UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

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

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

SECTION A: ANSWER **ALL** QUESTIONS

Q1 (a) Discuss **THREE (3)** circumstances prestressed concrete will have priority over reinforced concrete.

(6 marks)

(b) A post-tensioned bridge girder has encountered severe cracks due to localised corrosion problems caused by poor grouting of the tendons. Discuss the effect of this durability problem on the structural capacity of the girder. Propose a solution using prestressing method to strengthen the existing girder.

(8 marks)

(c) **Figure Q1(c)** shows a centroidal axial prestress beam of a rectangular cross section subjected to a uniformly distributed load of w. The initial prestressing force is P. Prove that $w = \frac{4Pd}{3L^2}$ when no tensile stress is allowed.

(11 marks)

SECTION B: ANSWER **TWO** QUESTIONS ONLY

Q2 **Figure Q2** shows the cross section of a 20 m span simply supported post-tensioned concrete beam. The prestressed beam contains 18 nos of 7-wire standard strand of 15.2 mm diameter each. The prestressing wires are fully bonded and stressed up to 72.5%. The beam carries a dead load and live load of 13 kN/m and 12 kN/m respectively, in addition to the self-weight. The total prestress loss is 25%. Given the following data:

Strength of concrete at 28 days	=	40 MPa
Young's Modulus of concrete	=	28 GPa
Young's Modulus of prestressing wire	=	205 GPa
Strength of wire, f_{pu}	=	1670 N/mm^2
Cross sectional area of prestressing wire	=	139 mm^2
Cross sectional area of concrete	=	490 x 10^3 mm^2
Moment of inertia	=	70.1 x 10^9 mm^4
Unit weight of concrete	=	24 kN/m^3

Determine ultimate moment resistance of the section. Use strain compatibility analysis.

(25 marks)

Q3 **Figure Q3** shows a prestressed inverted T-beam has the cross sectional area of 310 x 10^3 mm^2 and second moment of area of 36 x 10^9 mm^4. The area of the prestressing tendon is 1800 mm^2 which has strength of 1750 N/mm^2. The tendon is located at a distance of 290 mm below the neutral axis and stressed up to 60% of its strength in service. The concrete is grade 50. Design the section for a shear of 400 kN and associated moment of 800 kNm.

(25 marks)

Q4 **Figure Q4** shows the solid end-block of a post-tensioned prestressed beam of 25 m span containing three cables, each of 7-15 mm strands and tensioned up to 1200 kN. The anchorage plates are square with a side length of 180 mm. Design the end block for resisting the bursting forces. Use steel reinforcement of 10 mm diameter and steel stress is limited to 200 MPa.

(25 marks)

- END OF QUESTIONS-

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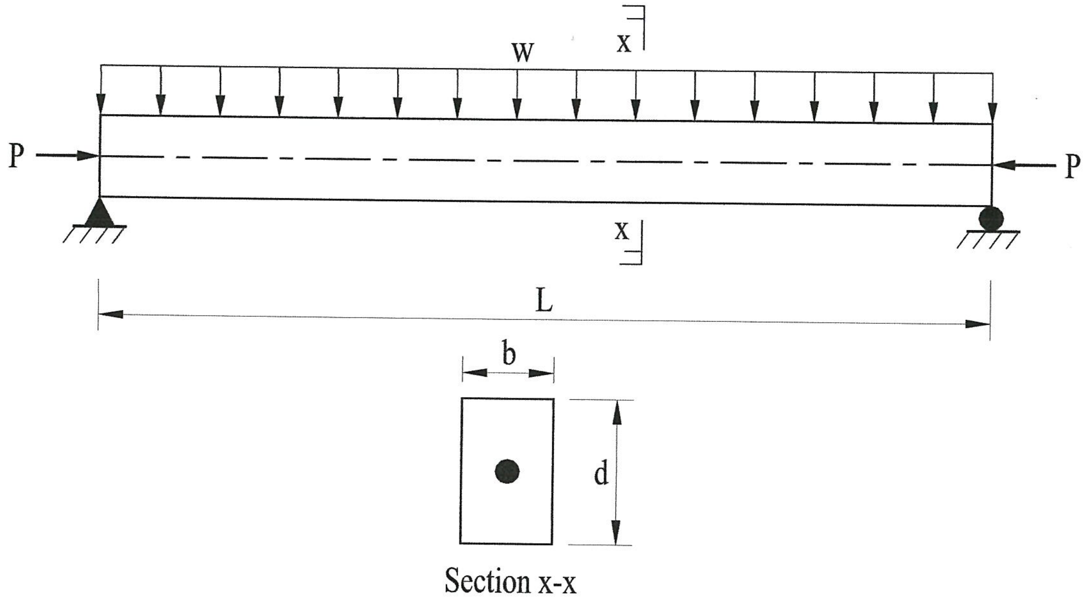

