UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS40303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	DECEMBER 2018/JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN SECTION A AND **TWO (2)** QUESTIONS FROM SECTION B

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

SECTION A: ANSWER **ALL** QUESTIONS

Q1 (a) Discuss **TWO (2)** advantages of post-tensioning compared to pre-tensioning.
(6 marks)

(b) **Figure Q1** shows a composite section of a bridge deck. The deck slab is cast in-situ on the precast prestressed beam. Sketch the flexural stresses at various stages of loading if the beam is:

(i) Unpropped.

(ii) Propped.

(8 marks)

(c) A 10m long rectangular beam of cross section 350 mm x 700 mm, which is subjected to uniformly distributed load of 20 kN/m, has a minimum cover distance of 150 mm from soffit anywhere on the beam. Assume density of concrete to be 24 kN/m^3. By using load balancing method, suggest the cable profile and the prestressing force for:

(i) Deflected tendon.

(ii) Parabolic tendon.

(11 marks)

SECTION B: ANSWER **TWO** QUESTIONS ONLY

Q2 **Figure Q2** shows the plan view, side elevation and cross section of a pedestrian bridge using precast prestressed concrete deck slab. The slab carries a service load of 5 kN/m^2. Given the following information,

Unit weight of concrete	=	24 kN/m^3
Short term losses	=	10%
Total losses (short + long)	=	20%
Maximum allowable concrete stress at transfer, f'_{max}	=	20 MPa
Maximum allowable concrete stress at service, f_{max}	=	16.7 MPa
Minimum allowable concrete stress at transfer, f'_{min}	=	-1.0 MPa
Minumum allowable concrete stress at service, f_{min}	=	0 MPa

(a) Evaluate the initial and service bending moments of the slab.
(6 marks)

(b) Determine the minimum depth (D) of slab required.
(10 marks)

(c) Round up the minimum depth of slab required to the nearest 5 mm and assume the maximum eccentricity of the wires at mid-span is 50 mm above the sofit. Calculate the minimum prestress force required.

(9 marks)

Q3 **Figure Q3** shows the post-tensioned unbounded prestressed concrete T-beam. The properties of the section are as follows:

Strength of concrete	=	40 N/mm^2
Young's Modulus of concrete	=	28 kN/mm^2
Strength of prestressing tendons	=	1770 N/mm^2
Young's Modulus of tendons	=	195 kN/mm^2
Moment of inertia	=	3.53 x 10^{10} mm^4
Cross sectional area of tendons	=	2232 mm^2
Initial prestressing force	=	3150 kN
Total losses	=	25%
Bond factors:		
β_1	=	0.5
β_2	=	0.2

(a) Determine the neutral axis. Assume it is located in the web. Use strain compatibility approach.

(20 marks)

(b) Evaluate the ultimate moment of resistance. Use the neutral axis obtained in **Q3 (a).**

(5 marks)

Q4 Two horizontal cables, each comprising 7 strands of 18.0 mm diameter, are symmetrically anchored in a rectangular end block 450 mm wide and 1200 mm deep. The anchorages have 250 mm square bearing plates and are placed 700 mm apart as shown in **Figure Q4**. The maximum jacking force at transfer of prestress is 1750 kN in each cable. Both cables are stressed simultaneously. The following information is given:

Concrete strength at transfer	=	35 N/mm^2
Concrete strength at 28 days	=	50 N/mm^2
Limiting steel stress	=	150 N/mm^2

Assuming that the dimensions of the bearing plates are adequate to exclude bearing failure of the concrete, design the reinforcement for the end block.

