Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	REINFORCED CONCRETE DESIGN I
COURSE CODE	:	BFC 32102 / BFC 3142
PROGRAMME	:	3 BFF
EXAMINATION DATE	:	DECEMBER 2013/JANUARY 2014
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	A) ANSWER **ALL** QUESTIONS IN PART A AND **TWO (2)** QUESTIONS FROM PART B. B) ALL CALCULATION SHOULD BE BASED ON EN 1992-1.

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

PART A: ANSWER ALL QUESTIONS

Q1 (a) Answer the following questions:

(i) State **Two (2)** principal types of limit state.

(ii) Define partial factors of safety.

(iii) Name **Two (2)** structural elements which are usually did not require shear reinforcement.

(6 marks)

(b) Figure **Q1** shows a first floor plan of a double story building.

(i) Illustrate with sketch the load carried on beam FB 1, FB 2 and FB 3.

(6 marks)

(ii) Locate the tension reinforcements for beam FB 1, FB 2, FB 3 and FB 4.

(12 marks)

(iii) If column C1 has to be omitted, in your opinion which structural elements need to be redesign. State the reason.

(6 marks)

PART B: ANSWER TWO QUESTIONS ONLY

Q2 (a) Figure **Q2(a)** shows a cross section for a simply supported beam. Given the following data:

Characteristic strength of concrete, f_{ck}	=	30 N/mm^2
Characteristic strength of steel reinforcement, f_{yk}	=	460 N/mm^2

(i) Based on simplified rectangular stress block, determine the ultimate moment resistance.

(17 marks)

(ii) If the opening is fully filled with grade C30 concrete, evaluate the additional moment can be resisted by the beam.

(6 marks)

(b) Figure **Q2(b)** shows the singly reinforced section with its simplified rectangular stress block. Given the x_{bal} = 0.617d, derive the equation for the ultimate moment of resistance of the balanced section.

(12 marks)

Q3 Figure **Q3** shows part of a first floor shop office plan. The beams are exposing to long-term water contact, 1 hour fire resistance and 50 years design life. Given the following data:

Characteristics strength of concrete, f_{ck}	=	25 N/mm^2
Characteristics strength of steel bar, f_{yk}	=	500 N/mm^2
Characteristics strength of link, f_{yk}	=	500 N/mm^2
All beam size	=	200 mm wide x 450 mm deep

Assume diameter of main bar in single layer is 20 mm and diameter of shear link is 8 mm. If the total characteristics variable and permanent actions on beam 2/A-D are 8.75 kN/m and 11.76 kN/m respectively.

(a) Determine the maximum envelop shear force and bending moment.

(8 marks)

(b) Calculate the required nominal concrete cover.

(8 marks)

(c) Design all the longitudinal reinforcements.

(14 marks)

(d) Check the cracking of the beam.

(5 marks)

Q4 Figure **Q4** shows part of the first floor layout plan of a reinforced concrete building. The concrete for slabs and beams are poured together and the thickness of the slabs is 175 mm. Detail specification is given as follows:

Design action, n	=	15 kN/m^2
Characteristic strength of concrete, f_{ck}	=	25 N/mm^2
Characteristic strength of steel bar, f_{yk}	=	500 N/mm^2
Nominal concrete cover	=	25 mm

(a) Determine all the positive and negative moments for slab S1.

(8 marks)

(b) Calculate the minimum and maximum area of reinforcements.

(4 marks)

(c) Design the flexural reinforcement required at mid span. Assume bar size is 10 mm.

(12 marks)

(d) Check the deflection.

