**UNIVERSITI SAINS MALAYSIA**

Second Semester Examination
2010/2011 Academic Session

April/May 2011

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

Duration: 2 hours
*Masa : 2 jam*

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Please check that this examination paper consists of **SEVEN (7)** pages of printed material before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH (7)** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*]

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

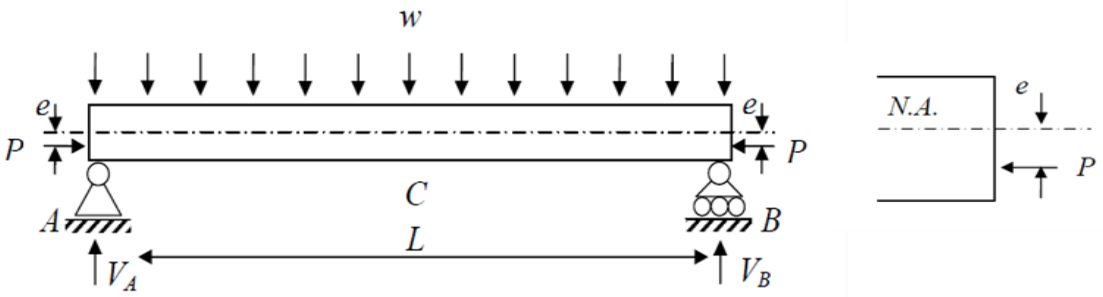
You may answer the question either in Bahasa Malaysia or English.
[*Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris*].

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 akan diguna pakai*].

1. (a) Consider a simple rectangular beam pre-stressed by a tendon is placed 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 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]




(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 simply supported Class 1 post-tensioned concrete beam with 10 meter span is subjected to a service load and its own selfweight. The total pre-stress loss is taken as 20% and transfer of pre-stress force is done after 7 days of concrete casting. Determine the pre-stressing force, P and eccentricity, e at critical section using Magnel Diagram

Given:

| | | | |
|---|---|---|---|
| *i.* | $f_{cu}$ (28 days) | = | 50 N/mm$^2$ |
| *ii.* | $f_{ci}$ (7 days) | = | 36 N/mm$^2$ |
| iii. | Service load | = | 20 kN/m |
| iv. | Selfweight load | = | 4.32 kN/m |
| *v.* | $Z_t = Z_b$ | = | 18 x 10$^6$ mm$^3$ |
| *vi* | $A$ | = | 180,000 mm$^2$ |

[25 marks]

3. (a) Lists the different type of losses encountered in the pre-tensioning and post-tensioning systems.

[5 marks]

(b) A pre-tensioned concrete beam, 100mm wide and 300mm deep, is pre-stressed by straight wires carrying an initial force of 150kN at an eccentricity of 50mm. The modulus of elasticity of steel and concrete are 210 and 35kN/mm$^2$ respectively. Estimate the percentage loss of stress in steel due to elastic deformation of concrete if the area of steel wires is 188mm$^2$.

[10 marks]

(c) A simply supported prestressed concrete beam supports a uniformly distributed load (UDL) of 3kN/m, half of which is non permanent has the following characteristics:

Cross sectional area A = 50000 mm$^2$
Span = 10 m
Tendon profile= an eccentricity of 100mm within the middle third of the span and varies linearly from the third-span points to zero at supports
Area of tendons $A_p$ = 350 mm$^2$
Effective prestress = 1290 N/mm$^2$
Density of concrete = 23.6 kN/m$^3$
Creep coefficient = 2
Concrete shrinkage $\varepsilon_{cs}$ = 450x 10$^{-6}$
Relaxation of steel stress = 10%
Modulus of elasticity of concrete $E_c$ = 34 kN/mm$^2$
Modulus of elasticity of reinforcement $E_s$ = 200 kN/mm$^2$
Second area of moment of area $I_g$ = 4.5 x 10$^8$ mm$^4$

Calculate the short term and the long term deflections.

[10 marks]

4. (a) Discuss the **TWO (2)** modes of failure for shear in prestressed concrete beams.

