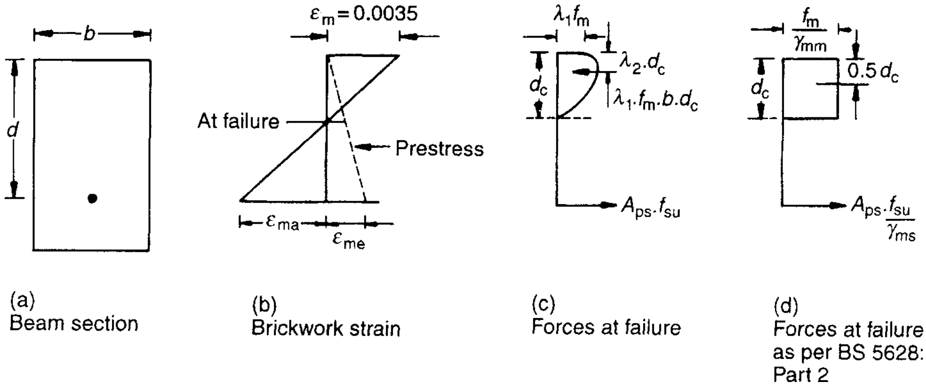

Fig. 11.7 The strain and stress block at failure of a prestressed masonry beam.

The ultimate strain ε_{su} in prestressing steel consists of strain due to prestress and applied load, hence

$$\varepsilon_{su} = \varepsilon_{sa} + \varepsilon_{se} \tag{11.19}$$

where ε_{sa} is due to applied load and ε_{se} is due to effective prestress after losses. From Fig. 11.7(b) it can be seen that strain due to the applied load is equal to

$$\varepsilon_{sa} = \varepsilon_{ma} + \varepsilon_{me}$$

where

$$\varepsilon_{me} = \frac{\text{prestressing stress at tendon level}}{E_m} \tag{11.20}$$

Assuming full bond exists between the steel, grout and masonry at failure, then the strain in steel may be given by

$$\varepsilon_{sa} = \varepsilon_m \left(\frac{d - d_c}{d_c} \right) + \varepsilon_{me} \tag{11.21}$$

Substituting the value of ε_{sa} from equation (11.21) into equation (11.19), we get

$$\varepsilon_{su} = \varepsilon_m \left(\frac{d - d_c}{d_c} \right) + \varepsilon_{me} + \varepsilon_{se}$$

or

$$d_c = \frac{\varepsilon_m}{\varepsilon_{su} + \varepsilon_m - \varepsilon_{me} - \varepsilon_{se}} d \tag{11.22}$$

Combining equations (11.18) and (11.22) gives

$$f_{su} = \frac{\lambda_1 f_m bd}{A_{ps}} \frac{\varepsilon_m}{\varepsilon_{su} + \varepsilon_m - \varepsilon_{me} - \varepsilon_{se}}$$

$$= \frac{\lambda_1 f_m}{\rho} \frac{\varepsilon_m}{\varepsilon_{su} + \varepsilon_m - \varepsilon_{me} - \varepsilon_{se}} \qquad (11.23)$$

At the ultimate limit state, the values of f_{su} and ε_{su} must satisfy equation (11.23) and also define a point on the stress-strain curve for the steel (see Fig. 2.7). Having found f_{su} and the tendon strain ε_{su}, the depth of the neutral axis d_c can be obtained from equation (11.22). The ultimate moment of resistance is then

$$M_u = A_{su} f_{su}(d - \lambda_2 d_c)$$

$$= A_{su} f_{su}\left(1 - \rho\frac{\lambda_2 f_{su}}{\lambda_1 f_m}\right)d \qquad (11.24)$$

Generally, an idealized stress block is used for design purposes. Figure 11.7(d) shows the rectangular stress block suggested in the British Code of Practice for prestressed masonry. The values of λ_1 and λ_2 corresponding to this stress block are 1 and 0.5.

The materials partial safety factors are γ_{mm} for masonry and γ_{ms} for steel. The general flexural theory given in this section can easily be modified to take account of these.

Example 3

A bonded post-tensioned masonry beam of rectangular cross-section 210×365 mm as shown in Fig. 11.8 has been prestressed to effective stress of 900 N/mm^2 by four 10.9 mm diameter stabilized strands of characteristic strength of 1700 N/mm^2. The area of steel provided is 288mm^2. The initial modulus of elasticity of the steel is 195 kN/mm^2 and the stress-strain relationship is given in Fig. 2.7. The masonry in 1:$\frac{1}{4}$:3 mortar has a characteristic strength parallel to the bed joint of 21N/mm^2 and modulus of elasticity 15.3kN/mm^2.

Using the simplified stress block of BS 5628: Part 2, calculate the ultimate moment of resistance of the beam.

Solution

We have

$$\text{area } A = 210 \times 365 = 76\,650\,\text{mm}^2$$

$$I = bd^3/12 = 210 \times (365)^3/12 = 8.5 \times 10^8\,\text{mm}^4$$

$$P_e = 900 \times 288 = 259.2 \times 10^3\,\text{N}$$