(25 marks)

- END OF QUESTIONS-

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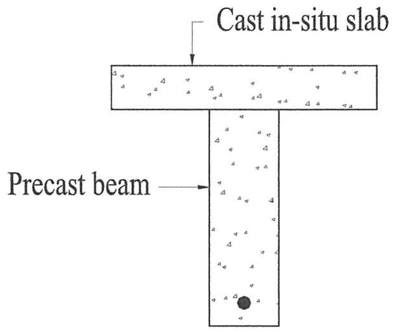

FIGURE Q1

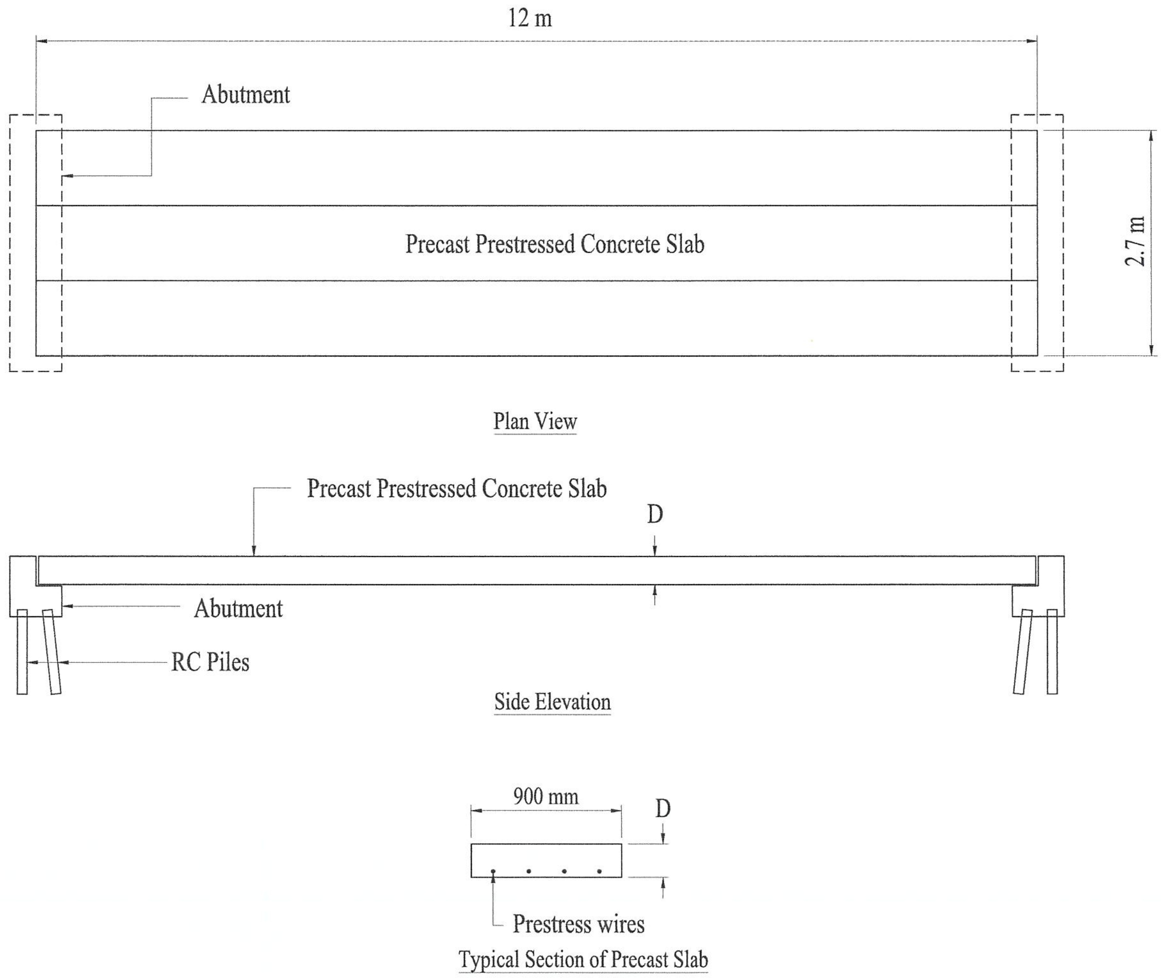

FIGURE Q2

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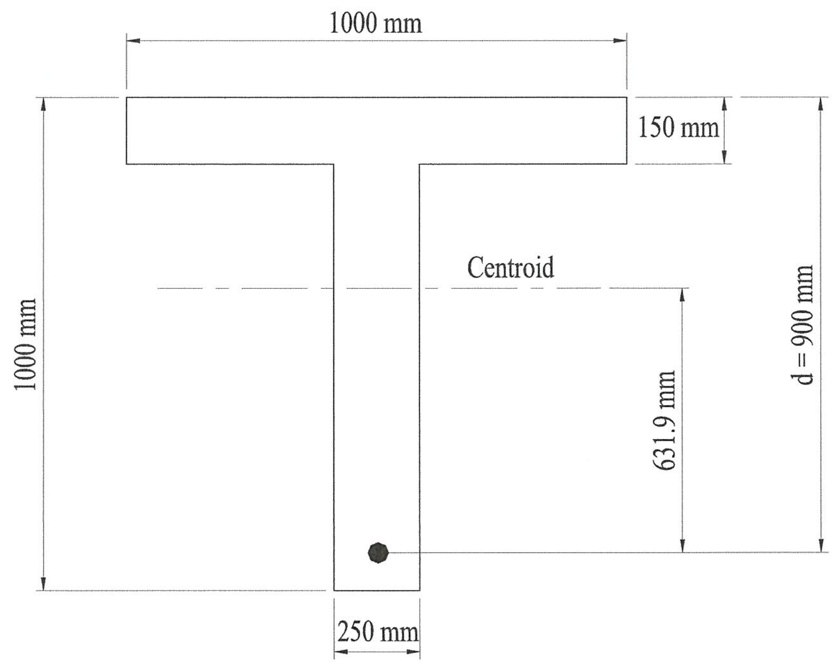

