K. K. Wagh Institute of Engineering Education and Research, Nashik

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Model Answer sheet

End-Sem Examination-I	Winter 2025
Academic Year: 2025-26	Sem: II
Class: F.Y.	Program: M.Tech.
Branch Code: CIV	Pattern: 2024
Name of Course: Design of Prestressed concrete Structures	Course Code: 2404514A

Q. No.	Details	Max. Marks
Q.1	**What are the advantages and disadvantages of Prestressed concrete.** **Advantages of Prestressed Concrete:-** 1) Prestressing the steel and anchoring it against the concrete produces desirable strains and stresses which serve to reduce or eliminate cracks in concrete. 2) The high strength crack free concrete structure improves the durability of the structure under aggressive environmental conditions. 3) The entire section of the concrete becomes effective in Prestressed concrete, whereas only the portion of section above neutral axis is supposed to act in case of reinforced concrete. 4) By increasing the eccentricity of the Prestressing force in Prestressed concrete element, the dead load can be counteracted up to certain limits, thus savings in the materials. 5) The use of curved tendons and the precompression of concrete helps to resist shear. 6) Prestressing of concrete improves the ability of the material to resist shock, impact loads and repeated working loads. 7) The use of high strength concrete and steel in Prestressed members results in lighter and slender members which reduces the design loads and hence the cost of foundations. 8) Large size Prestressed concrete liquid retaining structures are economical and preferably safe against cracking and consequent leakage. 9) The Prestressed concrete design is economical when same unit is repeated many times or when heavy dead loads on long spans are encountered. **Disadvantages of prestressed concrete:-** 1) Prestressed concrete requires high strength concrete and steel which will have a higher unit cost. 2) Prestressed concrete members do require more care in design, construction and erection than those of ordinary concrete, because of higher strength, smaller sections and sometimes delicate design features involved, 3) It requires complicated tensioning equipment and anchoring devices. **4)** More complicated formwork is also needed, since non rectangular shapes are often necessary for Prestressed concrete.	**[6]**
Q.2	**Enlist different losses which occur only in pretensioned prestressed concrete members. Explain loss due to elastic shortening in detail for pretensioned memebers.** 1. Loss due to Elastic shortening 2. Loss due to Creep of concrete 3. Loss due to Shrinkage of concrete	**[6]**

	4. Loss due to Relaxation of steel **Loss of Prestress Due to Elastic Shortening for Pretensioned Members** In pretensioned members, the tendons are tensioned before casting concrete. After the concrete gains sufficient strength, the tendons are released. When the prestress force is transferred to concrete, the concrete shortens elastically under compression. Since the steel is fully bonded to concrete along its length, the steel shortens by the same amount as the concrete. This shortening causes a reduction in strain in the prestressing steel, resulting in a loss of prestress. Loss of stress $= \alpha_e \times f_c$	
Q.3	**a) Design one way prestressed concrete slab of span 6.5m. by using parallel post tensioned strands of diameter 12.5mm. The slab is required to support Uniformly distributed imposed load of 18 kN/m^2 and floor finish 1.5 kN/m^2. The strength of concrete at transfer of prestress is 40 N/mm^2. Determine permissible stresses as per IS 1343.Consider grade of concrete as 50 N/mm^2 and characteristic tensile strength of strand as 1600N/mm^2. Design the spacing of the ducts and their position at mid span section. Assume loss ratio 0.85. Check the section only for flexure. (Ignore Check for stresses and check for deflection) (8marks)** 1) Determination of Permissible Stresses- fct ; ftt; ftw; fcw from IS 1343. 2) Load and BM calculation $f_{br}=\eta f_{ct} - f_{tw}$ 3) Required section modulus $Z_{bx}= \frac{M_{XL} +(1-n) M_{XD}}{f_{br}}$ 4) Prestressing force and eccentricity- $f_{inf}= \frac{f_{tw}}{\eta} + \frac{(M_{XD}+M_{XL})}{\eta Z_b}$ $f_{sup}= f_{tt} - \frac{M_{XD}}{Z_t}$ $P= \frac{A (f_{inf}+ f_{sup})}{2}$ $e= \frac{Z(f_{inf} - f_{sup})}{A(f_{inf} + F_{sup})}$ Revised prestressing force= $\frac{A*f_{inf} * Z}{Z+(A*e)}$ 5) Spacing and position of ducts- 6) Check for flexure- $\frac{A_{ps} f_{pu}}{bdf_{ck}}$ $\frac{f_{pb}}{0.87*f_{pu}}$ $M_{ur}=f_{pb} A_{ps} (d-0.42x_u)$	**[16]**

