CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2011/2012

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS 4033
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	JUNE 2012
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **THREE (3)** QUESTIONS ONLY.

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

CONFIDENTIAL

Q1 Figure **Q1** shows the cross section of a 15 m span simply supported prestressed beam will be post-tensioned by 11 groups of 7-wire standard strand of 12.5 mm diameter. The total initial prestressing force is 1350 kN. All tendons are placing in the plastic duct and will be tensioned individually from one end. The tendon profile is parabolic with an eccentricity of 300 mm at the mid-span and zero at both ends. Given the following data:

Tendon:

Tensile strength, f_{pu}	=	1770 N/mm^2		
Young's Modulus, E	=	200 kN/mm^2		
Nominal area	=	93 mm^2		
Profile coefficient, K	=	30×10^{-4}		
Friction coefficient, μ	=	0.12		
Anchorage draw-in	=	2 mm		
Relaxation class 2				
Relaxation factor	=	1.5		
1000 hours relaxation value for 70% initial force			=	2.5
1000 hours relaxation value for 80% initial force			=	4.5

Concrete:

28 days Compressive strength	=	45 N/mm^2
Cross sectional area	=	370×10^3 mm^2
Moment of Inertia	=	9.17×10^9 mm^4
Transfer after 7 days		
Shrinkage length	=	250×10^{-6}
Creep coefficient	=	1.5

(a) Determine the immediate prestress losses.

(20 marks)

(b) Determine the time-dependent prestress losses.

(10 marks)

(c) If the total prestress loss is more than 30%, suggest a method to reduce the losses.

(3 marks)

Q2 A 8 m simply supported class 2 pre-tensioned prestressed concrete solid slab carries a service load of 10 kN/m^2. The 28 days concrete strength is 45 N/mm^2 and the tendon will be transferred when the concrete achieved the minimum strength of 30 N/mm^2. The total short and long term losses are 10% and 20%, respectively.

(a) Determine the minimum depth of slab required.

(16 marks)

(b) Based on the minimum depth from Q2(a), calculate:

(i) Initial moment
(ii) Service moment

(iii) Elastic modulus of the slab
(iv) Moment of inertia of the slab

(4 marks)

(c) Determine the range of the prestress force if the maximum eccentricity of the tendons at mid-span is 30 mm above the bottom soffit. Use the basic inequalities given in the appendix.

(10 marks)

(d) If hollow core slab is used, what do you think of the design changes to be made?

(3 marks)

Q3 (a) A bonded prestressed concrete beam is of rectangular section 400 mm by 1200 mm, as 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.

(i) Based on the first principles, calculate the ultimate moment of resistance of the beam section.

(20 marks)

(ii) 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.

(10 marks)

(b) Based on your understanding, what are the major differences in designing of shear reinforcement between reinforced concrete and prestressed concrete?

(3 marks)

Q4 (a) The cross section of the composite bridge deck shown in Figure **Q4(a)** has a span of 20 m and the thickness of the deck slab is 180 mm. The steel reinforcement is grade 460 and the concrete is grade C35.

(i) Determine the maximum horizontal shear stress.

(5 marks)

(ii) Design the horizontal shear link. Assume deck slab is cast in-situ on of the precast concrete beam.

(8 marks)

(iii) Sketch **THREE (3)** types of suitable detailing for the horizontal shear link.

(3 marks)

(b) Explain **THREE (3)** reasons why end block is needed for the prestressed concrete beam.

(3 marks)

(c) A horizontal tendon comprising 7 strands of 12.5 mm diameter is anchored at the centre of a rectangular end block using a 200 mm square bearing plate as shown in Figure **Q4(b)**. The maximum jacking force at transfer is 1400 kN. The following information is given:

28 days concrete strength, f_{cu}	=	45 MPa
Concrete strength at transfer, f_{ci}	=	30 MPa
Maximum steel stress, f_s	=	150 MPa
Reinfocement strength (link)	=	460 MPa
Diameter of link	=	10 mm

(i) Design the vertical reinforcement for the end block.

(6 marks)

(ii) Design the horizontal reinforcement for the end block.

(5 marks)

(iii) Design the reinforcement to resist the surface spalling tensile force.

