UNIVERSITI SAINS MALAYSIA

First Semester Examination
2011/2012 Academic Session

January 2012

EAA 455/2 – Reinforced Concrete Structural Design II

[*Rekabentuk Struktur Konkrit Bertetulang II*]

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

Please check that this examination paper consists of **NINETEEN (19)** pages of printed material including appendices before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEMBILAN BELAS (19)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **FIVE (5)** questions. Answer **FOUR** questions.
[***Arahan** : Kertas ini mengandungi **LIMA (5)** soalan. Jawab **EMPAT** 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. Figure 1 shows the internal part of flat slab layout plan with four columns. The columns are at 7.0m centers in each direction and the slab supports an imposed load at 5 kN/m^2. Grade 30 concrete and grade 250 reinforcement are used.

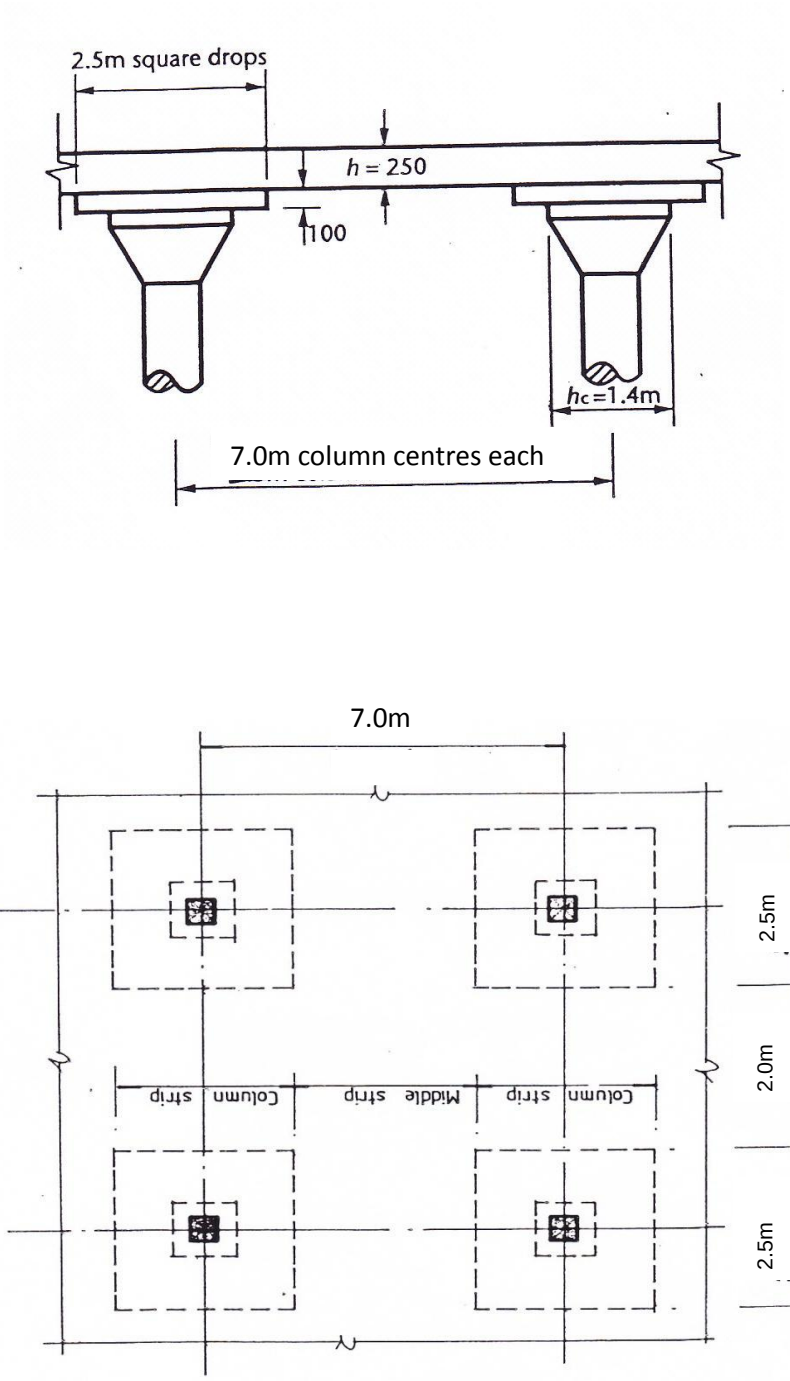


Figure 1

(a) Calculate the effective span, ℓ, between columns.

[2 marks]

(b) Calculate the moment at column and middle strips.

[5 marks]

(c) Determine the amount of reinforcement required at column and middle strips.

[8 marks]

(d) Evaluate the shearing stress at the critical positions.

[6 marks]

(e) Calculate span/depth ratio with respect to deflection.

[2 marks]

(f) Sketch the arrangement of reinforcement at cross-section.

[2 marks]

2. (a) A simply supported pre-stressed rectangular beam, 350mm x 150mm, over a 4.2m span carry an imposed load of 12 kN/m. Given a straight tendon at an eccentricity of 70mm below the centroid of the section,

(i) Calculate the minimum pre-stress force with zero tension under imposed local at mid-span.

[3 marks]

(ii) Determine stresses at mid-span under self weight only.

[4 marks]

(iii) Identify the stresses at the ends of the member.

