Z_y is the section modulus about the minor axis;

β_{2f} is the limiting value of b/T from Table 11 for a class 2 compact flange;

β_{2w} is the limiting value of d/t from Table 11 for a class 2 compact web;

β_{3f} is the limiting value of b/T from Table 11 for a class 3 semi-compact flange;

β_{3w} is the limiting value of d/t from Table 11 for a class 3 semi-compact web.

3.5.6.3 *Rectangular hollow sections*

For class 3 semi-compact RHS the effective plastic moduli $S_{x,eff}$ and $S_{y,eff}$ for major and minor axis bending may both be obtained by considering bending about the respective axis, using the following:

$$S_{eff} = Z + (S - Z)\left[\frac{\dfrac{\beta_{3w}}{d/t} - 1}{\dfrac{\beta_{3w}}{\beta_{2w}} - 1}\right] \quad \text{but} \quad S_{eff} \le Z + (S - Z)\left[\frac{\dfrac{\beta_{3f}}{b/t} - 1}{\dfrac{\beta_{3f}}{\beta_{2f}} - 1}\right]$$

where

β_{2f} is the limiting value of b/t from Table 12 for a class 2 compact flange;

β_{2w} is the limiting value of d/t from Table 12 for a class 2 compact web;

β_{3f} is the limiting value of b/t from Table 12 for a class 3 semi-compact flange;

β_{3w} is the limiting value of d/t from Table 12 for a class 3 semi-compact web;

and the dimensions b, d and t of an RHS are as defined in Table 12.

NOTE For an RHS subject to bending B and b are always flange dimensions and D and d are always web dimensions, but the definition of which sides of the RHS are webs and which are flanges changes according to the axis of bending, see **3.5.1**.

3.5.6.4 *Circular hollow sections*

For class 3 semi-compact CHS of diameter D and thickness t the effective plastic modulus S_{eff} should be obtained from:

$$S_{eff} = Z + 1.485\left[\left[\left(\frac{140}{D/t}\right)\left(\frac{275}{p_y}\right)\right]^{0.5} - 1\right](S - Z)$$

3.6 Slender cross-sections

3.6.1 Effective section properties

The local buckling resistance of class 4 slender cross-sections may be allowed for in design by adopting effective section properties. Due allowance should be made for the possible effects of any shift of the centroid of the effective cross-section compared to that of the gross cross-section, see **3.6.3**.

Generally the methods given in **3.6.2**, **3.6.3**, **3.6.4**, **3.6.5** and **3.6.6** should be used, but more exact methods of calculating resistance to local buckling may also be used where appropriate.

In members that are mainly stressed by axial compression, the possible effects of local buckling on serviceability should be taken into account for cross-sections that include internal elements wider than 70ε times their thickness for cold formed RHS, or 80ε times for other sections.