(3 marks)

S1 Rajah **Q1** menunjukkan keratan rentas untuk rasuk prategasan disokong mudah dengan rentang 15 m yang akan dipascategang menggunakan 11 kumpulan utas piawai 7-wayar berdiameter 12.5 mm. Jumlah daya pratengangan awal ialah 1350 kN. Semua tendon diletakkan di dalam saluran plastik dan akan ditengangkan secara individu daripada satu hujung. Profil tendon adalah berbentuk parabola dengan kesipian 300 mm pada tengah rentang dan sifar pada kedua-dua hujung. Diberikan data berikut:

Tendon:

Kekuatan tegangan, f_{pu}	=	1770 N/mm^2
Modulus Young, E	=	200 kN/mm^2
Luas nominal	=	93 mm^2
Pekali profil, K	=	30×10^{-4}
Pekali geseran, μ	=	0.12
Kemasukan tambatan	=	2 mm
Kelesuan kelas 2		
Faktor kelesuan	=	1.5
Nilai kelesuan 1000 jam untuk daya awalan 70%	=	2.5
Nilai kelesuan 1000 jam untuk daya awalan 80%	=	4.5

Konkrit:

Kekuatan mampatan 28 hari	=	45 N/mm^2
Luas keratan rentas	=	370×10^3 mm^2
Momen inertia	=	9.17×10^9 mm^4
Pindahan selepas 7 hari		
Panjang pengecutan	=	250×10^{-6}
Pekali rayapan	=	1.5

(a) Tentukan kehilangan prategasan serta merta.

(20 markah)

(b) Tentukan kehilangan prategasan jangka panjaang.

(10 markah)

(c) Sekiranya jumlah kehilangan prategasan melebihi 30%, cadangkan satu kaedah untuk mengurangkan kehilangan prategasan.

(3 markah)

S2 Satu papak prategangan kelas 2 disokong mudah dengan rentang 8 m membawa beban khidmat 10 kN/m^2. Kekuatan konkrit pada 28 hari ialah 45 N/mm^2 dan tendon akan dipindah apabila konkrit mencapai kekuatan minimum 30 N/mm^2. Kehilangan jangka pendek dan jangka panjang masing-masing ialah 10% dan 20%.

(a) Tentukan ketebalan minimum yang diperlukan untuk papak.

(16 markah)

(b) Berdasarkan ketebalan minimum di S2(a), kirakan:

(i) Momen awal

(ii) Momen khidmat
(iii) Modulus elastik untuk papak
(iv) Momen inertia untuk papak

(4 markah)

(c) Sekiranya kesipian tendon pada tengah rentang ialah 30 mm dari permukaan bawah, tentukan julat daya prategasan dengan menggunakan asas *inequalities* yang diberikan dalam lampiran.

(10 markah)

(d) Sekiranya papak berongga digunakan, apakah pandangan anda terhadap perubahan rekabentuk yang perlu dilakukan

(3 markah)

S3 (a) Satu rasuk prategasan yang terikat berkeratan segiempat 400 mm x 1200 mm seperti ditunjukkan dalam Rajah **Q3**. Tendon terdiri daripada utas piawai 3300 mm^2 berkekuatan ciri 1700 N/mm^2 dan Modulus Young 200 kN/mm^2 ditegangkan dengan prategasan berkesan 910 N/mm^2. Tendon diletakkan pada kedudukan 870 mm daripada permukaan atas rasuk. Kekuatan ciri konkrit ialah 60 N/mm^2 dan modulus keanjalan ialah 36 kN/mm^2.

(i) Berdasarkan prinsip pertama, kirakan momen rintangan muktamad untuk keratan rasuk tersebut.

(20 markah)

(ii) Disebabkan kesilapan di tapak bina, tendon tersebut tidak ditegangkan (prategasan berkesan tendon ialah sifar). Kirakan momen rintangan muktamad untuk keratan rasuk.

(10 markah)

(b) Berdasarkan kefahaman anda, apakan perbezaan yang utama dalam rekabentuk tetulang ricih untuk konkrit bertetulang dan konkrit prategasan?