[2 marks]

(b) Figure 2 show a pre-stressed rectangular beam subjected to eccentric pre-stress force. The stress distributions are similar to the member subjected to axial pre-stress force, however the additional term $\pm Pe/z$ to the eccentricity, e of the pre-stressing force is provided. Formulate the net stresses at the outer fibers of the beam.

[8 marks]

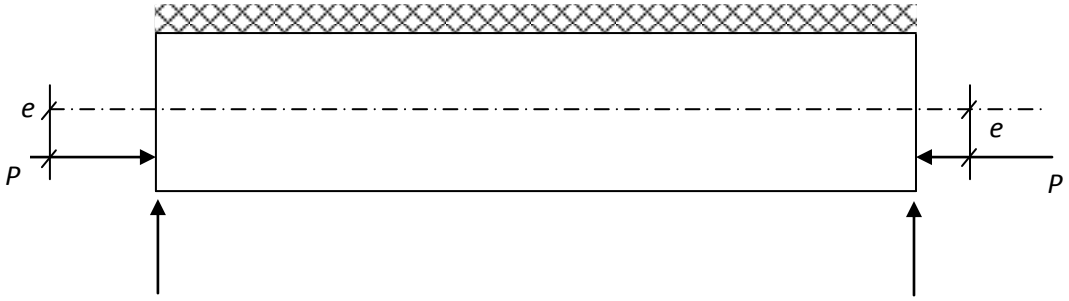


Figure 2

(c) A rectangular post-tensioned beam is required to carry a uniformly distributed load of 3 kN/m (extending self weight) over a simply supported span of 10m. Determine the size of the rectangular section where the member to be designed as class I with grade 40 concrete, no lateral support. Assume 15 percent loss of pre-stress ($k = 0.85$).

[8 marks]

3. (i) Describe in brief with the help of sketches the following types of retaining walls:

(a) Gravity walls

(b) Cantilever retaining walls

(d) Counterfort retaining walls

(e) Buttressed walls

[4 marks]

(ii) A T-shaped cantilever retaining wall to retain earth embankment 3m high above ground level. The embankment is surcharhed at an angle 16º to the horizontal. The unit weight of earth is 18kN/m^3 and the angle of repose is 30º. The safe bearing capacity of the soil is 100 kN/m^2 and the coefficient of friction between soil and concrete is assumed as 0.5. It is proposed by the consultant that the T-shaped cantilever is as described in Figure 3. The concrete grade used is C30 and the characteristic strength of steel reinforcement (f_y) is 500 N/mm^2. The main reinforcement diameter is 16mm.

Given for concrete grade and reinforcement steel used, the limiting moment of resistance for balanced section ($R_{u, limit}$) is 3.990 and the limiting distance of neutral axis ($x_u(max)/d$) is 0.456.

Verify that the proposed dimensions are acceptable for design purposes

[8 marks]

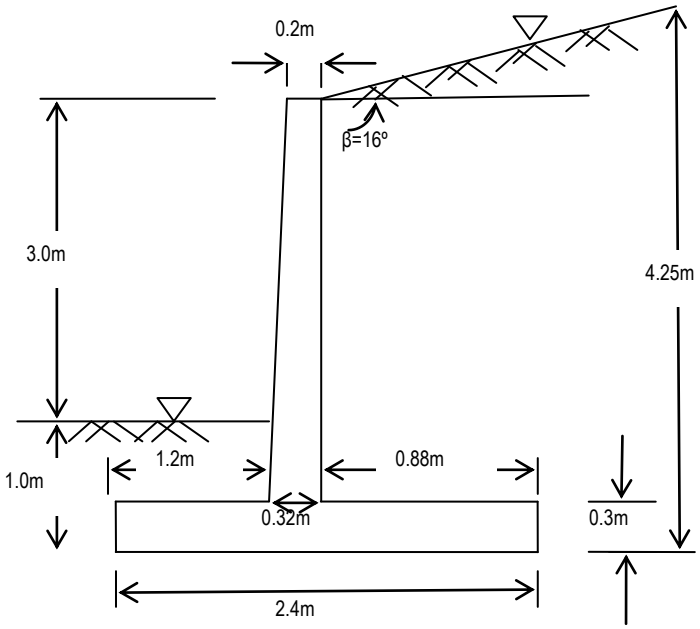


Figure 3 Proposed T shaped retaining wall

(iii) A T-shaped cantilever retaining wall to retain earth embankment 3m high above ground level. The embankment is horizontal at the top. The unit weight of earth is 18kN/m^3 and the angle of repose is 30º. The safe bearing capacity of the soil is 100 kN/m^2 and the coefficient of friction between soil and concrete is assumed as 0.5. It is proposed by the consultant that the T-shaped cantilever is as described in Figure 4. The concrete grade used is C30 and the characteristic strength of steel reinforcement (f_y) is 500 N/mm^2. The main reinforcement diameter is 16mm.

Given for concrete grade and reinforcement steel used, the limiting moment of resistance for balanced section ($R_{u, limit}$) is 3.990 and the limiting distance of neutral axis ($x_u(max)/d$) is 0.456.

(a) Check the stability of the wall against overturning and sliding.

