CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS 40303
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	DECEMBER 2014/JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

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

CONFIDENTIAL

Q1 (a) Discuss **THREE (3)** main advantages of using prestressed concrete.

(6 marks)

(b) A simply supported pre-tensioned concrete beam with span 12 m and has a rectangular cross section of 450 mm wide and 650 mm overall depth. The beam is prestressed with 10 numbers of 15.2 mm diameter straight strands, each with a nominal cross sectional area of 139 mm^2. The beam carries no dead load other than its own weight and all surfaces are exposed to the environment having an average relative humidity of 75%. The following information is given:

Young's Modulus of tendon, E_{ps}	=	195 GPa
Young's Modulus of Concrete, E_c	=	35 GPa
Initial prestressing stress, σ_{pi}	=	1150 MPa
Strength of tendon, f_{pu}	=	1670 MPa

Calculate the long term loss of prestress due to shrinkage and creep.

(19 marks)

Q2 A post-tensioned prestressed concrete bridge deck is in the form of a solid slab as shown in Figure **Q2**. The bridge deck is simply supported over 20 m. It carries a service load of 0.3 kN/m^2. The allowable concrete stresses are given below:

Allowable compressive stress at transfer, f'_{max}	=	20 MPa
Allowable compressive stress at service, f_{max}	=	16.7 MPa
Allowable tensile stress at transfer, f'_{min}	=	-1.0 MPa
Allowable tensile stress at service, f_{min}	=	0 MPa

(a) If the total short-term and long –term losses are 10% and 20%, respectively, determine the minimum depth of slab required.

(13 marks)

(b) If the depth of the deck slab is 525 mm and the maximum eccentricity of the tendons at mid-span is 75 mm above the soffit, find the minimum value of the prestress force required.

(12 marks)

Q3 A bonded prestressed concrete beam is of T section is shown in Figure **Q3**. The tendon consists of 3300 mm^2 of standard strands with the characteristic strength of 1700 N/mm^2 and Young's Modulus equal to 200 kN/mm^2 was stressed to an effective prestress of 910 N/mm^2. The strands are located 870 mm from the top face of the beam. The concrete characteristic strength is 60 N/mm^2 and its modulus of elasticity is 36 kN/mm^2. Assume the neutral axis is in the web.

(a) Calculate the ultimate moment of resistance of the beam section based on the first principles.

(17 marks)

(b) Due to the site error, the strands have not been tensioned (the effective tendon prestress is zero). Calculate the ultimate moment of resistance of the beam section.

(8 marks)

Q4 A prestressed concrete girder, simply supported over a span of 20 m has been designed for flexure to carry in addition to its own weight, a characteristic dead load and live load of 4.5 kN/m and 10 kN/m, respectively. The beam is pre-tensioned with 16 numbers of 15.7 mm diameter strands with nominal cross sectional area of each strand, A_{ps} = 150 mm^2. However, due to debonding only 8 of the strands are active at a section 3 m from the support (Figure **Q4**). These 8 strands supply an effective prestressing force of 1200 kN. Given the following additional information:

Cross sectional area of concrete, A_c	=	324,000 mm^2
Second moment of area, I	=	38.1 x 10^9 mm^4
y_b of the cross section	=	445 mm
Strength of concrete, f_{cu}	=	40 MPa
Strength of steel, f_{yv}	=	250 MPa
Ratio of σ_{pe}/f_{pu}	=	0.56

If the section is cracked in flexure, design the shear reinforcement at a distance 3 m from the support. Use 10 mm diameter shear reinforcement.

(25 marks)

Q5 (a) Figure **Q5(a)** shows a end block containing a single, centrally placed anchorage with a bearing plate of height, h. The beam analogy model together with the shear force and bending moment diagrams for the end block is shown in Figure **Q5(a)(ii)**. Prove that the bursting tension force, T_b as,

$$T_b = (F/4)(1 - h/D)$$

(12 marks)

(b) Two horizontal tendons are symmetrically anchored in a rectangular end block 400 mm wide and 1000 mm deep. The anchorages have 220 mm square bearing plates and are placed 600 mm apart is divided into two prisms as shown in Figure **Q5(b)**. The maximum jacking force at transfer of prestress is 1400 kN in each tendon. The allowable stress of steel is 200 N/mm^2. Design the reinforcement for the end block.

