UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/May 2009

EAS 452/3 – Pre-Stressed Concrete Design
[Rekabentuk Konkrit Pra-Tegasan]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **FOURTEEN (14)** printed pages including appendix before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **EMPAT BELAS (14)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions only. All questions carry the same marks.

*[**Arahan**: Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan sahaja. Semua soalan membawa jumlah markah yang sama.]*

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.]*

Write the answered question numbers on the cover sheet of the answer script.
[Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.]

1. a) State **FOUR (4)** important basic equations used in determining the stress criteria of a pre-stressed beam. Sketch the stress distribution diagrams for any typical section of a pre-stressed beam at transfer.

[6 Marks]

b) A simply supported 25 meter span Class 1 post-tensioned beam with parabolic single tendon is subjected to selfweight, Dead Load = 3 kN/m and Imposed Load = 18 kN/m. Calculate the final **support and mid span stresses** both at **transfer and service** based on the requirements given. Discuss the results obtained :-

i)	fcu (at 28 days)	$= 45 \text{ N/mm}^2$
ii)	fci (at transfer)	$= 35 \text{ N/mm}^2$
iii)	Jacking Force, P	$= 3500 \text{ kN}$
iv)	Efficiency, μ	$= 0.75$
v)	Tendon eccentricity (at support)	$= -50 \text{ mm}$
vi)	Tendon eccentricity (at mid span)	$= +400 \text{ mm}$
vii)	Z_1 (top)	$= 150 \times 10^6 \text{ mm}^3$
viii)	Z_2 (bottom)	$= 100 \times 10^6 \text{ mm}^3$
ix)	Beam cross sectional area	$= 450 \times 10^3 \text{ mm}^2$
x)	Concrete density	$= 24 \text{ kN/m}^3$

[14 Marks]

2. a) Briefly discuss the basic analysis in determining the Ultimate Moment of Resistance of a pre-stressed member. State **THREE (3)** assumptions considered in the analysis.

[5 Marks]

b) A simply supported Class 2 post-tensioned beam is subjected to a service load 25 kN/m apart from its own selfweight. The total pre-stress loss is taken as 25%. Determine the pre-stressing force, **P** and eccentricity, **e** at critical section subject to the following data :-

i)	Beam span	= 20 meter
ii)	fcu (28 days)	= 40 N/mm^2
iii)	fci (at transfer)	= 28 N/mm^2
vi)	Beam cross sectional area	= 490 x 10^3 mm^2
v)	Z (top)	= 128.8 x 10^6 mm^3
vi)	Z (bottom)	= 126 x 10^6 mm^3
vii)	Concrete density	= 24 kN/m^3

[15 Marks]

3. a) A Class 2 post-tensioned concrete beam with single tendon is subjected to a Jacking Force, P = 3500 kN (jack at one end only) as shown in Figure 1. Calculate the pre-stress losses taking into consideration all the data below :-

i)	Ec (28 days)	= 28 kN/mm^2
ii)	fcu (28 days)	= 45 N/mm^2
iii)	fci (at transfer)	= 30 N/mm^2
iii)	Es	= 200 kN/mm^2
iv)	Beam cross section	= 400 mm (B) x 1200 (H)
v)	No of strand per tendon	= 22
vi)	Strand diameter/area	= 15.2 mm/139 mm^2
vii)	Duct/sleeve type	= plastic (greased)
viii)	Shrinkage coefficient	= 200 x 10^{-6}
ix)	Creep coefficient at transfer	= 1.5
x)	Initial force/tendon strength	= 68 %

[20 Marks]

Midspan

P →

N.A.

22,000

a) Longitudinal profile (all units in mm)

