UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2007/2008

October/November 2007

EAS 353/3 – Design of Reinforced Concrete Structures
[Rekabentuk Struktur Konkrit Bertetulang]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of TWELVE pages of printed material including appendix before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi DUA BELAS muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]

Instructions: Answer **FIVE (5)** questions only. All questions carry the same marks.
*[**Arahan**: 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 sheet.
*[Semua jawapan **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] Sketch the position of the required reinforcement in a longitudinal staircase slab as shown in Figure 1(a). The sketches must indicate the items below:-

[i] Spanning direction of staircase
[ii] Position of sagging moment reinforcements at mid-span
[iii] Position of hogging moment reinforcement at support
[iv] Position of distribution reinforcement

Give the general equation for maximum moment near the mid-span and over the supports.

(5 marks)

Lakarkan kedudukan tetulang yang diperlukan untuk papak tangga membujur seperti yang ditunjukkan dalam Rajah 1(a). Lakaran tersebut hendaklah menunjukkan perkara-perkara berikut:-

[i] Arah rentang tangga
[ii] Kedudukan tetulang lendutan di pertengahan rentang
[iii] Kedudukan tetulang cembung pada penyokong
[iv] Kedudukan tetulang agihan

Berikan rumusan momen maksima di pertengahan rentang dan di penyokong.

[b] Figure 1(b) shows part of a floor plan of reinforced concrete slab for an office building. The following data are given for the design purpose.

Characteristic strength of concrete, f_{cu}	25 N/mm^2
Characteristic strength of reinforcement, f_y	250 N/mm^2
Cover	20 mm
Slab thickness	125 mm
Building services load	1.0 kN/m^2
Imposed load	4.0 kN/m^2

Based on the above mentioned data;

[i] Calculate the design load for slab panel S2.
[ii] Using 10mm of reinforcement, design all the required reinforcement for panel S2 ignoring torsion reinforcement.
[iii] Checks shear, deflection and cracking for panel S2
[iv] Calculate the design load on Beam 2/B–C beam with only considering all the loadings from the slab and self weight of the beam (225 mm x 600 mm)

(15 marks)

1. (b) *Rajah 1(b) menunjukkan sebahagian daripada papak lantai konkrit bertetulang sebuah bangunan pejabat. Data berikut diberikan untuk tujuan reka bentuk.*

Kekuatan ciri Konkrit , f_{cu}	*25 N/mm²*
Kekuatan ciri tetulang, f_y	*250 N mm²*
Ketebalan penutup	*20 mm*
Ketebalan papak	*125 mm*
Perkhidmatan bangunan	*1.0 kN/m²*
Beban Kenaan	*4.0 kN m²*

Berdasarkan data yang diberikan di atas,

[i] Kirakan beban rekabentuk papak S2

[ii] Menggunakan tetulang bergaris pusat 10mm rekabentuk semua tetulang papak yang diperlukan untuk panel S2 tanpa mengambil kira tetulang puntiran.

[iii] Semak ricihan, pesongan dan kereta[illegible] papak S2.

[iv] Kirakan beban rekabentuk ke atas rasuk 2/B-C dengan hanya mengambilkira semua beban dari papak dan berat sendiri rasuk (225 mm x 600 mm).

2. (a) State the assumption applied for theory of bending for reinforced concrete. (2 marks)

Nyatakan andaian yang digunakan untuk teori lenturan konkrit bertetulang.

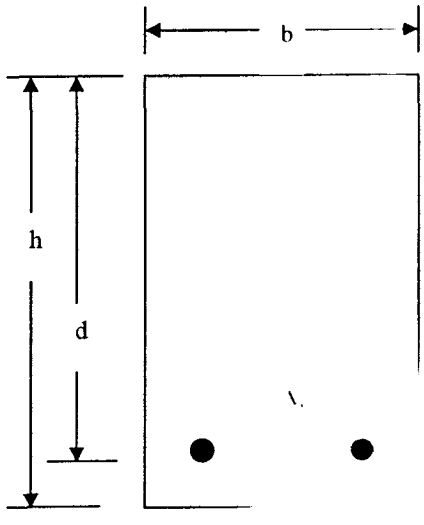


Figure 2

2. (b) A rectangular beam of cross-section shown in Figure 2 is subjected to bending. To analyse the beam, the stress strain relationship is considered. Please discuss the following:

Strain diagram;
[i] Triangular stress distribution.
[ii] Rectangular-parabolic stress block.
[iii] Equivalent rectangular stress block.

