

**LONG SPANS IN BUILDINGS**

A common requirement within public buildings is for a large floor area clear of internal columns, even though the structure has floors above the area where clear space is required. There are several ways of achieving the requirement, and these are discussed below. In the first two cases considered below it is assumed that the floor loads arising from the clear span are supported by the structure or foundation beneath the floor.

The simplest and perhaps the most obvious solution to supporting the loads above the clear span is to use a beam of sufficient depth to resist the applied loads without overstress or undue deflection. Unfortunately, there is a limit to depth of beams available commercially, and this simple solution has to be rejected on the grounds of practicality.

The next solution is to use a truss in place of the beam considered above. This is structurally feasible on the grounds of buildability, and a simple method of designing a truss is given in the following notes.

Figure 1 shows two trusses, both supporting ceiling loads from beneath and floor loads from above.

Sometimes a Vierendeel girder is used instead of a truss. The parts of the building where these main structural elements are located are usually taken up with utility areas, plant rooms, and similar uses where the presence of obvious structural steelwork is not intrusive.

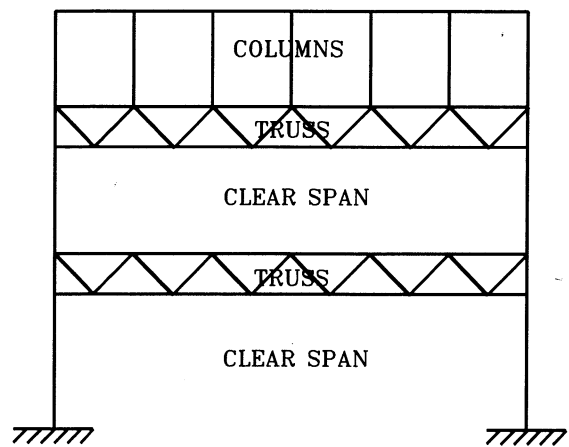


Figure 1

Figure 2 shows the same structure, but utilising two Vierendeel girders to the same effect as the trusses in Figure 1. Vierendeel girders have an advantage that there are no diagonal members to restrict access on the floors of the utility areas. In large structures, however, there may be fabrication problems associated with the large forces produced at the connections in the girder.

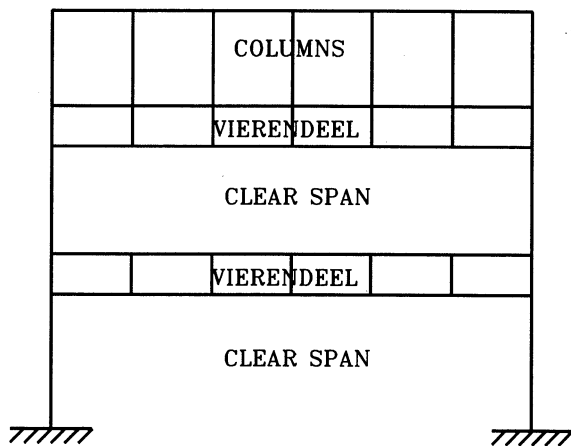


Figure 2

In Figure 3, the truss at the top of the structure is supporting almost all of the internal load of the structure. Load is transferred from each floor into the internal columns, causing these to go into tension. The load is then transmitted to the outer columns as compressive load, and ultimately to the ground through the foundation

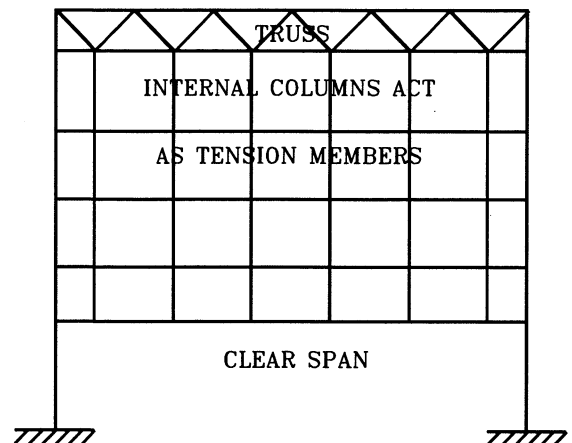


Figure 3

# CONTINUING PROFESSIONAL DEVELOPMENT - NOTES FOR PARTICIPANTS ENGINEERS AUSTRALIA - APRIL 2010

## RAPID DESIGN OF STEELWORK TRUSSES

As a general rule for the design of a steel truss under "normal" loading, the depth of the truss should be about span/16 - span/10 to ensure that the top and bottom members of the truss are stressed to reasonable proportions of their load-carrying capacity. The truss should be divided into 6, 8, or 10 equal-sized panels, having vertical members and diagonals as shown in Figure 1, and it is assumed that the truss carries a vertical load distributed along its length acting downwards. Note the direction of the diagonal members; the loading will put these members into tension, rather than compression, and better economy of material is likely using this technique.

A "quick" method of designing (in the engineering sense) a truss is described below. **Beware of buckling produced by compression in the top boom of the truss.** The following method will work provided adequate restraint is available to prevent out-of-plane buckling. If this is not the case, the allowable stresses should be reduced by a factor of least 2.



Figure 1

The aim of the design is to obtain a suitable section size for a truss solution to a particular problem. The calculations proceed as follows:

i) determine the full applied load on the truss, based on the dead load, ie. the self-weight of the truss and concrete floors and services, and the imposed load which can be identified from Standards/Codes of Practice (eg. AS/NZS 1170, BS 6399, or from the client's specification. The horizontal spacing (centres) between two adjacent trusses is important in determining the load carried by a single truss;

ii) assuming that the load is applied as a uniformly distributed load ( $w$  per metre span) over the full span of the truss, the maximum bending moment,  $M_{MAX}$ , which occurs at mid-span is equal to

$$M_{MAX} = \frac{w L^2}{8} \quad \text{where } L \text{ is the span of the truss.}$$

iii) This moment is resisted mainly by a tensile force in the lower boom of the truss and a compressive force of equal magnitude in the top boom.

The magnitude of each of these forces can be found by considering the effect of these two forces which are separated by a vertical distance,  $d$ , equal to the distance between the longitudinal centre-lines of the top and bottom boom members. Thus the magnitude,  $P$ , of the force in each of the booms is given by

$$P = \frac{M_{MAX}}{d}$$

iv) The axial stress,  $\sigma$ , in each of the booms at mid-span is given approximately by

$$\sigma = \frac{P}{A}$$

where  $A$  is the cross-sectional area of one of the boom members.

Assuming a **Factor of Safety = 1.7**, and **max. permissible stress = yield stress / Factor of Safety**

For Steel **Grade 250** (yield stress = 250 MPa), max permissible stress = 250 MPa / 1.7  
= 147.0 MPa = **145 MPa**

For Steel **Grade 350** (yield stress = 350 MPa), max permissible stress = 350 MPa / 1.7  
= 205.9 MPa = **205 MPa**

For Steel **Grade 450** (yield stress = 450 MPa), max permissible stress = 450 MPa / 1.7  
= 264.7 MPa = **265 MPa**

NB: higher strength steel normally costs more than lower strength steel

The above equation can be re-arranged to give the required cross-sectional area to produce the maximum permissible stress. Thus if Grade 250 steel is used, the cross-section must have an area (expressed in mm<sup>2</sup>) which satisfies the equation

$$A = \frac{P}{145}$$

where **P** is expressed in Newtons.

- v) The deflection of the truss at mid-span must also be taken into consideration. Deflection due to dead load and self weight is important, although the visual effect can be countered by pre-cambering the truss if this is desirable.

If the **imposed** load determined earlier is treated as a uniformly distributed load,  $w_L$ , the deflection at mid-span is given by

$$\frac{5 w_L L^4}{384 E I}$$

where  $E$  = Young's modulus ( $200 \times 10^3$  MPa for all steel)  
 $I$  = Second moment of area of the truss at mid-span.

The second moment of area of the truss can be represented approximately by

$$I = \frac{A \times d^2}{2}$$

As a general guide, the deflection at mid-span of a beam or a truss due to imposed loads should be restricted to span/360 or span/350. Using this as a limiting value, the above equations can be re-arranged:

$$\frac{5 w_L L^4}{384 E I} = \frac{5 \times w_L \times L^4}{384 \times E \times \frac{A d^2}{2}} \leq \frac{L}{360}$$

which gives

$$A \geq \frac{3600 w_L L^3}{384 E d^2}$$

- vi) Thus two values for the cross-sectional area of the boom members can now be found; one from consideration of stress, the other by taking deflection into account. The higher value is the one to be selected and this cross-sectional area is required for each boom. The choice of the steel section can be made from tables of cross-sectional areas. The vertical and diagonal members of the truss can be made from the same size sections as the horizontal members; note that some economy can usually be achieved by reducing the section sizes for the diagonal and vertical members if this is desired.

## Worked Example: Rapid Truss Design

A truss is required to span 30 metres and support a uniformly distributed dead load of 5 kN/m, including its own self-weight, and a uniformly distributed imposed load of = 15 kN/m.

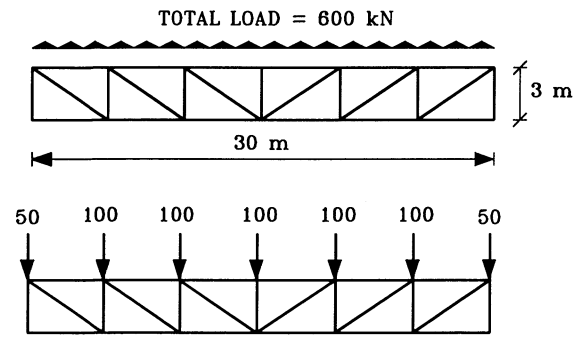


Figure 2

Given that the truss is to be formed from a single size of **square hollow section** in Steel Grade 350, produce an approximate engineering design for the truss, indicating the depth of the truss and the chosen section size. It can be assumed that the truss is simply-supported at its ends, made of pin-ended members, that the load is applied at the joints and that the top boom of the truss is restrained against buckling. The maximum permissible stress in Grade 350 steel is 205MPa, and the maximum deflection of the truss (under imposed loading only) is limited to span/360.

Sketch the elevation of the truss, and calculate the weight and budget cost of the truss, assuming that the cost of erected steelwork is A\$1950 per tonne.

The value of Young's Modulus for steel can be assumed to be  $200 \times 10^3$  MPa ( $= 200 \times 10^6$  kN/m<sup>2</sup>).

