
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)	f_{cu} (at 28 days)	= 45 N/mm ²
ii)	f_{ci} (at transfer)	= 35 N/mm ²
iii)	Jacking Force, P	= 3500 kN
iv)	Efficiency, μ	= 0.75
v)	Tendon eccentricity (at support)	= -50 mm
vi)	Tendon eccentricity (at mid span)	= + 400 mm
vii)	Z_1 (top)	= 150 x 10 ⁶ mm ³
viii)	Z_2 (bottom)	= 100 x 10 ⁶ mm ³
ix)	Beam cross sectional area	= 450 x 10 ³ mm ²
x)	Concrete density	= 24 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)	f_{cu} (28 days)	= 40 N/mm ²
iii)	f_{ci} (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)	E_c (28 days)	= 28 kN/mm ²
ii)	f_{cu} (28 days)	= 45 N/mm ²
iii)	f_{ci} (at transfer)	= 30 N/mm ²
iii)	E_s	= 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]

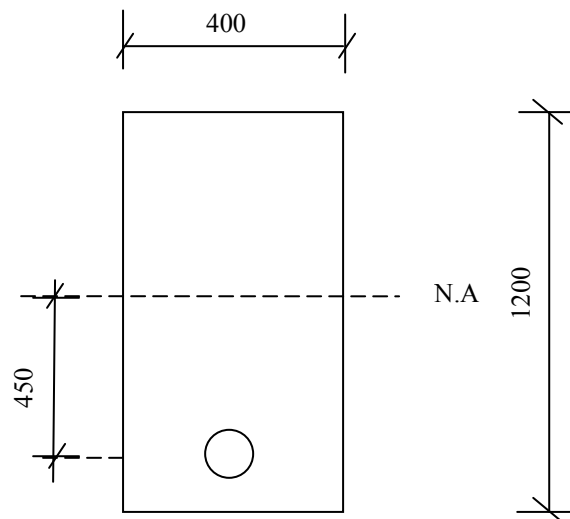
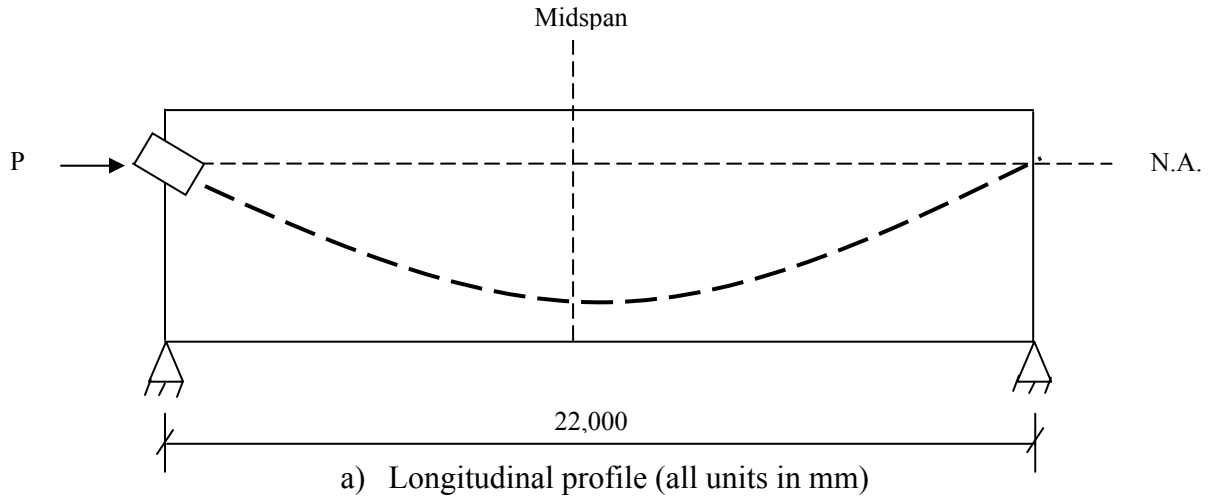


