NARSIMHA REDDY ENGINEERING COLLEGE
UGC AUTONOMOUS INSTITUTION
Maisammaguda (V), Kompally - 500100, Secunderabad, Telangana State, India
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Accredited by NBA & NAAC with 'A' Grade
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DEPARTMENT OF
CIVIL ENGINEERING

Lecture Notes
on
23CE703 - Prestressed Concrete

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UNIT II

Losses in Prestress

The initial prestressing concrete undergoes a gradual reduction with time from the stages of transfer due to various causes. This is generally defined as total “Loss of Prestress”. The various losses are explained below:

2.1 Types of losses in prestress

Pretensioning

1. Elastic deformation of concrete
2. Relaxation of stress in steel
3. Shrinkage of concrete
4. Creep of concrete

Post-tensioning

1. No loss due to elastic deformation if all wires are simultaneously tensioned. If the wires are successively tensioned, there will be loss of prestress due to elastic deformation of concrete.
2. Relaxation of stress in steel
3. Shrinkage of concrete
4. Creep of concrete
5. Friction
6. Anchorage slip

2.2 Loss due to elastic deformation of the concrete

The loss of prestress due to deformation of concrete depends on the modular ratio & the average stress in concrete at the level of steel.

f_c →Prestress in concrete at the level of steel

E_s →Modulus of elasticity of steel

E_c →Modulus of elasticity of concrete

α_e →Modular ratio

Strain in concrete at the level of steel $= \frac{f_c}{E_c}$

Stress in steel corresponding to this strain $= \frac{f_c}{E_c} E_s$

Therefore, Loss of stress in steel = $\alpha_e f_c$

If the initial stress in steel is known, the percentage loss of stress in steel due to elastic deformation of concrete can be computed.

2.3 Loss due to shrinkage of concrete

Factors affecting the shrinkage in concrete

1. The loss due to shrinkage of concrete results in shortening of tensioned wires & hence contributes to the loss of stress.
2. The shrinkage of concrete is influenced by the type of cement, aggregate & the method of curing used.
3. Use of high strength concrete with low water cement ratio results in reduction in shrinkage and consequent loss of prestress.
4. The primary cause of drying shrinkage is the progressive loss of water from concrete.
5. The rate of shrinkage is higher at the surface of the member.
6. The differential shrinkage between the interior surfaces of large member may result in strain gradients leading to surface cracking.

Hence, proper curing is essential to prevent cracks due to shrinkage in prestress members. In the case of pretensioned members, generally moist curing is restored in order to prevent shrinkage until the time of transfer. Consequently, the total residual shrinkage strain will be larger in pretensioned members after transfer of prestress in comparison with post-tensioned members, where a portion of shrinkage will have already taken place by the time of transfer of stress. This aspect has been considered in the recommendation made by the code (IS:1343) for the loss of prestress due to shrinkage of concrete and is obtained below:

$\varepsilon_{cs} \rightarrow$ Total residual shrinkage strain= 300×10^{-6} for pre-tensioning and

$$= \left[\frac{200 \times 10^{-6}}{\log_{10}(t+2)}\right] \text{for post-tensioning.}$$

Where,

$t \rightarrow$ Age of concrete at transfer in days.

Then, the loss of stress = $\varepsilon_{cs} E_s$

Here, $E_s \rightarrow$ Modulus of elasticity of steel

2.4 Loss due to creep of concrete

The sustained prestress in the concrete of a prestress member results in creep of concrete which is effectively reduces the stress in high tensile steel. The loss of stress in steel due to creep of concrete can be estimated if the magnitude of ultimate creep strain or creep- coefficient is known.

1. Ultimate Creep strain method

The loss of stress in steel due to creep of concrete = $\varepsilon_{cc} f_c E_s$

Where, $\varepsilon_{cc} \rightarrow$ Ultimate creep strain for a sustained unit stress.

$f_c \rightarrow$ Compressive stress in concrete at the level of steel

$E_s \rightarrow$ Modulus of elasticity of steel

2. Creep Coefficient Method

$$\text{Creep coefficient} = \frac{Creep\ \ strain}{Elastic\ \ strain} = \frac{\varepsilon_c}{\varepsilon_e}$$

$$\text{Therefore, loss of stress in steel} = \varepsilon_c E_s = \phi \varepsilon_e E_s = \phi\left(\frac{f_c}{E_c}\right) E_s = \phi f_c \alpha_e$$

Where, $\phi \rightarrow$ Creep Coefficient

$\varepsilon_c \rightarrow$ Creep strain

$\varepsilon_e \rightarrow$ Elastic strain

$\alpha_e \rightarrow$ Modular ratio

$f_c \rightarrow$ Stress in concrete

$E_c \rightarrow$ Modulus of elasticity of concrete

$E_s \rightarrow$ Modulus of elasticity of steel

The magnitude of creep coefficient varies depending upon the humidity, concrete quality, duration of applied loading and the age of concrete when loaded. The general value recommended varies from 1.5 for watery situation to 4.0 for dry conditions with a relative humidity of 35%.

2.5 Loss due to relaxation of stress in steel

Most of the codes provide for the loss of stress due to relaxation of steel as a percentage of initial stress in steel. The BIS recommends a value varying from 0 to 90 N/mm wires varying from

$0.5 f_{pu}$ to $0.8 f_{pu}$

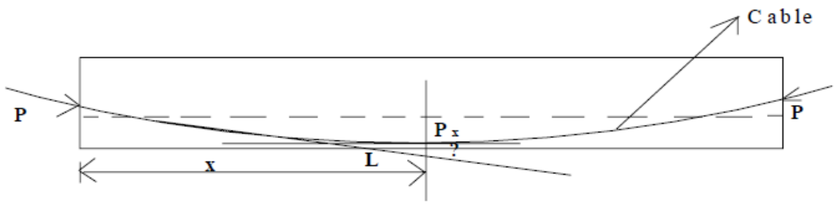
Where, $f_{pu} \rightarrow$ Characteristic strength of pre-stressing tendon.

2.6 Loss of stress due to friction

The magnitude of loss of stress due to friction is of following types: -

a. Loss due to curvature effect, which depends upon the tendon form or alignment, which generally follows a curved profile along the length of the beam.

b. Loss of stress due to wobble effect, which depends upon the local deviations in the alignment of the cable. The wobble or wave effect is the result of accidental or unavoidable misalignment, since ducts or sheaths cannot be perfectly located to follow a predetermined profile throughout the length of beam.



$$P_x = P_o e^{-(\mu\alpha + kx)}$$

Where ,

P_o= Prestressing force at the jacking end

μ = Coefficient of friction between cable and duct

α = cumulative angle in radians through the tangent to the cable profile has turned between any two points under consideration

k = Friction coefficient for wave effect.

The IS code recommends the following value for k

k = 0.15 per 100 m for normal condition

= 1.5 per 100 m for thin walled ducts where heavy vibration are encountered and in other adverse conditions.

If Δ = Slip of anchorage in mm

L= Length of the cable in mm

A = Cross- sectional area of the cable in mm

E_s= Modulus of elasticity of steel N/mm^2

P = Prestressing force in the cable in N

$\Delta = PL / A E_s$

Hence, Loss of stress due to anchorage slip = $\frac{P}{A} = \frac{E_s \Delta}{L}$;