OR

b) A slab spanning 7.5m is to be designed as a one way prestressed concrete slab with parallel post tensioned cables. The deck slab is required to support Uniformly distributed imposed load of 20 kN/m². Consider grade of concrete as 50 N/mm² and characteristic tensile strength of strand as 1700 N/mm². The permissible stresses in concrete should not exceed 16N/mm² in compression and (-) 1.5MPa in tension is permitted at any stage. Design the spacing of the ducts and their position at mid span section. Assume 16% losses and diameter of each strand as 12.5mm. Check the section for deflection. (Ignore Check for flexure and check for stresses) (8marks)

1) Determination of Permissible Stresses-
fct = 16 MPa; ftt = -1.5; ftw= -1.5; fcw = 16 MPa
2) Load and BM calculation
$f_{br} = \eta f_{ct} - f_{tw}$
3) Required section modulus

$$Z_{bx} = \frac{M_{XL} + (1-n) M_{XD}}{f_{br}}$$

4) Prestressing force and eccentricity-

$$f_{inf} = \frac{f_{tw}}{\eta} + \frac{(M_{XD} + M_{XL})}{\eta Z_b}$$

$$f_{sup} = f_{tt} - \frac{M_{XD}}{Z_t}$$

$$P = \frac{A (f_{inf} + f_{sup})}{2}$$

$$e = \frac{Z(f_{inf} - f_{sup})}{A(f_{inf} + F_{sup})}$$

$$\text{Revised prestressing force} = \frac{A * f_{inf} * Z}{Z + (A * e)}$$

5) Spacing and position of ducts-
6) Check for deflection

c) Design a post tension two way slab of effective span 5.2m ×7.2m with all discontinuous edges. The slab is subjected to superimposed load 6 kN/m². Consider grade of concrete as 40 N/mm² and characteristic tensile strength of strand as 1600 N/mm². The permissible stresses in concrete should not exceed 16N/mm² in compression and no tension is permitted at any stage. Assume 16% losses and diameter of each strand as 12.5mm. Design the spacing of cable in both direction. Don't apply checks. (8marks)

1) Permissible stresses and Thickness of slab

Depth $D = l_x/50$

2) Load and bending moment calculation

Refer table no.26 (IS 456:2000)

β = aspect ratio = l_y/l_x

$M_{XD} = \alpha_x w_d l_x^2$

$M_{XL}=\alpha_x w_l l_x^2$
$M_{yD}=\alpha_y w_d l_x^2$
$M_{yL}=\alpha_y w_l l_x^2$

3) Check for minimum section modulus

$f_{br}=\eta f_{ct} - f_{tw}$

$Z_{bx}= \frac{M_{XL}+(1-n) M_{XD}}{f_{br}}$

4) Minimum prestressing force

A) X-direction

$f_{inf}= \frac{f_{tw}}{\eta} + \frac{(M_{XD}+M_{XL})}{\eta Z_b}$

$f_{sup}= f_{tt} - \frac{M_{XD}}{Z_t}$

$P= \frac{A (f_{inf}+ f_{sup})}{2}$

$e=\frac{Z(f_{inf} - f_{sup})}{A(f_{inf} + F_{sup})}$

Revised prestressing force= $\frac{A*f_{inf}*Z}{Z+(A*e)}$

Spacing and position of ducts-

B) Y-direction

$f_{inf}= \frac{f_{tw}}{\eta} + \frac{(M_{YD}+M_{YL})}{\eta Z_b}$

$f_{sup}= f_{tt} - \frac{M_{YD}}{Z_t}$

Revised prestressing force= $\frac{A*f_{inf}*Z}{Z+A*e}$

5) Spacing and position of ducts-

OR

d) Design a post tension two way slab of effective span 6.2m ×7.2m with all discontinuous edges. The slab is subjected to superimposed load 4 kN/m^2. Take F.F. load = 2.0 kN/m^2. Consider grade of concrete as 50 N/mm^2 and characteristic tensile strength of strand as 1700 N/mm^2. The strength of concrete at transfer is 35 N/mm^2. Determine permissible stresses for type II structure as per IS 1343. Assume 14% losses and diameter of each strand as 13.5mm. Design the spacing of cable in both direction. Don't apply checks. (8marks)

1) Permissible stresses and Thickness of slab

Depth $D=l_x/50$

2) Load and bending moment calculation

Refer table no.26 (IS 456:2000)

