"ASSIGNMENT"

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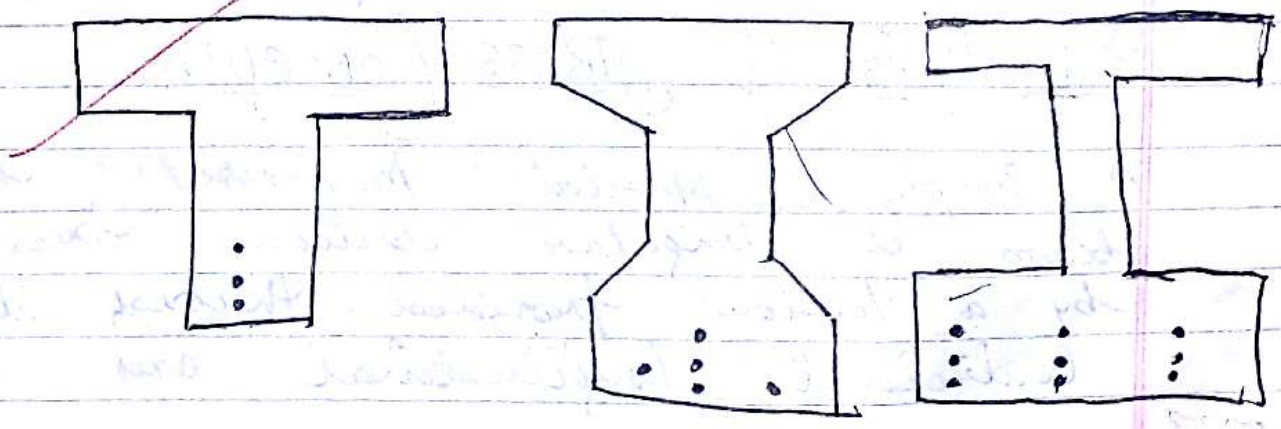
Topic:- PRESTRESSED CONCRETE

Introduction:-

A prestressed concrete member is a member of concrete in which internal stresses are introduced in a planned manner, so that the stresses resulting from the superimposed loads are counteracted to desired degree.

Concrete has high compressive strength as compared to its very low tensile strength which it not difficult to make concrete which can have a crushing strength of over 40N/mm² on 150mm cubes (after 28 days), it is very difficult to obtained a tensile strength greater than 2.5N/mm². This why concrete is reinforced with steel bars in such direction where tensile resistance has to be offered. In reinforced concrete member due to low tensile resistance of concrete, a large quantity of concrete steel is provided so that the entire tensile resistance is taken as offered by the reinforcement. The dimensions of the member may also have to be determined from diagonal



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A reinforced concrete member is also found to develop cracks even in the absence of loads, due to shrinkage of concrete in the hardening stage

In prestressed concrete member, all the above defects & weakness are made up. A very common aspect to be born in the mind of is that prestressed concrete member is essentially a concrete member. If only & the tendons (reinforcement) are considered as necessary. If stress can be introduced by external jacking, tensile stress consideration. In the case of long beams, where large shear force exist, the beam size have got to be large to limit the diagonal tensile stresses under certain limits, Prestresses diagonal tensile stresses & may even eliminate these stresses. This has led to adopt modified I. sections & T-sections.

General Principles:-

Analysis of Stress Concept:-

A simply supported prestressed concrete beam of rectangular section prestressed by a tendon provided through its centroidal longitudinal axis.

