Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS40303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE /JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

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Q1 **Figure Q1(a)** shows the structural layout plan at first floor of a factory building. The front part of the building (15 m x 18 m) consists of flat roofs using precast concrete slabs and post-tensioned I beams. The back of the building (25 m x 22 m) is proposed for production area by using post-tensioned U beams and cast in-situ concrete slab.

Figure Q1(b) shows the view for part of the cross section (section U-U) at first floor. The post-tensioned beams on the flat roof are supported by the columns along grid line B and the inclined prestressing cables. The post-tensioned beams are sitting on the corbels which are attached to the columns, and the connections between steel bracket and prestressing cable are hinged.

Given as follows are design data to be used in the design:

Unit weight of concrete	=	24 kN/m^3
Finishes of flat roof	=	1.5 kN/m^2
Finishes of production area	=	1.0 kN/m^2
Imposed load on flat roof	=	1.5 kN/m^2
Imposed load on production area	=	5.0 kN/m^2
Strength of concrete at service	=	45 N/mm^2
Strength of concrete at transfer	=	30 N/mm^2
Strength of cast in-situ concrete	=	30 N/mm^2
Assume selfweight of PSB1 & PSB2	=	8 kN/m
Short-term prestress losses	=	10%
Total prestress losses	=	15%
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) Calculate the permanent and variable working loads carry by PSB 1 and PSB 2.

(7 marks)

(b) Perform the analysis for PSB 2. Draw the initial (transfer) and service bending moment diagrams.

(10 marks)

(c) Based on the dimensions and section properties of I-Beam given in the appendix, determine the most economic section for the post-tensioned beam, PSB 2. Given $Z_t \geq \dfrac{\alpha M_s - \beta M_i}{\alpha f_{max} - \beta f'_{min}}$ and $Z_b \geq \dfrac{\alpha M_s - \beta M_i}{\beta f'_{max} - \alpha f_{min}}$.

(8 marks)

(d) Calculate the tensile force in the inclined prestressing bar.

(6 marks)

(e) Determine the minimum diameter of the prestressing bar required. Assume the bar can be stressed up to 0.8 times the ultimate strength of 2000 N/mm^2.

(5 marks)

(f) Discuss the changes of the internal force of the prestressing bar if the inclined angle is increased to 45^0.

(4 marks)

Q2 **Figure Q2(a)** and **Figure Q2(b)** show the elevation and cross section of PSB 3, respectively as the additional information given in **Q1**. PSB 3 is prestressed with five cables. Each cable has a cross sectional area of 139 mm^2 and stressed up to 70%. The characteristic strength of the cable is 1670 N/mm^2 and the Young's Modulus of concrete and creep coefficient are 35 GPa and 2.0, respectively.

(a) Calculate the long term deflection due to the prestressing. Ignore the cast in-situ concrete slab. Use moment inertial of precast beam = 34.48×10^9 mm^4.

(15 marks)

(b) Design the horizontal shear link between the cast in-situ concrete slab and PSB 3. Use 20 mm diameter link with the characteristic strength of 500 N/mm^2.

(15 marks)

Q3 Based on the information given in **Q1**, and **Figure Q3** shows the solid end-block for PSB 1. The end-block 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.

(30 marks)

