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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS 40303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE/JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

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Q1 (a) Illustrate the usual stages in producing a post-tensioned member.

(6 marks)

(b) A rectangular concrete beam of cross-section 300 mm deep and 200 mm wide is prestressed by means of 15 wires of 5 mm diameter located 65 mm from the bottom of the beam and 3 wires of diameter of 5 mm, 25 mm from the top. Assume the effective prestress in the steel is 840 N/mm^2. The beam is supporting its own weight over a span of 6 m and uniformly distributed live load of 6 kN/m is imposed. The density of concrete is 24 kN/m^3.

(i) Develop the stresses at the extreme fibres of the mid-span section.

(12 marks)

(ii) Evaluate the maximum working stress in concrete.

(7 marks)

Q2 (a) Distinguish between concentric and eccentric tendons by indicating their applications.

(10 marks)

(b) A prestressed concrete pile, 250 mm square, contains 60 pre-tension wires that are initially tensioned on the prestressing bed with a total force of 300kN. Given the following data :

Es: 210 kN/mm^2
Ec:32 kN/mm^2
Shortening due to creep: 30 X 10^{-6} mm/mm per N/mm2 of stress
Total Shrinkage: 200 X 10^{-6} per unit length
Relaxation of Steel stress : 5%

Evaluate the final stress in concrete and the percentage losses of stress in steel.

(15 marks)

Q3 (a) Describe the significance of minimum prestressing force, corresponding maximum eccentricity in the design of prestressing concrete section.

(5 marks)

(b) A prestressed concrete beam supports a live load of 5 kN/m along a simply supported span of 10 m. The beam has an I-section as shown in **FIGURE Q3**. The beam is to be prestressed by an effective prestressing force of 240 kN at a suitable eccentricity such that the resultant stresses at the soffit of the beam at the mid-span is zero. Use density of concrete = 24 kN/m^3

(i) Determine the eccentricity required for the prestressed concrete beam

(10 marks)

(ii) If the tendon is concentric, generate the magnitude of the prestressing force for the resultant stress to be zero at the bottom fibre at the central span section.

(10 marks)

Q4 A post-tensioned prestressed beam of rectangular section 250 mm wide is to be designed for an imposed load of 12 kN/m, uniformly distributed on a span of 12 m. The stress in the concrete must not exceed 17 N/mm^2 in compression and 1.4 N/mm^2 in tension at any time and the loss of prestress may be assumed to be 15%.

(a) Determine the minimum depth of the beam.

(5 marks)

(b) Calculate the minimum prestressing force and corresponding eccentricity.

(10 marks)

(c) Construct the Magnel diagram and evaluate the minimum prestressing force corresponding to eccentricity.

(10 marks)

Q5 The cross section of a prestressed concrete composite beam is shown in **FIGURE Q5**. The beam is to span 20 m on simple supports and carry a characteristic imposed dead load of 4.5 kN/m and a characteristic imposed live load of 5 kN/m. The method of construction used was unshored. The following information is given:

Precast beam (Class 1)

fci = 30 MPa; fcu = 50 MPa; Eci = 27 GPa; Ec = 32 GPa; Ac = 324,400 mm^2;
Ig = 38.1 x 10^9 mm^4; $(dc)_{min}$ = 120 mm ; η = 0.8

Cast-in-place slab

$f\bar{cu}$ = 30 MPa; Ec = 27 GPa; $(\sigma_{cs})_{slab}$ = 10 MPa

Composite section

A_{cc} = 552,250 mm^2; I_{gc} = 90 x10^9 mm^4; Y_{bc} = 711 mm; Z_{tc} = 205 x 10^6 mm^3;
Z'_{tc} = 311 x 10^6 mm^3; Z_{bc} = 127 x 10^6 mm^3

(a) Justify the adequacy of 150 mm thickness of the slab.

(10 marks)

(b) Develop the minimum initial prestressing force necessary at mid-span using direct solution approach and graphical construction.

(15 marks)

- END OF QUESTIONS -

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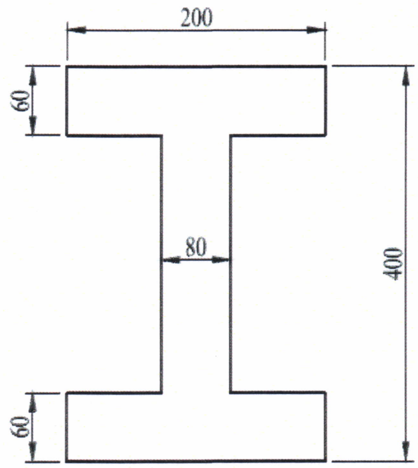
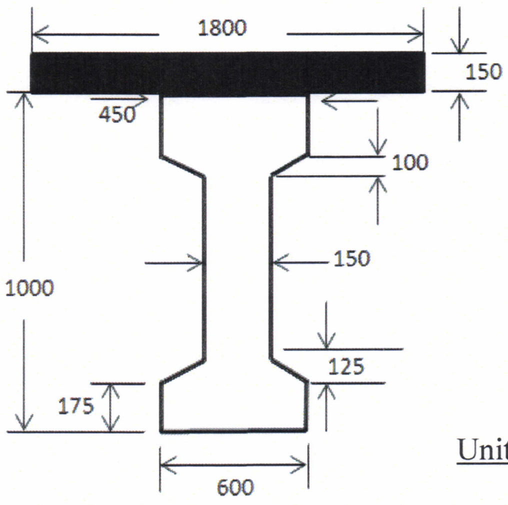


