16BECE8E05 PRE-STRESSED CONCRETE STRUCTURES 3 0 0 3 100

OBJECTIVES:

- To learn the principles, materials, methods and systems of prestressing
- To know the different types of losses and deflection of prestressed members
- To learn the design of prestressed concrete beams for flexural, shear and tension and to calculate ultimate flexural strength of beam
- To learn the design of anchorage zones, composite beams, analysis and design of continuous beam
- To learn the design of water tanks

UNIT I 9

Introduction – Theory and Behaviour: Basic concepts – Advantages – Materials required – Systems and methods of prestressing – Analysis of sections – Stress concept – Strength concept – Load balancing concept – Effect of loading on the tensile stresses in tendons – Effect of tendon profile on deflections – Factors influencing deflections – Calculation of deflections – Short term and long term deflections **-** Losses of prestress – Estimation of crack width

UNIT II 9

Design : Flexural strength – Simplified procedures as per codes – strain compatibility method – Basic concepts in selection of cross section for bending – stress distribution in end block, Design of anchorage zone reinforcement – Limit state design criteria – Partial prestressing – Applications.

UNIT III 9

Circular Prestressing: Methods of circular prestressing – types classifications **-** merits and demerits – effects **-** Design of prestressed concrete tanks – Poles and sleepers –Applications.

UNIT IV 9

Composite Construction : Various types of composite construction **-** beams and columns –Analysis for stresses – Estimate for deflections – Flexural and shear strength of composite members

UNIT V 9

Pre-Stressed Concrete Bridges : General aspects –Methods of pretensioning –methods of post tensioning-pretensioned slabs- pretensioned bridge decks – Post tensioned prestressed bridge decks – Principles of design only.

TEXT BOOKS:

Sl.No	**Title of Book**	**Author of Book**	**Publisher**	**Year of Publishing**
1	Prestressed concrete	Krishna Raju N	Tata McGraw Hill Company, New Delhi	2012
2	Prestressed concrete	Mallic S.K. and Gupta A.P.,	Oxford and IBH publishing Co. Pvt. Ltd.	2010

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1	Modern prestressed concrete design	Ramaswamy G.S	Arnold Heinimen, New Delhi	2003
2	Design of prestressed concrete	Raymond Ian Gilbert and Neil Mickleborough	CRC Press	2004
3	Plant Cast precast and prestressed concrete – A design guide	David.A. Sheppard, William.R..and Philips	McGraw Hill,New Delhi.	2003

WEBSITES:

- http://www.icivilengineer.com
- http://www.engineeringcivil.com/
- http://www.aboutcivil.com/
- http://www.engineersdaily.com
- http://www.asce.org/
- http://www.cif.org/
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- http://www.ice.org.uk/
- http://www.engineering-software.com/ce/

COURSE OUTCOMES

On completion of the course, the students will be able to:

- Design a pre-stressed concrete beam accounting for losses.
- Design the anchorage zone for post tensioned members.
- Design composite members.
- Design continuous beams.
- design water tanks

KARPAGAM ACADEMY OF HIGHER EDUCATION

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FACULTY OF ENGINEERING
DEPARMENT OF CIVIL ENGINEERING

16BECE8E05 / PRE-STRESSED CONCRETE STRUCTURES
LECTURE PLAN

Number of credits : 3
Contact hours : 4 hours per week
Lecturer : V.Johnpaul

S.No	Period/ Hours	Topics	Units	T(Book)	Page No
		UNIT-1 INTRODUCTION			
1	1	Basic concepts – Advantages	**1**	T1	
2	1	Materials required – Systems and methods of prestressing		T1	
3	1	Analysis of sections – Stress concept – Strength concept – Load balancing concept		T1	
4	1	Effect of loading on the tensile stresses in tendons – Effect of tendon profile on deflections		T1	
5	1	Factors influencing deflections – Calculation of deflections		T1	
6	1	Short term and long term deflections - Losses of prestress		T1	
7	1	Estimation of crack width		T1	
Total					
		UNIT-II DESIGN			
8	1	Flexural strength – Simplified procedures as per codes	**2**	T1	
9	1	strain compatibility method – Basic concepts in selection of cross section for bending		T1	
10	1	stress distribution in end block, Design of anchorage zone reinforcement		T1	
11	1	Limit state design criteria – Partial prestressing		T1	
12	1	Applications.		T1	
Total					
		UNIT III CIRCULAR PRESTRESSING			

