 |
| 20 | 144 | 130 | 25.9 | 51.8 | 38.9 | 77.8 | 51.8 | 104 | 64.8 | 130 |
| 22 | 177 | 159 | 31.9 | 63.7 | 47.8 | 95.6 | 63.7 | 127 | 79.7 | 159 |
| 24 | 207 | 186 | 37.3 | 74.5 | 55.9 | 112 | 74.5 | 149 | 93.2 | 186 |
| 27 | 234 | 211 | 42.1 | 84.2 | 63.2 | 126 | 84.2 | 168 | 105 | 211 |
| 30 | 286 | 257 | 51.5 | 103 | 77.2 | 154 | 103 | 206 | 129 | 257 |

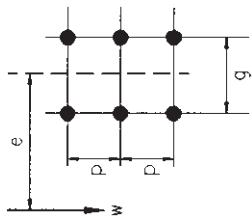
HIGHER GRADE COUNTERSUNK HSFG BOLTS IN S 355

| Diameter of Bolt mm | Min. Shank Tension P_o kN | Bolt Tension Capacity $0.9P_o$ kN | Slip Resistance P_{sl} | | | | | | | |
|------------------------------|---|---|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | $\mu = 0.2$ | | $\mu = 0.3$ | | $\mu = 0.4$ | | $\mu = 0.5$ | |
| | | | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN | Single Shear kN | Double Shear kN |
| 16 | 104 | 93.5 | 18.7 | 37.4 | 28.1 | 56.1 | 37.4 | 74.8 | 46.8 | 93.5 |
| 20 | 162 | 146 | 29.1 | 58.2 | 43.7 | 87.4 | 58.2 | 116 | 72.8 | 146 |
| 22 | 200 | 180 | 36.0 | 72.1 | 54.1 | 108 | 72.1 | 144 | 90.1 | 180 |
| 24 | 233 | 210 | 42.0 | 84.0 | 63.0 | 126 | 84.0 | 168 | 105 | 210 |
| 27 | 303 | 273 | 54.5 | 109 | 81.8 | 164 | 109 | 218 | 136 | 273 |
| 30 | 370 | 333 | 66.6 | 133 | 99.9 | 200 | 133 | 266 | 167 | 333 |



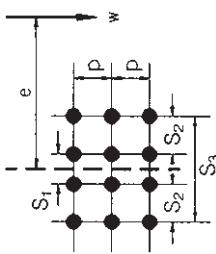
Bolt groups

One row of fasteners; fasteners in the plane of the force



Bolt groups
Two rows of fasteners; fasteners in the plane of the force

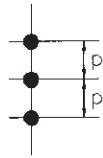
| No. of fasteners in vertical row | Pitch, p (mm) | Gauge, g (mm) | Values of Z_{xx} (cm^3) for diameter of bolt, D (mm) | | | | | | |
|-------------------------------------|--------------------|--------------------|--|-------|-------|--------|--------|--------|-------|
| | | | 12 | 16 | 20 | 22 | 24 | 27 | 30 |
| 2 | 70 | 60 | 15.7 | 29.5 | 46.5 | 57.9 | 67.9 | 89.2 | 110.3 |
| 3 | | | 27.8 | 52.0 | 81.7 | 101.3 | 118.4 | 154.8 | 190.4 |
| 4 | 43.5 | | 81.3 | 127.2 | 157.6 | 184.1 | 240.0 | 294.5 | |
| 5 | 63.1 | | 117.8 | 184.2 | 228.0 | 266.1 | 346.7 | 424.8 | |
| 6 | 86.7 | | 161.6 | 252.6 | 312.7 | 364.6 | 474.8 | 581.4 | |
| 7 | 114.2 | | 212.8 | 332.5 | 411.5 | 479.7 | 624.4 | 764.2 | |
| 8 | 145.6 | | 271.4 | 423.9 | 524.4 | 611.3 | 795.6 | 973.4 | |
| 9 | 181.0 | | 337.3 | 526.7 | 651.6 | 759.5 | 988.2 | 1208.8 | |
| 2 | 100 | 60 | 19.8 | 37.1 | 58.2 | 72.2 | 84.6 | 110.6 | 136.3 |
| 3 | | | 36.8 | 68.6 | 107.4 | 133.1 | 155.4 | 202.6 | 248.5 |
| 4 | 59.2 | | 110.4 | 172.5 | 213.5 | 249.1 | 324.4 | 397.3 | |
| 5 | 87.2 | | 162.6 | 254.0 | 314.3 | 366.4 | 476.9 | 568.7 | |
| 6 | 120.9 | | 225.3 | 351.8 | 435.3 | 507.4 | 660.2 | 807.7 | |
| 7 | 160.2 | | 298.5 | 466.0 | 576.5 | 671.9 | 874.2 | 1069.1 | |
| 8 | 205.1 | | 382.2 | 596.6 | 738.0 | 860.1 | 1118.8 | 1368.1 | |
| 9 | 255.7 | | 476.3 | 743.5 | 919.7 | 1071.8 | 1394.0 | 1704.5 | |



Bolt groups
Four rows of fasteners; fasteners in the plane of the force

| No. of fasteners in vertical row | Pitch, P (mm) | S_1 (mm) | S_2 (mm) | S_3 (mm) | Values of Z_{xx} (cm ³) for diameter of bolt, D (mm) | | | | | | |
|-------------------------------------|--------------------|---------------|---------------|---------------|---|-------|--------|--------|--------|--------|--------|
| | | | | | 12 | 16 | 20 | 22 | 24 | 27 | 30 |
| 2 | 70 | 120 | 60 | 240 | 55.3 | 103.2 | 161.3 | 199.8 | 233.1 | 303.7 | 372.2 |
| 3 | | | | | 89.5 | 166.9 | 261.0 | 323.0 | 376.8 | 490.8 | 601.3 |
| 4 | | | | | 128.1 | 238.9 | 373.4 | 462.2 | 539.0 | 701.9 | 859.4 |
| 5 | | | | | 172.1 | 320.8 | 501.3 | 620.4 | 723.4 | 941.6 | 1152.6 |
| 6 | | | | | 222.3 | 414.3 | 647.2 | 800.8 | 933.6 | 1215.1 | 1486.9 |
| 7 | | | | | 279.3 | 520.6 | 813.0 | 1005.9 | 1172.6 | 1525.7 | 1866.6 |
| 8 | | | | | 343.6 | 640.2 | 999.8 | 1236.9 | 1441.7 | 1875.7 | 2294.4 |
| 9 | | | | | 415.3 | 773.8 | 1208.2 | 1494.7 | 1742.0 | 2266.3 | 2771.8 |
| 2 | 70 | 120 | 85 | 290 | 61.3 | 114.3 | 178.7 | 221.2 | 258.0 | 336.1 | 411.6 |
| 3 | | | | | 98.0 | 182.8 | 285.6 | 353.5 | 412.3 | 536.8 | 657.3 |
| 4 | | | | | 139.1 | 259.3 | 405.1 | 501.3 | 584.6 | 761.0 | 931.5 |
| 5 | | | | | 185.2 | 345.1 | 539.1 | 667.1 | 777.8 | 1012.3 | 1238.8 |
| 6 | | | | | 237.1 | 441.8 | 690.0 | 853.7 | 995.2 | 1295.1 | 1584.5 |
| 7 | | | | | 295.4 | 550.4 | 859.6 | 1063.5 | 1239.6 | 1612.9 | 1973.0 |
| 8 | | | | | 360.7 | 672.0 | 1049.3 | 1298.1 | 1512.9 | 1968.3 | 2407.5 |
| 9 | | | | | 433.1 | 807.0 | 1259.9 | 1558.6 | 1816.5 | 2363.1 | 2890.0 |
| 2 | 70 | 140 | 50 | 240 | 58.8 | 109.7 | 171.5 | 212.4 | 247.8 | 322.8 | 395.5 |
| 3 | | | | | 94.2 | 175.7 | 274.7 | 340.0 | 396.7 | 516.6 | 632.8 |
| 4 | | | | | 133.6 | 249.2 | 389.4 | 481.9 | 562.0 | 731.8 | 896.0 |
| 5 | | | | | 178.1 | 331.9 | 518.6 | 641.7 | 748.2 | 974.0 | 1192.1 |
| 6 | | | | | 228.5 | 425.9 | 665.2 | 823.1 | 959.6 | 1248.8 | 1528.1 |
| 7 | | | | | 285.7 | 532.4 | 831.4 | 1028.7 | 1199.1 | 1560.3 | 1908.8 |
| 8 | | | | | 350.0 | 652.2 | 1018.4 | 1260.0 | 1468.6 | 1910.7 | 2337.2 |
| 9 | | | | | 421.8 | 785.9 | 1227.1 | 1518.0 | 1769.1 | 2301.5 | 2814.8 |

| | | | | | | | | | | | |
|---|-----|-----|----|-----|-------|--------|--------|--------|--------|--------|---------|
| 2 | 70 | 140 | 75 | 290 | 64.3 | 119.8 | 187.3 | 231.8 | 270.3 | 352.1 | 431.1 |
| 3 | 70 | 140 | 75 | 290 | 102.1 | 190.4 | 297.5 | 368.2 | 429.4 | 559.1 | 684.5 |
| 4 | 70 | 140 | 75 | 290 | 144.0 | 268.4 | 419.4 | 518.9 | 605.1 | 787.7 | 964.1 |
| 5 | 70 | 140 | 75 | 290 | 190.6 | 355.3 | 554.9 | 686.7 | 800.5 | 1041.9 | 1225.0 |
| 6 | 70 | 140 | 75 | 290 | 242.8 | 452.5 | 706.8 | 874.5 | 1019.4 | 1326.6 | 1623.0 |
| 7 | 70 | 140 | 75 | 290 | 301.4 | 561.6 | 877.0 | 1085.1 | 1264.8 | 1645.6 | 2013.0 |
| 8 | 70 | 140 | 75 | 290 | 366.8 | 683.4 | 1067.2 | 1320.2 | 1538.7 | 2001.8 | 2448.5 |
| 9 | 70 | 140 | 75 | 290 | 439.4 | 818.6 | 1278.1 | 1581.1 | 1842.7 | 2397.1 | 2931.6 |
| 2 | 100 | 120 | 60 | 240 | 59.8 | 111.5 | 174.4 | 215.8 | 251.8 | 328.0 | 401.9 |
| 3 | 100 | 120 | 60 | 240 | 101.6 | 189.5 | 296.1 | 366.4 | 427.4 | 556.4 | 681.3 |
| 4 | 100 | 120 | 60 | 240 | 151.1 | 281.7 | 440.1 | 544.5 | 634.9 | 826.3 | 1011.3 |
| 5 | 100 | 120 | 60 | 240 | 209.8 | 391.0 | 610.6 | 755.5 | 880.6 | 1145.9 | 1401.9 |
| 6 | 100 | 120 | 60 | 240 | 278.6 | 519.2 | 810.6 | 1002.9 | 1168.8 | 1520.7 | 1860.0 |
| 7 | 100 | 120 | 60 | 240 | 358.1 | 667.2 | 1041.7 | 1288.6 | 1501.7 | 1953.5 | 2389.0 |
| 8 | 100 | 120 | 60 | 240 | 448.6 | 835.6 | 1304.5 | 1613.6 | 1880.4 | 2445.9 | 2990.8 |
| 9 | 100 | 120 | 60 | 240 | 550.0 | 1024.6 | 1599.4 | 1978.4 | 2305.4 | 2998.5 | 36666.1 |
| 2 | 100 | 120 | 85 | 290 | 65.2 | 121.6 | 190.1 | 235.3 | 274.4 | 357.3 | 437.6 |
| 3 | 100 | 120 | 85 | 290 | 109.1 | 203.4 | 317.9 | 393.3 | 458.7 | 597.0 | 730.8 |
| 4 | 100 | 120 | 85 | 290 | 160.6 | 299.3 | 467.4 | 578.3 | 674.2 | 877.4 | 1073.6 |
| 5 | 100 | 120 | 85 | 290 | 220.7 | 411.2 | 642.2 | 794.5 | 926.1 | 1205.0 | 1474.0 |
| 6 | 100 | 120 | 85 | 290 | 290.5 | 541.3 | 845.2 | 1045.6 | 1218.6 | 1585.4 | 1939.0 |
| 7 | 100 | 120 | 85 | 290 | 370.7 | 690.7 | 1078.3 | 1333.9 | 1554.5 | 2022.1 | 2422.8 |
| 8 | 100 | 120 | 85 | 290 | 461.7 | 860.0 | 1342.6 | 1660.7 | 1935.3 | 2517.2 | 3077.9 |
| 9 | 100 | 120 | 85 | 290 | 563.5 | 1049.7 | 1638.6 | 2026.8 | 2361.7 | 3071.7 | 3755.7 |
| 2 | 100 | 140 | 50 | 240 | 63.2 | 117.8 | 184.2 | 228.0 | 265.9 | 346.4 | 424.3 |
| 3 | 100 | 140 | 50 | 240 | 105.8 | 197.3 | 308.3 | 381.6 | 445.0 | 579.4 | 709.3 |
| 4 | 100 | 140 | 50 | 240 | 155.7 | 290.2 | 453.3 | 560.9 | 654.0 | 851.2 | 1041.6 |
| 5 | 100 | 140 | 50 | 240 | 214.5 | 399.7 | 624.3 | 772.3 | 900.3 | 1171.5 | 1433.1 |
| 6 | 100 | 140 | 50 | 240 | 283.4 | 528.0 | 824.4 | 1019.9 | 1188.7 | 1546.5 | 1891.5 |
| 7 | 100 | 140 | 50 | 240 | 362.9 | 676.1 | 1055.5 | 1305.7 | 1521.6 | 1979.4 | 2420.6 |
| 8 | 100 | 140 | 50 | 240 | 453.3 | 844.5 | 1318.3 | 1630.7 | 1900.2 | 2471.7 | 3022.3 |
| 9 | 100 | 140 | 50 | 240 | 554.8 | 1033.4 | 1613.2 | 1995.4 | 2325.1 | 3024.2 | 3697.6 |
| 2 | 100 | 140 | 75 | 290 | 68.1 | 127.0 | 198.4 | 245.6 | 286.4 | 372.9 | 456.6 |
| 3 | 100 | 140 | 75 | 290 | 112.9 | 210.4 | 328.7 | 406.8 | 474.3 | 617.4 | 755.6 |
| 4 | 100 | 140 | 75 | 290 | 164.8 | 307.1 | 479.6 | 593.5 | 691.8 | 900.3 | 1101.6 |
| 5 | 100 | 140 | 75 | 290 | 225.1 | 419.5 | 655.1 | 810.5 | 944.7 | 1229.1 | 1503.6 |
| 6 | 100 | 140 | 75 | 290 | 295.1 | 549.8 | 858.4 | 1062.0 | 1237.7 | 1610.2 | 1969.3 |
| 7 | 100 | 140 | 75 | 290 | 375.4 | 699.3 | 1091.7 | 1350.5 | 1573.8 | 2047.2 | 2503.5 |
| 8 | 100 | 140 | 75 | 290 | 466.3 | 868.7 | 1356.0 | 1677.4 | 1954.6 | 2542.4 | 3108.7 |
| 9 | 100 | 140 | 75 | 290 | 568.2 | 1058.3 | 1652.0 | 2043.4 | 2381.1 | 3097.0 | 3786.5 |

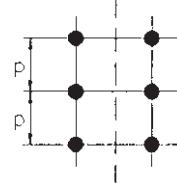
**Bolt groups**

One row of fasteners; fasteners not in the plane of the force

| No. of fasteners in vertical row | Pitch, p (mm) | Values of Z_{xx} (cm^3) for diameter of bolt, D (mm) | | | | | |
|-------------------------------------|--------------------|--|-------|-------|-------|--------|--------|
| | | 12 | 16 | 20 | 22 | 24 | 27 |
| 2 | 70 | 13.3 | 24.8 | 38.8 | 48.0 | 55.9 | 72.8 |
| 3 | | 25.5 | 47.5 | 74.2 | 91.8 | 107.0 | 139.2 |
| 4 | | 41.7 | 77.6 | 121.2 | 149.9 | 174.6 | 227.2 |
| 5 | | 61.8 | 115.0 | 179.5 | 222.1 | 258.8 | 336.5 |
| 6 | | 85.8 | 159.8 | 249.4 | 308.4 | 359.4 | 467.3 |
| 7 | | 113.7 | 211.8 | 330.6 | 408.9 | 476.4 | 619.6 |
| 8 | | 145.6 | 271.2 | 423.3 | 523.5 | 610.0 | 793.2 |
| 9 | | 181.5 | 338.0 | 527.4 | 652.3 | 760.0 | 988.3 |
| 2 | 100 | 15.4 | 28.7 | 44.8 | 55.4 | 64.6 | 84.1 |
| 3 | | 31.4 | 58.5 | 91.3 | 112.9 | 131.6 | 171.2 |
| 4 | | 53.0 | 98.8 | 154.2 | 190.7 | 222.2 | 288.9 |
| 5 | | 80.3 | 149.5 | 233.4 | 288.6 | 336.3 | 437.3 |
| 6 | | 113.2 | 210.8 | 328.9 | 406.8 | 474.0 | 616.3 |
| 7 | | 151.6 | 282.4 | 440.8 | 545.2 | 635.1 | 825.9 |
| 8 | | 195.8 | 364.6 | 569.0 | 703.7 | 819.9 | 1066.1 |
| 9 | | 245.5 | 457.2 | 713.5 | 882.5 | 1028.1 | 1336.9 |

Centre of rotation is assumed 60 mm below the bottom bolt

The tabulated values are conservative when the centre of rotation is located more than 60 mm below the bottom bolt. The tabulated values are unconservative when the centre of rotation is located less than 60 mm below the bottom line.

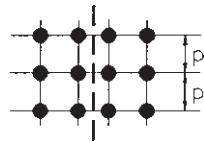
**Bolt groups**

Two rows of fasteners; fasteners not in the plane of the force

| No. of fasteners in vertical row | Pitch, p (mm) | Values of Z_{xx} (cm^3) for diameter of bolt, D (mm) | | | | | |
|-------------------------------------|--------------------|--|-------|--------|--------|--------|--------|
| | | 12 | 16 | 20 | 22 | 24 | 27 |
| 2 | 70 | 26.6 | 49.6 | 77.5 | 95.9 | 111.8 | 145.6 |
| 3 | | 51.0 | 95.1 | 148.5 | 183.7 | 214.1 | 278.5 |
| 4 | | 83.3 | 155.2 | 242.3 | 299.7 | 349.3 | 454.3 |
| 5 | | 123.5 | 230.1 | 359.1 | 444.1 | 517.5 | 673.1 |
| 6 | | 171.5 | 319.5 | 498.7 | 616.8 | 718.7 | 934.7 |
| 7 | | 227.5 | 423.7 | 661.2 | 817.8 | 952.8 | 1239.1 |
| 8 | | 291.2 | 542.5 | 846.6 | 1047.1 | 1219.9 | 1586.4 |
| 9 | | 362.9 | 675.9 | 1054.8 | 1304.6 | 1520.0 | 1976.5 |
| 2 | 100 | 30.8 | 57.4 | 89.6 | 110.9 | 129.3 | 168.2 |
| 3 | | 62.8 | 117.0 | 182.6 | 225.9 | 263.2 | 342.4 |
| 4 | | 106.1 | 197.5 | 308.3 | 381.4 | 444.4 | 577.9 |
| 5 | | 160.6 | 299.1 | 466.7 | 577.3 | 672.6 | 874.7 |
| 6 | | 226.3 | 421.5 | 657.8 | 813.6 | 947.9 | 1232.6 |
| 7 | | 303.3 | 564.9 | 881.6 | 1090.3 | 1270.3 | 1651.8 |
| 8 | | 391.5 | 729.2 | 1138.0 | 1407.4 | 1639.7 | 2132.2 |
| 9 | | 491.0 | 914.5 | 1427.1 | 1765.0 | 2056.3 | 2673.8 |

Centre of rotation is assumed 60 mm below the bottom bolts

The tabulated values are conservative when the centre of rotation is located more than 60 mm below the bottom bolts. The tabulated values are unconservative when the centre of rotation is located less than 60 mm below the bottom bolts.