(8 marks)

Sebuah rasuk segi empat yang berkeratan rentas seperti di Rajah 2 dilenturkan. Untuk menganalisa rasuk tersebut, perhubungan tegasan-terikan. Bincangkan perkara-perkara berikut:

Rajah terikan;
[i] Agihan tegasan segi-tiga.
[ii] Blok tegasan segi-empat-parabolik.
[iii] Blok tegasan segi-empat separa.

(c) A rectangular beam of cross-section shown above is subjected to bending. Using the rectangular-parabolic stress block method, prove the following;

a. Depth of neutral axis is;

$$\frac{x}{d} = \frac{A_s}{bdf_{cu}} \frac{f_{st}}{0.4}$$

b. Lever arm, l_a is

$$\frac{M_u}{bd^2 f_{cu}} = 0.89\,(1 - 1a)1a$$

where ;

x = depth to neutral axis

d = effective depth

A_s = area of steel

b = width of beam

f_{cu} = characteristic strength of concrete

f_{st} = tensile stress in the reinforcement

(10 marks)

2. (c) *Sebuah rasuk segi empat yang berkeratan rentas di atas dilenturkan. Dengan menggunakan kaedah blok tegangan segi-empat-parabolik, buktikan yang berikut:*

a *Kedalaman paski neutral adalah;*

$$\frac{x}{d} = \frac{A_s}{bdf_{cu}} \frac{f_{st}}{0.4}$$

b *Lengan tuil, l_a adalah*

$$\frac{M_u}{bd^2 f_{cu}} = 0.89\,(1 - 1a)\ \ 1a$$

iaitu;

x = kedalaman paksi neutral

d = kedalaman efektif

A_s = keluasan keluli

b = lebar rasuk

f_{cu} = kekuatan ciri konkrit

f_{st} = tegasan tegangan dalam tetulang

3. (a) Sketch the following retaining walls:

[i] Gravity wall
[ii] Counterfort wall

(4 marks)

Lakarkan tembok penahan berikut:

[i] *Tembok graviti*
[ii] *Tembok 'Counterfort'*

3. (b) Prepare a basic design calculation of a cantilever retaining wall as shown in Figure 3. Assume the wall and the base thickness are 400mm. The soil behind the wall is granular material with the following properties:

Density, γ_s	$= 20\ kN/m^3$
Internal angle of friction, ϕ	$= 30^o$

Assuming that soil bearing pressure is 160 kN/m^2, the coefficient of friction is 0.55 and the unit weight of reinforced concrete is $24kN/m^3$ and passive pressure force (P_p) = 0.

The basic design calculation should include the following:

[i] Checking on the stability of the wall against **sliding** and **overturning**. (10 marks)

[ii] Calculation of the actual bearing pressure. (6 marks)

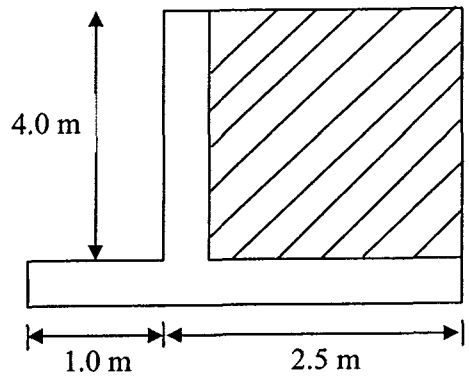


Figure 3

(b) Sediakan asas kiraan rekabentuk untuk tembok penahan julur seperti ditunjukkan dalam rajah berikut. Anggap dinding tembok dan ketebalan asas tersebut adalah 400mm. Tanah dibelakang tembok adalah bahan granular dengan ciri-ciri berikut:

Ketumpatan, γ_s	$= 20\ kN/m^3$
Sudut geseran dalaman, ϕ	$=30^o$

Andaikan tekanan galas tanah adalah 160 kN/m^2, pekali geseran adalah 0.55 dan berat unit konkrit adalah $24kN/m^3$ dan daya tekanan pasif (P_p) = 0.

Asas kiraan rekabentuk mesti mengandungi pekara berikut:

*[i] Semakan kestabilan tembok penahan tersebut terhadap **kegelinciran dan putaran.***

[ii] Kiraan tekanan galas sebenar.

