Second Semester Examination
2021/2022 Academic Session

July/August 2022

EAS458 – Pre-Stressed Concrete Design

Duration : 1 hour

Please ensure that this examination paper contains **FIVE (5)** printed pages including appendix before you begin the examination.

Instructions: This paper contains **THREE (3)** questions. Answer **TWO (2)** questions.

All questions **MUST BE** answered on a new page.

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1. (a) A concrete beam of 10 m span, 250 mm wide and 300 mm deep, is pre-stressed by two cables. The cross-sectional area of each cable is 139 mm^2, and the initial stress in the cable is 1336 MPa for each cable. Cable 1 is in a parabolic profile with an eccentricity of 50 mm above the centroid at the ends, and 50 mm below the centroid at the centre of the span. Cable 2 is in a straight line with 100 mm uniform eccentricity below the centroid. Determine the maximum service load (excluding the self-weight) this beam can carry by considering only the allowable section stresses at the mid-span with no tension.
Use $\gamma_{\text{con.}} = 25\,\text{kN/m}^3$, $f_{\text{ck}}(t) = 27\text{ MPa}$ and concrete strength C40/50. Assume total losses are 20%.

[40 marks]

(b) Based on the solution in (a), discuss any significant effect on the determination of the maximum service load this beam can carry if the concrete class is increased to C50/60.

[10 marks]

2. (a) A post tensioned beam with cross-sectional dimension of 400 mm × 900 mm is equipped with a double tendon arrangement. The depth of the tendons at midspan measured from the top of the beam to the centre of the tendon is 600 mm and 750 mm. Each tendon consists of pre-stressing strand with area, A_{ps} = 1056 mm^2 and characteristic tensile strength, f_{pk} = 1860 N/mm^2. If the initial pre-stress applied to each tendon is 1100 N/mm^2 and 30% losses are anticipated, verify that x = 372 mm can be used as the depth of the neutral axis. Subsequently, determine the ultimate moment of resistance for the section. Consider f_{ck} = 40 N/mm^2, E_p = 205 kN/mm^2, γ_m = 1.15 and γ_p = 0.9.

[45 marks]

(b) Briefly discuss **ONE (1)** of the most practical solutions to increase the moment of resistance of a pre-stressed beam.

[5 marks]

3. A pre-stressed concrete beam shown in **Figure 1** is constant in cross-section over a 25 m simply supported span equipped with a parabolic tendon profile. The tendon is located 300 mm below the centroid at both ends and 750 mm at mid-span. The beam supports an ultimate uniformly distributed load of 42 kN/m and f_{ck} = 40 N/mm^2.

Given data:

Pre-stress force after losses = 2600 kN

A_{s1} = 3500 mm^2

A = 520 x10^3 mm^2

A_{ps} = 3700 mm^2

f_{yk} = 500 N/mm^2 for the shear links

f_{ctk} = 2.2 N/mm^2

γ_c = 1.5

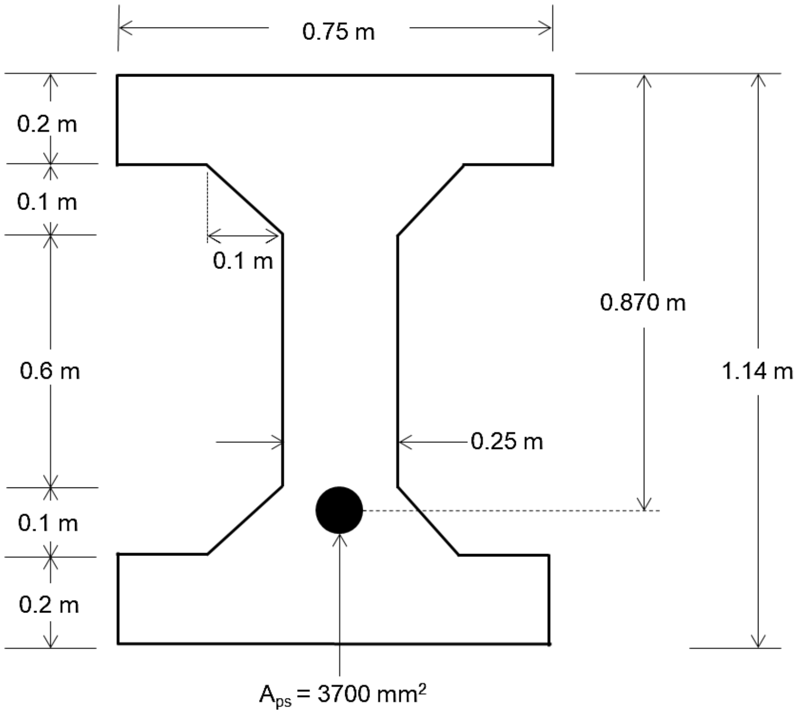

Figure 1

(a) Determine shear force for the section.

[5 marks]

(b) Assess if shear reinforcement is required.

[15 marks]

(c) Evaluate the crushing strength $V_{Rd,max}$ of the concrete strut.

[10 marks]

(d) Determine the area and spacing of links.

[7 marks]

(e) Determine the minimum link requirement.

[8 marks]

(f) Determine the additional longitudinal force.

[5 marks]

APPENDIX

Governing inequalities:

At transfer:

$$\frac{P_{\mathrm{m0}}}{A_{\mathrm{c}}} - \frac{P_{\mathrm{m0}}e}{Z_{\mathrm{t}}} + \frac{M_0}{Z_{\mathrm{t}}} \geq f_{\mathrm{ct,0}} --- \text{top fibre}$$

$$\frac{P_{\mathrm{m0}}}{A_{\mathrm{c}}} + \frac{P_{\mathrm{m0}}e}{Z_{\mathrm{b}}} - \frac{M_0}{Z_{\mathrm{b}}} \leq f_{\mathrm{cc,0}} --- \text{bottom fibre}$$

At service:

$$\frac{P_{\mathrm{m,t}}}{A_{\mathrm{c}}} - \frac{P_{\mathrm{m,t}}e}{Z_{\mathrm{t}}} + \frac{M_{\mathrm{T}}}{Z_{\mathrm{t}}} \leq f_{\mathrm{cc,t}} --- \text{top fibre}$$

$$\frac{P_{\mathrm{m,t}}}{A_{\mathrm{c}}} + \frac{P_{\mathrm{m,t}}e}{Z_{\mathrm{b}}} - \frac{M_{\mathrm{T}}}{Z_{\mathrm{b}}} \geq f_{\mathrm{ct,t}} --- \text{bottom fibre}$$

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