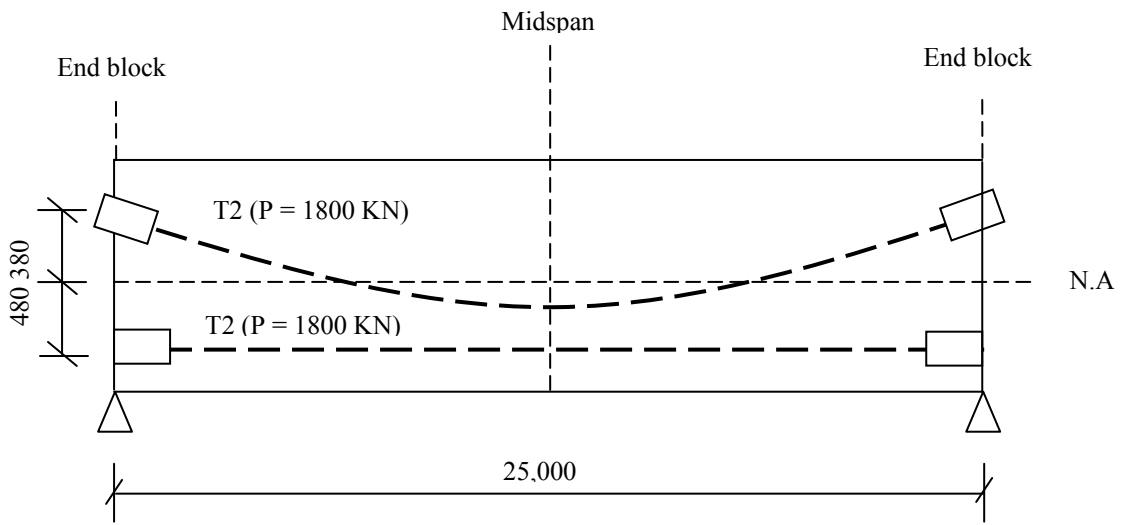
Figure 1: Post-tensioned Beam with Single tendon (All units in mm)

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

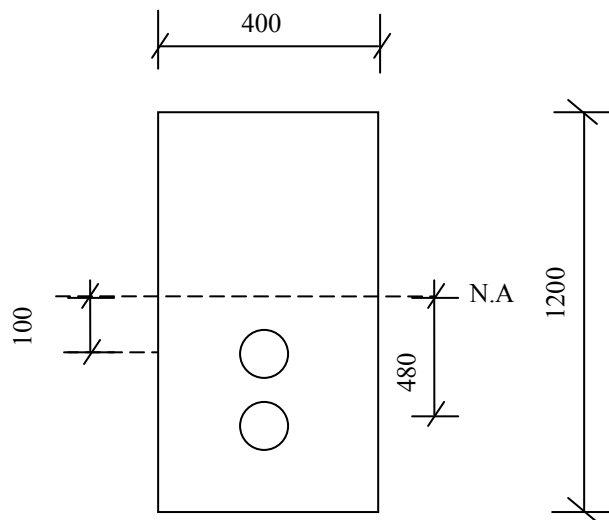
[6 Marks]

- 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 $E_c = 28 \text{ kN/mm}^2$, concrete density = 24 kN/m^3 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	=	$300 \times 10^3 \text{ mm}^2$
I	=	$36 \times 10^9 \text{ mm}^4$
Area of pre-stressing tendon (A_{ps})	=	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:

$$\begin{aligned}
 V &= V_c - P_e \sin \beta - \text{ for uncracked section} \\
 V &= \left. \begin{aligned} &V_c - P_e \sin \beta \\ &V_c \end{aligned} \right\} \text{ whichever is greater for} \\
 &= \text{ section cracked}
 \end{aligned}$$

[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 $f_y = 460 \text{ N/mm}^2$, 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]