If the truss is considered as a simply-supported beam structure subject to a total distributed load of 600 kN, the maximum value of bending moment  $M_{MAX}$  (which occurs at mid-span) is given by

$$M_{MAX} = \frac{w_{TOTAL} L^2}{8} = \frac{(5 + 15) \text{ kN/m} \times (30 \text{ m})^2}{8} = 2250 \text{ kNm}$$

It will be assumed that the effective depth (d) of the truss is 3 m, the axial load in the top and bottom booms is

$$P = \frac{M_{MAX}}{d} = \frac{2250 \text{ kNm}}{3 \text{ m}} = 750 \text{ kN}$$

If the maximum permissible stress for Grade 350 Steel is 205MPa, the required cross-sectional area A of the truss to limit the stress to this value is

$$A \geq \frac{750 \times 10^3 \text{ N}}{205 \text{ MPa}} = 3659 \text{ mm}^2$$

If the maximum deflection of the truss is restricted to span/360 ( $= 83.3$  mm) and the imposed load is 15 kN/m, then

$$\frac{L}{360} \geq \frac{5 w_L L^4}{384 E I} = \frac{5 \times w_L \times L^4}{384 \times E \times \frac{A d^2}{2}}$$

$$\rightarrow A \geq \frac{3600 \times w_L \times L^3}{384 \times E \times d^2} = \frac{3600 \times 15 \text{ kN/m} \times (30 \text{ m})^3}{384 \times 200 \times 10^6 \times (3 \text{ m})^2} = 2.109 \times 10^{-3} \text{ m}^2 = 2109 \text{ mm}^2$$

The previous value for A obtained by considering maximum stress is higher ( $3659 \text{ mm}^2$ ), and therefore must be taken as the required cross-sectional area for the truss members. Using OneSteel Cold Formed Section Catalogue (page 24), the square hollow section with the nearest cross-sectional area greater than this area is  $200 \times 200 \times 5$  mm SHS with an area of  $3810 \text{ mm}^2$ , which has a mass per unit length of 29.9 kg/m.

The total length of steel section in one truss is approximately

$$2 \times 30 \text{ m} + 7 \times 3 \text{ m} + 6 \times \sqrt{5^2 + 3^2} \text{ m} = 116.0 \text{ m}$$

Thus the total weight of steel in the truss is:  $116.0 \text{ m} \times 29.9 \text{ kg/m} = 3468.4 \text{ kg}$

and if the cost of erected steelwork is \$1950 per tonne, the total cost of the truss is

$$3.4684 \text{ T} \times \text{A\$1950/T} = \text{A\$6763}$$

## Tutorial Questions for Private Study

### Question 1:

A steel truss (with horizontal top and bottom booms) is urgently required to give temporary support to a roof structure which has been damaged by severe weather. The truss spans 40 metres and is subjected to an imposed vertical load of 8 kN/metre span, in addition to its own self-weight, which can be assumed to be 0.45 kN/metre span.

The space available for construction is limited, and the maximum overall height of the truss must not exceed 2.2 metres. If the maximum permissible axial stress within the truss must not exceed 205MPa, and the maximum allowable deflection under imposed load is restricted to **span/350**:

- i) provide a sketch of the shape of the truss you would recommend, bearing in mind the immediate requirement for the steelwork and the need for economic design;
- ii) use suitable calculations to determine a structural square hollow steel section which you would recommend to be used for the fabrication of the truss;
- iii) estimate the cost of the truss, given that the overall cost of erected steelwork can be estimated as A\$1800 per tonne.

The value of Young's Modulus for steel can be assumed to be  $200 \times 10^3$  MPa ( $= 200 \times 10^6$  kN/m<sup>2</sup>).

(10 panels, 200 × 200 × 9 SHS, 7599.1 kg, A\$13678)

### Question 2:

A steel truss (with horizontal top and bottom booms) is required to span 25 metres and is subjected to an imposed vertical load of 5 kN/metre span, in addition to its own self-weight, which can be assumed to be 0.35 kN/metre span.

The space available for construction is limited, and the maximum height of the truss must not exceed 1.5 metres. If Steel Grade 350 is to be used (maximum permissible axial stress within the truss is 205MPa), and the maximum allowable deflection under imposed load is restricted to **span/350**:

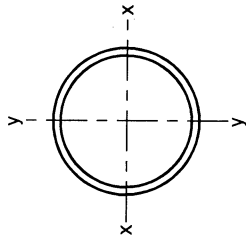
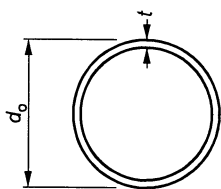
- i) provide a sketch of the shape of the truss you would recommend;
- ii) use suitable calculations to determine a steel section which you would recommend to be used for the fabrication of the truss. You should consider SHS, RHS and CHS section, and your recommendation should be based on achieving minimum weight while still meeting all the above design criteria;
- iii) estimate the cost of the truss, given that the overall cost of erected steelwork can be estimated as A\$1880 per tonne.

The value of Young's Modulus for steel can be assumed to be  $200 \times 10^3$  MPa ( $= 200 \times 10^6$  kN/m<sup>2</sup>).

(8 panels, 200 × 100 × 4 RHS, 1578.8 kg, A\$2968)

TABLE 1.2(a)

**DIMENSIONS AND PROPERTIES**  
**TUBELINE®/ULTRAPIPE® CIRCULAR HOLLOW SECTIONS**  
**GRADE C350L0 (AS 1163)**



| DIMENSION AND RATIOS |            |                       | PROPERTIES      |                   |                   |                  |                                 |                                 |                                 | PROPERTIES FOR DESIGN TO AS 4100 |                                 |                                 |                                 |       |             |                            |       |  |
|----------------------|------------|-----------------------|-----------------|-------------------|-------------------|------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|-------|-------------|----------------------------|-------|--|
| Designation          | Mass per m | External Surface Area | $\frac{d_o}{t}$ | About any axis    |                   | Torsion Constant |                                 | Form Factor                     | About any axis                  |                                  |                                 |                                 |                                 |       |             |                            |       |  |
|                      |            |                       |                 | per m             | per t             | $A_g$            | $I$                             |                                 | $Z$                             | $S$                              | $r$                             | $J$                             | $C$                             | $k_t$ | $\lambda_s$ | Compactness <sup>(3)</sup> | $Z_e$ |  |
| $d_o$                | $t$        | mm                    | kg/m            | m <sup>2</sup> /m | m <sup>2</sup> /t | mm <sup>2</sup>  | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm                               | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> |       |             |                            |       |  |
| 457.0 x 12.7 CHS     | 139        | 1.44                  | 10.3            | 36.0              | 17700             | 438              | 1920                            | 2510                            | 157                             | 876                              | 3830                            | 1.00                            | 50.4                            | N     | 2500        |                            |       |  |
|                      | 105        | 1.44                  | 13.7            | 48.1              | 13400             | 334              | 1460                            | 1900                            | 158                             | 669                              | 2930                            | 1.00                            | 67.3                            | N     | 1790        |                            |       |  |
|                      | 71.1       | 1.44                  | 20.2            | 71.4              | 9060              | 230              | 1010                            | 1300                            | 159                             | 460                              | 2010                            | 0.904                           | 100                             | N     | 1090        |                            |       |  |
| 406.4 x 12.7 CHS     | 123        | 1.28                  | 10.4            | 32.0              | 15700             | 305              | 1500                            | 1970                            | 139                             | 609                              | 3000                            | 1.00                            | 44.8                            | C     | 1970        |                            |       |  |
|                      | 93.0       | 1.28                  | 13.7            | 42.8              | 11800             | 233              | 1150                            | 1500                            | 140                             | 467                              | 2300                            | 1.00                            | 59.9                            | N     | 1450        |                            |       |  |
|                      | 63.1       | 1.28                  | 20.2            | 63.5              | 8040              | 161              | 792                             | 1020                            | 141                             | 322                              | 1580                            | 0.960                           | 88.9                            | N     | 895         |                            |       |  |
| 355.6 x 12.7 CHS     | 107        | 1.12                  | 10.4            | 28.0              | 13700             | 201              | 1130                            | 1490                            | 121                             | 403                              | 2260                            | 1.00                            | 39.2                            | C     | 1490        |                            |       |  |
|                      | 81.1       | 1.12                  | 13.8            | 37.4              | 10300             | 155              | 871                             | 1140                            | 122                             | 310                              | 1740                            | 1.00                            | 52.4                            | N     | 1130        |                            |       |  |
|                      | 55.1       | 1.12                  | 20.3            | 55.6              | 7020              | 107              | 602                             | 781                             | 123                             | 214                              | 1200                            | 1.00                            | 77.8                            | N     | 710         |                            |       |  |
| 323.9 x 12.7 CHS     | 97.5       | 1.02                  | 10.4            | 25.5              | 12400             | 151              | 930                             | 1230                            | 110                             | 301                              | 1860                            | 1.00                            | 35.7                            | C     | 1230        |                            |       |  |
|                      | 73.7       | 1.02                  | 13.8            | 34.1              | 9380              | 116              | 717                             | 939                             | 111                             | 232                              | 1430                            | 1.00                            | 47.7                            | C     | 939         |                            |       |  |
|                      | 50.1       | 1.02                  | 20.3            | 50.6              | 6380              | 80.5             | 497                             | 645                             | 112                             | 161                              | 994                             | 1.00                            | 70.9                            | N     | 601         |                            |       |  |
| 273.1 x 12.7 CHS     | 81.6       | 0.858                 | 10.5            | 21.5              | 10400             | 88.3             | 646                             | 862                             | 92.2                            | 177                              | 1290                            | 1.00                            | 30.1                            | C     | 862         |                            |       |  |
|                      | 60.5       | 0.858                 | 14.2            | 29.4              | 7710              | 67.1             | 492                             | 647                             | 93.3                            | 134                              | 983                             | 1.00                            | 41.1                            | C     | 647         |                            |       |  |
|                      | 42.1       | 0.858                 | 20.4            | 42.7              | 5360              | 47.7             | 349                             | 455                             | 94.3                            | 95.4                             | 699                             | 1.00                            | 59.7                            | N     | 441         |                            |       |  |
| 4.8 CHS              | 31.8       | 0.858                 | 27.0            | 56.9              | 4050              | 36.4             | 267                             | 346                             | 94.9                            | 72.8                             | 533                             | 1.00                            | 79.7                            | N     | 312         |                            |       |  |

- NOTES: 1. This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.  
2. Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.  
3. C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.

