UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS 40303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN SECTION A AND **TWO (2)** QUESTIONS FROM SECTION B

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

SECTION A: ANSWER ALL QUESTIONS

Q1 **Figure Q1** shows the elevation and cross section of an arch bridge. The bridge is used for pedestrian. The timber decks are supported by the steel cables welded to the steel hollow section at both sides.

(a) Describe with relevant sketches load path of the overall structural system. Discuss structural behavior of each structure.

(13 marks)

(b) Due to the rapid development of the surrounding area, the bridge is proposed to be opened for the light vehicle to use. However, the timber decks are not able to support the additional traffic load. Therefore, the timber deck is proposed to be strengthened using post-tensioned cable. Illustrate and explain the strengthening method.

(12 marks)

SECTION B: ANSWER TWO QUESTIONS ONLY

Q2 A simply supported post-tensioned concrete beam bridge of 25 m span is shown in **Figure Q2**. The bridge carries a 16 m carriageway with 8 nos of longitudinal precast I-beams sitting on the abutment at both ends. Given the following data:

Thickness of concrete deck	=	150 mm
Thickness of asphalt	=	75 mm
Unit weight of concrete	=	24 kN/m^3
Unit weight of asphalt	=	22 kN/m^3
Self weight of precast I-beam	=	7.5 kN/m
Service load (imposed load)	=	10 kN/m^2
Maximum allowable concrete stress at service load	=	17.0 N/mm^2
Maximum allowable concrete stress at transfer	=	20.0 N/mm^2
Minimum allowable concrete stress at service load	=	0 N/mm^2
Minimum allowable concrete stress at transfer	=	-1.0 N/mm^2

(a) If the total short-term and long-term losses are 12% and 20% respectively, determine the most economic section based on the precast beam section given in **Appendix A**. Assume the prestressed beam is subjected to uniformly distributed load and ignore all other bridge loading.

(15 marks)

(b) Assume I-6 beam is used for the prestressed beam and the maximum eccentricity of the tendons at midspan is 80 mm above the soffit, find the minimum value of the prestress force required. Use the inequalities in **Appendix B**.

(10 marks)

Q3 **Figure Q3** shows the cross section of box girder proposed for a simply supported 24 m spans pedestrian bridge. Given the following data:

Unit weight of concrete	=	24 kN/m^3
Moment of Inertia, I_{xx}	=	92.5 x 10^9 mm^4
Imposed load	=	4.0 kN/m^2
Finishing and services	=	1.0 kN/m^2
Total prestress losses	=	20 %
Maximum allowable concrete stress at service load	=	17.0 N/mm^2
Maximum allowable concrete stress at transfer	=	20.0 N/mm^2
Minimum allowable concrete stress at service load	=	0 N/mm^2
Minimum allowable concrete stress at transfer	=	-1.0 N/mm^2

(a) Determine the maximum bending moment due to self-weight and service load. (6 marks)

(b) Construct the Krishnamurthy Magnel diagram. (16 marks)

(c) Identify the range of prestress force if the maximum eccentricity of the tendons at midspan is 100 mm above the soffit. (3 marks)

Q4 A horizontal cable comprising 7 strands of 18 mm diameter is anchored in a rectangular end block 500 mm wide and 1000 mm deep using a 250 mm square bearing plate placed at a distance of 250 mm above the bottom soffit as shown in **Figure Q4**. Given the following information.

Strength of concrete, f_{cu}	=	45 MPa
Strength of concrete at transfer, f_{ci}	=	30 MPa
Allowable maximum stress of steel, f_s	=	150 MPa

Based on beam analogy:

(a) Design the reinforcement for bursting tension forces (14 marks)

(b) Design the reinforcement for splitting tension force. (8 marks)

(c) Draw the reinforcement details. (3 marks)