13	2	Methods of circular prestressing	**3**	T1	
14	2	types classifications - merits and demerits calculation		T1	
15	1	effects - Design of prestressed concrete tanks		T1	
16	1	Poles and sleepers –Applications.		T1	
17					
UNIT IV COMPOSITE CONSTRUCTION					
18	1	Various types of composite construction	**4**	T1	
19	1	beams and columns		T1	
20	1	Analysis for stresses		T1	
21	1	Estimate for deflections		T1	
22	1	Flexural and shear strength of composite members		T1	
UNIT V- PRE-STRESSED CONCRETE BRIDGES					
23	1	General aspects	**5**	T1	
24	1	Methods of pretensioning –methods of post tensioning		T1	
25	1	pretensioned slabs- pretensioned bridge decks		T1	
26	1	Post tensioned prestressed bridge decks		T1	
27	1	Principles of design only		T1	
Total					

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- Design a pre-stressed concrete beam accounting for losses.
- Design the anchorage zone for post tensioned members.
- Design composite members.
- Design continuous beams.
- design water tanks

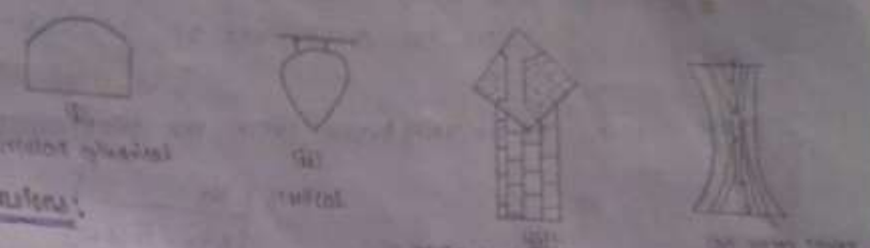
* Design of circular water tanks [prestressed], (Design problem)
* Design of poles [vertical members used for Electrical transmission], (Design problem)
* Design of sleepers, [Theory]

WATER TANKS:

D ⇒ 100m; Liquid depth ⇒ 16.00m; capacities ⇒ 5 million litres,

liquid oxygen ⇒ 1 million litres at $-196^{\circ}C$

Shapes:



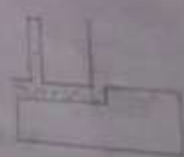
Economical dimensions:

Refer book, page No: 575 [Table & Fig.]

Junction of tank wall & base slab:

* Fixed base,
* Hinged base,
* Sliding base.

IS 3370 - part II/III



(iii)

Q1. Design a cylindrical prestressed concrete water tank to suit the following data:

Capacity of the tank ⇒ 3.5×10^{6} lits, (Volume)

Ratio of diameter to height ⇒ 4,

max. compressive stress (f_{ct})

In concrete at transfer not to exceed 14 N/mm² (comp).

Min. compressive stress under working load to be 1 N/mm²; ($f_{min,w}$)

The prestress is to be provided by circumferential winding of 5mm wires and by a vertical cable of 12 wires of 07mm ø. The stress in wires at transfer ⇒ (f_s) 1000 N/mm². Loss ratio is 0.75 (η) Design a wall of tank

... circumferential wire winding and vertical cables for the repeat.

b). sliding loss,

[Assume co-efficient of friction as 0.500]

DESIGN STEPS:

* Determine diameter, depth of water, thickness of tank wall, initialy it can be assume [t ⇒ 150mm to 150mm], [Ring tension (Nd) Moment: M_w]

* Determine max. Ring tension(Nd) and moment(Mw) in the tankwall using the co-efficient of IS: 3370 - Part IV.

[for fixed and hinged base]

based on the ring tension check the thickness of wall,

$$t \Rightarrow \left[\frac{Nd}{\eta f_{ct} - f_{min\,w}}\right]$$

Where,

f_{ct} → permissible compressive stress at transfer.

$f_{min\,w}$ → min. compressive stress under working load

This value, [$f_{min\,w}$] have to be taken as tensile force (or) service load (-ve).