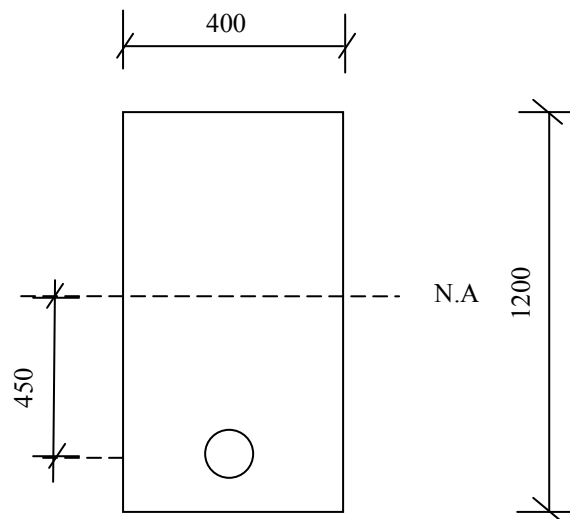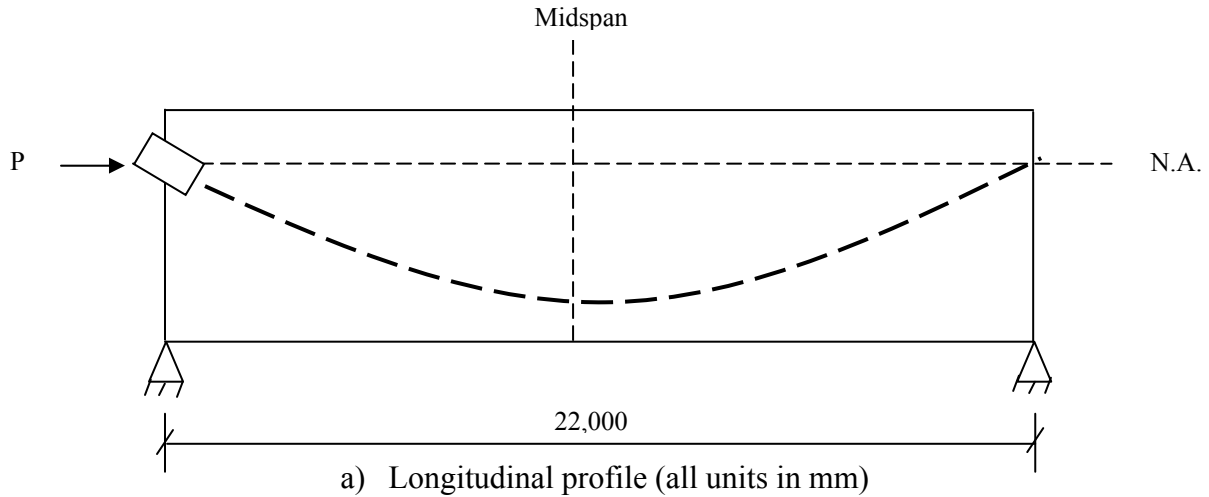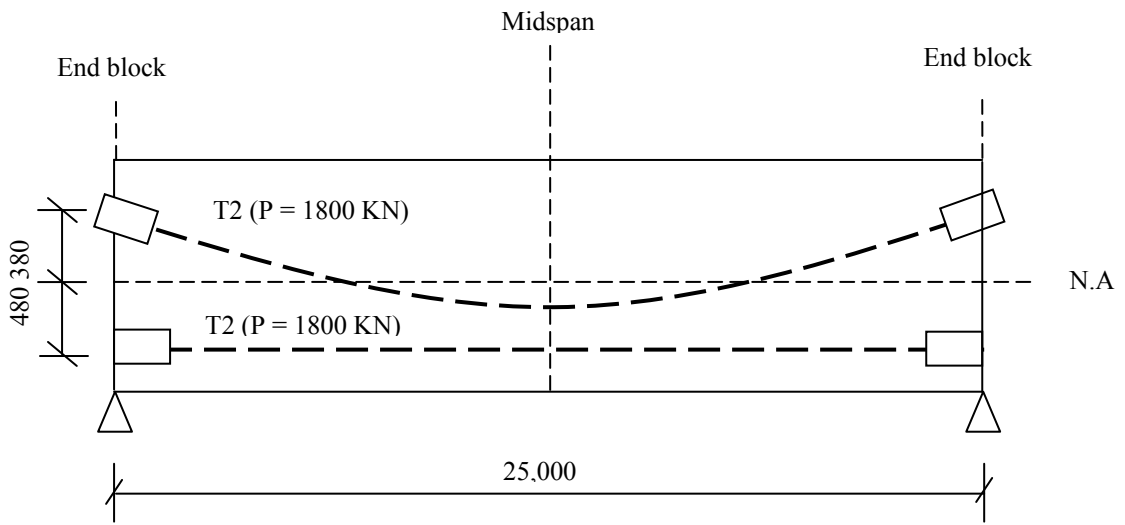400

N.A

1200

450

b) Cross section at mid span

Figure 1: Post-tensioned Beam with Single tendon (All units in mm)