- END OF QUESTIONS-

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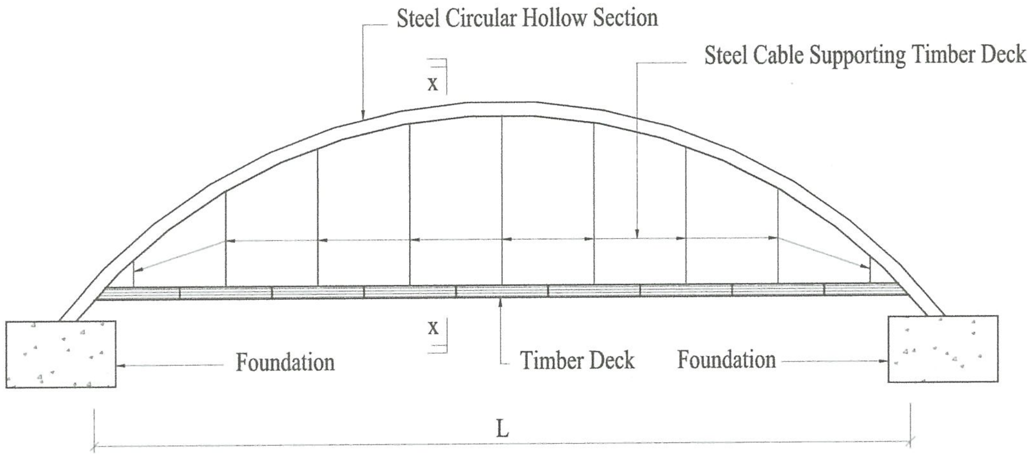
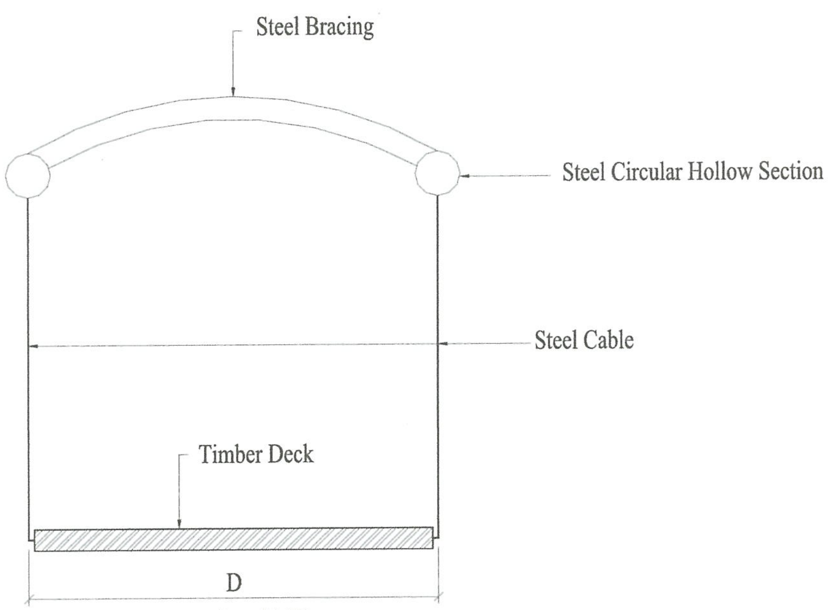