[5 marks]

(b) Design the toe slab

[8 marks]

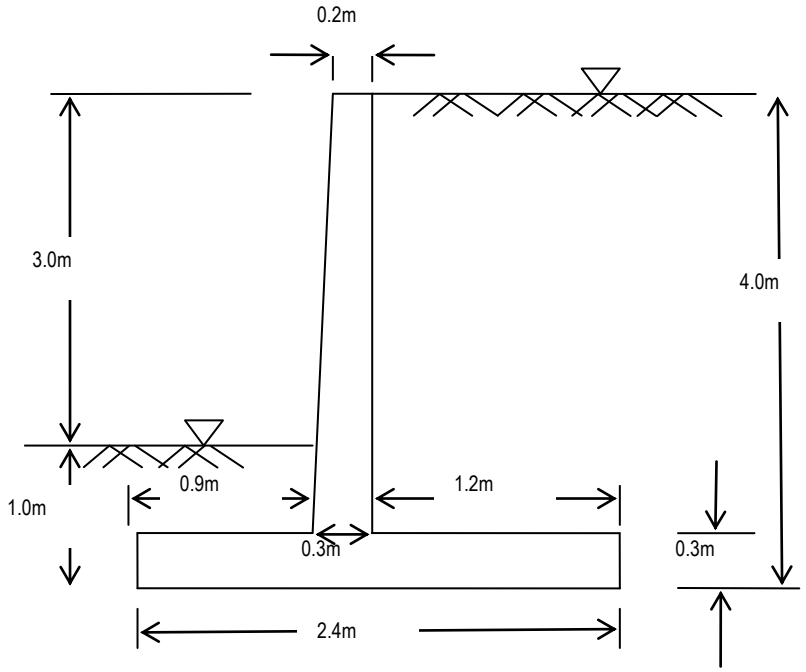


Figure 4 Proposed T shaped retaining wall

4. (a) A pile cap can be design using either the Truss Analogy or Bending Theory Methods. Briefly discuss **FIVE (5)** differences between these two methods.

[5 marks]

(b) Design and provide relevant detailing for a pile cap on the following requirements:

(i)	Column service load	= 3300 kN
(ii)	Allowable pile working capacity	= 400 kN
(iii)	Pile size	= 300 mm diameter RC square pile
(iv)	Pile spacing	= 900 mm center to center
(v)	Edge distance	= 150 mm
(vi)	Pile embedded length	= 100 mm

(vii)	Concrete grade	= 35 N/mm^2
(viii)	Main reinforcement size	= 25 mm diameter
(ix)	Main reinforcement grade,f_y	= 460 N/mm^2
(x)	Column size	= 500 mm x 500 mm

[20 marks]

5. (a) Discuss the design concept that effect the structural capacity of bored pile and micro piles.

[5 marks]

(b) A typical cross section of an abutment wall having vertical and raked piles is shown in Figure 5. Determine the adequacy of the pile arrangement if the allowable pile working load is 400 kN. The ratio of the raked pile is taken as 1:4.

[20 marks]