Bolt groups

Four rows of fasteners; fasteners not in the plane of the force

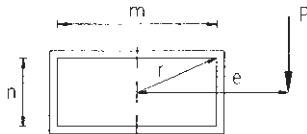
| No. of fasteners in vertical row | Pitch, p (mm) | Values of Z_{xx} (cm^3) for diameter of bolt, D (mm) | | | | | |
|-------------------------------------|--------------------|--|--------|--------|--------|--------|--------|
| | | 12 | 16 | 20 | 22 | 24 | 27 |
| 2 | 70 | 53.2 | 99.2 | 155.0 | 191.8 | 223.7 | 291.1 |
| 3 | | 102.1 | 190.2 | 296.9 | 367.3 | 428.1 | 557.0 |
| 4 | | 166.7 | 310.5 | 484.7 | 599.5 | 698.6 | 908.7 |
| 5 | | 247.0 | 460.1 | 718.2 | 888.3 | 1035.0 | 1346.1 |
| 6 | | 343.1 | 639.1 | 997.4 | 1233.7 | 1437.4 | 1869.3 |
| 7 | | 454.9 | 847.3 | 1322.4 | 1635.6 | 1905.7 | 2478.2 |
| 8 | | 582.5 | 1084.9 | 1693.2 | 2094.1 | 2439.9 | 3172.8 |
| 9 | | 725.8 | 1351.8 | 2109.7 | 2609.2 | 3039.9 | 3953.1 |
| | | | | | | | 4832.0 |
| 2 | 100 | 61.6 | 114.8 | 179.2 | 221.8 | 258.5 | 336.4 |
| 3 | | 125.6 | 234.0 | 365.2 | 451.8 | 526.5 | 684.8 |
| 4 | | 212.1 | 395.1 | 616.7 | 762.7 | 888.7 | 1155.8 |
| 5 | | 321.1 | 598.1 | 933.5 | 1154.5 | 1345.2 | 1749.3 |
| 6 | | 452.6 | 843.0 | 1315.6 | 1627.2 | 1895.8 | 2465.3 |
| 7 | | 606.6 | 1129.8 | 1763.1 | 2180.6 | 2540.6 | 3303.7 |
| 8 | | 783.1 | 1458.4 | 2276.0 | 2814.9 | 3279.5 | 4264.5 |
| 9 | | 982.0 | 1828.9 | 2854.2 | 3529.9 | 4112.6 | 5347.7 |
| | | | | | | | 6536.4 |

Centre of rotation is assumed 60 mm below the bottom bolts

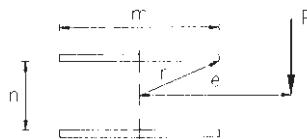
The tabulated values are conservative when the centre of rotation is located more than 60 mm below the bottom bolts. The tabulated values are unconservative when the centre of rotation is located less than 60 mm below the bottom bolts.

Weld data

Weld groups
Welds in the plane of the force

Values of Z_p (cm^3) for 1 mm throat thickness

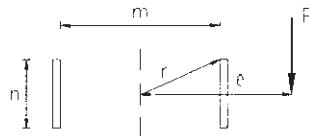
| Values of n (mm) | Values of m (mm) | | | | | | | | | | |
|-----------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 |
| 50 | 4.7 | 7.2 | 10.1 | 13.3 | 16.9 | 20.9 | 25.3 | 30.1 | 35.3 | 40.9 | 47.0 |
| 75 | 7.2 | 10.6 | 14.3 | 18.3 | 22.6 | 27.4 | 32.5 | 37.9 | 43.8 | 50.1 | 56.8 |
| 100 | 10.1 | 14.3 | 18.9 | 23.7 | 28.9 | 34.4 | 40.2 | 46.5 | 53.1 | 60.1 | 67.5 |
| 125 | 13.3 | 18.3 | 23.7 | 29.5 | 35.5 | 41.8 | 48.5 | 55.5 | 62.9 | 70.6 | 78.7 |
| 150 | 16.9 | 22.6 | 28.9 | 35.5 | 42.4 | 49.6 | 57.2 | 65.0 | 73.2 | 81.7 | 90.6 |
| 175 | 20.9 | 27.4 | 34.4 | 41.8 | 49.6 | 57.7 | 66.1 | 74.8 | 83.9 | 93.2 | 102.9 |
| 200 | 25.3 | 32.5 | 40.2 | 48.5 | 57.2 | 66.1 | 75.4 | 85.0 | 94.9 | 105.1 | 115.6 |
| 225 | 30.1 | 37.9 | 46.5 | 55.5 | 65.0 | 74.8 | 85.0 | 95.5 | 106.2 | 117.3 | 128.6 |
| 250 | 35.3 | 43.8 | 53.1 | 62.9 | 73.2 | 83.9 | 94.9 | 106.2 | 117.9 | 129.8 | 142.0 |
| 275 | 40.9 | 50.1 | 60.1 | 70.6 | 81.7 | 93.2 | 105.1 | 117.3 | 129.8 | 142.6 | 155.7 |
| 300 | 47.0 | 56.8 | 67.5 | 78.7 | 90.6 | 102.9 | 115.6 | 128.6 | 142.0 | 155.7 | 169.7 |
| 325 | 53.5 | 64.0 | 75.3 | 87.2 | 99.8 | 112.9 | 126.4 | 140.3 | 154.5 | 169.1 | 184.0 |
| 350 | 60.3 | 71.5 | 83.4 | 96.1 | 109.4 | 123.3 | 137.6 | 152.3 | 167.4 | 182.8 | 198.6 |
| 375 | 67.6 | 79.4 | 92.0 | 105.4 | 119.4 | 134.0 | 149.1 | 164.6 | 180.6 | 196.9 | 213.5 |
| 400 | 75.4 | 87.8 | 101.1 | 115.1 | 129.8 | 145.1 | 161.0 | 177.3 | 194.1 | 211.2 | 228.7 |
| 425 | 83.5 | 96.5 | 110.5 | 125.2 | 140.6 | 156.7 | 173.3 | 190.4 | 207.9 | 225.9 | 244.2 |
| 450 | 92.0 | 105.7 | 120.3 | 135.7 | 151.8 | 168.5 | 185.9 | 203.8 | 222.1 | 240.9 | 260.0 |
| 475 | 101.0 | 115.3 | 130.5 | 146.6 | 163.4 | 180.8 | 198.9 | 217.5 | 236.6 | 256.2 | 276.2 |
| 500 | 110.4 | 125.3 | 141.2 | 157.9 | 175.4 | 193.5 | 212.3 | 231.7 | 251.6 | 271.9 | 292.7 |
| 525 | 120.2 | 135.8 | 152.3 | 169.6 | 187.8 | 206.6 | 226.1 | 246.2 | 266.8 | 288.0 | 309.5 |
| 550 | 130.4 | 146.6 | 163.8 | 181.8 | 200.6 | 220.1 | 240.3 | 261.1 | 282.5 | 304.4 | 326.8 |
| 575 | 141.0 | 157.9 | 175.7 | 194.3 | 213.8 | 234.0 | 254.9 | 276.4 | 298.5 | 321.2 | 344.3 |
| 600 | 152.0 | 169.5 | 188.0 | 207.3 | 227.4 | 248.3 | 269.8 | 292.1 | 314.9 | 338.3 | 362.2 |



Weld groups
Welds in the plane of the force

Values of Z_P (cm^3) for 1 mm throat thickness

| Values of n (mm) | Values of m (mm) | | | | | | | | | | |
|-----------------------|--------------------|------|------|------|------|-------|-------|-------|-------|-------|-------|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 |
| 50 | 2.4 | 3.6 | 5.2 | 7.2 | 9.5 | 12.2 | 15.4 | 18.9 | 22.9 | 27.3 | 32.1 |
| 75 | 3.6 | 5.3 | 7.2 | 9.3 | 11.7 | 14.6 | 17.8 | 21.3 | 25.3 | 29.7 | 34.6 |
| 100 | 4.8 | 7.1 | 9.4 | 11.9 | 14.6 | 17.5 | 20.9 | 24.6 | 28.6 | 33.1 | 37.9 |
| 125 | 6.1 | 9.0 | 11.8 | 14.7 | 17.8 | 21.0 | 24.6 | 28.4 | 32.6 | 37.2 | 42.1 |
| 150 | 7.4 | 10.9 | 14.3 | 17.7 | 21.2 | 24.8 | 28.7 | 32.8 | 37.2 | 41.9 | 47.0 |
| 175 | 8.6 | 12.8 | 16.8 | 20.8 | 24.8 | 28.9 | 33.1 | 37.5 | 42.2 | 47.1 | 52.4 |
| 200 | 9.9 | 14.7 | 19.4 | 24.0 | 28.5 | 33.1 | 37.7 | 42.5 | 47.5 | 52.7 | 58.2 |
| 225 | 11.2 | 16.6 | 21.9 | 27.1 | 32.2 | 37.3 | 42.5 | 47.7 | 53.1 | 58.7 | 64.5 |
| 250 | 12.4 | 18.5 | 24.5 | 30.3 | 36.0 | 41.7 | 47.4 | 53.1 | 58.9 | 64.9 | 71.1 |
| 275 | 13.7 | 20.4 | 27.0 | 33.4 | 39.8 | 46.1 | 52.3 | 58.6 | 64.9 | 71.3 | 77.9 |
| 300 | 14.9 | 22.3 | 29.5 | 36.6 | 43.6 | 50.5 | 57.3 | 64.1 | 71.0 | 77.8 | 84.9 |
| 325 | 16.2 | 24.2 | 32.0 | 39.8 | 47.4 | 54.9 | 62.3 | 69.7 | 77.1 | 84.5 | 92.0 |
| 350 | 17.4 | 26.1 | 34.6 | 43.0 | 51.2 | 59.3 | 67.4 | 75.4 | 83.3 | 91.3 | 99.2 |
| 375 | 18.7 | 27.9 | 37.1 | 46.1 | 55.0 | 63.8 | 72.5 | 81.0 | 89.6 | 98.1 | 106.6 |
| 400 | 19.9 | 29.8 | 39.6 | 49.3 | 58.8 | 68.2 | 77.5 | 86.7 | 95.8 | 104.9 | 114.0 |
| 425 | 21.2 | 31.7 | 42.1 | 52.4 | 62.6 | 72.7 | 82.6 | 92.4 | 102.1 | 111.8 | 121.5 |
| 450 | 22.5 | 33.6 | 44.7 | 55.6 | 66.4 | 77.1 | 87.7 | 98.1 | 108.5 | 118.7 | 129.0 |
| 475 | 23.7 | 35.5 | 47.2 | 58.7 | 70.2 | 81.5 | 92.7 | 103.8 | 114.8 | 125.7 | 136.5 |
| 500 | 25.0 | 37.4 | 49.7 | 61.9 | 74.0 | 86.0 | 97.8 | 109.5 | 121.1 | 132.6 | 144.1 |
| 525 | 26.2 | 39.2 | 52.2 | 65.0 | 77.8 | 90.4 | 102.9 | 115.2 | 127.5 | 139.6 | 151.6 |
| 550 | 27.5 | 41.1 | 54.7 | 68.2 | 81.6 | 94.8 | 107.9 | 120.9 | 133.8 | 146.6 | 159.2 |
| 575 | 28.7 | 43.0 | 57.2 | 71.3 | 85.4 | 99.2 | 113.0 | 126.6 | 140.1 | 153.5 | 166.8 |
| 600 | 30.0 | 44.9 | 59.7 | 74.5 | 89.1 | 103.7 | 118.1 | 132.3 | 146.5 | 160.5 | 174.4 |



Weld groups

Welds in the plane of the force

Values of Z_p (cm^3) for 1 mm throat thickness

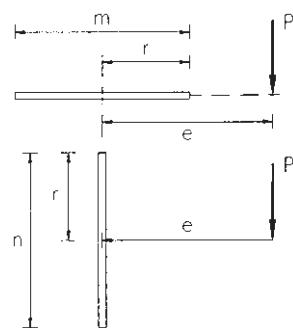
| Values of n (mm) | Values of m (mm) | | | | | | | | | | |
|-----------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 |
| 50 | 2.4 | 3.6 | 4.8 | 6.1 | 7.4 | 8.6 | 9.9 | 11.2 | 12.4 | 13.7 | 14.9 |
| 75 | 3.6 | 5.3 | 7.1 | 9.0 | 10.9 | 12.8 | 14.7 | 16.6 | 18.5 | 20.4 | 22.3 |
| 100 | 5.2 | 7.2 | 9.4 | 11.8 | 14.3 | 16.8 | 19.4 | 21.9 | 24.5 | 27.0 | 29.5 |
| 125 | 7.2 | 9.3 | 11.9 | 14.7 | 17.7 | 20.8 | 24.0 | 27.1 | 30.3 | 33.4 | 36.6 |
| 150 | 9.5 | 11.7 | 14.6 | 17.8 | 21.2 | 24.8 | 28.5 | 32.2 | 36.0 | 39.8 | 43.6 |
| 175 | 12.2 | 14.6 | 17.5 | 21.0 | 24.8 | 28.9 | 33.1 | 37.3 | 41.7 | 46.1 | 50.5 |
| 200 | 15.4 | 17.8 | 20.9 | 24.6 | 28.7 | 33.1 | 37.7 | 42.5 | 47.4 | 52.3 | 57.3 |
| 225 | 18.9 | 21.3 | 24.6 | 28.4 | 32.8 | 37.5 | 42.5 | 47.7 | 53.1 | 58.6 | 64.1 |
| 250 | 22.9 | 25.3 | 28.6 | 32.6 | 37.2 | 42.2 | 47.5 | 53.1 | 58.9 | 64.9 | 71.0 |
| 275 | 27.3 | 29.7 | 33.1 | 37.2 | 41.9 | 47.1 | 52.7 | 58.7 | 64.9 | 71.3 | 77.8 |
| 300 | 32.1 | 34.6 | 37.9 | 42.1 | 47.0 | 52.4 | 58.2 | 64.5 | 71.1 | 77.9 | 84.9 |
| 325 | 37.3 | 39.8 | 43.2 | 47.4 | 52.4 | 58.0 | 64.1 | 70.6 | 77.4 | 84.6 | 92.0 |
| 350 | 42.9 | 45.4 | 48.9 | 53.2 | 58.2 | 63.9 | 70.2 | 76.9 | 84.1 | 91.6 | 99.3 |
| 375 | 48.9 | 51.5 | 55.0 | 59.3 | 64.4 | 70.2 | 76.7 | 83.6 | 91.0 | 98.8 | 106.9 |
| 400 | 55.4 | 57.9 | 61.4 | 65.8 | 71.0 | 76.9 | 83.5 | 90.6 | 98.2 | 106.3 | 114.7 |
| 425 | 62.3 | 64.8 | 68.3 | 72.8 | 78.0 | 84.0 | 90.7 | 98.0 | 105.8 | 114.0 | 122.7 |
| 450 | 69.6 | 72.1 | 75.7 | 80.1 | 85.4 | 91.5 | 98.2 | 105.7 | 113.6 | 122.1 | 131.0 |
| 475 | 77.3 | 79.8 | 83.4 | 87.8 | 93.2 | 99.3 | 106.2 | 113.7 | 121.9 | 130.5 | 139.7 |
| 500 | 85.4 | 88.0 | 91.5 | 96.0 | 101.4 | 107.6 | 114.5 | 122.2 | 130.4 | 139.3 | 148.6 |
| 525 | 94.0 | 96.5 | 100.1 | 104.6 | 110.0 | 116.2 | 123.2 | 131.0 | 139.4 | 148.4 | 157.9 |
| 550 | 102.9 | 105.5 | 109.0 | 113.6 | 119.0 | 125.3 | 132.4 | 140.2 | 148.7 | 157.8 | 167.5 |
| 575 | 112.3 | 114.9 | 118.4 | 123.0 | 128.4 | 134.7 | 141.9 | 149.8 | 158.4 | 167.6 | 177.5 |
| 600 | 122.1 | 124.7 | 128.2 | 132.8 | 138.2 | 144.6 | 151.8 | 159.8 | 168.5 | 177.8 | 187.8 |

Weld groups

Welds in the plane of the force

Values of Z_p (cm^3) for 1 mm of throat thickness

| m or n (mm) | Z_p (cm^3) |
|-----------------|-------------------------|
| 50 | 0.4 |
| 75 | 0.9 |
| 100 | 1.7 |
| 125 | 2.6 |
| 150 | 3.8 |
| 175 | 5.1 |
| 200 | 6.7 |
| 225 | 8.4 |
| 250 | 10.4 |
| 275 | 12.6 |
| 300 | 15.0 |
| 325 | 17.6 |
| 350 | 20.4 |
| 375 | 23.4 |
| 400 | 26.7 |
| 425 | 30.1 |
| 450 | 33.8 |
| 475 | 37.6 |
| 500 | 41.7 |
| 525 | 45.9 |
| 550 | 50.4 |
| 575 | 55.1 |
| 600 | 60.0 |



BS 5950-1 :2000
 BS EN 440
 BS EN 499
 BS EN 756
 BS EN 758
 BS EN 1668

FILLET WELDS

WELD CAPACITIES WITH E35 ELECTRODE WITH S275

| Leg Length s mm | Throat Thickness a mm | Longitudinal Capacity | | Transverse Capacity |
|-----------------------|-----------------------------|-------------------------|-------------------------|-------------------------|
| | | P _L kN/mm | P _T kN/mm | P _T kN/mm |
| 3.0 | 2.1 | 0.462 | | 0.577 |
| 4.0 | 2.8 | 0.616 | | 0.770 |
| 5.0 | 3.5 | 0.770 | | 0.963 |
| 6.0 | 4.2 | 0.924 | | 1.155 |
| 8.0 | 5.6 | 1.232 | | 1.540 |
| 10.0 | 7.0 | 1.540 | | 1.925 |
| 12.0 | 8.4 | 1.848 | | 2.310 |
| 15.0 | 10.5 | 2.310 | | 2.888 |
| 18.0 | 12.6 | 2.772 | | 3.465 |
| 20.0 | 14.0 | 3.080 | | 3.850 |
| 22.0 | 15.4 | 3.388 | | 4.235 |
| 25.0 | 17.5 | 3.850 | | 4.813 |

Welds are between two elements at 90° to each other.

$$P_L = p_w a$$

$$P_T = K p_w a$$

$$p_w = 220 \text{ N/mm}^2$$

$$K = 1.25 \text{ for elements at } 90^\circ \text{ to each other.}$$

BS 5950-1 :2000
 BS EN 440
 BS EN 499
 BS EN 756
 BS EN 758
 BS EN 1668

FILLET WELDS

WELD CAPACITIES WITH E42 ELECTRODE WITH S355

| Leg Length s mm | Throat Thickness a mm | Longitudinal Capacity | | Transverse Capacity |
|-----------------------|-----------------------------|-------------------------|-------------------------|-------------------------|
| | | P _L kN/mm | P _T kN/mm | P _T kN/mm |
| 3.0 | 2.1 | 0.525 | | 0.656 |
| 4.0 | 2.8 | 0.700 | | 0.875 |
| 5.0 | 3.5 | 0.875 | | 1.094 |
| 6.0 | 4.2 | 1.050 | | 1.312 |
| 8.0 | 5.6 | 1.400 | | 1.750 |
| 10.0 | 7.0 | 1.750 | | 2.188 |
| 12.0 | 8.4 | 2.100 | | 2.625 |
| 15.0 | 10.5 | 2.625 | | 3.281 |
| 18.0 | 12.6 | 3.150 | | 3.938 |
| 20.0 | 14.0 | 3.500 | | 4.375 |
| 22.0 | 15.4 | 3.850 | | 4.813 |
| 25.0 | 17.5 | 4.375 | | 5.469 |

Welds are between two elements at 90° to each other.