- END OF QUESTIONS-

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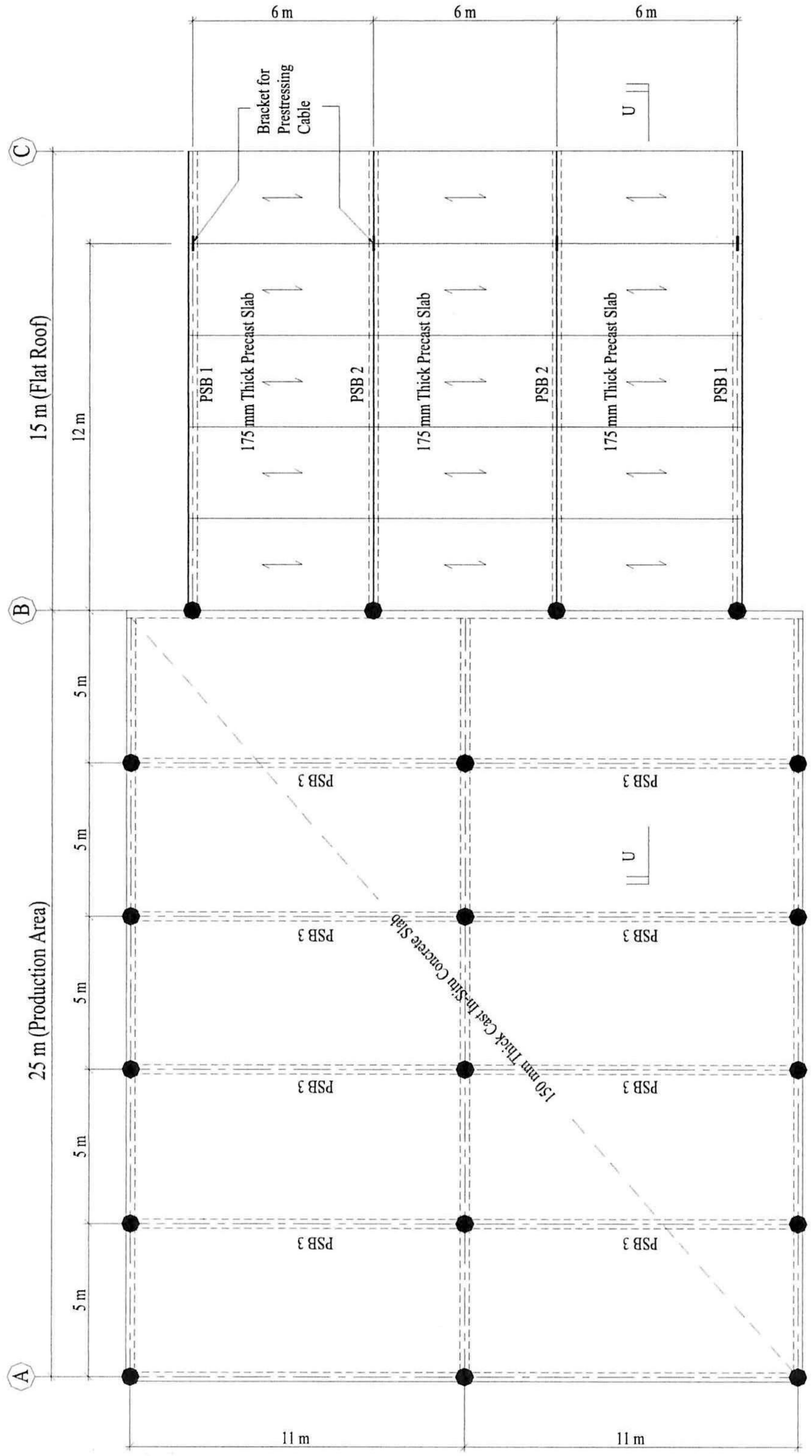

FIGURE Q1(a)

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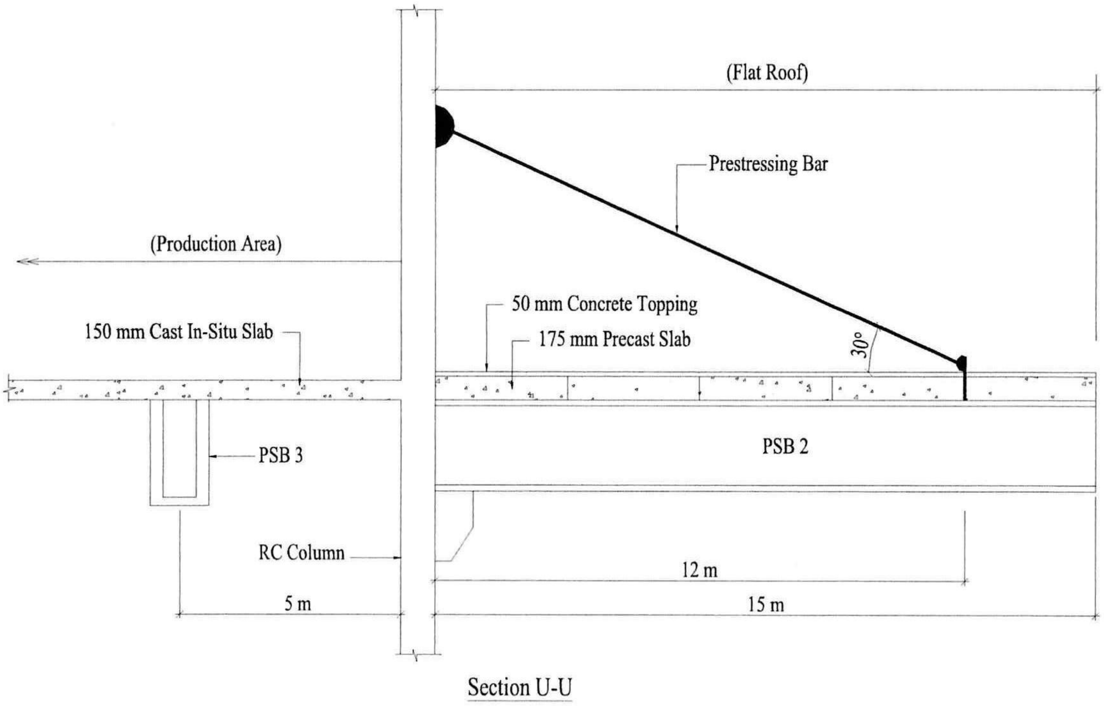