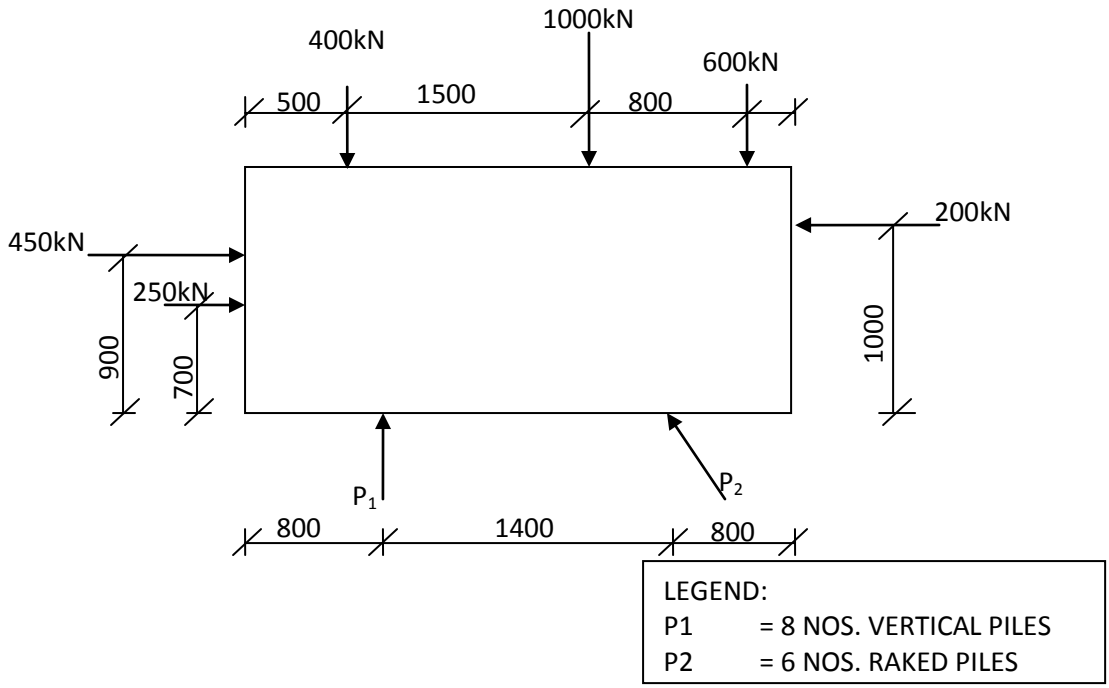
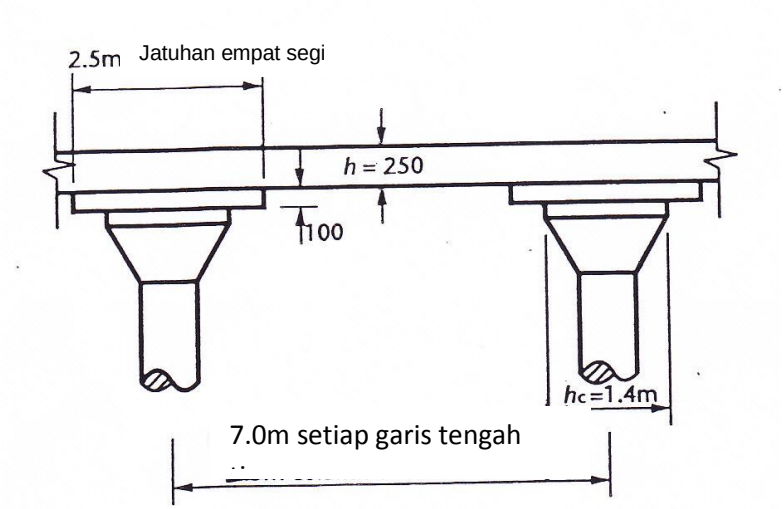
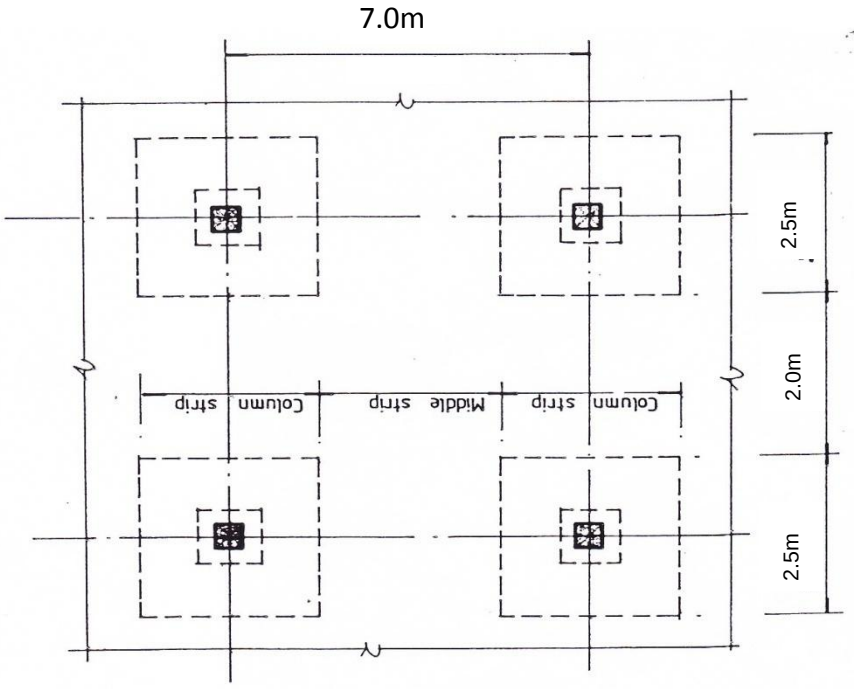


Figure 5 (All dimension in mm)

1. (a) *Rajah 1 menunjukan sebahagian pelan dalaman tataatur papak rata yang mempunyai empat tiang. Tiang terletak pada 7.0m disetiap arah dan papak menanggung beban kenaan 5 kN/m^2. Konkrit gred 30 dan tetulang gred 250 digunakan.*





Rajah 1

(i) *Kirakan rentang efektif, ℓ, antara tiang.*

[2 markah]

(ii) Kirakan momen-momen pada jalur tiang dan jalur tegak.

[5 markah]

(iii) Tentukan jumlah tetulang yang diperlukan pada jalur tiang dan jalur tengah.

[8 markah]

(iv) Nilaikan tegasan ricih pada kedudukan kritikal.

[6 markah]

(v) Kirakan nisbah rentang/dalam terhadap pesongan.

[2 markah]

(vi) Tunjukkan susunatur tetulang (hanya keratan rentas sahaja).

[2 markah]

2. *(a) Rasuk segiempat pra-tegasan 350mm* x *150mm mempunyai sepanjang rentang 4.2m dan membawa beban kenaan 12 kN/m. Diberi tendon lurus pada kedudukan sipi 70mm di bawah sentroid keratan,*

(i) Kirakan daya minimum pra-tegasan dengan tegangan sifar di bawah beban kenaan pada rentang tengah.

[3 markah]

(ii) Tentukan tegasan-tegasan pada rentang tengah di bawah berat sendiri sahaja.

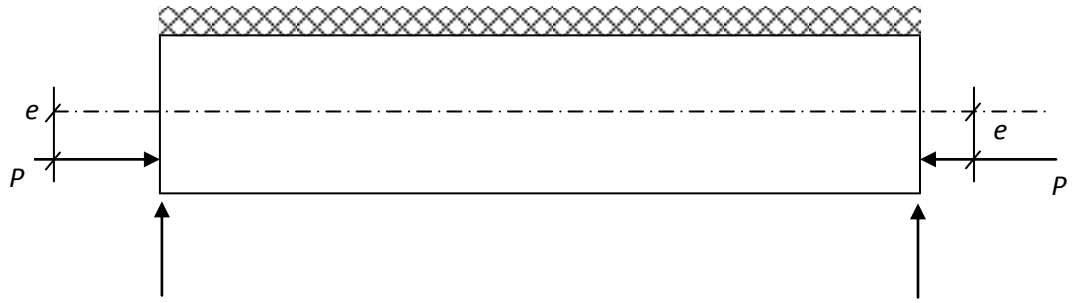
[4 markah]

(iii) Kenal pasti tegasan-tegasan pada hujung anggota.

