UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2011/2012 Academic Session

June 2012

EAS 453/2 – Pre-Stressed Concrete Design
[*Rekabentuk Konkrit Pra-Tegasan*]

Duration : 2 hours
[*Masa : 2 jam*]

Please check that this examination paper consists of **ELEVEN (11)** pages of printed material before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi* ***SEBELAS (11)*** *muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **FIVE (5)** questions. Answer **FOUR (4)** question.
[***Arahan*** *: Kertas ini mengandungi* ***LIMA (5)*** *soalan. Jawab* ***EMPAT (4)*** *soalan.*

You may answer the question either in Bahasa Malaysia or English.
[*Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris*].

All questions **MUST BE** answered on a new page.
[*Semua soalan* ***MESTILAH*** *dijawab pada muka surat baru*].

In the event of any discrepancies, the English version shall be used.
[*Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai*].

1. (a) Consider a simple rectangular beam pre-stressed by a tendon is places eccentrically with respect to the centroid of the concrete section. The resultant compressive force in the concrete acts at the centroid of the tendon at a distance e from the Neutral Axis (below the Neutral Axis) of the section as shown in Figure 1 below. Determine the stress distribution equation across an eccentrically pre-stressed concrete section with an aid of stress distribution diagram for the top and bottom fibre.

[10 marks]

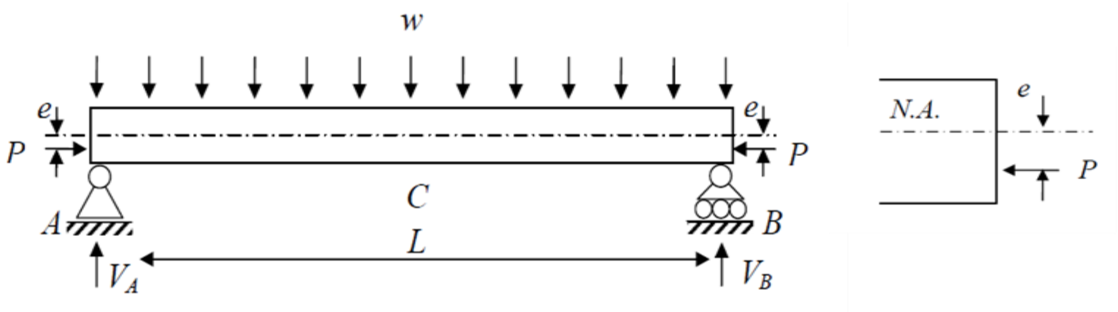


Figure 1

(b) Use the stress distribution equation in 1(a) to answer this question.

A pre-stressed concrete rectangular beam 500 mm x 750 mm with 7.30m span is loaded by a uniform load of 45 kN/m including its own self-weight. The pre-stressing tendon is located 145 mm below the neutral axis at mid-span of the section (take it as positive sign) and produces an effective pre-stress of 1620 kN. Calculate the fibre stresses in the concrete at mid-span. Assume compressive stress as positive.

[15 marks]

2. A 15 meter simply supported Class 1 post-tensioned beam is subjected to a combined dead and live load of 30 kN/m, apart from its own self weight. Determine a suitable pre-stress force, Po (or P) and associated eccentricity at critical section, (e), using Magnel Diagram. The maximum pre-stress loss is assumed to be 20%. The concrete grade at 28 days is 40 N/mm^2 and at transfer is 28 N/mm^2. The typical cross sectional area of the beam is 410 x 10^3 mm^2 with z_t = 100.4 x 10^6 mm^3 and z_b = 96.1 x 10^6 mm^3.

[25 marks]

3. (a) For prestressed concrete , breiefly describe the following terms;

(i) Ultimate shear capacity of uncracked sections in flexure

(ii) Ultimate shear capacity of cracked sections in flexure

[4 marks]