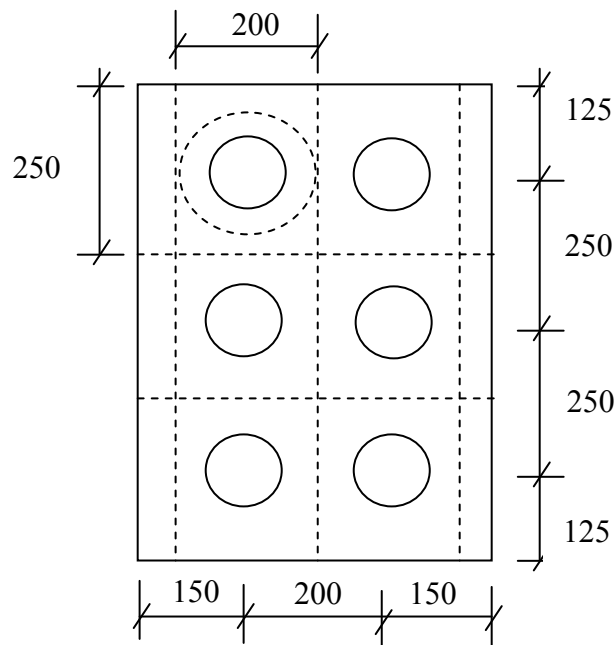
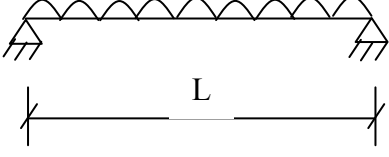
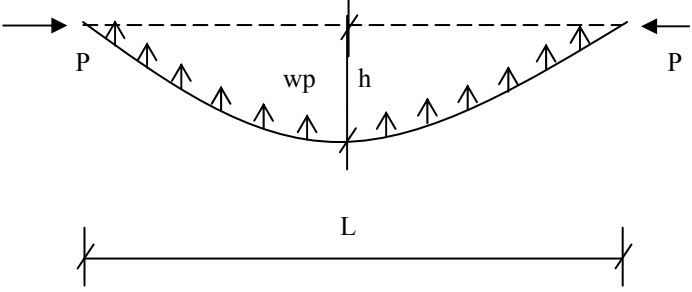
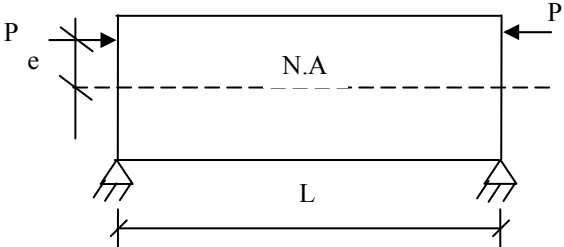


Figure 3

APPENDIX A

STANDARD FORMULAE FOR DEFLECTION

CONDITION	DEFLECTION (δ)
<p>a) Uniformly Distributed Load</p> <p style="text-align: center;">W kN/m</p> 	$\delta_{\max} = \frac{5}{384} \times \frac{WL^4}{EI}$
<p>b) Due pre-stress of parabolic tendon</p> 	$W_p = \frac{8Ph}{L^2}$ $\delta_{\max} = \frac{5}{384} \times \frac{W_p L^4}{EI}$
<p>c) Due P at ends</p> 	$\delta_{\max} = \frac{1}{8} \times \frac{PeL^2}{EI}$

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 kebolehhidmatan berdasarkan kehendak-kehendak yang diberikan. Bincang keputusan yang diperolehi :-

i)	<i>f_{cu} (pada 28 hari)</i>	= 45 N/mm ²
ii)	<i>f_{ci} (masa pindah)</i>	= 35 N/mm ²
iii)	<i>Daya Tujahan, P</i>	= 3500 kN
iv)	<i>Kecekapan, μ</i>	= 0.75
v)	<i>Kesipian tendon (di sangga)</i>	= -50 mm
vi)	<i>Kesipian tendon (di tengah rentang)</i>	= + 400 mm
vii)	<i>Z₁ (atas)</i>	= 150 x 10 ⁶ mm ³
viii)	<i>Z₂ (bawah)</i>	= 100 x 10 ⁶ mm ³
ix)	<i>Luas keratan rentas rasuk</i>	= 450 x 10 ³ mm ²
x)	<i>Ketumpatan konkrit</i>	= 24 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 analisis 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 :-