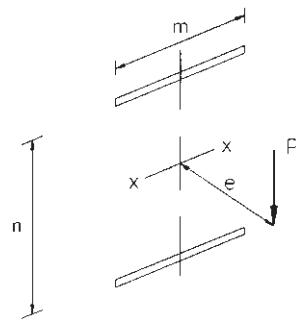
$$P_L = p_w a$$

$$P_T = K p_w a$$

$$p_w = 250 \text{ N/mm}^2$$

$$K = 1.25 \text{ for elements at } 90^\circ \text{ to each other.}$$

Weld groups
Welds not in the plane of the force



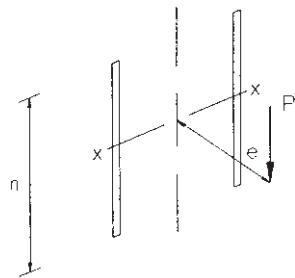
| Values of n (mm) | Values of Z_{xx} (cm^3) for 1 mm throat thickness | | | | | | | | | | |
|-----------------------|--|------|------|------|------|-------|-------|-------|-------|-------|-------|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 |
| 50 | 2.5 | 3.8 | 5.0 | 6.3 | 7.5 | 8.8 | 10.0 | 11.3 | 12.5 | 13.8 | 15.0 |
| 75 | 3.8 | 5.6 | 7.5 | 9.4 | 11.3 | 13.1 | 15.0 | 16.9 | 18.8 | 20.6 | 22.5 |
| 100 | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 17.5 | 20.0 | 22.5 | 25.0 | 27.5 | 30.0 |
| 125 | 6.3 | 9.4 | 12.5 | 15.6 | 18.8 | 21.9 | 25.0 | 28.1 | 31.3 | 34.4 | 37.5 |
| 150 | 7.5 | 11.3 | 15.0 | 18.8 | 22.5 | 26.3 | 30.0 | 33.8 | 37.5 | 41.3 | 45.0 |
| 175 | 8.8 | 13.1 | 17.5 | 21.9 | 26.3 | 30.6 | 35.0 | 39.4 | 43.8 | 48.1 | 52.5 |
| 200 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 | 45.0 | 50.0 | 55.0 | 60.0 |
| 225 | 11.3 | 16.9 | 22.5 | 28.1 | 33.8 | 39.4 | 45.0 | 50.6 | 56.3 | 61.9 | 67.5 |
| 250 | 12.5 | 18.8 | 25.0 | 31.3 | 37.5 | 43.8 | 50.0 | 56.3 | 62.5 | 68.8 | 75.0 |
| 275 | 13.8 | 20.6 | 27.5 | 34.4 | 41.3 | 48.1 | 55.0 | 61.9 | 68.8 | 75.6 | 82.5 |
| 300 | 15.0 | 22.5 | 30.0 | 37.5 | 45.0 | 52.5 | 60.0 | 67.5 | 75.0 | 82.5 | 90.0 |
| 325 | 16.3 | 24.4 | 32.5 | 40.6 | 48.8 | 56.9 | 65.0 | 73.1 | 81.3 | 89.4 | 97.5 |
| 350 | 17.5 | 26.3 | 35.0 | 43.8 | 52.5 | 61.3 | 70.0 | 78.8 | 87.5 | 96.3 | 105.0 |
| 375 | 18.8 | 28.1 | 37.5 | 46.9 | 56.3 | 65.6 | 75.0 | 84.4 | 93.8 | 103.1 | 112.5 |
| 400 | 20.0 | 30.0 | 40.0 | 50.0 | 60.0 | 70.0 | 80.0 | 90.0 | 100.0 | 110.0 | 120.0 |
| 425 | 21.3 | 31.9 | 42.5 | 53.1 | 63.8 | 74.4 | 85.0 | 95.6 | 106.3 | 116.9 | 127.5 |
| 450 | 22.5 | 33.8 | 45.0 | 56.3 | 67.5 | 78.8 | 90.0 | 101.3 | 112.5 | 123.8 | 135.0 |
| 475 | 23.8 | 35.6 | 47.5 | 59.4 | 71.3 | 83.1 | 95.0 | 106.9 | 118.8 | 130.6 | 142.5 |
| 500 | 25.0 | 37.5 | 50.0 | 62.5 | 75.0 | 87.5 | 100.0 | 112.5 | 125.0 | 137.5 | 150.0 |
| 525 | 26.3 | 39.4 | 52.5 | 65.6 | 78.8 | 91.9 | 105.0 | 118.1 | 131.3 | 144.4 | 157.5 |
| 550 | 27.5 | 41.3 | 55.0 | 68.8 | 82.5 | 96.3 | 110.0 | 123.8 | 137.5 | 151.3 | 165.0 |
| 575 | 28.8 | 43.1 | 57.5 | 71.9 | 86.3 | 100.6 | 115.0 | 129.4 | 143.8 | 158.1 | 172.5 |
| 600 | 30.0 | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 | 150.0 | 165.0 | 180.0 |

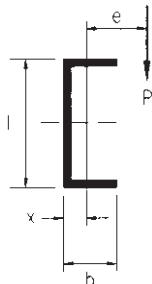
Weld groups

Welds not in the plane of the force

Values of Z_{xx} (cm^3) for 1 mm throat thickness

| n (mm) | Z_{xx} (cm^3) |
|----------|----------------------------|
| 50 | 0.8 |
| 75 | 1.9 |
| 100 | 3.3 |
| 125 | 5.2 |
| 150 | 7.5 |
| 175 | 10.2 |
| 200 | 13.3 |
| 225 | 16.9 |
| 250 | 20.8 |
| 275 | 25.2 |
| 300 | 30.0 |
| 325 | 35.2 |
| 350 | 40.8 |
| 375 | 46.9 |
| 400 | 53.3 |
| 425 | 60.2 |
| 450 | 67.5 |
| 475 | 75.2 |
| 500 | 83.3 |
| 525 | 91.9 |
| 550 | 100.8 |
| 575 | 110.2 |
| 600 | 120.0 |





Weld groups

Welds in the plane of the force

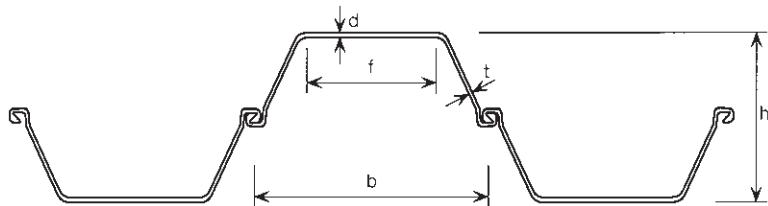
Values of Z_p (cm^3) for 1 mm throat thickness

| Values of n (mm) | Values of m (mm) | | | | | | | | | | |
|-----------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 |
| 50 | 2.8 | 4.3 | 6.2 | 8.5 | 11.2 | 14.3 | 17.9 | 21.9 | 26.2 | 31.0 | 36.2 |
| 75 | 4.3 | 6.2 | 8.4 | 11.0 | 13.9 | 17.3 | 21.1 | 25.2 | 29.8 | 34.8 | 40.3 |
| 100 | 6.2 | 8.5 | 11.0 | 13.9 | 17.1 | 20.7 | 24.7 | 29.2 | 34.0 | 39.2 | 44.9 |
| 125 | 8.3 | 11.0 | 14.0 | 17.2 | 20.7 | 24.6 | 28.9 | 33.6 | 38.7 | 44.1 | 50.0 |
| 150 | 10.6 | 13.9 | 17.3 | 20.9 | 24.8 | 29.0 | 33.5 | 38.5 | 43.8 | 49.6 | 55.7 |
| 175 | 13.2 | 17.0 | 20.8 | 24.9 | 29.1 | 33.7 | 38.6 | 43.8 | 49.4 | 55.4 | 61.8 |
| 200 | 16.0 | 20.3 | 24.7 | 29.1 | 33.8 | 38.8 | 44.0 | 49.6 | 55.5 | 61.8 | 68.4 |
| 225 | 19.0 | 23.9 | 28.8 | 33.7 | 38.8 | 44.2 | 49.8 | 55.7 | 61.9 | 68.5 | 75.5 |
| 250 | 22.2 | 27.7 | 33.1 | 38.5 | 44.1 | 49.9 | 55.9 | 62.2 | 68.8 | 75.7 | 82.9 |
| 275 | 25.6 | 31.7 | 37.7 | 43.6 | 49.7 | 55.9 | 62.3 | 69.0 | 75.9 | 83.2 | 90.8 |
| 300 | 29.2 | 35.9 | 42.5 | 49.0 | 55.5 | 62.2 | 69.0 | 76.1 | 83.4 | 91.1 | 99.0 |
| 325 | 33.1 | 40.4 | 47.5 | 54.5 | 61.6 | 68.7 | 76.0 | 83.5 | 91.3 | 99.3 | 107.6 |
| 350 | 37.1 | 45.0 | 52.7 | 60.3 | 67.9 | 75.5 | 83.3 | 91.3 | 99.4 | 107.8 | 116.5 |
| 375 | 41.4 | 49.9 | 58.2 | 66.3 | 74.5 | 82.6 | 90.9 | 99.3 | 107.8 | 116.7 | 125.7 |
| 400 | 45.9 | 55.0 | 63.8 | 72.6 | 81.2 | 89.9 | 98.7 | 107.5 | 116.6 | 125.8 | 135.3 |
| 425 | 50.6 | 60.3 | 69.7 | 79.0 | 88.3 | 97.5 | 106.7 | 116.1 | 125.6 | 135.3 | 145.1 |
| 450 | 55.4 | 65.8 | 75.8 | 85.7 | 95.5 | 105.3 | 115.0 | 124.9 | 134.8 | 145.0 | 155.3 |
| 475 | 60.6 | 71.5 | 82.2 | 92.6 | 103.0 | 113.3 | 123.6 | 133.9 | 144.4 | 155.0 | 165.7 |
| 500 | 65.9 | 77.4 | 88.7 | 99.8 | 110.7 | 121.5 | 132.4 | 143.2 | 154.2 | 165.2 | 176.5 |
| 525 | 71.4 | 83.6 | 95.4 | 107.1 | 118.6 | 130.0 | 141.4 | 152.8 | 164.2 | 175.8 | 187.5 |
| 550 | 77.1 | 89.9 | 102.4 | 114.6 | 126.7 | 138.7 | 150.6 | 162.5 | 174.5 | 186.5 | 198.7 |
| 575 | 83.0 | 96.5 | 109.6 | 122.4 | 135.1 | 147.6 | 160.1 | 172.6 | 185.0 | 197.6 | 210.2 |
| 600 | 89.2 | 103.2 | 116.9 | 130.4 | 143.7 | 156.8 | 169.8 | 182.8 | 195.8 | 208.9 | 222.0 |

Sheet pile sections

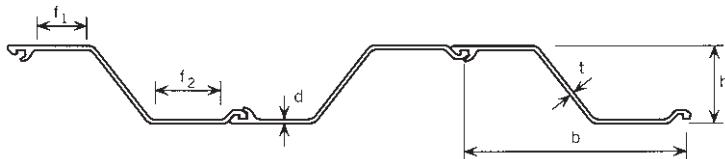
The full range of current Corus steel sheet pile and bearing pile sections are available from Corus Piling on 01724 404040 or from website www.corusconstruction.com. A selection of Corus piling products are shown below.

Larssen sections



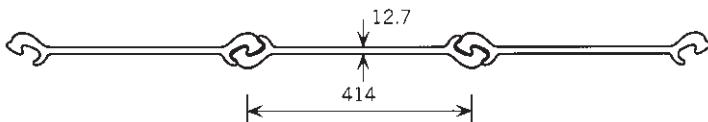
| Section | <i>b</i> mm | <i>h</i> mm | <i>d</i> mm | <i>t</i> mm | <i>f</i> mm | Area cm ² /m | Mass | | <i>I</i> cm ⁴ /m | <i>Z</i> cm ³ /m |
|-----------------|----------------|----------------|----------------|----------------|----------------|----------------------------|-------|------------------------------|--------------------------------|--------------------------------|
| | | | | | | | kg/m | kg/m ² of wall | | |
| LX8 | 600 | 310 | 8.2 | 8.0 | 250 | 116.0 | 54.6 | 91.0 | 12863 | 830 |
| LX12 | 600 | 310 | 9.7 | 8.2 | 386 | 136.0 | 63.9 | 106.5 | 18727 | 1208 |
| LX12d | 600 | 310 | 10.0 | 8.3 | 386 | 139.0 | 65.3 | 108.8 | 19217 | 1240 |
| LX12d10 | 600 | 310 | 10.0 | 10.0 | 382 | 155.0 | 72.9 | 121.5 | 19866 | 1282 |
| LX16 | 600 | 380 | 10.5 | 9.0 | 365 | 157.0 | 74.1 | 123.5 | 31184 | 1641 |
| LX20 | 600 | 430 | 12.5 | 9.0 | 330 | 177.0 | 83.2 | 138.7 | 43484 | 2023 |
| LX20d | 600 | 450 | 11.2 | 9.7 | 330 | 179.0 | 84.3 | 140.5 | 45197 | 2009 |
| LX25 | 600 | 460 | 13.5 | 10.0 | 351 | 202.0 | 95.0 | 158.3 | 57233 | 2488 |
| LX25d | 600 | 450 | 15.0 | 11.0 | 326 | 212.0 | 100.0 | 166.7 | 57246 | 2544 |
| LX32 | 600 | 460 | 19.0 | 11.0 | 340 | 243.0 | 114.4 | 190.7 | 73802 | 3209 |
| LX32d | 600 | 450 | 21.5 | 13.0 | 320 | 269.0 | 126.5 | 210.8 | 75325 | 3348 |
| LX38 | 600 | 460 | 22.5 | 14.5 | 337 | 298.0 | 140.4 | 234.0 | 87511 | 3805 |
| <i>Larssen:</i> | | | | | | | | | | |
| 6W | 525 | 212 | 7.8 | 6.4 | 333 | 109.0 | 44.8 | 85.3 | 6508 | 614 |
| 20Wd | 525 | 400 | 11.3 | 10.0 | 333 | 196.0 | 80.7 | 153.7 | 40574 | 2029 |
| GSP2 | 400 | 200 | 10.5 | 8.6 | 266 | 157.0 | 49.4 | 123.5 | 8756 | 876 |
| GSP3 | 400 | 250 | 13.5 | 8.6 | 270 | 191.0 | 60.1 | 150.3 | 16316 | 1305 |
| GSP4 | 400 | 340 | 15.5 | 9.7 | 259 | 242.0 | 76.1 | 190.3 | 38742 | 2279 |
| 6-42 | 500 | 450 | 20.5 | 14.0 | 329 | 339.0 | 133.0 | 266.0 | 94755 | 4211 |
| 6(122) | 420 | 440 | 22.0 | 14.0 | 250 | 371.0 | 122.5 | 291.7 | 92115 | 4187 |
| 6(131) | 420 | 440 | 25.4 | 14.0 | 250 | 396.0 | 130.7 | 311.2 | 101598 | 4618 |
| 6(138.7) | 420 | 440 | 28.6 | 14.0 | 251 | 419.0 | 138.3 | 329.3 | 110109 | 5005 |

Frodingham sections

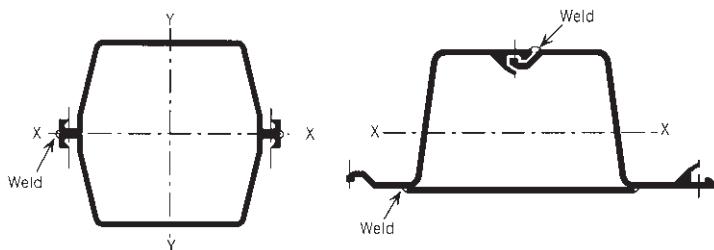


| Section | b mm | h mm | d mm | t mm | f_1 mm | f_2 mm | Area cm^2/m | Mass | | I cm^4/m | Z cm^3/m |
|---------|-----------|-----------|-----------|-----------|-------------|-------------|--------------------------------|-------|------------------------------|-------------------------------|-------------------------------|
| | | | | | | | | kg/m | kg/m ² of wall | | |
| 1BXN | 476 | 143 | 12.7 | 12.7 | 77 | 122 | 170 | 63.4 | 133.2 | 4947 | 692 |
| 1N | 483 | 170 | 9.0 | 9.0 | 107 | 142 | 126 | 48.0 | 99.4 | 6072 | 714 |
| 2N | 483 | 235 | 9.7 | 8.4 | 91 | 146 | 145 | 54.8 | 113.5 | 13641 | 1161 |
| 3NA | 483 | 305 | 9.7 | 9.5 | 90 | 148 | 166 | 62.7 | 129.8 | 25710 | 1687 |
| 4N | 483 | 330 | 14.0 | 10.4 | 75 | 128 | 218 | 82.7 | 171.2 | 39869 | 2415 |
| 5 | 426 | 311 | 17.1 | 11.9 | 87 | 119 | 302 | 101.0 | 237.1 | 49329 | 3171 |

Frodingham straight web sheet piles



| Section | b mm | t mm | Area Single Pile cm^2 | Mass per m of pile kg/m | Mass per m^2 of pile kg/m^2 | Mass per m of junction kg/m | Ultimate strength t/m | interlock | Coating area per pile m^2/m | Coating area per m wall m^2/m^2 | Max deviation angle degrees |
|---------|-----------|-----------|---|--|---|---|---|-----------|--|---|--------------------------------------|
| | | | | | | | | | | | |
| SW1A | 414 | 12.7 | 81 | 63.5 | 153.7 | 95.2 | 285 | 384 | 1.00 | 2.41 | 6 |

Box sheet piles

Larssen

Frodingham

Larssen box piles

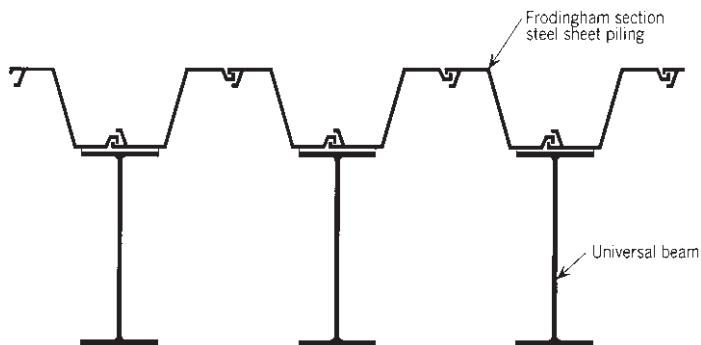
| Section | Section modulus cm ³ | |
|---------|---------------------------------|-------------------------|
| | XX axis cm ³ | YY axis cm ³ |
| LX25 | 3424 | 3257 |
| LX32 | 4377 | 3544 |
| LX38 | 5271 | 4374 |
| 6-42 | 4920 | 3902 |

Frodingham 4N box piles

| Section | Section modulus cm ³ | |
|---------|---------------------------------|------------|
| | Plated box | Double box |
| Frod 4N | 2662 | 5805 |

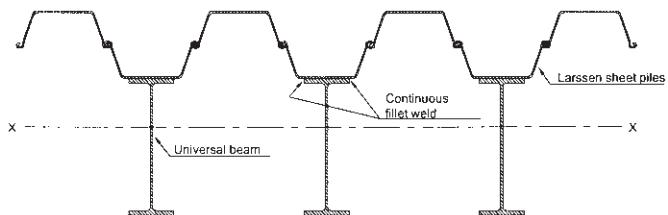
High modulus piles

Frodingham high modulus piles

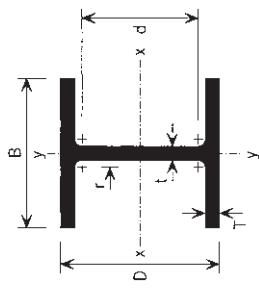


| <i>Universal beam</i> | | <i>Centres of UBs</i> | <i>Mass</i> | | <i>Combined moment of inertia</i> | <i>Elastic section modulus</i> |
|---------------------------|----------------------|---------------------------|-------------|-------------------------|---|--|
| <i>Serial size mm</i> | <i>Mass kg/m</i> | <i>mm</i> | <i>kg/m</i> | <i>kg/m²</i> | <i>cm⁴/m</i> | <i>cm³/m</i> |
| 533 × 210 | 101 | 966 | 267 | 276 | 259478 | 4832 |
| 610 × 305 | 147 | 966 | 314 | 326 | 397108 | 7198 |
| 762 × 267 | 176 | 966 | 338 | 350 | 584576 | 9026 |
| 838 × 292 | 194 | 966 | 359 | 372 | 732365 | 10621 |
| 914 × 305 | 253 | 966 | 419 | 433 | 1005797 | 14254 |
| 914 × 419* | 388 | 966 | 522 | 540 | 1353126 | 21435 |

* Denotes beam section with one flange reduced to 310 mm to facilitate fabrication.

