Second Semester Examination
2020/2021 Academic Session

July/August 2021

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.

1. A simply supported post-tensioned prestressed beam of a rectangular section 300 mm wide is to be designed for a permanent load of 2.5 kN/m (excluding self-weight) and a variable load of 5.5 kN/m which is uniformly distributed on a span of 10 m. The member is to be designed with a concrete strength class C50/60. The equations for inequalities are given in the **Appendix**.

(a). Taking the density of pre-stressed concrete to be 25 kN/m^3 and the characteristic compressive strength of the concrete at transfer is 33 MPa, determine the minimum depth of the beam if the losses are 20%.

[18 marks]

(b). If the economic value of pre-stressing force is to be designed for this section, determine the range of eccentricities at the mid-span for the cable zone limit.

[32 marks]

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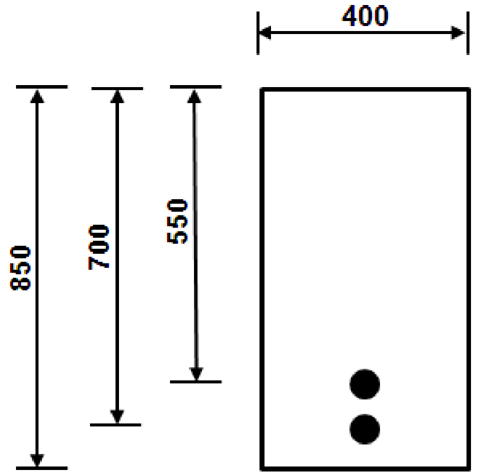
2. **Figure 1** shows the cross-section of a 400 mm × 850 mm post-tensioned beam at the mid-span and the corresponding double tendon. Each tendon consists of prestressing strand with area, A_{ps} = 1056 mm^2 and characteristic tensile strength, f_{pk} = 1770 N/mm^2. If the initial pre-stress applied to each tendon is 1000 N/mm^2 and 30% losses are anticipated, determine the ultimate moment of resistance for the section. Take f_{ck} = 40 N/mm^2, E_p = 205 kN/mm^2, γ_m = 1.15 and γ_p = 0.9. Verify that x = 349 mm can be used as the depth of the neutral axis.

[40 marks]



All dimensions in mm

Figure 1

(b). In the case where the ultimate moment of resistance (M_{Rd}) is found to be slightly lower than the design moment (M_{Ed}), propose with justification **TWO (2)** economical methods that can be adopted in order to increase M_{Rd}.

[10 marks]

3. **Figure 2** shows the end and side elevations of anchorage zone of a flexural member with the given dimensions. The size of the square bearing plate is 315 mm with a duct diameter of 106 mm. Given the strength of concrete at transfer is 35 MPa and jacking force is 3000 kN. Assuming the design load is 1.15 Pj and Ø=0.6, determine

(a). the design strength by considering bearing is taken as 50 % greater than the value obtained in the equation below.

$$F_b = \emptyset \times 0.85 f'_{ci} \sqrt{\frac{A_2}{A_1}} \qquad (\leq \emptyset \times 1.7 f'_{ci})$$

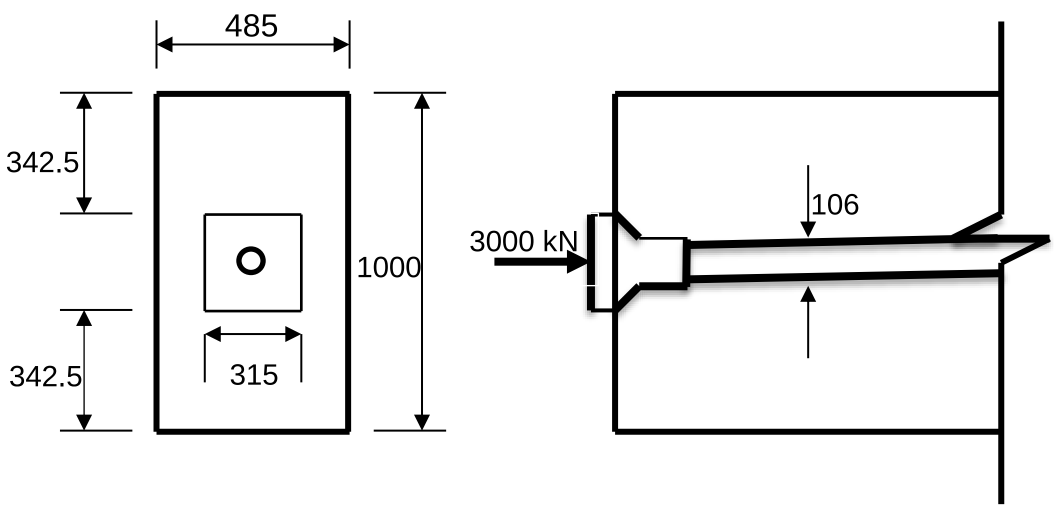
[15 marks]

(b). the amount of vertical transverse reinforcement by assuming σ_s=150 MPa.

[18 marks]

(c). the amount of horizontal transverse reinforcement.

[17 marks]



All dimensions in mm

Figure 2

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:

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

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

Minimum section moduli:

$$(M_T - \Omega M_0) \leq (f_{cc,t} - \Omega f_{ct,0})Z_t$$
$$(M_T - \Omega M_0) \leq (\Omega f_{cc,0} - f_{ct,t})Z_b$$

Losses:

The remaining force after elastic shortening, P'(pretensioned) $= \dfrac{P_{m0}}{1 + m\dfrac{A_{\mathrm{p}}}{A_{\mathrm{c}}}\left(1 + \dfrac{e^2 A_{\mathrm{c}}}{I}\right)}$

Loss of prestressing force due to creep $= E_{\mathrm{p}}P'\dfrac{A_{\mathrm{p}}}{A_{\mathrm{c}}}\left(1 + \dfrac{e^2 A_{\mathrm{c}}}{I}\right)\left(\dfrac{\varphi(\infty, t_0)}{1.05E_{\mathrm{cm,0}}}\right)$

Loss in prestressing force due to shrinkage $= \varepsilon_{\mathrm{cs}}E_{\mathrm{p}}A_{\mathrm{p}}$

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