At service

$$\text{stress at top} \quad f_2 = \alpha\left(\frac{P}{A} - \frac{Pey_2}{I}\right) + \frac{M_s}{z_2} \leqslant f_{cs} \tag{11.3}$$

$$= \alpha(P/A - Pe/z_2) + M_s/z_2 \leqslant f_{cs}$$

and

$$\text{stress at bottom} \quad f_1 = \alpha\left(\frac{P}{A} + \frac{Pey_2}{I}\right) - \frac{M_s}{z_2} \geqslant f_{ts} \tag{11.4}$$

$$= \alpha(P/A + Pe/z_1) - M_s/z_1 \geqslant f_{ts}$$

From equations (11.1) and (11.3) we get

$$z_2 \geqslant \frac{M_s - \alpha M_i}{f_{cs} - \alpha f_{tt}} \tag{11.5}$$

$$z_1 \geqslant \frac{M_s - \alpha M_i}{\alpha f_{ct} - f_{ts}} \tag{11.6}$$

11.3.3 Critical sections

The conditions of equations (11.5) and (11.6) must be satisfied at the critical sections. In a post-tensioned, simply supported masonry beam with curved tendon profile, the maximum bending moment will occur at mid-span, at both transfer and service.

Assuming the values of bending moments M_s, M_{d+L} and M_i all are for mid-span, let

$$M_s = M_{d+L} + M_i \tag{11.7}$$

Substituting the value of M_s, equations (11.5) and (11.6) become *at transfer*

$$z_2 \geqslant \frac{M_{d+L} + (1-\alpha)M_i}{f_{cs} - \alpha f_{tt}} \tag{11.8}$$

$$z_1 \geqslant \frac{M_{d+L} + (1-\alpha)M_i}{\alpha f_{ct} - f_{ts}} \tag{11.9}$$

In prestressed or post-tensioned fully bonded beams with straight tendons the critical sections of the beam at transfer will be near the ends. At the end of the beam, moment M_i may be assumed to be zero.

Substituting the value of M_i in equations (11.5) and (11.6)

$$z_2 \geqslant \frac{M_{d+L} + M_i}{f_{cs} - \alpha f_{tt}} \tag{11.10}$$

$$z_1 \geqslant \frac{M_{d+L} + M_i}{\alpha f_{ct} - f_{ts}} \tag{11.11}$$

Depending on the chosen cable profiles, the values of z_1 and z_2 can be found from the equations (11.8) to (11.11).

Having found the values of z_1 and z_2 the values of prestressing force and the eccentricity can be found from equations (11.1) and (11.4) as

$$P_{\min} = \frac{[(M_s - \alpha M_i) + (z_1 f_{ts} + \alpha z_2 f_{tt})]A}{\alpha(z_1 + z_2)} \tag{11.12}$$

$$e_{\max} = \frac{z_2}{A} + \frac{M_i - z_2 f_{tt}}{P} \tag{11.13}$$

11.3.4 Permissible tendon zone

The prestressing force will be constant throughout the length of the beam, but the bending moment is variable. As the eccentricity was calculated from the critical section, where the bending moment was maximum, it is essential to reduce it at various sections of the beam to keep the tensile stresses within the permissible limit. Since the tensile stresses become the critical criteria, using equations (11.1) and (11.4), we get

$$e_1(\text{lower limit}) \leqslant \frac{z_2}{A} + \frac{M_i - z_2 f_{tt}}{P} \tag{11.14}$$

$$e_2(\text{upper limit}) \leqslant -\frac{z_1}{A} - \frac{M_s - z_1 f_{ts}}{\alpha P} \tag{11.15}$$

At present, in a prestressed masonry beam, no tension is allowed and since the bending moment due to self-weight will be zero at the end, the lower limit of eccentricity from equation (11.14) will become

$$e_1 \leqslant z_2 / A \tag{11.16}$$

where z_2 / A is the 'kern' limit.

In the case of a straight tendon this eccentricity will govern the value of prestressing force, and hence from equations (11.1) and (11.4), P can be obtained as

$$P = \frac{M_s A}{\alpha(z_1 + z_2)} \tag{11.17}$$