FIGURE Q1(b)

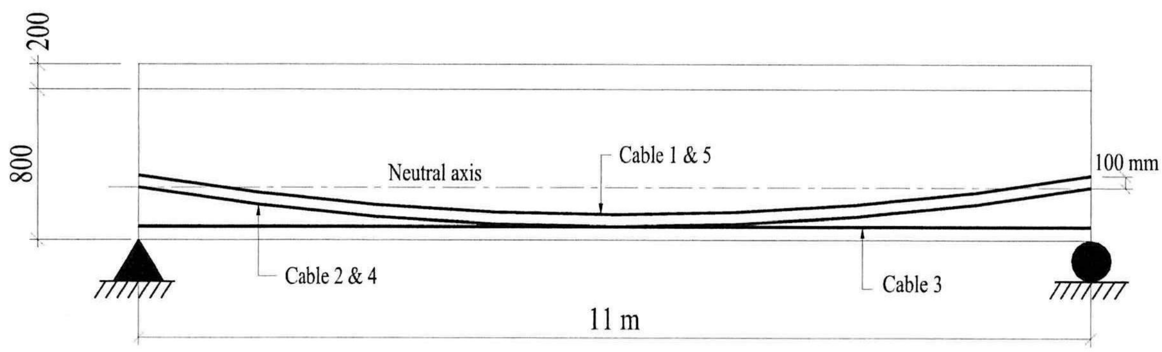

FIGURE Q2(a)

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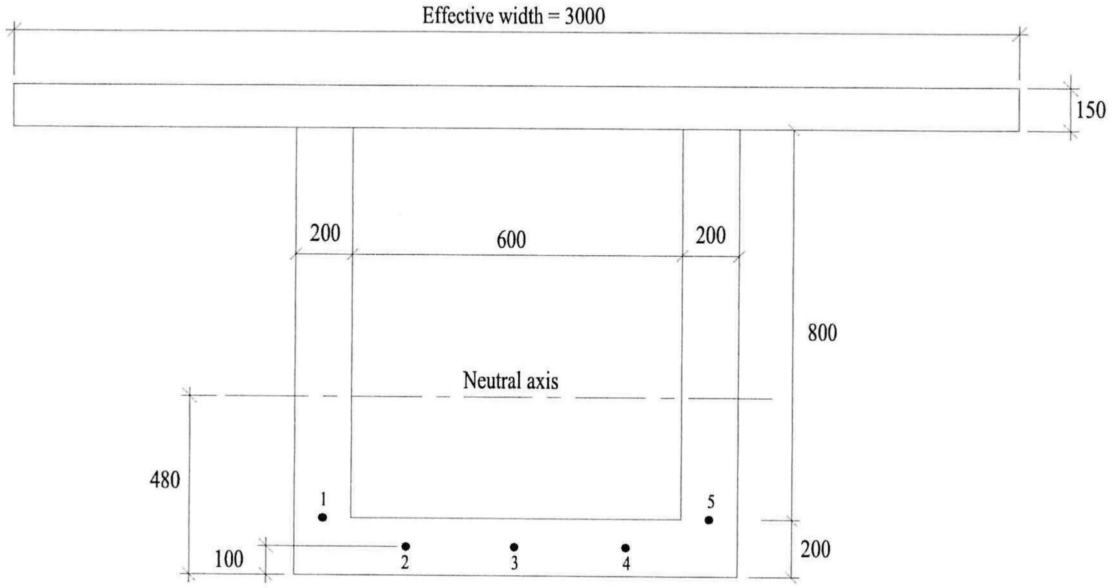

