UNIVERSITI SAINS MALAYSIA

First Semester Examination
2015/2016 Academic Session

December 2015 / January 2016

EAS353 – Reinforced Concrete Structural Design 1
[Rekabentuk Struktur Konkrit Bertetulang 1]

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

Please check that this examination paper consists of **EIGHT (8)** pages of printed material including **ONE (1**) appendix before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **LAPAN (8)** muka surat yang bercetak termasuk **SATU (1)** 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. [a] A 3-span continuous beam of 250 mm x 650 mm, and each span of 5.0 m as shown in **Figure 1**. The slab thickness is 180 mm. In the transverse direction, the beams spacing (B) are at 4.0 m centres with the supports of 250 mm.

The permanent load is 30 kN/m including self weight and the variable load is 12.5 kN/m. The characteristic strength of concrete is f_{ck} = 30 N/mm^2 and characteristic strength of steel is f_{yk} = 500 N/mm^2.

Assume that the nominal cover is 30 mm, nominal aggregate size is 20 mm and the fire resistance is for 1 hour. Life of building is 50 years. Use 16 mm and 8 mm size of longitudinal and shear reinforcement, respectively.

Design the reinforcements for bending and shear for the beam.

*Sebuah rasuk 3-rentang selanjar berdimensi 250 mm x 650 mm, dan setiap rentang 5.0 m seperti di **Rajah 1**. Ketebalan papak ialah 180 mm. Di arah melintang, jarak rasuk (B) ialah 4.0 m pusat ke pusat. Manakala lebar penyokong adalah 250 mm.*

Beban tetap adalah 30 kN/m termasuk beban diri dan beban boleh ubah ialah 12.5 kN/m. Ciri kekuatan konkrit f_{ck} = 30 N/mm^2 dan ciri kekuatan keluli f_{yk} = 500 N/mm^2.

Andaikan penutup konkrit nominal ialah 30 mm, saiz nominal aggregat 20 mm dan rintangan kebakaran ialah 1 jam. Hayat rekabentuk adalah 50 tahun. Guna saiz 16 mm dan 8 mm masing-masing untuk tetulang membujur dan tetulang ricih.

Rekabentuk tetulang lenturan dan ricih untuk rasuk.

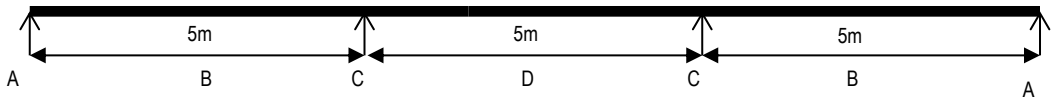

Figure 1/*Rajah 1*

[25 marks/*markah*]

2. [a] A free body diagram of continuous beam as shown in **Figure 2** has a constant cross-section and supports uniformly distributed permanent action of 30 kN/m and a variable action of 10 kN/m. Establish four critical loading patterns in accordance with EC2 for analysis of structure.

*Sebuah gambarajah jasad bebas rasuk selanjar ditunjukkan dalam **Rajah 2** mempunyai keratan rentas sekata dan menanggung beban tetap teragih seragam 30 kN/m dan beban boleh ubah 10 kN/m. Tentukan empat susunan beban kritikal berdasarkan EC2 untuk analisis struktur.*

[8 marks/*markah*]

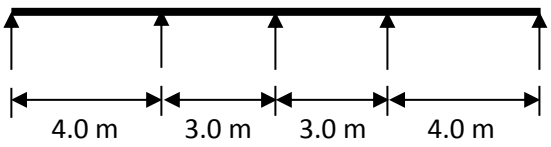

Figure 2/*Rajah 2*

[b] Determine the ultimate moment of resistance of the cross section shown in **Figure 3**. Given, the characteristic strengths of the reinforcement and concrete are 500 N/mm^2 and 30 N/mm^2, respectively. The tension reinforcement provided is 3-H20.

