UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

Module Number: CE 6301 **Module Name: Design of Concrete Structures II**

[Three Hours]

[Answer **all questions**, each Question carries 15 marks]

Code of Practice BS 8110 Part 1: 1997 and BS 8007: 1987 are provided

Q1 (a) Comment on the following statements, i.e., do you agree or disagree or both? Ensure that the main issues involved are explained, giving arguments (reasons) and/or counter-arguments

(i) Plastic shrinkage cracking in concrete can be controlled by providing reinforcement

(ii) When considering temporary open sections in wall construction, the only temperature effect to be considered is the temperature rise due to heat of hydration.

(iii) Stabilizing period for testing water tightness depends on the capacity of the water tank

(iv) Reinforcement requirement to control cracking in immature concrete should be in addition to the reinforcement requirement to control cracking in mature concrete due to imposed loads.

(v) Self-healing of cracks in concrete depends on the crack width only.

[0.5 x 5 = 2.5 Marks]

(b) Without performing calculations discuss how you will determine the maximum crack width of the reinforced concrete wall in a water tank under maximum serviceability bending moment.

[2.5 Marks]

(c) Why Grade 35A concrete is recommended for water retaining structures? Explain the constituents in selecting mix proportions and their limitation for Grade 35A concrete. Discuss issues arising when placing such concrete in large sections.

[4.0 Marks]

(d) Suggest a suitable structural arrangement for the floor slab to reduce the slab thickness.

[3.0 Marks]

(e) During construction, the entire length of a wall was concreted. After several weeks, vertical cracks at regular intervals were observed along the wall. Give possible reasons for this behavior and how to avoid this kind of cracking.

[3.0 Marks]

Q2 A reinforced concrete water tank is required to construct on a solid ground for a factory. The proposed internal dimensions of this tank are 6.0m x 6.0m x 2.5m. This is an open tank without a top cover slab. Based on the location of this water tank, the wind load can be neglected.

Following design parameters are given to you.
Strength of structural concrete: $35N/mm^2$
Modulus of elasticity of concrete: $27kN/mm^2$
Modulus of elasticity of steel: $200kN/mm^2$
Density of water: $9.81kN/m^3$
Coefficient of thermal expansion in concrete $\alpha = 1.0 \times 10^{-5}$
Concrete cover: 40mm
Fall in temperature between hydration peak and ambient: $T_1 = 31^0 C$
Temperature falls due to seasonal changes: $T_2 = 7^0 C$
Freeboard in the service condition is 200mm (i.e., the water top level is 200mm below the tank top at the service condition.)

(a) Describe the following items

(i) Movement Joints
(ii) Construction Joints
(iii) Kicker
(iv) Water-bar or Water-stop
(v) Neoprene pad

[0.5 x 5 = 2.5 Marks]

(b) Determine the effective length, effective width, and effective height of the tank walls. Identify types of walls as one-way spanning or two-way spanning.

[2.5 Marks]

(c) Calculate maximum water pressure acting on the short wall at severability and ultimate limit states

[2 Marks]

(d) Calculate required moments and forces acting (axial and transverse) on the each wall under serviceability and ultimate limit state.

[2 Marks]

(e) Design Engineer proposed to use 20mm diameter reinforcement bars at 200mm spacing in the vertical direction and 12mm diameter reinforcement bars at 200mm spacing in horizontal direction for this wall as shown in the Figure Q2(a),

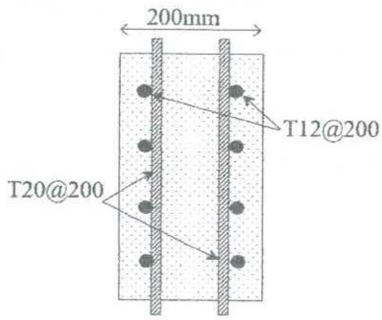

Figure Q2(a)

(i) Check whether the amount of vertical reinforcement provided is sufficient to withstand the ULS bending moment of the wall

[2 Marks]

(ii) Check whether the amount of reinforcement provided is sufficient to control crack spacing and crack widths in relation to temperature and moisture effects.

[4 Marks]

Q3 (a) Explain the meaning/application of the following terminologies, which are used in prestressed concrete

(i) Camber
(ii) Duct
(iii) Transmission length
(iv) Post-tensioning
(v) Transfer stage

[2.5 Marks]

(b) Explain the immediate loss (short term) and time-dependent loss (long term) in prestressed concrete members, and give three examples for each case.

[4.5 Marks]

(c) A rectangular post-tensioned concrete beam 200 mm wide and 400 mm deep is prestressed by a tendon with a 150 mm² cross-sectional area as shown in Fig. Q3 (a). The beam is simply supported with a span of 10m. The Prestressing stress of 1800 N/mm² is applied at end **A** (where, $x = 0$).

