5.12.2 Design summary for axially loaded steel columns

The general procedure for the design of axially loaded columns, using grade 43 UC sections, may be summarized as follows:

(a) Calculate the ultimate axial load F applied to the column.
(b) Determine the effective length L_E from the guidance given in Table 5.10.
(c) Select a trial section.
(d) Calculate the slenderness λ from L_E/r and ensure that it is not greater than 180.
(e) Using the slenderness λ and steel design strength p_y, obtain the compression strength p_c of the column from Table 27a–d of BS 5950.
(f) Calculate the compression resistance P_c of the column from the expression $P_c = A_g p_c$, where A_g is the gross sectional area of the column.
(g) Finally, check that the compression resistance P_c is equal to or greater than the ultimate axial load F.

Example 5.11

Design a suitable grade 43 UC column to support the ultimate axial load shown in Figure 5.31. The column is restrained in position at both ends but not restrained in direction.

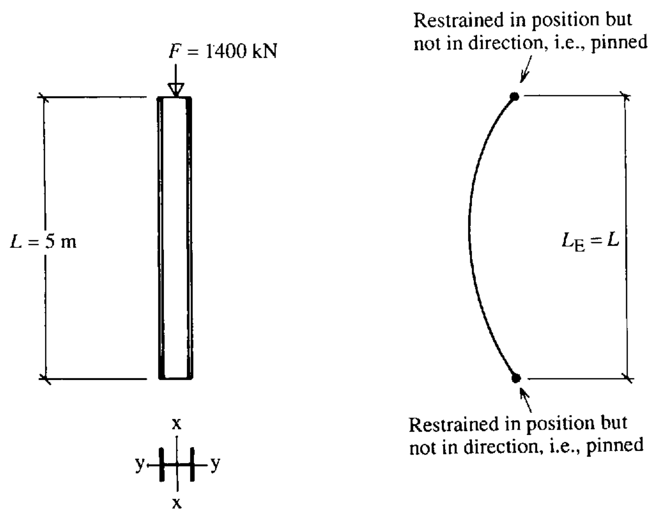

Figure 5.31 *Column load and effective lengths*

Ultimate axial load $F = 1400\,\text{kN}$

Effective length $L_E = 1.0L = 5000\,\text{mm}$

It is first necessary to assume a trial section for checking: try 203 × 203 × 86 kg/m UC. The relevant properties from section tables are as follows:

Flange thickness $T = 20.5\,\text{mm}$

Area $A_g = 110\,\text{cm}^2 = 110 \times 10^2\,\text{mm}^2$

Radius of gyration $r_x = 9.27\,\text{cm} = 92.7\,\text{mm}$

Radius of gyration $r_y = 5.32\,\text{cm} = 53.2\,\text{mm}$

It has already been stated that all UC sections when acting as columns are classified as semi-compact; therefore it is unnecessary to show that the section is not slender.

The ultimate design strength p_y for grade 43 steel sections, from Table 5.1, is $275\,\text{N/mm}^2$ provided that the flange thickness does not exceed 16 mm. If the flange thickness is greater than 16 mm then p_y reduces to $265\,\text{N/mm}^2$. In this case $T = 20.5\,\text{mm} > 16\,\text{mm}$, and therefore $p_y = 265\,\text{N/mm}^2$.

The slenderness values are given by

$$\lambda_x = \frac{L_{Ex}}{r_x} = \frac{5000}{92.7} = 54 < 180$$

$$\lambda_y = \frac{L_{Ey}}{r_y} = \frac{5000}{53.2} = 94 < 180$$

These are satisfactory.

The relevant BS 5950 strut table to use may be determined from Table 5.11. For buckling about the x–x axis use Table 27b; for buckling about the y–y axis use Table 27c. Hence

For $\lambda_x = 54$ and $p_y = 265\,\text{N/mm}^2$: $p_c = 223\,\text{N/mm}^2$

For $\lambda_y = 94$ and $p_y = 265\,\text{N/mm}^2$: $p_c = 133\,\text{N/mm}^2$

Therefore p_c for design is $133\,\text{N/mm}^2$.

The compression resistance is given by

$$P_c = A_g p_c = 110 \times 10^2 \times 133 = 1\,463\,000\,\text{N} = 1463\,\text{kN} > 1400\,\text{kN}$$

That is, $P_c > F$. Thus:

Adopt 203 × 203 × 86 kg/m UC.

The *Steelwork Design Guide to BS 5950* produced by the Steel Construction Institute contains tables giving resistances and capacities for grade 43 UCs subject to both axial load and bending. A typical example for a number of UC sections is reproduced here as Table 5.12. From the table it may be seen that for the 203 × 203 × 86 kg/m UC section that has just been checked, the relevant axial capacity P_{cy} is given as 1460 kN. This again shows the advantage of such tables for reducing the amount of calculation needed to verify a section.

Example 5.12

If a tie beam were to be introduced at the mid-height of the column in Example 5.11, as shown in Figure 5.32, determine a suitable grade 43 UC section.

Ultimate axial load $F = 1400\,\text{kN}$

By introducing a tie at mid-height on either side of the y–y axis, the section is effectively pinned at mid-height and hence the effective height about the y–y axis