(3 markah)

S4 (a) Keratan rentas untuk papak jambatan rencam seperti ditunjukkan dalam Rajah **Q4(a)** mempunyai rentang 20 m dan tebal papak ialah 180 mm. Kekuatan tetulang keluli ialah gred 460 dan konkrit ialah gred C35.

(i) Tentukan tegasan ricih ufuk maksimum.

(5 markah)

(ii) Rekebentuk perangkai ricih ufuk. Anggap papak ialah tuang *in-situ* di atas rasuk konkrit pratuang.

(8 markah)

(iii) Lakarkan **TIGA (3)** jenis perincian yang sesuai untuk perangkai ricih ufuk.

(3 markah)

(b) Terangkan **TIGA (3)** sebab mengapa blok hujung diperlukan dalam rasuk konkrit prategasan.

(3 markah)

(c) Satu tendon ufuk terdiri daripada 7 utas yang berdiameter 12.5 mm ditambatkan pada pusat blok hujung segiempat menggunakan plat tegasan segiempat sama 200 mm seperti ditunjukkan dalam Rajah **Q4(b)**. Daya prategasan maksimum pada pindahan ialah 1400 kN. Diberikan maklumat berikut:

Kekuatan konkrit 28 hari, f_{cu}	=	45 MPa
Kekuatan konkrit pada pindahan, f_{ci}	=	30 MPa
Tegasan keluli maksimum, f_s	=	150 MPa
Kekuatan tetulang (perangkai	=	460 MPa
Diameter perangkai	=	10 mm

(i) Rekabentuk tetulang pugak untuk blok hujung.

(6 markah)

(ii) Rekabentuk tetulang ufuk untuk blok hujung.

(5 markah)

(iii) Rekabentuk tetulang untuk merintangi daya tegangan pemecahan permukaan.

(3 markah)

FINAL EXAMINATION

SEMESTER/SESSION	: SEMESTER II 2011/2012	PROGRAM	: BFF
COURSE NAME	: PRESTRESSED CONCRETE DESIGN	COURSE CODE	: BFS 4033

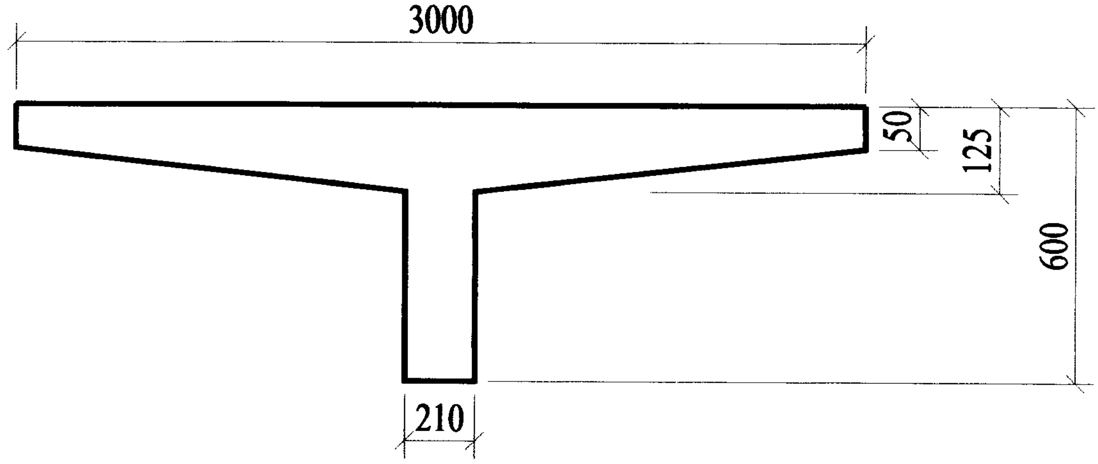

FIGURE Q1

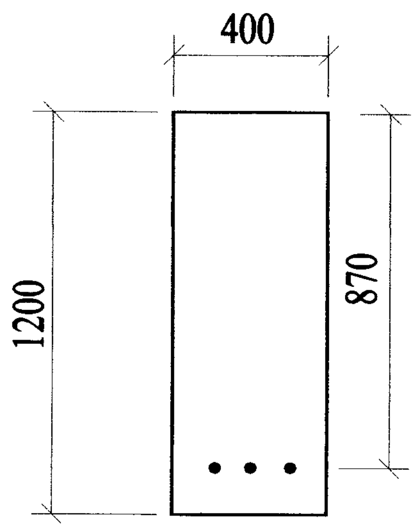

FIGURE Q3

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER II 2011/2012
COURSE NAME : PRESTRESSED CONCRETE DESIGN
PROGRAM : BFF
COURSE CODE : BFS 4033

