8.3 Combined Bending and Axial Compression

In this section:

ϕ = 0.9 (Table 3.4 of AS 4100)

ϕM_{sx} = design section moment capacity for bending about the major principal x-axis

ϕM_{sy} = design section moment capacity for bending about the minor principal y-axis

N^* = design axial compressive force

ϕN_s = design section capacity in compression

ϕN_{cx} = design member capacity in compression, buckling about the x-axis

ϕN_{cy} = design member capacity in compression, buckling about the y-axis

8.3.1 Compression and Uniaxial Bending – about the major principal x-axis

For a member subject to uniaxial bending about the major principal x-axis and axial compression, the following condition must be satisfied:

$M_x^* \leq \min.[\phi M_{rx}; \phi M_{ix}; \phi M_{ox}]$

where ϕ = 0.9 (Table 3.4 of AS 4100)

M_x^* = design bending moment about the major principal x-axis

ϕM_{rx} = design section moment capacity (ϕM_s) for bending about the major principal x-axis reduced by axial force (see Section 8.3.1.1)

ϕM_{ix} = design in-plane member moment capacity (ϕM_i) for bending about the major principal x-axis (see Section 8.3.1.2(a))

ϕM_{ox} = design out-of-plane member moment capacity (ϕM_o) for bending about the major principal x-axis (see Section 8.3.1.2(b))

8.3.1.1 Section Capacity

The value of ϕM_{rx} must be determined at all points along the member and the minimum value used to satisfy Section 8.3.1.

$$\phi M_{rx} = \phi M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right) \quad \text{(Clause 8.3.2 of AS 4100)}$$

Alternatively, for RHS and SHS to AS 1163, which are compact about the x-axis with k_f = 1.0 subject to bending and compression

$$\phi M_{rx} = 1.18\phi M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right) \leq \phi M_{sx} \quad \text{(Clause 8.3.2 of AS 4100)}$$

For RHS and SHS to AS 1163, which are compact about the x-axis with k_f < 1.0 subject to bending and compression

$$\phi M_{rx} = \phi M_{sx}\left(1 - \frac{N^*}{\phi N_s}\right)\left[1 + 0.18\left(\frac{82 - \lambda_w}{82 - \lambda_{wy}}\right)\right] \leq \phi M_{sx} \quad \text{(Clause 8.3.2 of AS 4100)}$$

where λ_w = the element slenderness of the web (Clause 6.2.3 of AS 4100)

$$= \frac{d - 2t}{t}\sqrt{\frac{f_y}{250}}$$

λ_{wy} = the web yield slenderness limit (Table 6.2.4 of AS 4100)

= 40 for RHS and SHS considered in this publication.

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8.3.1.2 Member Capacity

This section only applies to members analysed using an elastic method of analysis. Where there is sufficient restraint to prevent lateral buckling, only the in-plane requirements of Sections 8.3.1.1 and 8.3.1.2 need to be satisfied. If there is insufficient restraint to prevent lateral buckling, then both the in-plane and out-of-plane requirements of Sections 8.3.1.1 and 8.3.1.2 need to be satisfied.

(a) In-plane capacity

$$\phi M_{ix} = \phi M_{sx}\left(1-\frac{N^*}{\phi N_{cx}}\right) \qquad \text{(Clause 8.4.2.2 of AS 4100)}$$

For braced and sway members, the above value of ϕN_{cx} is calculated using an effective length factor (k_{ex}) equal to 1.0 (i.e. $L_{ex} = L$), unless a lower value of k_{ex} has been calculated for a braced member, provided that $N^* \leq \phi N_{cx}$ where the value of ϕN_{cx} in this inequality is calculated using the correct value of k_{ex}.

Clause 8.4.2.2 of AS 4100 also provides a higher tier method for evaluating M_i which is dependent on the ratio of the member's end bending moments. Due to the variable nature of these end bending moments, the further consideration of this higher tier method is beyond the scope of this publication.

(b) Out-of-plane capacity

$$\phi M_{ox} = \phi M_{bx}\left(1-\frac{N^*}{\phi N_{cy}}\right) \qquad \text{(Clause 8.4.4.1 of AS 4100)}$$

where ϕM_{bx} = design member moment capacity for bending about the major principal x-axis.