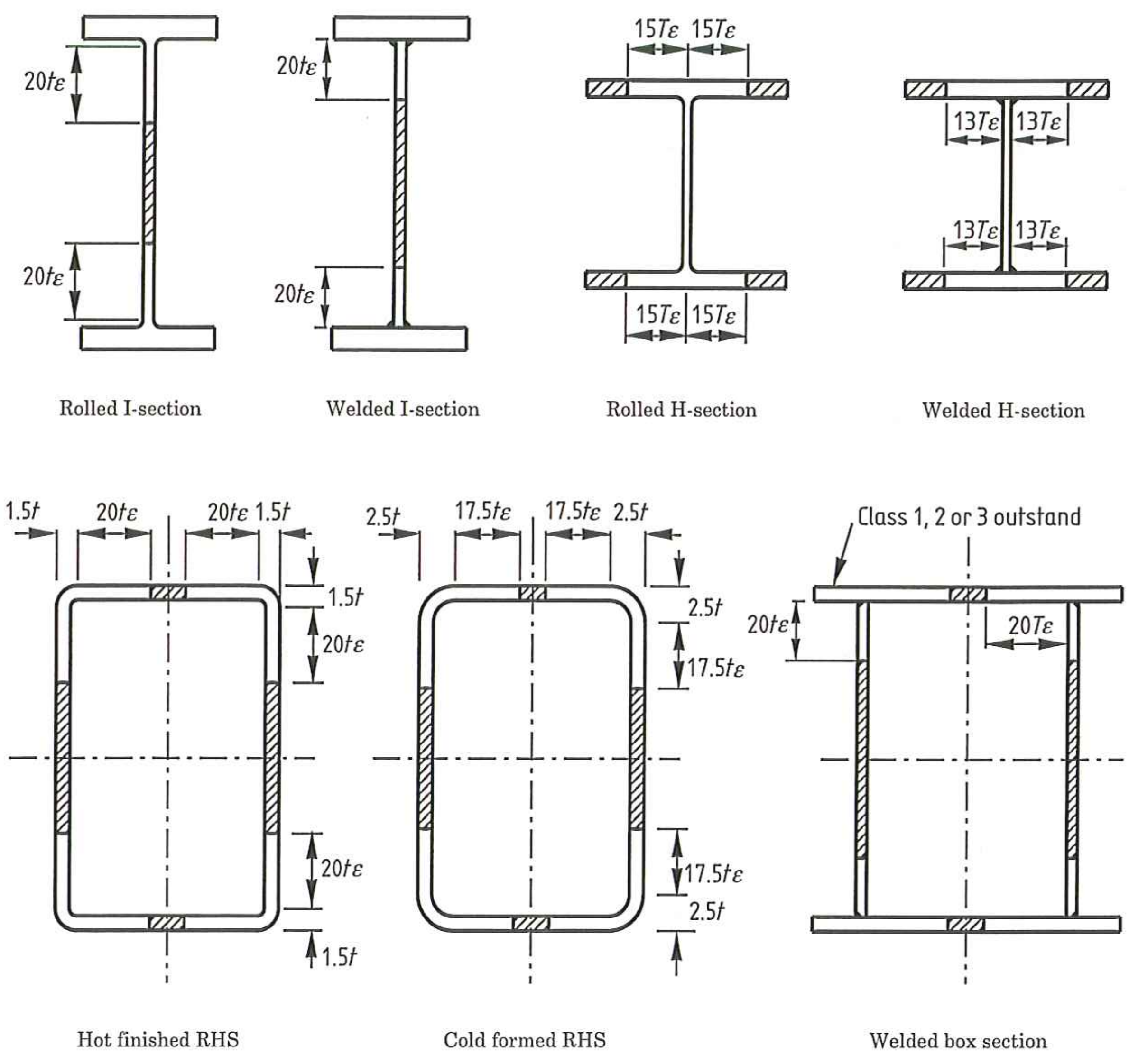
3.6.2 Doubly symmetric cross-sections

3.6.2.1 *General*

The methods given in **3.6.2.2**, **3.6.2.3** and **3.6.2.4** may be used for doubly symmetric cross-sections that include class 4 slender elements. The effective cross-sectional area A_{eff} and the values of effective section modulus Z_{eff} for bending about the major and minor axes should each be determined from separate effective cross-sections as detailed in **3.6.2.2**, **3.6.2.3** and **3.6.2.4**.