[2 markah]

(b) Rajah 2 menunjukan rasuk pra-tegasan segiempat yang di kenakan daya sipi pra-tegasan. Taburan tegasan anggota adalah sama dengan anggota yang di kenakan daya pra-tegasan memugak, walau bagaimanapun, terma tambahan $\pm Pe/z$ *hasil daripada daya pra-tegasan sipi,* e*, diberikan. Rumuskan tegasan-tegasan bersih pada gentian luaran rasuk.*

[8 markah]



Rajah 2

(c) *Rasuk segiempat pasca-tegasan diperlukan untuk menbawa beban teragih seragam, 3 kN/m (tidak termasuk berat sendiri) bagi rentang 10m terletak mudah. Tentukan saiz keratan rasuk yang mana anggota direkabentuk sebagai kelas I konkrit gred 40 tanpa penyokong sisi. Anggap kehilangan pra-tegasan, 15% ($k = 0.85$).*

[8 markah]

3. (i) *Terangkan dengan ringkas berbantukan lakaran tembok penahan berikut :*

(a) Tembok graviti

(b) Tembok penahan julur tuas

(c) Tembok penahan berpenegang

(d) Dinding banir

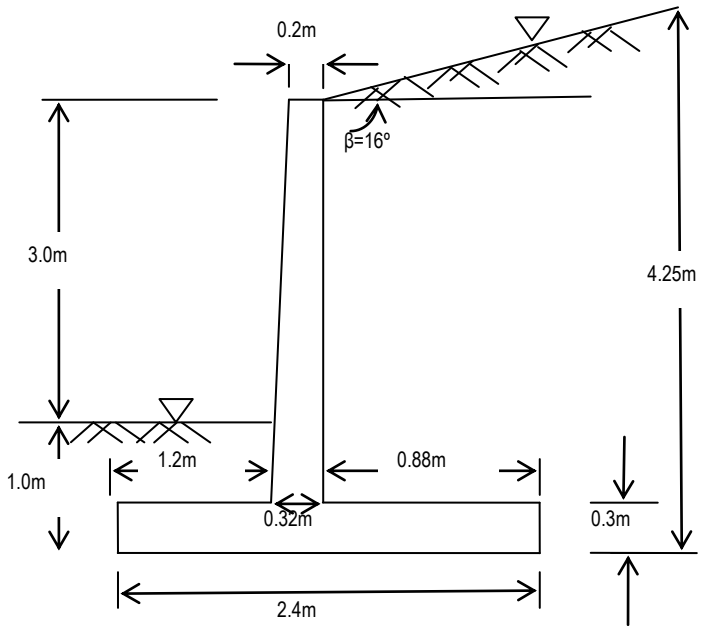
[4 markah]

(ii) *Sebuah tembok penahan julur tuas bentuk T direkabentuk untuk tambakan benteng tanah 3m high dari aras tanah. Benteng tersebut adalah di surcaj dengan sudut 16º di bahagian atas. Berat unit tanah ialah 18kN/m^3 dan sudut rehat ialah 30º. Keupayaan galas tanah yang selamat ialah 100 kN/m^2 dan pekali geseran antara tanah dan konkrit diandai sebagai 0.5. Dicadangkan oleh perunding sebuah tembok penahan julur tuas bentuk T seperti dalam Rajah 3.*

Gred konkrit yang digunaan ialah C30 dan ciri kekuatan tetulang keluli ialah (f_y) is 500 N/mm^2. Garispusat tetulang utama 16mm. Diberi untuk gred konkrit dan tetulang keluli yang digunakan, rintangan had momen untuk keratan yang seimbang ($R_{u,\,limit}$) ialah 3.990 dan had jarak paksi neutral (x_u(max)/d) ialah 0.456.

Menentusahkan ukuran yang dicadangkan boleh diterima untuk rekabentuk

[8 markah]



Rajah 3 Cadangan tembok penahan julur tuas bentuk T

(iii) *Sebuah tembok penahan julur tuas bentuk T direkabentuk untuk tambakan benteng tanah 3m high dari aras tanah. Benteng tersebut adalah mendatar di bahagian atas. Berat unit tanah ialah 18kN/m^3 dan sudut rehat ialah 30º. keupayaan galas tanah yang selamat ialah 100 kN/m^2 dan pekali geseran antara tanah dan konkrit diandai sebagai 0.5. Dicadangkan oleh perunding tembok penahan julur tuas bentuk T seperti dalam Rajah 4.*