(13 marks)

- END OF QUESTION-

FINAL EXAMINATION

SEMESTER/SESSION	: SEMESTER I 2014/2015	PROGRAM	: 4BFF
COURSE NAME	: PRESTRESSED CONCRETE DESIGN	COURSE CODE	: BFS 40303

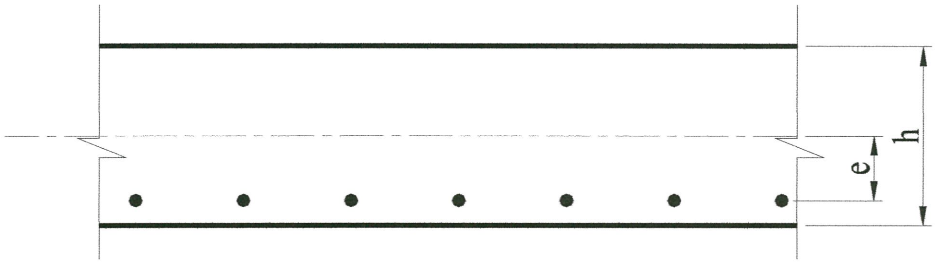


FIGURE Q2

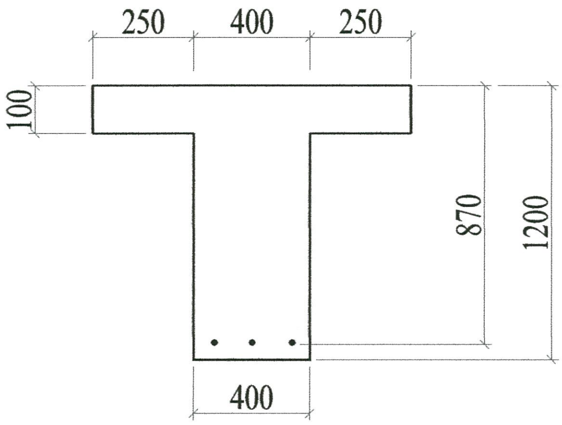


FIGURE Q3

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2014/2015 PROGRAM : 4BFF
COURSE NAME : PRESTRESSED CONCRETE DESIGN COURSE CODE : BFS 40303

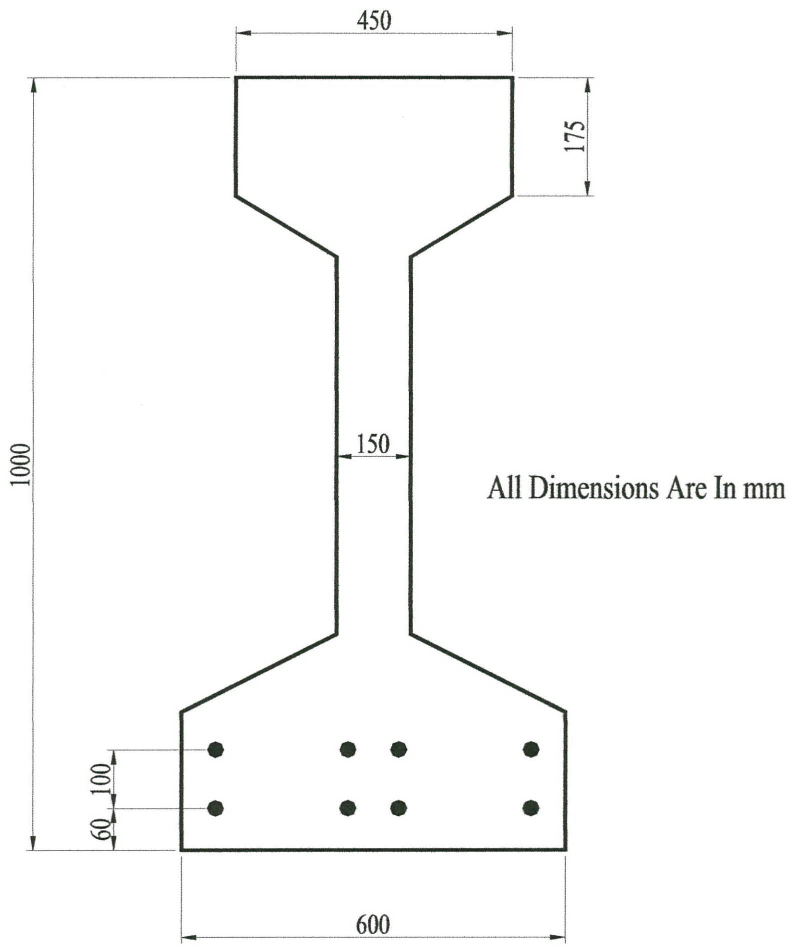
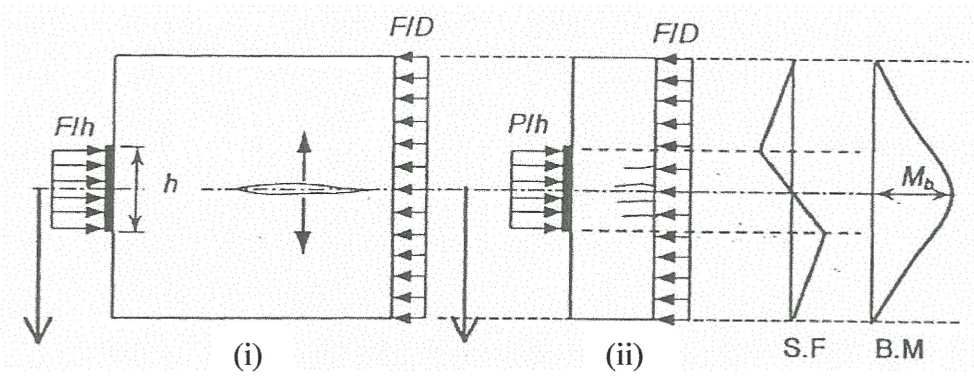


