Example 3.11

A 250 mm thick simply supported reinforced concrete slab spans 5 m. Design a suitable slab using grade 40 concrete and high yield reinforcement to support the following characteristic loads:

Imposed 4.0 kN/m^2
Finishes 0.5 kN/m^2
Concrete 24 kN/m^3

The slab will be in a mild exposure situation.

Consider a 1 m width of slab as shown in Figure 3.28. In this example it is necessary first to calculate the ultimate design load and ultimate bending moment.

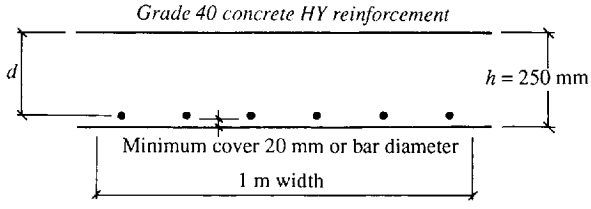

Figure 3.28 *Cross-section through slab considered for design*

Loading

Characteristic imposed load = 4 kN/m^2

Characteristic imposed UDL $Q_k = 4 \times 5 \times 1 = 20$ kN

Characteristic dead load:	finishes	0.5
	self-weight 24×0.25	6.0
	total	6.5 kN/m^2

Characteristic dead UDL $G_k = 6.5 \times 5 \times 1 = 32.5$ kN

ULS imposed	UDL $\gamma_f Q_k = 1.6 \times 20$	32.0 kN
ULS dead	UDL $\gamma_f G_k = 1.4 \times 32.5$	45.5 kN
ULS total	UDL	77.5 kN

The slab load diagram is shown in Figure 3.29.

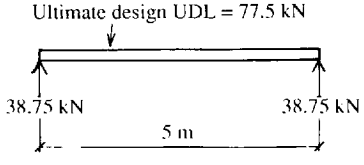

Figure 3.29 *Slab load diagram*

Bending

$$M_u = \frac{WL}{8} = \frac{77.5 \times 5}{8} = 48.44\,\text{kN m} = 48.44 \times 10^6\,\text{N mm}$$

Use the BS 8110 simplified stress block formulae. First,

$$K = \frac{M}{bd^2 f_{cu}} \leqslant K' = 0.156$$

Let us assume that 12 mm diameter main bars will be used with a cover of 20 mm. Hence the effective depth provided is

$$d = 250 - 20 - \frac{12}{2} = 224\,\text{mm}$$

Therefore

$$K = \frac{48.44 \times 10^6}{1000 \times 224^2 \times 40} = 0.024 < K' = 0.156$$

$$z = d[0.5 + \sqrt{(0.25 - K/0.9)}]$$
$$= d[0.5 + \sqrt{(0.25 - 0.024/0.9)}] = 0.97d > 0.95d$$

Therefore use $0.95d$. Next,

$$A_s \text{ required} = \frac{M}{0.87 f_y z} = \frac{48.44 \times 10^6}{0.87 \times 460 \times 0.95 \times 224} = 569\,\text{mm}^2 \text{ per metre width}$$

Provide 12 mm diameter HY main bars at 175 mm centres (A_s per metre = 646 mm^2).

$$\text{Minimum area of distribution steel} = \frac{0.13}{100} \times 1000 \times 250 = 325\,\text{mm}^2 \text{ per metre run.}$$

Provide 10 mm diameter HY distribution bars at 225 mm centres (A_s per metre = 349 mm^2).

Cracking

Check the maximum bar spacing needed to satisfy the cracking SLS. The overall depth $h = 250 > 200$ mm for HY reinforcement. However, the percentage of main reinforcement provided is not greater than 0.3 per cent:

$$\frac{100A_s}{bd} = \frac{100 \times 646}{1000 \times 224} = 0.288 < 0.3 \text{ per cent}$$

Therefore the clear distance between bars should not exceed the lesser of $3d = 3 \times 224 = 672$ mm or 750 mm. Therefore both the main and distribution bar spacing provided is satisfactory.

Shear

Check the shear ULS. The ultimate design shear force (at support) is

$$V = \frac{\text{ultimate UDL}}{2} = \frac{77.5}{2} = 38.75\,\text{kN}$$