Elevation



Section X-X

FIGURE Q1

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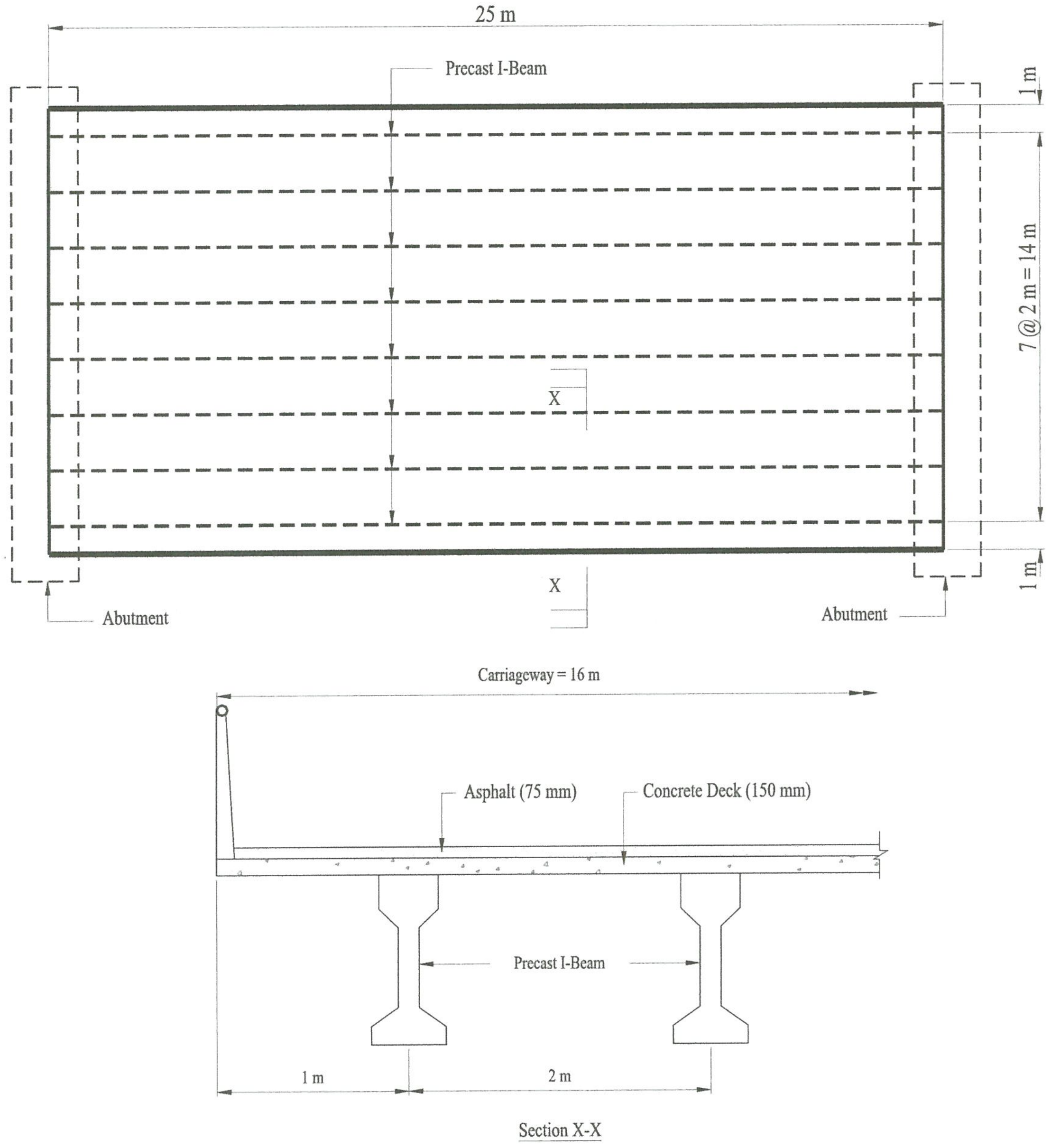

FIGURE Q2

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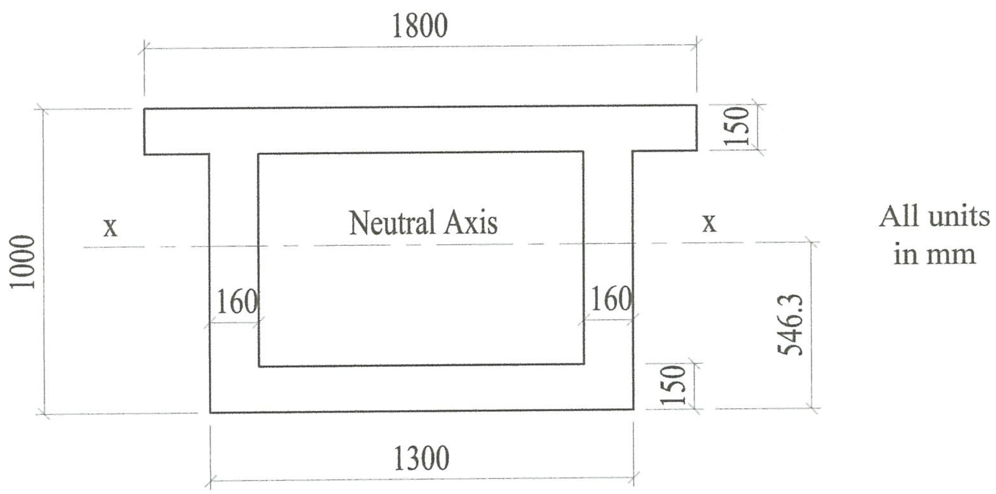