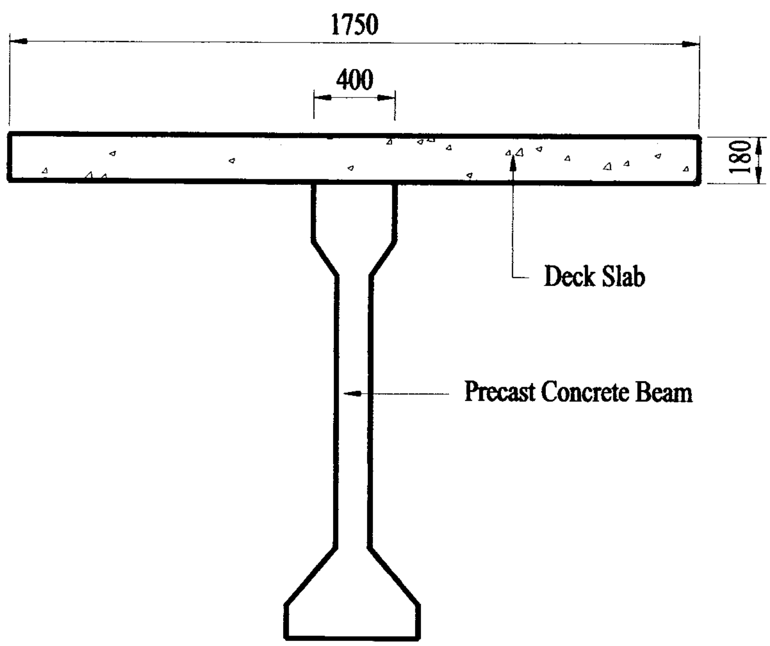

FIGURE Q4(a)

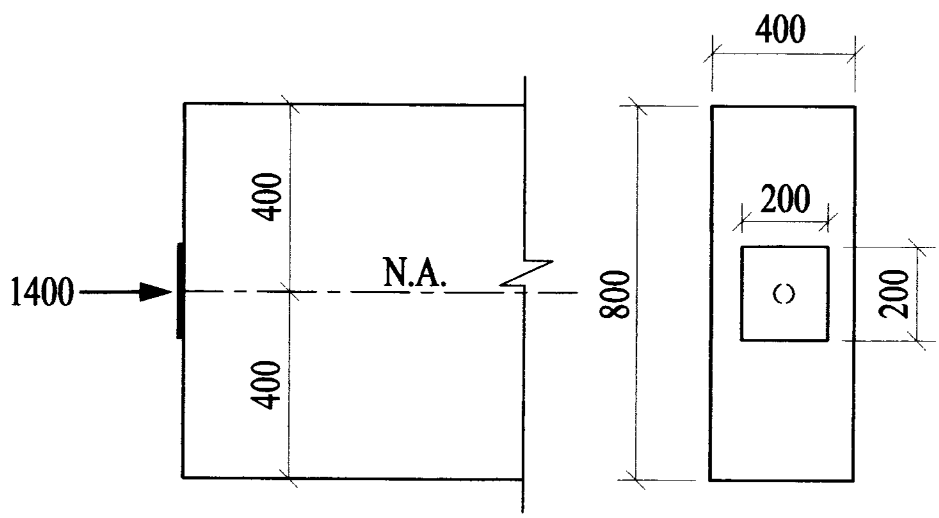

FIGURE Q4(b)

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER II 2011/2012 — PROGRAM : BFF
COURSE NAME : PRESTRESSED CONCRETE DESIGN — COURSE CODE : BFS 4033

APPENDIX

Basic Inequalities:

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

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

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

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

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

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

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;

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

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