(11 marks)

- END OF QUESTION-

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2013/2014
COURSE NAME : REINFORCED CONCRETE DESIGN I
PROGRAM : 3BFF
COURSE CODE : BFC 32102/ 3142

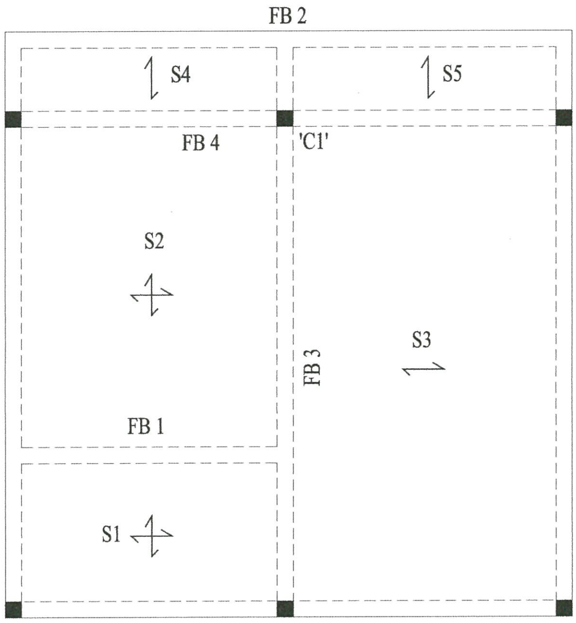

FIGURE Q1

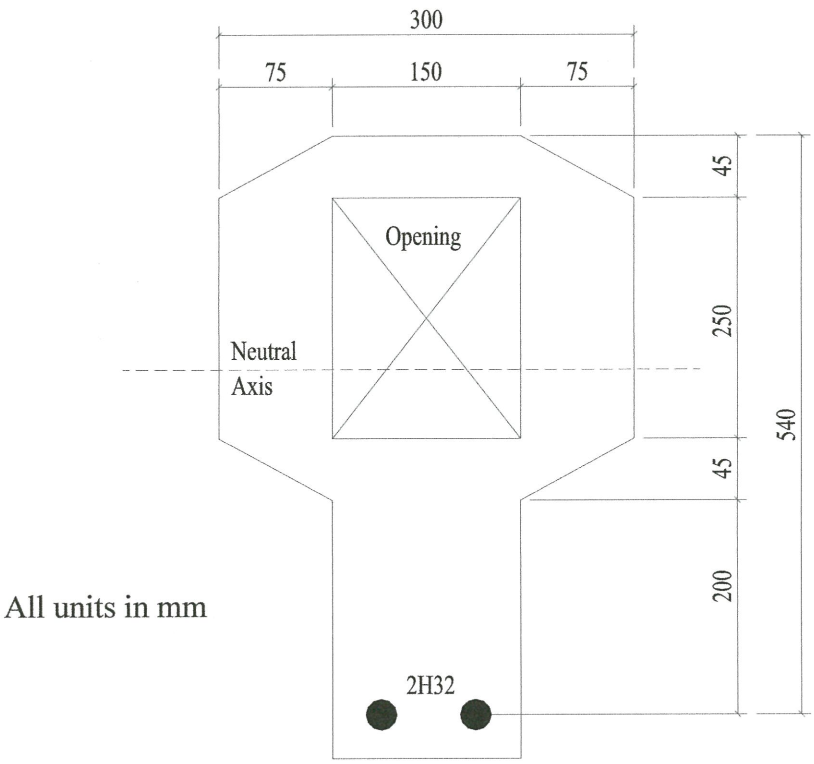

FIGURE Q2(a)

FINAL EXAMINATION

SEMESTER/SESSION	: SEMESTER I 2013/2014	PROGRAM	: 3BFF
COURSE NAME	: REINFORCED CONCRETE DESIGN I	COURSE CODE	: BFC 32102/ 3142

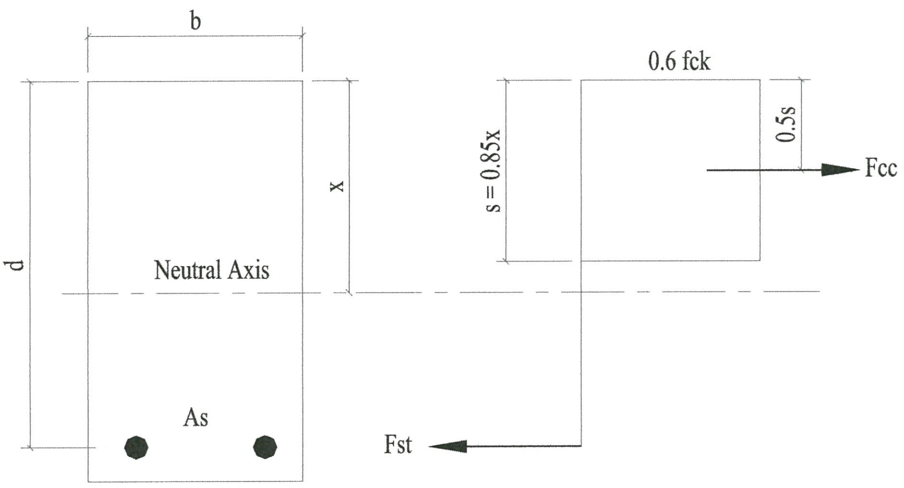

FIGURE Q2(b)

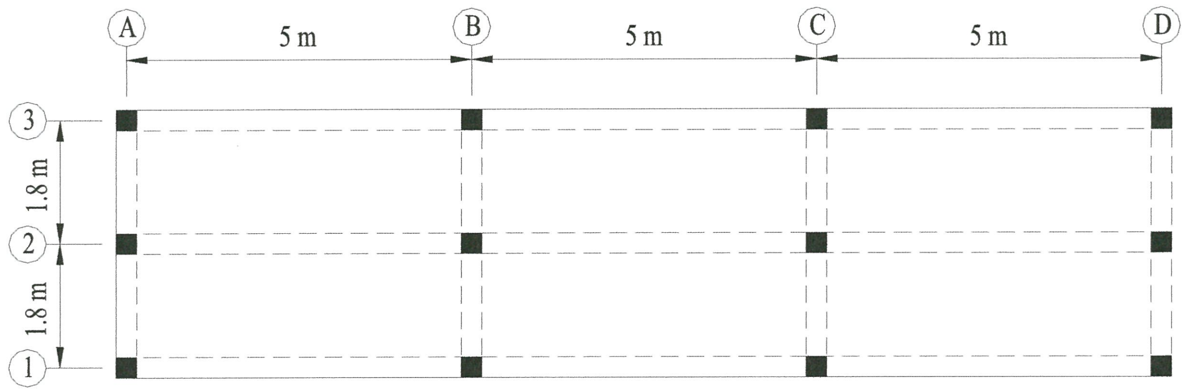

FIGURE Q3

FINAL EXAMINATION

SEMESTER/SESSION	: SEMESTER I 2013/2014	PROGRAM	: 3BFF
COURSE NAME	: REINFORCED CONCRETE DESIGN I	COURSE CODE	: BFC 32102/ 3142

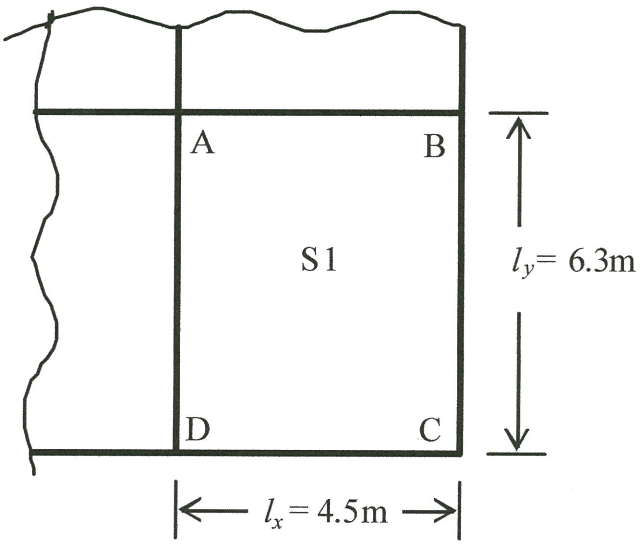

FIGURE Q4

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2013/2014
COURSE NAME : REINFORCED CONCRETE DESIGN I
PROGRAM : 3BFF
COURSE CODE : BFC 32102/ 3142