8.3.1.3 Tables

For RHS, Tables 8-3 to 8-4 list ϕM_{sx}, ϕN_s and ϕM_{rx} *(comp)* - the latter parameter refers to ϕM_{rx} as noted in Section 8.3.1.1. Tables 8-5 to 8-6 for SHS refer to these three parameters as ϕM_s, ϕN_s and ϕM_r *(comp)* respectively. For CHS, Tables 8-1 to 8-2 list ϕN_s, ϕM_s and the relationship to ϕM_r (i.e. the design section moment capacity reduced by compression). Designers should evaluate $n = N^*/\phi N_s$, then use it to calculate the value of ϕM_{rx} and ensure that it is **less than or equal to** the design section capacity ϕM_{sx}. For specific hollow sections, the 8 Series tables also provide references to other tables (e.g. ϕM_b (for RHS only), ϕN_{cx} and ϕN_{cy}) to evaluate ϕM_{ix} and ϕM_{ox}.

8.3.2 Compression and Uniaxial Bending – about the minor principal y-axis

For a member subject to uniaxial bending about the minor principal y-axis and axial compression, the following condition must be satisfied:

$$M_y^* \leq \text{min.}\ [\phi M_{ry};\phi M_{iy}]$$

where ϕ = 0.9 (Table 3.4 of AS 4100)

M_y^* = design bending moment about the minor principal y-axis

ϕM_{ry} = design section moment capacity (ϕM_s) for bending about the minor principal y-axis reduced by axial force (see Section 8.3.2.1)

ϕM_{iy} = design in-plane member moment capacity (ϕM_i) for bending about the minor principal y-axis (see Section 8.3.2.2)

8.3.2.1 Section Capacity

The value of ϕM_{ry} must be determined at all points along the member and the minimum value is used to satisfy Section 8.3.2:

$$\phi M_{ry} = \phi M_{sy}\left(1-\frac{N^*}{\phi N_s}\right) \qquad \text{(Clause 8.3.3 of AS 4100)}$$

Alternatively, for RHS and SHS to AS 1163, which are compact about the y-axis subject to bending and compression:

$$\phi M_{ry} = 1.18\phi M_{sy}\left(1-\frac{N^*}{\phi N_s}\right) \leq \phi M_{sy} \qquad \text{(Clause 8.3.3 of AS 4100)}$$

8.3.2.2 Member Capacity

This section only applies to members analysed using an elastic method of analysis. For bending about the minor principal y-axis only the in-plane requirements need to be satisfied.

(a) In-plane capacity

$$\phi M_{iy} = \phi M_{sy}\left(1-\frac{N^*}{\phi N_{cy}}\right) \qquad \text{(Clause 8.4.2.2 of AS 4100)}$$

For braced and sway members, the above value of ϕN_{cy} is calculated using an effective length factor (k_{ey}) equal to 1.0 (i.e. $L_{ey} = L$), unless a lower value of k_{ey} has been calculated for a braced member, provided that $N^* \leq \phi N_{cy}$ where the value of ϕN_{cy} in this inequality is calculated using the correct value of k_{ey}.

Clause 8.4.2.2 of AS 4100 also provides a higher tier method for evaluating M_i which is dependent on the ratio of the member's end bending moments. Due to the variable nature of these end bending moments, the further consideration of this higher tier method is beyond the scope of this publication.

8.3.2.3 Tables

For RHS, Tables 8-3 to 8-4 list ϕM_{sy}, ϕN_s and ϕM_{ry}. Designers should evaluate $n = N^*/\phi N_s$, then use it to calculate the value of ϕM_{ry} and ensure that it is **less than or equal to** the design section capacity ϕM_{sy}. For specific hollow sections, the 8 Series tables also provide references to other tables (e.g. ϕN_{cy}) to evaluate ϕM_{iy}.

8.3.3 Compression and Biaxial Bending

For a member subject to biaxial bending and axial compression, both the conditions defined in Sections 8.3.3.1 and 8.3.3.2 must be satisfied.

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8.3.3.1 Section Capacity

$$\frac{N^*}{\phi N_s}+\frac{M_x^*}{\phi M_{sx}}+\frac{M_y^*}{\phi M_{sy}} \leq 1 \qquad \text{(Clause 8.3.4 of AS 4100)}$$

Alternatively, for RHS and SHS to AS 1163, which are compact about both the x- and y-axes:

$$\left(\frac{M_x^*}{\phi M_{rx}}\right)^{\gamma} + \left(\frac{M_y^*}{\phi M_{ry}}\right)^{\gamma} \leq 1 \qquad \text{(Clause 8.3.4 of AS 4100)}$$

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

ϕM_{rx} and ϕM_{ry} are calculated using the alternatives presented in Sections 8.3.1.1 and 8.3.2.1.