Unit in mm

FIGURE Q3



Unit in mm

FIGURE Q5

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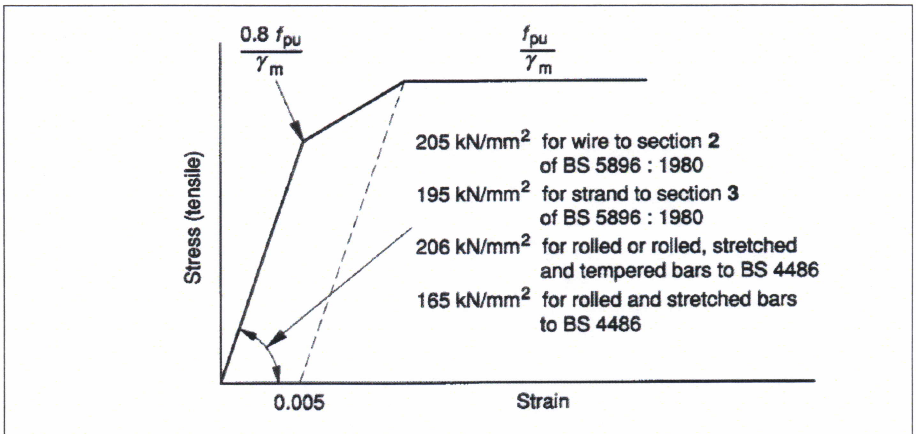
APPENDIX

(A) Stress-Strain Curve of Prestressing Tendons



NOTE f_{pu} is in N/mm².

(B) Basic Inequalities

$$\frac{\alpha P_i}{A} - \frac{\alpha P_i e}{Z_t} + \frac{M_i}{Z_t} \geq f_{tt}$$

$$\frac{\alpha P_i}{A} + \frac{\alpha P_i e}{Z_b} - \frac{M_i}{Z_b} \geq f_{ct}$$

$$\frac{\beta P_i}{A} - \frac{\beta P_i e}{Z_t} + \frac{M_s}{Z_t} \geq f_{cs}$$

$$\frac{\beta P_i}{A} + \frac{\beta P_i e}{Z_b} - \frac{M_s}{Z_b} \geq f_{ts}$$

$$Z_t \geq \frac{M_{max} - \eta M_{min}}{f_{cs} - \eta f_{tt}}$$

$$Z_b \geq \frac{M_{max} - \eta M_{min}}{\eta f_{ct} - f_{ts}}$$

$$P_i \geq \frac{Z_t f_{tt} - M_i}{\propto \left(\frac{Z_t}{A} - e\right)}$$

$$P_i \leq \frac{Z_b f_{ct} + M_i}{\propto \left(\frac{Z_b}{A} + e\right)}$$

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$$P_i \leq \frac{Z_t f_{cs} - M_s}{\beta\left(\frac{Z_t}{A} - e\right)}$$

$$P_i \geq \frac{Z_b f_{ts} + M_s}{\beta\left(\frac{Z_b}{A} + e\right)}$$

(C) Strain Compatibility Analysis

$$\varepsilon_{pb} = \varepsilon_{pe} + \varepsilon_{pa}$$

$$\varepsilon_{pe} = \frac{\beta P}{A_{ps} E_s}$$

$$\varepsilon_{pa} = \beta_1 \varepsilon_e + \beta_2 \varepsilon_u$$

Where;

β_1 and β_2 = bond coefficients

β_1 and β_2 = 1.0 for fully bonded tendon

$\varepsilon_e = \frac{1}{E_c}$ x stress in concrete at tendon level due to effective prestress.

$$\varepsilon_e = \frac{\beta}{E_c}\left[\frac{P}{A} + \frac{Pe^2}{I}\right]$$

$$\varepsilon_u = \frac{d-x}{x}\varepsilon_{cu}$$

where ε_{cu} = 0.0035

$$\varepsilon_{pb} = \varepsilon_{pe} + \beta_1 \varepsilon_e + \beta_2 \varepsilon_{cu}\left(\frac{d-x}{x}\right)$$

$$x = \left[\frac{\beta_2 \varepsilon_{cu}}{\beta_2 \varepsilon_{cu} + \varepsilon_{pb} - \varepsilon_{pe} - \beta_1 \varepsilon_e}\right] d$$