β =aspect ratio=l_y/l_x

$M_{XD}=\alpha_x w_d l_x^2$

	$M_{XL}=\alpha_x w_l l_x^2$ $M_{yD}=\alpha_y w_d l_x^2$ $M_{yL}=\alpha_y w_l l_x^2$ **3) Check for minimum section modulus** $f_{br}=\eta f_{ct} - f_{tw}$ $Z_{bx}= \frac{M_{XL}+(1-n) M_{XD}}{f_{br}}$ **4) Minimum prestressing force** **A) X-direction** $f_{inf}= \frac{f_{tw}}{\eta} + \frac{(M_{XD}+M_{XL})}{\eta Z_b}$ $f_{sup}= f_{tt} - \frac{M_{XD}}{Z_t}$ $P= \frac{A (f_{inf}+ f_{sup})}{2}$ $e=\frac{Z(f_{inf} - f_{sup})}{A(f_{inf} + F_{sup})}$ Revised prestressing force= $\frac{A*f_{inf}*Z}{Z+(A*e)}$ **Spacing and position of ducts-** **B) Y-direction** $f_{inf}= \frac{f_{tw}}{\eta} + \frac{(M_{YD}+M_{YL})}{\eta Z_b}$ $f_{sup}= f_{tt} - \frac{M_{YD}}{Z_t}$ Revised prestressing force= $\frac{A*f_{inf}*Z}{Z+A*e}$ **6) Spacing and position of ducts-**	
Q.4	**a) A post - tensioned prestressed beam of rectangular section 450 mm wide is to be designed for a uniformly distributed imposed load of 20kN/m, on a span of 9m. The stress in the concrete must not exceed 16 N/mm^{2}in compression or 1.4N/mm^2 in tension at any time and the loss of prestress may be assumed to be 16%. diameter of each strand as 12.5mm. Design the section and decide arrangement of ducts. Also determine limiting zone. Don't apply checks. (8marks)** 1) Determination of permissible stresses 2) Preliminary dimensions and section properties 3) SF and BM calculations 4) Minimum section modulus 5) Prestressing force and eccentricity 6) Limiting zone and arrangement of ducts **OR**	**[16]**

	b) A pre - tensioned I- section has both flanges are 400 mm wide and 150 mm deep. The rib is 150 mm wide and 400 mm deep. The effective depth of the cross section is 500 mm. If fck = 50 N/mm2, fpu = 1600N/mm^2, and the area of prestressing steel Aps =491 mm^2, Calculate the ultimate flexural strength of the section using IS1343 code provisions. **(8 marks)** $\frac{A_{ps}\,f_{pu}}{bdf_{ck}}$ $\frac{f_{pb}}{0.87*f_{pu}}$ From Table No11 calculate Xu and Fpb $M_{ur}=f_{pb}\,A_{ps}\,(d-0.42x_u)$	
	c) A prestressed concrete beam 300 mm wide & 400mm deep is provided with two symmetrical cables each with a prestressing force of 650 kN. Design the end block with reinforcement required to resist bursting forces. (8 marks) a) On the areas immediately behind external anchorages, the permissible unit bearing stress on the concrete, after accounting for losses due to relaxation of steel, elastic shortening and seating of anchorages, shall not exceed $0.48 f_{ci}\sqrt{\frac{A_{br}}{A_{pun}}}$ or $0.8 f_{ck}$ whichever is smaller, where f_{ci} is the cube strength at transfer, A_{br} is the bearing area and A_{pun} is the punching area. $\frac{F_{bst}}{P_0} = 0.32 - 0.3\frac{y_{p0}}{y_0}$ where F_{bst} = bursting tensile force, P_0 = load in the tendon assessed as above, y_{p0} = side of loaded area, and y_0 = side of end block. **OR** **d) A prestressed concrete beam of rectangular section 400 mm wide by 400 mm deep is to be designed to support an ultimate shear force of 300 kN. All the ducts are straight.** **The uniform prestress across the section is 6.5 N/mm^2. The characteristic cube strength of the concrete is 50N/mm^2 and steel is Fe415 with bar diameter 8 mm. Design suitable spacing for the stirrups conforming to IS1343 recommendations for uncracked section. Assume effective cover as**	