* Determine circumferential pre-stress, (f_c)

$$f_c \Rightarrow \left[\frac{Nd}{\eta \cdot t_{eff}}\right] + \left[\frac{f_{min\,w}}{\eta}\right]$$

Where,

η → loss Ratio,

* Determine the spacing of cable wires of diameter (d). [d ⇒ 5-10mm] (5, 7 mm)

$$\text{Spacing } (s) \Rightarrow \left[\frac{2\,Nd}{W_w}\right] + \left[\frac{f_s \cdot A_s}{f_c \cdot D \cdot t}\right]$$

Where,

f_s → stress in wire at transfer

A_s → Ast,

W_w ⇒ weight of water

* Determine Radial pressure due to prestress,

$$W_t \Rightarrow \frac{2 \cdot f_s \cdot A_s}{s \cdot D}$$

$$M_t \Rightarrow M_w \left[\frac{W_t}{W_w}\right]$$

- Find section modulus, (Z) for 1m width $Z \Rightarrow \frac{bt^2}{6}$, where, $b \Rightarrow 1000mm$

- Vertical pre-stress based on the vertical moment (f_c),

$$f_c \Rightarrow \left[\frac{f_{min} \cdot w_t}{\eta} + \frac{w_t}{2}\right]$$

- Find limit of prestressing force and fixed spacing of the wire (5 to 10mm).

- Check load factor against collapse and F.S against cracking

01. Hinged base:

Solution:

Capacity of tank $\Rightarrow 3.5 \times 10^6$ litres $\Rightarrow 3.5 \times 10^3\ m^3$

$$\frac{\pi d^2}{4} \times H \Rightarrow 3.5 \times 10^3$$

In this case, $\frac{D}{H} = 4$

$$D = 4H$$

$$\frac{\pi d^2}{4} \times H = 3.5 \times 10^3$$

$$\frac{\pi}{4}[4H]^2 \times H = 3.5 \times 10^3$$

$$H \Rightarrow 6.53m \simeq 7.00m$$

$$D = 4 \times 7 \Rightarrow 28.00m$$

Assume thickness of wall (t) $\Rightarrow$ 150.00mm

From table of IS: 3370 - part $\overline{IV}$.

For max ring tension co-efficient $\Rightarrow$ 0.75 / 0.01 ... = 0.07 ...

unit wt. of water $\Rightarrow 10KN/m^3$

co-eff $\cdot W \cdot H \cdot R$ $(\because R = D/2)$

$\Rightarrow 0.0042 \times 10 \times 7^2 \Rightarrow 14.4$ KN/m.

Based on ring tension check the thickness,

$$t \Rightarrow \frac{Nd}{n f_{ct} - f_{minw}}$$

$$t = \frac{725.2}{0.75 \times 14 - 1} \Rightarrow 76.33 \text{ mm}$$

$\therefore$ provided wall thickness (t) 150.00 mm > 76.33 mm

Circumferential stress $(f_c) \Rightarrow \frac{Nd}{n\, t_{eff}} + \frac{f_{minw}}{n}$

$$= \frac{725.2}{0.75 \times 120} + \frac{1}{0.75}$$

$$f_c \Rightarrow 9.39 \text{ N/mm}^2$$

thickness adopted for (t) ⇒ 120 mm practically considering having the cable of 5 mm ϕ ⇒ 20 cover allow. $\therefore$ effective thick (t) ⇒ 150-30 ⇒ 120 m

Spacing of 5 mm ϕ wires;

$$s \Rightarrow \left[\frac{2Nd}{W_w}\right] + \left[\frac{F_s \cdot A_s}{f_c \cdot D \cdot t_{eff}}\right]$$

$W_w \Rightarrow 10 \times 7 \Rightarrow 70 \frac{KN}{m^2}$

$\Rightarrow 0.07$ N/mm^2

$$s \Rightarrow \left[\frac{2 \times 725.2}{18.070}\right] \times \left[\frac{1000 \times 19.6349}{9.39 \times 2 \times 120 \times 10^3}\right] \qquad \frac{\pi [5]^2}{4} \Rightarrow 19.6$$

$$S \Rightarrow 12.83 \text{ mm}$$

Nos. of wires /m $\Rightarrow \frac{1000 \text{ mm}}{s} \Rightarrow \frac{1000}{12.93} = 77.44$ mm $\simeq$ 80 mm

Since the water pressure occurs at bottom of the tank we are providing 80 nos of 5 mm ϕ wires.

