UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2012/2013

COURSE NAME	:	PRESTRESSED CONCRETE DESIGN
COURSE CODE	:	BFS 4033
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	DECEMBER 2012/JANUARY 2013
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **THREE (3)** QUESTIONS ONLY.

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

Q1 (a) Figure **Q1(a)** shows a cross section for a 8 m span simply supported class 2 pre-tensioned beam carrying a uniformly distributed load throughout the whole span. A straight tendon is located at a distance of 350 mm below the neutral axis of the cross section was prestressed with the initial force of 1200 kN. Determine the maximum service load (self-weight is not included) can be carried by the beam to fulfill the allowable compressive stress limit at the mid-span. Assume the total prestress loss is 28%.

(13 marks)

(b) Figure **Q1(b)** shows the tendon profile of a simply supported pre-tensioned concrete beam. The span of the beam is 10 m. The tendon consists of 7-wire strand with relaxation class 2. Given the following data:

Cross section area	=	5×10^4 mm^2
Moment of Inertia	=	4.5×10^8 mm^4
Nominal area of tendon	=	372 mm^2
Strength of tendon	=	1770 N/mm^2
Young's Modulus of concrete	=	34 kN/mm^2
Young's Modulus of tendon	=	200 kN/mm^2
Shrinkage	=	300×10^{-6}
Creep coefficient	=	2.0
Relaxation factor	=	1.5
1000 hours relaxation value for 60% initial force	=	1.0
1000 hours relaxation value for 70% initial force	=	2.5
Initial prestressing stress of the tendon	=	1200 N/mm^2

Calculate the percentage of prestress loss.

(20 marks)

Q2 A simply supported post-tensioned rectangular solid slab span of 10 m carry a uniformly distributed load in addition to its self-weight of 3 kN/m^2. The member is to be designed as class 1 with grade 40 concrete. The total short and long term losses are 15 % and 25%, respectively.

(a) Determine the minimum depth of slab required.

(16 marks)

(b) 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.

(14 marks)

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

(3 marks)

Q3 (a) The cross section of a pre-tensioned beam shown in Figure **Q3(a)** is stressed by ten 5 mm wires of characteristic strength of 1470 N/mm^2. If these wires are initially stressed to 1000 N/mm^2 and a total of 30% losses are anticipated, estimate the ultimate moment of resistance of the section if grade 40 concrete is used.

(20 marks)

(b) The crack pattern for a simply supported prestressed concrete beam subjected to a four-points bending test is shown in Figure **Q3(b).**

(i) Discuss the types of cracks on the beam.

(6 marks)

(ii) If a deflected tendon is provided, discuss the component that will be contributed for the shear resistance.

(7 marks)

Q4 (a) The cross section of the composite bridge deck shown in Figure **Q4(a)** has a span of 24 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 top 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 1600 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	=	12 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 (a) Rajah **Q1(a)** menunjukkan keratan rentas untuk rasuk prategangan kelas 2 yang disokong mudah dengan rentang 8 m membawa beban teragih seragam sepanjang rentang. Satu tendon lurus terletak pada jarak 350 mm di bawah paksi neutral keratan rentas tersebut dan ditegangkan dengan daya awal 1200 kN. Tentukan beban khidmat maksimum (tidak termasuk berat sendiri) yang boleh dibawa oleh rasuk dengan memenuhi had tegasan mampatan untuk keadaan khidmat pada pertengahan rentang. Anggap kehilangan keseluruhan prategasan ialah 28%.

(13 markah)

(b) Rajah **Q1(b)** menunjukkan profil tendon untuk satu rasuk konkrit prategangan yang disokong mudah. Rentang rasuk ialah 10 m. Tendon ini terdiri daripada 7-wayar lembar dengan kelesuan kelas 2 . Diberikan data berikut:

Luas keratan rentas	=	5×10^4 mm^2
Momen inertia	=	4.5×10^8 mm^4
Luas nominal tendon	=	372 mm^2
Kekuatan tendon	=	1770 N/mm^2
Modulus Young konkrit	=	34 kN/mm^2
Modulus Young tendon	=	200 kN/mm^2
Pengecutan	=	300×10^{-6}
Pekali rayapan	=	2.0
Faktor kelesuan	=	1.5
Nilai kelesuan 1000 jam untuk daya awalan 60%	=	1.0
Nilai kelesuan 1000 jam untuk daya awalan 70%	=	2.5
Tegasan prategasan awal untuk tendon	=	1200 N/mm^2

Kirakan peratus kehilangan prategasan.