Tentukan rintangan momen maksimum keratan rentas yang ditunjukkan dalam ***Rajah 3****. Diberikan, kekuatan ciri tetulang dan konkrit masing-masing ialah 500 N/mm^2 dan 30 N/mm^2. Tetulang tegangan yang disediakan ialah 3-H20.*

[17 marks/*markah*]

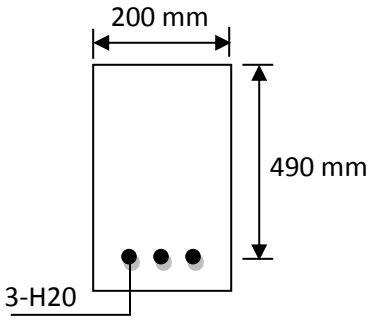

Figure 3/*Rajah 3*

3. A rectangular column section as shown in **Figure 4** is subjected to an axial load of 1200 kN and a moment of 240 kNm at the Ultimate Limit State (ULS). The arrangement of the reinforcement is non-symmetrical which lateral forces acting in the direction. Assuming the characteristic material strengths are f_{yk} = 500 N/mm^2 and f_{ck} = 30 N/mm^2, determine if the areas of reinforcement required are sufficient to carry the above mentioned loads.

Keratan tiang segiempat tepat seperti yang ditunjukkan dalam ***Rajah 4*** *dikenakan beban paksi sebesar 1200 kN dan momen 240 kNm pada keadaan Had Muktamad. Susunatur tetulang adalah tak simetri iaitu daya-daya sisi bertindak dalam arah. Anggapkan kekuatan ciri bahan f_{yk} = 500 N/mm^2 dan f_{ck} = 30 N/mm^2, tentukan sama ada luas tetulang yang diperlukan mencukupi untuk membawa beban-beban dinyatakan di atas.*

[25 marks/*markah*]

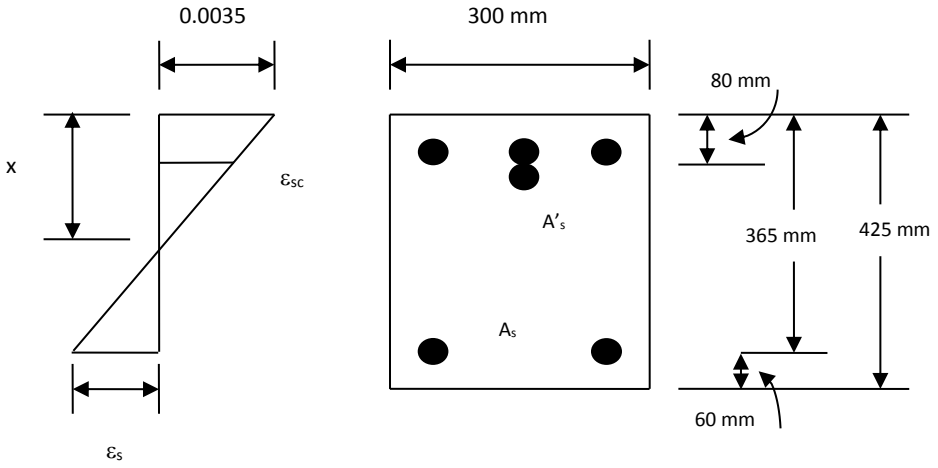

Figure 4/*Rajah 4*: Cross section of 300 x 425 mm rectangular column/
Keratan rentas 300 x 425 mm tiang segiempat

4. [a] Foundation is an importance structure which transmits the designed loads from the structure to the soil or rock. Sketch **FIVE (5)** types of reinforced concrete foundation for building.

*Asas adalah struktur yang penting untuk menyalurkan beban rekabentuk daripada struktur ke tanah atau batu. Lakarkan **LIMA (5)** jenis asas konkrit bertetulang untuk bangunan.*

[5 marks/*markah*]

[b] A strip footing is required to carry 350 mm square columns which are equally spaced at 3.25 m centres (see **Figure 5**). Each column carries a design load of 1800 kN. The safe bearing pressure of soil is 200 kN/m^2 and the characteristic material strengths are f_{ck} = 30 N/mm^2 and f_{yk} = 500 N/mm^2. Based on the geometry and reinforcements shown in **Figure 5**, justify that the punching shear resistance, longitudinal and transverse reinforcements are designed adequately.