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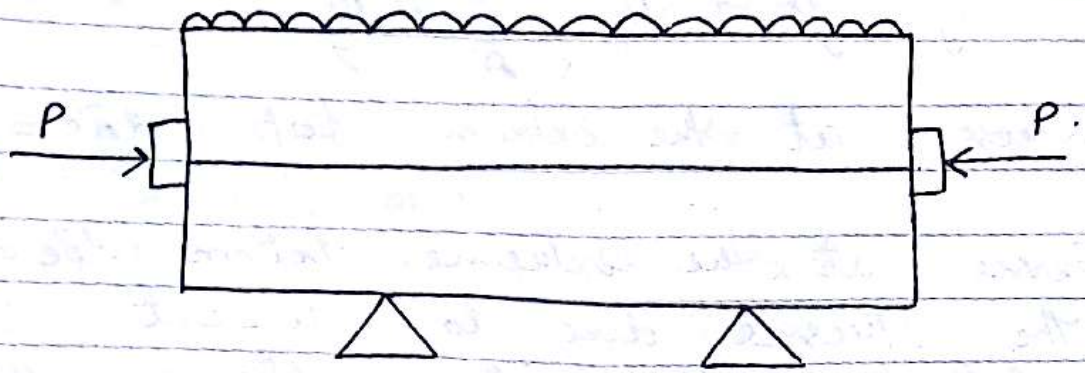
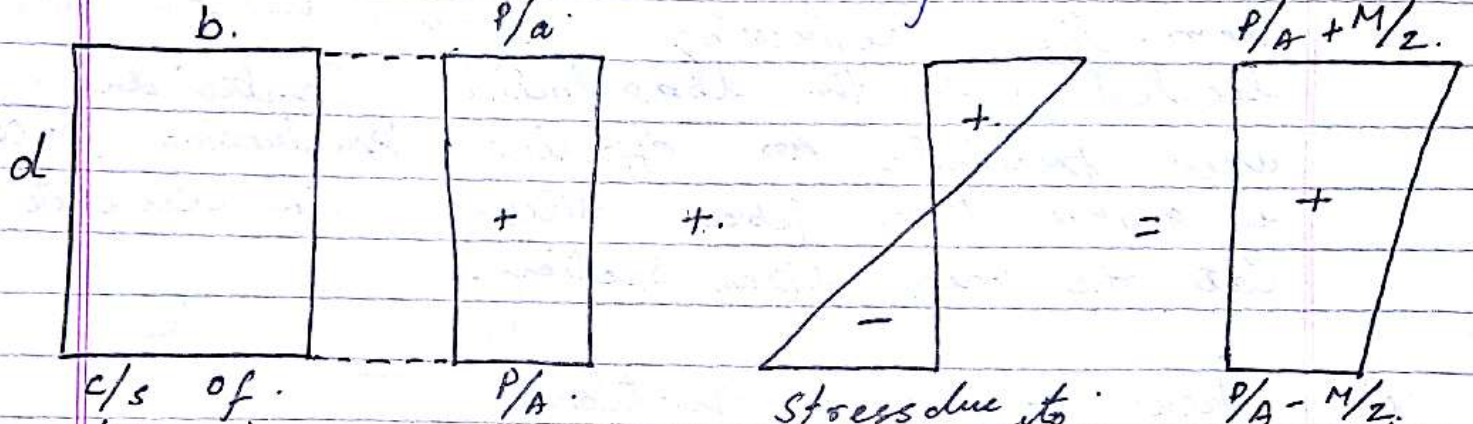


Let the beam be subjected to an external load system.

Let P be prestressing forces supplied by the tendon. Due to this, the compressive stresses induced in concrete, $f_a = P/A$ where A is the sectional area of member.



If due to the dead load & external loads, the bending moment at the section is M, then the extreme stresses at the section due to bending moment along

$$= f_a = \pm \frac{M}{Z}$$

where, Z is the section modulus of the beam section

Hence, the final extreme stresses on the beam section are given by,

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$$f = f_a \pm f_b = \frac{P}{A} \pm \frac{M}{Z}$$

Stress at the extreme top edge $= \frac{P}{A} + \frac{M}{Z}$

& stresses at the extreme bottom edge $= P/A - M/Z$

The Stresses due to direct load, bending and the final stresses are shown above.

Q: A Prestressed concrete beam 400mm x 600mm in section has a span of 6m & is subjected to uniformly distributed load of 16KN/m including the self wt. of the beam. The prestressing tendons which are located along the longitudinal Centroidal axis provide an effective prestressing force of 960KN. Det. fibre stresses in concrete at the mid span section.