[4 marks]

(b) Discuss with the aid of diagrams the **TWO (2)** types of shear cracks of prestressed concrete members.

[6 marks]

(c) A prestressed concrete beam in an unsymmetrical T-section with the following characteristics:

Overall depth = 1500 mm
Thickness of web = 150 mm
Distance of top fibre from centroid = 545 mm
Distance of bottom fibre from centroid = 755 mm
Ultimate moment $M_u$ = 2130 kNm
Shear Force V = 230 kN
Effective depth d = 1100 mm
Cube strength of concrete $f_{cu}$ = 45 N/mm$^2$
Effective prestress at tensile face of the beam $f_{cp}$ = 19.3 N/mm$^2$
Second moment of area I = 665 x 108 mm$^4$
Area of steel in the section $A_p$ = 2310 mm$^2$
Tensile strength of tendon $f_p$ = 1500 N/mm$^2$
Effective stress in tendons after all losses $f_{pc}$ = 890 N/mm$^2$
Design shear strength of concrete $\tau_c$ = 0.77 N/mm$^2$

Calculate the flexure shear resistance of the section.

[7 marks]

d) The support section of a prestressed concrete beam, 120 mm wide and 275 mm deep is required to support an ultimate shear force of 75 kN. The compressive prestress at the centroidal axis is 5 N/mm$^2$. The characteristic cube strength of concrete is 40 N/mm$^2$. The cover to the tension reinforcement is 60 mm. The characteristics tensile strength of steel in stirrups is 250 N/mm$^2$. Design the reinforcements at the section.

[8 marks]

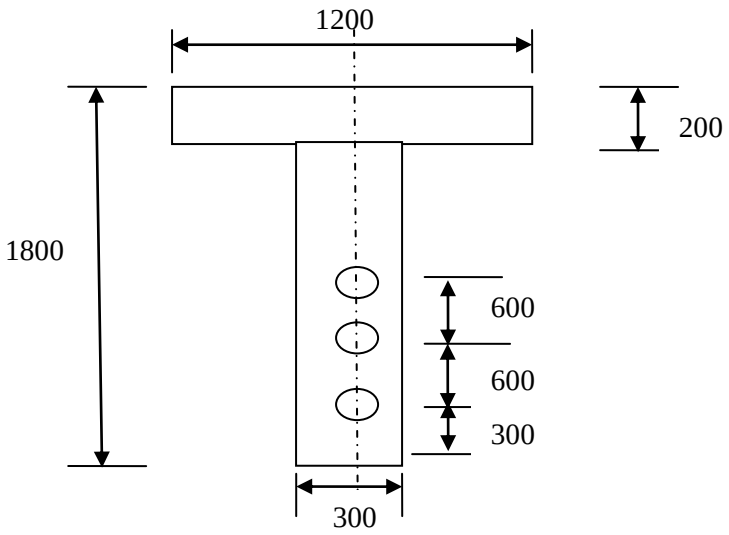
5. a) Discuss the **TWO (2)** problems associated with end-block design.

[4 marks]

b) In the design of end blocks, discuss the bursting forces in the anchorage zones.

[6 marks]

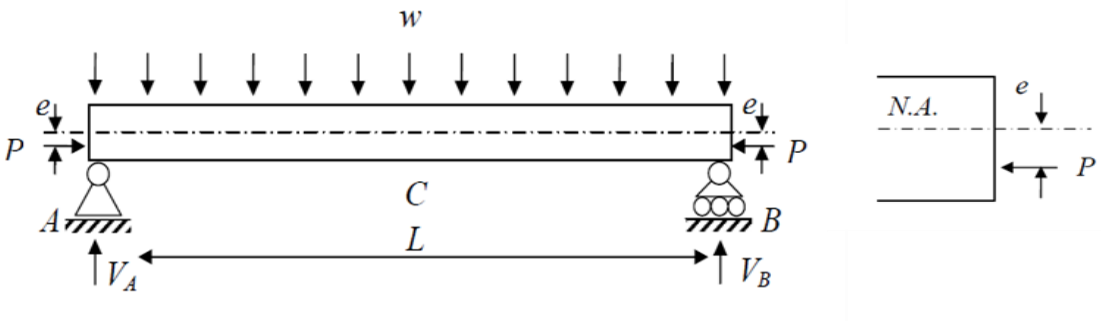
c) The figure below shows the cross section at the support of a post tensioned T beam with **THREE (3)** anchors of area 200mm$^2$ each. Each tendon with a force of 1500 kN. Calculate the bursting force and design the necessary reinforcement to prevent the end-block from bursting.