FIGURE Q3

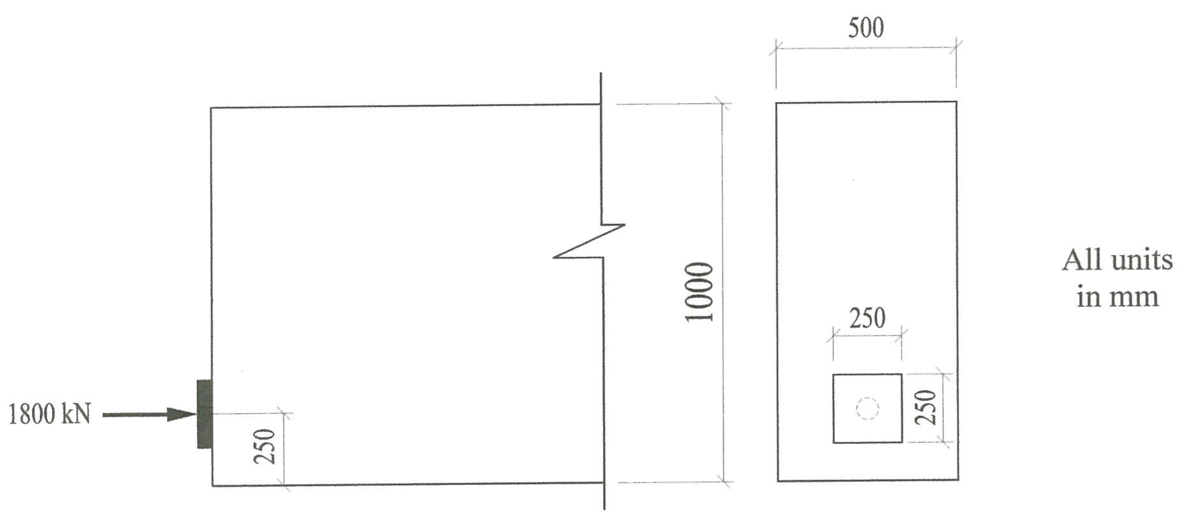

FIGURE Q4

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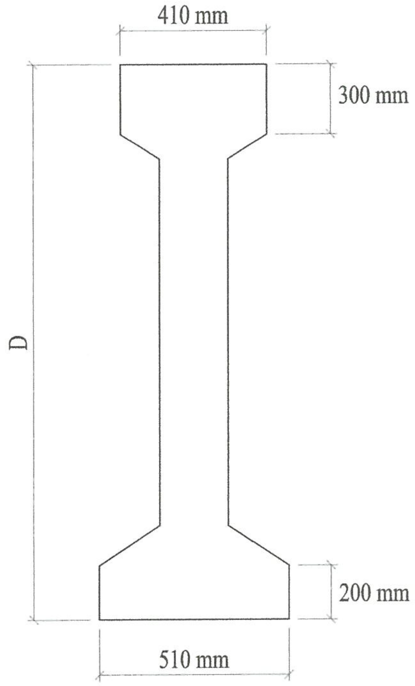
APPENDIX A



Description	I-Beam Type		
	I-12	I-13	I-14
Depth (D) (mm)	1420	1475	1550
Weight (kN/m)	10.30	10.84	11.21
Sectional Area (mm^2)	423050	445600	460600
Neutral axis Y_t (mm)	752	768	806
Neutral axis Y_b (mm)	668	707	744
Moment of Inertia (mm^4)	93.64×10^9	106.61×10^9	122.07×10^9
Section Modulus (Z_t) (mm^3)	124.36×10^6	138.81×10^6	151.34×10^6
Section Modulus (Z_b) (mm^3)	140.19×10^6	150.79×10^6	160.07×10^6

