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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION (ONLINE) SEMESTER II SESSION 2019/2020

COURSE NAME	:	REINFORCED CONCRETE DESIGN 1
COURSE CODE	:	BFC32102
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2020
DURATION	:	5 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. UNLESS OTHERWISE SPECIFIED, ALL DESIGN **MUST** BE BASED ON **EN 1990, EN 1991** and **EN 1992**.

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

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Q1 **Figure Q1** shows the layout plan at first floor for a double storey building. The layout plan consists of two parts, where A0-B/1-3 is the existing structure plan and B-C/1-3 is the proposed new extension. All beams, columns and slabs are reinforced concrete. The concrete for the beam and slab is cast simultaneously.

Given as follows are design data to be used in the design and based on BS EN 1992-1-1 and information in Appendix:

Existing Structures (A0-B/1-3)

All slab thickness	= 150 mm
All beam size	= 250 mm wide x 650 mm depth
Characteristic strength of concrete	= 30 MPa
Characteristic strength of steel reinforcement	= 500 MPa
Tensile strength of concrete (C30), f_{ctm}	= 2.9 MPa
Unit weight of reinforced concrete	= 25 kN/m^3
Finishes and services	= 1.5 kN/m^2
Brickwall	= 2.6 kN/m^2
Variable action	= 3.0 kN/m^2

Proposed New Extension (B-C/1-3)

Maximum depth of beam	= 650 mm
Maximum thickness of slab	= 170 mm

(a) Propose a structural layout plan for the new extension. The maximum depth of the beam and slab is governed by the ratio of L/13 and L/30 respectively. L is the span of the beam or span of slab.

(10 marks)

(b) Calculate the characteristic permanent and variable actions on beam A/1-3.

(20 marks)

(c) Illustrate all the possible load combinations need to be considered for beam A/1-3. State all the load value on each span.

(10 marks)

Q2 Based on the information given in **Q1** and **Figure Q1**. The slab A0-A/1-3 (S1) is a cantilever slab supported by beam A/1-3. A 3 m height brickwall is sitting at the edge of the slab along gridline A0/1-3. The cross section of the cantilever slab is shown in **Figure Q2**.

(a) Determine the ultimate bending moment and shear force for the cantilever slab (S1).

(10 marks)

(b) Design all the flexural reinforcement required by the slab. Use nominal concrete cover 20 mm and diameter of main reinforcement 10 mm.

(10 marks)

(c) Check shear and cracking of the slabs.

(7 marks)

(d) Draw the detailing of the slabs.

(3 marks)

Q3 Referring to **Figure Q1** and based on the information given in **Q1.** Beam 2/A-B of 250 mm x 650 mm is a simply supported flanged beam.

(a) Determine the effective width of beam 2/A-B.

(6 marks)

(b) Calculate the design action on beam 2/A-B.

(6 marks)

(c) Analyze beam 2/A-B to get the maximum bending moment and shear force.

(4 marks)

(d) Design all main reinforcement for beam 2/A-B. Use nominal concrete cover 30 mm, diameter of main reinforcement 20 mm and diameter of link 10 mm.

(8 marks)

(e) Check deflection of beam 2/A-B.

(6 marks)