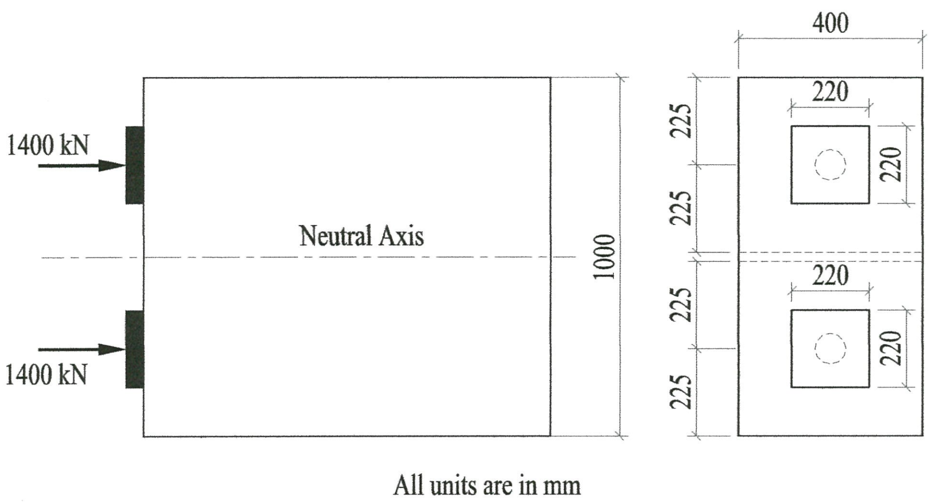
FIGURE Q4

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2014/2015 PROGRAM : 4BFF
COURSE NAME : PRESTRESSED CONCRETE DESIGN COURSE CODE : BFS 40303



FIGRURE Q5(a)



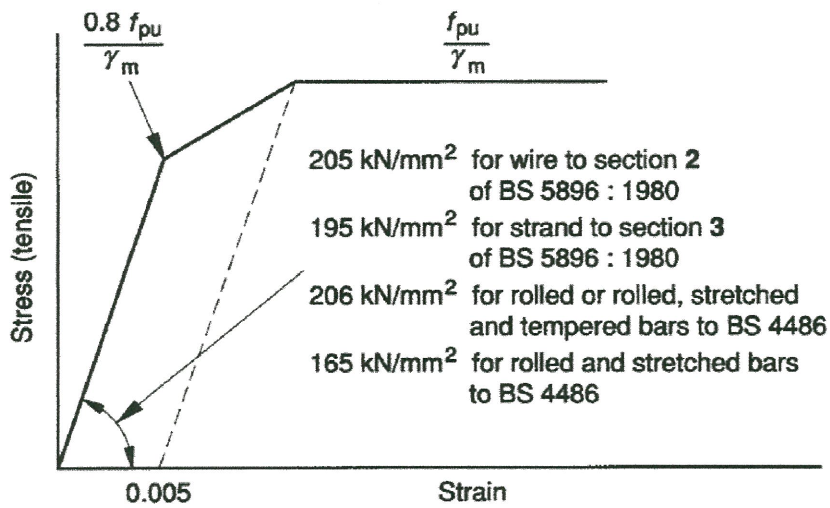
FIGRURE Q5(b)

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2014/2015
COURSE NAME : PRESTRESSED CONCRETE DESIGN
PROGRAM : 4BFF
COURSE CODE : BFS 40303

APPENDIX

(A) Stress-Strain Curve of Prestressing Tendons



NOTE f_{pu} is in N/mm².