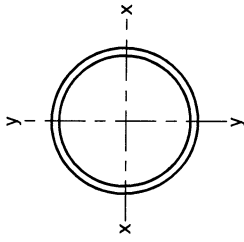
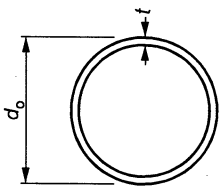


TABLE 1.2(b)

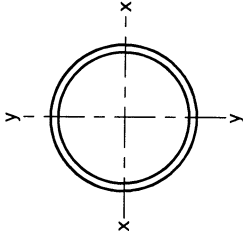
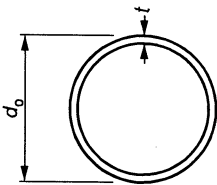
**DIMENSIONS AND PROPERTIES**  
**TUBELINE®/ULTRAPIPE® CIRCULAR HOLLOW SECTIONS**  
**GRADE C350L0 (AS 1163)**

| DIMENSION AND RATIOS |            |                       | PROPERTIES        |                    |                 |                                 |                                 |                                 |             | PROPERTIES FOR DESIGN TO AS 4100 |                                 |                                 |                                 |             |                                  |   |
|----------------------|------------|-----------------------|-------------------|--------------------|-----------------|---------------------------------|---------------------------------|---------------------------------|-------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------|----------------------------------|---|
| Designation          | Mass per m | External Surface Area |                   | About any axis     |                 |                                 | Torsion Constant Modulus        |                                 | Form Factor | About any axis                   |                                 |                                 |                                 |             |                                  |   |
|                      |            | per m                 | per t             | $\frac{d_o}{t}$    | $A_g$           | $I$                             | $Z$                             | $S$                             |             | $r$                              | $J$                             | $C$                             | $k_f$                           | $\lambda_s$ | Compactness <sup>(3)</sup> $Z_e$ |   |
| $d_o$<br>mm          | $t$<br>mm  | kg/m                  | m <sup>2</sup> /m | m <sup>2</sup> /ft | mm <sup>2</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm          | mm                               | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> |             |                                  | (C,N,S) 10 <sup>3</sup> mm <sup>3</sup> |
| 219.1 x 8.2 CHS      | 42.6       | 0.688                 | 16.1              | 26.7               | 5430            | 30.3                            | 276                             | 365                             | 74.6        | 60.5                             | 60.5                            | 552                             | 37.4                            | 1.00        | C                                | 365                                     |
| 6.4 CHS              | 33.6       | 0.688                 | 20.5              | 34.2               | 4280            | 24.2                            | 221                             | 290                             | 75.2        | 48.4                             | 48.4                            | 442                             | 47.9                            | 1.00        | C                                | 290                                     |
| 4.8 CHS              | 25.4       | 0.688                 | 27.1              | 45.6               | 3230            | 18.6                            | 169                             | 220                             | 75.8        | 37.1                             | 37.1                            | 339                             | 63.9                            | 1.00        | N                                | 210                                     |
| 168.3 x 7.1 CHS      | 28.2       | 0.529                 | 18.7              | 23.7               | 3600            | 11.7                            | 139                             | 185                             | 57.0        | 23.4                             | 23.4                            | 278                             | 33.2                            | 1.00        | C                                | 185                                     |
| 6.4 CHS              | 25.6       | 0.529                 | 20.7              | 26.3               | 3260            | 10.7                            | 127                             | 168                             | 57.3        | 21.4                             | 21.4                            | 254                             | 36.8                            | 1.00        | C                                | 168                                     |
| 4.8 CHS              | 19.4       | 0.529                 | 27.3              | 35.1               | 2470            | 8.25                            | 98.0                            | 128                             | 57.8        | 16.5                             | 16.5                            | 196                             | 49.1                            | 1.00        | C                                | 128                                     |
| 165.1 x 3.5 CHS      | 13.9       | 0.519                 | 37.2              | 47.2               | 1780            | 5.80                            | 70.3                            | 91.4                            | 57.1        | 11.6                             | 11.6                            | 141                             | 66.0                            | 1.00        | N                                | 86.6                                    |
| 139.7 x 3.5 CHS      | 11.8       | 0.439                 | 37.3              | 39.9               | 1500            | 3.47                            | 49.7                            | 64.9                            | 48.2        | 6.95                             | 6.95                            | 99.5                            | 55.9                            | 1.00        | N                                | 63.7                                    |
| 3.0 CHS              | 10.1       | 0.439                 | 43.4              | 46.6               | 1290            | 3.01                            | 43.1                            | 56.1                            | 48.3        | 6.02                             | 6.02                            | 86.2                            | 65.2                            | 1.00        | N                                | 53.3                                    |
| 114.3 x 3.6 CHS      | 9.83       | 0.359                 | 36.5              | 31.8               | 1250            | 1.92                            | 33.6                            | 44.1                            | 39.2        | 3.84                             | 3.84                            | 67.2                            | 44.5                            | 1.00        | C                                | 44.1                                    |
| 3.2 CHS              | 8.77       | 0.359                 | 41.0              | 35.7               | 1120            | 1.72                            | 30.2                            | 39.5                            | 39.3        | 3.45                             | 3.45                            | 60.4                            | 50.0                            | 1.00        | N                                | 39.5                                    |
| 101.6 x 3.2 CHS      | 7.77       | 0.319                 | 41.1              | 31.8               | 989             | 1.20                            | 23.6                            | 31.0                            | 34.8        | 2.40                             | 2.40                            | 47.2                            | 44.5                            | 1.00        | C                                | 31.0                                    |
| 2.6 CHS              | 6.35       | 0.319                 | 50.3              | 39.1               | 809             | 0.991                           | 19.5                            | 25.5                            | 35.0        | 1.98                             | 1.98                            | 39.0                            | 54.7                            | 1.00        | N                                | 25.1                                    |

NOTES: 1. This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.  
 2. Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification is AS 4100.  
 3. C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.  
 4. Sizes shown in *italics*: These sizes may not be stocked in all states or minimum order quantities may apply

TABLE 1.2(c)

**DIMENSIONS AND PROPERTIES**  
**TUBELINE® CIRCULAR HOLLOW SECTIONS**  
**GRADE C350L0 (AS 1163)**

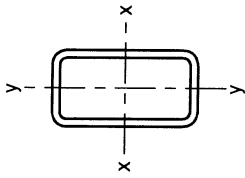
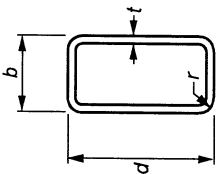


| Designation |     | DIMENSION AND RATIOS |                       |                   |                    | PROPERTIES                      |                                 |                                 |                  |                                 |                                 |             |                |                            |                                 |
|-------------|-----|----------------------|-----------------------|-------------------|--------------------|---------------------------------|---------------------------------|---------------------------------|------------------|---------------------------------|---------------------------------|-------------|----------------|----------------------------|---------------------------------|
|             |     | Mass per m           | External Surface Area | $\frac{d_o}{t}$   | Gross Section Area | About any axis                  |                                 |                                 | Torsion Constant |                                 |                                 | Form Factor | About any axis |                            |                                 |
| $d_o$       | t   | kg/m                 | per m                 | per t             | $A_g$              | I                               | Z                               | S                               | r                | J                               | C                               | $k_f$       | $\lambda_s$    | Compactness <sup>(3)</sup> | $Z_e$                           |
| mm          | mm  |                      | m <sup>2</sup> /m     | m <sup>2</sup> /t | mm <sup>2</sup>    | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm               | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> |             |                | (C,N,S)                    | 10 <sup>3</sup> mm <sup>3</sup> |
| 88.9 x 3.2  | CHS | 6.76                 | 0.279                 | 41.3              | 862                | 0.792                           | 17.8                            | 23.5                            | 30.3             | 1.58                            | 35.6                            | 1.00        | 38.9           | C                          | 23.5                            |
| 2.6         | CHS | 5.53                 | 0.279                 | 50.5              | 705                | 0.657                           | 14.8                            | 19.4                            | 30.5             | 1.31                            | 29.6                            | 1.00        | 47.9           | C                          | 19.4                            |
| 76.1 x 3.2  | CHS | 5.75                 | 0.239                 | 41.6              | 733                | 0.488                           | 12.8                            | 17.0                            | 25.8             | 0.976                           | 25.6                            | 1.00        | 33.3           | C                          | 17.0                            |
| 2.3         | CHS | 4.19                 | 0.239                 | 57.1              | 533                | 0.363                           | 9.55                            | 12.5                            | 26.1             | 0.727                           | 19.1                            | 1.00        | 46.3           | C                          | 12.5                            |
| 60.3 x 2.9  | CHS | 4.11                 | 0.189                 | 46.1              | 523                | 0.216                           | 7.16                            | 9.56                            | 20.3             | 0.432                           | 14.3                            | 1.00        | 29.1           | C                          | 9.56                            |
| 2.3         | CHS | 3.29                 | 0.189                 | 57.6              | 419                | 0.177                           | 5.85                            | 7.74                            | 20.5             | 0.353                           | 11.7                            | 1.00        | 36.7           | C                          | 7.74                            |
| 48.3 x 2.9  | CHS | 3.25                 | 0.152                 | 46.7              | 414                | 0.107                           | 4.43                            | 5.99                            | 16.1             | 0.214                           | 8.86                            | 1.00        | 23.3           | C                          | 5.99                            |
| 2.3         | CHS | 2.61                 | 0.152                 | 58.2              | 332                | 0.0881                          | 3.65                            | 4.87                            | 16.3             | 0.176                           | 7.30                            | 1.00        | 29.4           | C                          | 4.87                            |
| 42.4 x 2.6  | CHS | 2.55                 | 0.133                 | 52.2              | 325                | 0.0646                          | 3.05                            | 4.12                            | 14.1             | 0.129                           | 6.10                            | 1.00        | 22.8           | C                          | 4.12                            |
| 2.0         | CHS | 1.99                 | 0.133                 | 66.8              | 254                | 0.0519                          | 2.45                            | 3.27                            | 14.3             | 0.104                           | 4.90                            | 1.00        | 29.7           | C                          | 3.27                            |
| 33.7 x 2.6  | CHS | 1.99                 | 0.106                 | 53.1              | 254                | 0.0309                          | 1.84                            | 2.52                            | 11.0             | 0.0619                          | 3.67                            | 1.00        | 18.1           | C                          | 2.52                            |
| 2.0         | CHS | 1.56                 | 0.106                 | 67.7              | 199                | 0.0251                          | 1.49                            | 2.01                            | 11.2             | 0.0502                          | 2.98                            | 1.00        | 23.6           | C                          | 2.01                            |
| 26.9 x 2.3  | CHS | 1.40                 | 0.0845                | 60.6              | 178                | 0.0136                          | 1.01                            | 1.40                            | 8.74             | 0.0271                          | 2.02                            | 1.00        | 16.4           | C                          | 1.40                            |
| 2.0         | CHS | 1.23                 | 0.0845                | 68.8              | 156                | 0.0122                          | 0.907                           | 1.24                            | 8.83             | 0.0244                          | 1.81                            | 1.00        | 18.8           | C                          | 1.24                            |

- NOTES: 1. This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.  
2. Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.  
3. C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.