Sol: Area of beam section

$= 400 \times 600 = 2.4 \times 10^5 \text{ mm}^2$

Section modulus $= Z = \frac{bd^2}{6} = \frac{400 \times 600^2}{6}$

$= 2.4 \times 10^7 \text{ mm}^3$.

Max. bending moment $M = \frac{16 \times 6^2}{8} = 72 \text{ KNm}$

Direct stress due to prestressing force

$= + \frac{P}{A} = + \frac{960 \times 10^3 \text{ N}}{24 \times 10^3 \text{ mm}^2} = 4 \text{ N/mm}^2$

Extreme Stress due to bending moment

$= \pm \frac{M}{Z} = \pm \frac{72 \times 10^6}{2.4 \times 10^7} = \pm 3 N/mm^2$

∴ final stresses in the extreme fibres will be as follows,

final stress in the extreme, top fibres
$= 4 - 3 = 1 N/mm^2$.

METHODS OF PRE-STRESSING :-

The main methods of prestressing are given below:

1. Pre-tensioning.
2. Post-tensioning.

Pre-tensioning System :-

In pretensioning, the tendons are first tensioned b/w rigid anchor blocks cast on the ground or in the column or unit mould type pretensioning bed, prior to the casting of concrete in the moulds. A typical column type pretensioning bed shown below. The tendons comprising of individual wires or strands are stretched with constant eccentricity as shown in fig(a) or variable eccentricity as shown in fig(b) with tendons anchorage at one end jacks at the other. With the forms in place, the concrete is cast around the stressed tendon High early strength concrete is often

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used in factory to facilitate early stripping & reuse of moulds. When the concrete attains sufficient strength, the jacking pressure is released. The high tensile wires tend to shorten but are checked by the bond b/w concrete & steel. In this way the prestress is transferred to concrete by the bond, mostly near the ends of the beam & no special anchorages are required in prestressed members.

For mass production of pretensioned elements, the long-line process developed by Hoyer is generally used in a factory. In this method the tendons are stretched b/w two bulk heads several hundred metres apart so that a no. of similar units may be caste along the same group of tensioned wires. The tension is applied by hydraulic jacks or by a moveable stressing when tensioned singly or in groups are generally anchored to the abutments by steel wedges. The transfer of prestress to concrete is usually achieved by large hydraulic or screw jacks by which all the wires are simultaneously released after the concrete attains the requisite compressive strength.