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APPENDIX B

A: Basic Inequalities

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

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

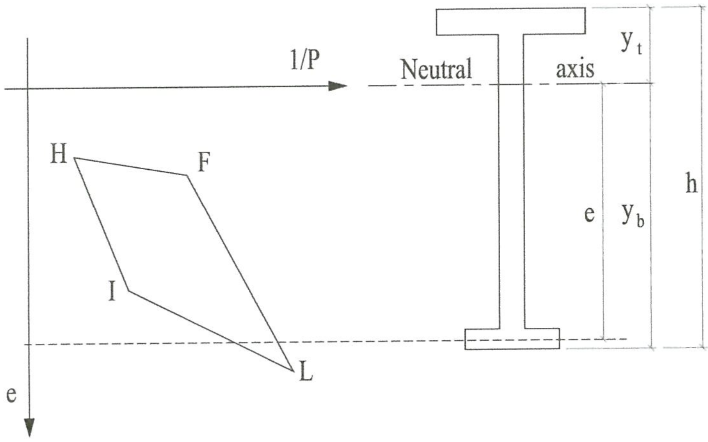
$$P_i \leq \frac{Z_t f_{max} - M_s}{\beta(\frac{Z_t}{A_c} - e)}$$

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

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

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

B: Krishnamurthy Magnel Diagram Inequalities



Corner L:

$$\frac{1}{P_L} = \frac{\beta(Z_t + Z_b)}{A_c[M_s + (1-\beta)M_i - \beta f'_{min} Z_t - f_{min} Z_b]}$$

$$e_L = (f'_{min} Z_t + M_i)\left(\frac{1}{P_L}\right) + \frac{Z_t}{A_c}$$

or;

$$e_L = \left(\frac{M_s + M_i - f_{min} Z_b}{\beta}\right)\left(\frac{1}{P_L}\right) - \frac{Z_b}{A_c}$$

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Corner I:

$$\frac{1}{P_I} = \frac{h}{A_c(f'_{max}y_t - f'_{min}y_b)}$$

$$e_I = (f'_{min}Z_t + M_i)\left(\frac{1}{P_I}\right) + \frac{Z_t}{A_c}$$

or;

$$e_I = (f'_{max}Z_b + M_i)\left(\frac{1}{P_I}\right) - \frac{Z_b}{A_c}$$

Corner H:

If $f_{max} < \frac{M_s + M_i}{Z_t}$

$$\frac{1}{P_H} = \frac{\beta(Z_t + Z_b)}{A_c[(\beta - 1)M_i - M_s + \beta f'_{max}Z_b + f_{max}Z_t]}$$

$$e_H = (f'_{max}Z_b + M_i)\left(\frac{1}{P_H}\right) - \frac{Z_b}{A_c}$$

or;

$$e_H = \left(\frac{M_s + M_i - f_{max}Z_t}{\beta}\right)\left(\frac{1}{P_H}\right) + \frac{Z_t}{A_c}$$

If $f_{max} > \frac{M_s + M_i}{Z_t}$

$$\frac{1}{P_H} = \frac{Z_t + Z_b}{A_c(f_{max}Z_t + f'_{max}Z_b - M_s)}$$

$$e_H = (f'_{max}Z_b + M_i)\left(\frac{1}{P_H}\right) - \frac{Z_b}{A_c}$$

or;

$$e_H = (M_s + M_i - f_{max}Z_t)\left(\frac{1}{P_H}\right) + \frac{Z_t}{A_c}$$

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Corner F:

$If\ f_{max} < \frac{M_s+M_i}{Z_t}$

$$\frac{1}{P_F} = \frac{\beta h}{A_c(f_{max}y_b - f_{min}y_t)}$$

$$e_F = \left(\frac{M_s + M_i - f_{max}Z_t}{\beta}\right)\left(\frac{1}{P_F}\right) + \frac{Z_t}{A_c}$$

or;

$$e_F = \left(\frac{M_s + M_i - f_{min}Z_b}{\beta}\right)\left(\frac{1}{P_F}\right) - \frac{Z_b}{A_c}$$

$If\ f_{max} > \frac{M_s+M_i}{Z_t}$

$$\frac{1}{P_F} = \frac{\beta(Z_t + Z_b)}{A_c[(M_s + M_i)(1-\beta) + \beta f_{max}Z_t - f_{min}Z_b]}$$

$$e_F = (M_s + M_i - f_{max}Z_t)\left(\frac{1}{P_F}\right) + \frac{Z_t}{A_c}$$

or;

$$e_F = \left(\frac{M_s + M_i - f_{min}Z_b}{\beta}\right)\left(\frac{1}{P_F}\right) - \frac{Z_b}{A_c}$$