As water pressure goes on decreasing towards the top the number of wires can be required to be less

...ssure due to prestress,

$$W_t \Rightarrow \frac{2 \cdot f_s A_s}{s \cdot D} \Rightarrow \frac{2 \times 1000 \times 19.63}{11.93 \times 125 \times 10^3}$$

$$\Rightarrow 0.10 \, N/mm^2$$

Max. Vertical moment due to prestress,

$$M_t \Rightarrow M_w \left[\frac{W_t}{W_w} \right]$$

$$= 14.4 \left[\frac{0.10}{0.07} \right] \times 10^6$$

$$= 20.57 \times 10^6 \, Nmm \quad (\text{or } 20.57 \, kNm)$$

Section modulus (z) for 1m width $\Rightarrow \frac{bt^2}{6}$

$$\Rightarrow \frac{1000 \times (150)^2}{6} \Rightarrow 3.75 \times 10^6 \, mm^3$$

Vertical prestress required is (f_c) $\Rightarrow \left[\frac{f_{min\,w}}{\eta} + \frac{M_t}{z} \right]$

$$= \left[\frac{1}{0.75} + \frac{20.57 \times 10^6}{3.75 \times 10^6} \right]$$

$$f_c \Rightarrow 6.81 \simeq 7.0 \, N/mm^2$$

$\therefore$ Vertical prestressing force $\Rightarrow$ [stress $\times$ area of the cross-section]

$$= [f_c \times A] \Rightarrow 7 \times 1000 \times 150 \Rightarrow 1.05 \times 10^6$$

$$F \Rightarrow 1050 \, kN / m$$

Spacing of 12 wires of 7mm ⌀ cables;

$$S \Rightarrow$$

Using 7mm ⌀ 12 Nos, of cables $\therefore$ force / cable, $\Rightarrow (f_s) \left[\frac{12 \pi (7)^2}{4} \right]$

both faces at a cover of 20mm.

12. **Fixed base:**

$D \Rightarrow 28.00m$; $H \Rightarrow 7.0m$; $t \Rightarrow 150mm$; $\eta \Rightarrow 0.75$

Data's from; [Refer previous problem]

From IS: 3370 - part IV,

N_d co-efficient $\Rightarrow 0.610$

M_w co-efficient $\Rightarrow 0.011$

From given problem;

$f_{ct} \Rightarrow 14 N/mm^2$,

$f_{minw} \Rightarrow 1 N/mm^2$,

$f_s \Rightarrow 1000 N/mm^2$

$W_w \Rightarrow 10 \times 7 \Rightarrow 70 KN/m^2 \Rightarrow 00.0700 N/mm^2$

Max. Ring tension $(N_d) \Rightarrow$ co.eff. $\times$ WHR

$N_d \Rightarrow 0.61 \times 10 \times 7 \times 14 \Rightarrow 597.8 KN/m$ or 597.8

moment in tank wall $(M_w) \Rightarrow$ co.eff. $\cdot WH^3$

$\Rightarrow 0.011 \times 10 \times 7^3 \Rightarrow 37.73$ KN.m per m

Minimum wall thickness $(t) \Rightarrow \dfrac{N_d}{\eta f_{ct} - f_{minw}}$

$\Rightarrow \dfrac{597.8}{(0.75 \times 14) - (1.00)}$

$t \Rightarrow 62.96mm < 150.00mm.$

Hence it's ok

Net thickness $(t_e) \Rightarrow 150 - 30 \Rightarrow 120.00mm$

Circumferential prestress:

$f_c \Rightarrow \dfrac{N_d}{\eta t_e} + \dfrac{f_{minw}}{\eta}$

$f_c \Rightarrow \left[\dfrac{597.800}{\ldots} + \dfrac{1}{\ldots}\right]$

since the max. water pressure occur at bottom of the tank. we are 80 nos, of 5mm ø wires,

As water pressure goes on decreasing towards the top the no. of wires can be reduced to 25 nos.