4. Design a square pad footing to support a 400 mm square column carries the loads as shown in Table 1.

Table 1 : Loading for foundation

Type of load	Unit (ton)
Dead load (including self-weight)	80
Imposed load	25

From soil investigation, the bearing capacity of the soil is 18 ton/m^2. The materials to be used are grade 35 concrete and high yield steel (f_y = 460 MPa). Assume a cover of reinforcement (Table 3, BS8110 : Part 1 : 1997), overall depth of the pad footing and diameter of the bar is 40mm, 600mm, 20mm, respectively.

(20 marks)

Reka bentuk asas pad segiempat sama untuk menyokong tiang segiempat sama 400 mm yang membawa beban seperti di Jadual 1

Jadual 1 : Beban untuk asas

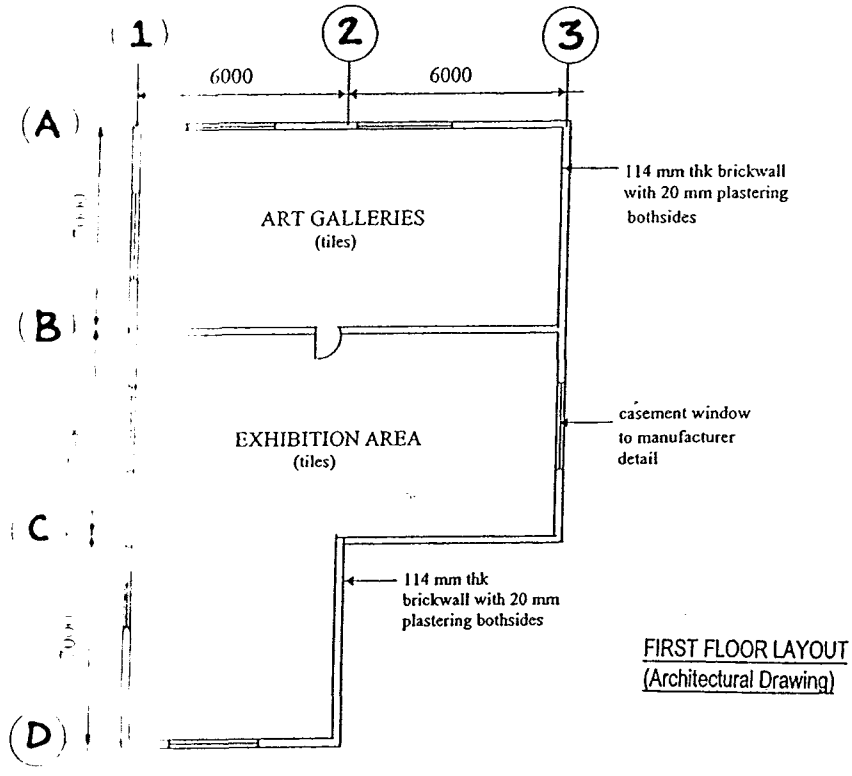
Jenis beban	*Unit (ton)*
Beban mati (termasuk swa-berat)	*80*
Beban kenaan	*25*

Dari penyiasatan tanah, keupayaan galas tanah adalah 18 ton/m^2. Bahan yang digunakan adalah konkrit gred 35 dan keluli tegangan tinggi (f_y = 460 MPa). Anggap penutup tetulang konkrit (Jadual 3, BS8110 : Bahagian 1:1997), kedalaman keseluruhan asas pad dan garis pusat tetulang adalah masing-masing 40mm, 600mm, 20mm.

5. (a) Design and provide all relevant detailing for the reinforced concrete beam on gridline 1/A-D as shown in Figure 4. Assume a typical floor height of the Museum is 3.0 meter. No curtailment of reinforcement is required. Finishes load may be taken as 1.2 kN/m^2.

(12 marks)

Rekabentuk dan sediakan semua perincian yang berkaitan untuk rasuk konkrit bertetulang pada garisan grid 1/A-D seperti di Rajah 4. Anggap ketinggian tipikal bangunan Muzium 3.0 meter. Pemotongan tetulang tidak perlu dilakukan. Beban kemasan boleh diambil sebagai 1.2 kN/m^2.