Larssen LX20 high modulus piles

| <i>Universal beam</i> | | <i>Centres of UBs</i> | <i>Mass</i> | | <i>Combined moment of inertia</i> | <i>Elastic section modulus</i> |
|-----------------------|------------------|-----------------------|-------------|-------------------------|-----------------------------------|--------------------------------|
| <i>Serial size mm</i> | <i>Mass kg/m</i> | <i>mm</i> | <i>kg/m</i> | <i>kg/m²</i> | <i>cm⁴/m</i> | <i>cm³/m</i> |
| 686 × 254 | 125 | 1200 | 208.4 | 243.0 | 200426 | 3945 |
| 762 × 267 | 147 | 1200 | 230.1 | 261.1 | 267505 | 4918 |
| 838 × 292 | 176 | 1200 | 259.1 | 285.3 | 363085 | 6273 |
| 914 × 305 | 253 | 1200 | 336.6 | 349.8 | 558248 | 9453 |
| 1016 × 305 | 222 | 1200 | 305.2 | 323.7 | 555491 | 8673 |
| 1016 × 305 | 487 | 1200 | 570.2 | 544.5 | 1132123 | 16938 |

H-piles


| Size | <i>M</i> | <i>D</i> | <i>B</i> | <i>t</i> | <i>T</i> | <i>r</i> | <i>d</i> | <i>A</i> | <i>I_{xx}</i> | <i>I_{yy}</i> | <i>R_{xx}</i> | <i>R_{yy}</i> | <i>Z_{xx}</i> | <i>Z_{yy}</i> |
|-----------|----------|----------|----------|----------|----------|----------|----------|-----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <i>mm</i> | kg/m | mm | mm | mm | mm | mm | mm | cm ² | cm ⁴ | cm ⁴ | cm | cm | cm ³ | cm ³ |
| 356 × 368 | 174 | 361.5 | 378.1 | 20.4 | 20.4 | 15.2 | 290.1 | 2222.2 | 51134 | 18444 | 15.17 | 9.11 | 2829 | 975.7 |
| | 152 | 356.4 | 375.5 | 17.9 | 17.9 | 15.2 | 290.1 | 193.6 | 43916 | 15799 | 15.06 | 9.03 | 2464 | 841.5 |
| | 133 | 351.9 | 373.3 | 15.6 | 15.6 | 15.2 | 290.1 | 169.0 | 37840 | 13576 | 14.96 | 8.96 | 2150 | 727.4 |
| | 109 | 346.4 | 370.5 | 12.9 | 12.9 | 15.2 | 290.1 | 138.4 | 30515 | 10900 | 14.85 | 8.87 | 1762 | 588.4 |
| 305 × 305 | 223 | 338.0 | 325.4 | 30.5 | 30.5 | 15.2 | 246.5 | 284.8 | 52821 | 17571 | 13.62 | 7.85 | 3125 | 1080.0 |
| | 186 | 328.3 | 320.5 | 25.6 | 25.6 | 15.2 | 246.5 | 237.3 | 42628 | 14109 | 13.40 | 7.71 | 2597 | 880.4 |
| | 149 | 318.5 | 315.6 | 20.7 | 20.7 | 15.2 | 246.5 | 190.0 | 33042 | 10869 | 13.19 | 7.56 | 2075 | 688.8 |
| | 126 | 312.4 | 312.5 | 17.7 | 17.7 | 15.2 | 246.5 | 161.3 | 27483 | 8999 | 13.06 | 7.47 | 1760 | 575.8 |
| | 110 | 307.9 | 310.3 | 15.4 | 15.4 | 15.2 | 246.5 | 140.4 | 23580 | 7689 | 12.96 | 7.40 | 1532 | 495.6 |
| | 95 | 303.8 | 308.3 | 13.4 | 13.4 | 15.2 | 246.5 | 121.4 | 20113 | 6530 | 12.87 | 7.33 | 1324 | 423.7 |
| | 88 | 301.7 | 307.2 | 12.3 | 12.3 | 15.2 | 246.5 | 111.8 | 18404 | 5959 | 12.83 | 7.30 | 1220 | 388.0 |
| | 79 | 299.2 | 306.0 | 11.1 | 11.1 | 15.2 | 246.5 | 100.4 | 16400 | 5292 | 12.78 | 7.26 | 1096 | 345.9 |
| 254 × 254 | 85 | 254.3 | 259.7 | 14.3 | 14.3 | 12.7 | 200.2 | 108.1 | 12264 | 4188 | 10.65 | 6.22 | 964.5 | 322.6 |
| | 71 | 249.9 | 257.5 | 12.2 | 12.2 | 12.7 | 200.2 | 91.1 | 10153 | 3451 | 10.56 | 6.15 | 812.7 | 268.1 |
| | 63 | 246.9 | 256.0 | 10.6 | 10.6 | 12.7 | 200.2 | 79.7 | 8775 | 2971 | 10.49 | 6.11 | 710.9 | 232.1 |
| 203 × 203 | 54 | 203.9 | 207.2 | 11.3 | 11.3 | 10.2 | 160.8 | 68.4 | 4987 | 1683 | 8.54 | 4.96 | 489.2 | 162.4 |
| | 45 | 200.2 | 205.4 | 9.5 | 9.5 | 10.2 | 160.8 | 57.0 | 4079 | 1369 | 8.46 | 4.90 | 407.6 | 133.4 |

M = Mass per unit length
D = Depth of section
B = Width of section
t = Thickness of web
T = Thickness of flange
r = Root radius
d = Depth between fillets

A = Area of section
I_{xx} = Moment of inertia about X-X axis
I_{yy} = Moment of inertia about Y-Y axis
R_{xx} = Radius of gyration about X-X axis
R_{yy} = Radius of gyration about Y-Y axis
Z_{xx} = Section modulus about X-X axis
Z_{yy} = Section modulus about Y-Y axis

Ultimate load capacity (kN/m²) for floor plates simply supported on two edges stressed to 275 N/mm²

| Thickness on plain mm | Span (mm) | | | | | | | |
|-----------------------------|-----------|-------|-------|-------|-------|-------|-------|-------|
| | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 4.5 | 20.48 | 11.62 | 7.45 | 5.17 | 3.80 | 2.95 | 2.28 | 1.87 |
| 6.0 | 36.77 | 20.68 | 13.28 | 9.20 | 6.73 | 5.20 | 4.07 | 3.30 |
| 8.0 | 65.40 | 36.87 | 23.48 | 16.38 | 11.97 | 9.23 | 7.23 | 5.93 |
| 10.0 | 102.03 | 57.42 | 36.67 | 25.55 | 18.70 | 14.45 | 11.30 | 9.25 |
| 12.5 | 159.70 | 89.85 | 57.40 | 39.98 | 29.27 | 22.62 | 17.68 | 14.50 |

Stiffeners should be used for spans in excess of 1100 mm to avoid excessive deflections.

Ultimate load capacity (kN/m²) for floor plates simply supported on all four edges stressed to 275 N/mm² (Values obtained using Pounder's formula allowing corners to lift)

| Thickness on plain mm | Breadth B mm | Length (mm) | | | | | | | |
|-----------------------------|--------------------|-------------|------|------|------|-------|-------|-------|-------|
| | | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 4.5 | 600 | 34.9 | 25.5 | 22.7 | 21.7 | 21.2 | 21.0 | 20.8 | 20.8 |
| | 800 | | 19.6 | 15.1 | 13.4 | 12.6 | 12.2 | 12.0 | 11.8 |
| | 1000 | | | 12.6 | 10.0 | 8.8 | 8.3 | 7.9 | 7.7 |
| | 1200 | | | | 8.7 | 7.1 | 6.3 | 5.9 | 5.6 |
| | 1400 | | | | | 6.4 | 5.3 | 4.8 | 4.4 |
| | 1600 | | | | | | 4.9 | 4.1 | 3.7 |
| | 1800 | | | | | | | 3.8 | 3.3 |
| 6.0 | 600 | 62.1 | 45.3 | 40.4 | 38.5 | 37.7 | 37.3 | 37.0 | 36.9 |
| | 800 | | 34.9 | 26.8 | 23.7 | 22.3 | 21.7 | 21.3 | 21.1 |
| | 1000 | | | 22.4 | 17.8 | 15.8 | 14.8 | 14.2 | 13.9 |
| | 1200 | | | | 15.5 | 12.7 | 11.3 | 10.6 | 10.1 |
| | 1400 | | | | | 11.4 | 9.5 | 8.5 | 7.9 |
| | 1600 | | | | | | 8.7 | 7.4 | 6.7 |
| | 1800 | | | | | | | 6.9 | 5.9 |
| 8.0 | 600 | 110 | 80.6 | 71.1 | 68.4 | 67.0 | 66.2 | 65.8 | 65.6 |
| | 800 | | 62.1 | 47.7 | 42.2 | 39.7 | 38.5 | 37.8 | 37.4 |
| | 1000 | | | 39.7 | 31.7 | 28.1 | 26.2 | 25.2 | 24.6 |
| | 1200 | | | | 27.6 | 22.6 | 20.1 | 18.8 | 17.9 |
| | 1400 | | | | | 20.3 | 17.0 | 15.2 | 14.1 |
| | 1600 | | | | | | 15.5 | 13.3 | 11.9 |
| | 1800 | | | | | | | 12.3 | 10.6 |
| 10.0 | 600 | 172* | 126* | 112* | 107* | 105* | 103* | 103* | 103* |
| | 800 | | 97.0 | 74.5 | 65.9 | 62.1 | 60.1 | 59.1 | 58.5 |
| | 1000 | | | 62.1 | 49.5 | 43.9 | 41.0 | 39.4 | 38.5 |
| | 1200 | | | | 43.1 | 35.4 | 31.5 | 29.3 | 28.0 |
| | 1400 | | | | | 31.7 | 26.6 | 23.8 | 22.1 |
| | 1600 | | | | | | 24.3 | 20.7 | 18.6 |
| | 1800 | | | | | | | 19.2 | 16.6 |
| 12.5 | 600 | 269* | 197* | 175* | 167* | 163* | 162* | 161* | 160* |
| | 800 | | 152 | 116* | 103* | 97.0* | 94.0* | 92.3* | 91.4* |
| | 1000 | | | 97.0 | 77.4 | 68.5 | 64.1 | 61.6 | 60.1 |
| | 1200 | | | | 67.4 | 55.3 | 49.2 | 45.8 | 43.8 |
| | 1400 | | | | | 49.5 | 41.5 | 37.1 | 34.5 |
| | 1600 | | | | | | 37.9 | 32.4 | 29.1 |
| | 1800 | | | | | | | 29.9 | 25.9 |

Ultimate load capacity (kN/m²) for floor plates fixed on all four edges stressed to 275 N/mm²

| Thickness on plain mm | Breadth B mm | Length (mm) | | | | | | | |
|-----------------------------|--------------------|-------------|-------|-------|-------|-------|-------|-------|-------|
| | | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 4.5 | 600 | 47.7* | 36.8* | 33.5* | 32.2* | 31.6* | 31.4* | 31.2* | 31.1* |
| | 800 | | 26.8 | 21.5* | 19.5* | 18.6* | 18.1* | 17.9* | 17.7* |
| | 1000 | | | 17.2* | 14.2* | 12.9* | 12.2* | 11.8* | 11.6* |
| | 1200 | | | | 11.9 | 10.1 | 9.1 | 8.6 | 8.3 |
| | 1400 | | | | | 8.7 | 7.5 | 6.9 | 6.5 |
| | 1600 | | | | | | 6.7 | 5.8 | 5.3 |
| | 1800 | | | | | | | 5.3 | 4.7 |
| 6.0 | 600 | 84.8* | 65.4* | 59.5* | 57.3* | 56.2* | 55.7* | 55.5* | 55.3* |
| | 800 | | 47.7* | 38.3* | 34.7* | 33.1* | 32.2* | 31.7* | 31.5* |
| | 1000 | | | 30.5* | 25.3* | 22.9* | 21.7* | 21.0* | 20.6* |
| | 1200 | | | | 21.2* | 18.0* | 16.3* | 15.4* | 14.9* |
| | 1400 | | | | | 15.6* | 13.4* | 12.3* | 11.6 |
| | 1600 | | | | | | 11.9 | 10.4 | 9.5 |
| | 1800 | | | | | | | 9.4 | 8.3 |
| 8.0 | 600 | 151* | 116 * | 106 * | 102 * | 100 * | 99.1* | 98.6* | 98.3* |
| | 800 | | 68.1* | 61.7* | 58.8* | 57.3* | 56.4* | 55.9* | |
| | 1000 | | | 54.3* | 44.9* | 40.7* | 38.6* | 37.4* | 36.7* |
| | 1200 | | | | 37.7* | 31.9* | 29.0* | 27.4* | 26.5* |
| | 1400 | | | | | 27.7* | 23.9* | 21.8* | 20.6* |
| | 1600 | | | | | | 21.2* | 18.6* | 17.0* |
| | 1800 | | | | | | | 16.9* | 14.8* |
| 10.0 | 600 | 236* | 182* | 165 * | 159 * | 156 * | 155 * | 154 * | 154 * |
| | 800 | | 132* | 106 * | 96.4* | 91.8* | 89.5* | 88.2* | 87.4* |
| | 1000 | | | 84.8* | 70.2* | 63.7* | 60.3* | 58.4* | 57.3* |
| | 1200 | | | | 58.9* | 49.9* | 45.4* | 42.9* | 41.3* |
| | 1400 | | | | | 43.3* | 37.3* | 34.1* | 32.2* |
| | 1600 | | | | | | 33.1* | 29.0* | 26.6* |
| | 1800 | | | | | | | 26.2* | 23.2* |
| 12.5 | 600 | 368* | 284* | 258* | 249 * | 244 * | 242 * | 241 * | 240 * |
| | 800 | | 207* | 166* | 151 * | 144 * | 140 * | 138 * | 137 * |
| | 1000 | | | 132* | 110 * | 99.5* | 94.2* | 91.2* | 89.5* |
| | 1200 | | | | 92.0* | 77.9* | 70.9* | 67.0* | 64.6* |
| | 1400 | | | | | 67.6* | 58.3* | 53.3* | 50.3* |
| | 1600 | | | | | | 51.8* | 45.3* | 41.6* |
| | 1800 | | | | | | | 40.9* | 36.2* |

Note on tables:

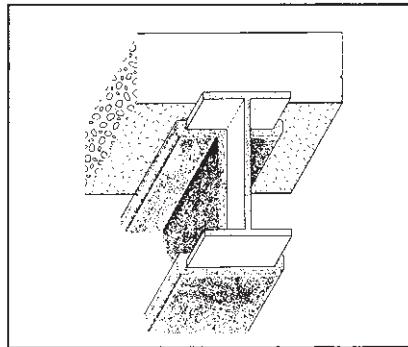
Values without an asterisk cause deflection greater than B/100 at serviceability, assuming that the only dead load present is due to self-weight.

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

SPRAYED PROTECTION

UP TO 4 HRS



METHOD

Fire protective insulation can be applied by spraying to almost any type of steel member. Most products can achieve up to 4 hours rating.

PRINCIPLE

Insulation reduces the heating rate of a steel member so that its limiting temperature is not exceeded for the required fire resistance period. The protection material thickness necessary depends on the section factor (H_p/A) of the member and the fire rating required.

ADVANTAGES

- a) Low cost
- b) Rapid application
- c) Easy to cover complex details
- d) Often applied to non-primed steelwork
- e) Some products may be suitable for external use

LIMITATIONS (check with manufacturer)

- a) Appearance may be inadequate for visible members
- b) Overspray may need masking or shielding
- c) Primer, if used, must be compatible

FOR MORE DETAILED INFORMATION SEE:-
 "Fire protection of Structural Steel in Building"
 Published jointly by:
 ASFP - (01252 336318) and
 The Steel Construction Institute - (01344 23345)

Sheet Code
 ISF/No.01
 January 1997

PROTECTION THICKNESS

Thickness recommendations given in "Fire Protection of Structural Steel in Building" have normally been derived from fire tests on orthodox H or I rolled sections. For other sections the recommended thickness for a given section factor and fire rating should be modified as follows:

CASTELLATED SECTIONS

The thickness of fire protection material on a castellated section should be 20% greater than that required for the section from which it was cut.

HOLLOW SECTIONS

For spray applied fire protection materials the recommended thickness (t) should be increased as follows

For section factor (Hp/A) less than 250
modified thickness = $t [1 + (Hp/A) / 1000]$

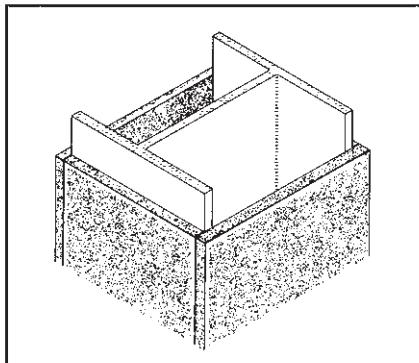
For section factor (Hp/A) 250 or over
modified thickness = $1.25 \times t$

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

BOARD PROTECTION

UP TO 4 HRS



METHOD

Fire protective insulation can be applied by fixing boards to almost any type of steel member. Most products can achieve up to 4 hour rating. Fixing methods vary.

PRINCIPLE

Insulation reduces the heating rate of a steel member so that its limiting temperature is not exceeded during the required fire resistance period. The protection board thickness necessary depends on the section factor (H_p/A) of the member and the fire rating required.

ADVANTAGES

- a) Boxed appearance suitable for visible members
- b) Clean dry fixing
- c) Factory manufactured, guaranteed thickness
- d) Often applied to non-primed steelwork
- e) Some products may be suitable for external use

LIMITATIONS (check with manufacturer)

- a) Require fitting around complex details
- b) May be more expensive and slower to fix than sprays

FOR MORE DETAILED INFORMATION SEE:-
 "Fire protection of Structural Steel in Building"
 Publication jointly by:
 ASFP - (01252 336318) and
 The Steel Construction Institute - (01344 23345)

Sheet Code
 ISF/No.02
 January 1997

PROTECTION THICKNESS

Thickness recommendations given in "Fire Protection of Structural Steel in Building" have normally been derived from fire tests on orthodox H or I rolled sections. For other sections the recommended thickness for a given section factor and fire rating should be modified as follows.

CASTELLATED SECTIONS

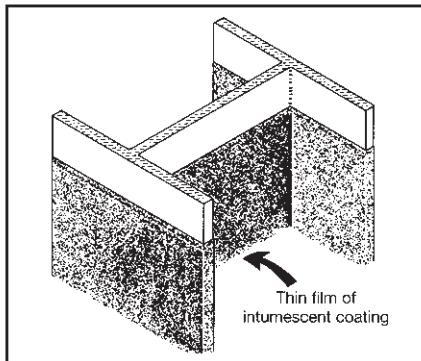
The thickness of fire protection material on a castellated section should be 20% greater than that required for the section from which it was cut.

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

THIN FILM INTUMESCENT COATINGS

UP TO 2 HRS



METHOD

Most thin film intumescent coatings can be applied by spray, brush or roller and can achieve up to 1 hour fire resistance on fully exposed steel members. Some products can achieve up to 2 hours fire resistance on some section sizes.

PRINCIPLE

Insulation is created by swelling of the coating at elevated temperatures to generate a foam like char. This reduces the heating rate so that the limiting temperature of the steel member is not exceeded during the required fire resistance period. The coating thickness necessary depends on the section factor (H_p/A) and the fire rating required.

ADVANTAGES

- a) Decorative finish
- b) Rapid application
- c) Easy to cover complex details
- d) Easy post protection fixings to steelwork eg service hangers

LIMITATIONS (check with manufacturer)

- a) May be suitable for dry internal environments only
- b) May be more expensive than sprayed insulation
- c) May require blast cleaned surface and compatible primer

FOR MORE DETAILED INFORMATION SEE:-
"Fire protection of Structural Steel in Building"
 Publication jointly by:
 ASFP - (01252 336318) and
 The Steel Construction Institute - (01344 23345)

Sheet Code
 ISF/No.03
 January 1997

PROTECTION THICKNESS

Thickness recommendations given in "Fire Protection of Structural Steel in Building" have normally been derived from fire tests on orthodox H or I rolled sections. For other sections the recommended thickness for a given section factor and fire rating should be modified as follows:

CASTELLATED SECTIONS

The thickness of fire protection material on a castellated section should be 20% greater than that required for the section from which it was cut.