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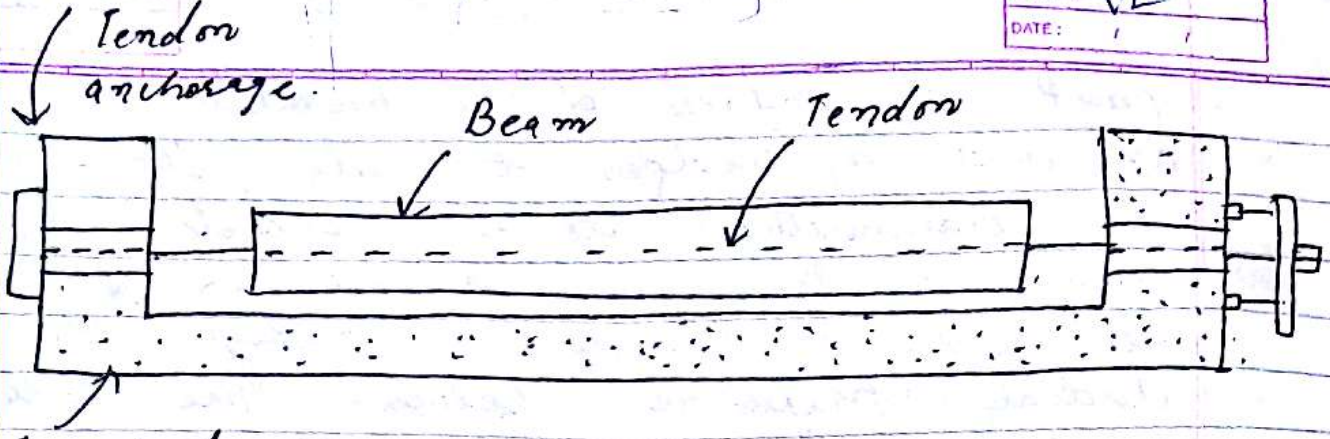
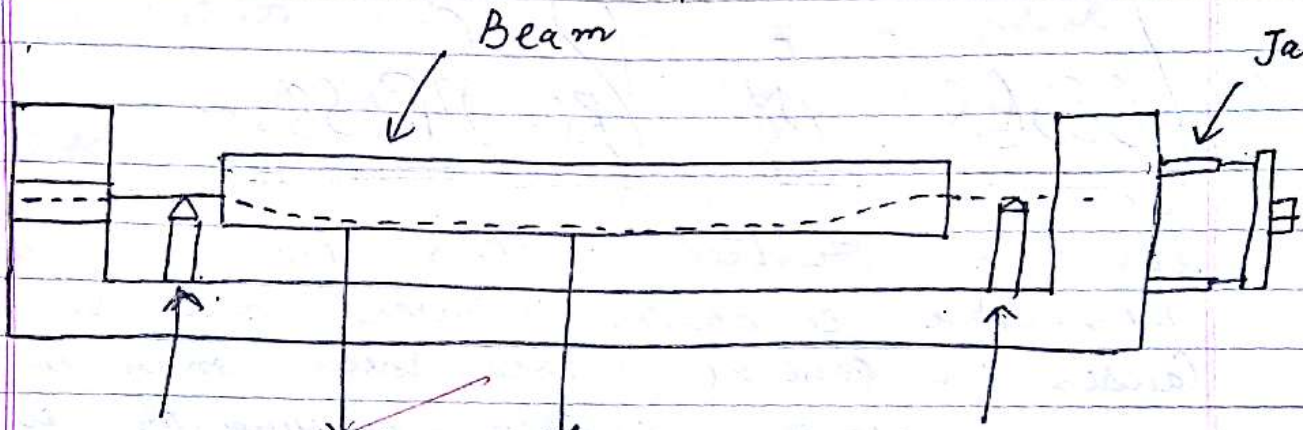


a) Beam with straight tendon



b) Beam with Variable eccentricity.

Post-tensioning Systems:-

In post tensioning concrete units are first cast by incorporating ducts or grooves to the tendons, when the concrete attains sufficient strength, the high tensile wires are tensioned by means of jack bearing

on the end face of the member & anchored by wedges or nuts. The forces are transmitted to the concrete by means of the end anchorages & when the cable is curved, through the radial pressure between the cable & the duct. The space b/w the Tendons and duct is generally grouted after the tensioning operation.

LOSSES IN PRE-STRESS:-

Losses of prestress takes place in a prestressed concrete member due to many causes. In general these losses may be as,

1). Loss of prestress during the tensioning process.

2. Loss of prestress at the end anchoring stage.

3. Losses occuring subsequently.

(1) Loss of Prestress during the tensioning process due to friction:-

There always exist a certain

amount of friction in the jacking & anchoring system & on the wall of the duct where the wires fan out at the anchorages with the result, the actual stress in the tendon is less than what is indicated by the pressure gauge. The losses due to friction in the jack & at the anchorages are difficult for different system of prestressing. The properties of these systems have recommended suitable loss coefficients which may be adapted.

Considerable frictional loss takes place due to friction may be the tendons & material surrounding it namely the concrete sheating. This loss due to friction may be classified into

1. Loss due to length effect.
2. Loss due to Curvature effect.

2. Loss of Prestress Due to friction:-

This loss is due to the fact that the anchorage fixtures themselves are subjected to a stretch. It is also possible that the friction wedges holding the wires may slip a little. The amount of this slip may be taken on the average as 0.75mm. But in case of direct bearing anchorages the slip may be on the average only 0.75mm. This loss of stress is of importance in post tensioned beams.