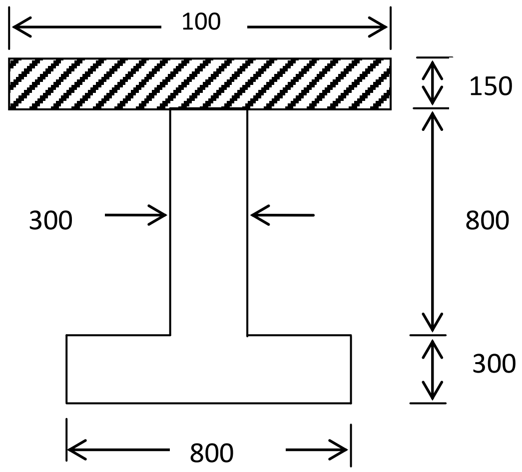


Figure 2

(b) An inverted T beam made from composite with an in-situ slab is shown in Figure 2. A total factored UDL of 18kN/m and 28kN/m live load are imposed over a simply supported span of 25m. The total pre-stressing force P_s at service load is 4,000kN supplied by 30 numbers 15mm diameter 7-wire strand of breaking loads of 230kN. The characteristic strength of concrete is 50N/mm^2 and for the insitu slab is 35N/mm^2. The 30 cables are positioned at the following positions; 10 cables 60mm from soffit, 12 cables 100mm from soffit, 6 cables 150mm from soffit, and 2 cables 1000mm from soffit respectively.

The properties of the precast section are A = 4.425 x 10^5 mm^2 , y_b = 442mm, y_t = 658mm, I = 4.90 x 10^{10} mm^4 , Z_b = 111.0 x 10^6 mm^3 , Z_t = 74.5 x 10^6 mm^3 and e =280mm. The properties of the composite section are A_{comp} = 6.025 x 10^5 mm^2 , $y_{b\ comp}$ = 638mm, $y_{t\ comp}$ = 622mm, I_{comp} = 11.33 x 10^{10} mm^4 , $Z_{b\ comp}$ = 117.6 x 10^6 mm^3 ,and $Z_{t\ comp}$ = 182.2 x 10^6 mm$^{3.}$ The properties of the prestressing steel are A_{ps} = 138.92 mm^2 , f_{pu} = 1670 N/mm^2.

(i) Calculate the ultimate shear capacity of sections cracked in flexure

[12 marks]

(ii) Calculate the ultimate shear capacity of sections uncracked in flexure when number of cables have been reduced to 50% by debonding all cables at 60mm and 6 cables at 100mm from soffit respectively.

[6 marks]

(iii) Determine the shear reinforcement/s.

[3 marks]

4. (a) Describe the **EIGHT (8)** factors affecting deflections of prestressed structures.

[8 marks]

(b) A prestressed rectangular beam shown in Figure 3 below is prestressed using a cable, symmetric parabolic. The force in the cables is 400kN and the modulus of elasticity is $40kN/m^2$.

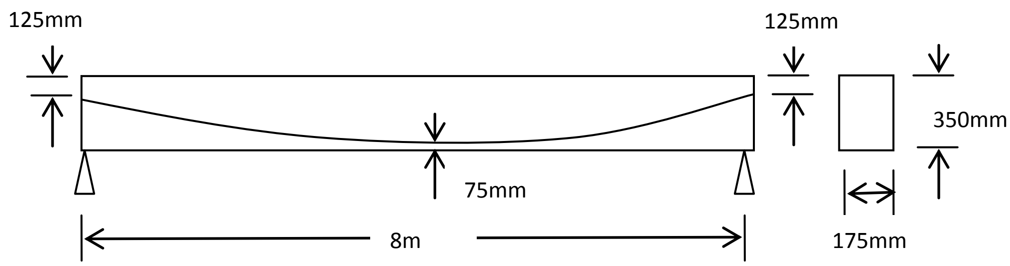


Figure 3

(i) Calculate the deflection of the beam at mid-span when supporting its self weight.

(ii) The load to be applied at mid-span to restore it back to the level of supports.

[5 marks]

(c) A prestressed rectangular beam shown in Figure 4 below supports a uniformly distributed imposed loads of 4kN/m, where half of it is not permanent. The tendon follows a trapezoidal profile where the eccentricity is 100mm within the middle third of the span, and it varies linearly from the one-third spans to zero at the supports. The tendons have an effective prestress of 1300 N/mm^2 after transfer. The beam cross sectional area is 6x 10^4 mm^2 and the density of concrete is 23.6 kN/m^3. The creep coefficient is 2 where the concrete shrinkage is 450 x 10^{-6}. The area of tendon for is 360mm^2 and relaxation of steel stress is 12%. Assuming E_c = 5 x 10^4 mm^2 and E_s = 200 kN/mm^2, calculate