FIGURE Q1(C)

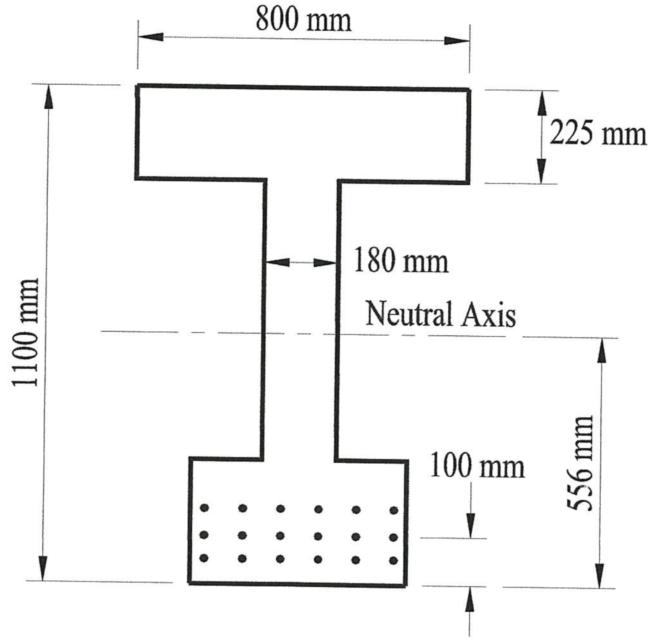

FIGURE Q2

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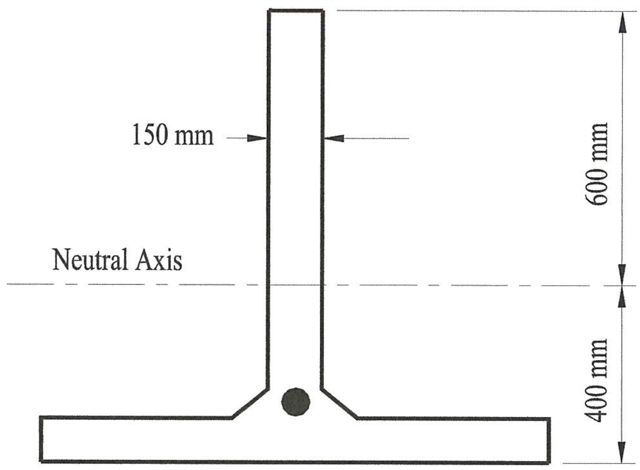