BASIC DESIGN EQUATIONS

(A) Design for Bending

For a singly reinforced section:

$$A_s = \frac{M}{0.87 f_{yk} z}$$

$$z = d\left\{0.5 + (0.25 - K/1.134)^{1/2}\right\}$$

$$K = M / bd^2 f_{ck}$$

For a doubly reinforced section ($K > K_{bal}$) – see figure A.3:

$$A'_s = \frac{(K - K_{bal}) f_{ck} bd^2}{0.87 f_{yk}(d - d')}$$

$$A_s = \frac{K_{bal} f_{ck} bd^2}{0.87 f_{yk} z_{bal}} + A'_s$$

(B) Design for Shear

$$V_{Rd,\max(22)} = 0.124 b_w d(1 - f_{ck}/250) f_{ck}$$

$$V_{Rd,\max(45)} = 0.18 b_w d(1 - f_{ck}/250) f_{ck}$$

$$\theta = 0.5 \sin^{-1}\left\{\frac{V_{Ed}}{0.18 b_w d f_{ck}(1 - f_{ck}/250)}\right\} \leq 45^\circ$$

$$\frac{A_{sw}}{s} = \frac{V_{Ed}}{0.78 d f_{yk} \cot\theta}$$

$$\frac{A_{sw,\min}}{s} = \frac{0.08 f_{ck}^{0.5} b_w}{f_{yk}}$$

FINAL EXAMINATION

SEMESTER/SESSION	: SEMESTER I 2013/2014	PROGRAM	: 3 BFF
COURSE NAME	: REINFORCED CONCRETE DESIGN I	COURSE CODE	: BFC 32102/ 3142

Minimum dimensions and axis distance for RC beams for fire resistance

Standard fire resistance		*Minimum dimensions (mm)*							
		Possible combinations of a and b_{min} where a is the average axis distance and b_{min} is the width of the beam							
		Simply supported				*Continuous*			
		A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
R60	b_{min} =	120	160	200	300	120	200		
	a =	40	35	30	25	25	12		
R90	b_{min} =	150	200	300	400	150	250		
	a =	55	45	40	35	35	25		
R120	b_{min} =	200	240	300	500	200	300	450	500
	a =	65	60	55	50	45	35	35	30
R240	b_{min} =	280	350	500	700	280	500	650	700
	a =	90	80	75	70	75	60	60	50

Note: The axis distance a_{sd} from the side of a beam to the corner bar should be $a + 10$ mm except where b_{min} is greater than the values in columns C and F

Nominal cover to reinforcement (50-year design life, Portland cement concrete with 20mm maximum aggregate size) [Based on BS 8500]

Exposure class	*Nominal Cover (mm)*								
XO	Not recommended for reinforced concrete								
XC1	25 →								
XC2	–	35	35 →						
XC3/4	–	45	40	35	35	35	30 →		
XD1	–	–	45[1]	45	40[1]	40	35[1]	35	35
XD2	–	–	50[2]	50[1]	45[2]	45[1]	40[2]	40[1]	40
XD3	–	–	–	–	–	60[2]	55[2]	50[1]	50
XS1	–	–	–	–	50[2]	45[2]	45[1]	40[1]	40
XS2	–	–	50[2]	50[1]	45[2]	45[1]	40[2]	40[1]	40
XS3	–	–	–	–	–	–	60[2]	55[1]	55
Maximum free water/cement	0.70	0.65	0.60	0.55	0.55	0.50	0.45	0.35	0.35
Minimum cement (kg/m^3)	240	260	280	300	300	320	340	360	380
Lowest concrete	C20/25	C25/30	C28/35	C30/37	C32/40	C35/45	C40/50	C45/55	C50/60

Notes:

1. Cement content should be increased by 20 kg/m^3 above the values shown in the table.
2. Cement content should be increased by 40 kg/m^3 *AND* water–cement ratio reduced by 0.05 compared with the values shown in the table.