FIGURE Q3

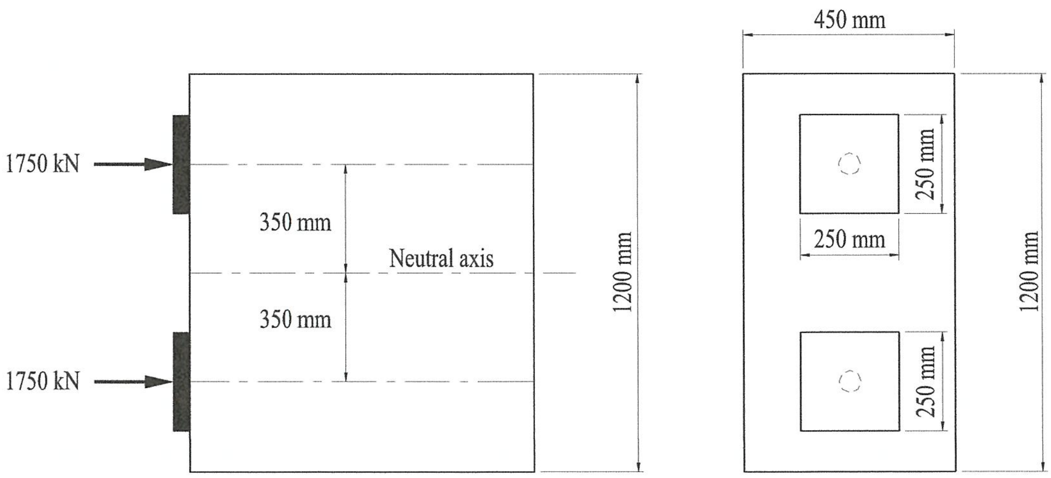

FIGURE Q4

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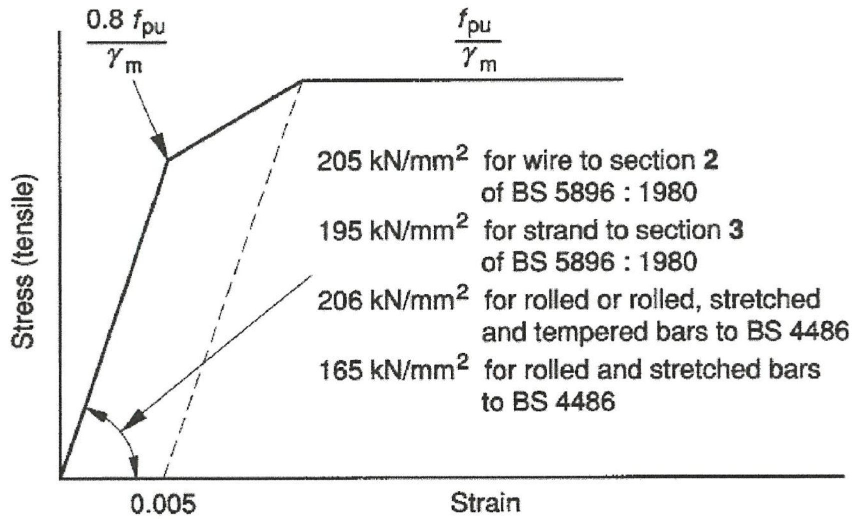
APPENDIX

(A) Stress-Strain Curve of Prestressing Tendons



(B) 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.

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

$$f_{pb} = \frac{0.4 f_{cu} b d}{A_{ps}}\left(\frac{\beta_2 \varepsilon_{cu}}{\beta_2 \varepsilon_{cu} + \varepsilon_{pb} - \varepsilon_{pe} - \beta_1 \varepsilon_e}\right) + \frac{0.45}{A_{ps}}(b - b_w) h_f$$ .... (for T section neutral axis in web)

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

where $\varepsilon_{cu} = 0.0035$

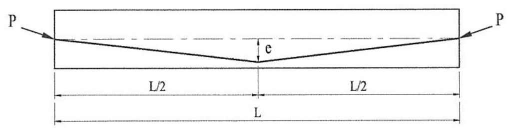
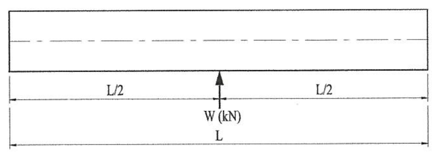
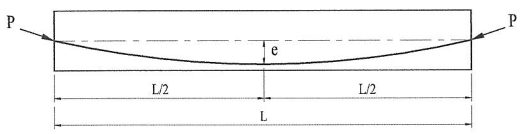
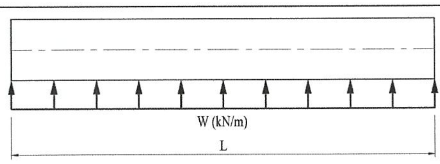
$$\varepsilon_{pb} = \varepsilon_{pe} + \beta_1\varepsilon_e + \beta_2\varepsilon_{cu}\left(\frac{d-x}{x}\right)$$