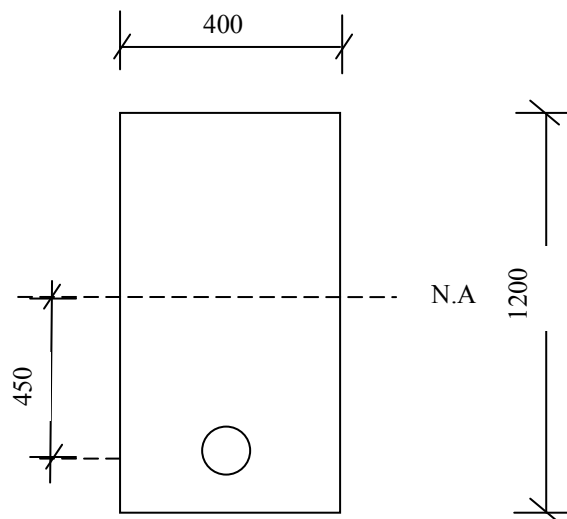
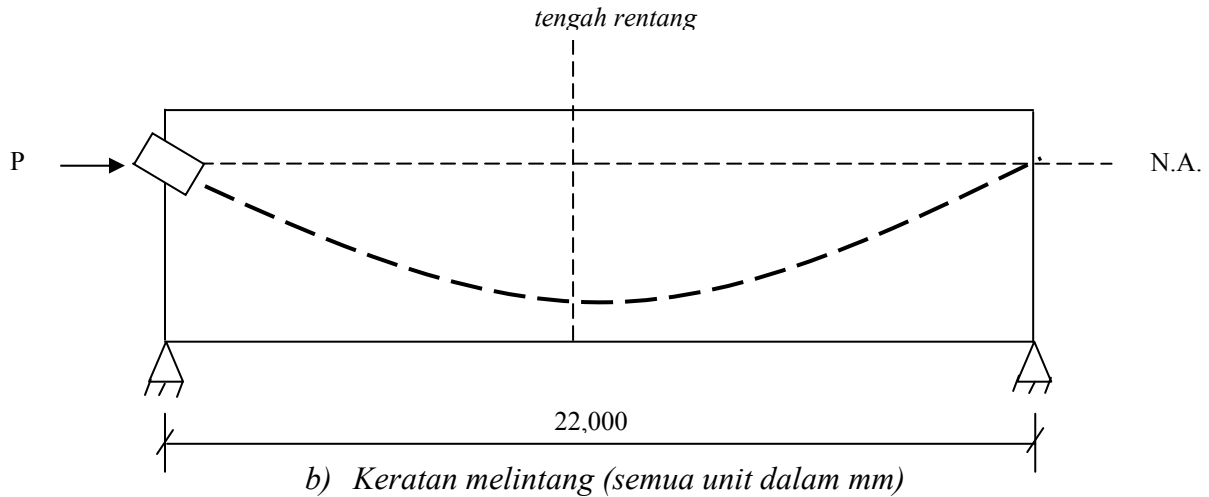
i)	Rentangan rasuk	= 20 meter
ii)	f_{cu} (28 hari)	= 40 N/mm ²
iii)	f_{ci} (masa pindah)	= 28 N/mm ²
vi)	Luas keratan rentas rasuk	= 490 x 10 ³ mm ²
v)	Z (atas)	= 128.8 x 10 ⁶ mm ³
vi)	Z (bawah)	= 126 x 10 ⁶ mm ³
vii)	Ketumpatan konkrit	= 24 kN/m ³

[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)	E_c (28 hari)	= 28 kN/mm ²
ii)	f_{cu} (28 hari)	= 45 N/mm ²
iii)	f_{ci} (masa pindah)	= 30 N/mm ²
iii)	E_s	= 200 kN/mm ²
iv)	Keratan rentas rasuk	= 400 mm (B) x 1200 (H)
v)	Bilangan lembar setiap tendon	= 22
vi)	Garis pusat 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]



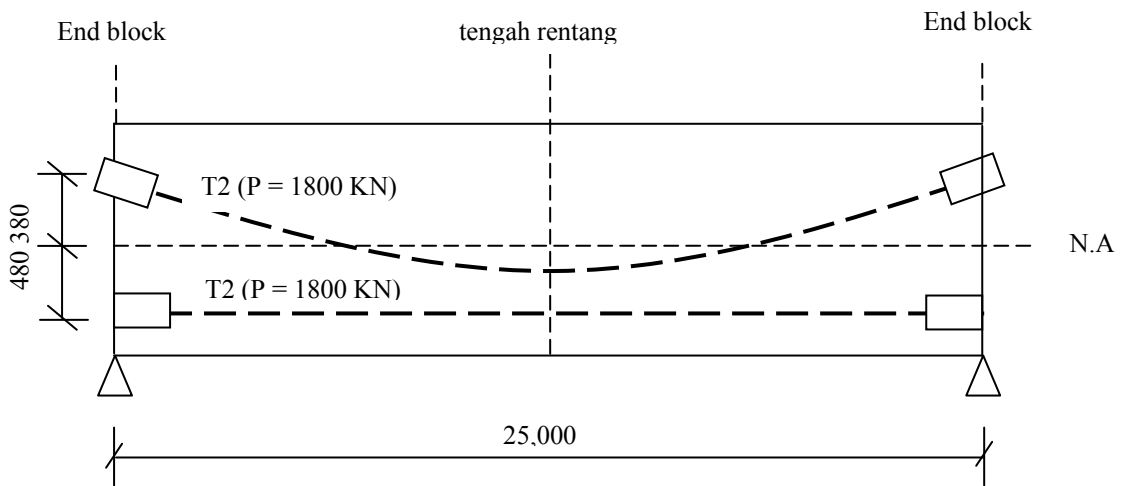
Rajah 1 : Rasuk pasca tegasan dengan tendon tunggal (semua unit dalam mm)