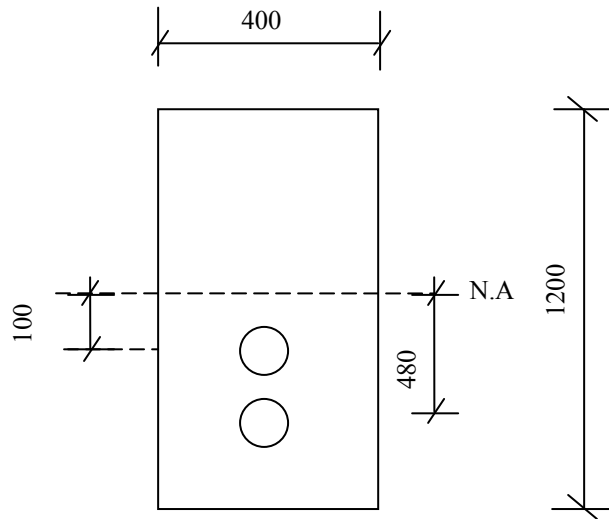4. a) Briefly discuss the practical considerations for evaluating deflection of a pre-stressed concrete element.

[6 Marks]

b) A 25 meter span post-tensioned beam has been designed using double tendons is shown in Figure 2. Calculate the total short term deflection at transfer and provide relevant comments. Assume Ec = 28 kN/mm², concrete density = 24 kN/m³ and Jacking Force = 1800 kN . The standard formulae for deflection is in Appendix A.

[14 Marks]

a) Longitudinal profile (all units in mm)

b) Section at midspan (all units in mm)

Figure 2 : Post – Tensioned Beam Profile and Section

5. a) Describe the effects of shear in pre-stress beams.

[5 Marks]

   b) Describe the shear reinforcement used in pre-stress beams.

[5 Marks]

   c) For a symmetrical pre-stress I section, given that the shear force is 400 kN and bending moment 820 kNm, design the shear reinforcement required.

   The characteristics of the I section are :

   Rib width   =   210 mm
   Overall depth   =   1000 mm
   Area   = 300×10^3 mm^2
   I   = 36×10^9 mm^4
   Area of pre-stressing tendon (Aps)   =   1803 mm^2
   f_{pu} =   1750 N/mm^2
   f_{pc} =   1050 N/mm^2
   e_s =   290 mm
   β = 3° at section considered
   f_{cu} =   50 N/mm^2
   f_{yv} =   250 N/mm^2

   Shear force, V can be calculated from:

   V   = $V_c - P_e \sin \beta$ -   for uncracked section

   V   = $V_c - P_e \sin \beta$ ⎤   whichever is greater for
           = V_c ⎦   section cracked

[10 Marks]

6. a) Describe the main difference between anchorage used in pre-tensioning and post-tensioning systems.

[4 Marks]

b) Describe the **THREE (3)** main categories of post tensioning anchorages :

   i)   Wedge anchorages
   ii)   Button head anchorages
   iii)   Threaded anchorages

[6 Marks]

a) A beam shown in Figure 3 has **SIX (6)** anchorages, each with conical anchors of 100 mm diameter and a characteristic force of 450 kN applied to the tendon. If the concrete grade is Grade C40/C50 and fy = 460 N/mm^2, determine the bearing stresses under the anchorages, the reinforcement required to resist bursting forces and the local stresses in the concrete end-block.
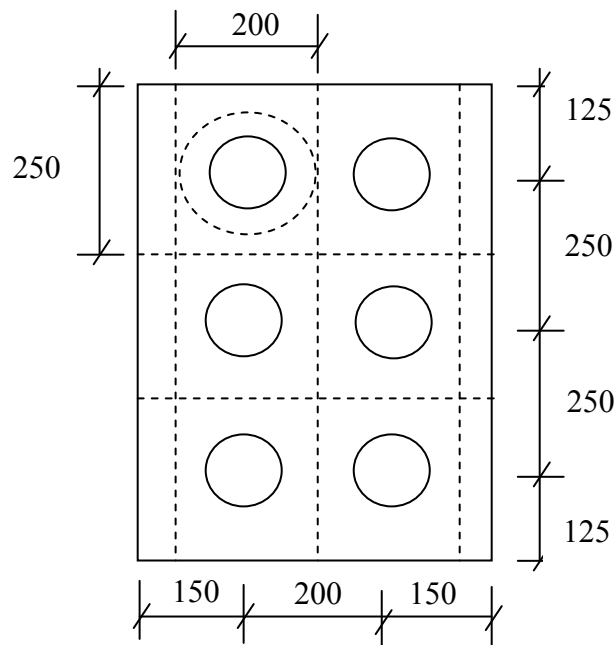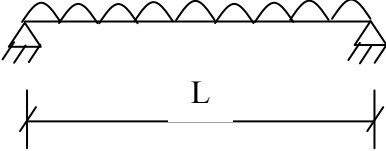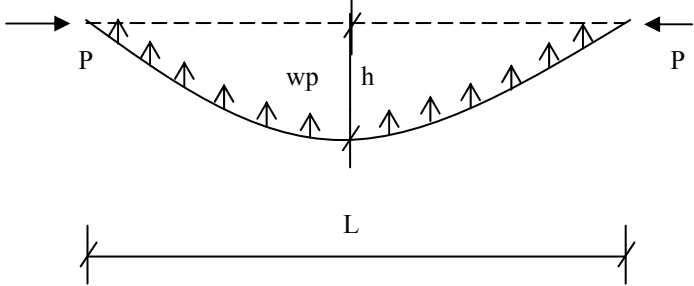
[10 Marks]

