Effective depth d	350
Diameter of lower bars	25
Diameter of links assumed	10
Cover, mild exposure assumed	25
Overall beam depth h	410 mm

Provide a 410 mm × 250 mm grade 30 concrete beam. Check percentage steel content:

$$\text{Steel content} = \frac{2416}{410 \times 250} \times 100 = 2.35 > 0.24 < 4 \text{ per cent}$$

The beam is adequate for the bending ULS.

Grade 35 concrete, HY reinforcement

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

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

$M_u = 140\,\text{kN m} = 140 \times 10^6\,\text{N mm}$

$$d \text{ required} = \sqrt{\left(\frac{M}{0.156bf_{cu}}\right)} = \sqrt{\left(\frac{140 \times 10^6}{0.156 \times 250 \times 35}\right)} = 320.25\,\text{mm:} \quad \text{use } 325\,\text{mm}$$

$$A_s \text{ required} = \frac{M}{0.87f_y 0.777d} = \frac{140 \times 10^6}{0.87 \times 460 \times 0.777 \times 325} = 1385\,\text{mm}^2$$

Provide three 25 mm diameter HY bars ($A_s = 1474\,\text{mm}^2$).

Determine the beam depth (see Figure 3.10):

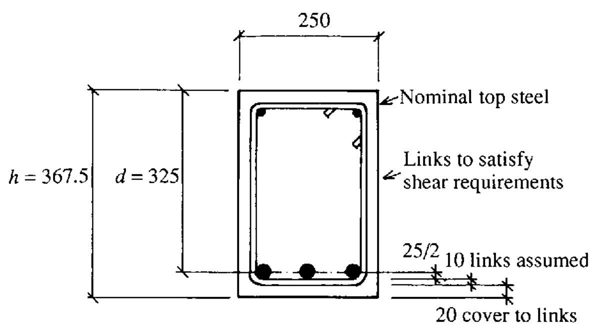

Figure 3.10 *Beam cross-section: grade 35 concrete, HY reinforcement*

Effective depth d	325
Main bar diameter/2	12.5
Diameter of links assumed	10
Cover, mild exposure assumed	20
Overall beam depth h	367.5 mm

Provide a 370 mm × 250 mm grade 35 concrete beam. Check percentage steel content:

$$\text{Steel content} = \frac{1474}{370 \times 250} \times 100 = 1.59 > 0.13 < 4 \text{ per cent}$$

The beam is adequate for the bending ULS.

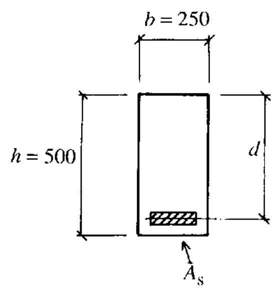

Figure 3.11 *Beam cross-section*

Example 3.6

A reinforced concrete beam with an effective span of 7 m is 500 mm deep overall by 250 mm wide. It supports a characteristic imposed load of 9 kN per metre run and a characteristic dead load of 11 kN per metre run in addition to the load due to the beam self-weight, which may be taken as 24 kN/m^3. Using the simplified stress block formulae given in BS 8110 Part 1, check that the beam depth is adequate. Choose suitable tension reinforcement if the steel has a yield stress of 460 N/mm^2 and the concrete is grade 30.

The beam cross-section is shown in Figure 3.11.

First let us ensure that the slenderness limits for beams are satisfied to avoid lateral buckling. Maximum distance between lateral restraints is the lesser of

$$60b_c = 60 \times 250 = 15\,000 \text{ mm} = 15 \text{ m}$$

$$250\frac{b_c^2}{d} = \frac{250 \times 250^2}{500} = 31\,250 \text{ mm} = 31.25 \text{ m}$$

These are both greater than the 7 m effective span of the beam and therefore the slenderness limits are satisified.

Now let us calculate the ultimate design load and the ultimate bending moment:

Characteristic imposed Q_k UDL = 9 kN/m = 9 × 7 = 63 kN

Characteristic dead G_k UDL = 11 kN/m = 11 × 7 = 77 kN

Characteristic own weight G_k UDL = 24 × 7 × 0.5 × 0.25 = 21 kN

ULS imposed	UDL = $(\gamma_f Q_k)$ = 1.6 × 63 =	100.8 kN
ULS dead	UDL = $(\gamma_f G_k)$ = 1.4 × 77 =	107.8 kN
ULS self-weight	UDL = $(\gamma_f \text{SW})$ = 1.4 × 21 =	29.4 kN
ULS total	UDL =	238 kN

The beam load diagram is shown in Figure 3.12. Thus

$$M_u = \frac{WL}{8} = \frac{238 \times 7}{8} = 208.25 \text{ kN m} = 208.25 \times 10^6 \text{ N mm}$$

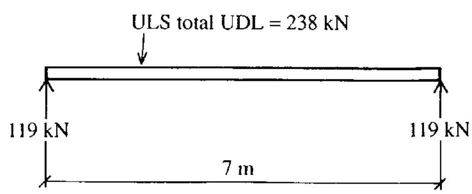

Figure 3.12 *Beam load diagram*