Next $\lambda = L_E/r_y$, where $L_E = 1.0L$ in this instance from Table 5.6; L is the distance between restraints; and $r_y = 4.23$ cm from section tables, that is 4.23×10 mm. Thus

$$\lambda = \frac{L_E}{r_y} = \frac{1.0 \times 4000}{4.23 \times 10} = 94.56$$

Here $x = 30.9$ from section tables. Therefore $\lambda/x = 94.56/30.9 = 3.06$, and so $v = 0.91$ from Table 5.7.

Finally, therefore,

$$\lambda_{LT} = nuv\lambda = 0.782 \times 0.877 \times 0.91 \times 94.56 = 59$$

Using the values of p_y and λ_{LT}, $p_b = 215.6\ \text{N/mm}^2$ by interpolation from Table 5.5. In conclusion,

$$M_b = p_b S_x = 215.6 \times 1830 \times 10^3 = 394.5 \times 10^6\ \text{N mm} = 394.5\ \text{kN m} > 380\ \text{kN m}$$

Thus $\bar{M} < M_b$, and therefore the lateral torsional buckling resistance of the section is adequate.

Adopt 457 × 191 × 82 kg/m UB.

The M_{cx} and M_b values that we have calculated may be compared with those tabulated by the Steel Construction Institute for a 457 × 191 × 82 kg/m UB. From Table 5.9, $M_{cx} = 503$ kN m, and $M_b = 389$ kN m when n is 0.8 and the effective length is 4.0.

Laterally unrestrained beams, conservative approach

The suitability of laterally unrestrained UB, UC and RSJ sections may be checked, if desired, using a conservative approach. It should be appreciated that being conservative the design will not be as economic as that given by the rigorous approach; consequently beam sections that are proved to be adequate using the rigorous approach may occasionally prove inadequate using the conservative approach. However, it does have the advantage that members either loaded or unloaded between restraints are checked using one expression.

In the conservative approach the maximum moment M_x occurring between lateral restraints must not exceed the buckling resistance moment M_b:

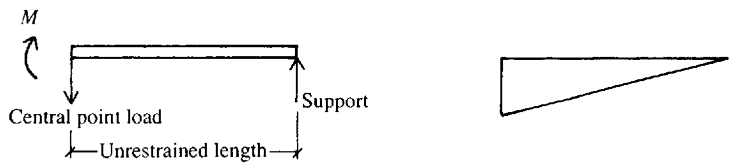
$$M_x \leqslant M_b$$

The buckling resistance moment is given by the expression

$$M_b = p_b S_x$$

For the conservative approach, p_b is obtained from the appropriate part of Table 19a–d of BS 5950 in relation to λ and x, the choice depending on the design strength p_y of the steel.

Loads occurring between restraints may be taken into account by multiplying the effective length by a slenderness correction factor n obtained either from BS 5950 Table 13 (reproduced earlier as Table 5.8) or alternatively from BS 5950 Table 20, except for destabilizing loads when it should be taken as 1.0. It is important to understand that the reactions shown on the diagrams in Table 20 are the lateral restraints and not just the beam supports. Therefore for a simply supported beam with a central point load providing lateral restraint, the relevant Table 20 diagram would be as shown in Figure 5.15. The corresponding value of n would then be 0.77.



(a) Portion of beam between lateral restraints

(b) Corresponding bending moment diagram

Figure 5.15 *Conservative approach slenderness correction factor diagrams for a simply supported beam restrained at mid-span*

Thus the minor axis slenderness ratio is given by

$$\lambda = \frac{nL_E}{r_y}$$

where n is the slenderness correction factor either from BS 5950 Table 13 or Table 20, L_E is the effective unrestrained length of the beam, and r_y is the radius of gyration of the section about its minor axis, found from section tables. The torsional index x of the section is taken from section tables.

For those who are familiar with BS 449, this approach is similar to the use of Table 3 in that standard, which was related to the l/r and D/T ratios of the section.

Example 5.4

Check the beam section selected in Example 5.3, using the conservative approach.

The maximum ultimate moment $M_x = 380$ kN n at midspan. Check 457 × 191 × 82 kg/m UB ($S_x = 1830\,\text{cm}^3$). $T = 16$ mm; hence $p_y = 275\,\text{N/mm}^2$. Thus

$$M_{cx} = p_y S_x = 275 \times 1830 \times 10^3 = 503.25 \times 10^6\,\text{N mm} = 503.25\,\text{kN m} > 380\,\text{kN m}$$

This is satisfactory:

Check lateral torsional buckling, that is show

$$M_x \leqslant M_b = p_b S_x$$

For the conservative approach, p_b is obtained from BS 5950 Table 19b when p_y is 275 N/mm², using λ and x. The slenderness correction factor n obtained from BS 5950 Table 20 is 0.77. Then

$$\lambda = \frac{nL_E}{r_y} = \frac{0.77 \times 4000}{4.23 \times 10} = 72.8$$

Now $x = 30.9$. Thus $p_b = 210\,\text{N/mm}^2$ by interpolation from BS 5950 Table 19b. So

$$M_b = p_b S_x = 210 \times 1830 \times 10^3 = 384.3 \times 10^6\,\text{N mm} = 384.3\,\text{kN m} > 380\,\text{kN m}$$

Therefore $M_x < M_b$, and so the lateral torsional buckling resistance of the section is adequate.