HOLLOW SECTIONS

For intumescent materials applied to hollow sections the manufacturers should have carried out separate tests and appraisal

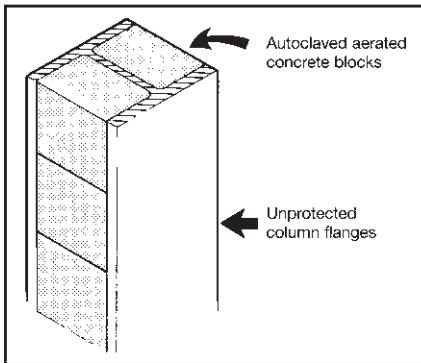
STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

BLOCK - FILLED COLUMNS



30 MINUTES



METHOD

Unprotected universal sections with section factors up to $69m^{-1}$ (see overleaf) can attain 30 minutes fire resistance by fitting autoclaved aerated concrete blocks between the flanges tied to the web at approximately 1m intervals

PRINCIPLE

Partial exposure of steel members affects fire resistance in two ways-

Firstly the reduction of exposed surface area reduces the rate of heating by radiation and thus increases the time to reach failure temperature.

Secondary, if the exposure creates both hot and cold regions in the cross section, plastic yielding occurs in the hot region and load is transferred to the stronger cooler region. Thus a non-uniformly heated section has a higher fire resistance than one heated evenly.

ADVANTAGES

- Reduced cost - compared with total encasement with insulation
- More slender finished columns occupy less floor space
- Good durability - high resistance to impact and abrasion damage

LIMITATIONS

With unprotected steel the method is limited to 30 minutes fire rating.

When higher ratings are required exposed steel must be treated with the full insulation or intumescence coating thickness recommended for the higher rating.

This method should not be used when the blockwork also forms a separating wall. In this case the column will be heated on one side only and thermal bowing may cause the wall to crack or collapse. In such cases the flange(s) should be protected. Alternatively, if the limit of wall deformation is known, the bowing can be calculated to ensure no integrity failure.

METHODS OF ACHIEVING 30 MINUTES FIRE RESISTANCE

| COLUMN SECTION - AXIALLY LOADED ⁽¹⁾ FREE STANDING | | |
|---|---|--|
| SERIAL SIZE mm | MASS/METRE kg | PROTECTION METHOD RECOMMENDED |
| 305 x 406 | 393 and over | No fire protection required |
| 356 x 406 305 x 305 254 x 254 203 x 203 203 x 203 | 340 and under All weights All weights 52 and over 46 ⁽²⁾ | Block filling with autoclaved aerated concrete blocks |
| 152 x 203 | All weights | Apply fire protection material as per manufacturer's recommendations |

| BEAM SECTIONS ACTING AS PORTAL FRAME STANCHIONS ⁽¹⁾ | | |
|--|---|--|
| | | |
| 914 x 419 914 x 305 *610 x 305 | All weights 289 238 | No fire protection required |
| *914 x 305 838 x 292 762 x 267 686 x 254 *610 x 305 610 x 229 533 x 210 457 x 191 457 x 152 406 x 178 356 x 171 305 x 165 305 x 127 254 x 146 | 252 and under All weights All weights All weights 179 and under All weights All weights All weights 60 and over 60 and over 57 and over 54 48 43 | Block filling with autoclaved aerated concrete blocks |
| Other beam sizes | | Apply fire protection material as per manufacturer's recommendations |

Notes:

1) This table applies to sections designed to BS 5950: Part 1:1990 provided the load factor (γ_f) does not exceed 1.5

2) To achieve 30 min fire resistance, a 203 x 203 x 46 kg/m column with blocked in webs should be loaded only up to 80% of the maximum allowable per BS 449:Part 2:1969 or BS 5950:Part 1:1990

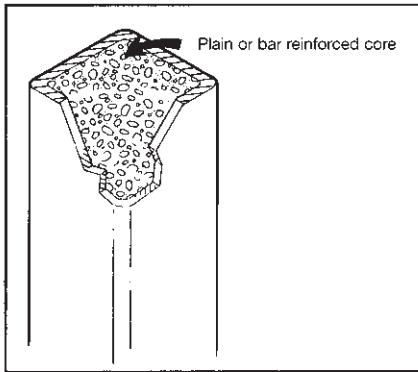
*3) The table revises BRE Digest 317 (1986) in accordance with BS 5950:Part 8:1990

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

CONCRETE FILLED HOLLOW COLUMNS

UP TO 2 HRS



METHOD

Unprotected square or rectangular hollow sections can attain up to 120 minutes fire resistance by filling with plain, fibre reinforced or bar reinforced concrete.

PRINCIPLE

Heat flows through the steel wall into the concrete core which being a poor conductor heats up slowly. As the temperature increases the steel yield strength reduces and the load is progressively transferred into the concrete core.

The steel acts as a restraint to the concrete preventing spalling and hence the rate of degradation of the concrete.

ADVANTAGES

- Steel acts as a permanent shuttering
- More slender finished columns occupy less floor space
- Good durability - high resistance to impact and abrasion damage

LIMITATIONS

- A minimum column size of 140mm x 140mm or 100mm x 200mm is required for plain or fibre reinforced sections.
- A minimum column size of 200mm x 200mm or 150mm x 250mm is required for bar reinforced sections.
- CHS columns are not included due to insufficient data at present.

FOR MORE DETAILED INFORMATION SEE:-

BS 5950 Part 8
Concrete filled column design manual TD 296 from
British Steel Tubes & Pipes - (01536 404005)

Sheet Code
ISF/No.05
January 1997

CONCRETE FILLED RECTANGULAR HOLLOW SECTIONS

The fire resistance of externally unprotected concrete filled hollow sections is dependent on three main variables.

- The concrete strength selected
- The ratio of axial load and moment
- The addition of fibre or bar reinforcement

CONCRETE STRENGTH

The core capacity and hence its fire resistance is directly related to the concrete strength selected.

AXIAL LOAD AND MOMENT

Plain concrete does not perform well in tension and when subject to axial load and moment it is necessary to produce a resultant compressive stress in the core.

REINFORCEMENT

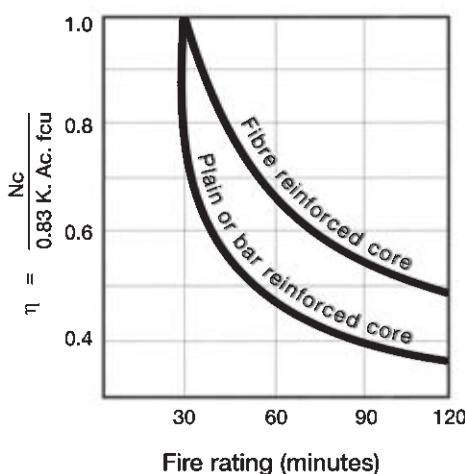
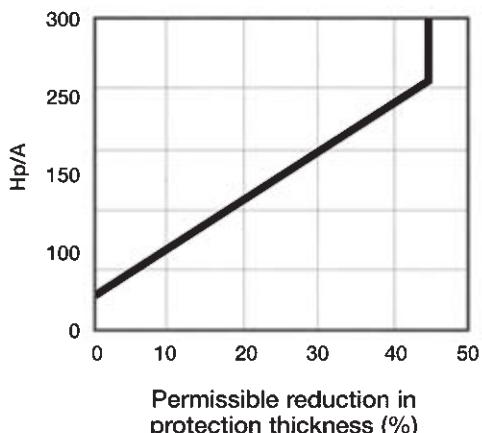
Fibre reinforcement will enhance the core axial capacity yet retain the advantage of filling into a section without obstructions.

Bar reinforcement will enhance the moment capacity.

COMBINED PROTECTION

As an alternative the concrete filled section can be designed for full factored loads and provided with external fire protection.

The thickness of the external fire protection is assessed as far as for an unfilled section, and, due to the effect of the core, the thickness can be reduced.

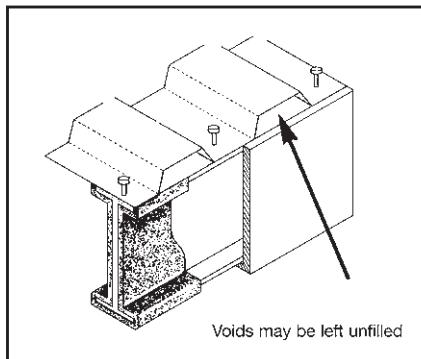


STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

COMPOSITE SLABS WITH PROFILED METAL DECK WITH UNFILLED VOIDS

UP TO 2 HRS



METHOD

In composite construction using profiled metal deck floors it is unnecessary to fill the deck voids above the top flange for any fire resistance period using dovetail deck, or up to 90 minutes using trapezoidal deck (see overleaf)

PRINCIPLE

In a composite beam/slab member the neutral axis in bending lies in, or close to, the beam top flange. Thus the top flange makes little significant contribution to the structural behaviour of the total composite system and its temperature can be allowed to increase with little detriment to performance in fire.

ADVANTAGES

- Saving in time on site
- Saving in cost for filling voids
- It is unnecessary to build up the full thickness of protection on toes of upper flange
- Void filling is unnecessary when using dovetail deck

LIMITATIONS

- Voids must be filled where:-
- Trapezoidal deck is used for fire ratings over 90 minutes
 - Trapezoidal deck is used in non-composite construction
 - Any type of deck crosses a fire separating wall

FOR MORE DETAILED INFORMATION SEE:-

Technical Report 109
"Fire resistance of composite beams"
The British Steel Construction Institute - (01344 23345)

Sheet Code
ISF/No.06
January 1997

COMPOSITE BEAMS - UNFILLED VOIDS

| TRAPEZOIDAL DECK | | | | |
|---------------------|-------------------------|---|---|------------|
| Construction | Fire Protection On Beam | Fire Resistance (minutes) | | |
| | | Up to 60 | 90 | Over 90 |
| Composite Beams | BOARD or SPRAY | No Increase in thickness* | Increase thickness* by 10% (or use thickness* appropriate to beam Hp/A + 15% whichever is less) | Fill voids |
| | INTUMESCENT | Increase thickness* by 20% (or use thickness* appropriate to beam Hp/A + 30% whichever is less) | Increase thickness* by 30% (or use thickness* appropriate to beam Hp/A + 50% whichever is less) | Fill voids |
| Non-Composite Beams | All types | Fill voids | | |

| DOVETAIL DECK | | | |
|----------------------------------|-------------------------|---|--|
| Construction | Fire Protection On Beam | Fire Resistance (minutes) | |
| Composite or Non-composite Beams | All Types | Voids may be left unfilled for all fire resistance periods. | |

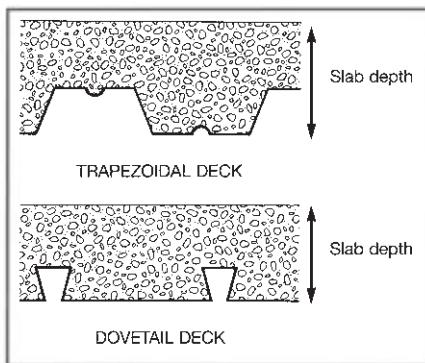
* Thickness is the board, spray or intumescent thickness given for 30, 60 or 90 minutes rating in "Fire Protection for Structural Steel in Buildings" published by ASFP (01252 336318) and The Steel Construction Institute (01344 23345)

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

COMPOSITE SLABS WITH PROFILED METAL DECK

UP TO 2 HRS



METHOD

Fire resistance of composite slabs up to 90 mins can be achieved using normal A142 mesh reinforcement. This can be increased to 120 mins if heavier mesh is used and the slab depth increased (see overleaf).

Other cases outside the limit overleaf can be evaluated by the "Fire Engineering Method" (See below)

PRINCIPLE

Mesh reinforcement, which is not designed to act structurally under normal conditions, makes a significant contribution to structural continuity in fire.

ADVANTAGES

- a) Standard mesh, without additional reinforcing bars, may be used
- b) No fire protection is required on the deck soffit

LIMITATIONS

- a) Applies only to slabs designed to BS5950 Part 4
- b) Mesh overlaps should exceed 50 times bar diameters
- c) Mesh bar ductility should exceed 12% elongation in tension (to BS 4449)
- d) Mesh should lie between 20 & 45mm from slab upper surface
- e) Imposed load should not exceed 6.7kN/m² (including finishes)

FOR MORE DETAILED INFORMATION SEE:-

SCI Technical Report 056

"Fire resistance of composite floors with steel decking".

The Steel Construction Institute - (01344 23345) and CIRIA Special publication 42 CIRIA (0171 222 8891)

Sheet Code

ISF/No.07

January 1997

FIRE RESISTANT COMPOSITE SLABS

TRAPEZOIDAL DECK



| Maximum Span (m) | Fire Rating (h) | Minimum Dimensions | | | Mesh Size | |
|------------------|-----------------|--------------------|--------------------|--------------------|-----------|--|
| | | Sheet thickness | Slab depth (mm) | | | |
| | | | NWC ⁽²⁾ | LWC ⁽³⁾ | | |
| 2.7 | 1 | 0.8 | 130 | 120 | A142 | |
| 3.0 | 1 | 0.9 | 130 | 120 | A142 | |
| | 1.5 | 0.9 | 140 | 130 | A142 | |
| | 2 | 0.9 | 155 | 140 | A193 | |
| 3.6 | 1 | 1.0 | 130 | 120 | A193 | |
| | 1.5 | 1.2 | 140 | 130 | A193 | |
| | 2 | 1.2 | 155 | 140 | A252 | |

DOVETAIL DECK



| Maximum Span (m) | Fire Rating (h) | Minimum Dimensions | | | Mesh Size | |
|------------------|-----------------|--------------------|--------------------|--------------------|-----------|--|
| | | Sheet thickness | Slab depth (mm) | | | |
| | | | NWC ⁽²⁾ | LWC ⁽³⁾ | | |
| 2.5 | 1 | 0.8 | 100 | 100 | A142 | |
| | 1.5 | 0.8 | 110 | 105 | A142 | |
| 3.0 | 1 | 0.9 | 120 | 110 | A142 | |
| | 1.5 | 0.9 | 130 | 120 | A142 | |
| | 2 | 0.9 | 140 | 130 | A193 | |
| 3.6 | 1 | 1.0 | 125 | 120 | A193 | |
| | 1.5 | 1.2 | 135 | 125 | A193 | |
| | 2 | 1.2 | 145 | 130 | A252 | |

1) Imposed load not exceeding 5kN/M² (+ 1.7kN/m² ceiling and services)

2) NWC = Normal weight concrete

3) LWC = Light weight concrete

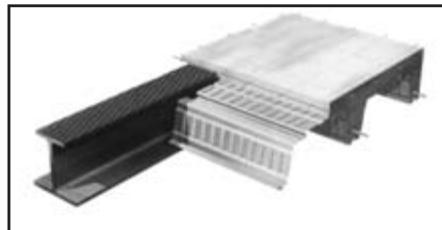
NOTE: Minimum slab depths given in BS 5950 part 8 are to satisfy the insulation criterion only. Figures given in the table above incorporate a strength criterion also and thus may exceed the minimum depth given in the code.

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

SLIMDEK BEAMS WITH DEEP DECK

UP TO 1 HOUR UNPROTECTED



METHOD

The SLIMDEK system consists of an asymmetric beam, with a narrow upper flange and a 225mm deep deck positioned on the outstand of the lower flange. The floor is formed from in-situ applied concrete. This arrangement, shown above, can be designed to provide 60 minutes fire resistance in most cases without the need for applied fire protection.

PRINCIPLE

The section is protected from the effects of fire by the insulating concrete floor. Thus only the bottom flange is directly exposed in fire. Composite action, which develops as a consequence of the raised pattern on the upper flange compensates for much of the loss of strength in the steel at high temperatures.

ADVANTAGES

- Fire resistance periods of 60 minutes can be achieved in most instances without any restrictions in loadings.
- Flat slab construction.

- Clear service runs.
- Reduced construction runs and building heights.
- Services can be passed through prepared openings in the rib of the decking to further reduce floor depth.

LIMITATIONS

- a) For fire resistance periods greater than 60 minutes, the exposed lower flange requires fire protection.
- b) Where holes are cut in the beam to allow services to pass through, the exposed bottom flange will generally require fire protection.

*SLIMDEK is a Registered Trade Mark of British Steel plc.

FOR MORE DETAILED INFORMATION SEE:-
SCI Publication 175 "Design of Asymmetric Slimflor Beams using Deep Composite Decking"
 The Steel Construction Institute (01344 23345)

Sheet Code
 ISF/No.9
 April 1997

Table 1**Summary of recommendations**

| Fire Resistance (Minutes) | Design Type | |
|-----------------------------------|--|------------------------|
| | Without holes or action | With service holes |
| 30 Minutes | No protection required | No protection required |
| 60 Minutes | No protection required in most circumstances (see table 2) | Protect bottom flange |
| Greater than 60 | Protect bottom flange | |

Table 2

Load table for ASB beams for 60 minutes fire resistance (Concrete grade 30, steel grade S355)

| Section | Span of Beam (mm) | Effective width of slab (mm) | Moment resistance at ultimate limit state (kNm) | Moment resistance at fire resistance of 60 mins. (kNm) | Maximum Load Ratio |
|--|-------------------|------------------------------|---|--|--------------------|
| 280 ASB 100 | 5500 | 688 | 554 | 257 | 0.48 |
| | 6000 | 750 | 562 | 258 | 0.47 |
| | 6500 | 813 | 570 | 260 | 0.47 |
| 280 ASB 136 | 5500 | 688 | 726 | 376 | 0.52 |
| | 6000 | 750 | 736 | 378 | 0.51 |
| | 6500 | 813 | 745 | 381 | 0.51 |
| | 7000 | 875 | 754 | 383 | 0.51 |
| 300 ASB 153 | 6000 | 750 | 870 | 472 | 0.51 |
| | 6500 | 813 | 880 | 475 | 0.54 |
| | 7000 | 875 | 890 | 478 | 0.54 |
| | 7500 | 938 | 900 | 481 | 0.54 |
| 300 ASB 153 (slab flush with top flange, and lightweight concrete used) | 6000 | 750 | 835 | 440 | 0.53 |
| | 6500 | 813 | 842 | 442 | 0.53 |
| | 7000 | 875 | 849 | 443 | 0.52 |
| | 7500 | 938 | 856 | 445 | 0.52 |

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

SHELF ANGLE FLOOR BEAMS



METHOD

Shelf Angle Floor Beams consist of Universal Beams with angles bolted or welded to the web. The floor is formed from concrete floor slabs which sit on the outstand of the angle. The gap between the web and the floor slab is filled with grout or concrete to ensure that an effective heat sink is created around the section. This arrangement can be designed to provide 30 or 60 minutes fire resistance in many cases without the need for applied fire protection.

PRINCIPLE

The section is partly protected from the effects of fire by the insulating concrete floor and infill. Thus only part of the web and the bottom flange is exposed to the fire. The angles, which are ignored in cold design, are considered in fire and provide additional capacity. As the angles are placed further down the web, the insulated area, and thus the fire resistance is increased. Where fire protection is required, the reduced exposed perimeter leads in turn to reduced fire protection thicknesses.

UP TO 1 HOUR UNPROTECTED



ADVANTAGES

- Fire resistance periods of 30 minutes can be achieved in most cases without fire protection to the exposed web and bottom flange.
- Fire resistance periods of 60 minutes can be achieved in some instances depending on the load and the exposed area of the beam.
- Reduced construction runs and building height
- Where the exposed steelwork requires fire protection, reduced thicknesses are possible

LIMITATIONS

- a) The angle must be 125 x 75 x 12 Grade S355, short leg attached vertically to the beam as shown overleaf.
- b) For 60 minutes fire resistance at high loads, the required depth of floor slab may be unavailable or uneconomic.
- c) For fire resistance periods over 60 minutes, fire protection to the exposed perimeter will always be necessary.