(B) Bursting Forces in End-Blocks

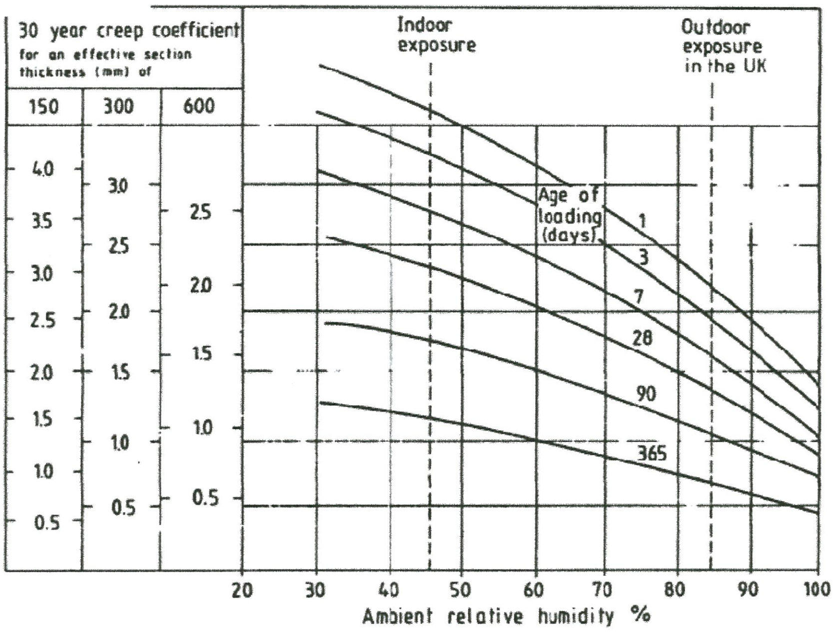
y_{po}/y_o	0.2	0.3	0.4	0.5	0.6	0.7
F_{bst}/P_i	0.23	0.23	0.20	0.17	0.14	0.11

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

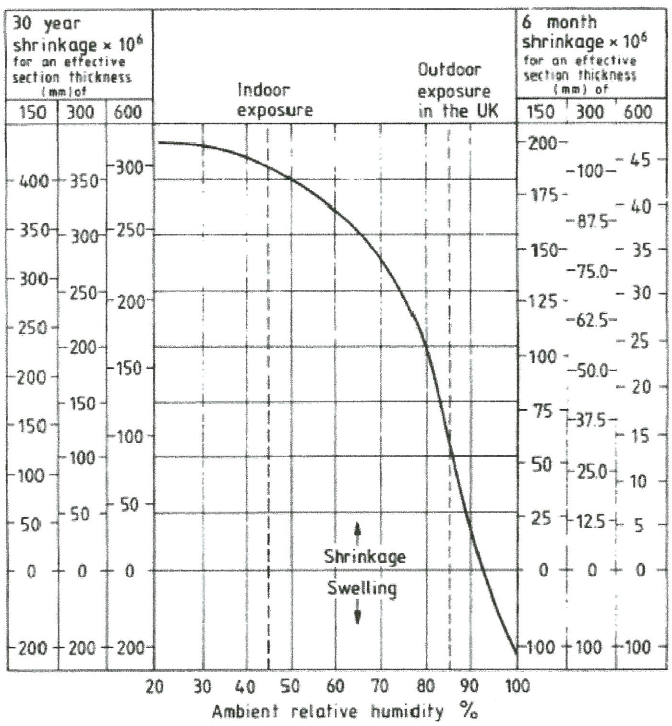
FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2014/2015 PROGRAM : 4BFF
COURSE NAME : PRESTRESSED CONCRETE DESIGN COURSE CODE : BFS 40303

(C) Creep Coefficient, φ



(D) Drying Shrinkage of Normal-Weight Concrete



FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2014/2015 PROGRAM : 4BFF
COURSE NAME : PRESTRESSED CONCRETE DESIGN COURSE CODE : BFS 40303

(E) 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.

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

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

For rectangular section and flange section with neutral axis in the flange;

$$f_{pb} = \frac{0.4 f_{cu} bd}{A_{ps}}\left[\frac{\beta_2 \varepsilon_{cu}}{\beta_2 \varepsilon_{cu} + \varepsilon_{pb} - \varepsilon_{pe} - \beta_1 \varepsilon_e}\right]$$

$$M_u = A_{ps} f_{pb} (d - 0.45x)$$

For flange section with neutral axis in the web:-

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