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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2013/2014

COURSE NAME	:	REINFORCED CONCRETE DESIGN I
COURSE CODE	:	BFC 32102
PROGRAMME	:	3 BFF
EXAMINATION DATE	:	JUNE 2014
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **ALL** QUESTIONS FROM **SECTION A** AND **TWO (2)** QUESTIONS FROM **SECTION B** DESIGN SHOULD BE BASED ON: BS EN 1990:2002+A1:2005 NA BS EN 1990:2002+A1:2005 BS EN 1991-1-1:2002 NA BS EN 1991-1-1:2002 BS EN 1992-1-1:2004 BS 8110:PART 1:1997

THIS QUESTION PAPER CONSISTS OF **TWELVE (12)** PAGES

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SECTION A

Q1 (a) Explain the fundamental assumptions that have been made in flexural theory of reinforced concrete design.

(4 marks)

(b) In elastic analysis, some of elastic moment at support can be reduced. Describe the purpose of moment redistribution especially in beam-column connections.

(4 marks)

(c) A cross section of reinforced concrete beam is 250 x 450 mm as shown in Figure **Q1**. The tension and compression reinforcements provided are 4H25 and 2H16 respectively.

(i) Draw the simplified rectangular stress and strain block for the cross section beam in ultimate limit state.

(6 marks)

(ii) Based on the simplified rectangular stress block, determine the ultimate moment resistance of the section, if f_{ck} = 30 N/mm^2 and f_{yk} = 500 N/mm^2. The depth to compression reinforcement and tension reinforcement are 50 mm and 410 mm, respectively.

(12 marks)

(iii) Based on the simplified rectangular stress block, determine the strain for compression reinforcement of the beam.

(4 marks)

SECTION B

Q2 Figure **Q2** shows the plan view of slab-beam system in one building. Due to construction works, beam and a part of the slab has to act as a pre-cast concrete slab. Given;

Slab thickness	=	125 mm
Beam size	=	250 mm x 500 mm
Finishes	=	1.0 kN/m^2
Ceiling	=	1.0 kN/m^2
Weight of concrete	=	25 kN/m^3
3 m height brickwall (entire building)	=	2.6 kN/m^2

Characteristic variable action, q_k	=	3.0 kN/m^2
Characteristic. strength of concrete, f_{ck}	=	25 N/mm^2
Characteristic strength of steel, f_{yk}	=	500 N/mm^2

Referring to a simply supported beam A/1-3,

(a) Determine the design action act on the beam

(15 marks)

(b) Draw shear force and bending diagram of the beam

(3 marks)

(c) Determine the amount and number of reinforcement required for the beam given the nominal cover is 35mm. Assume that diameter of reinforcement bar is 12mm and 20mm for top and bottom of the section, respectively, and diameter of link is 8mm.

(14 marks)

(d) Sketch reinforcement detailing for the beam

(3 marks)

Q3 Figure **Q3** shows the simply supported slab spanning in two directions. Given slab thickness is 220mm and the effective span in each direction is 4.0 m and 6.0 m respectively. The slab subjected to a variable action of 15kN/m^2. The characteristic material strength are f_{ck} = 25 N/mm^2 and f_{yk} = 500 N/mm^2. Assume the C_{nom} =35mm and diameter of reinforcement bar is 10 mm.

(a) Calculate the ultimate load of the slab.

(5 marks)

(b) Determine moment for both direction of slab.

(4 marks)

(c) Design the required reinforcement for both direction slabs.

(16 marks)

(d) Check the $A_{s,min}$ and $A_{s.max}$ with $A_{s},_{prov.}$

(5 marks)

a) Sketch the arrangement of reinforcement of slab.

(5 marks)

Q4 Figure **Q4(a)** shows a continuous beam with each span length is 8m. Given, the total permanent action and the total variable action for the beam is 22.5kN/m and 10kN/m.

(a) By using Simplified Method, draw the diagram for bending moment and shear force for the beam.

(10 marks)

(b) Design a T section for critical part of the beam based on the analysis in 4(a) . The beam cross section is shown in Figure **Q4(b)**. Given the characteristic material strength are f_{yk}= 500N/mm^2 and f_{ck}= 30N/mm^2. Assume x=0.45d. (Hint: use stress block to lead you with the solution)

(25 marks)

-END OF QUESTIONS-

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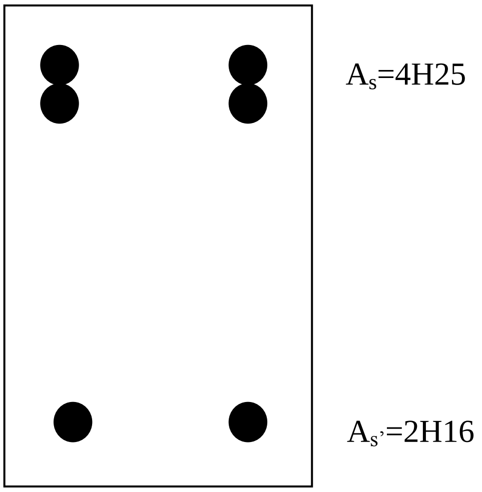

FIGURE Q1

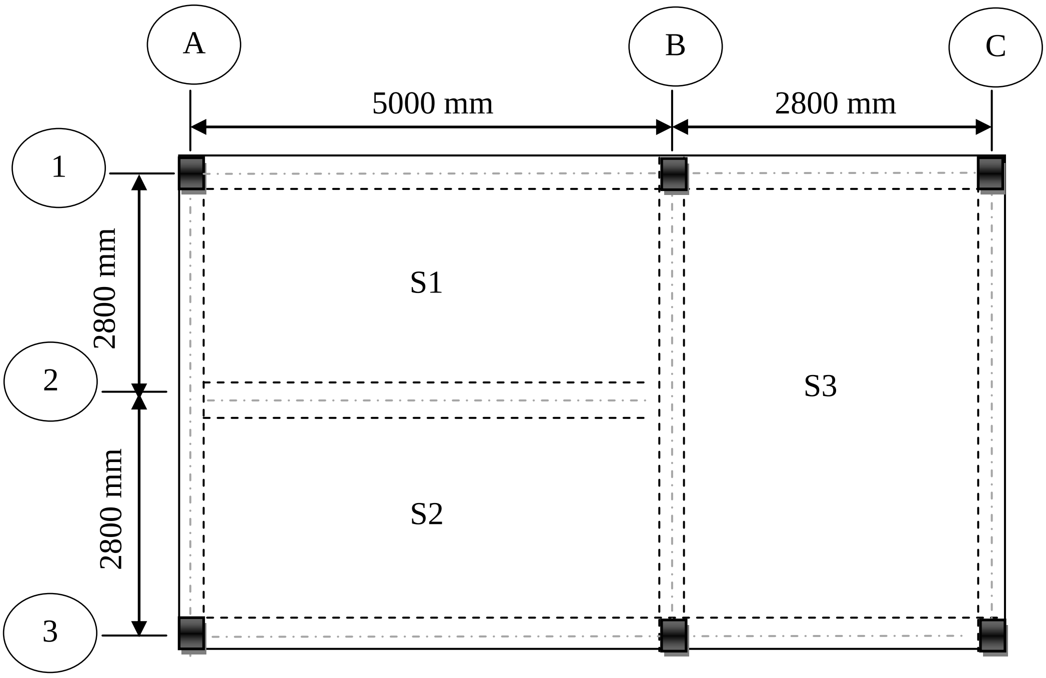

FIGURE Q2

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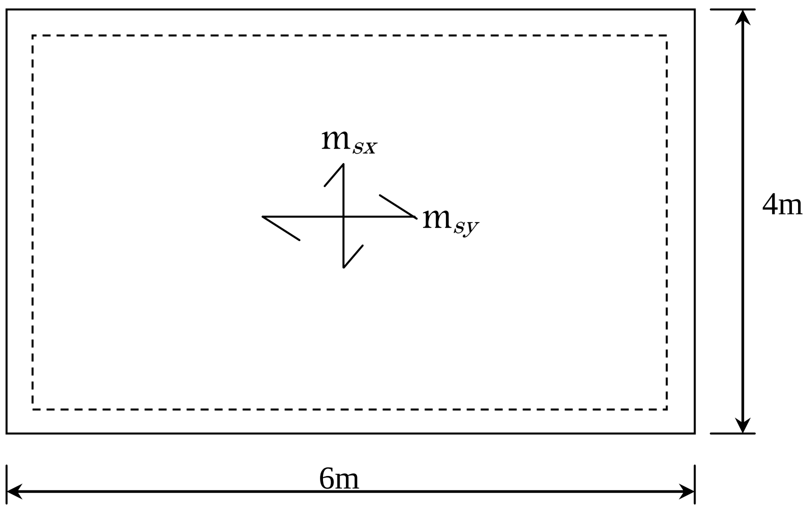

FIGURE Q3

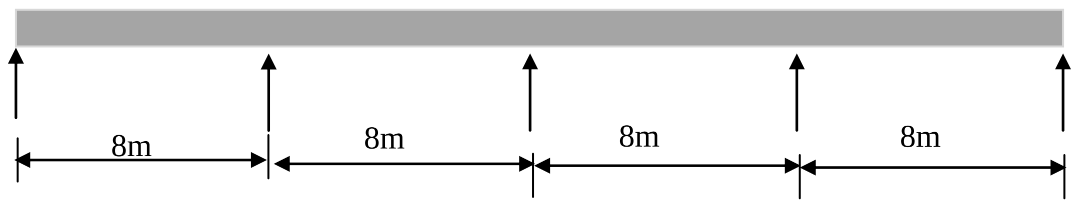

FIGURE Q4(a)

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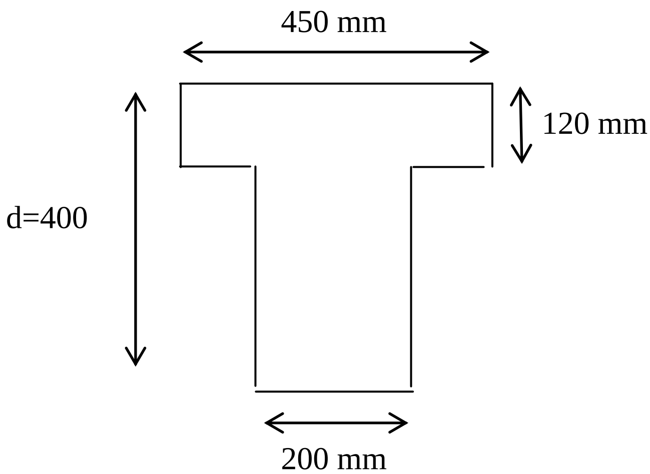

FIGURE Q4(b)

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FORMULA

$$A_S' = \frac{(K - K_{bal}) f_{ck} b d^2}{0.87 f_{yk}(d - d')}$$ if $d'/x \leq 0.38$ or

$$A_S' = \frac{(K - K_{bal}) f_{ck} b d^2}{f_{sc}(d - d')}$$ if $d'/x > 0.38$

$$f_{sc} = 700\left(1 - \frac{d'}{x}\right)$$

$$A_S = \frac{K_{bal} f_{ck} b d^2}{0.87 f_{yk}(d - d')} + A_S'\left(\frac{f_{sc}}{0.87 f_{yk}}\right)$$

$$M_f = (0.567 f_{ck} b_{eff} h_f)(d - h_f / 2)$$

$$A_S = \frac{K_{bal} f_{ck} b d^2}{0.87 f_{yk} z} + A_S'$$

$$f_s = \frac{f_{yk}}{1.15}\left[\frac{G_k + 0.3Q_k}{1.35G_k + 1.5Q_k}\right]\frac{1}{\delta}$$

$$M_{bal} = (0.454 f_{ck} b_w 0.45d)(d - 0.4(0.45d) + (0.567 f_{ck})(b_{eff} - b_w) h_f (d - 0.5h_f)$$

$$A_s = \frac{M + 0.454 f_{ck} b_w x[0.4x - 0.5h_f]}{0.87 f_{yk}(d - 0.5h_f)}$$

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Table 1: Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corner (Source: Table 3.15, *BS EN 1992 -1-2)*

Type of panel and location	β_{vx} for values of l_y/l_x								β_{vy}
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Four edges continuous									
Continuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33
One short edge discontinuous									
Continuous edge	0.36	0.39	0.42	0.44	0.45	0.47	0.50	0.52	0.36
Discontinuous edge	—	—	—	—	—	—	—	—	0.24
One long edge discontinuous									
Continuous edge	0.36	0.40	0.44	0.47	0.49	0.51	0.55	0.59	0.36
Discontinuous edge	0.24	0.27	0.29	0.31	0.32	0.34	0.36	0.38	—
Two adjacent edges discontinuous									
Continuous edge	0.40	0.44	0.47	0.50	0.52	0.54	0.57	0.60	0.40
Discontinuous edge	0.26	0.29	0.31	0.33	0.34	0.35	0.38	0.40	0.26
Two short edges discontinuous									
Continuous edge	0.40	0.43	0.45	0.47	0.48	0.49	0.52	0.54	—
Discontinuous edge	—	—	—	—	—	—	—	—	0.26
Two long edges discontinuous									
Continuous edge	—	—	—	—	—	—	—	—	0.40
Discontinuous edge	0.26	0.30	0.33	0.36	0.38	0.40	0.44	0.47	—
Three edges discontinuous (one long edge discontinuous)									
Continuous edge	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.63	—
Discontinuous edge	0.30	0.32	0.34	0.35	0.36	0.37	0.39	0.41	0.29
Three edges discontinuous (one short edge discontinuous)									
Continuous edge	—	—	—	—	—	—	—	—	0.45
Discontinuous edge	0.29	0.33	0.36	0.38	0.40	0.42	0.45	0.48	0.30
Four edges discontinuous									
Discontinuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33

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Table 2: Minimum dimensions and axis distances for reinforced and prestressed concrete simply supported one-way and two-way solid slabs (Source: Table 5.8 *BS EN 1992 -1-2)*

(1) Table 5.8 provides minimum values of axis distance to the soffit of simply supported slabs for standard fire resistances of R 30 to R 240,

(2) In two-way spanning slabs *a* denotes the axis distance of the reinforcement in the lower layer.

Standard fire resistance	Minimum dimensions (mm)			
	slab thickness h_s (mm)	axis-distance *a*		
		one way	two way: $l_y/l_x \leq 1,5$	two way: $1,5 < l_y/l_x \leq 2$
1	2	3	4	5
REI 30	60	10*	10*	10*
REI 60	80	20	10*	15*
REI 90	100	30	15*	20
REI 120	120	40	20	25
REI 180	150	55	30	40
REI 240	175	65	40	50

l_x and l_y are the spans of a two-way slab (two directions at right angles) where l_y is the longer span.

For prestressed slabs the increase of axis distance according to 5.2(5) should be noted.

The axis distance *a* in Column 4 and 5 for two way slabs relate to slabs supported at all four edges. Otherwise, they should be treated as one-way spanning slab.

* Normally the cover required by EN 1992-1-1 will control.

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Table 3: Design ultimate bending moments and shear forces
(Source: Table 3.5, *BS 8110 -1: 1997)*

	At outer support	Near middle of end span	At first interior support	At middle of interior spans	At interior supports
Moment	**0**	**0.09*Fl***	**-0.11*Fl***	**0.07*Fl***	**-0.08*Fl***
Shear	**0.45*F***	**-**	**0.6*F***	**-**	**0.55*F***

NOTE: *l* is the effective span;
F is the total design ultimate load ($1.35G_k + 1.5\ Q_k$)
No redistribution of the moment calculated from this table should be made.

Table 4: Ultimate bending moment and shear force in one-way spanning slabs
(Source: Table 3.5, *BS 8110 -1: 1997)*

	End support/slab connection				At first interior support	Middle interior spans	Interior supports
	Simple		Continuous				
	At outer support	Near middle of end span	At outer support	Near middle of end span			
Moment	**0**	**0.086*Fl***	**-0.04*Fl***	**0.075*Fl***	**-0.086*Fl***	**0.063*Fl***	**-0.063*Fl***
Shear	**0.45*F***	**-**	**0.46*F***	**-**	**0.6*F***	**-**	**0.5*F***

NOTE: *l* is the effective span;
F is the total design ultimate load ($1.35G_k + 1.5\ Q_k$)

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Table 5: Bending moment coefficients for slabs spanning in two directions at right angles, simply-supported on four sides (Sources: Table 3.13, BS8110:1:1997)

l_y/l_x	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0
α_{sx}	0.062	0.074	0.084	0.093	0.099	0.104	0.113	0.118
α_{sy}	0.062	0.061	0.059	0.055	0.051	0.046	0.037	0.029