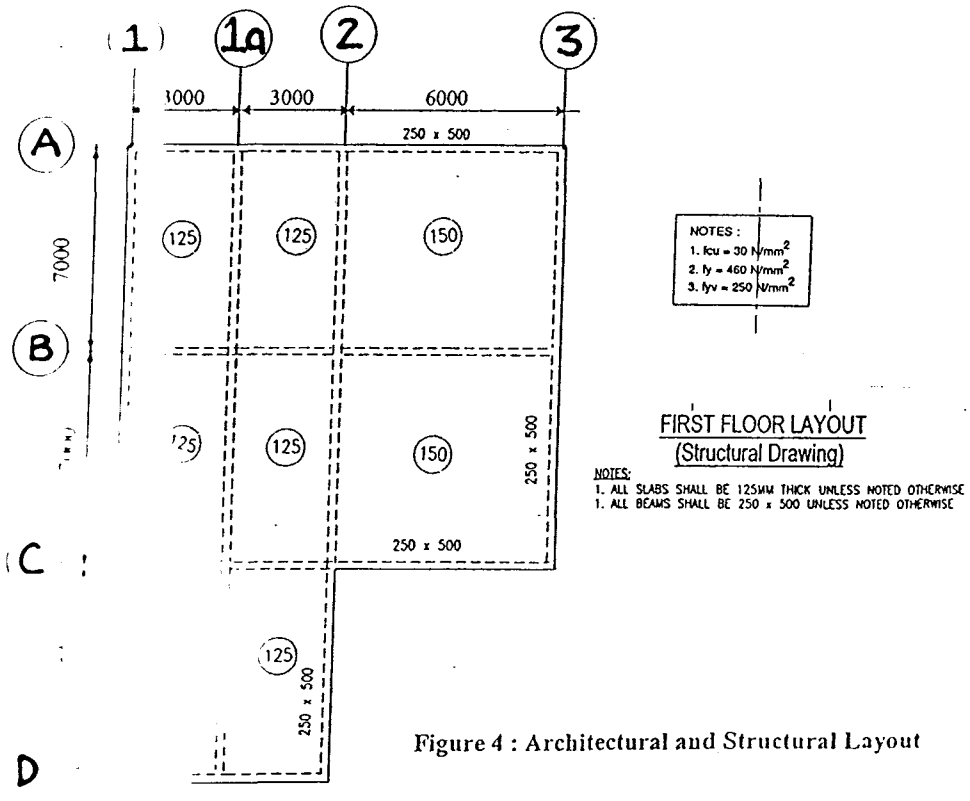


Figure 4 : Architectural and Structural Layout

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5. (b) If the same beam is then subjected to a uniform torsional moment of 10 kNm, design the new reinforcement required at interior support and provide a typical cross section.

(8 marks)

Sekiranya rasuk yang sama dikenakan momen kilasan sekata 10 kNm, rekabentuk keperluan tetulang baru di topang dalaman dan sediakan satu keratan tipikal.

6. (a) As a senior engineer, you are given a set of design calculation and detailing of a reinforced concrete column performed by a trainee engineer as shown in Figure 5. From your observation, the column shall be considered short, braced and subjected to biaxial bending. Provide all relevant comments pertaining to the calculation and detailing. Sketch the new column details based on your calculation.

(10 marks)

Sebagai seorang jurutera kanan, anda telah diberikan satu set pengiraan rekabentuk dan perincian satu tiang konkrit bertetulang yang telah dilakukan oleh jurutera pelatih seperti di Rajah 5. Berdasarkan pemerhatian anda, tiang tersebut sepatutnya dipertimbangkan sebagai tiang pendek, terembat dan mengalami dwi lenturan. Sediakan komen yang berkaitan terhadap pengiraan dan perincian tersebut. Lakarkan perician tiang yang baru berdasarkan pengiraan anda.

(b) Briefly describe the physical meaning of 'anchorage bond' in reinforced concrete design.

(5 marks)

Terangkan makna fizikal 'ikatan tambatan' dalam rekabentuk konkrit bertetulang.

(c) Calculate and sketch the anchorage length for a cantilever beam reinforcement using the following data:-

Reinforcement Type	: Mild Steel
Reinforcement Size	: 20 mm
f_y	: 250 N/mm^2
Stress Type	: Compression
f_s	: 185 N/mm^2
f_{cu}	: 30 N/mm^2

(5 marks)

Kira dan lakarkan panjang tambatan tetulang rasuk julur menggunakan data-data berikut:-

Jenis Tetulang	*: Keluli Lembut*
Saiz Tetulang	*: 20 mm*
f_y	*: 250 N/mm^2*
Jenis Tegasan	*: Mampatan*
f_s	*: 185 N/mm^2*
f_{cu}	*: 30 N/mm^2*