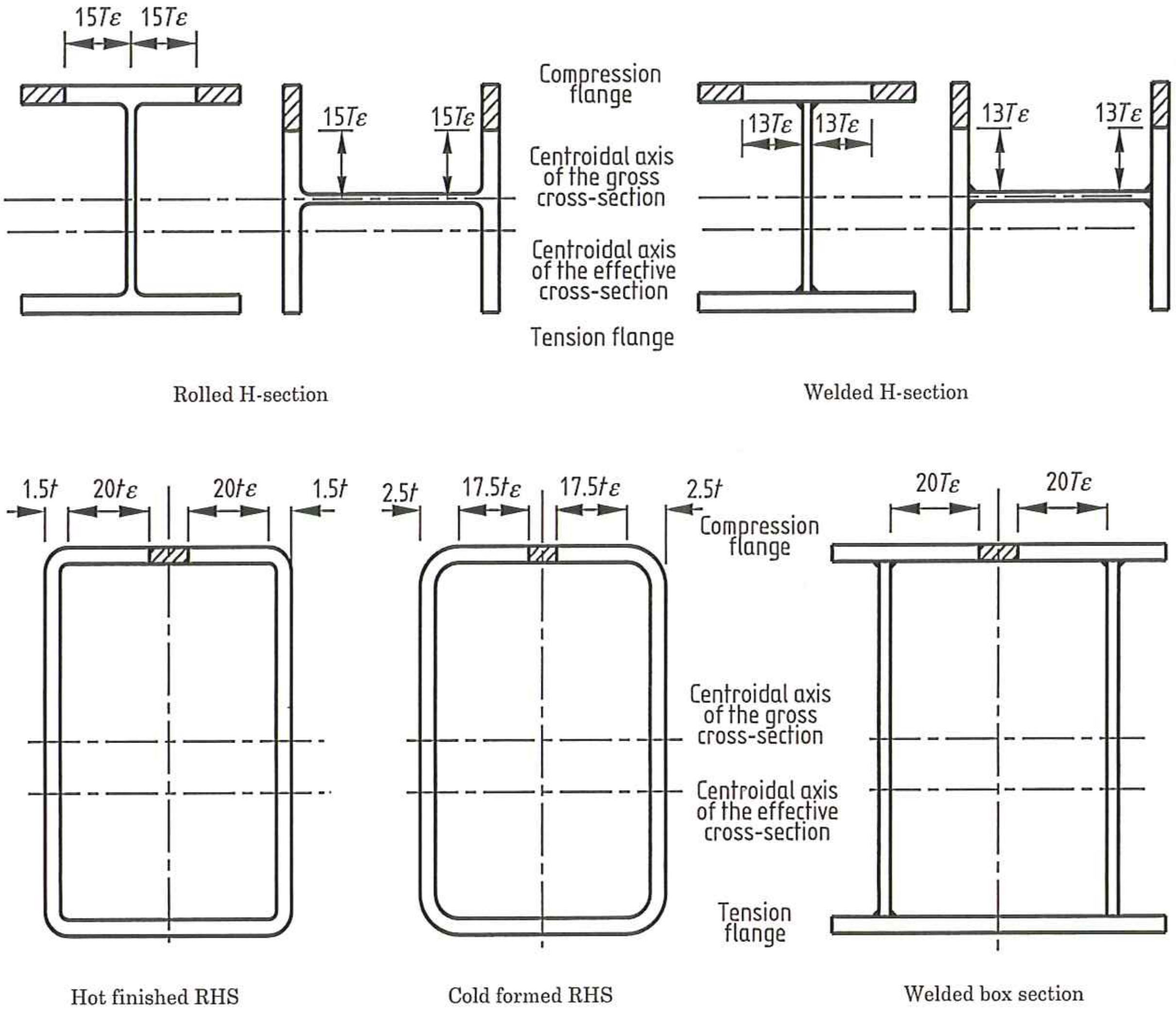
3.6.2.2 *Effective area*

The effective cross-sectional area A_{eff} should be determined from the effective cross-section as shown in Figure 8a). The effective width of a class 4 slender web element or internal flange element should be taken as 35ε times its thickness for cold formed RHS, or 40ε times for other sections, comprising two equal portions with a central non-effective zone. The effective width of a class 4 slender outstand element should be taken as equal to the maximum width for class 3 derived from Table 11.



a) Effective cross-sections under pure compression, for determining A_{eff}

Figure 8 — Doubly symmetric slender cross-sections



b) Effective cross-sections, webs fully effective under pure moment, for determining Z_{eff}

Figure 8 — Doubly symmetric slender cross-sections (*continued*)

3.6.2.3 *Effective modulus when web is fully effective*

For cross-sections with webs that are not class 4 slender under pure bending, the effective section modulus Z_{eff} should be determined from an effective cross-section in which the effective width of any class 4 slender element in the compression flange is determined as detailed in **3.6.2.2**, see Figure 8b).