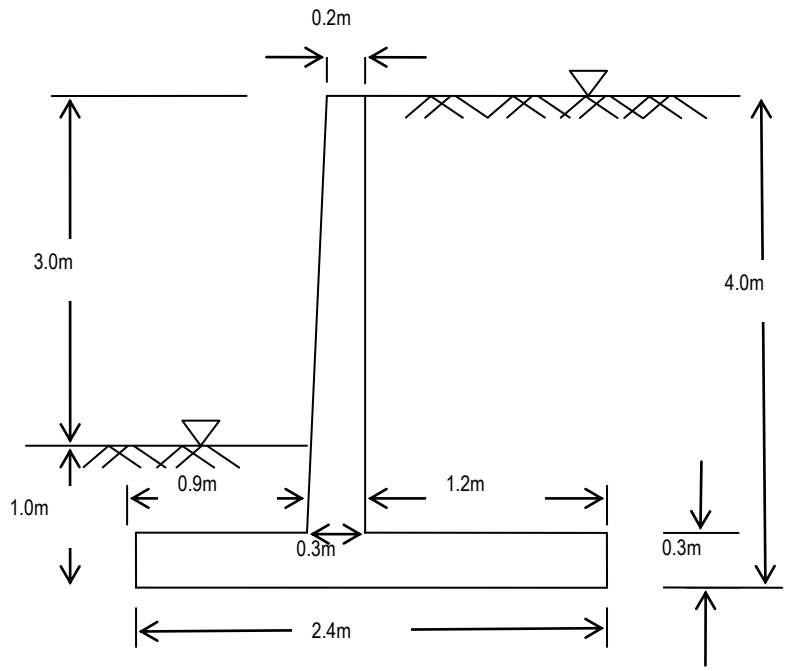
Gred konkrit yang digunaan ialah C30 dan ciri kekuatan tetulang keluli ialah (f_y) is 500 N/mm^2. Garispusat tetulang utama 16mm. Diberi untuk gred konkrit dan tetulang keluli yang digunakan, rintangan had momen untuk keratin yang seimbang ($R_{u,\ limit}$) ialah 3.990 dan had jarak paksi neutral ($x_u(max)/d$) ialah 0.456.

(a) Semak kestabilan dinding untuk tidak terbalikkan dan mengelonsor.

[5 markah]

(b) Rekabentuk tetulang untuk papak tumit

[8 markah]



Rajah 4 Cadangan tembok penahan julur tuas bentuk T

*4. (a) Satu tetopi cerucuk boleh direkabentuk menggunakan kaedah Analogi Kerangka atau Teori Lenturan. Bincangkan dengan ringkas **LIMA (5)** perbezaan antara kedua-dua kaedah tersebut.*

[5 markah]

(b) *Rekabentuk dan sediakan perincian yang bersesuaian untuk satu tetopi cerucuk yang memenuhi syarat berikut:*

(i)	*Beban kebolehkhidmatan tiang*	=	*3300 kN*
(ii)	*Keupayaan cerucuk dibenarkan*	=	*400 kN*
(iii)	*Saiz cerucuk*	=	*300 mm diameter RC square pile*
(iv)	*Selaan cerucuk*	=	*900 mm center to center*
(v)	*Jarak tepi*	=	*150 mm*
(vi)	*Kedalaman keseluruhan tetopi cerucuk*	=	*100 mm*
(vii)	*Gred konkrit*	=	*35 N/mm^2*
(viii)	*Saiz tetulang utama*	=	*25 mm diameter*
(ix)	*Gred tetulang utama,f_y*	=	*460 N/mm^2*
(x)	*Saiz tiang*	=	*500 mm x 500 mm*

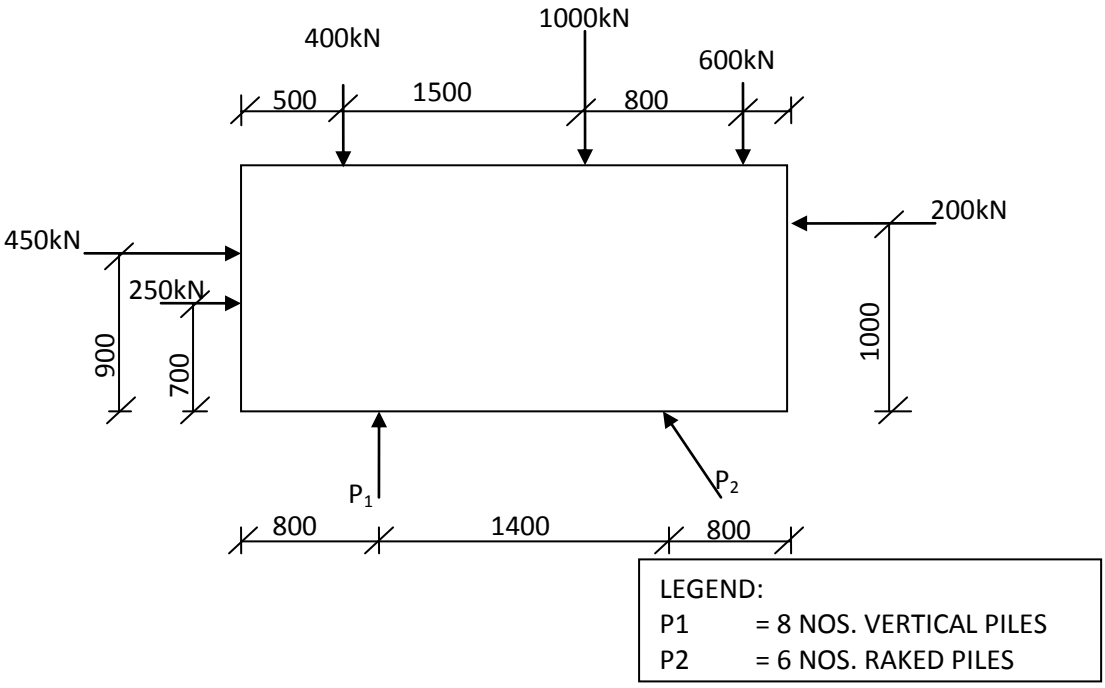
[20 markah]