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

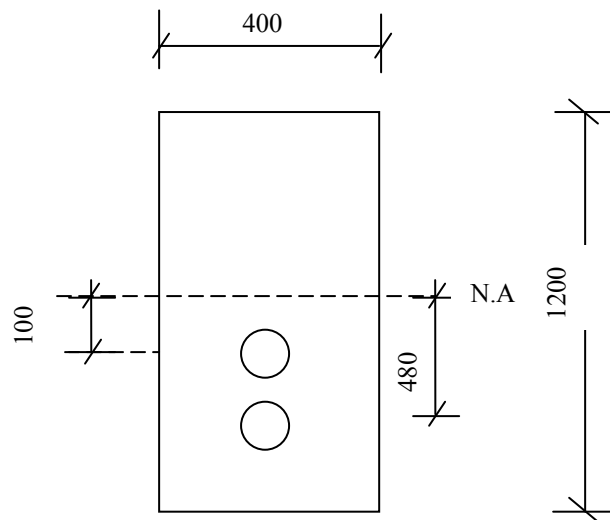
[6 Markah]

- 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 $E_c = 28\text{kN/mm}^2$, 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 I adalah seperti berikut :

<i>Lebar rasuk</i>	=	<i>210 mm</i>
<i>Kedalaman keseluruhan</i>	=	<i>1000 mm</i>
<i>Luas</i>	=	<i>$300 \times 10^3 \text{ mm}^2$</i>
<i>I</i>	=	<i>$36 \times 10^9 \text{ mm}^4$</i>
<i>Luas tendon pra-tegasan (Aps)</i>	=	<i>1803 mm²</i>
<i>f_{pu}</i>	=	<i>1750 N/mm²</i>
<i>f_{pc}</i>	=	<i>1050 N/mm²</i>
<i>e_s</i>	=	<i>+290 mm</i>
<i>β</i>	=	<i>3° pada keratan yang dipertimbangkan</i>
<i>f_{cu}</i>	=	<i>50 N/mm²</i>
<i>f_{yv}</i>	=	<i>250 N/mm²</i>

Daya ricih, V boleh dikira seperti berikut :

$$\begin{aligned}
 V &= V_c - P_e \sin \beta && \text{untuk keratan tanpa retak} \\
 V &= \left. \begin{aligned} &V_c - P_e \sin \beta \\ &V_c \end{aligned} \right\} \text{yang mana lebih besar untuk} \\
 & && \text{keratan retak}
 \end{aligned}$$

[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 $f_y = 460 \text{ N/mm}^2$, 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]

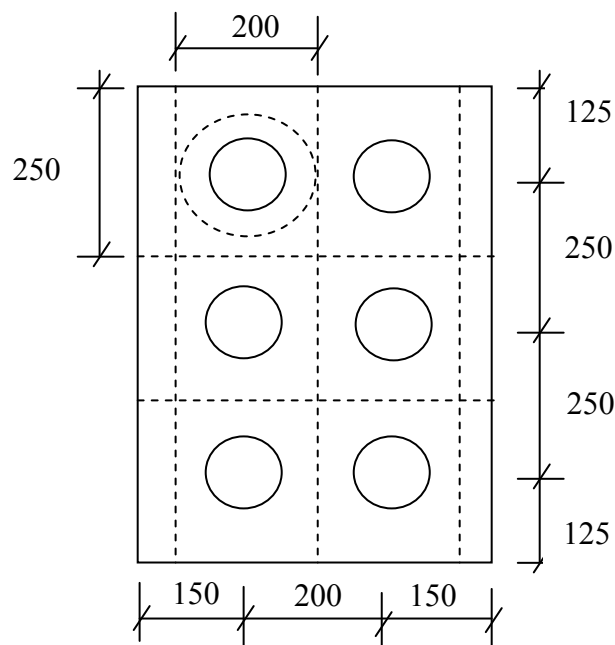


Figure 3

oooOOOooo