If the whole cross-section is fully effective for bending about a given axis then Z_{eff} should be taken as equal to the section modulus Z about that axis.

If the cross-section is not fully effective in resisting bending about the major or minor axis, causing the relevant effective cross-section to be asymmetric about the axis of bending, the smaller of the two values of Z_{eff} for that axis should be used.

3.6.2.4 *Effective modulus when web is slender*

For cross-sections with webs that are class 4 slender under pure bending, the effective section modulus Z_{eff} should be determined from an effective cross-section obtained by adopting an effective width b_{eff} for the compression zone of the web, arranged as indicated in Figure 9, with $0.4b_{eff}$ adjacent to the compression flange and $0.6b_{eff}$ adjacent to the elastic neutral axis.

The effective width b_{eff} of the compression zone under pure bending should be obtained from:

$$b_{eff} = \frac{120\varepsilon t}{\left(1 + \frac{f_{cw} - f_{tw}}{p_{yw}}\right)\left(1 + \frac{f_{tw}}{f_{cw}}\right)}$$

where

f_{cw} is the maximum compressive stress in the web, see Figure 9;

f_{tw} is the maximum tensile stress in the web, see Figure 9;

p_{yw} is the design strength of the web;

t is the web thickness.

The values of f_{cw} and f_{tw} used to determine b_{eff} should be based on a cross-section in which the web is taken as fully effective, using the effective width of the compression flange if this is class 4 slender.

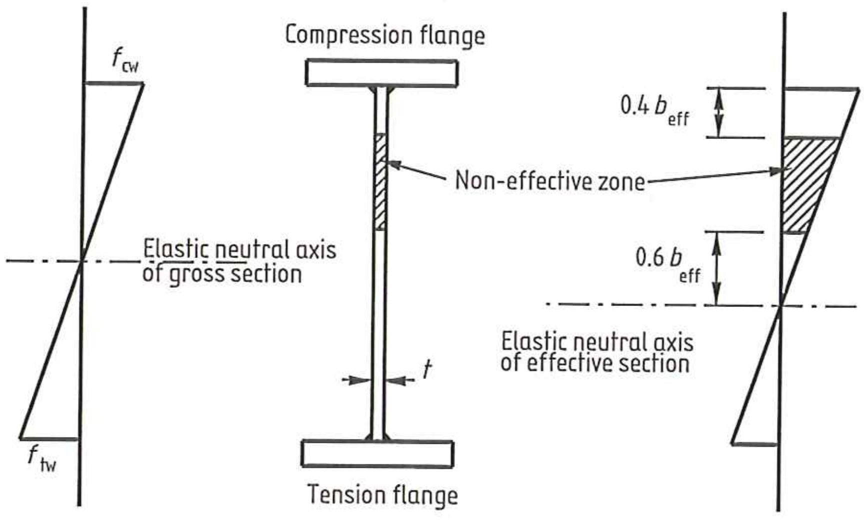


Figure 9 — Effective width for class 4 slender web under pure bending

3.6.3 Singly symmetric and unsymmetric cross-sections

The effective widths detailed in **3.6.2.2** may also be used for class 4 singly symmetric and unsymmetric cross-sections, provided that account is taken of the additional moments induced in the member due to the shift of the centroid of the effective cross-section compared to that of the gross cross-section.

These additional moments should be obtained by assuming that the axial compressive force F_c acts at the centroid of the gross cross-section, but is resisted by an equal and opposite force acting at the centroid of the effective cross-section that corresponds to the case of a uniform stress equal to the design strength p_y acting throughout its effective cross-sectional area. The additional moments should be taken into account in the checks on cross-section capacity and member buckling resistance given in **4.2**, **4.3**, **4.4**, **4.7**, and **4.8**, except where a more onerous condition occurs if they are omitted.