FOR MORE DETAILED INFORMATION SEE:-

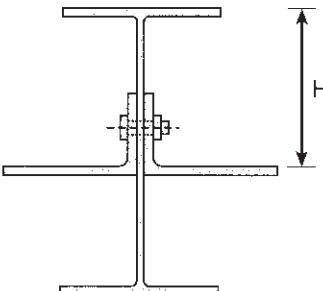
SCI Publication 126 "The Fire Resistance of Shelf Angle Floor Beams to BS5950 Part 8" The Steel Construction Institute
(01344 23345)

Sheet Code
ISF/No.10
April 1997

Typical recommendations for fire resistance of Shelf Angle Floor Beams, taken from the Steel Construction Institute publication, are given in Table 1. These can be expanded to take into account other grades of steel and fire resistance periods. The allowable angle connection force must also be considered.

Table 1**Fire Resistance 60 minutes**

Beam Grade S355
Angle Grade S355

**H(mm), Position of angle below top of beam for load ratio¹ of**

| Section Size | M _p (KNm) | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 |
|-------------------|----------------------|-----|------|-----|------|-----|------|-----|
| 305 x 102 x 25 UB | 120 | 129 | 144 | 158 | 172 | 184 | 196 | 208 |
| 305 x 102 x 28 UB | 145 | 137 | 152 | 167 | 180 | 193 | 205 | 217 |
| 305 x 102 x 33 UB | 170 | 144 | 159 | 174 | 188 | 201 | 214 | 227 |
| 305 x 127 x 37 UB | 192 | 145 | 160 | 174 | 188 | 202 | 209 | 222 |
| 305 x 127 x 42 UB | 217 | 150 | 166 | 181 | 196 | 207 | 216 | 230 |
| 305 x 127 x 48 UB | 251 | 158 | 174 | 190 | 206 | 212 | 227 | 235 |

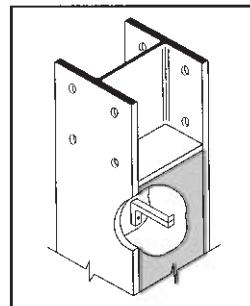
¹Load Ratio is defined in BS5950 Part 8 is the ratio of the load at the fire limit state to the cold capacity of the section.

STEELWORK IN FIRE INFORMATION SHEET

This series of information sheets is intended to illustrate methods of achieving fire resistance in steel structures. It should not be used for design without consulting detailed design guidance referenced below.

WEB INFILLED COLUMNS

UP TO 1 HOUR UNPROTECTED



METHOD

Shear connectors are shot fired or welded to the web of the column. A web stiffening plate is welded to the column below the connection zone to contain the concrete. The area below the stiffener and between the flanges is then filled with concrete.

PRINCIPLE

In cold design any beneficial effects of the concrete are ignored. In fire however, as the steel becomes hot, the load is transferred to the concrete. Load transfer is accommodated both by the shear studs and the welded stiffener plate. The unconcreted part of the column and the connections are protected by the same system used to protect the steel beam.

ADVANTAGES

- Fire resistance periods of 60 minutes can be achieved in most cases without fire protection to the exposed flanges.

- For higher periods of fire resistance reduced fire protection thicknesses are required.
- The complete column can be constructed off-site.
- The complete section takes up no space not already occupied by the steel column.

LIMITATIONS

- a) The method should not be used where a high specification is required and the column is exposed.
- b) Although the system can be used in simple construction where moments are relatively small, it is not suitable for columns in moment resisting frames.
- c) For fire resistance periods over 60 minutes, fire protection to the exposed perimeter will always be necessary.
- d) The method can only be used for 203x203x46 UCs and above in size.

FOR MORE DETAILED INFORMATION SEE:-

SCI Publication 124 "The Fire Resistance of Web Infilled Steel Columns"
The Steel Construction Institute (01344 23345)

Sheet Code
ISF/No.11
April 1997

Typical recommendations for fire resistance of Web Infilled Columns, taken from the Steel Construction Institute publication, are given in Table 1

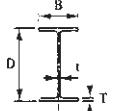
Table 1**Fire Resistance 60 minutes****Column Grade S275**

| Section Size | Moment Capacity (kNm) | | Load Ratio ¹ | Compressive Capacity (kN) at effective lengths used for normal design | | | | |
|----------------|-----------------------|----------------------------|-------------------------|---|--------|--------|--------|--------|
| | M _{fx} | M <subfy< sub=""></subfy<> | | 2500mm | 3000mm | 3500mm | 4000mm | 4500mm |
| 203 x 203 x 46 | 40.3 | 22.9 | 0.57 | 744 | 682 | 616 | 551 | 488 |
| 203 x 203 x 52 | 47.0 | 25.4 | 0.54 | 803 | 738 | 669 | 600 | 533 |
| 203 x 203 x 60 | 56.7 | 29.0 | 0.52 | 882 | 881 | 735 | 659 | 586 |
| 203 x 203 x 71 | 69.9 | 34.6 | 0.49 | 974 | 899 | 820 | 740 | 662 |

¹Load Ratio is defined in BS5950 Part 8 as the ratio of the load at the fire limit state to the cold capacity of the section.

M_{fx} = the moment capacity in fire conditions for bending about the x - x axis.

M_{fy} = the moment capacity in fire conditions for bending about the y - y axis.

| Universal beams | |  | | Section factor $\frac{A_m}{V}$ | | |
|------------------------|---------------------------|---|------------------|--|-----------------------|-------|
| | | | | Profile | | |
| Designation | Depth of section D | Width of section B | Thickness | Profile | Box | |
| Serial size | Mass per metre | mm | mm | mm | mm | |
| | | | | m⁻¹ | m⁻¹ | |
| 914×419 | 388 | 920.5 | 21.5 | 36.6 | 494.4 | |
| | 343 | 911.4 | 19.4 | 32.0 | 437.4 | |
| 914×305 | 289 | 926.6 | 307.8 | 19.6 | 32.0 | 368.8 |
| | 253 | 918.5 | 305.5 | 17.3 | 27.9 | 322.8 |
| | 224 | 910.3 | 304.1 | 15.9 | 23.9 | 285.2 |
| | 201 | 903 | 303.4 | 15.2 | 20.3 | 256.4 |
| 838×292 | 226 | 850.9 | 293.8 | 16.1 | 26.8 | 288.7 |
| | 194 | 840.7 | 292.4 | 14.7 | 21.7 | 247.1 |
| | 176 | 834.9 | 291.6 | 14 | 18.8 | 224.1 |
| 762×267 | 197 | 769.6 | 268 | 15.6 | 25.4 | 250.7 |
| | 173 | 762 | 266.7 | 14.3 | 21.6 | 220.4 |
| | 147 | 753.9 | 265.3 | (2.9) | 17.5 | 188.0 |
| 686×254 | 170 | 692.9 | 255.8 | 14.5 | 23.7 | 216.5 |
| | 152 | 687.6 | 254.5 | 13.2 | 21.0 | 193.8 |
| | 140 | 683.5 | 253.7 | 12.4 | 19.0 | 178.6 |
| | 125 | 677.9 | 253 | 11.7 | 16.2 | 159.6 |
| 610×305 | 238 | 633 | 311.5 | 18.6 | 31.1 | 303.7 |
| | 179 | 617.5 | 307 | 14.1 | 23.6 | 227.9 |
| | 149 | 609.6 | 304.8 | 11.9 | 19.7 | 190.1 |
| 610×229 | 140 | 617 | 230.1 | 13.1 | 22.1 | 178.3 |
| | 125 | 611.9 | 229 | 11.9 | 19.6 | 159.5 |
| | 113 | 607.3 | 228.2 | 11.2 | 17.3 | 144.4 |
| | 101 | 602.2 | 227.6 | 10.6 | 14.8 | 129.1 |
| 533×210 | 122 | 544.6 | 211.9 | 12.8 | 21.3 | 155.7 |
| | 109 | 539.5 | 210.7 | 11.6 | 18.8 | 138.5 |
| | 101 | 536.7 | 210.1 | 10.9 | 17.4 | 129.7 |
| | 92 | 533.1 | 209.3 | 10.2 | 15.6 | 117.7 |
| | 82 | 528.3 | 208.7 | 9.6 | 13.2 | 104.4 |
| 457×191 | 98 | 467.4 | 192.8 | 11.4 | 19.6 | 125.2 |
| | 89 | 463.6 | 192 | 10.6 | 17.7 | 113.9 |
| | 82 | 460.2 | 191.3 | 9.9 | 16.0 | 104.5 |
| | 74 | 457.2 | 190.5 | 9.1 | 14.5 | 94.98 |
| | 67 | 453.6 | 189.9 | 8.5 | 12.7 | 85.44 |
| 457×152 | 82 | 465.1 | 153.5 | 10.7 | 18.9 | 104.4 |
| | 74 | 461.3 | 152.7 | 9.9 | 17.0 | 94.99 |
| | 67 | 457.2 | 151.9 | 9.1 | 15.0 | 85.41 |
| | 60 | 454.7 | 152.9 | 8.0 | 13.3 | 75.93 |
| | 52 | 449.8 | 152.4 | 7.6 | 10.9 | 66.49 |
| 406×178 | 74 | 412.8 | 179.7 | 9.7 | 16.0 | 94.95 |
| | 67 | 409.4 | 178.8 | 8.8 | 14.3 | 85.49 |
| | 60 | 406.4 | 177.8 | 7.8 | 12.8 | 76.01 |
| | 54 | 402.6 | 177.6 | 7.6 | 10.9 | 68.42 |
| 406×140 | 46 | 402.3 | 142.4 | 6.9 | 11.2 | 58.96 |
| | 39 | 397.3 | 141.8 | 6.3 | 8.6 | 49.40 |
| 356×171 | 67 | 364 | 173.2 | 9.1 | 15.7 | 85.42 |
| | 57 | 358.6 | 172.1 | 8 | 13.0 | 72.18 |
| | 51 | 355.6 | 171.5 | 7.3 | 11.5 | 64.58 |
| | 45 | 352 | 171 | 6.9 | 9.7 | 56.96 |
| 356×127 | 39 | 352.8 | 126 | 6.5 | 10.7 | 49.40 |
| | 33 | 248.5 | 125.4 | 5.9 | 8.5 | 41.83 |
| 305×165 | 54 | 310.9 | 166.8 | 7.7 | 13.7 | 68.38 |
| | 46 | 307.1 | 165.7 | 6.7 | 11.8 | 58.90 |
| | 40 | 303.8 | 165.1 | 6.1 | 10.2 | 51.50 |
| 305×127 | 48 | 310.4 | 125.2 | 9.9 | 14.0 | 60.83 |
| | 42 | 306.6 | 124.3 | 8 | 12.1 | 53.18 |
| | 37 | 303.8 | 123.5 | 7.2 | 10.7 | 47.47 |
| 305×102 | 33 | 312.7 | 102.4 | 6.6 | 10.8 | 41.77 |
| | 28 | 308.9 | 101.9 | 6.1 | 8.9 | 36.30 |
| | 25 | 304.8 | 101.6 | 5.8 | 6.8 | 31.39 |
| 254×146 | 43 | 259.6 | 147.3 | 7.3 | 12.7 | 55.10 |
| | 37 | 256 | 146.4 | 6.4 | 10.9 | 47.45 |
| | 31 | 251.5 | 146.1 | 6.1 | 8.6 | 40.00 |
| 254×102 | 28 | 260.4 | 102.1 | 6.4 | 10.0 | 36.19 |
| | 25 | 257 | 101.9 | 6.1 | 8.4 | 32.17 |
| | 22 | 254 | 101.6 | 5.8 | 6.8 | 28.42 |
| 203×133 | 30 | 206.8 | 133.8 | 6.3 | 9.6 | 38.00 |
| | 25 | 203.2 | 133.4 | 5.8 | 7.8 | 32.31 |
| 203×102 | 23 | 203.2 | 101.6 | 5.2 | 9.3 | 29 |
| 178×102 | 19 | 177.8 | 101.6 | 4.7 | 7.9 | 24.2 |
| 152×89 | 16 | 152.4 | 88.9 | 4.6 | 7.7 | 20.5 |
| 127×76 | 13 | 127 | 76.2 | 4.2 | 7.6 | 16.8 |

| Section factor $\frac{A_m}{V}$ | | | | | | | | | |
|--------------------------------|---|---|---|--|--|---|--|---|--|
| | | | | | Profile | | Box | | |
| | | | | | 3 sides | 4 sides | 3 sides | 4 sides | |
| Designation | Depth of section D | Width of section B | Thickness Web t | Area of section | | | | | |
| Serial size | Mass per metre kg | mm | mm | mm | cm ² | m ⁻¹ | m ⁻¹ | m ⁻¹ | m ⁻¹ |
| Universal columns | | | | | | | | | |
| | | B | D | T | | | | | |
| 356 × 406 | 634 551 467 393 340 287 235 | 474.7 455.7 436.6 419.1 406.4 393.7 381.0 | 424.1 418.5 412.4 407.0 403.0 394.0 395.0 | 47.6 42.0 35.9 30.6 26.5 22.6 18.5 | 77.0 67.5 58.0 49.2 42.9 36.5 30.2 | 806.1 701.8 595.5 500.9 432.7 366.0 299.8 | 25 30 35 40 45 50 65 | 15 20 20 25 30 30 40 | 20 25 30 35 35 45 50 |
| 356 × 368 | 202 177 153 129 | 374.7 368.3 362.0 355.6 | 374.4 372.1 370.2 368.3 | 16.8 14.5 12.6 10.7 | 27.0 23.8 20.7 17.5 | 257.9 225.7 195.2 164.9 | 70 80 90 105 | 85 95 110 130 | 45 50 55 65 |
| 305 × 305 | 283 240 198 158 137 118 97 | 365.3 352.6 339.9 327.2 320.5 314.5 307.8 | 321.8 317.9 314.1 310.6 308.7 306.8 304.8 | 26.9 23.0 19.2 15.7 13.8 11.9 9.9 | 44.1 37.7 31.4 25.0 21.7 18.7 15.4 | 360.4 305.6 252.3 201.2 174.6 149.8 123.3 | 45 50 60 75 85 100 120 | 55 60 75 90 105 120 145 | 30 35 40 50 55 60 75 |
| 254 × 254 | 167 132 107 89 73 | 289.1 276.4 266.7 260.4 254.0 | 264.5 261.0 258.3 255.9 254.0 | 19.2 15.6 13.0 10.5 8.6 | 31.7 25.3 20.5 17.3 14.2 | 212.4 167.7 136.6 114.0 92.9 | 60 75 90 110 130 | 75 90 110 130 160 | 40 50 60 70 80 |
| 203 × 203 | 86 71 60 52 46 | 222.3 215.9 209.6 206.2 203.2 | 208.8 206.2 205.2 203.9 203.2 | 13.0 10.3 9.3 8.0 7.3 | 20.5 17.3 14.2 12.5 11.0 | 110.1 91.1 75.8 66.4 58.8 | 95 110 130 150 165 | 110 135 160 180 200 | 60 70 80 95 105 |
| 152 × 152 | 37 30 23 | 161.8 157.5 152.4 | 154.4 152.9 152.4 | 8.1 6.6 6.1 | 11.5 9.4 6.8 | 47.4 38.2 29.8 | 160 195 245 | 190 235 300 | 100 120 155 |

| Circular hollow sections | | Section factor $\frac{A_m}{V}$ | | | | Section factor $\frac{A_m}{V}$ | | | | | |
|--------------------------|--------------------|--------------------------------|-------------------|---------------------------------|-----------------|--------------------------------|--------------------|-------------|-------------------|---------------------------------|-----------------|
| | | Profile or Box | | | | Profile or Box | | | | | |
| Designation | Outside diameter D | Thickness t | Mass per metre kg | Area of section cm ² | | Designation | Outside diameter D | Thickness t | Mass per metre kg | Area of section cm ² | |
| | mm | mm | kg | cm ² | m ⁻¹ | | mm | mm | kg | cm ² | m ⁻¹ |
| 21.3 | 3.2 | 1.43 | 1.82 | 370 | | 244.5 | 6.3 | 37.0 | 47.1 | 165 | |
| 26.9 | 3.2 | 1.87 | 2.38 | 355 | | 8.0 | 46.7 | 59.4 | 130 | | |
| 33.7 | 2.6 | 1.99 | 2.54 | 415 | | 10.0 | 57.8 | 73.7 | 105 | | |
| | 3.2 | 2.41 | 3.07 | 345 | | 12.5 | 71.5 | 91.1 | 85 | | |
| | 4.0 | 2.93 | 3.73 | 285 | | 16.0 | 90.2 | 115 | 65 | | |
| 42.4 | 2.6 | 2.55 | 3.25 | 410 | | 20.0 | 111 | 141 | 55 | | |
| | 3.2 | 3.09 | 3.94 | 340 | | 273.0 | 6.3 | 41.4 | 52.8 | 160 | |
| | 4.0 | 3.79 | 4.83 | 275 | | 8.0 | 52.3 | 66.6 | 130 | | |
| 48.3 | 3.2 | 3.56 | 4.53 | 335 | | 10.0 | 64.9 | 82.6 | 105 | | |
| | 4.0 | 4.37 | 5.57 | 270 | | 12.5 | 80.3 | 102 | 85 | | |
| | 5.0 | 5.34 | 6.80 | 225 | | 16.0 | 101 | 129 | 65 | | |
| 60.3 | 3.2 | 4.51 | 5.74 | 330 | | 20.0 | 125 | 159 | 55 | | |
| | 4.0 | 5.55 | 7.07 | 270 | | 25.0 | 153 | 195 | 45 | | |
| | 5.0 | 6.82 | 8.69 | 220 | | 323.9 | 6.3 | 49.3 | 62.9 | 160 | |
| 76.1 | 3.2 | 5.75 | 7.33 | 325 | | 8.0 | 62.3 | 79.4 | 130 | | |
| | 4.0 | 7.11 | 9.06 | 265 | | 10.0 | 77.4 | 98.6 | 105 | | |
| | 5.0 | 8.77 | 11.2 | 215 | | 12.5 | 96.0 | 122 | 85 | | |
| 88.9 | 3.2 | 6.76 | 8.62 | 325 | | 16.0 | 121 | 155 | 65 | | |
| | 4.0 | 8.38 | 10.70 | 260 | | 20.0 | 150 | 191 | 55 | | |
| | 5.0 | 10.3 | 13.2 | 210 | | 25.0 | 184 | 235 | 45 | | |
| 114.3 | 3.6 | 9.83 | 12.5 | 285 | | 355.6 | 8.0 | 68.6 | 87.4 | 130 | |
| | 5.0 | 13.5 | 17.2 | 210 | | 10.0 | 85.2 | 109 | 100 | | |
| | 6.3 | 16.8 | 21.4 | 170 | | 12.5 | 106 | 135 | 85 | | |
| 139.7 | 5.0 | 16.6 | 21.2 | 205 | | 16.0 | 134 | 171 | 65 | | |
| | 6.3 | 20.7 | 26.4 | 165 | | 20.0 | 166 | 211 | 55 | | |
| | 8.0 | 26.0 | 33.1 | 135 | | 25.0 | 204 | 260 | 45 | | |
| | 10.0 | 32.0 | 40.7 | 110 | | 406.4 | 10.0 | 97.8 | 125 | 100 | |
| 168.3 | 5.0 | 20.1 | 25.7 | 205 | | 12.5 | 121 | 155 | 80 | | |
| | 6.3 | 25.2 | 37.1 | 165 | | 16.0 | 154 | 196 | 65 | | |
| | 8.0 | 31.6 | 40.3 | 130 | | 20.0 | 191 | 243 | 55 | | |
| | 10.0 | 39.0 | 49.7 | 105 | | 25.0 | 235 | 300 | 45 | | |
| 193.7 | 5.0 | 23.3 | 29.6 | 205 | | 32.0 | 295 | 376 | 35 | | |
| | 6.3 | 29.1 | 37.1 | 165 | | 457.0 | 10.0 | 110 | 140 | 105 | |
| | 8.0 | 36.6 | 46.7 | 130 | | 12.5 | 137 | 175 | 80 | | |
| | 10.0 | 45.3 | 57.7 | 105 | | 16.0 | 174 | 222 | 65 | | |
| | 12.5 | 55.9 | 71.2 | 85 | | 20.0 | 216 | 275 | 50 | | |
| | 16.0 | 70.1 | 89.3 | 70 | | 25.0 | 266 | 339 | 40 | | |
| 219.1 | 5.0 | 26.4 | 33.6 | 205 | | 32.0 | 335 | 427 | 35 | | |
| | 6.3 | 33.1 | 42.1 | 165 | | 40.0 | 411 | 524 | 25 | | |
| | 8.0 | 41.6 | 53.1 | 130 | | 508.0 | 10.0 | 123 | 156 | 100 | |
| | 10.0 | 51.6 | 65.7 | 105 | | 12.5 | 153 | 195 | 80 | | |
| | 12.5 | 63.7 | 81.1 | 85 | | 16.0 | 194 | 247 | 65 | | |
| | 16.0 | 80.1 | 102 | 65 | | | | | | | |
| | 20.0 | 98.2 | 125 | 55 | | | | | | | |