Radial pressure due to prestress: [

$$W_t \Rightarrow \frac{2 f_s . A_s}{S . D} \Rightarrow \frac{2 \times 1000 \times \frac{\pi (5)^2}{4}}{12.52 \times 28 \times 10^3} \Rightarrow 0.11$$

max. vertical moment due to prestress,

$$M_t \Rightarrow M_w \left[\frac{W_t}{W_w}\right] \Rightarrow 37.73 \times 10^6 \left[\frac{0.111}{0.070}\right]$$

$$M_t \Rightarrow 60.37 \times 10^6 \text{ Nmm per } m^2$$

Find the section modulus (z) $\Rightarrow \frac{bt^2}{6} \Rightarrow \frac{1000 [150]^2}{6} \Rightarrow 3.75 \times 10^6$

Vertical pressure required,

$$f_c \Rightarrow \frac{f_{min} w}{n} + \frac{M_t}{z} \Rightarrow \left[\frac{1}{0.75} + \frac{60.37 \times 10^6}{3.75 \times 10^6}\right]$$

$$f_c \Rightarrow 17.43 \text{ N/mm}^2$$

Since this stress exceeds permissible value $f_{ct} \Rightarrow 14 \text{ N/mm}^2$, the thickness of the tank wall at base is in increased to 200.00 mm,

Then,

$$z \Rightarrow \frac{bt^2}{6} \Rightarrow \frac{1000 \times (200)^2}{6} \Rightarrow 666 \times 10^4 \text{ mm}^3$$

$$f_c \Rightarrow \frac{f_{min} w}{\lambda} + \frac{M_t}{z} \Rightarrow \left[\frac{1}{0.75} + \frac{60.37 \times 10^6}{666 \times 10^4}\right]$$

$$f_c \Rightarrow 10.39 \text{ N/mm}^2$$

For per cable $\Rightarrow f_t$ [Cable area]

$\Rightarrow 1000 \left[461.76 \right]$

$\Rightarrow 461.76 \times 10^3 N \simeq 461.9 kN$

Spacing of Vertical cable $\Rightarrow \dfrac{\text{Force per cable}}{\text{Total force}} \Rightarrow \dfrac{461.900}{2078.00} \times 1000$

$S \Rightarrow 222.24 mm \simeq 200.00 mm$

03. <u>Sliding base</u> (or) Free end flexible base : simple supported base

Refer Hinged (or) fixed force. ; Assume thickness (t) $\Rightarrow$ 230mm, (line) (cable)
$t_e \Rightarrow 200mm$.

Determination of max. tension (ring), moment [free end].

Ring tension (or) Hoop tension (N_d) $\Rightarrow$ W.H.R

$\Rightarrow [10 \times 7 \times 28/2] \Rightarrow 980.00 kN/m$

Minimum Wall thickness (t) $\Rightarrow \dfrac{N_d}{\eta f_{ct} - f_{min w}}$

$= \dfrac{980.00}{(0.75 \times 14) - 1} \Rightarrow 103.00 mm$

$t \Rightarrow 103.00 mm < 230.00 mm$

Hence it's safe.

Circumferential prestress (f_c) $\Rightarrow \dfrac{N_d}{\eta . t_{eff}} + \dfrac{f_{min w}}{\eta}$

$\Rightarrow \dfrac{980.00}{0.75 \times 200} + \dfrac{1}{0.75}$

461.2 KN

1.200 / 678.00 X 1000

red base

230mm, (stem) (base) 300
200mm.

⇒ 980.00 kN/m

60 mm

$$S \Rightarrow \left[\frac{2 \times 980.00 \times 1000 \times \pi (5)^2/4}{0.870 \times 7.86 \times (27 \times 10^3) \times 200.00}\right] \Rightarrow 51.00\,mm.$$

∴ Nos of wires, $n_0 \Rightarrow \frac{1000}{12.5} = 80$ Nos.

∴ provide 80 Nos at the bottom of tank wall. Since water pressure ... decreases towards the top of the wall Reinforcement is reduced @ provide 20 Nos of 5mm ϕ.

Radial pressure due to prestress ⇒ $W_t \Rightarrow \frac{2 S_1 \cdot A_s}{S D}$

$$\Rightarrow \left[2 \times 1000 \times \pi (5)^2/4\right] / \left[12.50 \times 28 \times 10^3\right]$$

max. Radial pressure due to prestress at transverse d.