Figure 3

APPENDIX A

STANDARD FORMULAE FOR DEFLECTION

CONDITION	DEFLECTION (δ)
a) Uniformly Distributed Load W kN/m L	$\delta \text{ max} = \dfrac{5}{384} \times \dfrac{WL^4}{EI}$
b) Due pre-stress of parabolic tendon P wp h P L	$\text{Wp} = \dfrac{8Ph}{L^2}$ $\delta \text{ max} = \dfrac{5}{384} \times \dfrac{WpL^4}{EI}$
c) Due P at ends P e N.A P L	$\delta \text{ max} = \dfrac{1}{8} \times \dfrac{PeL^2}{EI}$

Note : P = Pre-Stressing Force at Transfer

(TERJEMAHAN)

2. a) *Nyatakan* **EMPAT (4)** *persamaan asas yang penting dan digunakan untuk menentukan kriteria tegasan satu rasuk pra-tegasan. Lakarkan rajah-rajah agihan tegasan masa pindah untuk satu keratan tipikal rasuk pra-tegasan*

[6 Markah]

b) *Satu rasuk pasca-tegasan tersangga mudah Kelas 1 dengan rentangan 25 meter beserta tendon tunggal parabolik dikenakan beban swa-berat, Beban Mati = 3 kN/m dan Beban Hidup = 18 kN/m. Kira tegasan akhir di sangga dan tengah rentang pada masa pindah dan kebolehkhidmatan berdasarkan kehendak-kehendak yang diberikan. Bincang keputusan yang diperolehi :-*

i)	*fcu (pada 28 hari)*	$= 45 \text{ N/mm}^2$
ii)	*fci (masa pindah)*	$= 35 \text{ N/mm}^2$
iii)	*Daya Tujahan, P*	$= 3500 \text{ kN}$
iv)	*Kecekapan, µ*	$= 0.75$
v)	*Kesipian tendon (di sangga)*	$= -50 \text{ mm}$
vi)	*Kesipian tendon (di tengah rentang)*	$= + 400 \text{ mm}$
vii)	Z_1 *(atas)*	$= 150 \times 10^6 \text{ mm}^3$
viii)	Z_2 *(bawah)*	$= 100 \times 10^6 \text{ mm}^3$
ix)	*Luas keratan rentas rasuk*	$= 450 \times 10^3 \text{ mm}^2$
x)	*Ketumpatan konkrit*	$= 24 \text{ kN/m}^3$

[14 Marks]

2. a) *Bincangkan dengan ringkas asas analisis untuk menentukan Momen Rintangan Muktamad anggota pra-tegasan. Nyatakan* **TIGA (3)** *anggapan yang dipertimbangkan dalam análisis tersebut.*

[5 Markah]