| Rectangular hollow sections | | | B | D | Section factor $\frac{A_m}{V}$ | | |
|-----------------------------|------|-------------|----------------|-----------------|--------------------------------|-----|---------|
| Designation | | Thickness t | Mass per metre | Area of section | 3 sides | | 4 sides |
| Size D×B | mm | mm | kg | cm² | m⁻¹ | m⁻¹ | m⁻¹ |
| 50×25 | 2.5 | 2.72 | 3.47 | 360 | 290 | 430 | |
| | 3.0 | 3.22 | 4.10 | 305 | 245 | 365 | |
| | 3.2 | 3.41 | 4.34 | 290 | 230 | 345 | |
| 50×30 | 2.5 | 2.92 | 3.72 | 350 | 295 | 430 | |
| | 3.0 | 3.45 | 4.40 | 295 | 250 | 365 | |
| | 3.2 | 3.66 | 4.66 | 280 | 235 | 345 | |
| | 4.0 | 4.46 | 5.68 | 230 | 195 | 280 | |
| | 5.0 | 5.40 | 6.88 | 190 | 160 | 235 | |
| 60×40 | 2.5 | 3.71 | 4.72 | 340 | 295 | 425 | |
| | 3.0 | 4.39 | 5.60 | 285 | 250 | 355 | |
| | 3.2 | 4.66 | 5.94 | 270 | 235 | 335 | |
| | 4.0 | 5.72 | 7.28 | 220 | 190 | 275 | |
| | 5.0 | 6.97 | 8.88 | 180 | 160 | 225 | |
| | 6.3 | 8.49 | 10.8 | 150 | 130 | 185 | |
| | 8.0 | | | | | | |
| 80×40 | 3.0 | 5.34 | 6.80 | 295 | 235 | 355 | |
| | 3.2 | 5.67 | 7.22 | 275 | 220 | 330 | |
| | 4.0 | 6.97 | 8.88 | 225 | 180 | 270 | |
| | 5.0 | 8.54 | 10.9 | 185 | 145 | 220 | |
| | 6.3 | 10.5 | 13.3 | 150 | 120 | 180 | |
| | 8.0 | 12.8 | 16.3 | 125 | 100 | 145 | |
| | 8.0 | | | | | | |
| | 15.3 | | | | | | |
| 90×50 | 3.0 | 6.28 | 8.00 | 290 | 240 | 350 | |
| | 3.6 | 7.46 | 9.50 | 240 | 200 | 295 | |
| | 5.0 | 10.1 | 12.9 | 180 | 145 | 215 | |
| | 6.3 | 12.5 | 15.9 | 145 | 120 | 175 | |
| | 8.0 | 15.3 | 19.5 | 120 | 95 | 145 | |
| | 8.0 | | | | | | |
| 100×50 | 3.0 | 6.75 | 8.60 | 290 | 235 | 350 | |
| | 3.2 | 7.18 | 9.14 | 275 | 220 | 330 | |
| | 4.0 | 8.86 | 11.3 | 220 | 175 | 265 | |
| | 5.0 | 10.9 | 13.9 | 180 | 145 | 215 | |
| | 6.3 | 13.4 | 17.1 | 145 | 115 | 175 | |
| | 8.0 | 16.6 | 21.1 | 120 | 95 | 140 | |
| 100×60 | 3.0 | 7.22 | 9.20 | 285 | 240 | 350 | |
| | 3.6 | 8.59 | 10.9 | 240 | 200 | 295 | |
| | 5.0 | 11.7 | 14.9 | 175 | 150 | 215 | |
| | 6.3 | 14.4 | 18.4 | 140 | 120 | 175 | |
| | 8.0 | 17.8 | 22.7 | 115 | 95 | 140 | |
| 120×60 | 3.6 | 9.72 | 12.4 | 240 | 195 | 290 | |
| | 5.0 | 13.3 | 16.9 | 180 | 140 | 215 | |
| | 6.3 | 16.4 | 20.9 | 145 | 115 | 170 | |
| | 8.0 | 20.4 | 25.9 | 115 | 95 | 140 | |
| | 8.0 | | | | | | |
| 120×80 | 5.0 | 14.8 | 18.9 | 170 | 150 | 210 | |
| | 6.3 | 18.4 | 23.4 | 135 | 120 | 170 | |
| | 8.0 | 22.9 | 29.1 | 110 | 95 | 135 | |
| | 10.0 | 27.9 | 35.5 | 90 | 80 | 115 | |
| 150×100 | 5.0 | 18.7 | 23.9 | 165 | 145 | 210 | |
| | 6.3 | 23.8 | 29.7 | 135 | 120 | 170 | |
| | 8.0 | 29.1 | 37.1 | 110 | 95 | 135 | |
| | 10.0 | 35.7 | 45.5 | 90 | 75 | 110 | |
| | 12.5 | 43.6 | 55.5 | 70 | 65 | 90 | |
| 160×80 | 5.0 | 18.0 | 22.9 | 175 | 140 | 210 | |
| | 6.3 | 22.3 | 28.5 | 140 | 110 | 170 | |
| | 8.0 | 27.9 | 35.5 | 115 | 90 | 135 | |
| | 10.0 | 34.2 | 43.5 | 90 | 75 | 110 | |
| | 12.5 | 41.6 | 53.0 | 75 | 60 | 90 | |
| 200×100 | 5.0 | 22.7 | 28.9 | 175 | 140 | 210 | |
| | 6.3 | 28.3 | 36.0 | 140 | 110 | 165 | |
| | 8.0 | 35.4 | 45.1 | 110 | 90 | 135 | |
| | 10.0 | 43.6 | 55.5 | 90 | 70 | 110 | |
| | 12.5 | 53.4 | 68.0 | 75 | 60 | 90 | |
| | 16.0 | 66.4 | 84.5 | 60 | 45 | 70 | |
| 250×150 | 6.3 | 38.2 | 48.6 | 135 | 115 | 165 | |
| | 8.0 | 48.0 | 61.1 | 105 | 90 | 130 | |
| | 10.0 | 59.3 | 75.5 | 85 | 75 | 105 | |
| | 12.5 | 73.0 | 93.0 | 70 | 60 | 85 | |
| | 16.0 | 91.5 | 117 | 55 | 45 | 70 | |
| | 16.0 | | | | | | |
| 300×200 | 6.3 | 48.1 | 61.2 | 130 | 115 | 165 | |
| | 8.0 | 60.5 | 77.1 | 105 | 90 | 130 | |
| | 10.0 | 75.0 | 95.5 | 85 | 75 | 105 | |
| | 12.5 | 92.6 | 118 | 70 | 60 | 85 | |
| | 16.0 | 117 | 149 | 55 | 45 | 65 | |
| | 16.0 | | | | | | |
| 400×200 | 10.0 | 99.7 | 116 | 85 | 70 | 105 | |
| | 12.5 | 112 | 143 | 70 | 55 | 85 | |
| | 16.0 | 142 | 181 | 55 | 45 | 65 | |
| 450×250 | 10.0 | 106 | 136 | 85 | 70 | 105 | |
| | 12.5 | 132 | 168 | 70 | 55 | 85 | |
| | 16.0 | 167 | 213 | 55 | 45 | 65 | |

| Rectangular hollow sections (square) | | Section factor $\frac{A_m}{V}$ | | | | Section factor $\frac{A_m}{V}$ | | | | | | | |
|--------------------------------------|------------|--------------------------------|----------------|-----------------|-----------------|--------------------------------|------------|-------------|----------------|-----------------|-----------------|-----|-----|
| | | 3 sides | 4 sides | | | 3 sides | 4 sides | | | | | | |
| Designation | Size D × D | Thickness t | Mass per metre | Area of section | | Designation | Size D × D | Thickness t | Mass per metre | Area of section | | | |
| mm | mm | mm | kg | cm ² | m ⁻¹ | mm | mm | mm | kg | cm ² | m ⁻¹ | | |
| 20×20 | | 2.0 | 1.12 | 1.42 | 425 | 565 | 120×120 | | 5.0 | 18.0 | 22.9 | 155 | 210 |
| | | 2.5 | 1.35 | 1.72 | 350 | 465 | | | 6.3 | 22.3 | 28.5 | 125 | 170 |
| 25×25 | | 2.0 | 1.43 | 1.82 | 410 | 550 | | | 8.0 | 27.9 | 35.5 | 100 | 135 |
| | | 2.5 | 1.74 | 2.22 | 340 | 450 | | | 10.0 | 34.2 | 43.5 | 85 | 110 |
| 30×30 | | 2.0 | 2.04 | 2.60 | 290 | 385 | | | 12.5 | 41.6 | 53.0 | 70 | 90 |
| | | 3.2 | 2.15 | 2.74 | 275 | 365 | 140×140 | | 5.0 | 21.1 | 26.9 | 155 | 210 |
| 30×30 | | 2.5 | 2.14 | 2.72 | 330 | 440 | | | 6.3 | 26.3 | 33.5 | 125 | 165 |
| | | 3.0 | 2.51 | 3.20 | 280 | 375 | | | 8.0 | 32.9 | 41.9 | 100 | 135 |
| 30×30 | | 3.2 | 2.65 | 3.38 | 265 | 355 | | | 10.0 | 40.4 | 51.5 | 80 | 110 |
| 40×40 | | 2.5 | 2.92 | 3.72 | 325 | 430 | | | 12.5 | 49.5 | 63.0 | 65 | 90 |
| | | 3.0 | 3.45 | 4.40 | 275 | 365 | 150×150 | | 5.0 | 22.7 | 28.9 | 155 | 210 |
| | | 3.2 | 3.66 | 4.66 | 260 | 345 | | | 6.3 | 28.3 | 36.0 | 125 | 165 |
| | | 4.0 | 4.46 | 5.68 | 210 | 280 | | | 8.0 | 35.4 | 45.1 | 100 | 135 |
| 50×50 | | 5.0 | 5.40 | 6.88 | 175 | 235 | | | 10.0 | 43.6 | 55.5 | 80 | 110 |
| | | 5.2 | 4.66 | 5.94 | 255 | 335 | | | 12.5 | 53.4 | 68.0 | 65 | 90 |
| 50×50 | | 5.5 | 3.71 | 4.72 | 320 | 425 | | | 16.0 | 66.4 | 84.5 | 55 | 70 |
| | | 5.0 | 4.39 | 5.60 | 270 | 335 | 180×180 | | 6.3 | 34.2 | 43.6 | 125 | 165 |
| | | 5.2 | 4.66 | 5.94 | 255 | 335 | | | 8.0 | 43.0 | 54.7 | 100 | 130 |
| 60×60 | | 4.0 | 5.72 | 7.28 | 205 | 275 | | | 10.0 | 53.0 | 67.5 | 80 | 105 |
| | | 5.0 | 6.97 | 8.88 | 170 | 225 | | | 12.5 | 65.2 | 83.0 | 65 | 85 |
| 60×60 | | 6.3 | 8.49 | 10.8 | 140 | 185 | | | 16.0 | 81.4 | 104 | 50 | 70 |
| | | 3.0 | 5.34 | 6.80 | 265 | 355 | 200×200 | | 6.3 | 38.2 | 48.6 | 125 | 165 |
| | | 3.2 | 5.67 | 7.22 | 250 | 330 | | | 8.0 | 48.0 | 61.1 | 100 | 130 |
| 70×70 | | 4.0 | 6.97 | 8.88 | 205 | 270 | | | 10.0 | 59.3 | 75.5 | 80 | 105 |
| | | 5.0 | 8.54 | 10.9 | 165 | 220 | | | 12.5 | 73.0 | 93.0 | 65 | 85 |
| 70×70 | | 6.3 | 10.5 | 13.3 | 135 | 180 | | | 16.0 | 91.5 | 117 | 50 | 70 |
| | | 8.0 | 12.8 | 16.3 | 110 | 145 | 250×250 | | 6.3 | 48.1 | 61.2 | 125 | 165 |
| 80×80 | | 3.0 | 6.28 | 8.00 | 260 | 350 | | | 8.0 | 60.5 | 77.1 | 95 | 130 |
| | | 3.6 | 7.46 | 9.50 | 220 | 295 | | | 10.0 | 75.0 | 95.5 | 80 | 105 |
| 80×80 | | 5.0 | 10.1 | 12.9 | 165 | 215 | | | 12.5 | 92.6 | 118 | 65 | 85 |
| | | 6.3 | 12.5 | 15.9 | 130 | 175 | | | 16.0 | 117 | 149 | 50 | 65 |
| 80×80 | | 8.0 | 15.3 | 19.5 | 110 | 145 | 300×300 | | 10.0 | 90.7 | 116 | 80 | 105 |
| | | 3.0 | 7.22 | 9.20 | 260 | 350 | | | 12.5 | 112 | 143 | 65 | 85 |
| 80×80 | | 3.6 | 8.59 | 10.9 | 220 | 295 | | | 16.0 | 142 | 181 | 50 | 65 |
| | | 5.0 | 11.7 | 14.9 | 160 | 215 | 350×350 | | 10.0 | 106 | 136 | 75 | 105 |
| 80×80 | | 6.3 | 14.4 | 18.4 | 130 | 175 | | | 12.5 | 132 | 168 | 65 | 85 |
| | | 8.0 | 17.8 | 22.7 | 105 | 140 | | | 16.0 | 167 | 213 | 50 | 65 |
| 90×90 | | 3.6 | 9.72 | 12.4 | 220 | 290 | 400×400 | | 10.0 | 106 | 136 | 75 | 105 |
| | | 5.0 | 13.3 | 16.9 | 160 | 215 | | | 12.5 | 152 | 193 | 60 | 85 |
| 90×90 | | 6.3 | 16.4 | 20.9 | 130 | 170 | | | 16.0 | 192 | 245 | 50 | 65 |
| | | 8.0 | 20.4 | 25.9 | 105 | 140 | | | 16.0 | 192 | 245 | 50 | 65 |
| 100×100 | | 4.0 | 12.0 | 15.3 | 195 | 260 | | | 16.0 | 192 | 245 | 50 | 65 |
| | | 5.0 | 14.8 | 18.9 | 160 | 210 | | | 16.0 | 192 | 245 | 50 | 65 |
| 100×100 | | 6.3 | 18.4 | 23.4 | 130 | 170 | | | 16.0 | 192 | 245 | 50 | 65 |
| | | 8.0 | 22.9 | 29.1 | 105 | 135 | | | 16.0 | 192 | 245 | 50 | 65 |
| 100×100 | | 10.0 | 27.9 | 35.5 | 85 | 115 | | | 16.0 | 192 | 245 | 50 | 65 |

Minimum thickness of a typical spray protection to an I-section

| A_m/V up to | Dry thickness (mm) to provide fire resistance of | | | | | |
|------------------|--|--------|----------------------|---------|---------|---------|
| | $\frac{1}{2}$ hour | 1 hour | $1\frac{1}{2}$ hours | 2 hours | 3 hours | 4 hours |
| 30 | 10 | 10 | 10 | 10 | 15 | 25 |
| 50 | 10 | 10 | 10 | 14 | 21 | 29 |
| 70 | 10 | 10 | 12 | 17 | 27 | 36 |
| 90 | 10 | 10 | 14 | 20 | 31 | 42 |
| 110 | 10 | 10 | 16 | 22 | 34 | 47 |
| 130 | 10 | 10 | 17 | 24 | 37 | 51 |
| 150 | 10 | 11 | 18 | 25 | 40 | 54 |
| 170 | 10 | 12 | 19 | 27 | 42 | 57 |
| 190 | 10 | 12 | 20 | 28 | 44 | 59 |
| 210 | 10 | 13 | 21 | 29 | 45 | |
| 230 | 10 | 13 | 21 | 30 | 47 | |
| 250 | 10 | 14 | 22 | 31 | 48 | |
| 270 | 10 | 14 | 23 | 31 | 49 | |
| 290 | 10 | 14 | 23 | 32 | 50 | |
| 310 | 10 | 14 | 23 | 33 | 51 | |

Linear interpolation is permissible between values of H_p/A

Basic data on corrosion

Atmospheric corrosivity categories and examples of typical environments (ISO 12944 Part 2)

| Corrosivity category and risk | Mass loss per unit surface/thickness loss (see Note 1) | | Examples of typical environments in a temperate climate (informative only) |
|-----------------------------------|---|--|--|
| | Low-carbon steel Thickness loss μm | Exterior | |
| C1 very low | ≤ 1.3 | — | Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels |
| C2 low | $>1.3\text{--}25$ | Atmospheres with low level of pollution. Mostly rural areas | Unheated buildings where condensation may occur, e.g. depots, sports halls |
| C3 medium | $>25\text{--}60$ | Urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal area with low salinity | Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, dairies |
| C4 high | $>50\text{--}80$ | Industrial areas and coastal areas with moderate salinity | Chemical plants, swimming pools, coastal, ship and boatyards |
| C5-I very high (industrial) | $>80\text{--}200$ | Industrial areas with high humidity and aggressive atmosphere | Buildings or areas with almost permanent condensation and high pollution |
| C5-M very high (marine) | $>80\text{--}200$ | Coastal and offshore areas with high salinity | Buildings or areas with almost permanent condensation and with high pollution |

1. The thickness loss values are after the first year of exposure. Losses may reduce over subsequent years.
2. The loss values used for the corrosivity categories are identical to those given in ISO 9223.
3. In coastal areas in hot, humid zones, the thickness losses can exceed the limits of category C5-M. Special precautions must therefore be taken when selecting protective paint systems for structures in such areas.