TABLE 2.1(a)

## DIMENSIONS AND PROPERTIES

TUBELINE® RECTANGULAR HOLLOW SECTIONS  
GRADE C350L0 (AS 1163)

| Designation  |     | DIMENSION AND RATIOS |                       |                  |                  | PROPERTIES         |                   |                    |                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 | PROPERTIES FOR DESIGN TO AS 4100 |                |                 |                            |                                 |                 |                            |                                 |
|--------------|-----|----------------------|-----------------------|------------------|------------------|--------------------|-------------------|--------------------|-----------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------|-----------------|----------------------------|---------------------------------|-----------------|----------------------------|---------------------------------|
|              |     | Mass per m           | External Surface Area | $\frac{b-2t}{t}$ | $\frac{d-2t}{t}$ | Gross Section Area | About x-axis      |                    |                 | About y-axis                    |                                 |                                 | Torsion Constant Modulus        |                                 | Form Factor                     | About x-axis                    |                                  | About y-axis   |                 |                            |                                 |                 |                            |                                 |
| d            | b   | t                    | per m                 | per m            | mm <sup>2</sup>  | kg/m               | m <sup>2</sup> /m | m <sup>2</sup> /t  | mm <sup>2</sup> | S <sub>x</sub>                  | Z <sub>x</sub>                  | I <sub>x</sub>                  | S <sub>y</sub>                  | Z <sub>y</sub>                  | I <sub>y</sub>                  | J                               | C                                | k <sub>t</sub> | λ <sub>ex</sub> | Compactness <sup>(2)</sup> | Z <sub>ex</sub>                 | λ <sub>ey</sub> | Compactness <sup>(2)</sup> | Z <sub>ey</sub>                 |
| mm           | mm  | mm                   | per m                 | per m            | mm <sup>2</sup>  | kg/m               | m <sup>2</sup> /m | mm <sup>2</sup> /t | mm <sup>2</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>2</sup> mm <sup>3</sup>  |                |                 | (C,N,S)                    | 10 <sup>3</sup> mm <sup>3</sup> |                 | (C,N,S)                    | 10 <sup>3</sup> mm <sup>3</sup> |
| 250x150x9.0  | RHS | 51.8                 | 0.761                 | 14.7             | 14.7             | 25.8               | 6600              | 53.7               | 430             | 533                             | 90.2                            | 24.3                            | 324                             | 375                             | 60.7                            | 56.0                            | 554                              | 1.00           | 17.4            | C                          | 533                             | 30.5            | N                          | 373                             |
| 6.0          | RHS | 35.6                 | 0.774                 | 21.8             | 23.0             | 39.7               | 4530              | 38.4               | 307             | 374                             | 92.0                            | 17.5                            | 233                             | 264                             | 62.2                            | 39.0                            | 395                              | 0.907          | 27.2            | C                          | 374                             | 46.9            | S                          | 208                             |
| 5.0          | RHS | 29.9                 | 0.779                 | 26.0             | 28.0             | 48.0               | 3810              | 32.7               | 262             | 317                             | 92.6                            | 15.0                            | 199                             | 224                             | 62.6                            | 33.0                            | 337                              | 0.814          | 33.1            | N                          | 300                             | 56.8            | S                          | 156                             |
| 200x100x9.0  | RHS | 37.7                 | 0.561                 | 14.9             | 9.11             | 20.2               | 4800              | 22.8               | 228             | 293                             | 68.9                            | 7.64                            | 153                             | 180                             | 39.9                            | 19.9                            | 272                              | 1.00           | 10.8            | C                          | 293                             | 23.9            | C                          | 180                             |
| 6.0          | RHS | 26.2                 | 0.574                 | 22.0             | 14.7             | 31.3               | 3330              | 16.7               | 167             | 210                             | 70.8                            | 5.69                            | 114                             | 130                             | 41.3                            | 14.2                            | 200                              | 1.00           | 17.4            | C                          | 210                             | 37.1            | N                          | 119                             |
| 5.0          | RHS | 22.1                 | 0.579                 | 26.2             | 18.0             | 38.0               | 2810              | 14.4               | 144             | 179                             | 71.5                            | 4.92                            | 98.3                            | 111                             | 41.8                            | 12.1                            | 172                              | 0.925          | 21.3            | C                          | 179                             | 45.0            | S                          | 90.1                            |
| 4.0          | RHS | 17.9                 | 0.583                 | 32.5             | 23.0             | 48.0               | 2280              | 11.9               | 119             | 147                             | 72.1                            | 4.07                            | 81.5                            | 91.0                            | 42.3                            | 9.89                            | 142                              | 0.801          | 27.2            | C                          | 147                             | 56.8            | S                          | 63.1                            |
| 150x100x9.0  | RHS | 30.6                 | 0.461                 | 15.1             | 9.11             | 14.7               | 3900              | 10.9               | 145             | 185                             | 52.9                            | 5.77                            | 115                             | 140                             | 38.5                            | 13.2                            | 197                              | 1.00           | 10.8            | C                          | 185                             | 17.4            | C                          | 140                             |
| 6.0          | RHS | 21.4                 | 0.474                 | 22.1             | 14.7             | 23.0               | 2730              | 8.17               | 109             | 134                             | 54.7                            | 4.36                            | 87.3                            | 102                             | 40.0                            | 9.51                            | 147                              | 1.00           | 17.4            | C                          | 134                             | 27.2            | C                          | 102                             |
| 5.0          | RHS | 18.2                 | 0.479                 | 26.3             | 18.0             | 28.0               | 2310              | 7.07               | 94.3            | 115                             | 55.3                            | 3.79                            | 75.7                            | 87.3                            | 40.4                            | 8.12                            | 127                              | 1.00           | 21.3            | C                          | 115                             | 33.1            | N                          | 83.6                            |
| 4.0          | RHS | 14.8                 | 0.483                 | 32.7             | 23.0             | 35.5               | 1880              | 5.87               | 78.2            | 94.6                            | 55.9                            | 3.15                            | 63.0                            | 71.8                            | 40.9                            | 6.64                            | 105                              | 0.971          | 27.2            | C                          | 94.6                            | 42.0            | S                          | 60.9                            |
| 150x 50 x6.0 | RHS | 16.7                 | 0.374                 | 22.4             | 6.33             | 23.0               | 2130              | 5.06               | 67.5            | 91.2                            | 48.7                            | 0.860                           | 34.4                            | 40.9                            | 20.1                            | 2.63                            | 64.3                             | 1.00           | 7.49            | C                          | 91.2                            | 27.2            | C                          | 40.9                            |
| 5.0          | RHS | 14.2                 | 0.379                 | 26.6             | 8.00             | 28.0               | 1810              | 4.44               | 59.2            | 78.9                            | 49.5                            | 0.765                           | 30.6                            | 35.7                            | 20.5                            | 2.30                            | 56.8                             | 1.00           | 9.47            | C                          | 78.9                            | 33.1            | N                          | 34.1                            |
| 4.0          | RHS | 11.6                 | 0.383                 | 32.9             | 10.5             | 35.5               | 1480              | 3.74               | 49.8            | 65.4                            | 50.2                            | 0.653                           | 26.1                            | 29.8                            | 21.0                            | 1.93                            | 48.2                             | 0.963          | 12.4            | C                          | 65.4                            | 42.0            | S                          | 25.1                            |
| 3.0          | RHS | 8.96                 | 0.390                 | 43.5             | 14.7             | 48.0               | 1140              | 2.99               | 39.8            | 51.4                            | 51.2                            | 0.526                           | 21.1                            | 23.5                            | 21.5                            | 1.50                            | 38.3                             | 0.776          | 17.4            | C                          | 51.4                            | 56.8            | S                          | 16.0                            |
| 2.5          | RHS | 7.53                 | 0.391                 | 52.0             | 18.0             | 58.0               | 959               | 2.54               | 33.9            | 43.5                            | 51.5                            | 0.452                           | 18.1                            | 19.9                            | 21.7                            | 1.28                            | 32.8                             | 0.685          | 21.3            | C                          | 43.5                            | 68.6            | S                          | 11.9                            |
| 2.0          | RHS | 6.07                 | 0.393                 | 64.7             | 23.0             | 73.0               | 774               | 2.08               | 27.7            | 35.3                            | 51.8                            | 0.372                           | 14.9                            | 16.3                            | 21.9                            | 1.04                            | 26.9                             | 0.595          | 27.2            | C                          | 34.3                            | 86.4            | S                          | 8.32                            |

NOTES: 1. This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.

2. Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.

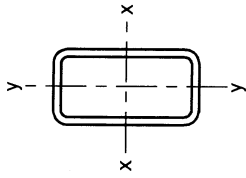
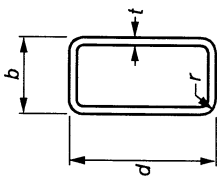
3. C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.

4. For Square and Rectangular Hollow Sections the outside corner radius  $r$  used in calculating the section properties is equal to  $2t$  for sections with thickness  $t \leq 3.0$ mm and  $2.5t$  for sections with  $t > 3.0$ mm.

TABLE 2.1(b)

**DIMENSIONS AND PROPERTIES**

**TUBELINE® RECTANGULAR HOLLOW SECTIONS  
GRADE C350L0 (AS 1163)**

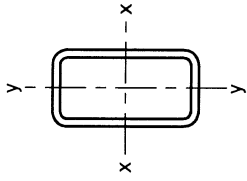
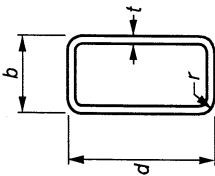