b) *Satu rasuk pasca-tegasan tersangga mudah Kelas 2 menanggung beban khidmat sebanyak 25 kN/m selain dari beban swa-berat. Jumlah keseluruhan kehilangan pra-tegasan adalah 25%. Tentukan daya pra-tegasan, **P** dan kesipian, **e** pada keratan genting dengan mengambil kira data berikut :-*
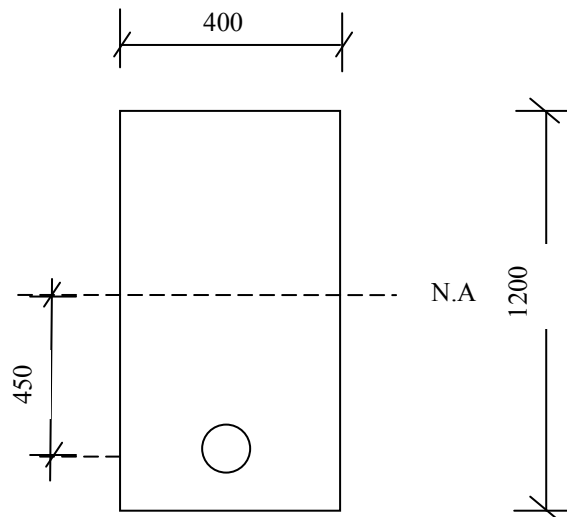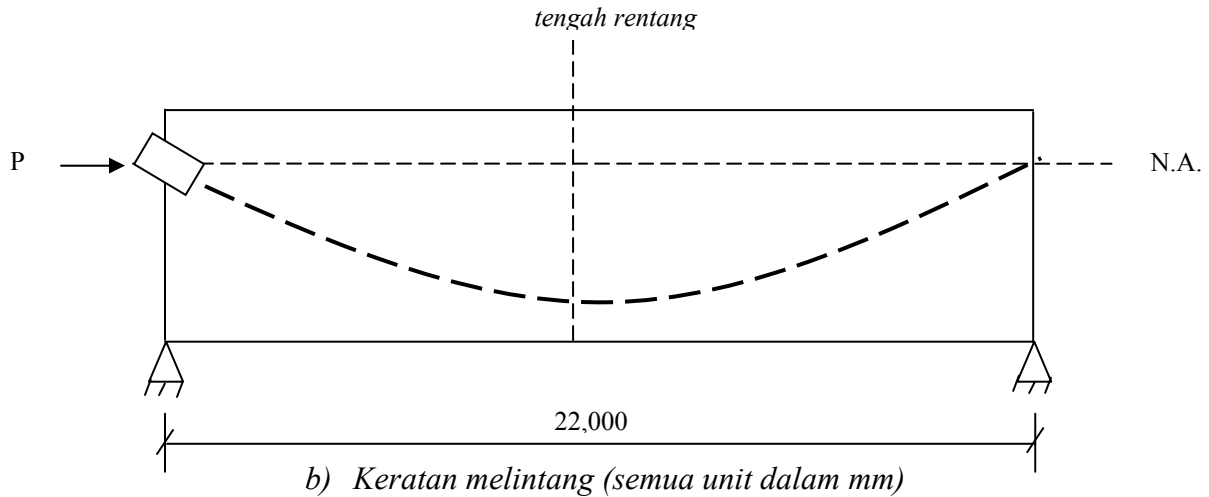
i)	*Rentangan rasuk*	= 20 meter
ii)	*fcu (28 hari)*	= 40 N/mm^2
iii)	*fci (masa pindah)*	= 28 N/mm^2
vi)	*Luas keratan rentas rasuk*	= 490 x 10^3 mm^2
v)	*Z (atas)*	= 128.8 x 10^6 mm^3
vi)	*Z (bawah)*	= 126 x 10^6 mm^3
vii)	*Ketumpatan konkrit*	= 24 kN/m^3

[5 Markah]

3. a) *Satu rasuk pasca-tegasan Kelas 2 dengan tendon tunggal dikenakan Daya Tujahan, P = 3500 kN (di bicu pada satu hujung sahaja) seperti di Rajah 1. Kira kehilangan para-tegasan dengan mengambil kira data-data di bawah.*

i)	*Ec (28 hari)*	= 28 kN/mm^2
ii)	*fcu (28 hari)*	= 45 N/mm^2
iii)	*fci (masa pindah)*	= 30 N/mm^2
iii)	*Es*	= 200 kN/mm^2
iv)	*Keratan rentas rasuk*	= 400 mm (B) x 1200 (H)
v)	*Bilangan lembar setiap tendon*	= 22
vi)	*Garispusat lembar/luas*	= 15.2 mm/139 mm^2
vii)	*Jenis sesalur*	= *plastik (bergris)*
viii)	*Pekali pengecutan*	= 200 x 10^{-6}
ix)	*Pekali rayapan masa pindah*	= 1.5
x)	*Daya awal/kekuatan tendon*	= 68 %

[20 Markah]

tengah rentang

P →

N.A.