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The loss due to deformation slip etc given by

$$\Delta f_s = \frac{\Delta_a E_s}{L}$$

where Δ_a = Effective slip
E_s = Young's modulus for tendon
L = Length of tendon.

Loss due to slip in anchorage is of special importance with short members & the necessary additional elongation may be provided for at the time of tensioning to compensate for this loss.

3. Loss of Prestress Occuring Subsequent

The losses which occur subsequently to prestressing are the following

1. Loss of Stress due to Shrinkage of Concrete
2. Loss of stress due to Creep of Concrete.
3. Loss of Stress due to elastic shortening of Concrete.
4. Loss of stress due to Creep of Steel.

The first three types of losses mentioned above takes place due to reduction in the length of concrete resulting in the reduction of initial extension

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of steel.

The loss of stress due to elastic shortening of concrete is max. in pretensioned members. In the case of pretensioned members these losses occures only when a no. of cables are progressively stressed one after the another.

Q:- A prestressed concrete beam 250mm wide & 360mm deep has a span of 12m. The beam is prestressed by steel wires of area 350mm^2 provided at a uniform eccentricity of 60mm with an initial prestress of 1250N/mm^2. Det. the percentage loss of stress in the wires.

a. If beam is a pretensioned beam.

b. If " " " post " " .

Take $E = 210 KN/mm^2$, $E_c = 35 KN/mm^2$

Ultimate creep strain $= 45 \times 10^{-6} KN/mm^2 = 22 \times 10^{-6} KN/mm^2$

Shrinkage of concrete $= 300 \times 10^{-6}$ for pretensioned beam

Shrinkage of concrete $= 215 \times 10^{-6}$ for post tensioned beam

Relaxation of steel stress = 5% of initial stress

Anchoriage slip = 1.25mm, friction coefficient for wave effect $K = 0.0015/m$

Sol: Area of beam section $A = 250 \times 360 = 9 \times 10^4 mm^4$

Moment of Inertia of the beam section

$$I = \frac{250 \times 360^3}{12} = 9.72 \times 10^8 mm^4.$$

Initial prestressing force $P_o = 350 \times 1250$

$= 437500 N$

$= 437.5 KN.$

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Modular ratio $m = \frac{210}{35} = 6$

Stress in Concrete at the level of steel

$$= \frac{P_o}{A} + \frac{P_o e^2}{I}$$

$$= \frac{43.75 \times 10^3}{9 \times 10^4} + \frac{437.5 \times 10^3 \times 60^2}{9.72 \times 10^8} = 4.86 + 1.62$$

$$= 6.48 N/mm^2$$

Thus losses of stress due to pre-tensi beam are calculated below.

Pre-tensioned Beam:

1. Loss of stress due to elastic shortening of Concrete =

$$6 \times 6.48 = 38.88 N/mm^2$$

2. Loss of stress due to Creep of Concrete

$$= 45 \times 10^{-6} \times 6.48 \times 210 \times 10^3 = 61.24 N/mm^2$$

3. Loss of stress due to Shrinkage of concrete

$$= 300 \times 10^{-6} \times 210 \times 10^3 = 63.50 N/mm^2$$

4. Relaxation loss $= \frac{5}{100} \times 1250 = 62.50 N/mm^2$

5. Loss of stress due to anchorage slip = 0

6. Loss of stress due to friction effect = 0

Total = $38.88 + 61.24 + 63 + 62.50 + 0 + 0$

$= 225.6 N/mm^2$.

