B. Sc. Engg. (CEE)/6th Semester 15 May, 2024 (Group-B)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Semester Final Examination **Summer Semester: 2022–2023**
Course Number: CEE 4613 **Full Marks: 150**
Course Title: Design of Pre-Stressed Concrete Structures **Time: 3.0 Hours**

There are 6 (Six) questions. Answer ALL the questions. The figures in the right margin indicate full marks. COs and POs are also specified in the right margin of the questions. The symbols have their usual meaning.

1. (a) Write down the advantages and disadvantages of Pre-tensioning and Post-tensioning system. [CO1, PO1: 5]

   (b) Calculate the ultimate moment capacity of the prestressed concrete beam section shown in **Fig.1**. The beam is prestressed with A_{ps}=2350 mm^2 with an effective prestress, f_{se}=1100 MPa. Addition to the prestressing steel the beam is reinforced with supplementary steel consisting of 2 bars each of 25 mm diameter, The c.g.s for both the prestressing steel and supplementary steels is 115 mm above the bottom of the beam as shown. Given: f_{pu}=1860 MPa, f_c'=48 MPa, f_y = 460 MPa [CO2, PO2: 22.5]

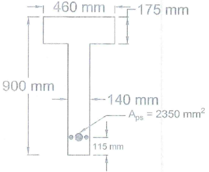

Fig. 1 for Question 1(b)

2. (a) Using a longitudinal section of beam, draw different categories of cracks and differentiate them with respect to shear vs moment ratio. [CO1, PO1:5]

   (b) The mid-span section of a composite beam is shown in **Fig. 2**. The precast stem is a section 750 mm deep having a hollow core which has a diameter of 200mm and is pretensioned with an initial force of 2200 kN at transfer. The effective prestress after time dependent losses may be taken as 1980 kN. Compute the stresses in the section at various stages and draw the stress distributions over the depth of the section if the bending moment at the section are as follows: [CO2, PO2: 22.5]

   - Due to weight of precast stem= 240 kN-m

- Due to top slab= 110 kN-m
- Due to live load= 720 kN-m

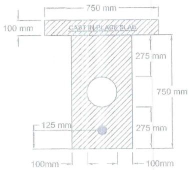

Fig. 2 for Question 2(b)

3. (a) List the factors affecting shrinkage strain of concrete. [CO1, PO1: 5]

   (b) A concrete beam with a single overhang is simply supported at A and B over a span of 8 m and the overhang BC = 2 m shown in **Fig. 3**. The beam s of rectangular cross section 300 mm wide by 900 mm deep and supports a UDLL of 3.52 kN/m over the entire length in addition to its self-weight. Determine the profile of the prestressing cable with an effective force of 500 kN which can balance the DL and LL on the beam. Sketch the profile of the cable along the length of the beam. [CO2, PO2: 22.5]

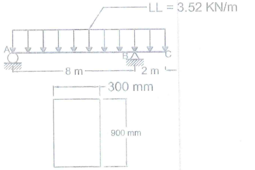

Fig. 3 for Question 3(b)

4. Design a Prestressed concrete beam for a simple span of 30 m (**Fig. 4**) having an overall depth of 1.7 m. The beam is to support a total load of 20 kN/m including self-weight. [CO3, PO3: 30]

   Given: $f_c' = 35$ MPa, $f_{pu} = 1600$ MPa , $f_{so} = 0.7\ f_{pu}$

   $f_t = -13.5$ Mpa , $f_b = -19.5$ MPa

$f_t = 2.1$ MPa , $f_b = 1.65$ MPa
Design as T beam and assume total loss=20%

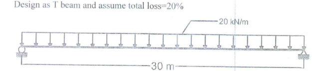

Fig. 4 for Question 4

5. A rectangular prestress concrete beam is shown in **Fig. 5** with deflected cable layout. It has to carry a superimposed dead load of 10.5 kN/m and service live load of 14kN/m in addition to its own weight. Prestressing steel is 1720 MPa Grade strands with total area 1760 mm^2. Calculate the flexural shear and web shear resistance of concrete at a section 4 meter from left support. Hence, find the vertical U-stirrup requirement of the said section. [CO3, PO3: 22.5]
Given: $f_c' = 49$ MPa f_{se}=1050 MPa
f_{vy}= 275 MPa γ_{con}= 24.1 kN/m3

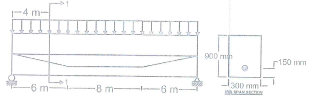

Fig. 5 for Question 5

6. Determine the bearing plate area for a tendon consisting of 12-12.7 mm diameter, 7 wire strands, **Fig. 6**. At time of posttensioning assume fci' is approximately 28 MPa and at service load after losses f'c = 38 MPa. The tendon forces for design are: 1700 kN due to maximum jacking force and 1320 kN at service lod after losses. Follow the guide specifications of the Post-Tensioning Institute (PTI) for allowable bearing stress on the concrete. [CO3, PO3: 15]

