Example 1.5

A series of reinforced concrete beams at 5 m centres span 7.5 m on to reinforced concrete columns 3.5 m high as shown in Figure 1.13. The beams, which are 400 mm deep by 250 mm wide, carry a 175 mm thick reinforced concrete simply supported slab, and the columns are 250 mm by 250 mm in cross-section. If the floor imposed loading is 3 kN/m^2 and the weight of reinforced concrete is 2400 kg/m^3, calculate: the total UDL carried by a beam; the reactions transmitted to the columns; and the load transmitted to the column foundations.

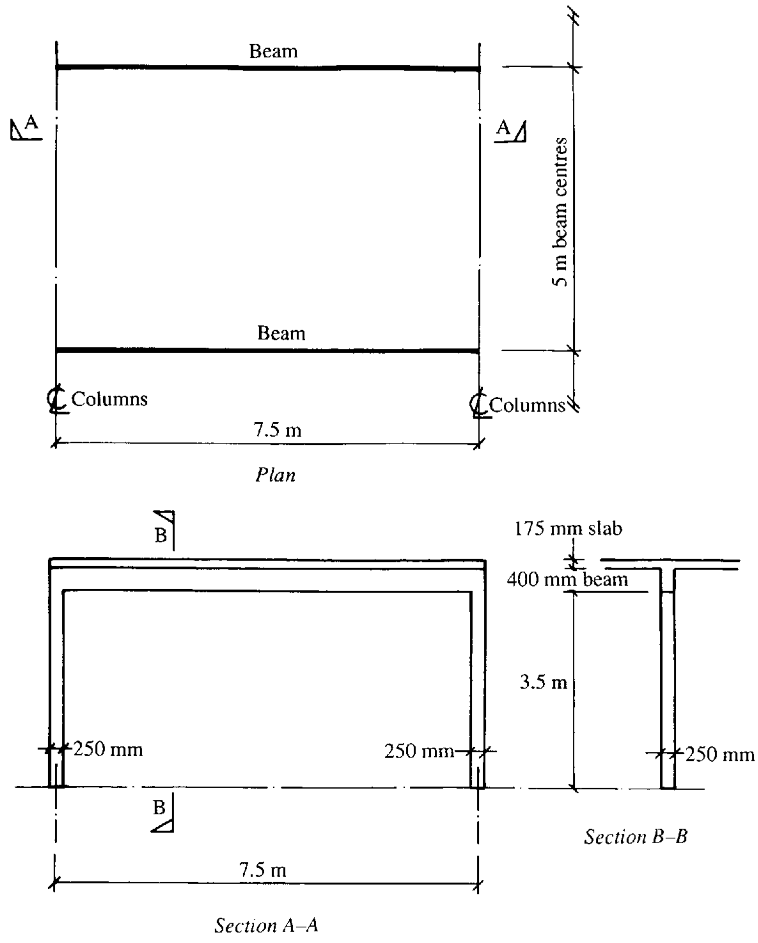

Figure 1.13 *Arrangement of beams and columns*

Combined floor loading: slab SW dead = (2400/100) × 0.175 = 4.2
imposed = 3.0
7.2 kN/m^2

Beam total UDL = UDL from slab + beam SW UDL

$$= (7.2 \times 7.5 \times 5) + (2400/100) \times 7.5 \times 0.4 \times 0.25$$

$$= 270 + 18 = 288 \text{ kN}$$

Beam reactions transmitted to columns = (total UDL)/2 = 288/2 = 144 kN

Column foundation load = beam reaction + column SW

$$= 144 + (2400/100) \times 3.5 \times 0.25 \times 0.25$$
$$= 144 + 5.25 = 149.25\,\text{kN}$$

1.4 Structural mechanics

Before the size of a structural element can be determined it is first necessary to know the forces, shears, bending moments and so on that act on that element. It is also necessary to know what influence these have on the stability of the element and how they can be resisted. Such information is obtained by reference to the principles of structural mechanics.

The reader should already be familiar with the principles of structural mechanics. However, two particular topics play a sufficiently important part in design to be repeated here. They are the theory of bending and the behaviour of compression members.

1.5 Theory of bending

The basic design procedure for beams conforms to a similar sequence irrespective of the beam material, and may be itemized as follows:

(a) Calculate the applied loads including the reactions and shear forces.
(b) Calculate the externally applied bending moments induced by the applied loads.
(c) Design the beam to resist the loads, shears, bending moments and resulting deflection in accordance with the guidelines appertaining to the particular beam material.

Item (a) allows a load diagram to be produced and also enables a shear force (SF) diagram to be drawn from which the maximum shear force can be determined.

The induced bending moments, item (b), can be derived from the SF diagram together with the location and magnitude of the maximum bending moment. This coincides with the point of zero shear, which is also known as the point of contraflexure. A bending moment (BM) diagram can then be drawn.

Formulae are given in various design manuals for calculating the maximum bending moments and deflections of simply supported beams carrying standard loading patterns such as a central point load, or equally spaced point loads, or a uniformly distributed load. The loading, shear force, bending moment and deflection diagrams for the two most common load conditions are illustrated together with the relevant formulae in Figure 1.14. That for a constant uniformly distributed load (UDL) is shown in Figure 1.14a and that for a central point load in Figure 1.14b. For unsymmetrical loading patterns the reactions, shear force, bending moment and deflection values have to be calculated from first principles using the laws of basic statics.