	40 mm. (8 marks) The ultimate shear resistance of a section uncracked in flexure, $V_c = V_{co}$, is given by: $$V_{co} = 0.67\, bD \sqrt{(f_t^2 + 0.8 f_{cp} f_t)}$$ where b = breadth of the member which for *T*, *I* and *L* beams should be replaced by breadth of the rib b_w, D = overall depth of the member, f_t = maximum principal tensile stress given by $0.24\sqrt{f_{ck}}$ taken as positive where f_{ck} is the characteristic compressive strength of concrete, and f_{cp} = compressive stress at centroidal axis due to prestress taken as positive. loads, is less than V_c, the shear force which can be carried by the concrete, minimum shear reinforcement should be provided in the form of stirrups such that: $$\frac{A_{sv}}{bs_v} = \frac{0.4}{0.87\, f_y}$$ where A_{sv} = total cross-sectional area of stirrup legs effective in shear; b = breadth of the member which for *T*, *I* and *L* beams should be taken as the breadth of the rib, b_w; s_v = stirrup spacing along the length of the member; and f_y = characteristic strength of the stirrup reinforcement which shall not be taken greater than 415 N/mm^2. However, shear reinforcement need not be provided in the following cases: a) where V is less than $0.5\, V_c$, and b) in members of minor importance. **23.4.3.2** When V exceeds V_c, shear reinforcement shall be provided such that: $$\frac{A_{sv}}{s_v} = \frac{V - V_c}{0.87\, f_y d_t}$$	
Q.5	**a) Design a post tensioned flat slab for the following data-** **Centre to centre distance between columns=6.2 m along both the directions** **Column size=500mm Circular; Flat Slab with drop** **Live load=6.5 kN/m^2** **Floor finish=1kN/m^2** **Materials= M40, Fpu= 1600 N/mm^2.** **Permissible stresses in the concrete= 15 N/mm^{2}in compression and 1.5 N/mm^2 in tension. Determine all bending moments and number of strands in middle strip and edge strip. Ignore check for flexure, shear and stresses. (8marks)** 1) Dimensions of flat slab-middle strip, edge strip, drop and capital	**[16]**

2) Load and stiffness calculations
3) BMs for end panels – midspan and support
4) BMs for interiors panel – midspan and support
5) Prestressing force and number of ducts in each panel .

OR

b) Design a post tensioned flat slab for the following data-
Centre to centre distance between columns=8.0 m along both the directions
Column size-750mm square; Flat Slab with drop
Live load=5.5 kN/m^2
Floor finish=2.0 kN/m^2
Materials= M50, Fpu= 1600 N/mm^2; fci = 40 N/mm^2
Determine all bending moments and number of strands in middle strip and edge strip. Ignore check for flexure, shear and stresses. (8marks)

1) Dimensions of flat slab-middle strip, edge strip, drop and capital
2) Load and stiffness calculations
3) BMs for end panels – midspan and support
4) BMs for interiors panel – midspan and support
5) Prestressing force and number of ducts in each panel .

c) Perform punching shear check for a post tensioned flat slab with column capital and drop for the following data-
Centre to centre distance between columns=6.5 m along both the directions
Column size-500mm Circular
Live load=8 kN/m^2
Floor finish=2.0 kN/m^2
Materials= M40, Fpu= 1600 N/mm^2.
Ignore BM calculations, check for flexure, stresses. (8marks)

Dimensions of flat slab-middle strip, edge strip, drop and capital

I) First location - at d/2 from the periphery of column capital
1) Area resisting shear –
2) Shear resisted by concrete section
3) Ultimate design shear at critical section
4) Check – safe/unsafe

II) Second location - at d/2 from the periphery of column drop
1) Area resisting shear –
2) Shear resisted by concrete section
3) Ultimate design shear at critical section
4) Check – safe/unsafe

OR

d) Perform punching shear check for a post tensioned flat slab with column capital and drop for the following data-
Centre to centre distance between columns=7.8 m along both the directions in both directions
Column size-650mm Sqaure

	Live load=6 kN/m^2 **Floor finish=2.0 kN/m^2** **Materials= M50, Fpu= 1600 N/mm^2.** **Ignore BM calculations, check for flexure, stresses. (8marks)** Dimensions of flat slab-middle strip, edge strip, drop and capital I) First location - at d/2 from the periphery of column capital 1) Area resisting shear – 2) Shear resisted by concrete section 3) Ultimate design shear at critical section 4) Check – safe/unsafe II) Second location - at d/2 from the periphery of column drop 1) Area resisting shear – 2) Shear resisted by concrete section 3) Ultimate design shear at critical section 4) Check – safe/unsafe	