PART 5 MEMBERS SUBJECT TO BENDING

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

Tables 5.1-1 to 5.1-12 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 for both the strength and serviceability limit states.

Designers should assess maximum design loads for the strength and serviceability limit states separately as different load combinations apply to these cases (AS 1170 Part 0)

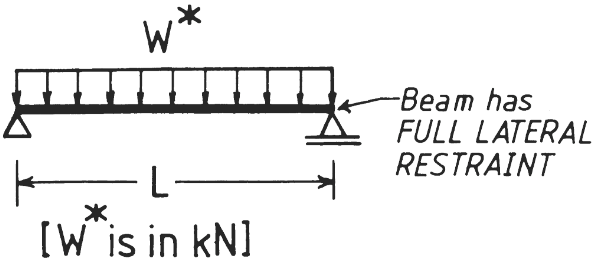

Figure 5.1: Beam configuration

NOTE: BEAM SELF WEIGHT: For Tables 5.1-1 to 5.1-12, 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 W_L^* or W_S^*.

Tables 5.1-1 to 5.1-12 also list the maximum segment length for full lateral restraint (FLR) required to be achieved for each section type loaded and configured as noted in Figure 5.1.

Examples of the use of these tables is given in Section 5.1.6.

For angles subject to bending, reference should be made to Part 8 of this publication.

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 section 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 $W_L^* = \text{min.}\ [W_{L1}^*; W_{L2}^*]$.

W_{L1}^* and W_{L2}^* are listed in **bold** within the first row of entries for each open section in Tables 5.1-1 to 5.1-12.

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).

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 values of ϕM_S are listed in Tables 5.2-1 to 5.2-10.

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:

$$M_{max} = \frac{W^*L}{8}$$

where W^* = total design load on the beam, including beam self weight, at the strength limit state

L = span of the beam.

The design section 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 section 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) for a section is given in Section 5.2.2.4 and values of ϕV_v are listed in Tables 5.2-1 to 5.2-10.

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

For the beam configuration shown in Figure 5.1, the value of maximum serviceability limit state design 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}), i.e.

$$W^*_S = \min\,[W^*_{S1}\ ;W^*_{YL}]$$

W^*_S is listed in *italics* within the second row of entries for each open section in Tables 5.1-1 to 5.1-12. Serviceability loads which are governed by yielding are shaded in these Tables.

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 Δ_{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 method given above but using the new limit.

5.1.2.2 W_{YL}^{*} – based on First Yield Load

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

$$W_{YL}^{*} = \frac{8Z_{x\min}f_y}{L} \quad \text{since} \quad \frac{W^{*}L}{8Z_{x\min}} \leq f_y$$

Where: f_y = yield stress of section flange

$Z_{x,\ min}$ = minimum section modulus about major principal x-axis

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 denoted as "FLR" in the Tables.

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 FLR values are listed in Tables 5.1-1 to 5.1-12, having been derived using the ratio β_m equal to -0.8. (applies for segments with transverse loads)

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 5.2-10.

5.1.5 Other Load Conditions

The values given in Tables 5.1-1 to 5.1-12 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 section moment capacity from Tables 5.1-1 to 5.1-12.

(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 design load (W_{ES}^{*}) from Table T5.1.

(7) Check that the section selected in (4) has an adequate maximum serviceability design load (W_S^{*}) to resist W_{ES}^{*}. If not, select a new section size which can resist W_{ES}^{*}.

(6) and (7) only work if first yield does not control if it does an extra check is needed

The above procedure is shown in Example *2* of Section 5.1.6.