(i) The short term deflections

(ii) The long term deflections

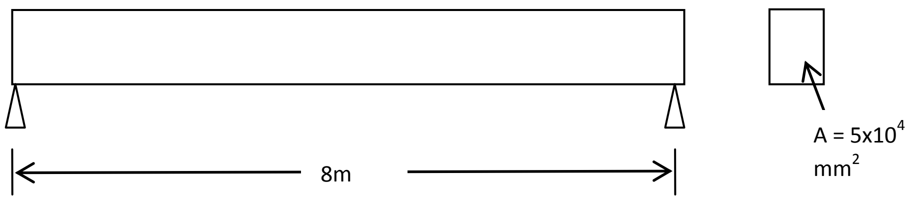


Figure 4

[12 marks]

5. (a) Describe the stress distribution in an end block of pre-stressed structures

[4 marks]

(b) Describe the following method for end block of pre-stressed structures;

(i) Magnel's Method

(ii) Guyon's Method

(iii) Zielenski and Rowe's Method

[9 marks]

(b) A pre-stressed beam's end block is 120mm wide and 250mm deep. The pre-stressing force of 100kN is transmitted to the concrete by a distribution plate of dimensions 120mm and 60mm deep.

(i) Using Magnel's Method, calculate the position and maximum tensile stress on the horizontal section through the centre and edge of anchor plate. Compute also the bursting forces.

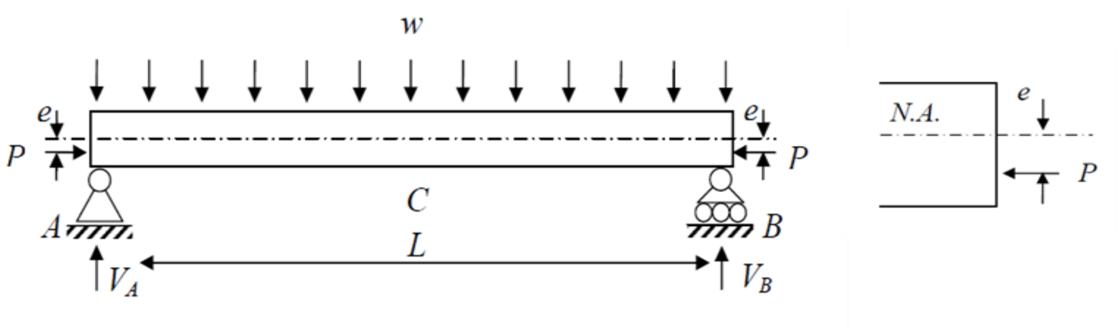
[8 marks]

(ii) Using Guyon's Method, calculate the position and maximum tensile stress on the horizontal section through the centre and edge of anchor plate. Compute also the bursting forces.

[4 marks]

1. (a) *Pertimbangkan rasuk segiempat sama pra-tegangan yang mempunyai tendon yang diletakkan pada kesipian kepada sentroid keratan konkrit. Daya mampatan paduan dalam konkrit bertindak pada sentroid tendon pada jarak e daripada Paksi Neutral (dibawah Paksi Neutral) seperti yang ditunjukkan dalam Rajah 1 dibawah. Kenalpasti persamaan pengagihan tegasan sepanjang kesipian keratan konkrit pra-tegasan dengan bantuan gambarajah pengagihan tegasan untuk gentian atas dan bawah.*

[10 markah]



Rajah 1

(b) *Jawab soalan ini dengan menggunakan persamaan pengagihan tegasan dalam soalan 1 (a).*

Rasuk segiempat sama pra-tegasan 500mm x 750mm dan rentang 7.30 m dibebani beban khidmat seragam 45kN/m dan beban swa-berat. Tendon pra-tegasan diletakkan pada 145mm dibawah Paksi Neutral pada rentang tengah keratan (ambil sebagai positif) dan menghasilkan daya pra-tegasan berkesan 1620 kN. Hitung tegasan gentian dalam konkrit pada pertengahan rentang. Andaikan tegasan mampatan sebagai positif.