| DIMENSION AND RATIOS |            |                             |                  | PROPERTIES         |                 |                 |                 |       |                 |                 |                 |       |                  | PROPERTIES FOR DESIGN TO AS 4100 |                 |                 |                 |                            |                 |                |                            |          |
|----------------------|------------|-----------------------------|------------------|--------------------|-----------------|-----------------|-----------------|-------|-----------------|-----------------|-----------------|-------|------------------|----------------------------------|-----------------|-----------------|-----------------|----------------------------|-----------------|----------------|----------------------------|----------|
| Designation          | Mass per m | External Surface Area per m | $\frac{b-2t}{t}$ | $\frac{d-2t}{t}$   | About x-axis    |                 |                 |       |                 | About y-axis    |                 |       |                  |                                  | Form Factor     | About x-axis    |                 | About y-axis               |                 |                |                            |          |
|                      |            |                             |                  |                    | $A_g$           | $I_x$           | $S_x$           | $r_x$ | $I_y$           | $Z_y$           | $S_y$           | $r_y$ | Torsion Constant | Torsion Modulus                  |                 | $k_f$           | $\lambda_{ex}$  | Compactness <sup>(3)</sup> | $Z_{ex}$        | $\lambda_{ey}$ | Compactness <sup>(3)</sup> | $Z_{ey}$ |
| $d$                  | $b$        | $t$                         | mm <sup>2</sup>  | mm <sup>2</sup> /m | mm <sup>4</sup> | mm <sup>4</sup> | mm <sup>3</sup> | mm    | mm <sup>4</sup> | mm <sup>3</sup> | mm <sup>3</sup> | mm    | mm <sup>4</sup>  | mm <sup>3</sup>                  | mm <sup>3</sup> | mm <sup>3</sup> | mm <sup>3</sup> | mm <sup>3</sup>            | mm <sup>3</sup> |                |                            |          |
| 125 x 75 x 6.0 RHS   | 16.7       | 0.374                       | 22.4             | 10.5               | 18.8            | 4.16            | 66.6            | 84.2  | 44.2            | 1.87            | 50.0            | 59.1  | 29.6             | 4.44                             | 86.2            | 1.00            | 12.4            | C                          | 84.2            | 22.3           | C                          | 59.1     |
| 5.0 RHS              | 14.2       | 0.379                       | 26.6             | 13.0               | 23.0            | 3.64            | 58.3            | 72.7  | 44.8            | 1.65            | 43.9            | 51.1  | 30.1             | 3.83                             | 75.3            | 1.00            | 15.4            | C                          | 72.7            | 27.2           | C                          | 51.1     |
| 4.0 RHS              | 11.6       | 0.383                       | 32.9             | 16.8               | 29.3            | 3.05            | 48.9            | 60.3  | 45.4            | 1.39            | 37.0            | 42.4  | 30.6             | 3.16                             | 63.0            | 1.00            | 19.8            | C                          | 60.3            | 34.6           | N                          | 39.9     |
| 3.0 RHS              | 8.96       | 0.390                       | 43.5             | 23.0               | 39.7            | 2.43            | 38.9            | 47.3  | 46.1            | 1.11            | 29.5            | 33.3  | 31.1             | 2.43                             | 49.5            | 0.908           | 27.2            | C                          | 47.3            | 46.9           | S                          | 26.3     |
| 2.5 RHS              | 7.53       | 0.391                       | 52.0             | 28.0               | 48.0            | 2.07            | 33.0            | 40.0  | 46.4            | 0.942           | 25.1            | 28.2  | 31.4             | 2.05                             | 42.1            | 0.815           | 33.1            | N                          | 37.8            | 56.8           | S                          | 19.8     |
| 2.0 RHS              | 6.07       | 0.393                       | 64.7             | 35.5               | 60.5            | 1.69            | 27.0            | 32.5  | 46.7            | 0.771           | 20.6            | 22.9  | 31.6             | 1.67                             | 34.4            | 0.706           | 42.0            | S                          | 26.3            | 71.6           | S                          | 14.0     |
| 100 x 50 x 6.0 RHS   | 12.0       | 0.274                       | 22.8             | 6.33               | 14.7            | 1.71            | 34.2            | 45.3  | 33.4            | 0.567           | 22.7            | 27.7  | 19.2             | 1.53                             | 40.9            | 1.00            | 7.49            | C                          | 45.3            | 17.4           | C                          | 27.7     |
| 5.0 RHS              | 10.3       | 0.279                       | 27.0             | 8.00               | 18.0            | 1.53            | 30.6            | 39.8  | 34.1            | 0.511           | 20.4            | 24.4  | 19.7             | 1.35                             | 36.5            | 1.00            | 9.47            | C                          | 39.8            | 21.3           | C                          | 24.4     |
| 4.0 RHS              | 8.49       | 0.283                       | 33.3             | 10.5               | 23.0            | 1.31            | 26.1            | 33.4  | 34.8            | 0.441           | 17.6            | 20.6  | 20.2             | 1.13                             | 31.2            | 1.00            | 12.4            | C                          | 33.4            | 27.2           | C                          | 20.6     |
| 3.5 RHS              | 7.53       | 0.285                       | 37.9             | 12.3               | 26.6            | 1.18            | 23.6            | 29.9  | 35.1            | 0.400           | 16.0            | 18.5  | 20.4             | 1.01                             | 28.2            | 1.00            | 14.5            | C                          | 29.9            | 31.4           | N                          | 18.1     |
| 3.0 RHS              | 6.60       | 0.290                       | 43.9             | 14.7               | 31.3            | 1.06            | 21.3            | 26.7  | 35.6            | 0.361           | 14.4            | 16.4  | 20.7             | 0.886                            | 25.0            | 1.00            | 17.4            | C                          | 26.7            | 37.1           | N                          | 15.0     |
| 2.5 RHS              | 5.56       | 0.291                       | 52.4             | 18.0               | 38.0            | 0.709           | 0.912           | 18.2  | 22.7            | 0.311           | 12.4            | 14.0  | 20.9             | 0.754                            | 21.5            | 0.926           | 21.3            | C                          | 22.7            | 45.0           | S                          | 11.4     |
| 2.0 RHS              | 4.50       | 0.293                       | 65.1             | 23.0               | 48.0            | 0.574           | 0.750           | 15.0  | 18.5            | 0.257           | 10.3            | 11.5  | 21.2             | 0.616                            | 17.7            | 0.802           | 27.2            | C                          | 18.5            | 56.8           | S                          | 7.98     |
| 1.6 RHS              | 3.64       | 0.295                       | 81.0             | 29.3               | 60.5            | 0.463           | 0.613           | 12.3  | 15.0            | 0.211           | 8.43            | 9.33  | 21.3             | 0.501                            | 14.5            | 0.705           | 34.6            | N                          | 13.8            | 71.6           | S                          | 5.61     |
| 75 x 50 x 6.0 RHS    | 9.67       | 0.224                       | 23.2             | 6.33               | 10.5            | 1.230           | 0.800           | 21.3  | 28.1            | 0.421           | 16.9            | 21.1  | 18.5             | 1.01                             | 29.3            | 1.00            | 7.49            | C                          | 28.1            | 12.4           | C                          | 21.1     |
| 5.0 RHS              | 8.35       | 0.229                       | 27.4             | 8.00               | 13.0            | 1.060           | 0.726           | 19.4  | 24.9            | 0.384           | 15.4            | 18.8  | 19.0             | 0.891                            | 26.4            | 1.00            | 9.47            | C                          | 24.9            | 15.4           | C                          | 18.8     |
| 4.0 RHS              | 6.92       | 0.233                       | 33.7             | 10.5               | 16.8            | 0.881           | 0.630           | 16.8  | 21.1            | 0.335           | 13.4            | 16.0  | 19.5             | 0.754                            | 22.7            | 1.00            | 12.4            | C                          | 21.1            | 19.8           | C                          | 16.0     |
| 3.0 RHS              | 5.42       | 0.240                       | 44.2             | 14.7               | 23.0            | 0.691           | 0.522           | 13.9  | 17.1            | 0.278           | 11.1            | 12.9  | 20.0             | 0.593                            | 18.4            | 1.00            | 17.4            | C                          | 17.1            | 27.2           | C                          | 12.9     |
| 2.5 RHS              | 4.58       | 0.241                       | 52.7             | 18.0               | 28.0            | 0.584           | 0.450           | 12.0  | 14.6            | 0.240           | 9.60            | 11.0  | 20.3             | 0.505                            | 15.9            | 1.00            | 21.3            | C                          | 14.6            | 33.1           | N                          | 10.6     |
| 2.0 RHS              | 3.72       | 0.243                       | 65.4             | 23.0               | 35.5            | 0.474           | 0.372           | 9.91  | 12.0            | 0.199           | 7.96            | 9.06  | 20.5             | 0.414                            | 13.1            | 0.971           | 27.2            | C                          | 12.0            | 42.0           | S                          | 7.70     |
| 1.6 RHS              | 3.01       | 0.245                       | 81.3             | 29.3               | 44.9            | 0.383           | 0.305           | 8.14  | 9.75            | 0.164           | 6.56            | 7.40  | 20.7             | 0.337                            | 10.8            | 0.852           | 34.6            | N                          | 9.01            | 53.1           | S                          | 5.42     |

NOTES: 1. This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.  
 2. Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.  
 3. C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.  
 4. For Square and Rectangular Hollow Sections the outside corner radius  $r$  used in calculating the section properties is equal to  $2t$  for sections with thickness  $t \leq 3.0$ mm and  $2.5t$  for sections with  $t > 3.0$ mm.

TABLE 2.1(c)

## DIMENSIONS AND PROPERTIES

TUBELINE® RECTANGULAR HOLLOW SECTIONS  
GRADE C350L0 (AS 1163)