5. *(a)* *Bincangkan konsep rekabentuk yang mempengaruhi keupayaan struktur cerucuk tergerek dan cerucuk mikro.*

[5 Markah]

(b) *Satu keratan tipikal tembok landas yang mempunyai cerucuk pugak dan sadak adalah seperti di Rajah 5. Tentukan susunan cerucuk sekiranya keupayaan kerja dibenarkan cerucuk tersebut adalah 400 kN. Nisbah cerucuk sadak di ambil sebagai 1:4.*

[20 markah]



Rajah 5 (Semua dimensi dalam mm)

Appendix 1 [a]

Lampiran 1[a]

Bar Areas and Perimeters

Sectional areas of groups of bars (mm^2)

Bar size (mm)	Number of bars									
	1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.9	113	142	170	198	226	255	283
8	50.3	101	151	201	252	302	352	402	453	503
10	78.5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	566	679	792	905	1020	1130
16	201	402	603	804	1010	1210	1410	1610	1810	2010
20	314	628	943	1260	1570	1890	2200	2510	2830	3140
25	491	982	1470	1960	2450	2950	3440	3930	4420	4910
32	804	1610	2410	3220	4020	4830	5630	6430	7240	8040
40	1260	2510	3770	5030	6280	7540	8800	10100	11300	12600

[EAA 455/2]

Appendix 1 [b]

Lampiran 1 [b]

Sectional areas per metre width for various bar spacings (mm^2)

Bar size (mm)	Spacing of bars								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	142	113	94.3
8	1010	671	503	402	335	287	252	201	168
10	1570	1050	785	628	523	449	393	314	262
12	2260	1510	1130	905	754	646	566	452	377
16	4020	2680	2010	1610	1340	1150	1010	804	670
20	6280	4190	3140	2510	2090	1800	1570	1260	1050
25	9820	6550	4910	3930	3270	2810	2450	1960	1640
32	16100	10700	8040	6430	5360	4600	4020	3220	2680
40	25100	16800	12600	10100	8380	7180	6280	5030	4190

Shear Reinforcement

A_{sv}/s_v for varying stirrup diameter and spacing

Stirrup diameter (mm)	Stirrup spacing (mm)										
	85	90	100	125	150	175	200	225	250	275	300
8	1.183	1.118	1.006	0.805	0.671	0.575	0.503	0.447	0.402	0.366	0.335
10	1.847	1.744	1.57	1.256	1.047	0.897	0.785	0.698	0.628	0.571	0.523
12	2.659	2.511	2.26	1.808	1.507	1.291	1.13	1.004	0.904	0.822	0.753
16	4.729	4.467	4.02	3.216	2.68	2.297	2.01	1.787	1.608	1.462	1.34

Appendix 2

Lampiran 2

From BS8110-1:1997

Table 3.4 — Nominal cover to all reinforcement (including links) to meet specified periods of fire resistance (see NOTE 1 and NOTE 2)

Fire resistance	Nominal cover mm						
	Beams[a]		Floors		Ribs		Columns[a]
	Simply supported	Continuous	Simply supported	Continuous	Simply supported	Continuous	
h							
0.5	20[b]	20[b]	20[b]	20[b]	20[b]	20[b]	20[b]
1	20[b]	20[b]	20	20	20	20[b]	20[b]
1.5	20	20[b]	25	20	35	20	20
2	40	30	35	25	45	35	25
3	60	40	45	35	55	45	25
4	70	50	55	45	65	55	25

NOTE 1 The nominal covers given relate specifically to the minimum member dimensions given in Figure 3.2. Guidance on increased covers necessary if smaller members are used is given in Section 4 of BS 8110-2:1985.

NOTE 2 Cases that lie below the bold line require attention to the additional measures necessary to reduce the risks of spalling (see Section 4 of BS 8110-2:1985).

[a] For the purposes of assessing a nominal cover for beams and columns, the cover to main bars which would have been obtained from Table 4.2 and Table 4.3 of BS 8110-2:1985 has been reduced by a notional allowance for stirrups of 10 mm to cover the range 8 mm to 12 mm (see also **3.3.6**).

[b] These covers may be reduced to 15 mm provided that the nominal maximum size of aggregate does not exceed 15 mm (see **3.3.1.3**).

Table 3.7 — Form and area of shear reinforcement in beams

Value of v N/mm^2	Form of shear reinforcement to be provided	Area of shear reinforcement to be provided
Less than $0.5v_c$ throughout the beam	See NOTE 1	—
$0.5v_c < v < (v_c + 0.4)$	Minimum links for whole length of beam	$A_{sv} \geq 0.4b_v s_v/0.87f_{yv}$ (see NOTE 2)
$(v_c + 0.4) < v < 0.8\sqrt{f_{cu}}$ or 5 N/mm^2	Links or links combined with bent-up bars. Not more than 50 % of the shear resistance provided by the steel may be in the form of bent-up bars (see NOTE 3)	Where links only provided: $A_{sv} \geq b_v s_v(v - v_c)/0.87f_{yv}$ Where links and bent-up bars provided: see **3.4.5.6**

NOTE 1 While minimum links should be provided in all beams of structural importance, it will be satisfactory to omit them in members of minor structural importance such as lintels or where the maximum design shear stress is less than half v_c.