$1 \mu\text{m} = 0.001 \text{ mm}$

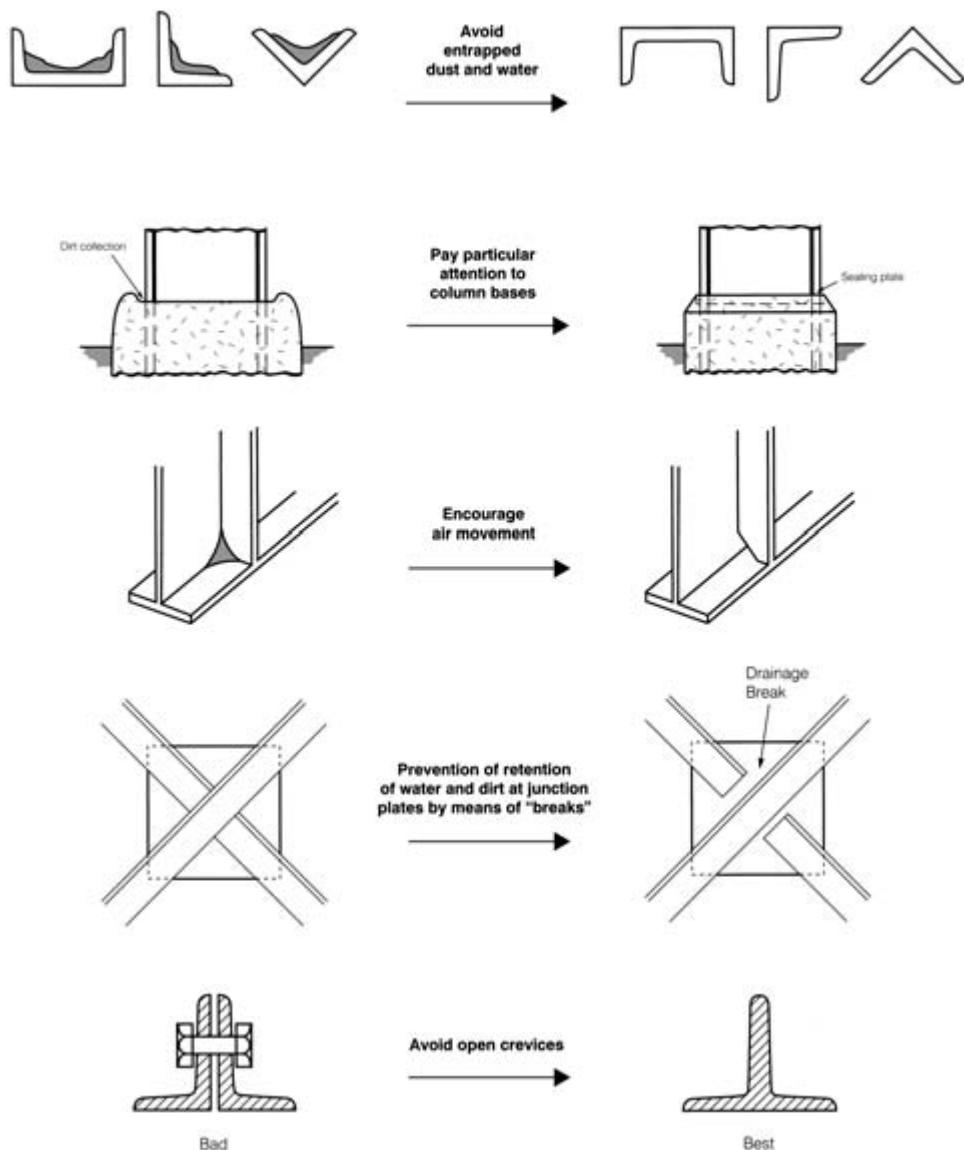
Main generic types of paint and their properties

| Binder | System cost | Tolerance of poor surface | Chemical resistance | Solvent resistance | Water resistance | Overcoating after ageing | Comments |
|---|--------------------------------------|--------------------------------|---------------------|--------------------|------------------|--------------------------------------|---|
| Black coatings (based on tar products) | Low | Good | Moderate | Poor | Good | Very Good with coatings of same type | Limited to black or dark colours. May soften in hot conditions |
| Alkyds | Low – medium | Moderate | Poor | Poor – moderate | Moderate | Good | Good decorative properties. High solvent levels |
| Acrylated rubbers | Medium – high | Poor | Good | Poor | Good | Good | High build films that remain soft and are susceptible to sticking |
| Epoxy | Surface tolerant High performance | Medium – high Medium – high | Good Very poor | Good Very good | Good Good | Good Very good | Can be applied to a range of surfaces and coatings* Susceptible to 'chalking' in U.V. light |
| Urethane and polyurethane | High | Very poor | Very good | Good | Very good | Poor | Can be more decorative than epoxies |
| Organic silicate and inorganic silicate | High | Very poor | Moderate | Good | Good | Moderate | May require special surface preparation |

*Widely used for maintenance painting

SOME EXAMPLES OF DETAILING TO MINIMISE CORROSION

Details should be designed to enhance durability by avoiding water entrapment.



British and European Standards covering the design and construction of steelwork

A basic list of standards covering the design and construction of steelwork is given.

Loading

- BS 5400 Steel concrete and composite bridges
Part 2: 1978 Specification for loads
Part 6: 1999 Specification for materials and workmanship, steel
- BS 6399 Loading for buildings
Part 1: 1997 Code of practice for dead and imposed loads
Part 2: 1997 Code of practice for wind loads
Part 3: 1998 Code of practice for imposed roof loads
- DD ENV 1991 Eurocode 1 Basis of design and actions on structures
DD ENV 1991-1: 1996 Basis of design
DD ENV 1991-2-2: 1996 Actions on structures exposed to fire (together with UK NAD)
DD ENV 1991-2-3: 1996 Actions on structures – Snow loads
DD ENV 1991-2-4: 1997 Actions on structures – Wind actions (together with UK NAD)
DD ENV 1991-2-6: 2000 Actions on structures – Actions during execution
DD ENV 1991-3: 2000 Traffic loads on bridges (together with UK NAD)
DD ENV 1991-4: 1996 Actions in silos and tanks

Design

- BS 5400 Steel concrete and composite bridges
Part 3: 2000 Code of practice for design of steel bridges
Part 5: 1979 Code of practice for design of composite bridges
Part 9: 1983 Bridge bearings
Part 10: 1980 Code of practice for fatigue
Part 10c: 1999 Charts for classification of details for fatigue
- BS 5427 Code of practice for the use of profiled sheet for roof and wall cladding on buildings
Part 1: 1996 Design
- BS 5950 Structural use of steelwork in building
Part 1: 2000 Code of practice for design in simple and continuous construction – Hot rolled sections

- Part 3: Section 3.1: 1990 Design of simple and continuous composite beams
- Part 4: 1994 Code of practice for design of floors with profiled steel sheeting
- Part 5: 1998 Code of practice for design of cold-formed sections
- Part 6: 1995 Code of practice for design of light gauge profiled steel sheeting
- Part 8: 1990 Code of practice for fire resistant design
- Part 9: 1994 Code of practice for stressed skin design

ENV 1991 Eurocode 1 Basis of design and actions on structures

ENV 1991-2-7: 1998 Actions on structures – Accidental actions due to impact and explosions

ENV 1991-5: 1998 Actions induced by cranes and other machinery

ENV 1993 Eurocode 3 Design of steel structures

ENV 1993-1-1: 1992 General rules and rules for buildings (together with UK NAD)

ENV 1993-1-2: 2001 General rules – Structural fire design (together with UK NAD)

ENV 1993-1-3: 2001 General rules – supplementary rules for cold formed thin gauge members and sheeting (together with UK NAD)

ENV 1993 Eurocode 3 Design of steel structures

ENV 1993-1-6: 1999 General rules – Supplementary rules for shell structures

ENV 1993-1-7: 1999 General rules – Supplementary rules for planar plated structural elements with out of plane loading

ENV 1993-4-1: 1999 Silos, tanks and pipelines – Silos

ENV 1993-4-2: 1999 Silos, tanks and pipelines – Tanks

ENV 1993-4-3: 1999 Silos, tanks and pipelines – Pipelines

ENV 1994 Eurocode 4 Design of composite steel and concrete structures

ENV 1994-1-1: 1994 General rules and rules for buildings (together with UK NAD)

ENV 1998 Eurocode 8 Design provisions for earthquake resistance of structures

ENV 1998-1-1: 1996 General rules – Seismic actions and general requirements for structures

ENV 1998-1-2: 1996 General rules – General rules for buildings

ENV 1998-1-3: 1996 General rules – Specific rules for various materials and elements

ENV 1998-1-4: 1996 General rules – Strengthening and repair of buildings

ENV 1998-2: 1996 Bridges

ENV 1998-4: 1999 Silos, tanks and pipelines

ENV 1998-5: 1996 Foundations, retaining structures and geotechnical aspects

Steel fabrication and erection

- BS 4604 Specification for the use of high strength friction grip bolts in structural steelwork – Metric series
Part 1: 1970 General grade
Part 2: 1970 Higher grade (parallel shank)
- BS 5400 Steel, concrete and composite bridges
Part 6: 1999 Specification for materials and workmanship, steel
- BS 5950 Structural use of steelwork in building
Part 2: 1992 Specification for materials, fabrication and erection – Hot-rolled sections
Part 7: 1992 Specification for materials and workmanship – Cold-formed sections
- ENV 1090 Execution of steel structures
ENV 1090-1: 1998 General rules and rules for buildings
ENV 1090-2: 1998 Supplementary rules for cold-formed thin gauge components and sheeting
ENV 1090-3: 2000 Supplementary rules for high yield strength steels
ENV 1090-4: 2000 Supplementary rules for hollow section structures
ENV 1090-6: 2000 Supplementary rules for stainless steel

Foundations and piling

- BS 4 Part 1: 1993 Structural steel sections – Specification for hot-rolled sections
- BS 449 Specification for the use of structural steel in building
Part 2: 1969 Metric units
- BS 5400: Steel concrete and composite bridges
Part 1: 1988 General statement
- BS 5493: 1977 Code of practice for protective coating of iron and steel structures against corrosion
- BS 5950 Structural use of steelwork in building
BS 5950-1: 2000 Code of practice for design in simple and continuous construction – Hot-rolled sections
- BS 8002: 1994 Code of practice for earth-retaining systems
- BS 8004: 1986 Code of practice for foundations
- BS 8081: 1989 Code of practice for ground anchorages
- BS EN 10248 Hot-rolled sheet piling of non alloy steels

BS EN 20149 Cold-formed sheet piling of non alloy steels

BS EN 12063: 1999 Execution of special geotechnical work – Sheet pile walls

Structural steel

BS 970 Specification for wrought steels for mechanical and allied engineering purposes

(*NB. Some sections withdrawn and replaced by BS ENs*)

BS 1449 Steel plate, sheet and strip (many sections)

(*NB. Some sections withdrawn and replaced by BS ENs*)

BS 4360 Specification for weldable structural steels

(*Withdrawn. Replaced by BS 7668: 1994, BS EN 10029: 1991, Parts 1–3 of BS EN 10133: 1999, BS EN 10137: 1996, BS EN 10155: 1993 and BS EN 10210–1: 1994*)

BS EN 10111: 1998 Continuously hot-rolled low carbon steel sheet and strip for cold forming – Technical delivery conditions

BS EN 10113 Hot rolled products in weldable fine grain structural steels

BS EN 10130: 1999 Cold-rolled low carbon steel flat products for cold forming – Technical delivery conditions

BS EN 10137: Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions

BS EN 10139: 1998 Cold-rolled uncoated mild steel narrow strip for cold forming – Technical delivery conditions

BS EN 10164: 1993 Steel products with improved deformation properties perpendicular to the surface of the product – Technical delivery conditions

BS EN 10210-1: 1994 Hot-finished structural hollow sections of non-alloy and fine grain structural steels – Technical delivery requirements.

BS EN 10219-1: 1997 Cold-formed structural hollow sections of non-alloy and fine grain structural steels – Technical delivery requirements

BS EN 10268: 1999 Cold-rolled flat products made of high yield strength micro-alloyed steels for cold forming – General delivery conditions

(*Supersedes BS 1449-1-1.5: 1991 and BS 1449-1-1.11: 1991*)

BS EN 10273: 2000 Hot-rolled weldable steel bars for pressure purposes with specified elevated temperature properties

Steel products

BS 4 Part 1: 1993 Structural steel sections. Specification for hot-rolled sections
BS EN 10029: 1991 Tolerances on dimensions, shape and mass for hot-rolled steel plates 3 mm thick or above

BS EN 10051: 1992 + A1: 1997 Continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels – Tolerances on dimensions and shape (including amendment A1: 1997)

BS EN 10055: 1996 Hot-rolled steel equal flange tees with radiused root and toes – Dimensions and tolerances on shape and dimensions

BS EN 10056 Specification for structural steel equal and unequal angles

BS EN 10056-1: 1998 Dimensions

BS EN 10056-2: 1993 Tolerances on shape and dimensions

BS EN 10067: 1997 Hot-rolled bulb flats – Dimensions and tolerances on shape, dimensions and mass

BS EN 10163 Specification for delivery requirements for surface conditions of hot-rolled steel plates, wide flats and sections

BS EN 10210-2: 1997 Hot-finished structural hollow sections of non-alloy and fine grain structural steels – Tolerances, dimensions and sectional properties

BS EN 10219-2: 1997 Cold-formed structural hollow sections of non-alloy and fine grain structural steels – Tolerances, dimensions and sectional properties

Euronorm 91: 1981 Hot-rolled wide flats – Tolerances on dimensions, shape and mass

Cold-rolled thin gauge sections and sheets

BS 1449 Steel plate, sheet and strip Section 1.9: 1991 Specification for cold-rolled narrow strip based on formability

BS 2994: 1976 (1987) Specification for cold-rolled steel sections

BS 5950 Structural use of steelwork in buildings

Part 5: 1987 Code of practice for the design of cold-rolled sections

Part 6: 1995 Code of practice for design of light gauge profiled steel sheeting

Part 7: 1992 Specification for materials and workmanship – Cold-formed sections

Part 9: 1994 Code of practice for stressed skin design

BS EN 10048: 1997 Hot-rolled narrow steel strip – Tolerances on dimensions and shape

BS EN 10031: 1991 Cold-rolled uncoated low carbon and high yield strength steel flat products for cold forming

BS EN 10140: 1997 Cold-rolled narrow steel strip – Tolerances on dimensions and shape

BS EN 10143: 1993 Continuously hot-dip metal coated steel sheet and strip – Tolerances on dimensions and shape

BS EN 10147: 2000 Continuously hot-dip zinc coated structural steels strip and sheet – Technical delivery conditions

BS EN 10149 Hot-rolled flat products made of high yield strength steels for cold forming

BS EN 10214: 1995 Continuously hot-dip zinc-aluminium (ZA) coated steel strip and sheet – Technical delivery conditions

BS EN 10215: 1995 Continuously hot-dip aluminium-zinc (AZ) coated steel strip and sheet – Technical delivery conditions

BS EN 10238: 1997 Automatically blast cleaned and automatically primed structural steel products

BS EN 10292: 2000 Continuously hot-dip coated strip and sheet of steels with higher yield strength for cold forming – Technical delivery conditions

DD ENV 10169 Continuously organic coated (coil coated) steel flat products
DD ENV 10169-2: 1999 Products for building exterior applications

ISO 4995: 1993 Hot-rolled steel sheet of structural quality

ISO 4997: 1991 Cold reduced steel sheet of structural quality

ISO 4999: 1999 Continuous hot-dip terne (lead alloy) coated cold-reduced steel sheet of commercial drawing and structural qualities

ISO 5951: 1993 Hot-rolled steel sheet of higher yield strength with improved formability

ISO 6316: 1993 Hot-rolled steel strip of structural quality

ISO 16162: 2000 Continuously cold-rolled products – Dimensional and shape tolerances

ISO 16163: 2000 Continuously hot-dipped coated steel products – Dimensional and shape tolerances

Stainless steels

- BS 7475: 1991 Specification for fusion welding of austenitic stainless steels
BS EN 10088 Stainless steels
BS EN ISO 3506 Mechanical properties of corrosion resistant stainless steel fasteners

Castings and forgings

- BS 3100: 1991 Specification for steel castings for general engineering purposes
BS EN 1560: 1997 Founding – Designation system for cast iron – Material symbols and material number
BS EN 1561: 1997 Founding – Grey cast irons
BS EN 1563: 1997 Founding – Spheroidal graphite cast irons

Steel construction components

- BS 2994: 1976 (1987) Specification for cold-rolled steel sections
BS 5427 Code of practice for the use of profiled sheet for roof and wall cladding on buildings
Part 1: 1996 Design
BS EN 1337 Structural bearings
BS EN 1462: 1997 Brackets for eaves gutters: Requirements and testing

Welding materials and processes

General

- BS 499 Specification for symbols for welding (formerly Welding terms and symbols)
Part 1: 1991 Glossary for welding, brazing and thermal cutting
BS 499-2C: 1999 European arc welding symbols in chart form
BS EN 29692: 1994 Specification for metal-arc welding with covered electrode, gas shielded metal arc-welding and gas welding. Joint preparation for steel

BS EN ISO 4063: 2000 Welding and allied processes – Nomenclature of processes and reference numbers

BS EN ISO 9692 Welding and allied processes – Joint preparation

BS EN ISO 9692-2: 1998 Submerged arc welding of steels

Processes and consumables

BS EN 440: 1995 Welding consumables: wire electrodes and deposits for gas shielded metal arc welding of non-alloy and fine grain steels: Classification

BS EN 499: 1995 Welding consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels: Classification

BS EN 756: 1996 Welding consumables – Wire electrodes and wire-flux combinations for submerged arc welding of non-alloy and fine grain steels – Classification

BS EN 757: 1997 Welding consumables – Covered electrodes for metal arc welding of high strength steels: Classification

BS EN 758: 1997 Welding consumables – Tubular cored electrodes for metal arc welding with and without a gas shield of non-alloy and fine grain steels – Classification

Testing and examination

BS 709: 1983 Methods of destructive testing fusion welded joints and weld metal in steel

BS 2600 Radiographic examination of fusion welded butt joints in steel
Part 1: 1983 Methods for steel 2mm up to and including 50mm thick
Part 2: 1973 Methods for steel over 50mm up to and including 200mm thick

BS 2910: 1986 Methods for radiographic examination of fusion welded circumferential butt joints in steel pipes

BS 3683 Glossary of terms used in non-destructive testing
Part 2: 1985 Magnetic particle flaw detection
Part 3: 1984 Radiological flaw detection

BS 4871 Specification for approval testing of welders working to approve welding procedures

BS 4872 Specification for approval testing of welders when welding procedure approval is not required

- BS 4872-1: 1982 Fusion welding of steel
- BS 6072: 1981 (1986) Method for magnetic particle flaw detection
- BS EN 287 Approval testing of welders for fusion welding
- BS EN 288 Specification and approval of welding procedures for metallic materials
- BS EN 970: 1997 Non-destructive examination of fusion welds – Visual examination
- BS EN 1289: 1998 Non-destructive examination of welds – Penetrant testing of welds – Acceptance testing of welds – Acceptance level
- BS EN 1290: 1998 Non-destructive examination of welds – Magnetic particle examination of welds
- BS EN 1291: 1998 Non-destructive examination of welds – Magnetic particle testing of welds – Acceptance levels
- BS EN 1435: 1997 Non-destructive examination of welds – Radiographic examination of welded joints
- BS EN 1713: 1998 Non-destructive examination of welds – ultrasonic examination – characterization of indication in welds
- BS EN 1714: 1998 Non-destructive examination of welded joints – Ultrasonic examination of welded joints (*Supersedes BS 3923-1: 1986*)
- BS EN 12062: 1998 Non-destructive examination of welds – General rules for metallic materials
- BS EN 25817: 1992 Arc-welded joints in steel: Guidance on quality levels for imperfections

Bolts and fasteners

- BS 4395 Specification for high strength friction grip bolts and associated nuts and washers for structural engineering
Part 1: 1969 General grade
Part 2: 1969 Higher grade bolts and nuts and general grade washers
- BS 4604 Specification for the use of high strength friction grip bolts in structural steelwork – Metric series
Part 1: 1970 General grade
Part 2: 1970 Higher grade (parallel shank)
- BS 7419: 1991 Specification for holding down bolts

- BS 7644 Direct tension indicators
Part 1: 1993 Specification for compressible washers
Part 2: 1993 Specification for nut face and bolt face washers

Fire resistance

- BS 476 Fire tests on building materials and structures
Part 20: 1987 Method for determination of the fire resistance of elements of construction (general principles)
Part 21: 1987 Methods for determination of the fire resistance of load-bearing elements of construction
Part 22: 1987 Methods for determination of the fire resistance of non-loadbearing elements of construction
Part 23: 1987 Methods for determination of the contribution of components to the fire resistance of a structure
- BS 5588 Fire precautions in the design, construction and use of buildings
- BS 5950 Structural use of steelwork in building
Part 8: 1990 Code of practice for fire resistant design
- BS 8202 Coatings for fire protection of building elements
Part 1: 1995 Code of practice for the selection and installation of sprayed mineral coatings
Part 2: 1992 Code of practice for the use of intumescent coating systems to metallic substrates for providing fire resistance

Corrosion prevention and coatings

- BS 2569 Specification for sprayed coatings
Part 2: 1965 (1997) Protection of iron and steel against corrosion and oxidation at elevated temperatures
- BS 4652: 1995 Specification for metallic zinc-rich priming paints (organic media)
- BS 4921: 1988 (1994) Specification for sherardized coatings on iron or steel
- BS 5493: 1977 Code of practice for protective coating of iron and steel structures against corrosion
- BS 7079 Preparation of steel substrates before application of paints and related products

Quality assurance

BS EN ISO 9000 Quality management and quality assurance standards

BS EN ISO 9001: 1994 Quality systems – Model for quality assurance in design, development, production, installation and servicing

Environmental

BS 6187: 2000 Code of practice for demolition

BS EN ISO 14001: 1996 Environmental management systems. Specification with guidance for use

BS EN ISO 14004: 1996 Environmental management systems. General guidelines on principles, systems and supporting techniques

BS EN ISO 14010: 1996 Guidelines for environmental auditing. General principles