| Designation   |         | DIMENSION AND RATIOS |                       |                   |                  | PROPERTIES         |                 |        |                 |                 |       |                 |                          |        |                |                            | PROPERTIES FOR DESIGN TO AS 4100 |                |                            |                 |   |      |
|---------------|---------|----------------------|-----------------------|-------------------|------------------|--------------------|-----------------|--------|-----------------|-----------------|-------|-----------------|--------------------------|--------|----------------|----------------------------|----------------------------------|----------------|----------------------------|-----------------|---|------|
|               |         | Mass per m           | External Surface Area | $\frac{b-2t}{t}$  | $\frac{d-2t}{t}$ | Gross Section Area | About x-axis    |        |                 | About y-axis    |       |                 | Torsion Constant Modulus |        | Form Factor    | About x-axis               |                                  | About y-axis   |                            |                 |   |      |
| d             | b       | t                    | per m                 | per t             | $A_g$            | $I_x$              | $S_x$           | $r_x$  | $I_y$           | $S_y$           | $r_y$ | J               | C                        | $k_f$  | $\lambda_{ex}$ | Compactness <sup>(2)</sup> | $Z_{ex}$                         | $\lambda_{ey}$ | Compactness <sup>(3)</sup> | $Z_{ey}$        |   |      |
| mm            | mm      | mm                   | kg/m                  | m <sup>2</sup> /m | mm <sup>2</sup>  | mm <sup>4</sup>    | mm <sup>3</sup> | mm     | mm <sup>4</sup> | mm <sup>3</sup> | mm    | mm <sup>4</sup> | mm <sup>3</sup>          |        |                | (C,N,S)                    | mm <sup>3</sup>                  |                | (C,N,S)                    | mm <sup>3</sup> |   |      |
| 75 x 25 x 2.5 | RHS     | 3.60                 | 0.191                 | 53.1              | 8.00             | 28.0               | 7.60            | 10.1   | 24.9            | 0.0487          | 3.89  | 4.53            | 10.3                     | 0.144  | 7.14           | 1.00                       | 9.47                             | C              | 10.1                       | 33.1            | N | 4.33 |
|               | 2.0 RHS | 2.93                 | 0.193                 | 65.8              | 10.5             | 35.5               | 6.36            | 8.31   | 25.3            | 0.0414          | 3.31  | 3.77            | 10.5                     | 0.120  | 6.04           | 0.964                      | 12.4                             | C              | 8.31                       | 42.0            | S | 3.18 |
|               | 1.6 RHS | 2.38                 | 0.195                 | 81.7              | 13.6             | 44.9               | 5.26            | 6.81   | 25.5            | 0.0347          | 2.78  | 3.11            | 10.7                     | 0.0993 | 5.05           | 0.813                      | 16.1                             | C              | 6.81                       | 53.1            | S | 2.22 |
| 65 x 35 x 4.0 | RHS     | 5.35                 | 0.183                 | 34.2              | 6.75             | 14.3               | 10.1            | 13.3   | 22.0            | 0.123           | 7.03  | 8.58            | 13.4                     | 0.320  | 12.5           | 1.00                       | 7.99                             | C              | 13.3                       | 16.9            | C | 8.58 |
|               | 3.0 RHS | 4.25                 | 0.190                 | 44.7              | 9.67             | 19.7               | 8.65            | 11.0   | 22.8            | 0.106           | 6.04  | 7.11            | 14.0                     | 0.259  | 10.4           | 1.00                       | 11.4                             | C              | 11.0                       | 23.3            | C | 7.11 |
|               | 2.5 RHS | 3.60                 | 0.191                 | 53.1              | 12.0             | 24.0               | 7.52            | 9.45   | 23.1            | 0.0926          | 5.29  | 6.13            | 14.2                     | 0.223  | 9.10           | 1.00                       | 14.2                             | C              | 9.45                       | 28.4            | C | 6.13 |
|               | 2.0 RHS | 2.93                 | 0.193                 | 65.8              | 15.5             | 30.5               | 6.28            | 7.80   | 23.4            | 0.0778          | 4.44  | 5.07            | 14.4                     | 0.184  | 7.62           | 1.00                       | 18.3                             | C              | 7.80                       | 36.1            | N | 4.69 |
| 50 x 25 x 3.0 | RHS     | 3.07                 | 0.140                 | 45.5              | 6.33             | 14.7               | 4.47            | 5.86   | 16.9            | 0.0367          | 2.93  | 3.56            | 9.69                     | 0.0964 | 5.18           | 1.00                       | 7.49                             | C              | 5.86                       | 17.4            | C | 3.56 |
|               | 2.5 RHS | 2.62                 | 0.141                 | 54.0              | 8.00             | 18.0               | 3.95            | 5.11   | 17.2            | 0.0328          | 2.62  | 3.12            | 9.91                     | 0.0843 | 4.60           | 1.00                       | 9.47                             | C              | 5.11                       | 21.3            | C | 3.12 |
|               | 2.0 RHS | 2.15                 | 0.143                 | 66.6              | 10.5             | 23.0               | 3.35            | 4.26   | 17.5            | 0.0281          | 2.25  | 2.62            | 10.1                     | 0.0706 | 3.92           | 1.00                       | 12.4                             | C              | 4.26                       | 27.2            | C | 2.62 |
|               | 1.6 RHS | 1.75                 | 0.145                 | 82.5              | 13.6             | 29.3               | 2.81            | 3.53   | 17.7            | 0.0237          | 1.90  | 2.17            | 10.3                     | 0.0585 | 3.29           | 1.00                       | 16.1                             | C              | 3.53                       | 34.6            | N | 2.05 |
| 50 x 20 x 3.0 | RHS     | 2.83                 | 0.130                 | 45.8              | 4.67             | 14.7               | 3.81            | 5.16   | 16.2            | 0.0212          | 2.12  | 2.63            | 7.67                     | 0.0620 | 3.88           | 1.00                       | 5.52                             | C              | 5.16                       | 17.4            | C | 2.63 |
|               | 2.5 RHS | 2.42                 | 0.131                 | 54.2              | 6.00             | 18.0               | 3.39            | 4.51   | 16.6            | 0.0192          | 1.92  | 2.32            | 7.89                     | 0.0550 | 3.49           | 1.00                       | 7.10                             | C              | 4.51                       | 21.3            | C | 2.32 |
|               | 2.0 RHS | 1.99                 | 0.133                 | 66.8              | 8.00             | 23.0               | 2.89            | 3.78   | 16.9            | 0.0167          | 1.67  | 1.96            | 8.11                     | 0.0466 | 3.00           | 1.00                       | 9.47                             | C              | 3.78                       | 27.2            | C | 1.96 |
|               | 1.6 RHS | 1.63                 | 0.135                 | 82.7              | 10.5             | 29.3               | 2.07            | 0.0608 | 2.43            | 0.0142          | 1.42  | 1.63            | 8.29                     | 0.0389 | 2.55           | 1.00                       | 12.4                             | C              | 3.14                       | 34.6            | N | 1.54 |

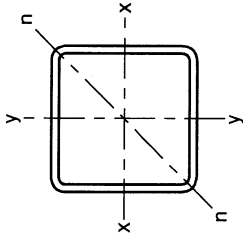
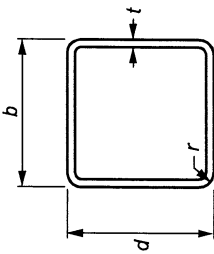
- NOTES:
- This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.
  - Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.
  - C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.
  - For Square and Rectangular Hollow Sections the outside corner radius  $r$  used in calculating the section properties is equal to  $2t$  for sections with thickness  $t \leq 3.0$ mm and  $2.5t$  for sections with  $t > 3.0$ mm.
  - Sizes shown in  $l/a$ 's: These sizes may not be stocked in all states or minimum order quantities may apply

TABLE 3.1(a)

## DIMENSIONS AND PROPERTIES

# TUBELINE® SQUARE HOLLOW SECTIONS

## GRADE C350L0 (AS 1163)



| Designation |     | DIMENSION AND RATIOS |                       |                   | PROPERTIES              |                 |                 |                  |                 |                 |                 |                 |                 |                 | PROPERTIES FOR DESIGN TO AS 4100 |                 |                 |       |             |                            |                                 |
|-------------|-----|----------------------|-----------------------|-------------------|-------------------------|-----------------|-----------------|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------------------------|-----------------|-----------------|-------|-------------|----------------------------|---------------------------------|
|             |     | Mass per m           | External Surface Area | $\frac{b-2t}{t}$  | About x-, y- and n-axis |                 |                 | Torsion Constant |                 |                 | Torsion Modulus |                 |                 | Form Factor     | About x- and y-axis              |                 |                 |       |             |                            |                                 |
| d           | b   | t                    | per m                 | per t             | $A_g$                   | $I_x$           | $I_y$           | $I_n$            | $J$             | $C$             | $k$             | $Z_x$           | $Z_y$           | $Z_n$           | $S_x$                            | $S_y$           | $S_n$           | $k_f$ | $\lambda_p$ | Compactness <sup>(3)</sup> | $Z_e$                           |
| mm          | mm  | mm                   | kg/m                  | m <sup>2</sup> /m | mm <sup>2</sup> /t      | mm <sup>2</sup> | mm <sup>4</sup> | mm <sup>4</sup>  | mm <sup>4</sup> | mm <sup>4</sup> | mm <sup>4</sup> | mm <sup>3</sup> | mm <sup>3</sup> | mm <sup>3</sup> | mm <sup>3</sup>                  | mm <sup>3</sup> | mm <sup>3</sup> |       |             | (C,N,S)                    | 10 <sup>3</sup> mm <sup>3</sup> |
| 250x250x9.0 | 250 | 9.0                  | 65.9                  | 0.961             | 14.6                    | 8400            | 79.8            | 639              | 477             | 750             | 97.5            | 129             | 972             | 1.00            | 30.5                             | N               | 744             | 1.00  | 30.5        | N                          | 744                             |
| 6.0         | 250 | 6.0                  | 45.0                  | 0.974             | 21.7                    | 5730            | 56.2            | 450              | 330             | 521             | 99.0            | 88.7            | 681             | 0.853           | 46.9                             | S               | 409             | 1.00  | 46.9        | S                          | 409                             |
| 200x200x9.0 | 200 | 9.0                  | 51.8                  | 0.761             | 14.7                    | 6600            | 39.2            | 392              | 297             | 465             | 77.1            | 64.5            | 599             | 1.00            | 23.9                             | C               | 465             | 1.00  | 23.9        | C                          | 465                             |
| 6.0         | 200 | 6.0                  | 35.6                  | 0.774             | 21.8                    | 4530            | 28.0            | 280              | 207             | 327             | 78.6            | 44.8            | 425             | 1.00            | 37.1                             | N               | 294             | 1.00  | 37.1        | N                          | 294                             |
| 5.0         | 200 | 5.0                  | 29.9                  | 0.779             | 26.0                    | 3810            | 23.9            | 239              | 175             | 277             | 79.1            | 37.8            | 362             | 0.890           | 45.0                             | S               | 223             | 1.00  | 45.0        | S                          | 223                             |
| 150x150x9.0 | 150 | 9.0                  | 37.7                  | 0.561             | 14.9                    | 4800            | 15.4            | 205              | 159             | 248             | 56.6            | 26.1            | 316             | 1.00            | 17.4                             | C               | 248             | 1.00  | 17.4        | C                          | 248                             |
| 6.0         | 150 | 6.0                  | 26.2                  | 0.574             | 22.0                    | 3330            | 11.3            | 150              | 113             | 178             | 58.2            | 18.4            | 229             | 1.00            | 27.2                             | C               | 178             | 1.00  | 27.2        | C                          | 178                             |
| 5.0         | 150 | 5.0                  | 22.1                  | 0.579             | 26.2                    | 2810            | 9.70            | 129              | 96.1            | 151             | 58.7            | 15.6            | 197             | 1.00            | 33.1                             | N               | 144             | 1.00  | 33.1        | N                          | 144                             |
| 125x125x9.0 | 125 | 9.0                  | 30.6                  | 0.461             | 15.1                    | 3900            | 8.38            | 134              | 106             | 165             | 46.4            | 14.5            | 208             | 1.00            | 14.1                             | C               | 165             | 1.00  | 14.1        | C                          | 165                             |
| 6.0         | 125 | 6.0                  | 21.4                  | 0.474             | 22.1                    | 2730            | 6.29            | 101              | 76.5            | 120             | 48.0            | 10.4            | 154             | 1.00            | 22.3                             | C               | 120             | 1.00  | 22.3        | C                          | 120                             |
| 5.0         | 125 | 5.0                  | 18.2                  | 0.479             | 26.3                    | 2310            | 5.44            | 87.1             | 65.4            | 103             | 48.5            | 8.87            | 133             | 1.00            | 27.2                             | C               | 103             | 1.00  | 27.2        | C                          | 103                             |
| 4.0         | 125 | 4.0                  | 14.8                  | 0.483             | 32.7                    | 1880            | 4.52            | 72.3             | 53.6            | 84.5            | 49.0            | 7.25            | 110             | 1.00            | 34.6                             | N               | 78.9            | 1.00  | 34.6        | N                          | 78.9                            |
| 100x100x9.0 | 100 | 9.0                  | 23.5                  | 0.361             | 15.4                    | 3000            | 3.91            | 78.1             | 63.6            | 98.6            | 36.1            | 7.00            | 123             | 1.00            | 10.8                             | C               | 98.6            | 1.00  | 10.8        | C                          | 98.6                            |
| 6.0         | 100 | 6.0                  | 16.7                  | 0.374             | 22.4                    | 2130            | 3.04            | 60.7             | 47.1            | 73.5            | 37.7            | 5.15            | 93.6            | 1.00            | 17.4                             | C               | 73.5            | 1.00  | 17.4        | C                          | 73.5                            |
| 5.0         | 100 | 5.0                  | 14.2                  | 0.379             | 26.6                    | 1810            | 2.66            | 53.1             | 40.5            | 63.5            | 38.3            | 4.42            | 81.4            | 1.00            | 21.3                             | C               | 63.5            | 1.00  | 21.3        | C                          | 63.5                            |
| 4.0         | 100 | 4.0                  | 11.6                  | 0.383             | 32.9                    | 1480            | 2.23            | 44.6             | 33.5            | 52.6            | 38.8            | 3.63            | 68.0            | 1.00            | 27.2                             | C               | 52.6            | 1.00  | 27.2        | C                          | 52.6                            |
| 3.0         | 100 | 3.0                  | 8.96                  | 0.390             | 43.5                    | 1140            | 1.77            | 35.4             | 26.0            | 41.2            | 39.4            | 2.79            | 53.2            | 1.00            | 37.1                             | N               | 37.1            | 1.00  | 37.1        | N                          | 37.1                            |
| 2.5         | 100 | 2.5                  | 7.53                  | 0.397             | 52.0                    | 959             | 1.57            | 30.7             | 21.9            | 34.9            | 39.6            | 2.35            | 45.2            | 0.897           | 45.0                             | S               | 28.7            | 0.897 | 45.0        | S                          | 28.7                            |
| 2.0         | 100 | 2.0                  | 6.07                  | 0.393             | 64.7                    | 774             | 1.23            | 24.6             | 17.8            | 28.3            | 39.9            | 1.91            | 36.9            | 0.706           | 56.8                             | S               | 20.2            | 0.706 | 56.8        | S                          | 20.2                            |