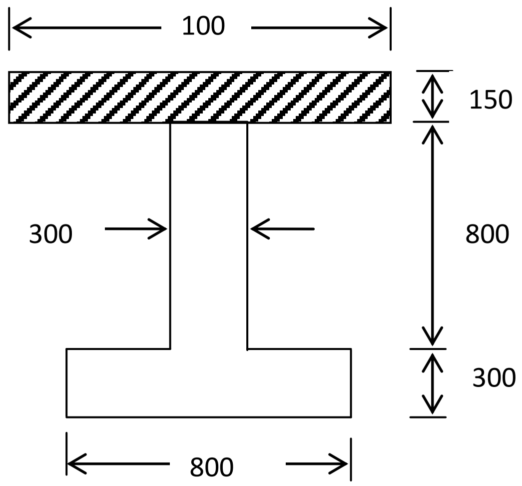
[15 markah]

2. *Satu rasuk konkrit pasca-tegasan tersangga mudah Kelas 1 yang berukuran 15 meter menanggung gabungan beban khidmat dan beban hidup selain beban swa-berat. Tentukan beban pra-tegasan P_o (atau P) dan kesipian, (e), dengan menggunakan Gambarajah Magnel. Jumlah keseluruhan kehilangan pra-tegasan adalah 20%. Grade konkrit pada 28 hari adalah $40N/mm^2$ dan perpindahan daya pra-tegasan adalah $28N/mm^2$. Luas keratan rentas tipikal rasuk adalah 410×10^3 mm^2 dengan $z_t = 100.4 \times 10^6$ mm^3 dan $z_b = 96.1 \times 10^6$ mm^3.*

[25 markah]

3. (a) *Untuk konkrit pra-tegasan, terangkan dengan ringkas istilah-istilah berikut:*
(i)Keupayaan ricih muktamad keratan tak retak dalam lenturan
(ii)Keupayaan ricih muktamad keratan yang retak dalam lenturan

[4 markah]



Rajah 2

(b) *Sebuah rasuk T terbalik dibuat daripada komposit dengan papak in-situ seperti di Rajah 2. Beban terfaktor beban teragih (UDL) ialah 18kN/m dan 28kN/m beban hidup yang disokong mudah dikenakan untuk rentang 25m. Daya pra-tegasan P_s di beban khidmat ialah 4,000kN dibekalkan oleh 30 bilangan 15mm garispusat 7-wayar lembar dengan beban pemutus 230kN. Ciri kekuatan konkrit ialah $50N/mm^2$ dan untuk papak in-situ ialah $35N/mm^2$. 30 kabel dipasangkan di lokasi berikut; 10 kabel 60mm daripada bawah lantai arca, 12 kabel 100mm daripada bawah lantai arca , 6 kabel 150mm daripada bawah lantai arca, 2 kabel 1000mm daripada bawah lantai arca.*

Ciri-ciri bahagian praruang adalah $A = 4.425 \times 10^5\ mm^2$, $y_b = 442mm$, $y_t = 658mm$, $I = 4.90 \times 10^{10}\ mm^4$, $Z_b = 111.0 \times 10^6\ mm^3$, $Z_t = 74.5 \times 10^6\ mm^3$ *dan* $e = 280mm$. *Ciri-ciri bahagian komposit adalah* $A_{comp} = 6.025 \times 10^5\ mm^2$, $y_{b\ comp} = 638mm$, $y_{t\ comp} = 622mm$, $I_{comp} = 11.33 \times 10^{10}\ mm^4$, $Z_{b\ comp} = 117.6 \times 10^6\ mm^3$, *dan* $Z_{t\ comp} = 182.2 \times 10^6\ mm^3$. *Ciri-ciri keluli pra-tegasan adalah* $A_{ps} = 138.92\ mm^2$, $f_{pu} = 1670\ N/mm^2$.

(i) *Kirakan keupayaan ricih muktamad keratan retak dalam lenturan .*

[12 markah]

(ii) *Kirakan keupayaan ricih muktamad keratan tak retak dalam lenturan apabila bilangan kabel dikurangkan ke 50% dengan tidak diikat semua kabel di 60mm dan 6 kabel di 100mm bawah lantai arca, masing-masing.*

[6 markah]

