where

- b overall section dimension perpendicular to y–y axis
- b' effective depth perpendicular to y–y axis
- h overall section dimension perpendicular to x–x axis
- h' effective depth perpendicular to x–x axis
- M_x bending moment about x–x axis
- M_y bending moment about y–y axis
- β coefficient obtained from BS 8110 Part 1 Table 3.24, reproduced here as Table 3.16

Table 3.16 Values of the coefficient β (BS 8110 Part 1 1985 Table 3.24)

N/bhf_{cu}	0	0.1	0.2	0.3	0.4	0.5	≥0.6
β	1.00	0.88	0.77	0.65	0.53	0.42	0.30

Having established the increased moment about one of the column axes, the section can then be designed for the combination of vertical load and bending.

Design charts for the design of symmetrically reinforced columns subject to vertical loads and bending are presented in BS 8110 Part 3. There is a separate chart for each grade of concrete combined with HY reinforcement and individual d/h ratios. The area of reinforcement can be found from the appropriate chart using the N/bh and M/bh^2 ratios for the column section being designed. Chart 38 is reproduced here as Figure 3.47.

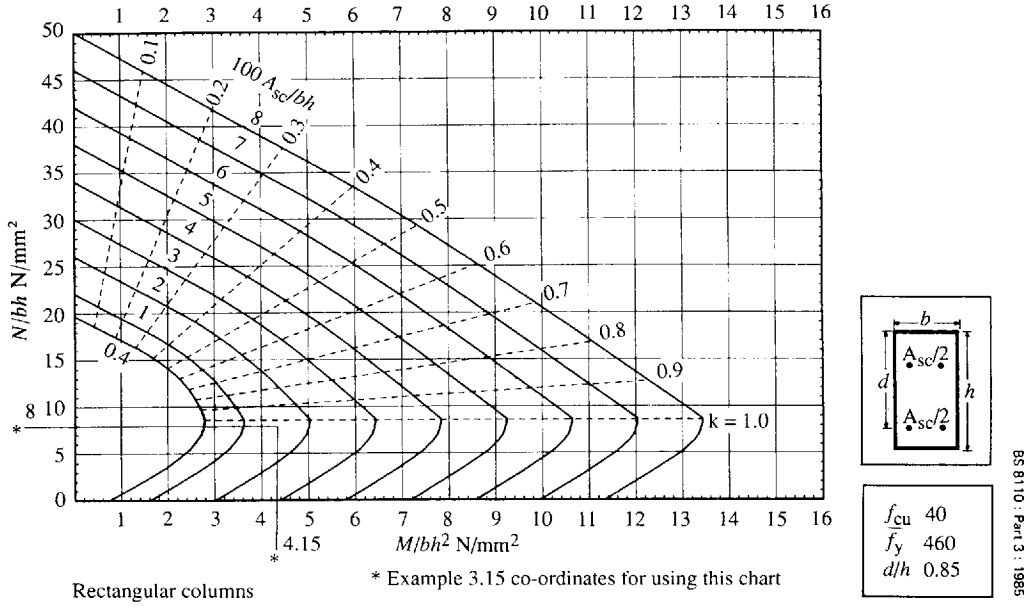

Figure 3.47 *BS 8110 Part 3 Chart 38 for rectangular column design*

3.11.7 Shear ULS

Axially loaded columns are not subjected to shear and therefore no check is necessary.

Rectangular columns subjected to vertical loading and bending do not need to be checked for shear when the ratio of the moment to the vertical load M/N is less than $0.75h$. However, this is only provided that the shear stress does not exceed the lesser of $0.8\sqrt{f_{cu}}$ or $5\,N/mm^2$; if it does, the size of the column section would have to be increased.

3.11.8 Cracking SLS

Since cracks are produced by flexure of the concrete, short columns that support axial loads alone do not require checking for cracking. Furthermore, it is advised in BS 8110 that cracks due to bending are unlikely to occur in columns designed to support ultimate axial loads greater than $0.2f_{cu}A_c$. All other columns subject to bending should be considered as beams for the purpose of examining the cracking SLS.

3.11.9 Lateral deflection

No deflection check is necessary for short braced columns. When for other types of column the deflection needs to be checked, reference should be made to Section 3 of BS 8110 Part 2 for guidance.

3.11.10 Design summary for concrete columns

The design procedure for short braced concrete columns may be summarized as follows:

(a) Ensure that the column satisfies the requirements for braced columns.
(b) Ensure that the column is a short column by reference to its slenderness ratio.
(c) (i) If the column is axially loaded, design for the compressive ULS using BS 8110 equation 38.
    (ii) If the column supports an approximately symmetrical arrangement of beams, design for the compressive ULS using BS 8110 equation 39.
    (iii) If the column is subjected to either uniaxial or biaxial bending, design for the combined ULS of compression and bending by reference to BS 8110 Part 3 design charts.
(d) Check shear ULS for columns subjected to vertical loading and bending. No check is necessary for axially loaded columns.
(e) Check cracking SLS for columns subjected to vertical loading and bending. No check is necessary for axially loaded columns.

Let us now look at some examples on the design of short braced columns.