PART 5 MEMBERS SUBJECT TO BENDING

5.1 Maximum Design Loads for Beams with Full Lateral Restraint Subject to Uniformly Distributed Loading

NOTE: BEAM SELF WEIGHT: For Tables 5.1-1 to 5.1-6, the self-weight of the beam has NOT been deducted. The designer must include the self-weight as part of the dead load when determining the maximum design load or W_L^* or W_S^*.

Tables 5.1-1 to 5.1-6 give values of the maximum design loads for single-span simply-supported beams with full lateral restraint subject to uniformly distributed loads as shown in Figure 5.1.

Designers should assess maximum design loads for the strength and serviceability limit states separately as different load combinations apply to these cases (AS 1170).

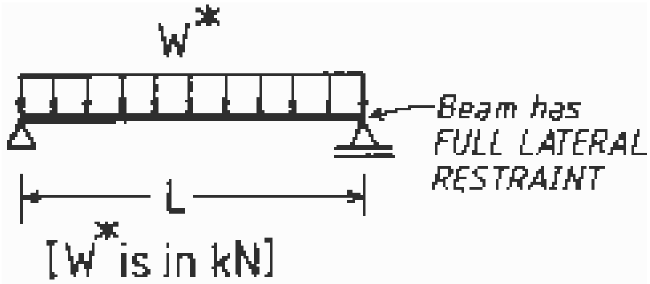

Figure 5.1 Beam configuration

Tables 5.1-1 to 5.1-6 also list the maximum segment length for full lateral restraint (FLR) for each section type loaded and configured as noted in Figure 5.1.

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5.1.1 Strength Limit State Design

For the beam configuration shown in Figure 5.1, the maximum strength limit state design load (W_L^*) is the *lesser* of the maximum design load (W_{L1}^*) associated with the design section moment capacity (ϕM_{sx}) and the maximum design load (W_{L2}^*) associated with the design shear capacity (ϕV_v).

The designer must ensure that the strength limit state design load (W^*) is less than or equal to the maximum design load W_L^*, i.e.

$$W^* \leq W_L^*$$

where $W_L^* = [W_{L1}^*; W_{L2}^*]$.

W_{L1}^* and W_{L2}^* are listed in the (A) series tables of the 5.1 Table Series – i.e. Tables 5.1-1 to 5.1-6. The (A) series tables in this instance consider the *strength* limit state. For a specific group of hollow sections, each respective (A) series table is immediately followed by a (B) series table which consider the *serviceability* limit state – see Section 5.1.2 below.

For the beam configuration shown in Figure 5.1, the strength of the beam is not controlled by the interaction of bending moment and shear force (Clause 5.12 of AS 4100). An example of the use of these tables is given in Section 5.1.6.

5.1.1.1 W_{L1}^*-based on Design Moment Capacity

The derivation of the design section moment capacity (ϕM_s) is given in Section 5.2.2.1 and listed in Tables 5.2-1 to 5.2-4 for RHS/SHS and Tables 8.1-1 to 8.1-6 for all hollow sections (including CHS).

For a single-span simply-supported beam subject to uniformly distributed loading (see Figure 5.1), the maximum design bending moment (M_{max}) is given by:

$$M_{max} = \frac{WL}{8}$$

where W = total load on the beam
L = length of the beam.

The design moment capacity for the beam in Figure 5.1 is ϕM_{sx}. Therefore, substituting ϕM_{sx} for M_{max}, and rearranging the above equation gives:

$$W^*_{L1} = \frac{8\phi M_{sx}}{L}$$

where W^*_{L1} is the *Maximum Design Load* based on the design moment capacity of the beam.

5.1.1.2 W^*_{L2} – based on Design Shear Capacity

The derivation of the design shear capacity (ϕV_v) is given in Section 5.2.2.4 and listed in Tables 5.2-1 to 5.2-4 for RHS/SHS and Tables 8.1-1 to 8.1-6 for all hollow sections (including CHS).

For a single-span simply-supported beam subject to uniformly distributed loading (see Figure 5.1), the maximum design shear force (V_{max}) is given by:

$$V_{max} = \frac{W}{2}$$

Therefore, substituting for ϕV_v for V_{max} and rearranging the equation gives:

$$W^*_{L2} = 2\phi V_v$$

where W^*_{L2} is the *Maximum Design Load* based on the design shear capacity of the beam.

5.1.2 Serviceability Limit State Design

The value of serviceability load (W^*_S) given in the tables is the *lesser* of the maximum design load (W^*_{S1}) which will achieve a **calculated total elastic deflection** of $L/250$ (where L is the span of the beam) and the load at which first yield occurs (W^*_{YL}). An example of the use of these tables is given in Section 5.1.6.

5.1.2.1 W^*_{S1} -based on a Deflection Limit of L / 250

The maximum *elastic* deflection (Δ_{max}) of the beam shown in Figure 5.1 is given by:

$$\Delta_{max} = \frac{5WL^3}{384EI_x}$$

where $E = 200 \times 10^3$ MPa

I_x = second moment of area about the major principal x-axis.

Therefore, substituting $\Delta_{max} = L/250$ and rearranging the equation gives the maximum design load for serviceability based on deflection (W^*_{S1}):

$$W^*_{S1} = \frac{384EI_x}{1250L^2}$$

For deflection limits other than $L/250$, the value of the maximum design load based on another deflection limit (W^*_{S2}) may be calculated by using the principle outlined above.