(20 markah)

S2 Satu papak pasca-tegangan disokong mudah dengan rentang 10 m membawa beban teragih seragam 3 kN/m^2 sebagai tambahan kepada berat sendirinya. Anggota ini akan direkabentuk sebagai kelas 1 dengan konkrit gred 40. Kehilangan jangka pendek dan jangka panjang masing-masing ialah 15% dan 25%.

(a) Tentukan ketebalan minimum yang diperlukan untuk papak.

(16 markah)

(b) Tentukan julat daya prategasan sekiranya kesipian maksimum untuk tendon pada pertengahan rentang ialah 30 mm di atas permukaan bawah papak. Gunakan persamaan asas *inequalities* yang diberikan dalam lampiran.

(14 markah)

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

(3 markah)

S3 (a) Keratan rentas untuk rasuk prategangan seperti ditunjukkan dalam Rajah **Q3(a)** ditegangankan dengan sepuluh wayar 5 mm dengan kekuatan ciri 1470 N/mm^2. Sekiranya tegasan awal untuk wayar ialah 1000 N/mm^2 dan jumlah kehilangan prategasan yang berlaku ialah 30%. Anggarkan momen rintangan muktamad untuk keratan ini jika gred konkrit 40 digunakan.

(20 marks)

(b) Corak keretakan untuk rasuk konkrit prategasan disokong mudah yang diuji dengan ujian lenturan empat-titik ditunjukkan dalam Rajah **Q3(b)**.

(i) Bincangkan jenis keretakan pada rasuk ini.

(6 markah)

(ii) Sekiranya satu tendon melengkung disediakan dalam rasuk ini, bincangkan komponen yang akan menyumbang kepada rintangan ricih.

(7 markah)

S4 (a) Keratan rentas untuk papak jambatan rencam seperti ditunjukkan dalam Rajah **Q4(a)** mempunyai rentang 24 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 1600 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	=	12 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)

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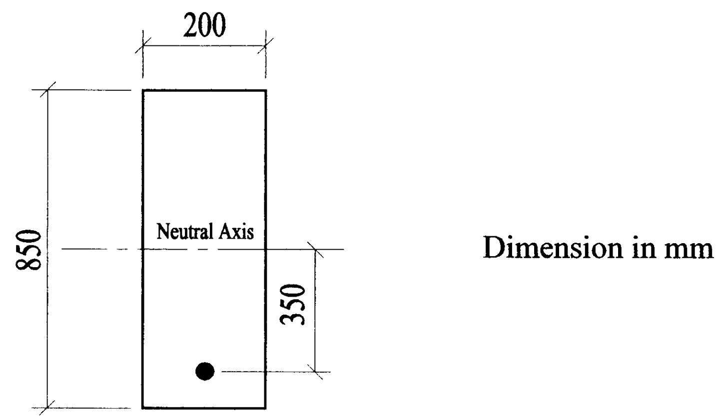

FIGURE Q1(a)

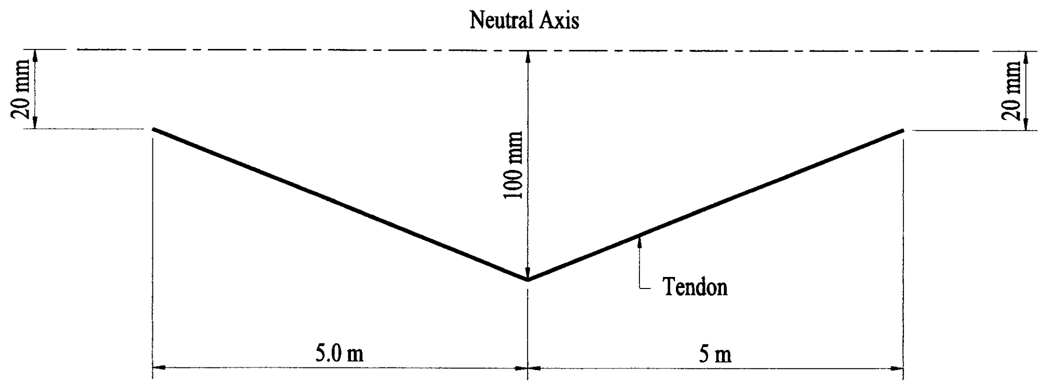

FIGURE Q1(b)