$W_t \Rightarrow 0.112\ N/mm^2$

max. vertical moment due to the wall @ bottom prestress.

$$\boxed{M_w \Rightarrow 0.247 \times N_0 \times \sqrt{Rt}}$$

where,

$N_0 \rightarrow$ Frictional force at base ⇒ [0.5 wt. of wall]

provide the thickness of wall @ bottom ⇒ 230mm ; 150 mm @ top.

$$N_0 \Rightarrow 0.5 \left[\frac{0.23 + 0.15}{2} \times 7\right] \times 24$$

$N_0 \Rightarrow 16\ kN/m.$

$$M_w \Rightarrow 0.247 \times 16 \times \sqrt{14 \times 0.23} \Rightarrow 7.1\,kNm/m \Rightarrow 7.1 \times 10^6\ Nmm/m$$

max. vertical moment at bottom water pressure due to that;

max. vertical moment due to prestress $(M_t) \Rightarrow M_w \left[\frac{W_t}{W_w}\right]$

$$\Rightarrow 7.1 \times 10^6 \left[\frac{0.11}{0.07}\right]$$

$\Rightarrow \frac{1}{0.15} + \frac{11.6 \times 10^6}{9.81 \times 10^6}$

$fc \Rightarrow 2.65\ N/mm^2$

(8)

As per IS code, min. vertical prestress required is 0.3 times of fct. (from code book).

$\Rightarrow 0.3 \times fct$

$\Rightarrow 0.3 \times 14 \Rightarrow 4.20\ N/mm^2$

$fc < 4.20\ N/mm^2$ — [large values] stress

Vertical prestressing force $\Rightarrow$ stress $\times$ area

$\Rightarrow 4.20\ [1000 \times 230] \Rightarrow 966 \times 10^3\ N$

(or)

966.000 KN.

Note. Without dia. ensure to simply for all cases

(For vertical prestressing 7mm ϕ use):

$\text{Force / cable} \Rightarrow 12\left[\frac{\pi[7]^2}{4}\right](1000) \Rightarrow 461.8 \times 10^3\ N$

$\Rightarrow 462.00\ KN.$

Spacing of cables $\Rightarrow \frac{\text{Force per cable}}{\text{Total force}} \Rightarrow \frac{462.00}{966.00} \times 1000$

$S \Rightarrow 478.00\ mm.$

Checking for collapse: Ultimate tensile stress $\Rightarrow 1500\ N/mm^2$

Load factor against clapse $\Rightarrow \frac{\text{Ultimate tensile force}}{Nd}$

$\Rightarrow \frac{\text{Area} \times \text{Stress}}{Nd} \Rightarrow \frac{80\ [\pi(5)^2/4] \times 1500}{980.00 \times 10^3}$

$\Rightarrow 2.400 > 1.20$

Hence

FOS against cracking $\Rightarrow \dfrac{\text{Cracking load}}{N_d}$

$$\Rightarrow \frac{b \times t\,[0.15\,p + 17]}{N_d}$$

$$\Rightarrow \frac{1000 \times 150\,[0.15 \times 14 + 17]}{990 \times 10^3}$$

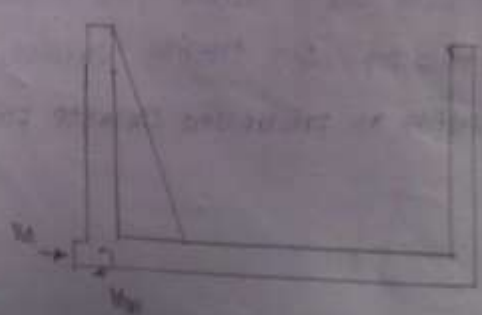
$$\Rightarrow 2.96 < 3.00$$

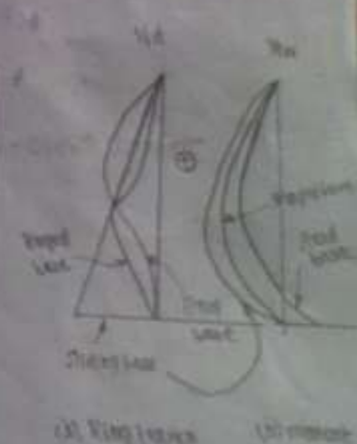
$\therefore$ Hence ok.