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

$M_u = 0.4f_{cu}b_wx(d - 0.45x) + 0.45f_{cu}(b - b_w)h_f(d - 0.5h_f)$... (For T section neutral axis in web)

$M_u = A_{ps}f_{pb}(d - 0.45x)$ .... (For T section neutral axis in flange)

(C) Load Balancing Concept

Prestressing Tendon Profile	Equivalent Loading Pattern	Equivalent load
		$W = \frac{4Pe}{L}$
		$W = \frac{8Pe}{L^2}$

(D) Basic Inequalities

Section Modulus:

$$Z_t \geq \frac{\alpha M_s - \beta M_i}{\alpha f_{max} - \beta f'_{min}}$$

$$Z_b \geq \frac{\alpha M_s - \beta M_i}{\beta f'_{max} - \alpha f_{min}}$$

Prestressing Force:

$$P_i \geq \frac{Z_t f'_{min} - M_i}{\alpha(\frac{Z_t}{A_c} - e)}$$

$$P_i \leq \frac{Z_t f_{max} - M_s}{\beta(\frac{Z_t}{A_c} - e)}$$

$$P_i \leq \frac{Z_b f'_{max} + M_i}{\alpha(\frac{Z_b}{A_c} + e)}$$

$$P_i \geq \frac{Z_b f_{min} + M_s}{\beta(\frac{Z_b}{A_c} + e)}$$