- END OF QUESTIONS-

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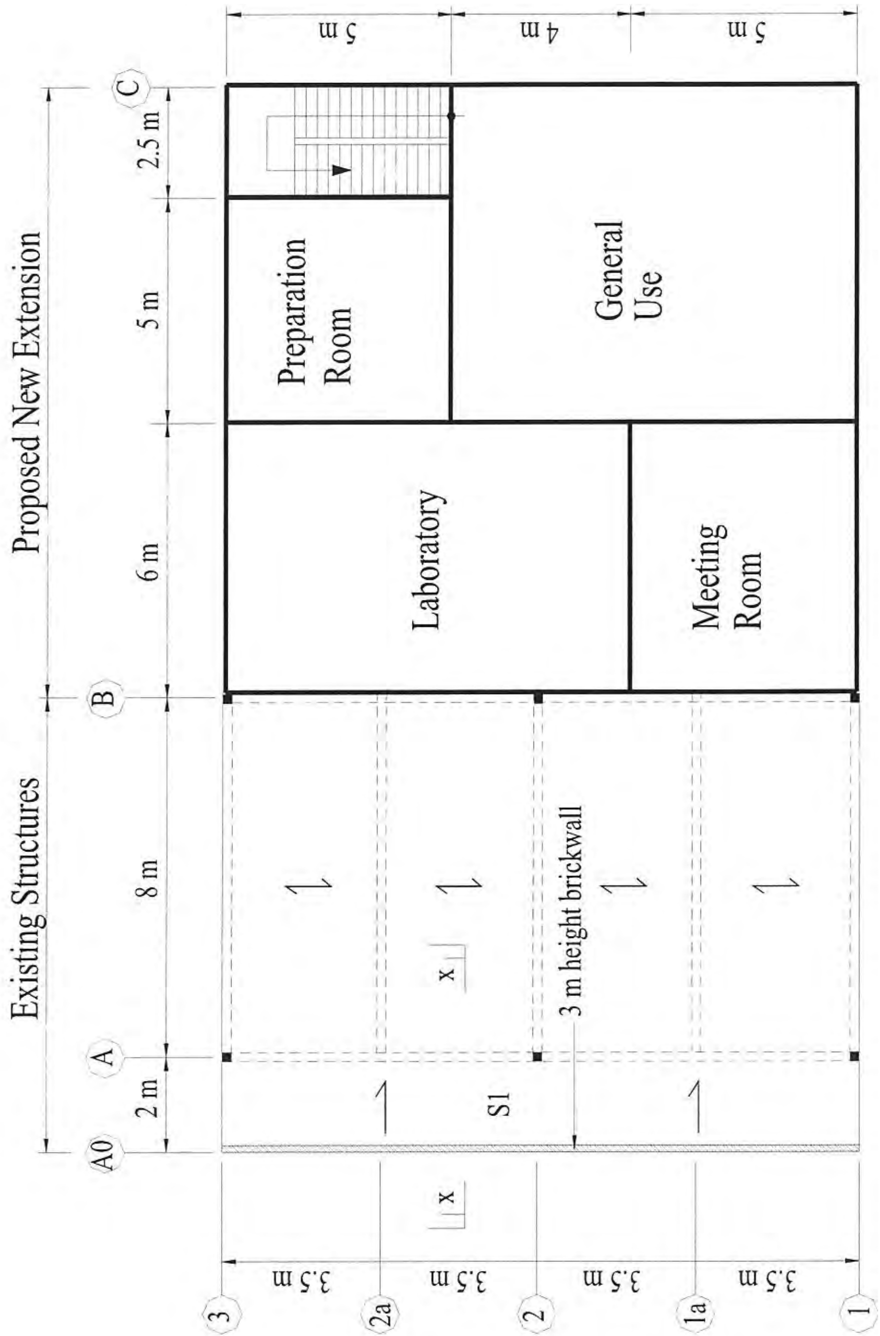

FIGURE Q1

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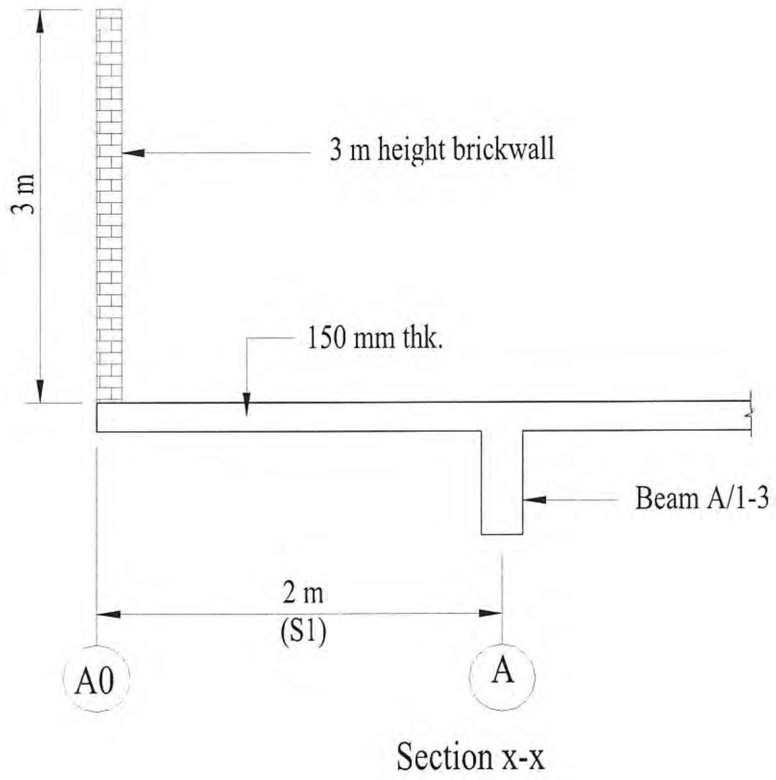