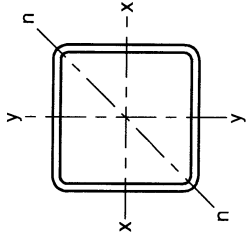
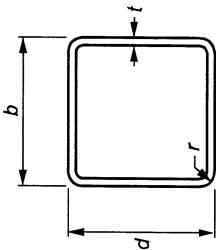
- NOTES:
- This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.
  - Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.
  - C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.
  - For Square and Rectangular Hollow Sections the outside corner radius  $r$  used in calculating the section properties is equal to  $2t$  for sections with thickness  $t \leq 3.0$ mm and  $2.5t$  for sections with  $t > 3.0$ mm.
  - Sizes shown in *italics*: These sizes may not be stocked in all states or minimum order quantities may apply

TABLE 3.1(b)

## DIMENSIONS AND PROPERTIES

# TUBELINE® SQUARE HOLLOW SECTIONS

## GRADE C350L0 (AS 1163)



| DIMENSION AND RATIOS |            |                       |       | PROPERTIES         |                          |                         |                                 |                                 |                                 |                                 | PROPERTIES FOR DESIGN TO AS 4100 |                                 |             |                 |                                  |         |                                 |
|----------------------|------------|-----------------------|-------|--------------------|--------------------------|-------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|-------------|-----------------|----------------------------------|---------|---------------------------------|
| Designation          | Mass per m | External Surface Area |       | $\frac{b-2t}{t}$   | Gross Section Area $A_g$ | About x-, y- and n-axis |                                 |                                 |                                 | Torsion Constant Modulus        |                                  | About x- and y-axis             |             |                 |                                  |         |                                 |
|                      |            | per m                 | per t |                    |                          | $k_x$                   | $Z_x$                           | $Z_n$                           | $S_x$                           | $r_x$                           | $J$                              | $C$                             | Form Factor | $\lambda_p$     | Compactness <sup>(2)</sup> $Z_e$ |         |                                 |
| d                    | b          | t                     | mm    | mm <sup>2</sup> /m | m <sup>2</sup> /t        | mm <sup>2</sup>         | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>6</sup> mm <sup>4</sup>  | 10 <sup>3</sup> mm <sup>3</sup> | mm          | mm <sup>3</sup> | mm <sup>3</sup>                  | (C,N,S) | 10 <sup>3</sup> mm <sup>3</sup> |
| 89 x 89 x 6.0 SHS    | 14.6       | 0.330                 | 22.5  | 12.8               | 1870                     | 2.06                    | 46.2                            | 36.3                            | 56.6                            | 33.2                            | 3.54                             | 71.6                            | 33.2        | 15.2            | C                                | 56.6    |                                 |
| 5.0 SHS              | 12.5       | 0.334                 | 26.7  | 15.8               | 1590                     | 1.81                    | 40.7                            | 31.4                            | 49.1                            | 33.7                            | 3.05                             | 62.7                            | 33.7        | 18.7            | C                                | 49.1    |                                 |
| 3.5 SHS              | 9.06       | 0.341                 | 37.6  | 23.4               | 1150                     | 1.37                    | 30.9                            | 23.2                            | 36.5                            | 34.5                            | 2.24                             | 47.1                            | 34.5        | 27.7            | C                                | 36.5    |                                 |
| 75 x 75 x 6.0 SHS    | 12.0       | 0.274                 | 22.8  | 10.5               | 1530                     | 1.16                    | 30.9                            | 24.7                            | 38.4                            | 27.5                            | 2.04                             | 48.2                            | 27.5        | 12.4            | C                                | 38.4    |                                 |
| 5.0 SHS              | 10.3       | 0.279                 | 27.0  | 13.0               | 1310                     | 1.03                    | 27.5                            | 21.6                            | 33.6                            | 28.0                            | 1.77                             | 42.6                            | 28.0        | 15.4            | C                                | 33.6    |                                 |
| 4.0 SHS              | 8.49       | 0.283                 | 33.3  | 16.8               | 1080                     | 0.882                   | 23.5                            | 18.0                            | 28.2                            | 28.6                            | 1.48                             | 36.1                            | 28.6        | 19.8            | C                                | 28.2    |                                 |
| 3.5 SHS              | 7.53       | 0.285                 | 37.9  | 19.4               | 959                      | 0.797                   | 21.3                            | 16.1                            | 25.3                            | 28.8                            | 1.32                             | 32.5                            | 28.8        | 23.0            | C                                | 25.3    |                                 |
| 3.0 SHS              | 6.60       | 0.290                 | 43.9  | 23.0               | 841                      | 0.716                   | 19.1                            | 14.2                            | 22.5                            | 29.2                            | 1.15                             | 28.7                            | 29.2        | 27.2            | C                                | 22.5    |                                 |
| 2.5 SHS              | 5.56       | 0.291                 | 52.4  | 28.0               | 709                      | 0.614                   | 16.4                            | 12.0                            | 19.1                            | 29.4                            | 0.971                            | 24.6                            | 29.4        | 33.1            | N                                | 18.3    |                                 |
| 2.0 SHS              | 4.50       | 0.293                 | 65.1  | 35.5               | 574                      | 0.505                   | 13.5                            | 9.83                            | 15.6                            | 29.7                            | 0.790                            | 20.2                            | 29.7        | 42.0            | S                                | 13.1    |                                 |
| 65 x 65 x 6.0 SHS    | 10.1       | 0.234                 | 23.1  | 8.83               | 1290                     | 0.706                   | 21.7                            | 17.8                            | 27.5                            | 23.4                            | 1.27                             | 34.2                            | 23.4        | 10.5            | C                                | 27.5    |                                 |
| 5.0 SHS              | 8.75       | 0.239                 | 27.3  | 11.0               | 1110                     | 0.638                   | 19.6                            | 15.6                            | 24.3                            | 23.9                            | 1.12                             | 30.6                            | 23.9        | 13.0            | C                                | 24.3    |                                 |
| 4.0 SHS              | 7.23       | 0.243                 | 33.6  | 14.3               | 921                      | 0.552                   | 17.0                            | 13.2                            | 20.6                            | 24.5                            | 0.939                            | 26.2                            | 24.5        | 16.9            | C                                | 20.6    |                                 |
| 3.0 SHS              | 5.66       | 0.250                 | 44.1  | 19.7               | 721                      | 0.454                   | 14.0                            | 10.4                            | 16.6                            | 25.1                            | 0.733                            | 21.0                            | 25.1        | 23.3            | C                                | 16.6    |                                 |
| 2.5 SHS              | 4.78       | 0.251                 | 52.6  | 24.0               | 609                      | 0.391                   | 12.0                            | 8.91                            | 14.1                            | 25.3                            | 0.624                            | 18.1                            | 25.3        | 28.4            | C                                | 14.1    |                                 |
| 2.0 SHS              | 3.88       | 0.253                 | 65.3  | 30.5               | 494                      | 0.323                   | 9.94                            | 7.29                            | 11.6                            | 25.6                            | 0.509                            | 14.9                            | 25.6        | 36.1            | N                                | 10.6    |                                 |
| 1.6 SHS              | 3.13       | 0.255                 | 81.2  | 38.6               | 399                      | 0.265                   | 8.16                            | 5.94                            | 9.44                            | 25.8                            | 0.414                            | 12.2                            | 25.8        | 45.7            | S                                | 7.54    |                                 |
| 50 x 50 x 5.0 SHS    | 6.39       | 0.179                 | 27.9  | 8.00               | 814                      | 0.257                   | 10.3                            | 8.51                            | 13.2                            | 17.8                            | 0.469                            | 16.3                            | 17.8        | 9.47            | C                                | 13.2    |                                 |
| 4.0 SHS              | 5.35       | 0.183                 | 34.2  | 10.5               | 681                      | 0.229                   | 9.15                            | 7.33                            | 11.4                            | 18.3                            | 0.403                            | 14.3                            | 18.3        | 12.4            | C                                | 11.4    |                                 |
| 3.0 SHS              | 4.25       | 0.190                 | 44.7  | 14.7               | 541                      | 0.195                   | 7.79                            | 5.92                            | 9.39                            | 19.0                            | 0.321                            | 11.8                            | 19.0        | 17.4            | C                                | 9.39    |                                 |
| 2.5 SHS              | 3.60       | 0.191                 | 53.1  | 18.0               | 459                      | 0.169                   | 6.78                            | 5.09                            | 8.07                            | 19.2                            | 0.275                            | 10.2                            | 19.2        | 21.3            | C                                | 8.07    |                                 |
| 2.0 SHS              | 2.93       | 0.193                 | 65.8  | 23.0               | 374                      | 0.141                   | 5.66                            | 4.20                            | 6.66                            | 19.5                            | 0.226                            | 8.51                            | 19.5        | 27.2            | C                                | 6.66    |                                 |
| 1.6 SHS              | 2.38       | 0.195                 | 81.7  | 29.3               | 303                      | 0.117                   | 4.68                            | 3.44                            | 5.46                            | 19.6                            | 0.185                            | 7.03                            | 19.6        | 34.6            | N                                | 5.10    |                                 |

NOTES: 1. This table is calculated in accordance with AS 4100 using design yield stress  $f_y = 350$  MPa and design tensile strength  $f_u = 430$  MPa as per AS 4100 table 2.1 for AS 1163 grade C350L0.  
 2. Grade C350L0 is cold formed and therefore is allocated the CF residual stresses classification in AS 4100.  
 3. C = Compact Section; N = Non-compact Section; S = Slender Section; as defined in AS 4100.  
 4. For Square and Rectangular Hollow Sections the outside corner radius  $r$  used in calculating the section properties is equal to  $2t$  for sections with thickness  $t \leq 3.0$ mm and  $2.5t$  for sections with  $t > 3.0$ mm.