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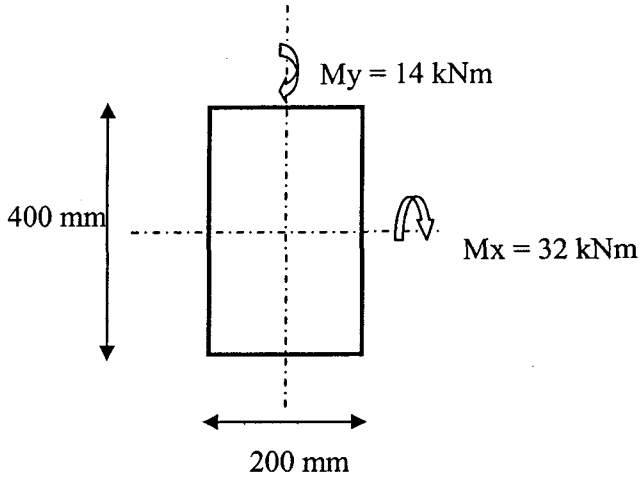
	PERUNDING B.A.T.S SDN BHD	Design Sheet No : 1
	Project : Proposed Extension to National Museum	
	Designed By : Mahadhir	
	Checked By : Ir Hamizat	
	Date : 30 August 2006	

f_{cu} = 30 N/mm^2
f_y = 460 N/mm^2
f_{yv} = 250 N/mm^2
cover to reinforcement (including link) = 30 mm
main reinforcement size = 20 mm



d = 360 mm
N/bh = 1200 x 10^3 /(200 x 400) = 15
M/bh^2 = 32 x 10^6 / (200 x 400^2) = 1

ok

Using Chart No : 28

100As/Ac = 1.2 %
As = 1.2 x 200 x 400 / (100) = 960 mm^2
Provide = 4 Y20 = 1256 mm^2
As_{min} = 0.4 x 200 x 400 = 320 mm^2
Links = R6 @ 250 c/c

Figure 5 : Design Sheet

APPENDIX A

Imposed loads on floors

Type of building		Use of floor	Uniformly distributed		Concentrated	
General	Particular		kN/m²	lb/ft²	kN	lb
Residential premises	Domestic: self-contained dwelling units	All rooms, including bedrooms, kitchens, laundries etc.	1.5	31.3	1.4	315
	Hotels, motels, hospitals	Bedrooms (including hospital wards)	2.0	41.8	1.8	405
	Boarding houses, hostels, residential clubs, schools, colleges, institutions	Bedrooms (including dormitories)	1.5	31.3	1.8	405
Places of public assembly or access	Public halls Theatres, cinemas Assembly areas in clubs, school, colleges Grandstands Sports halls (indoors)	With fixed seating	4.0	83.6	nil	nil
		Without fixed seating		104.5	3.6	809
	Dance halls, gymnasia			104.5	3.6	809
	Drill halls			104.5	9.0	2023
	Churches, classrooms	Including chapels etc.		62.7	2.7	607
	Library reading rooms	Without book storage	2.5	52.2	4.5	1011
		With book storage	4	83.6		
	Museums, art galleries		4	83.6	4.5	1011
	Hotels (see also residential) Banking halls	Bars, vestibules	5.0	104.5	nil	nil
			3.0	62.7		
	Shops	Display and sale	4.0	83.6	3.6	809
Commercial and industrial premises	Offices	General	2.5	52.2	2.7	607
		Filing and storage spaces	5.0	104.5	4.5	1011
		Computer rooms etc.	3.5	73.1		
	Theatres, cinemas, TV and radio studios etc. (see also places of assembly)	Stages: in theatres etc.	7.5	157	4.5	1011
		in colleges and gymnasia	5.0	104.5	3.6	809
		Grids	2.5	52.2	nil	nil
		Fly galleries (uniformly distributed over width)	4.5 per m	308 per ft		
		Projection rooms	5.0	104.5		
		Sports halls (indoor) equipment area	2.0	41.8	1.8	405
	Work places, factories etc	Utility rooms, X-ray rooms, operating theatres (hospitals)	3.0	41.8	4.5	1011
		Laundries: residential buildings (excl. domestic)		62.7		
		non-residential (excl. equipment)				
		Kitchens (communal) inc. normal equipment		62.7		
		Laboratories (incl. equipment)		62.7	4.5	1011
		Light workrooms (no storage)		52.2	1.8	405
		Workshops, factories		4.5	4.5	1011
		Foundries		4.8	nil	nil
		Printing works (see also *Table 5*)		261	9.0	2023
		Machinery halls (circulation space)		83.6	4.5	1011