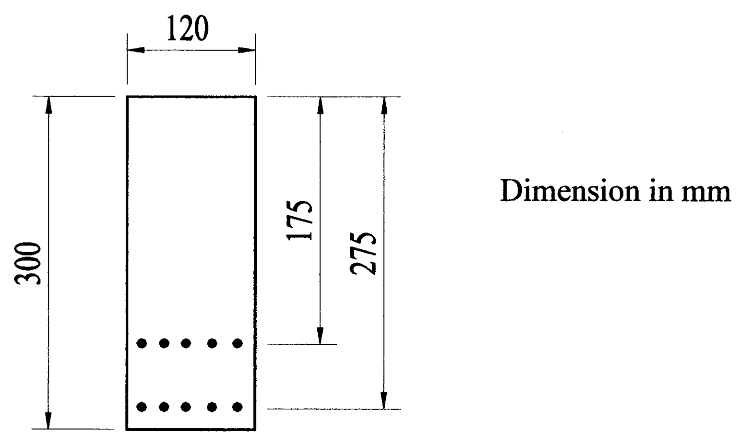

FIGURE Q3(a)

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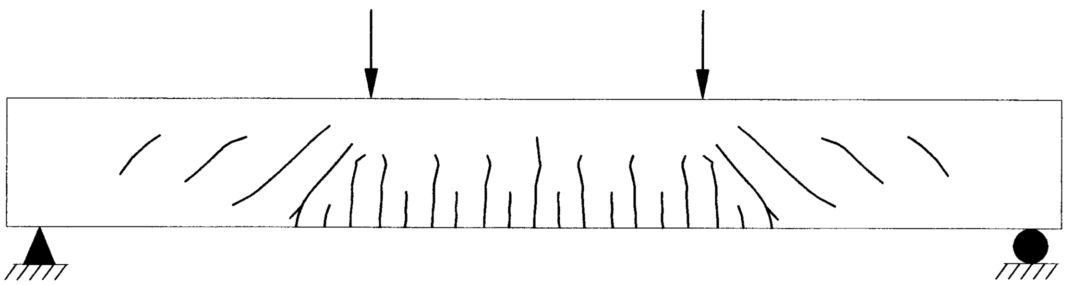

FIGURE Q3(b)

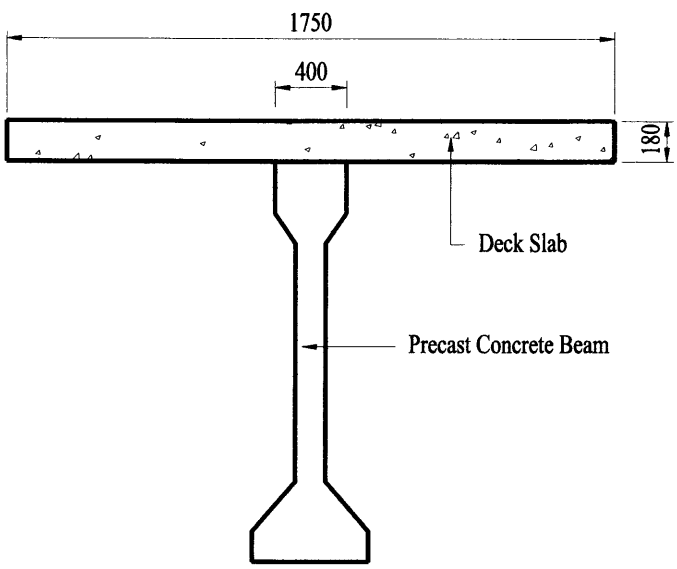

FIGURE Q4(a)

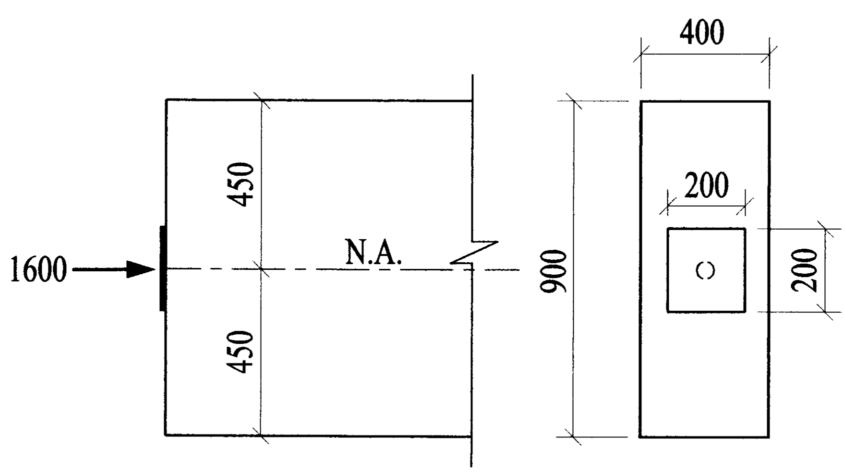

FIGURE Q4(b)

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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;

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

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