PSB3

FIGURE Q2(b)

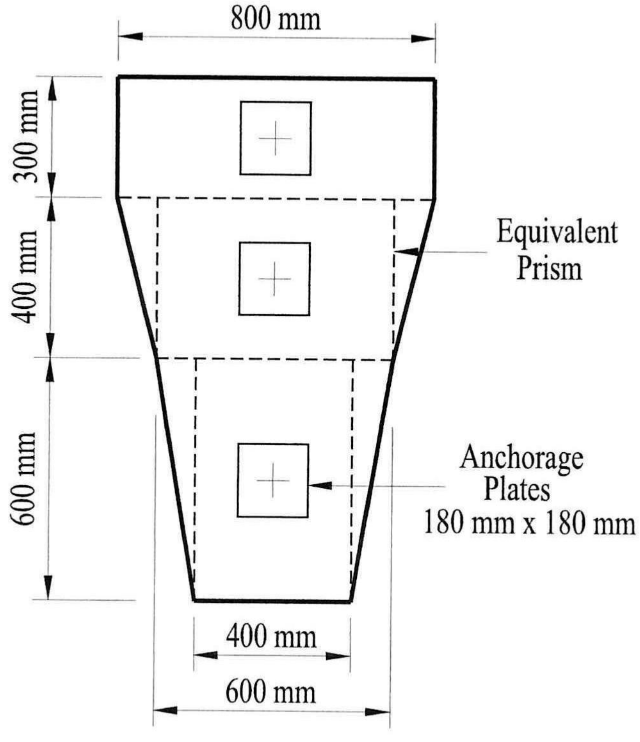

FIGURE Q3

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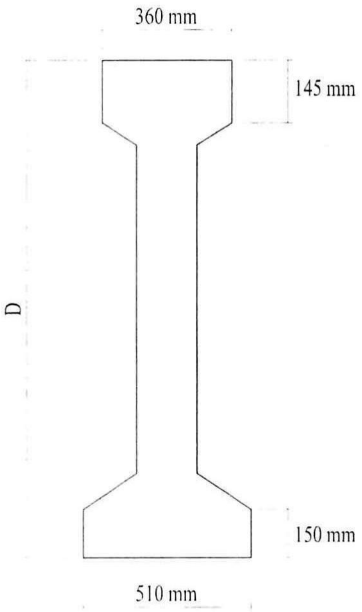
APPENDIX

(A) Section Properties of I-Beam



Description	I-Beam Type		
	I-5	I-6	I-7
Depth (D) (mm)	963	1040	1120
Weight (kN/m)	6.63	6.91	7.20
Sectional Area (mm^2)	272625	283875	295875
Neutral axis Y_t (mm)	538	579	623
Neutral axis Y_b (mm)	427	461	497
Moment of Inertia (mm^4)	28.15×10^9	34.46×10^9	42.09×10^9
Section Modulus (Z_t) (mm^3)	52.32×10^6	59.56×10^6	67.67×10^6
Section Modulus (Z_b) (mm^3)	65.80×10^6	74.76×10^6	84.68×10^6

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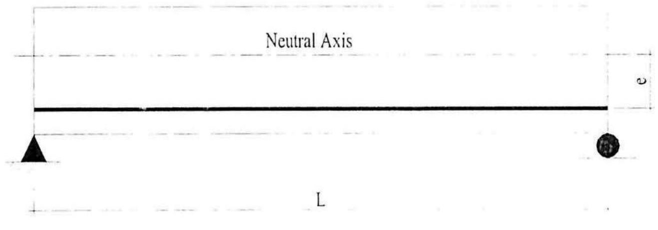
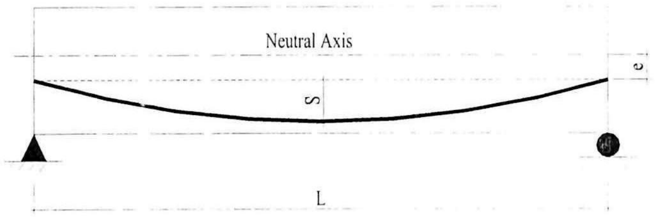
(B) Camber due to prestress