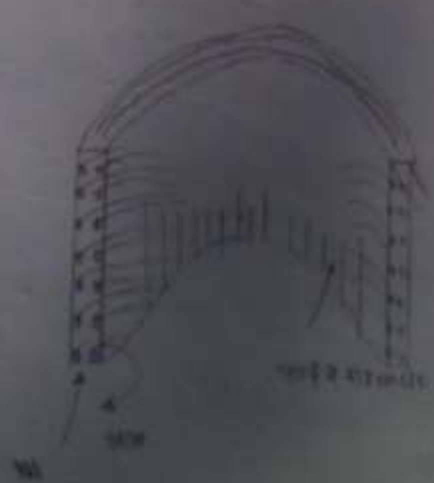
Design of RCC :

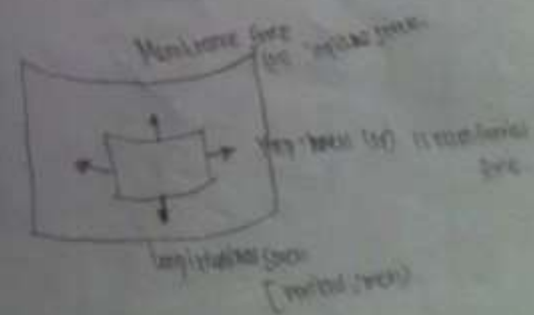
Nominal Reinforcement of 0.2% cross-sectional area to be provided in the circumferential and longitudinal Direction.

This is provided by 8mm ϕ MS bar spacing @ 300mm (or) both sides at a cover of 20.00mm.









DESIGN OF POLES:

Prestressed concrete poles are currently produced and are widely used in most of the country. for Railway power & signal line, lighting poles, Antennas masts, Telephone transmission, low and High voltage electric transmission and sub station towers.

Advantages:

- Resistant to corrosion,
- Freeze' thaw resistance, in cold regions,
- It has increased crack resistant, rigidity, and has resist
- dynamic loads better than RCC poles.

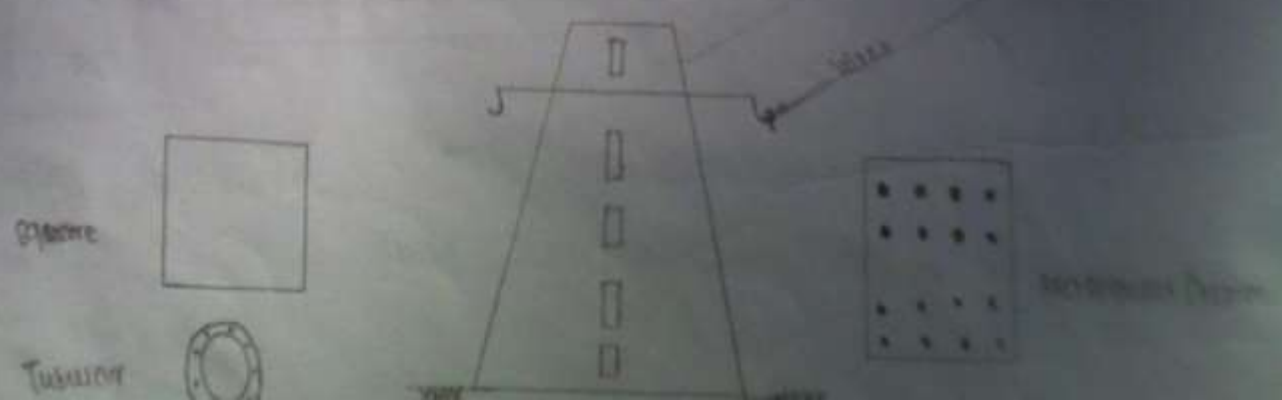
Design consideration:

Prestressed concrete poles are generally Designed as member with uniform prestress since they are subjected to BM of equal magnitude in opposite Direction. It's Design for following load conditions,

- Bending due to wind load,
- Combined bending and torsion due to Eccentric wires,
- Max. torsion due to skew (inclined) shaping of wires,
- Bending due to failure of all the loads,
- Handling and erecting stresses,

Typical cross-section of prestressed concrete poles:

page no:
563



Design prestressed pre-tensioned Main (?) poles is to be design to suit the following data :

Spacing of the poles ⇒ 100 m,

Free standing height of the pole above GL ⇒ 10m, [Pole is to be carry twin conductor high voltage power on a cross tree at 9m above GL]

Conduct the size i.e. c/s. Velo over all dimension ⇒ 10-16mm in[tension each wind pressure for each zone ⇒ 15]   ⇒ IS : 875 - 1964