*Asas jalur diperlukan untuk membawa tiang segiempat sama 350 mm pada jarak luang yang sama 3.25 m pusat ke pusat (lihat **Rajah 5**). Setiap tiang membawa beban rekabentuk sebesar 1800 kN. Tekanan galas selamat tanah ialah 200 kN/m^2 dan kekuatan ciri bahan ialah f_{ck} = 30 N/mm^2 and f_{yk} = 500 N/mm^2. Berdasarkan geometri dan tetulang yang ditunjukkan dalam **Rajah 5**, wajarkan bahawa rintangan ricih tebukan, tetulang membujur dan melintang yang direkabentuk adalah mencukupi.*

[20 marks/*markah*]

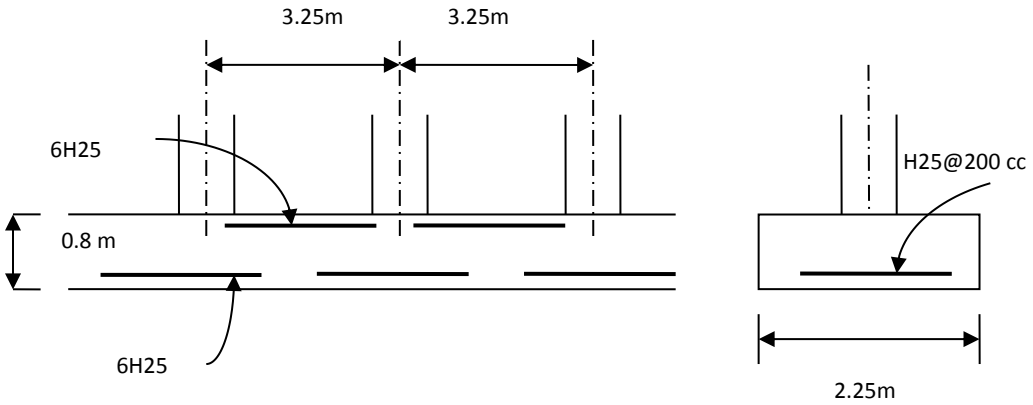

Figure 5/*Rajah 5*: Strip footing with longitudinal and transverse reinforcements/ *Asas jalur dengan tetulang membujur dan melintang*

5. Design the unrestrained simply supported floor shown in **Figure 6** when subjected to variable load of 4 kN/m^2. Given the characteristic strength of concrete, f_{ck} = 25 N/mm^2, characteristic strength of main reinforcement, f_{yk} = 500 N/mm^2, and nominal cover to reinforcement, c = 25 mm.

*Rekabentuk lantai tidak dikekang disokong mudah seperti yang di tunjukkan dalam **Rajah 6** yang dikenakan beban boleh ubah 4 kN/m^2. Diberikan kekuatan ciri konkrit, f_{ck} = 25 N/mm^2, kekuatan ciri tetulang utama, f_{yk} = 500 N/mm^{2}dan penutup nominal kepada tetulang, c = 25 mm.*

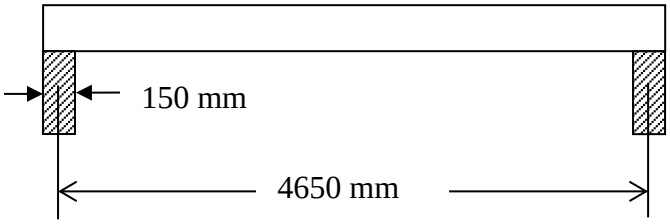

Figure 6/*Rajah 6*

[25 marks/*markah*]

APPENDIX/ LAMPIRAN

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

Capacity of concrete struts expressed as a stress, $v_{Rd,max}$

		$v_{Rd,max}$ (MPa)					
f_{ck}	cot θ	2.50	2.14	1.73	1.43	1.19	1.00
	θ	21.8°	25°	30°	35°	40°	45°
25		3.10	3.45	3.90	4.23	4.43	4.50
30		3.64	4.04	4.57	4.96	5.20	5.28
35		4.15	4.61	5.21	5.66	5.93	6.02
40		4.63	5.15	5.82	6.31	6.62	6.72
45		5.09	5.65	6.39	6.93	7.27	7.38
50		5.52	6.13	6.93	7.52	7.88	8.00

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