11.6 DEFLECTIONS

In the design of a prestressed member, both short- and long-term deflections need to be checked. The short-term deflection is due to the prestress, applied dead and live loads. The effect of creep increases the deflection in the long term, and hence this must be taken into consideration. The long-term deflection will result from creep under prestress and dead weight, i.e. permanent loads acting on the member plus the live load. If part of the live load is of a permanent nature, the effect of creep must be considered in the design. The deflections under service loading should not exceed the values given in the code of practice for a particular type of beam. The code, at present, does not allow any tension; hence the beam must remain uncracked. This makes deflection calculation much easier. However, the deflection of a prestressed beam after cracking and up to failure can be easily calculated by the rigorous method given elsewhere (Pedreschi and Sinha, 1985).

Example 4

The beam of example 3 is to be used as simply supported on a 6 m span. It carries a characteristic superimposed dead load of 2kN/m^2 and live load of 3.0 kN/m^2; 50% of the live load is of permanent nature. Calculate the short- and long-term deflection.

Solution

We have

$$\text{dead weight moment of the beam} = \frac{0.21 \times 0.365 \times 21 \times 6^2}{8} = 7.24\ \text{kN m}$$

$$\text{BM due to live + dead weight} = \frac{(2+3) \times 6^2}{8} = 22.5\ \text{kN}$$

$$\text{total applied moment} = 29.74\ \text{kN m}$$

$$\text{tensile stress} = 10^6 \times \frac{29.74 \times 6}{bd^2} = 10^6 \times \frac{29.74 \times 6}{210 \times (365)^2} = 6.38\ \text{N}/\text{mm}^2$$

$$\text{compressive stress due to effective prestress} = \frac{P_e}{A} + \frac{P_e e y}{I}$$

$$= \frac{259.2 \times 10^3}{210 \times 365} + \frac{259.2 \times 10^3 \times 182.5 \times 60}{210 \times (365)^3/12}$$

$$= 3.38 + 3.34 = 6.72\ \text{N}/\text{mm}^2 > 6.38\ \text{N}/\text{mm}^2$$

Hence the beam will remain uncracked.

The short-term deflection is calculated as follows.

$$\text{deflection due to prestress} = (-)\frac{ML^2}{8EI} = (-)\frac{P_e e L^2}{8EI} \quad \text{(hogging)}$$

$$= (-)\frac{259.2 \times 10^3 \times 60 \times 36 \times 10^6 \times 12}{8 \times 15.3 \times 10^3 \times 210 \times (365)^3} = (-)\ 5.38\ \text{mm}$$

Deflection due to self-weight+dead weight+50% live load, taking γ_f=1, is

$$\text{deflection due to loads} = +\frac{5\,wL^4}{384\,EI} \quad \text{(sagging)}$$

$$= +\frac{5 \times (1.61 + 1.5 + 2.0) \times (6000)^4 \times 12}{384 \times 15.3 \times 10^3 \times 210 \times (365)^3}$$

$$= 6.62 \quad \text{(sagging)}$$

deflection due to live load

$$= +\frac{5 \times 1.5 \times (6000)^4 \times 12}{384 \times 15.3 \times 10^3 \times 210 \times (365)^3} = 1.94 \quad \text{(sagging)}$$

Hence

short-term deflection=-5.38+6.62+1.94=3.18mm

The long-term deflection is given by

long-term deflection=(short-term deflection due to prestress +dead weight) (1+ϕ)+live load deflection

where ϕ is the creep factor from BS 5628: Part 2, ϕ=1.5. Hence

long-term deflection=(-5.38+6.62) (1+1.5)+1.94=5.04 mm.

11.7 LOSS OF PRESTRESS

The prestress which is applied initially is reduced due to immediate and long-term losses. The immediate loss takes place at transfer due to elastic shortening of the masonry, friction and slip of tendons during the anchorage. The long-term loss occurs over a period of time and may result from relaxation of tendons, creep, shrinkage and moisture movement of brickwork.

11.7.1 Elastic shortening

When the forces from the external anchorages are released on to the member to be prestressed, they cause elastic deformation, i.e. shortening of the masonry or surrounding concrete as the case may be. This will