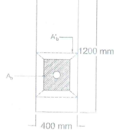

Fig. 6 for Question 6

Supporting equations:

f_{ps}= Stress in steel at failure

According to ACI code, for bonded tendon:

$$f_{ps} = f_{pu}[1 - 0.5\rho_p \frac{f_{pu}}{f'_c}]$$ Provide that, $f_{se} \geq 0.5 f_{pu}$

According to ACI Code, for un-bonded tendon:

$$f_{ps} = f_{se} + 69 + \frac{f'_c}{100\rho_p} \text{ where } f_{ps} \leq f_{py} \text{ and } f_{ps} \leq f_{se} + 414$$

For rectangular sections (prestressed + nonprestressed steel)

$M_n = A_{ps} f_{ps} (d_p - a/2) + A_s f_y (d - a/2)$

$$a = \frac{A_{ps} f_{ps} + A_s f_y}{0.85 f'_c b}$$

d_p=distance from extreme compression fiber to c.g. of PS

d= distance from extreme compression fiber to c.g. of nonprestressed steel

For Flanged sections (prestressed + nonprestressed steel):

$M_n = A_{pw} f_{ps} (d_p - a/2) + A_s f_y (d - a/2) + A_{pf} f_{ps} (d_p - h_f/2)$

Where, $A_{pw} = A_{ps} - A_{pf}$ and $a = (A_{pw} f_{ps} + A_s f_y)/(0.85 f'_c b_w)$

When prestressed+nonprestressed steel used, $f_{ps} = f_{pu}[1 - 0.5(\rho_p \frac{f_{pu}}{f'_c} + \frac{d}{d_p}\omega)]$

$\omega = \rho(f_y/f'_c)$ and $\rho = A_s/bd$ (nonprestressed steel)

$F = M_T/0.65h$, if M_G is large.

$F = M_L/0.5h$, if M_G is small.

$A_c = F/(0.5 f_c)$

[f_c= allowable compressive stress in concrete at service load= .45f'_c]

$e - k_b = M_G/F_o$

$e_1 = f'_t A k_b / F_o$ $\quad e_2 = M_G/F_o$ $\quad e_1 + e_2 = (M_G + f'_t A k_b)/F_o$

$F = M_T/(e + k_t)$

$f'_b = M' c_b / I = M' c_b / A r^2 = M'/A k_t$

$A_c = F_o h/(f_b c_t)$

$A_c = Fh/(f_t c_b)$

$\Rightarrow M' = f'_b A k_t$

$$A_c = \frac{Fh}{f_t c_b}$$

$M_T - M' = M_T - f'_b A k_t$

$\Rightarrow F = (M_T - f'_b A k_t)/(e + k_t)$

$$A_c = \frac{F_0}{f_b}\left(1 + \frac{e - (\frac{M_G}{F_0})}{k_t}\right) \quad \Rightarrow A_c = \frac{F_o h}{f_b c_t - f_t c_b} \quad \Rightarrow A_c = \frac{Fh}{f_t c_b - f_b c_t}$$

$V_{ci}=0.05b_w d\sqrt{f_c} + V_d + V_i M_{cr}/M_{max}$ For SI Unit i.e, N and mm

$M_{cr}=I/y_t(0.5\sqrt{f_c}+f_{pe}-f_d)$ For SI Unit i.e, N and mm

$M_{max}/V_i=(lx-x^2)/(l-2x)$

$V_{cw}=0.29\sqrt{f_c}b_w d+0.3f_{pc}b_w d+V_p$ For SI Unit i.e, N and mm

V_p= vertical component of prestress= $F_e\sin\theta$

$f_{pc}= F_e/A$

Shear, web reinforcement : ACI Code specification

$V_u=\phi V_n=\phi V_c+\phi V_s$

$=>\phi V_s= V_u-\phi V_c=A_v f_y d/s$

$=> s=\phi A_v f_y d/(V_u-\phi V_c)$

V_c is the smaller value of V_{ci} and V_{cw}.

s_{max}= smaller of[$A_v f_y/(0.34b_w)$, 0.75h or 610 mm]

At service load—

$f_{cp}=0.6f'_c\sqrt{A'_b/A_b}$

but not greater than f'_c

At transfer load—

$f_{cp}=0.8f'_{ci}\sqrt{(A'_b/A_b)-0.2}$

but not greater than $1.25f'_{ci}$