8.3.3.2 Member Capacity

$$\left(\frac{M_x^*}{\phi M_{cx}}\right)^{1.4} + \left(\frac{M_y^*}{\phi M_{iy}}\right)^{1.4} \leq 1 \qquad \text{(Clause 8.4.5.1 of AS 4100)}$$

where ϕM_{cx} = *lesser* of ϕM_{ix} and ϕM_{ox} (see Section 8.3.1.2)

and ϕM_{iy} is calculated using the alternative presented in Section 8.3.2.2.

8.3.3.3 Tables

For RHS, Tables 8-3 to 8-4 list ϕN_s, ϕM_{sx} and ϕM_{sy}. For SHS, Tables 8-5 and 8-6 list these parameters as ϕN_s and ϕM_s as do Tables 8-1 to 8-2 for CHS. As noted in Sections 8.3.1.3 and 8.3.2.3, the parameters ϕM_{rx}, ϕM_{ry}, ϕM_{ix}, ϕM_{iy} and ϕM_{oy} can also be calculated from these tables.

8.4 Combined Bending and Axial Tension

In this section:

ϕ = 0.9 (Table 3.4 of AS 4100)

ϕM_{sx} = design section moment capacity for bending about the major principal x-axis

ϕM_{sy} = design section moment capacity for bending about the minor principal y-axis

N^* = design axial tension force

ϕN_t = design section capacity in axial tension

8.4.1 Tension and Uniaxial Bending – about the major principal x-axis

For a member subject to uniaxial bending about the major principal x-axis and axial tension, the following conditions must be satisfied:

$M_x^* \leq \min. [\phi M_{rx}; \phi M_{ox}]$

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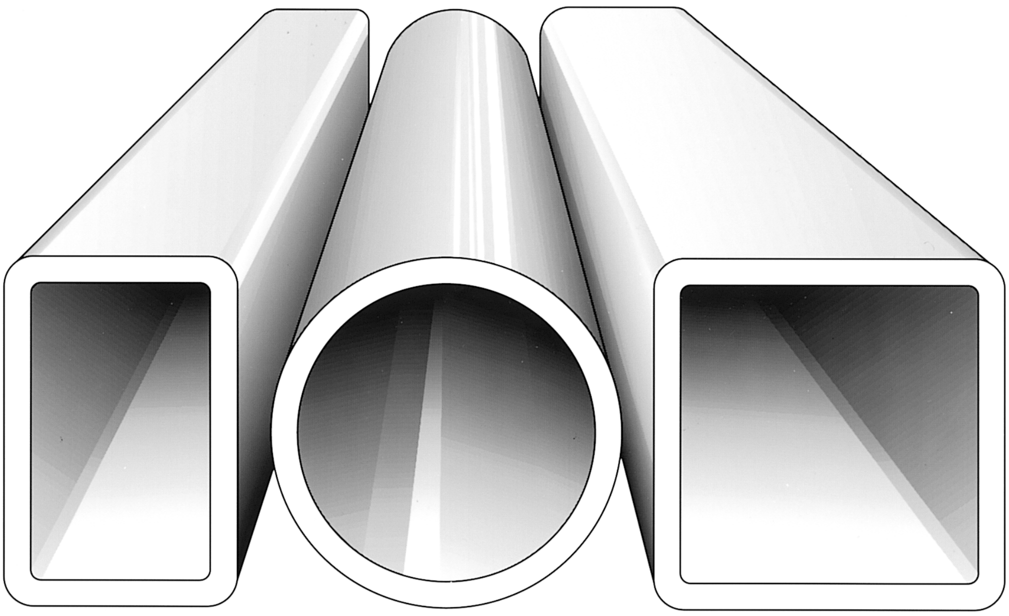

Volume 2: Hollow Sections

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CHS - Grade C250/C350 (to AS 1163)

RHS - Grade C350/C450 (to AS 1163)

SHS - Grade C350/C450 (to AS 1163)

LIMIT STATES EDITION TO AS 4100-1998 $S^* \leq \phi R_u$

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