# SHS

RAPID DESIGN OF STEELWORK TRUSSES

WORKED SOLUTIONS TO TUTORIAL QUESTIONS

**Question 1:**

A steel truss (with horizontal top and bottom booms) is urgently required to give temporary support to a roof structure which has been damaged by severe weather. The truss spans 40 metres and is subjected to an imposed vertical load of 8 kN/metre span, in addition to its own self-weight, which can be assumed to be 0.45 kN/metre span.

The space available for construction is limited, and the maximum overall height of the truss must not exceed 2.2 metres. If the maximum permissible axial stress within the truss must not exceed 205MPa, and the maximum allowable deflection under imposed load is restricted to *span/350*:

- i) provide a sketch of the shape of the truss you would recommend, bearing in mind the immediate requirement for the steelwork and the need for economic design;
- ii) use suitable calculations to determine a structural square hollow steel section which you would recommend to be used for the fabrication of the truss;
- iii) estimate the cost of the truss, given that the overall cost of erected steelwork can be estimated as A\$1800 per tonne.

The value of Young's Modulus for steel can be assumed to be  $200 \times 10^3$  MPa ( $= 200 \times 10^6$  kN/m<sup>2</sup>).

The truss will be considered as a 10-panel statically determinate framework acting as a simply-supported beam structure.

The total distributed load is  $8.45 \text{ kN/m} \times 40 \text{ m}$  ( $= 338$  kN), and the maximum value of bending moment  $M_{\text{MAX}}$  (which occurs at mid-span) is given by

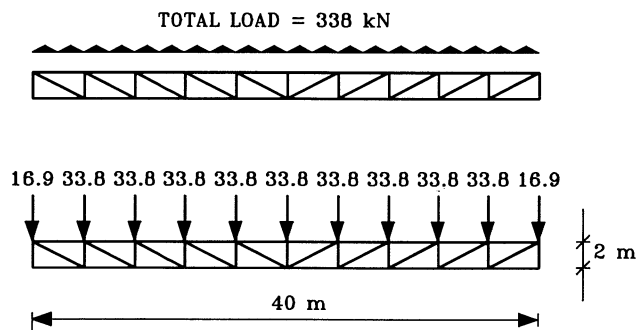


Figure 1

$$M_{\text{MAX}} = \frac{w L^2}{8} = \frac{(8 + 0.45) \text{ kN/m} \times (40 \text{ m})^2}{8} = 1690 \text{ kNm}$$

The effective depth (d) will be assumed to be 2.0 m, taking note of the restriction in overall depth. The axial load in the top and bottom booms is

$$P = \frac{M_{\text{MAX}}}{d} = \frac{1690 \text{ kNm}}{2 \text{ m}} = 845 \text{ kN}$$

If the maximum permissible stress for the steel is 205MPa, the required cross-sectional area A of the truss to limit the stress to this value is

$$A \geq \frac{845 \times 10^3 \text{ N}}{205 \text{ MPa}} = 4122.0 \text{ mm}^2$$

If the maximum deflection of the truss under the action of the imposed load is restricted to span/350 (= 114.3 mm), then

$$\frac{L}{350} \geq \frac{5 w_L L^4}{384 E I} = \frac{5 \times w_L \times L^4}{384 \times E \times \frac{A \times d^2}{2}}$$

$$\rightarrow A \geq \frac{3500 \times w_L \times L^3}{384 \times E \times d^2} = \frac{3500 \times 8\text{kN/m} \times (40\text{m})^3}{384 \times (200 \times 10^6) \times (2\text{m})^2}$$

$$A \geq 5.8333 \times 10^{-3} \text{ m}^2 = \mathbf{5833.3 \text{ mm}^2}$$

This value for A (5833.3 mm<sup>2</sup>) is significantly greater than that obtained by considering maximum stress, and therefore it is this higher value that must be taken as the required cross-sectional area for the truss members. Using the OneSteel Cold Formed Structural Hollow Sections and Profiles Catalogue, the square hollow section with the nearest cross-sectional area greater than this area is **200 × 200 × 9 mm SHS** with an area of 6600 mm<sup>2</sup>, which has a mass of 51.8 kg/m.

The total length of steel section in one truss is approximately

$$2 \times 40 \text{ m} + 11 \times 2 \text{ m} + 10 \times \sqrt{4^2 + 2^2} \text{ m} = 146.7 \text{ m}$$

Thus the total weight of steel in the truss is

$$146.7 \text{ m} \times 51.8 \text{ kg/m} = 7599.1 \text{ kg}$$

and if the cost of erected steelwork is A\$1800 per tonne, the total cost of the truss is

$$7.5991 \text{ T} \times \text{A\$1800/T} = \mathbf{\text{A\$13678}}$$

### Question 2:

*A steel truss (with horizontal top and bottom booms) is required to span 25 metres and is subjected to an imposed vertical load of 5 kN/metre span, in addition to its own self-weight, which can be assumed to be 0.35 kN/metre span.*

*The space available for construction is limited, and the maximum height of the truss must not exceed 1.5 metres. If Steel Grade 350 is to be used (maximum permissible axial stress within the truss is 205MPa), and the maximum allowable deflection under imposed load is restricted to **span/350**:*

- i) provide a sketch of the shape of the truss you would recommend;*
- ii) use suitable calculations to determine a steel section which you would recommend to be used for the fabrication of the truss. You should consider SHS, RHS and CHS section, and your recommendation should be based on achieving minimum weight while still meeting all the above design criteria;*
- iii) estimate the cost of the truss, given that the overall cost of erected steelwork can be estimated as A\$1880 per tonne.*

*The value of Young's Modulus for steel can be assumed to be  $200 \times 10^3 \text{ MPa}$  ( $= 200 \times 10^6 \text{ kN/m}^2$ ).*

The truss will be considered as a 8-panel statically determinate framework acting as a simply-supported beam structure. The total distributed load is 5.35 kN/m × 25 m (= 133.75 kN), and the maximum value of bending moment  $M_{\text{MAX}}$  (which occurs at mid-span) is given by

$$M_{\text{MAX}} = \frac{w \times L^2}{8}$$

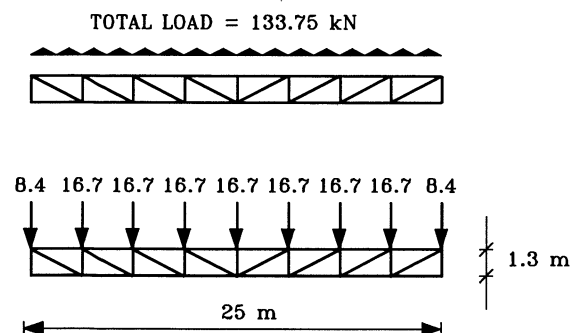


Figure 2

Thus 
$$M_{MAX} = \frac{(5 + 0.35)\text{kN/m} \times (25\text{m})^2}{8} = 418.0 \text{ kNm}$$

The effective depth (d) will be assumed to be 1.25 m, taking note of the restriction in **overall depth**. The axial load in the top and bottom booms is

$$P = \frac{M_{MAX}}{d} = \frac{418.0 \text{ kNm}}{1.25 \text{ m}} = 334.4 \text{ kN}$$

If the maximum permissible stress for the steel is 205 MPa, the required cross-sectional area A of the truss to limit the stress to this value is

$$A \geq \frac{334.4 \times 10^3 \text{ N}}{205 \text{ MPa}} = 1631.2 \text{ mm}^2$$

If the maximum deflection of the truss under the action of the imposed load is restricted to span/350 (= 71.4 mm), then

$$\frac{L}{350} \geq \frac{5 w_L L^4}{384 E I} = \frac{5 \times w_L \times L^4}{384 \times E \times \frac{A \times d^2}{2}}$$

$$\rightarrow A \geq \frac{3500 \times w_L \times L^3}{384 \times E \times d^2} = \frac{3500 \times 5\text{kN/m} \times (25\text{m})^3}{384 \times (200 \times 10^6) \times (1.25\text{m})^2}$$

$$A \geq 2.2786 \times 10^{-3} \text{ m}^2 = 2278.6 \text{ mm}^2$$

This value for A (2278.6 mm<sup>2</sup>) obtained by considering maximum stress is greater than the previous value for A (1631.2 mm<sup>2</sup>), and therefore the higher value must be taken as the required cross-sectional area for the truss members. Using the OneSteel Cold Formed Structural Hollow Sections and Profiles Catalogue:

- Square Hollow Section with the nearest cross-sectional area greater than 2278.6 mm<sup>2</sup> is 125 × 125 × 5 mm SHS with an area of 2310 mm<sup>2</sup>, which has a mass of 18.2 kg/m.
- Rectangular Hollow Section with the nearest cross-sectional area greater than 2278.6 mm<sup>2</sup> is 200 × 100 × 4 mm RHS with an area of 2280 mm<sup>2</sup>, which has a mass of 17.9 kg/m.
- Circular Hollow Section with the nearest cross-sectional area greater than 2278.6 mm<sup>2</sup> is 168.3 × 4.8 mm CHS with an area of 2470 mm<sup>2</sup>, which has a mass of 19.4 kg/m.

**The most economical section is the 200 × 100 × 4 mm RHS with a mass of 17.9 kg/m.**

*(NB Potential welding issues with 4mm wall thickness?)*

The total length of steel section in one truss is approximately

$$2 \times 25 \text{ m} + 9 \times 1.25 \text{ m} + 8 \times \sqrt{\left(\frac{25\text{m}}{8}\right)^2 + 1.25^2} \text{ m} = 88.2 \text{ m}$$

Thus the total weight of steel in the truss is

$$88.2 \text{ m} \times 17.9 \text{ kg/m} = 1578.8 \text{ kg}$$

and if the cost of erected steelwork is A\$1880 per tonne, the total cost of the truss is approximately

$$1.5788 \text{ T} \times \text{A\$1880/T} = \text{A\$2968}$$