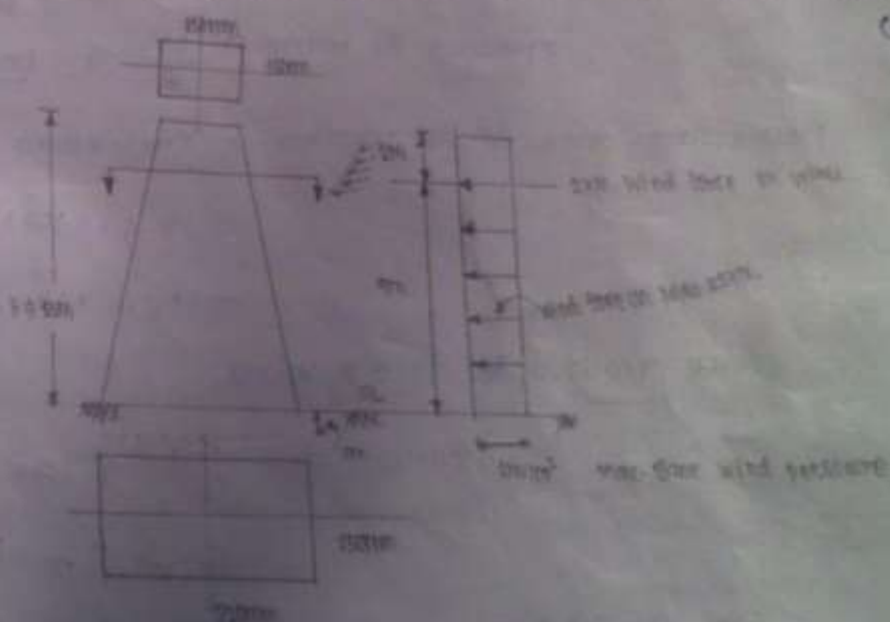
28 days cube strength of concrete ⇒ 35N/mm² (M35),

modulus of elasticity of concrete ⇒ 40.5 KN/mm²,

modulus of rupture ⇒ 5N/mm², High tensile wire of 5mm∅ available.

Ultimate tensile strength of wire is 1600 N/mm². Loss ratio is 0.7, permissible compressive stress in concrete is (f_{cw}) ⇒ 18 N/mm². Tensile stress in concrete (f_{tw})

<u>Solution</u>:



Bending moment M_d ⇒ (2×9) + (1.5×5) ⇒ 25.5 KNm.

Section modulus (Z) ⇒ $\dfrac{2M_d}{f_{cw} - f_{tw}}$ ⇒ $\dfrac{2 \times 25.5 \times 10^6}{(18 + 5.00)}$ ⇒ 2.23×10^6

Assume base width of poles ⇒ 150mm,

$$Z = bt^2/6$$

$$\frac{b \cdot D^2}{6} = 2.23 \times 10^6$$

150 mm x 150 mm,

Here, zero BM'

but cross-section provided @ top should be strong enough to withstand the wind force.

Ast calculation:

pre-stress in member $\Rightarrow \left[\frac{\delta_{tw}}{\eta} + \frac{M_w}{\eta \cdot Z}\right]$

$\Rightarrow \frac{-5.00}{0.70} + \frac{25.5 \times 10^6}{0.7 \times 2.56 \times 10^6} \Rightarrow 7.43\,N/mm$

Z provided for bottom $\Rightarrow \frac{bt^2}{6} \Rightarrow \frac{150 \times 320^2}{6} \Rightarrow 256 \times 10^6\,mm$

prestressing force in the member $\Rightarrow$ stress x area

$\Rightarrow 7.43 \times 150 \times 320 \Rightarrow$ 356.6 mm²

$\Rightarrow 356.6 \times 10^3 \simeq 357.00\,KN.$

Force required for 5mm ∅ wires,

Force / cables $\Rightarrow \frac{\pi}{4}[5]^2 \times$ permissible stress (fs)

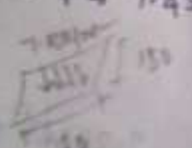
$= \left[\pi [5]^2/4\right] \times$ [0.8 x ultimate stress]

25KN for each wire,

$F \Rightarrow 7.43 \times 320 \times 150 \Rightarrow 357\,KN.$

(assume)

$= \frac{\pi [5]^2}{4} \times [0.8 \times 1600] \Rightarrow 25 \times 10^3 N$



no of wire (n) $\Rightarrow \frac{357}{25} \Rightarrow 14.5 \simeq 16$ No, $\left(\frac{F}{\delta}\right)$

$\therefore$ provide 16 No, of 5mm ∅ wire, the arrangement of wire are shown in fig.

Reinforcement details: