CONFIDENTIAL

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	REINFORCED CONCRETE DESIGN 1
COURSE CODE	:	BFC 32102
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE / JULY 2016
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS FROM SECTION A AND **THREE (3)** QUESTIONS FROM SECTION B. 2.DESIGN SHOULD BE BASED ON: BS EN 1990:2002+A1:2005 BS EN 1991-1-1:2002 BS EN 1992-1-1:2004

THIS PAPER CONSISTS OF **SIXTEEN (16)** PAGES

CONFIDENTIAL

SECTION A: ANSWER ALL QUESTIONS

Q1 (a) Design situations of limit state can be divided into several categories. Name and briefly explain the design situations that are involved in the design of reinforced concrete structures.

(8 marks)

(b) An architecture plan of second floor of residential house is shown in **FIGURE Q1**. By using an appropriate approach, produce a complete engineering layout of the floor plan.

(10 marks)

(c) Based on the engineering layout in **Q1(b)**, draw the cross section X-X and propose the suitable size of the beams and slabs.

(7 marks)

SECTION B: ANSWER THREE (3) QUESTIONS ONLY

Q2 A plan view of a terrace house is shown in **FIQURE Q2**. End beam 5/A-B is initially designed by considering rectangular shape with size 250 mm x 650 mm and singly reinforcement of 2H20. Other specifications of the design are given as follows:

Characteristic strength of concrete	= C25/30
Characteristic strength of steel	= 500 N/mm^2
Unit weight of concrete	= 25 kN/m^3
Nominal cover	= 30 mm
Thickness of slab	=125 mm

(a) Determine the moment resistance of section for end beam 5/A-B.

(6 marks)

(b) If the actual variable and permanent actions are 3.0 kN/m^2 and 1.5 kN/m^2 (excluding selfweight) respectively, classify the type of flexural failure that may happen on the beam.

(12 marks)

(c) Evaluate the required reinforcement area and compare the serviceability condition with the initial design.

(7 marks)

Q3 **FIGURE Q3** shows the first floor plan of residential building with 50 years design life and XC1 exposure class. All beams are subjected to 20kN/m of characteristic permanent action (excluding beam selfweight) and 10 kN/m of characteristic variable action. A 3 m brickwall is located at all beams with 2.6 kN/m^2 weight. The beam has width, b_w of 150mm and overall depth h, of 500mm. Thickness of all slabs, h_f is 150mm. The characteristic strength of concrete and steel are 25 N/mm^2 and 500 N/mm^2, respectively.

(a) Analyze shear force and bending moment diagram for beam B/1-5.

(5 marks)

(b) Design a flexural reinforcement at critical span for the beam. Sketch the detailing at cross section of the beam. Assume bar reinforcement $\phi_{tension}$ = 12 mm, $\phi_{compression}$=10 mm (if required) and ϕ_{link}= 8mm. Take nominal concrete cover as 30 mm.

(15 marks)

(c) Verify cracking for the beams.

(5 marks)

Q4 The beam shown in **FIGURE Q4** supports a permanent action of 20 kN/m (excluding beam selfweight) and variable action of 15 kN/m. The beam has a cross section of 400mm x 275mm and it is singly reinforced with provided bar of 6H16. Other specifications are as follows:

Unit weight of concrete	= 25 kN/m^3
Characteristic strength of concrete	= 30 N/mm^2
Characteristic strength of steel	= 500 N/mm^2
Nominal cover	= 25 mm
Thickness of slab	= 200 mm
Link diameter	= 8 mm

(a) Verify the provided flexural reinforcement for the beam.

(10 marks)

(b) Design shear reinforcement of the beam.

(9 marks)

(c) Determine the deflection criteria of the beam.

(6 marks)

Q5 **FIGURE Q5** shows the layout plan for the part of the third floor of library building. The concrete for slabs and beams are poured together and the thickness of the slab is 150 mm. The permanent and variable actions for slab are as follows:

Ceiling and tile finishes	=	1.75 kN/m^2
Variable action	=	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
Concrete cover	=	25 mm

(a) Determine the positive and negative moments for slab B-C/2-3.

(5 marks)

(b) Design the flexural reinforcement required at mid span by assuming that the bar size is 10mm. Determine the minimum and maximum reinforcement area.

(12 marks)

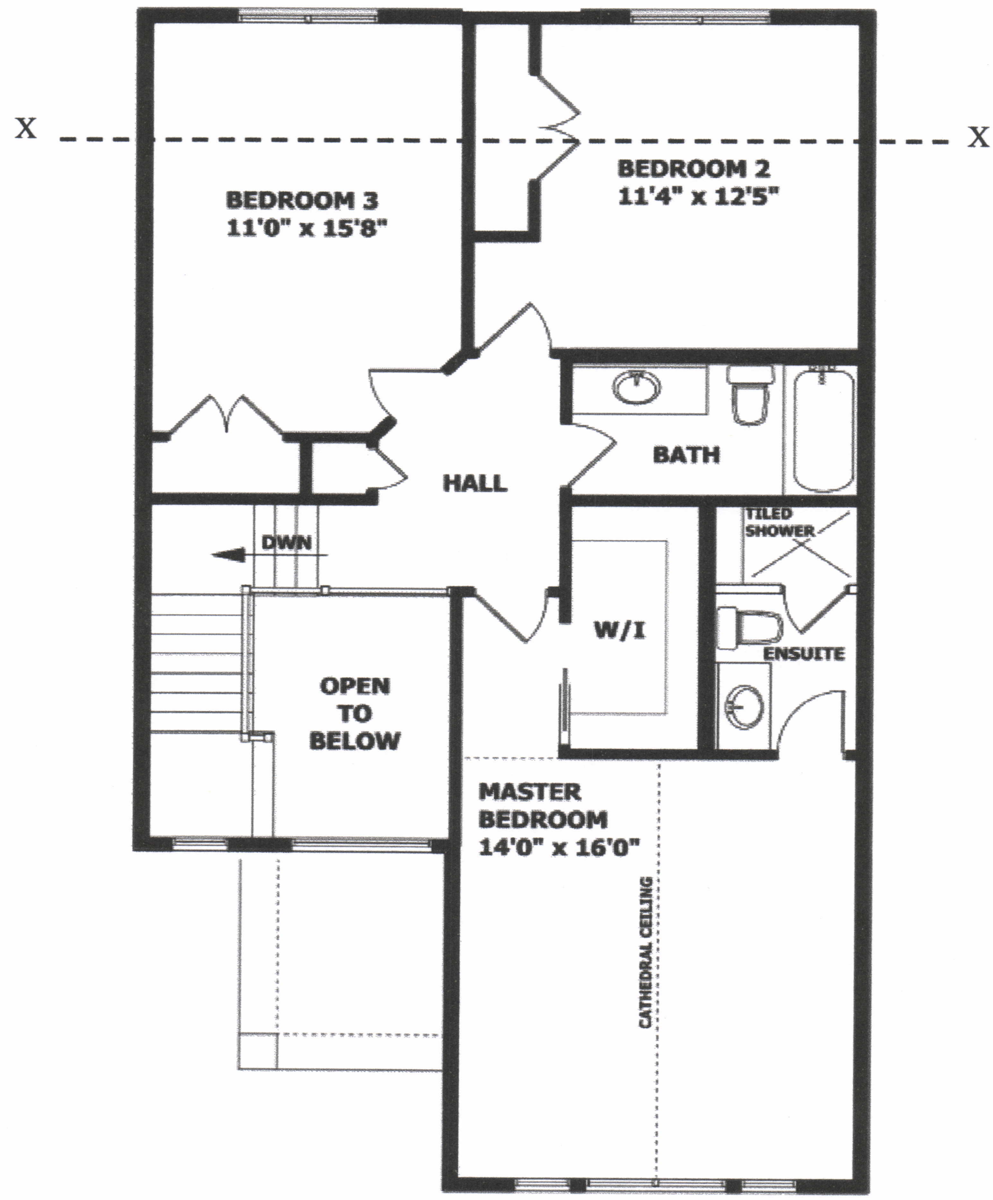
(c) Check the deflection for the slab panel.

(8 marks)