General Notes

These values may be reduced by 5 mm if an approved quality control system is specified.

Nominal cover should not be less than the bar diameter + 10 mm to ensure adequate bond performance.

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2013/2014 PROGRAM : 3 BFF
COURSE NAME : REINFORCED CONCRETE DESIGN I COURSE CODE : BFC 32102/ 3142

Design ultimate bending moments and shear forces

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

Note: l is the effective span
F is the total design ultimate load (1.35Gk + 1.5Qk)

Bending moment coefficients for rectangular panels supported on four sides with provision for torsion at corners

Type of panel and moments considered	Short span coefficients, β_{sx} Values of l_y/l_x								Long span coefficients, β_{sy} for all values of l_y/l_x
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Interior panels									
Negative moment at continuous edge	0.031	0.037	0.042	0.046	0.050	0.053	0.059	0.063	0.032
Positive moment at mid-span	0.024	0.028	0.032	0.035	0.037	0.040	0.044	0.048	0.024
One short edge discontinuous									
Negative moment at continuous edge	0.039	0.044	0.048	0.052	0.055	0.058	0.063	0.067	0.037
Positive moment at mid-span	0.029	0.033	0.036	0.039	0.041	0.043	0.047	0.050	0.028
One long edge discontinuous									
Negative moment at continuous edge	0.039	0.049	0.056	0.062	0.068	0.073	0.082	0.089	0.037
Positive moment at mid-span	0.030	0.036	0.042	0.047	0.051	0.055	0.062	0.067	0.028
Two adjacent edges discontinuous									
Negative moment at continuous edge	0.047	0.056	0.063	0.069	0.074	0.078	0.087	0.093	0.045
Positive moment at mid-span	0.036	0.042	0.047	0.051	0.055	0.059	0.065	0.070	0.034

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2013/2014
COURSE NAME : REINFORCED CONCRETE DESIGN I
PROGRAM : 3 BFF
COURSE CODE : BFC 32102/ 3142

Table 1: Cross Sectional Area (mm^2) according to Size and Numbers of Bar

Bar Size (mm)	Number of bar								Perimeter (mm)
	1	2	3	4	5	6	7	8	
6	28.3	56.6	84.9	113	141	170	198	226	18.9
8	50.3	101	151	201	251	302	352	402	25.1
10	78.6	157	236	314	393	471	550	629	31.4
12	113	226	339	453	566	679	792	905	37.7
16	201	402	603	805	1006	1207	1408	1609	50.3
20	314	629	943	1257	1571	1886	2200	2514	62.9
25	491	982	1473	1964	2455	2946	3438	3929	78.6
32	805	1609	2414	3218	4023	4827	5632	6437	100.6
40	1257	2514	3771	5029	6286	7543	8800	10057	125.7

Table 2: Cross Sectional Area (mm^2) for every meter width at distance between bar

Bar Size (mm)	Distance between Bar (mm)								
	50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	141	113	94
8	1006	670	503	402	335	287	251	201	168
10	1571	1048	786	629	524	449	393	314	262
12	2263	1509	1131	905	754	647	566	453	377
16	4023	2682	2011	1609	1341	1149	1006	805	670
20	6286	4190	3143	2514	2095	1796	1571	1257	1048
25	9821	6548	4911	3929	3274	2806	2455	1964	1637
32	16091	10728	8046	6437	5364	4598	4023	3218	2682
40	25143	16762	12571	10057	8381	7184	6286	5029	4190