FIGURE Q2

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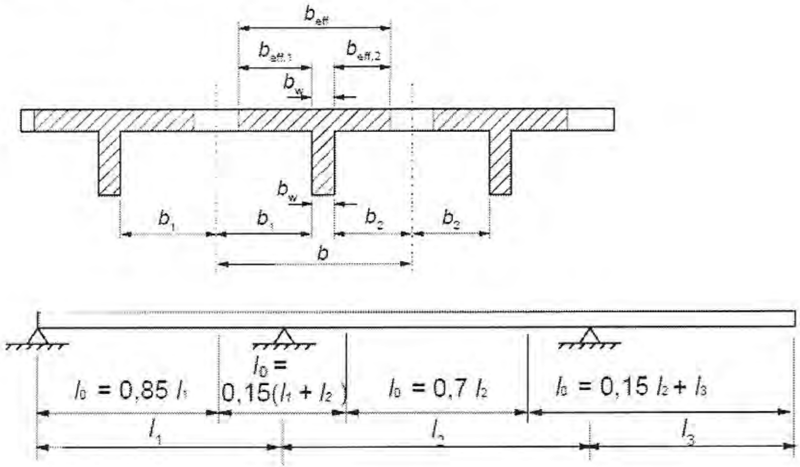
APPENDIX

1. Effective Width of Flanged Beam (b_{eff})



$$b_{eff} = \sum b_{eff,i} + b_w \leq b$$

where

$$b_{eff,i} = 0{,}2b_i + 0{,}1l_0 \leq 0{,}2l_0$$

and

$$b_{eff,i} \leq b_i$$

For simply supported beam, $l_o = 1.0l$

2. Minimum Area of Reinforcement

$$A_{s,min} = 0{,}26 \frac{f_{ctm}}{f_{yk}} b_t d \quad \text{but not less than } 0{,}0013 b_t d \qquad (9.1N)$$

Where:

b_t denotes the mean width of the tension zone; for a T-beam with the flange in compression, only the width of the web is taken into account in calculating the value of b_t.

3. Cracking / Maximum Spacing of Reinforcement for Slabs Not Exceeding 200 mm Thick

Principal / main reinforcement	$\leq$	3h or 400 mm whichever is the lesser
Secondary reinforcement	$\leq$	3.5h or 450 mm whichever is the lesser

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4. Equation for Flanged Beam Design

1. Calculate $M_f = 0.567 f_{ck}\, b h_f (d - 0.5h_f)$

2. If $M \leq M_f$, neutral axis in the flange

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

   ii. $z = d\{0.5 + \sqrt{(0.25 - K / 1.134)}\} \leq 0.95d$

   iii. $A_s = M / 0.87 f_{yk}\, z$

3. If $M > M_f$, neutral axis in the web

   i. Calculate $\beta_f = 0.167 \frac{b_w}{b} + 0.567 \frac{h_f}{d}\left(1 - \frac{b_w}{b}\right)\left(1 - \frac{h_f}{2d}\right)$

   ii. Calculate $M_{bal} = \beta_f\, f_{ck} b d^2$

   iii. Compare M and M_{bal}

4. If $M \leq M_{bal}$, compression reinforcement is not required.

   i. $A_s = \dfrac{M + 0.1 f_{ck} b_w d (0.36d - h_f)}{0.87 f_{yk} (d - 0.5h_f)}$

5. If $M > M_{bal}$, compression reinforcement is required.

   i. $A_s' = \dfrac{(M - M_{bal})}{0.87 f_{yk} (d - d')}$

   ii. $A_s = \dfrac{0.167 f_{ck} b_w d + 0.567 f_{ck} h_f (b - b_w)}{0.87 f_{yk}} + A_s'$

5. Design of Flexural Reinforcement (Rectangular Section)

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

If $K \leq K_{bal}$ (= 0.167), compression reinforcement is not required, and

(a) $z = d\{0.5 + \sqrt{0.25 - k/1.134}\}$

(b) $A_s = M / 0.87 f_{yk} z$

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6. Design of Shear

Section Not Requiring Shear Reinforcement ($V_{Ed} < V_{Rd,c}$)

$$V_{Rd,c} = [0.12k(100\rho_1 f_{ck})^{1/3}]\, b_w d \quad \geq \quad [0.035k^{3/2} f_{ck}^{\ 1/2}]\, b_w d$$

where:

k = $[1 + (200/d)^{1/2}] \leq 2.0$ with d expressed in mm
ρ_1 = $(A_{s1}/b_w d) \leq 0.02$
A_{s1} = the area of tensile reinforcement that extends $\geq (l_{bd} + d)$ beyond the section considered
b_w = the smallest width of the section in tensile area (mm).

7. Deflection

$$\frac{l}{d} = K\left[11 + 1{,}5\sqrt{f_{ck}}\,\frac{\rho_0}{\rho} + 3{,}2\sqrt{f_{ck}}\left(\frac{\rho_0}{\rho} - 1\right)^{3/2}\right] \quad \text{if } \rho \leq \rho_0$$

$$\frac{l}{d} = K\left[11 + 1{,}5\sqrt{f_{ck}}\,\frac{\rho_0}{\rho - \rho'} + \frac{1}{12}\sqrt{f_{ck}}\sqrt{\frac{\rho'}{\rho_0}}\right] \quad \text{if } \rho > \rho_0$$

where:
l/d is the limit span/depth
K is the factor to take into account the different structural systems
ρ_0 is the reference reinforcement ratio = $10^{-3}\sqrt{f_{ck}}$
ρ is the required tension reinforcement ratio at mid-span to resist the moment due to the design loads (at support for cantilevers)
ρ' is the required compression reinforcement ratio at mid-span to resist the moment due to design loads (at support for cantilevers)
f_{ck} is in MPa units

For flanged sections where the ratio of the flange breadth to the rib breadth exceeds 3, the values of l/d given by Expression (7.16) should be multiplied by 0.8.

For beams and slabs, other than flat slabs, with spans exceeding 7 m, which support partitions liable to be damaged by excessive deflections, the values of l/d given by Expression (7.16) should be multiplied by 7 / l_{eff} (l_{eff} in metres, see 5.3.2.2 (1)).

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Table 7.4N: Basic ratios of span/effective depth for reinforced concrete members without axial compression

Structural System	K	Concrete highly stressed $\rho = 1,5\%$	Concrete lightly stressed $\rho = 0,5\%$
Simply supported beam, one- or two-way spanning simply supported slab	1,0	14	20
End span of continuous beam or one-way continuous slab or two-way spanning slab continuous over one long side	1,3	18	26
Interior span of beam or one way or two-way spanning slab	1,5	20	30
Slab supported on columns without beams (flat slab) (based on longer span)	1,2	17	24
Cantilever	0,4	6	8

Note 1: The values given have been chosen to be generally conservative and calculation may frequently show that thinner members are possible.
Note 2: For 2-way spanning slabs, the check should be carried out on the basis of the shorter span. For flat slabs the longer span should be taken.
Note 3: The limits given for flat slabs correspond to a less severe limitation than a mid-span deflection of span/250 relative to the columns. Experience has shown this to be satisfactory.

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8. Cross Sectional Area of Reinforcement

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