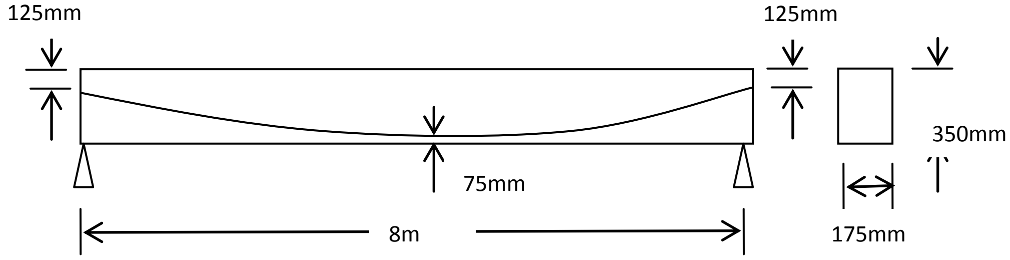
(iii) *Peroleh tetulang ricih.*

[3 markah]

4. (a) *Terangkan* ***LAPAN (8)*** *faktor yang memainkan peranan kepada lenturan struktur pra-tegasan.*

[8 markah]

(b) *Satu rasuk empat segi yang ditunjukkan pada Rajah 3 bawah diprategas dengan menggunakan kabel, simetri parabolik. Daya dalam kabel ialah 400kN dan modulus keanjalan ialah* $40kN/m^2$.



Rajah 3

(i) *Kirakan lenturan rasuk di tengah rentang apabila menyokong beban sendiri.*

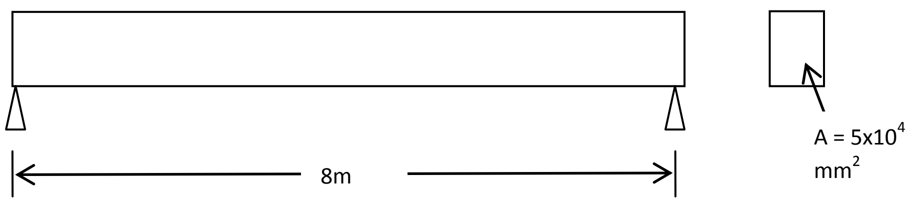
(ii) *Kirakan daya yang diperlukan ditengah rentang untuk mengemablikan ia balik ke aras penyokong.*

[5markah]

(c) *Sebuah rasuk segi-empat seperti Rajah 4 dibawah, menyokong beban teragih seragam 4kN/m, dimana separuhnya adalah tidak tetap. Tendon mengikuti profil trapezoid dimana kesipiannya ialah 100mm untuk sepertiga rentang, dan ianya berkadar secara lelerus daripada sepertiga rentang ke sifar di sokongan. Tendon mempunyai prategasan efektif 1300 N/mm*^{2} *selepas dipindahkan. Luas kawasan rentas rasuk ialah 6x 10*^{4} *mm*^{2} *dan ketumpatan konkrit ialah 23.6 kN/m*^{3}*. Pekali rayap ialah 2 dimana pengecutan konkrit ialah 450 x 10*$^{-6}$*. Luas kawasan tendon ialah 360mm*^{2} *dan pengenduran tegasan keluli ialah 12%. Andaikan* E_c = 5 x 10^4 *mm*^{2} *dan* E_s = 200 kN/mm^2*, kirakan*

(i) *Lenturan jangka pendek*

(ii) *Lenturan jangka panjang*



Rajah 4

[12 markah]

5. (a) *Terangkan agihan tegasan di blok hujung struktur pra-tegasan.*

[4 markah]

(b) *Terangkan kaedah untuk elemen Describe the following method for end block of prestressed members;*

(i) *Kaedah Magnel's*

(ii) *Kaedah Guyon's*

(iii) *Kaedah Zielenski and Rowe's*

[9 markah]

(c) *Blok hujung rasuk pra-tegasan ialah 120mm wide dan 250mm dalam. Daya pra-tegasan 100kN dialirkan kepada konkrit dengan menggunakan plet agihan berdimensi 120mm dan 60mm dalam.*

(i) *Dengan menggunakan kaedah Magnel's, kirakan posisi dan tegasan tegangan di bahagian mendatar melalui pusat dan hujung plat penambat. Kirakan juga daya letusan.*

[8 markah]

(ii) *Dengan menggunakan kaedah Guyon's, kirakan posisi dan tegasan tegangan di bahagian mendatar melalui pusat dan hujung plat penambat. Kirakan juga daya letusan.*

[4 markah]

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