Straight Tendon

$$\Delta = \frac{PeL^2}{8EI}$$



Curve Tendon

$$\Delta = \frac{PL^2}{8EI}\left(e + \frac{5}{6}S\right)$$

(C) Horizontal shear link

5.4.7.1 *Horizontal shear force due to design ultimate loads*

At the interface of the precast and in-situ components the horizontal shear force due to design ultimate loads is either:

a) where the interface is in the tension zone: the total compression (or tension) calculated from the ultimate bending moment; or

b) where the interface is in the compression zone: the compression from that part of the compression zone above the interface, calculated from the ultimate bending moment.

5.4.7.2 *Average horizontal design shear stress*

The average horizontal design shear stress is calculated by dividing the design horizontal shear force (see 5.4.7.1) by the area obtained by multiplying the contact width by the beam length between the point of maximum positive or negative design moment and the point of zero moment.

The average design shear stress should then be distributed in proportion to the vertical design shear force diagram to give the horizontal shear stress at any point along the length of the member. The design shear stress v_h, should be less than the appropriate value in Table 5.5.

5.4.7.3 *Nominal links*

When provided, nominal links should be of cross-section at least 0.15 % of the contact area. Spacing should not be excessive. The spacing of links in T-beam ribs with composite flanges should not exceed four times the minimum thickness of the in-situ concrete nor 600 mm, whichever is the greater. Links should be adequately anchored on both sides of the interface.

5.4.7.4 *Links in excess of minimum*

Where the horizontal shear stress from 5.4.7.2 exceeds the value given in Table 5.5, all the horizontal shear force should be carried on reinforcement anchored either side of the interface.

The amount of steel required A_h (in mm²/m) should be calculated from the following equation:

$$A_h = \frac{1\,000 b v_h}{0.95 f_y}$$

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Table 5.5 — Design ultimate horizontal shear stresses at interface

Precast unit	Surface type	Grade of in-situ concrete		
		25 N/mm^2	30 N/mm^2	40 and over N/mm^2
Without links	As-cast or as-extruded	0.4	0.55	0.65
	Brushed, screeded or rough-tamped	0.6	0.65	0.75
	Washed to remove laitance or treated with retarder and cleaned	0.7	0.75	0.80
With nominal links projecting into in-situ concrete	As-cast or as-extruded	1.2	1.8	2.0
	Brushed, screeded or rough-tamped	1.8	2.0	2.2
	Washed to remove laitance or treated with retarder and cleaned	2.1	2.2	2.5

NOTE 1 The description "as-cast" covers those cases where the concrete is placed and vibrated leaving a rough finish. The surface is rougher than would be required for finishes to be applied directly without a further finishing screed but not as rough as would be obtained if tamping, brushing or other artificial roughening had taken place.

NOTE 2 The description "as-extruded" covers those cases in which an open-textured surface is produced direct from an extruding machine.

NOTE 3 The description "brushed, screeded or rough-tamped" covers those cases where some form of deliberate surface roughening has taken place but not to the extent of exposing the aggregate.

NOTE 4 For structural assessment purposes, it may be assumed that the appropriate value of γ_m included in the table is 1.5.

(D) End block design

At the SLS the design bursting tensile force F_{bst} in an individual square end block loaded by a symmetrically-placed square bearing plate, may be derived from Table 4.7 on the basis of the tendon jacking load. With rectangular anchorages and/or rectangular end blocks, the bursting tensile forces in the two principal directions should be assessed in relation to the value of y_{po}/y_o for each direction where

y_o is half the side of the end block;

y_{po} is half the side of the loaded area;

P_o is the tendon jacking force.

Circular bearing plates should be treated as square plates of equivalent area.

Table 4.7 — Design bursting tensile forces in end blocks

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

NOTE Intermediate values may be interpolated.

This force, F_{bst}, will be distributed in a region extending from $0.2y_o$ to $2y_o$ from the loaded face, and should be resisted by reinforcement in the form of spirals or closed links, uniformly distributed throughout this region, and acting at a stress of 200 N/mm^2.