NOTE 2 Minimum links provide a design shear resistance of 0.4 N/mm^2.

NOTE 3 See **3.4.5.5** for guidance on spacing of links and bent-up bars.

Appendix 3

Lampiran 3

Table 3.8 — Values of v_c design concrete shear stress

$\frac{100A_s}{b_v d}$	Effective depth mm							
	125	150	175	200	225	250	300	400
	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
≤ 0.15	0.45	0.43	0.41	0.40	0.39	0.38	0.36	0.34
0.25	0.53	0.51	0.49	0.47	0.46	0.45	0.43	0.40
0.50	0.67	0.64	0.62	0.60	0.58	0.56	0.54	0.50
0.75	0.77	0.73	0.71	0.68	0.66	0.65	0.62	0.57
1.00	0.84	0.81	0.78	0.75	0.73	0.71	0.68	0.63
1.50	0.97	0.92	0.89	0.86	0.83	0.81	0.78	0.72
2.00	1.06	1.02	0.98	0.95	0.92	0.89	0.86	0.80
≥ 3.00	1.22	1.16	1.12	1.08	1.05	1.02	0.98	0.91

NOTE 1 Allowance has been made in these figures for a γ_m of 1.25.

NOTE 2 The values in the table are derived from the expression:

$0.79\{100A_s/(b_v d)\}^{1/3} (400/d)^{1/4}/\gamma_m$

where

$\frac{100A_s}{b_v d}$ should not be taken as greater than 3;

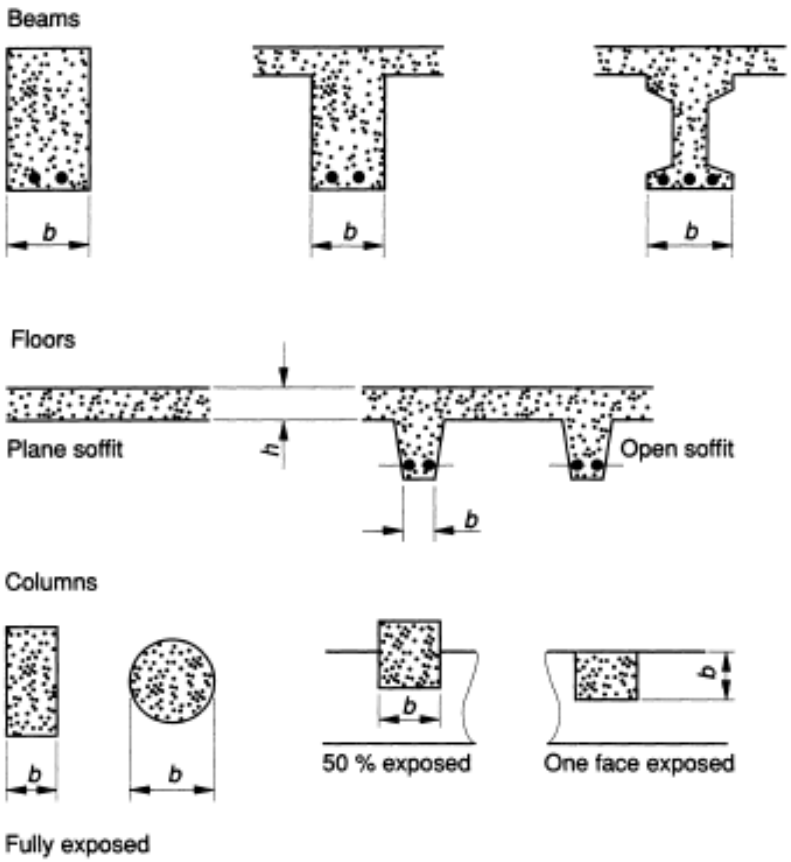
$\left(\frac{400}{d}\right)^{\frac{1}{4}}$ should not be taken as less than 0.67 for members without shear reinforcement;

$\left(\frac{400}{d}\right)^{\frac{1}{4}}$ should not be taken as less than 1 for members with shear reinforcement providing a design shear resistance of ≥ 0.4 N/mm².

For characteristic concrete strengths greater than 25 N/mm², the values in this table may be multiplied by $(f_{cu}/25)^{1/3}$. The value of f_{cu} should not be taken as greater than 40.

Appendix 4

Lampiran 4



Fire resistance	Minimum beam width (b)	Rib width (b)	Minimum thickness of floors (h)	Column width (b)			Minimum wall thickness		
				Fully exposed	50 % exposed	One face exposed	$p < 0.4$ %	0.4 % < p < 1 %	$p > 1$ %
h	mm	mm	mm	mm	mm	mm	mm	mm	mm
0.5	200	125	75	150	125	100	150	100	75
1	200	125	95	200	160	120	150	120	75
1.5	200	125	110	250	200	140	175	140	100
2	200	125	125	300	200	160	—	160	100
3	240	150	150	400	300	200	—	200	150
4	280	175	170	450	350	240	—	240	180

NOTE 1 These minimum dimensions relate specifically to the covers given in Table 3.4 and Table 4.9.

NOTE 2 p is the area of steel relative to that of concrete.

Figure 3.2 — Minimum dimensions of reinforced concrete members for fire resistance

oooOOOooo