5.1.2.2 W^*_{YL} - based on First Yield Load

The load at which first yield occurs in the member is given by:

$$W^*_{YL} = \frac{8Z_{xmin}f_y}{L}$$

5.1.3 Full Lateral Restraint

Full lateral restraint may be achieved for a beam by: (a) continuous lateral restraint (Clause 5.3.2.2 of AS 4100), or (b) full, partial or lateral restraint provided at sufficient locations along the beam (Clauses 5.3.2.3 and 5.3.2.4 of AS 4100). The distance between the locations in (b) is termed the segment length and the maximum value of segment length to maintain the full lateral restraint condition is generally noted as "FLR".

FLR values are not shown in the Tables for CHS and SHS as these sections are not considered to be susceptible to flexural-torsional buckling. However, FLR are given in Tables 5.1-3 and 5.1-4 as they consider RHS bending about the major principal axis and these sections may, in some instances, be subject to flexural-torsional buckling.

Formulae for calculating FLR are given in Clause 5.3.2.4 of AS 4100 and Section 5.2.2.2. For the beam configuration shown in Figure 5.1, the ratio β_m is equal to -0.8.

5.1.4 Additional Design Checks

Where loads are transmitted into the webs at supports or at load points, the capacity of the web to resist such forces should be checked in accordance with Section 5.2.2.5, and the values of the web capacities listed in Tables 5.2-1 to 5.2-4.

5.1.5 Other Load Conditions

The values given in Tables 5.1-1 to 5.1-6 are for single-span, simply-supported beams subject to uniformly distributed loads (Figure 5.1). However, the information presented in these tables may be used for beams with full lateral restraint and other loading situations using the equivalent uniform design loads given in Table T5.1 and the following procedure:

(1) Calculate the equivalent uniformly distributed maximum design load for moment (W^*_{EM}) using Table T5.1.

(2) Based on W^*_{EM} select a section with an adequate maximum design load (W^*_{L1}) associated with the design moment capacity from Tables 5.1-1 to 5.1-6.

(3) Calculate the equivalent uniformly distributed maximum design load for shear (W^*_{EV}) using Table T5.1.

(4) Check that the section selected in (2) has an adequate maximum design load (W^*_{L2}) associated with the design shear capacity to resist W^*_{EV}. If not, select a new section size which can resist W^*_{EV}.

(5) Check shear and bending interaction in accordance with Section 5.2.4. A check is not necessary if $V^* < 0.6\phi V_v$ or $M^* < 0.75\phi M_s$.

(6) Calculate the equivalent uniformly distributed serviceability (W^*_{ES}) from Table T5.1.

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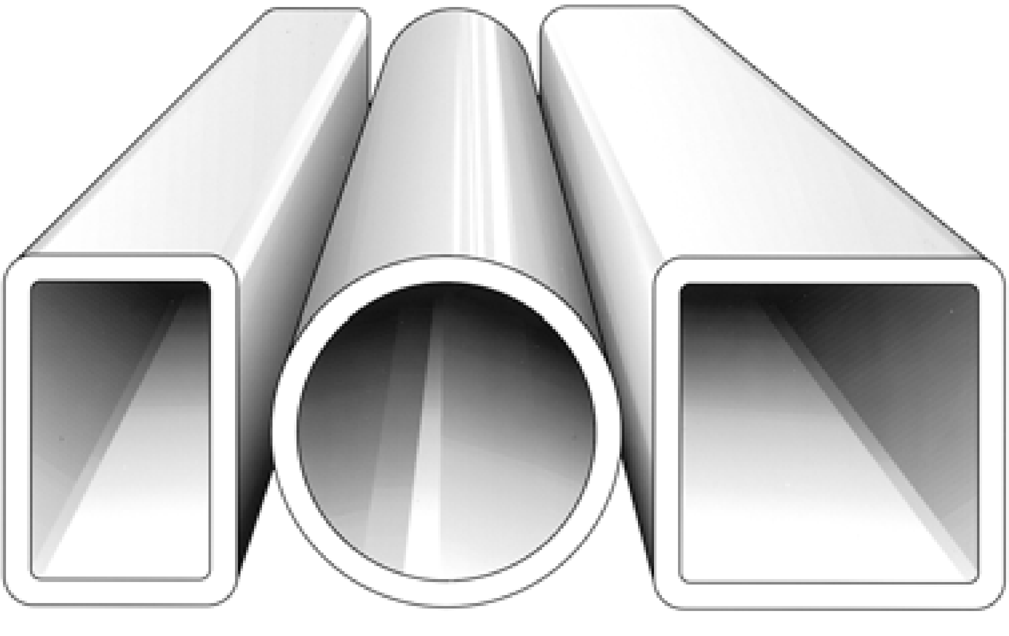

Volume 2: Hollow Sections

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CHS - Grade C250/C350 (to AS 1163)

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SHS - Grade C350/C450 (to AS 1163)

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

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TABLES

NOTE: SEE SECTION 2.1 FOR THE SPECIFIC MATERAL STANDARD (AS 1163) REFERRED TO BY THE SECTION TYPE AND STEEL GRADE IN THESE TABLES