$\therefore$ %age of loss of stress $= \frac{225.62}{1250} \times 100$

$= 18.05\%$

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b) Post tensioned beam:-

1. Loss of Stress due to elastic shortening of Concrete = 0

2. Loss of Stress due to creep of Concrete
$= 22 \times 10^{-6} \times 6.48 \times 210 \times 10^3 = 29.94 N/mm^2$

3. Loss of stress due to Shrinkage of concrete
$= 215 \times 10^{-6} \times 210 \times 10^3 = 45.15 N/mm^2$

4. Relaxation loss $= \frac{5}{100} + 1250 = 62.50 N/mm^2$

5. Loss of stress due to anchorage Slip $= \frac{1.25}{12 \times 1000} \times 210 \times 10^3$
$= 21.88 N/mm^2$

6. Loss of stress due to friction effect
$= 1250 \times 0.0015 \times 12 = 22.50 N/mm^2$

Total $= 0 + 29.94 + 45.15 + 62.50 + 21.88 + 22.50$
$= 181.97 N/mm^2$

% Loss of Stress $= \frac{181.97}{1250} \times 100$
$= 14.56\%$

Q: A prestressed concrete beam section is 250 mm wide & 300 mm deep. The initial prestressing force is 450 kN at an eccentricity of 60 mm. The beam has a span of 5.75 m & has to carry a superimposed

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load of 7.50 kN/m. Analyse the beam section for the stresses reduced at mid span before & after the application of live load. Allow a loss of prestress of 15%. Take wt. of concrete equal to 24 kN/m.

Sol: Area of the beam section

$$A = 250 \times 300 = 7.5 \times 10^4 \text{ mm}^4$$

$$\text{Section modulus} = Z = \frac{bd^2}{6} = \frac{250 \times 300^2}{6}$$

$$= 3.75 \times 10^6 \text{ mm}^3$$

Eccentricity $e = 60$ mm

Stresses before the application of the live load:-

$$\text{Dl of the beam} = 0.25 \times 0.30 \times 24 = 1.80 \text{ kN/m}$$

$$\text{Dl moment} = Md = \frac{1.80 \times 5.75^2}{8} = 7.439 \text{ kN-m}$$

Direct stress due to prestressing force

$$= +\frac{P_o}{A} = +\frac{450 \times 10^3}{7.5 \times 10^4} = +6 \text{ N/mm}^2$$

Extreme stress due D.L moment

$$= \pm \frac{Md}{Z} = \pm \frac{7.439 \times 10^6}{3.75 \times 10^6} = \pm 1.98 \text{ N/mm}^2$$

Extreme stress due to eccentricity of the prestressing force

$$= \pm \frac{P_o e}{Z} = \pm \frac{450 \times 10^3 \times 60}{3.75 \times 10^6} = 7.20 \text{ N/mm}^2$$

Hence, before the application of the live load, the extreme stress on the section will be as follows.

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∴ Stress at top = 6 + 1.98 − 7.20 = 0.78 N/mm²
Stress at bottom = 6 − 1.98 + 7.20 = 11.22 N/mm².

Stress after the application of line load :-

Final Stress prestressing force P = 0.85 × 450
= 382.5 kN

D.L moment = $\frac{7.5 \times 95.75^2}{8}$ = 30.996 kN m

Direct stress due to prestressing force
= $\frac{P}{A}$ = $\frac{382.5 \times 10^3}{7.5 \times 10^4}$ = 5.10 N/mm²

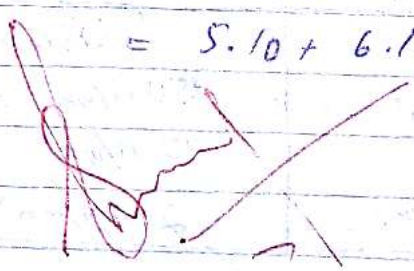
Extreme Stress due to D.L moment
= ± 1.98 N/mm²

Extreme Stress due to L.L moment
= ± $\frac{M_1}{Z}$

= ± $\frac{30.996 \times 10^6}{3.75 \times 10^6}$ = ± 8.26 N/mm²

Hence, the final stresses are as follows.
Stress at top = 5.10 − 6.12 + 1.98 + 8.26
= 9.22 N/mm²

Stress at bottom
= 5.10 + 6.12 − 1.96 − 8.26 = 0.98 N/mm²



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