22,000

b) *Keratan melintang (semua unit dalam mm)*

400

1200

N.A

450

b) *Keratas rentas pada tengah rentang*

Rajah 1 : Rasuk pasca tegasan dengan tendon tunggal (semua unit dalam mm)

4. a) Bincangkan dengan ringkas pertimbangan – pertimbangan yang praktikal untuk menilai pesongan suatu anggota konkrit para-tegasan

[6 Markah]

c) Satu rasuk pasca-tegasan dengan rentangan 25 meter telah direkabentuk menggunakan tendon berkembar seperti di Rajah 2. Kira jumlah pesongan jangka pendek masa pindah dan sediakan komen-komen yang berkaitan. Anggap E_c = 28kN/mm^2, ketumpatan konkrit = 24 kN/m^3 dan Daya Tujahan = 1800 kN.. Persamaan piawai untuk pesongan adalah seperti di Apendik A.

[14 Markah]

b)   Keratan melintang (semua unit dalam mm)

Keratan rentas pada tengah rentang

Rajah 2 : Rasuk pasca tegasan dan keratan

5. a) *Jelaskan kesan-kesan ricih di dalam rasuk pra-tegasan.*

    [5 Markah]

    c) *Jelaskan tetulang ricih yang digunakan di dalam rasuk-rasuk pra-tegasan.*

    [5 Markah]

    d) *Bagi satu keratan pra-tegasan I simetri yang dikenakan daya ricih, 400kN dan momen lentur 820kNm, rekabentukkan tetulang ricih yang diperlukan.*

        Ciri-ciri keratan 1 adalah seperti berikut :

Lebar rasuk	=	*210 mm*
Kedalaman keseluruhan	=	*1000 mm*
Luas	=	*300 x 10^3 mm^2*
I	=	*36 x 10^9 mm^4*
Luas tendon pra-tegasan (Aps)	=	*1803 mm^2*
f_{pu}	=	*1750 N/mm^2*
f_{pc}	=	*1050 N/mm^2*
e_s	=	*+290 mm*
β	=	*3° pada keratan yang dipertimbangkan*
f_{cu}	=	*50 N/mm^2*
f_{yv}	=	*250 N/mm^2*

        Daya ricih, V boleh dikira sepeti berikut :

        V = $V_c - P_e \sin β$ - *untuk keratan tanpa retak*

        V = $V_c - P_e \sin β$ ⎱ *yang mana lebih besar untuk*
            = V_c ⎰ *keratan retak*

    [10 Marks]

6. a) *Jelaskan perbezaan utama di antara tambatan yang digunakan dalam sistem-sistem pra-tegangan dan pasca tegangan.*

    [4 Markah]

b) Jelaskan **TIGA (3)** kategori utama untuk tambatan pasca tegangan berikut :

iv)   Tambatan baji

v)   Tambatan kepala butang

vi)   Tambatan berukir (berbenang)

[6 Markah]

d) Satu rasuk seperti yang ditunjukkan di Rajah 3 mempunyai **ENAM (6)** tambatan, setiap satu dengan penambat kon dengan garispusat 100 mm dan daya 450 kN dikenakan kepada tendon. Sekiranya konkrit adalah gred C40/C50 dan fy = 460 N/mm², tentukan tegasan-tegasan galas di bawah semua tambatan, tetulang yang diperlukan untuk menahan daya letusan dan tegasan-tegasan tempatan di dalam blok hujung konkrit.
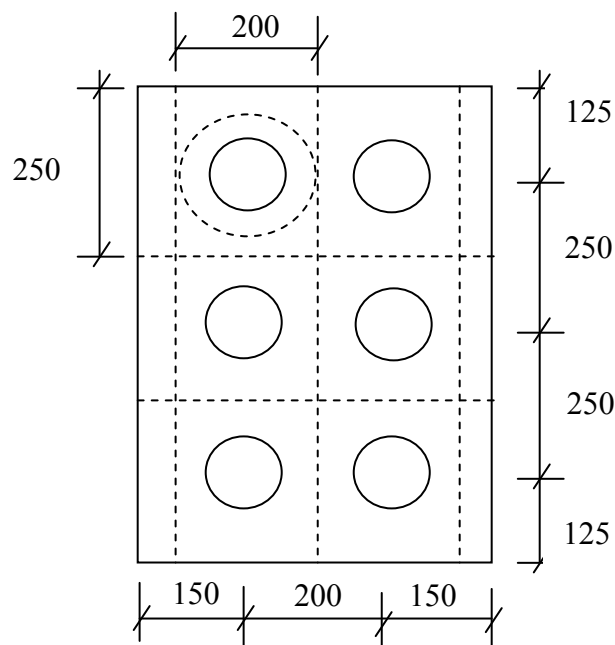
[10 Markah]

Figure 3

oooOOOooo