Example 2

A post-tensioned masonry beam (Fig. 11.6) of span 6m, simply supported, carries a characteristic superimposed dead load of 2kN/m and a characteristic live load of 3.5kN/m. The masonry characteristic strength f_k=19.2N/mm^2 at transfer and service, and the unit weight of masonry is 21kN/m^3. Design the beam for serviceability condition (γ_f=1).

Solution

$$f_{tc} = 0.5 \times 19.2 = 9.6 \text{ N/mm}^2$$

(clause 29.1, BS 5628: Part 2)

$$f_{cs} = 0.4 \times 19.2 = 7.68 \text{ N/mm}^2$$

(clause 29.2, BS 5628: Part 2)

$$f_{tt} = f_{ts} = 0$$

$$M_{d+L} \frac{(2 + 3.5) \times 6^2}{8} = 24.75 \text{ kN}$$

Assume M_i is 30% of M_{d+L} so

$$M_i = 0.3 \times 24.75 = 7.425 \text{kN m}$$

$$z_2 \geqslant \frac{(24.75 + 7.425) \times 10^6}{7.68 - 0} = 4.19 \times 10^6$$

(from equation (11.10))

$$z_1 \geqslant \frac{(24.75 + 7.425) \times 10^6}{0.8 \times 9.6} = 4.18 \times 10^6$$

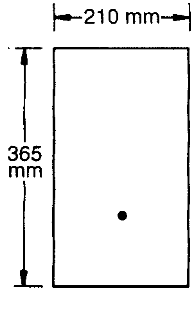

Fig. 11.6 Cross-section of the beam for example 2.

$$\text{loss ratio} = \alpha = \frac{\text{effective prestress}}{\text{prestress at transfer}} = 0.8 \quad \text{(assumed)}$$

Assume rectangular section

$$d = \left(\frac{4.19 \times 10^6 \times 6}{b}\right)^{1/2} = \left(\frac{4.19 \times 10^6 \times 6}{210}\right)^{1/2} = 346\,\text{mm}$$

Provide d=365 mm to take into account the thickness of a brick course. Correct value of M_i is

$$M_i = \frac{0.210 \times 0.365 \times 21 \times 6^2}{8} = 7.24\ \text{kN m} < 7.425 \quad \text{(assumed)}$$

For straight tendon,

$$e = z_2/A = bd^2/(6bd) = d/6 \quad \text{(from equation (11.16))}$$

$$= 365/6 = 60.83 \quad \text{(from equation (11.17))}$$

$$P = \frac{M_s A}{\alpha(z_1 + z_2)}$$

$$= \frac{(24.75 + 7.24) \times 10^6 \times 6}{0.8 \times 2 \times d}$$

$$= \frac{31.99 \times 10^6 \times 6}{0.8 \times 2 \times 365 \times 10^3} = 328.7\ \text{kN}$$

11.4 A GENERAL FLEXURAL THEORY

The behaviour of prestressed masonry beams at ultimate load is very similar to that of reinforced masonry beams discussed in Chapter 10. Hence, a similar approach as applied to reinforced masonry with a slight modification to find the ultimate flexural strength of a prestressed masonry beam is used. For all practical purposes, it is assumed that flexural failure will occur by crushing of the masonry at an ultimate strain of 0.0035, and the stress diagram for the compressive zone will correspond to the actual stress-strain curve of masonry up to failure.

Now, let us consider the prestressed masonry beam shown in Fig. 11.7(a). For equilibrium, the forces of compression and tension must be equal, hence

$$\lambda_1 f_m b d_c = A_{ps} f_{su} \qquad \text{or} \qquad f_{su} = \frac{\lambda_1 f_m b d_c}{A_{ps}} \tag{11.18}$$