3.6.4 Equal-leg angle sections

For class 4 slender hot rolled equal-leg angle sections, the method given in **3.6.3** may be used. Alternatively, the effective cross-sectional area A_{eff} and effective section modulus Z_{eff} about a given axis may conservatively be obtained using:

$$\frac{A_{eff}}{A} = \frac{12\varepsilon}{b/t}$$

$$\frac{Z_{eff}}{Z} = \frac{15\varepsilon}{b/t}$$

where

b is the leg length;

t is the thickness.

3.6.5 Alternative method

As an alternative to the methods detailed in **3.6.2**, **3.6.3** and **3.6.4**, a reduced design strength p_{yr} may be calculated at which the cross-section would be class 3 semi-compact. The reduced design strength p_{yr} should then be used in place of p_y in the checks on section capacity and member buckling resistance given in **4.2**, **4.3**, **4.4**, **4.7** and **4.8**. The value of this reduced design strength p_{yr} may be obtained from:

$$p_{yr} = (\beta_3/\beta)^2 p_y$$

in which β is the value of b/T, b/t, D/t or d/t that exceeds the limiting value β_3 given in Table 11 or Table 12 for a class 3 semi-compact section.

NOTE Unless the class 3 semi-compact limit is exceeded by only a small margin, the use of this alternative method can be rather conservative.

3.6.6 Circular hollow sections

Provided that the overall diameter D does not exceed $240t\varepsilon^2$ the effective cross-sectional area A_{eff} and effective section modulus Z_{eff} of a class 4 slender circular hollow section of thickness t may be determined from:

$$\frac{A_{eff}}{A} = \left[\left(\frac{80}{D/t}\right)\left(\frac{275}{p_y}\right)\right]^{0.5}$$

$$\frac{Z_{eff}}{Z} = \left[\left(\frac{140}{D/t}\right)\left(\frac{275}{p_y}\right)\right]^{0.25}$$

4.2.5.2 ***Low shear***

Provided that the shear force F_v does not exceed 60 % of the shear capacity P_v:

— for class 1 plastic or class 2 compact cross-sections:

$M_c = p_y S$

— for class 3 semi-compact sections:

$M_c = p_y Z$ or alternatively $M_c = p_y S_{eff}$

— for class 4 slender cross-sections:

$M_c = p_y Z_{eff}$

where

S is the plastic modulus;

S_{eff} is the effective plastic modulus, see **3.5.6**;

Z is the section modulus;

Z_{eff} is the effective section modulus, see **3.6.2**.

4.2.5.3 ***High shear***

Where $F_v > 0.6P_v$:

— for class 1 plastic or class 2 compact cross-sections:

$M_c = p_y(S - \rho S_v)$

— for class 3 semi-compact cross-sections:

$M_c = p_y(Z - \rho S_v/1.5)$ or alternatively $M_c = p_y(S_{eff} - \rho S_v)$

— for class 4 slender cross-sections:

$M_c = p_y(Z_{eff} - \rho S_v/1.5)$

in which S_v is obtained from the following:

— for sections with unequal flanges:

$S_v = S - S_f$

in which S_f is the plastic modulus of the effective section excluding the shear area A_v defined in **4.2.3**;

— otherwise:

S_v is the plastic modulus of the shear area A_v defined in **4.2.3**;

and ρ is given by:

$\rho = [2(F_v/P_v) - 1]^2$

NOTE The reduction factor ρ starts when F_v exceeds $0.5P_v$ but the resulting reduction in moment capacity is negligible unless F_v exceeds $0.6P_v$.

Alternatively, for class 3 semi-compact cross-sections reference may be made to **H.3**, or for class 4 slender cross-sections reference may be made to **3.6** and **H.3**.

If the ratio d/t exceeds 70ε for a rolled section, or 62ε for a welded section, the moment capacity should be determined allowing for shear buckling in accordance with **4.4.4**.