Example 3.10

A reinforced concrete slab is subjected to an ultimate moment M_u of 45 kN m per metre width, inclusive of its self-weight. The overall thickness of the slab is to be 200 mm, and 16 mm diameter main reinforcing bars are to be used. Using the simplified stress block formulae given in BS 8110 Part 1, check the adequacy of the slab thickness and determine the spacing for the main bars together with the size and spacing of the distribution bars for the following conditions:

Grade 40 concrete and mild steel reinforcement

Grade 35 concrete and high yield reinforcement

A 1 m width of slab will be considered for design purposes, as shown in Figure 3.27.

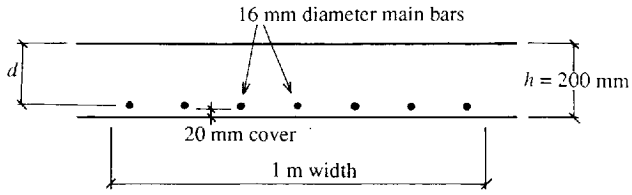

Figure 3.27 *Cross-section through slab considered for design*

First,

Effective depth d = overall depth h − (bar diameter/2) − cover = 200 − 8 − 20 = 172 mm

Grade 40 concrete, MS reinforcement

Grade 40 concrete $f_{cu} = 40\ \text{N/mm}^2$

MS reinforcement $f_y = 240\ \text{N/mm}^2$

Ultimate bending moment $M_u = 45\ \text{kN m} = 45 \times 10^6\ \text{N mm}$

Use the BS 8110 simplified stress block formulae. First,

$$K = \frac{M}{bd^2 f_{cu}} = \frac{45 \times 10^6}{1000 \times 172^2 \times 40} = 0.038 < K' = 0.156$$

Therefore compression reinforcement is not necessary and the slab thickness is adequate.

The area of main tensile reinforcement required can now be calculated. The lever arm is given by

$$z = d[0.5 + \sqrt{(0.25 - K/0.9)}] = d[0.5 + \sqrt{(0.25 - 0.038/0.9)}] = 0.956d$$

But the lever arm depth must not be taken as greater than $0.95d$; therefore this limiting value will be used to calculate the area of tensile reinforcement required. Thus

$$A_s \text{ required} = \frac{M}{0.87 f_y z} = \frac{45 \times 10^6}{0.87 \times 250 \times 0.95 \times 172} = 1266\ \text{mm}^2 \text{ per metre width}$$

This area can be compared with the reinforcement areas given in Table 3.13 to enable suitable centres to be chosen for the 16 mm diameter bars specified:

Provide 16 mm diameter MS main bars at 150 mm centres (A_s per metre = 1340 mm^2).

The area of distribution reinforcement may now be determined. For mild steel reinforcement the minimum area to be provided is 0.24 per cent of the gross cross-sectional area of the slab. Therefore

$$\text{Minimum area required} = \frac{0.24}{100} \times 1000 \times 200 = 480\,\text{mm}^2 \text{ per metre run}$$

Hence by reference to Table 3.13:

Provide 10 mm diameter MS distribution bars at 150 mm centres (A_s per metre = 524 mm^2)

Check the maximum bar spacing needed to satisfy the cracking SLS. The overall depth $h = 200\,\text{mm} \not> 250\,\text{mm}$ for MS reinforcement; therefore the clear distance between bars should not exceed the lesser of $3d$ or 750 mm. Hence the maximum clear distance between bars is $3 \times 172 = 516$ mm. Both the main and distribution bar spacing provided is therefore satisfactory.

Grade 35 concrete, HY reinforcement

Grade 35 concrete $f_{cu} = 35\,\text{N/mm}^2$

HY reinforcement $f_y = 460\,\text{N/mm}^2$

$$K = \frac{45 \times 10^6}{1000 \times 172^2 \times 35} = 0.043 < K' = 0.156$$

$$z = d[0.5 + \sqrt{(0.25 - 0.043/0.9)}] = 0.95d \not> 0.95d$$

$$A_s \text{ required} = \frac{45 \times 10^6}{0.87 \times 460 \times 0.95 \times 172} = 688\,\text{mm}^2 \text{ per metre width}$$

Provide 16 mm diameter HY main bars at 275 mm centres (A_s per metre = 731 mm^2).

The minimum area of HY distribution reinforcement to be provided is 0.13 per cent of the gross cross-sectional area of the slab. Therefore

$$\text{Minimum area required} = \frac{0.13}{100} \times 1000 \times 200 = 260\,\text{mm}^2 \text{ per metre run}$$

Provide 10 mm diameter HY distribution bars at 300 centres (A_s per metre = 262 mm^2).

Check the maximum bar spacing needed to satisfy the cracking SLS. The overall depth $h = 200\,\text{mm} \not> 200\,\text{mm}$ for HY reinforcement; therefore the clear distance between bars should again not exceed the lesser of $3d$ or 750 mm. Hence the maximum clear distance between bars will again be 516 mm, and therefore the spacing of both the main and distribution bars is satisfactory.