[15 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 gambarajah dibawah. Kenalpasti persamaan pengagihan tegasan sepanjang kesipian keratan konkrit pra-tegasan dengan bantuan gambarajah pengagihan tegasan untuk gentian atas dan bawah.*

*[10 markah]*




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

*Rasuk segiempat sama pra-tegasan 500 mm x 750 mm dan rentang 7.30 m dibebani beban khidmat seragam 45 kN/m dan beban swa-berat. Tendon pra-tegasan diletakkan pada 145 mm 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 menanggung beban khidmat dan swa-berat. Jumlah keseluruhan kehilangan pra-tegasan adalah 20% dan perpindahan daya pra-tegasan dilakukan selepas 7 hari konkrit dituang. Tentukan data pra-tegasan, P dan kesipian, e pada keratin genting menggunakan Gambarajah Magnel*

*Diberi:*

| | | | |
|---|---|---|---|
| *i.* | $f_{cu}$ *(28 hari)* | = | $50\ N/mm^2$ |
| *ii.* | $f_{ci}$ *(7 hari)* | = | $36\ N/mm^2$ |
| *iii.* | *Beban Khidmat* | = | *20 kN/m* |
| *iv.* | *Beban swa-berat* | = | *4.32 kN/m* |
| *v.* | $Z_t = Z_b$ | = | $18 \times 10^6\ mm^3$ |
| *vi* | *A* | = | $180{,}000\ mm^2$ |

*[25 markah]*

3. a) *Senaraikan jenis-jenis kehilangan yang lazimnya berlaku pada sistem pra-tegasan dan pasca-tegasan.*

*[5 markah]*

b) *Satu rasuk konkrit pra-tegasan dengan kelebaran 100 mm dan ketinggian 300 mm ditegaskan dengan wayar lurus yang menanggung daya awal 150 kN pada kesipian 50 mm. Modulus keanyalan bagi keluli adalah 210 kN/mm$^2$ dan konkrit adalah 35 kN/mm$^2$. Anggarkan peratus kehilangan yang disebabkan oleh perubahan elastic konkrit jika luas kawasan wayar keluli adalah 188 mm$^2$.*

*[15 markah]*

c) *Sebuah rasuk konkrit pra-tegasan yang disokong mudah menyokong beban agihan sama rata 3 kN/m, dimana separuh adalah tidak kekal mempunyai ciri-ciri berikut:*

*Luas Keratan rentas A = 50000 mm$^2$*
*Rentang = 10 m*
*Profil tendon = eksentrik sebanyak 100mm dibahagian sepertiga tengah rentang dan berbeza secara lelerus daripada sepertiga rentang ke sifar di penyokong*
*Luas kawasan tendon $A_p$ = 350 mm$^2$*
*Prategasan berkesan = 1290 N/mm$^2$*
*Ketumpatan konkrit = 23.6 kN/m$^3$*
*Pekali menyusur = 2*
*Kecutan konkrit $\varepsilon_{cs}$ = 450 x 10$^{-6}$*
*Pengenduran tegangan keluli = 10%*
*Modulus of keanjalan konkrit $E_c$ = 34 kN/mm$^2$*
*Modulus of keanjalan tetulang reinforcement $E_s$ = 200 kN/mm$^2$*
*Luas kawasan momen kawasan $I_g$ = 4.5 x 10$^8$ mm$^4$*

*Kirakan lenturan jangka pendek dan jangka panjang.*

*[10 markah]*

4. a) *Bincang **DUA (2)** mod kegagalan untuk ricih dalam rasuk konkrit prategasan.*