FIGURE Q3

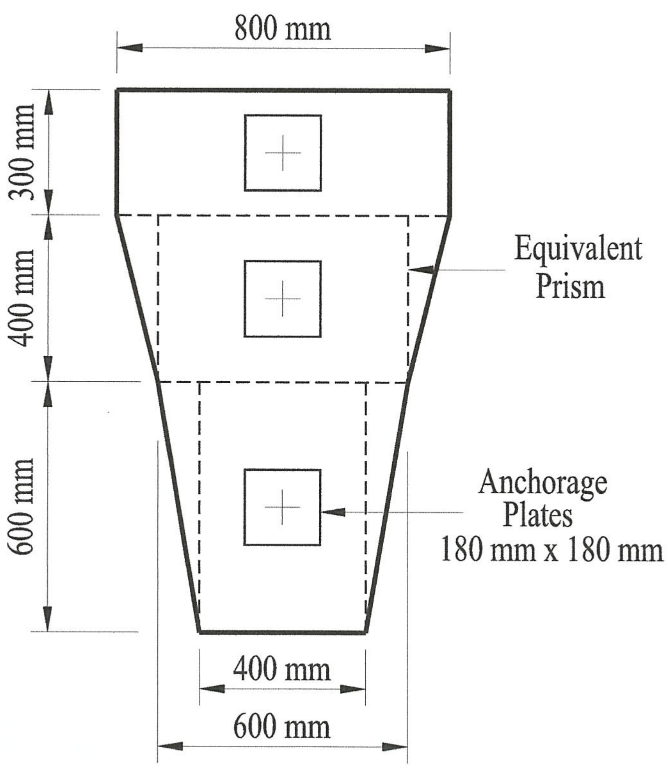

FIGURE Q4

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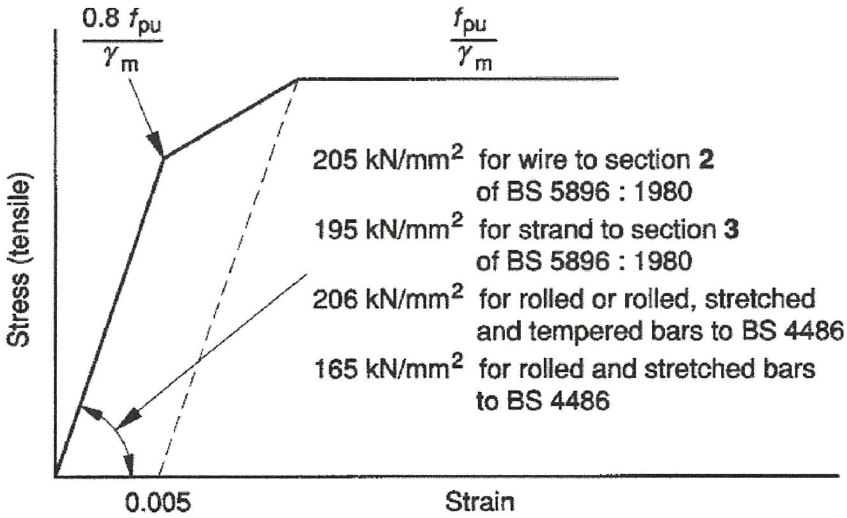
APPENDIX

(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.

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

$$f_{pb} = \frac{0.4 f_{cu} bd}{A_{ps}}\left(\frac{\beta_2 \varepsilon_{cu}}{\beta_2 \varepsilon_{cu} + \varepsilon_{pb} - \varepsilon_{pe} - \beta_1 \varepsilon_e}\right) + \frac{0.45}{A_{ps}}(b - b_w) h_f$$

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

where $\varepsilon_{cu} = 0.0035$

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

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

$$M_u = 0.4f_{cu}b_w x(d - 0.45x) + 0.45f_{cu}(b - b_w)h_f(d - 0.5h_f)$$

(C) Design Shear Resistance of Beams

$$M_o = 0.8\sigma_{pt}(I/y)$$

$$V_{co} = 0.67b_v h\sqrt{(f_t^2 + 0.8f_{cp}f_t)}$$

$$f_t = 0.24(f_{cu})^{1/2}$$

$$f_{cp} = (\beta P)/A_c$$

Values of $V_{co}/b_v h$

f_{cp} N/mm²	Concrete grade			
	30 N/mm²	40 N/mm²	50 N/mm²	60 N/mm²
2	1.30	1.45	1.60	1.70
4	1.65	1.80	1.95	2.05
6	1.90	2.10	2.20	2.35
8	2.15	2.30	2.50	2.65
10	2.35	2.55	2.70	2.85
12	2.55	2.75	2.95	3.10
14	2.70	2.95	3.15	3.30

$$V_{cr} = \left(1 - 0.55\frac{f_{pe}}{f_{pu}}\right) v_c b_v d + M_o \frac{V}{M}$$

$V_{cr} \geq 0.1bd(f_{cu})^{1/2}$

$v_c = (0.79/\gamma_m)(100A_s/bd)^{1/3}(400/d)^{1/4}(f_{cu}/25)^{1/3}$

where, $100A_s/bd \leq 3$

$400/d \geq 1$

$f_{cu}/25$, where $f_{cu} \geq 25$ MPa

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Shear reinforcement where V does not exceed $V_c + 0.4\, b_v d$

$$\frac{A_{sv}}{s_v} = \frac{0.4 b_v}{0.95 f_{yv}}$$

Shear reinforcement where V exceeds $V_c + 0.4\, b_v d$

$$\frac{A_{sv}}{s_v} = \frac{V - V_c}{0.95 f_{yv} d_t}$$

(D) Bursting Forces in End-Blocks

y_{po}/y_o	0.2	0.3	0.4	0.5	0.6	0.7
F_{bst}/P_i	0.23	0.23	0.20	0.17	0.14	0.11

y_o is half the side of the end block
y_{po} is half the side of the loaded area
P_i is the tendon jacking force