-END OF QUESTIONS-

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102



1' = 0.305 m

FIGURE Q1

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102

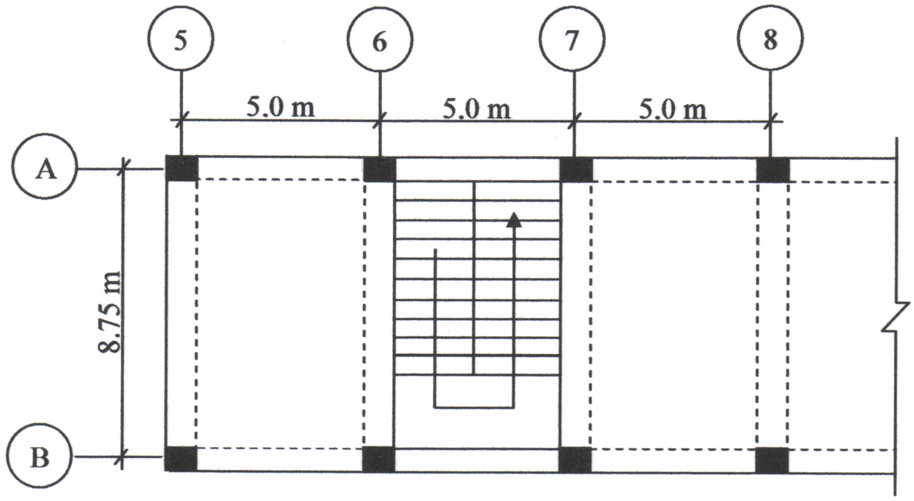


FIGURE Q2

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102

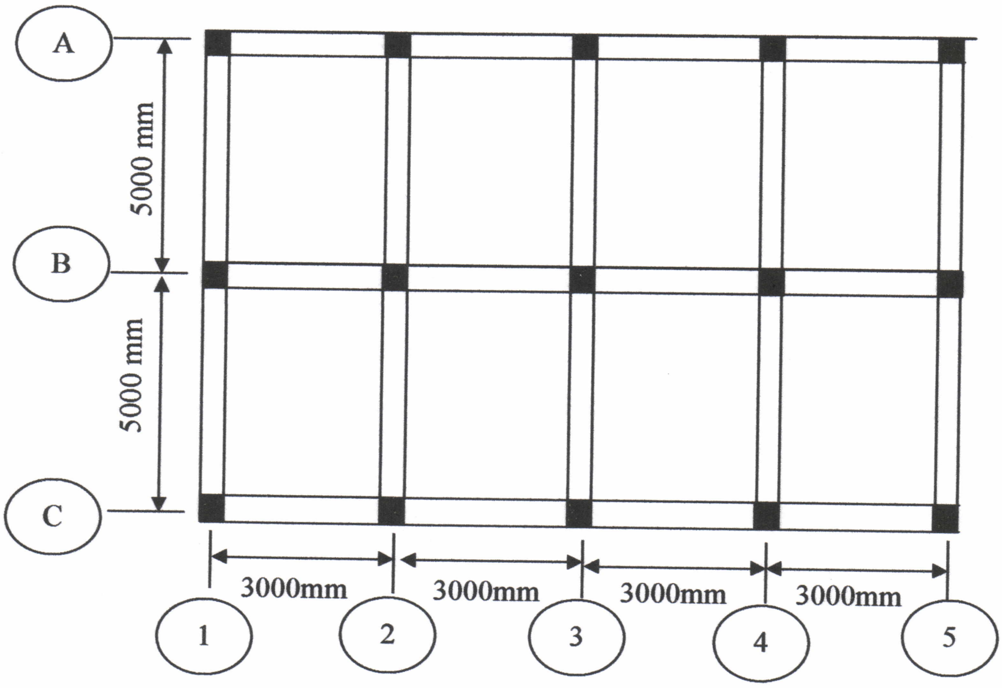


FIGURE Q3

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102

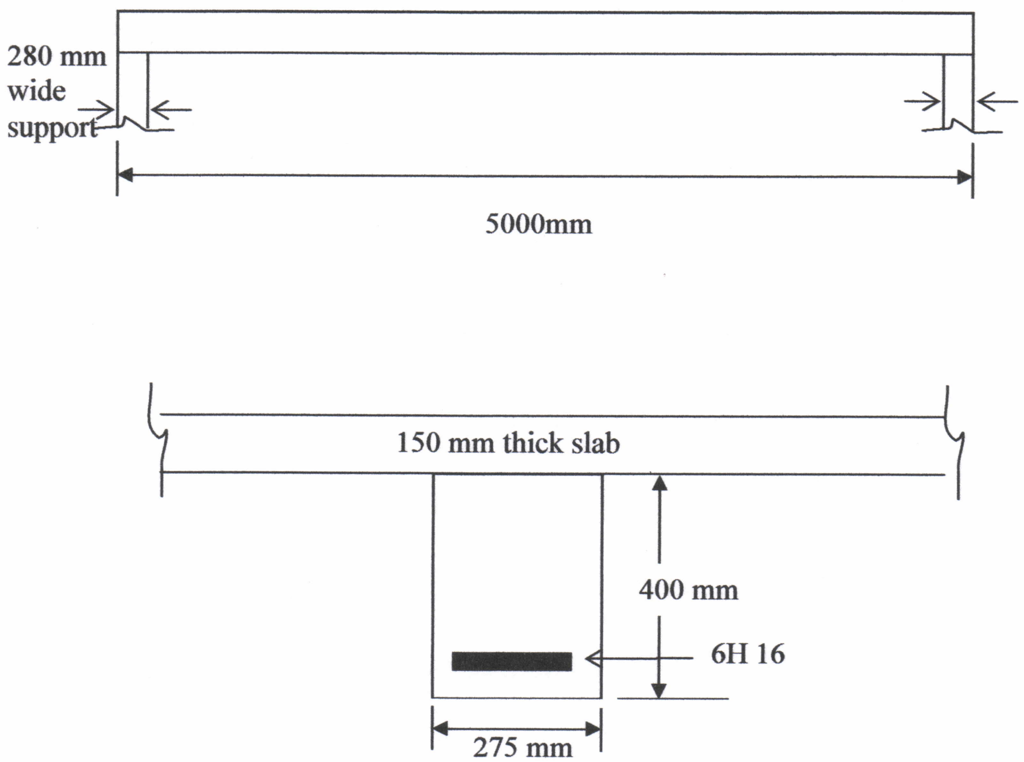
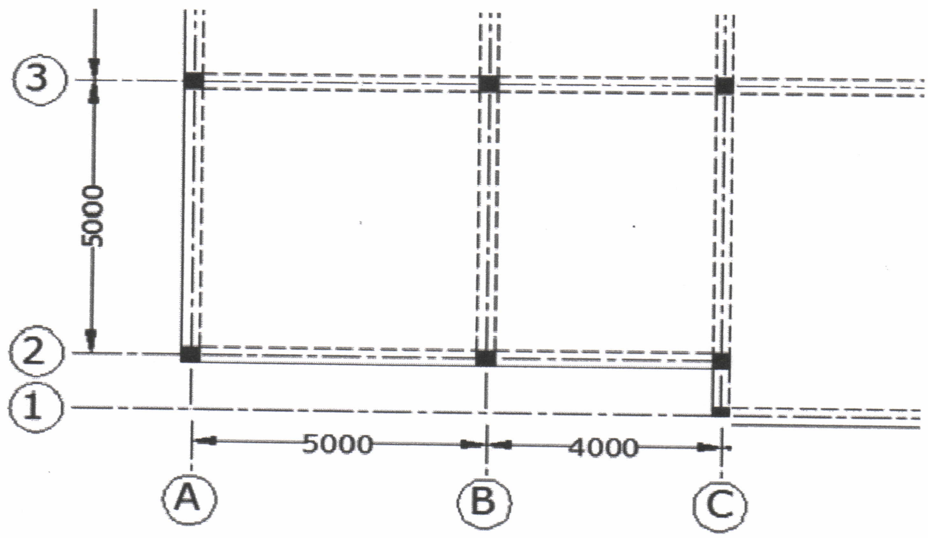


FIGURE Q4

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2015/2016 PROGRAMME : BFF
COURSE : REINFORCED CONCRETE DESIGN 1 COURSE CODE : BFC32102



Unit is in mm

FIGURE Q5

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102

FORMULA

$$A_S' = \frac{(K - K_{bal})f_{ck}bd^2}{0.87f_{yk}(d - d')} \qquad \text{if} \frac{d'}{x} > 0.38$$

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

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

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

$$V_{Rd,max} = \frac{0.36b_w d f_{ck}(1 - f_{ck}/250)}{cot\theta + tan\theta}$$

$$\theta = 0.5\sin^{-1}\left(\frac{V_{Ed}}{0.18bdf_{ck}(1 - f_{ck}/250)}\right)$$

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

$$\frac{A_{sw}}{s} = \frac{0.08b_w\sqrt{f_{ck}}}{0.78f_{yk}d\cot\theta}$$

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

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

$$M_{bal} = \beta_f f_{ck}b_{eff}d^2$$

$$\frac{M_{bal}}{f_{ck}b_{eff}d^2} = 0.167\frac{b_w}{b_{eff}} + 0.567\frac{h_f}{d}\left(1 - \frac{b_w}{b_{eff}}\right)\left(1 - \frac{h_f}{2d}\right)$$