*[4 markah]*

b) *Bincang dengan berbantukan rajah, **DUA (2)** jenis retakan ricih yang terdapat pada rasuk konkrit prategasan.*

*[6 markah]*

c) *Sebuah rasuk –T prategasan kertaan tak bersimetri mempunyai ciri-ciri berikut:*

*Kedalaman keseluruhan = 1500 mm*
*Tebal web = 150 mm*
*Jarak dari fiber atas dari pusat = 545 mm*
*Jarak dari fiber bawah dari pusat = 755 mm*
*Momen muktamad* $M_u$ *= 2130 kNm*
*Daya ricih V = 230 kN*
*Ukurt dalam berkesan d = 1100 mm*
*Kekuatan kiub konkrit* $f_{cu}$ *= 45 N/mm*$^2$
*Prategasan berkesan di permukaan tegangan rasuk* $f_{cp}$ *= 19.3 N/mm*$^2$
*Luas kawasan kedua I = 665 x 108 mm*$^4$
*Luas kawasan keluli* $A_p$ *= 2310 mm*$^2$
*Kekuatan tegangan tendon* $f_p$ *= 1500 N/mm*$^2$
*Tegasan berkesan dalam tendon selepas semua kehilanagn* $f_{pc}$ *= 890 N/mm*$^2$
*Kekuatan ricih rekabentuk konkrit* $\tau_c$ *= 0.77 N/mm*$^2$

*Kirakan rintangan ricih lenturan di bahagaian tersebut.*

*[7 markah]*

d) *Di bahagian penyokong rasuk konkrit prategasan , 120 mm lebar dan 275 mm kedalaman, perlu menyokong daya ricih muktamad 75kN. Prategasan mampat di paksi pusat ialah 5 N/mm*$^2$*. Kekuatan kiub konkrit ialah 40 N/mm*$^2$*. Penutup konkrit ke bertetulang ialah 60 mm. Ciri kekuatan tegangan keluli dalam rakap ialah 250 N/mm*$^2$*. Rekabentuk tetulang di bahagian tersebut.*

*[8 markah]*

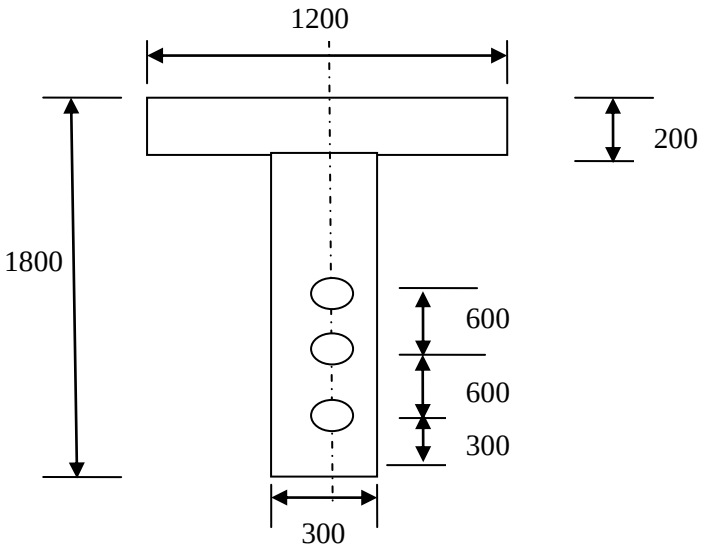
5. a) *Bincang **DUA (2)** masalah yang berkaitan dengan rekabentuk blok- hujung.*

*[4 markah]*

b) *Untuk rekabentuk blok hujung, bincang daya letusan di zon penambat.*

*[6 marks]*

c) *Rajah dibawah menunjukkan keratin rentas di sokongan rasuk-T pasca tegangan dengan **TIGA (3)** penambat dengan luas kawasan 200 mm*$^2$ *setiap satu. Setiap tendon di prategasan dengan daya 1500 kN. Kirakan daya letusan dan rekabentuk tetulang yang diperlukan untuk menghalang blok-hujung daripada meletus.*




*[15 markah]*

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