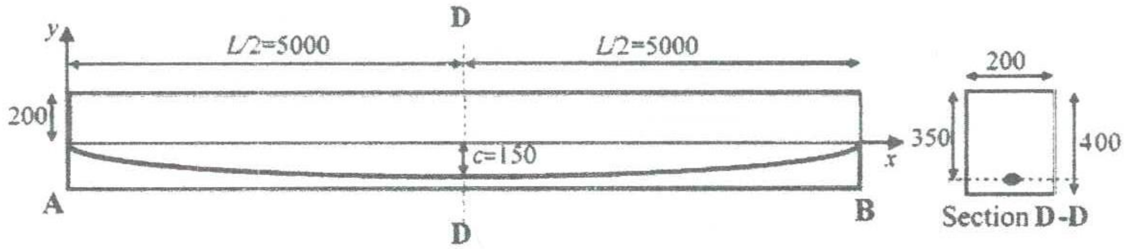

Fig. Q3(a): A post-tensioned simply supported beam (all dimensions are in mm)

- Cable profile: $y = -4c\left[(x/L) - (x/L)^2\right]$
- The prestressing force P_x at any distance x from the jack due to friction loss

  $P_x = P_o e^{-(Kx + \mu x / r_{ps})}$

  P_o : prestressing force in the tendon at the jacking end

  e : base of Naperian logarithms

  K : coefficient depending on the type of duct etc (assume $K = 45 \times 10^{-4}$ rad./m)

  μ : coefficient of friction (assume $\mu = 0.25$)

  $r_{ps} = \left|\left[(1 + (dy/dx)^2\right]^{3/2} / \left(dy^2/dx^2\right)\right|$: radius of curvature of the tendon profile

- Loss due to draw-in during anchorage can be calculated as shown in Fig. Q3(b).

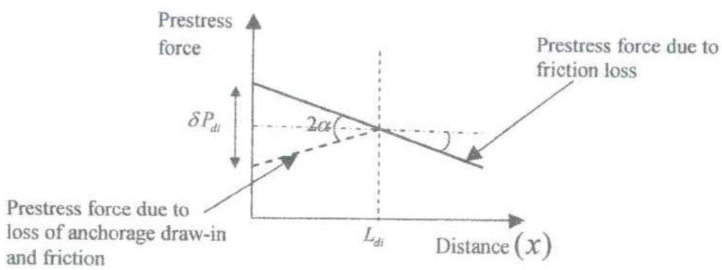

Fig. Q3(b): Idealized Prestressing force along the beam due to the loss of anchorage draw-in and friction

$$L_{di} = \sqrt{\frac{E_p A_p \Delta}{\alpha}}, \qquad \delta P_{di} = 2\alpha L_{di}$$

where Δ : Anchorage drawn-in (Assume $\Delta = 5$ mm)

E_p : Elastic modulus of tendon (Assume $E_p = 200$ kN/mm²)

α : It is assumed as loss of prestressing force due to friction per unit length near the anchorage ($\alpha = P_o - P_{1m}$), P_{1m} : prestressing force at $x = 1$ m after friction loss)

A_p : Cross-sectional area of tendon

δP_{di} : loss of the prestressing force due to anchorage draw-in at $x = 0$

You may assume any missing information and clearly state those.

(i) Calculate the loss due to elastic shortening at mid-span

(1.0 Mark)

(ii) Calculate the prestressing force at the mid-span due to friction loss

(2.0 Marks)

(iii) Calculate the prestressing force (P_{1m}) at $x = 1$ m from **A** due to friction loss

(2.0 Marks)

(iv) Calculate the prestressing force at the end of A of the beam ($x = 0$) due to the loss of anchorage draw-in.

(3.0 Marks)

Q4. A one-way slab is simply supported over a span of 10m (short span). The slab is post-tensioned by regularly spaced tendons with parabolic profiles. The slab is designed to carry a service load of 8 kPa.

- The allowable design tensile stress of concrete at transfer = 1.32 MPa
- The allowable design compressive stress of concrete at transfer = 14 MPa
- The allowable design tensile stress of concrete at serviceability limit = 1.58 MPa
- The allowable design compressive stress of concrete at serviceability limit = 20 MPa
- A flat duct containing 4 strands is used for post-tensioning. The properties of a strand: diameter - 11 mm, nominal steel area - 71 mm^2, nominal tensile strength - 1770 MPa.
- Minimum cover is 30 mm.
- Immediate loss 5% and long-term loss is 20%
- The concrete density is 25 kN/m^3

(a) Drive the equation for the minimum section modulus in the mid-span and find the most suitable value for depth of the slab.
(Hint – You may consider a 1 m wide strip of slab with 10 m span).

[5.0 Marks]

(b) Draw Magnel diagram and determine the most appropriate and economical prestressing force and corresponding eccentricity at mid.

[8.0 Marks]

(c) If the maximum allowable Jacking force is 70% of the nominal tensile strength of the tendon, determine spacing between strands.

[2.0 Marks]