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102

FORMULA

$$A_s = \frac{M}{0.87 f_{yk} z} \qquad \text{if } M < M_f$$

$$A_s = \frac{M + 0.1 f_{ck} b_w d [0.36d - h_f]}{0.87 f_{yk} (d - 0.5 h_f)} \qquad \text{if } M < M_{bal}$$

$$A_s = \frac{0.2 f_{ck} b_w d + 0.567 f_{ck} h_f (b_{eff} - b_w)}{0.87 f_{yk}} + A_s' \qquad \text{if } M > M_{bal}$$

$$A_s' = \frac{M - M_{bal}}{0.87 f_{yk} (d - d')} \qquad \text{if } M > M_{bal}$$

$$V_{Rd,c} = [0.12 k (100 \rho_1 f_{ck})^{1/3}] b_w d$$

$$V_{\min} = [0.035 k^{3/2} f_{ck}^{\ 1/2}] b_w d$$

FINAL EXAMINATION

SEMESTER / SESSION	: SEM II / 2015/2016	PROGRAMME	: BFF
COURSE	: REINFORCED CONCRETE DESIGN 1	COURSE CODE	: BFC32102

Table 1: Minimum dimensions and axis distances for simply supported beams made with reinforced and prestressed concrete (Source: *BS EN 1992 -1-2)*

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 beam				Web thickness b_w		
					Class WA	Class WB	Class WC
1	2	3	4	5	6	7	8
R 30	b_{min}= 80 a = 25	120 20	160 15*	200 15*	80	80	80
R 60	b_{min}= 120 a = 40	160 35	200 30	300 25	100	80	100
R 90	b_{min}= 150 a = 55	200 45	300 40	400 35	110	100	100
R 120	b_{min}= 200 a = 65	240 60	300 55	500 50	130	120	120
R 180	b_{min}= 240 a = 80	300 70	400 65	600 60	150	150	140
R 240	b_{min}= 280 a = 90	350 80	500 75	700 70	170	170	160
$a_{sd} = a + 10$mm (see note below)							

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

a_{sd} is the axis distance to the side of beam for the corner bars (or tendon or wire) of beams with only one layer of reinforcement. For values of b_{min} greater than that given in Column 4 no increase of a_{sd} is required.

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

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2015/2016 PROGRAMME : BFF
COURSE : REINFORCED CONCRETE DESIGN 1 COURSE CODE : BFC32102

Table 2: Minimum dimensions and axis distances for reinforced and prestressed concrete simply supported one-way and two-way solid slabs (Source: *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 resistance of R 30 and to R 40,
(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:	
			$l_y/l_x \leq 1,5$	$1,5 < l_y/l_x < 2$
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.

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2015/2016 PROGRAMME : BFF
COURSE : REINFORCED CONCRETE DESIGN 1 COURSE CODE : BFC32102

Table 3: Design ultimate bending moments and shear forces
(Source: *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	$0.09Fl$	$-0.11Fl$	$0.07Fl$	$-0.08Fl$
Shear	$0.45F$	-	$0.6F$	-	$0.55F$

NOTE: l is the effective span;
F is the total design ultimate load ($1.35G_k + 1.5\ Q_k$)
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: *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	$0.086Fl$	$-0.04Fl$	$0.075Fl$	$-0.086Fl$	$0.063Fl$	$-0.063Fl$
Shear	$0.45F$	-	$0.46F$	-	$0.6F$	-	$0.5F$

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

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2015/2016 PROGRAMME : BFF
COURSE : REINFORCED CONCRETE DESIGN 1 COURSE CODE : BFC32102

Table 5: Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corners

Table 3.15 — Shear force coefficient for uniformly loaded rectangular panels supported on four sides with provision for torsion at corners

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

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2015/2016 PROGRAMME : BFF
COURSE : REINFORCED CONCRETE DESIGN 1 COURSE CODE : BFC32102

Table 6: Bending moment coefficient for rectangular panels supported on four sides with provision for torsion at corners

Table 3.14 — 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}								Long span coefficients, β_{sy} for all values of l_y/l_x
	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
Two short edges discontinuous									
Negative moment at continuous edge	0.046	0.050	0.054	0.057	0.060	0.062	0.067	0.070	—
Positive moment at mid-span	0.034	0.038	0.040	0.043	0.045	0.047	0.050	0.053	0.034
Two long edges discontinuous									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.045
Positive moment at mid-span	0.034	0.046	0.056	0.065	0.072	0.078	0.091	0.100	0.034
Three edges discontinuous (one long edge continuous)									
Negative moment at continuous edge	0.057	0.065	0.071	0.076	0.081	0.084	0.092	0.098	—
Positive moment at mid-span	0.043	0.048	0.053	0.057	0.060	0.063	0.069	0.074	0.044
Three edges discontinuous (one short edge continuous)									
Negative moment at continuous edge	—	—	—	—	—	—	—	—	0.058
Positive moment at mid-span	0.042	0.054	0.063	0.071	0.078	0.084	0.096	0.105	0.044
Four edges discontinuous									
Positive moment at mid-span	0.055	0.065	0.074	0.081	0.087	0.092	0.103	0.111	0.056