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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	STRUCTURAL ANALYSIS AND DESIGN
COURSE CODE	:	BNP 20803
PROGRAMME CODE	:	BNA/BNB/BNC
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 3. STUDENTS ARE PROHIBITED TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA **CLOSED BOOK**

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

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Q1 (a) Structures can be classified into two category which is statically determinate and statically indeterminate structure. Define a statically indeterminate structure.

(2 marks)

(b) By using the moment distribution method, determine the final moments at all joints for the beam shown in **Figure Q1(b)**. The Young's Modulus, E, is 200 kN/mm^2 and the second moment of area, I, is 5×10^6 mm^4 for all members of the beam.

(13 marks)

(c) Find the reaction at supports A, B, C and D.

(4 marks)

(d) Draw the shear force and the bending moment diagrams for the beam.

(6 marks)

Q2 (a) Composite action is achieved through the combination of concrete and steel reinforcement. Describe the properties of concrete and steel reinforcement that result in an economical structure.

(4 marks)

(b) **Figure Q2(b)** shows the plan view of slab-beam system in a building. As a result of ongoing construction works, both the beam and a part of the slab are required to function act as a pre-cast concrete slab. Given;

Slab thickness	=	200 mm
Beam size	=	250 mm x 500 mm
Finishes	=	1.0 kN/m^2
Ceiling	=	1.0 kN/m^2
Brick wall	=	2.6 kN/m^2 (3.0 m height)
Chac. variable action, q_k	=	3.0 kN/m^2
Chac. strength of concrete, f_{ck}	=	30 N/mm^2
Chac. strength of steel, f_{yk}	=	500 N/mm^2

(i) Sketch the action distribution on the beam from each slab

(3 marks)

(ii) Referring to the simply supported beam B/1-2, determine the design action act on beam.

(12 marks)

(iii) Determine the maximum shear force and bending moment.

(6 marks)

Q3 (a) An interior one-way slab has an effective span of 4 m. The provided steel area is 503 mm^2 with the characteristic strength of 500 N/mm^2. Additionally, the concrete has a characteristic strength of 30 N/mm^2. Determine the service variable action (q_k) in kN/m^2 that the slab can support. Consider a nominal cover = 30 mm, slab thickness = 175 mm and the permanent load (excluding self-weight) = 1.5 kN/m^2.

(7 marks)

(b) **Figure Q3(b)** shows an interior two-way slab with a thickness of 175 mm and nominal cover of 25 mm. The bending moments and shear forces as tabulated in **Table Q3(b)** were calculated using the design action, η_d of 18.90 kN/m. The characteristic strength of concrete and steel reinforcement are 25 MPa and 500 MPa, respectively. Based on the information given,

(i) Design the steel reinforcement at the mid-short span.

(6 marks)

(ii) Check the shear capacity of the slab.

(5 marks)

(iii) Check the deflection of the slab.

(5 marks)

(c) If all four edges of the slab are discontinuous, describe the changes on the analysis and design of the slab.

(2 marks)

Q4 (a) **Figure Q4(a)** shown the I beam cross section. The chosen section is made of grade S275 steel and has two flanges measuring 189.9 mm × 12.7 mm each, along with a web of 453.4 mm× 8.5 mm. The weld size presented by the leg length s, is 6.0 mm. Classify the cross-section.

(6 marks)

(b) A steel member shown in **Figure Q4(b)** needs to be designed to carry combined bending and axial load. With the presence of a major axis (y-y) bending moment and an axial force of 300kN, please determine the cross-section classification of a 406×178UB54 in grade S275 steel.

(6 marks)

(c) In your own words, please explain **SIX (6)** advantages by using steel structure in construction compared to reinforced concrete structure.

(6 marks)

(d) By thinking out of the box, please explain how steel structure can save money in the construction industry.

(7 marks)

-END OF QUESTIONS -

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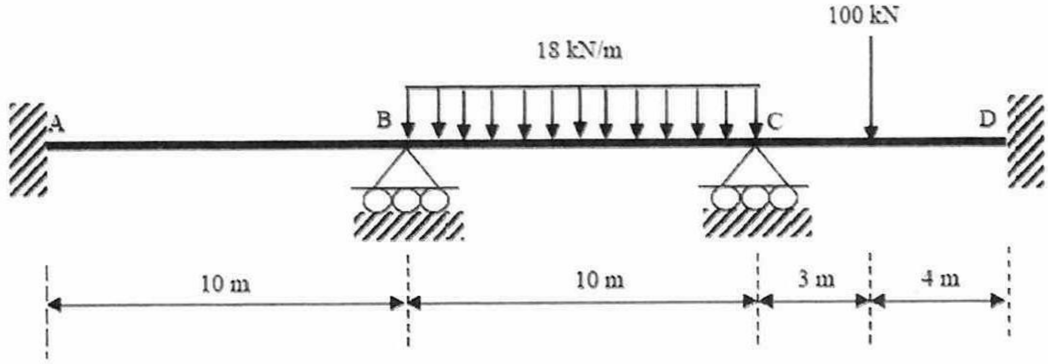

Figure Q1(b)

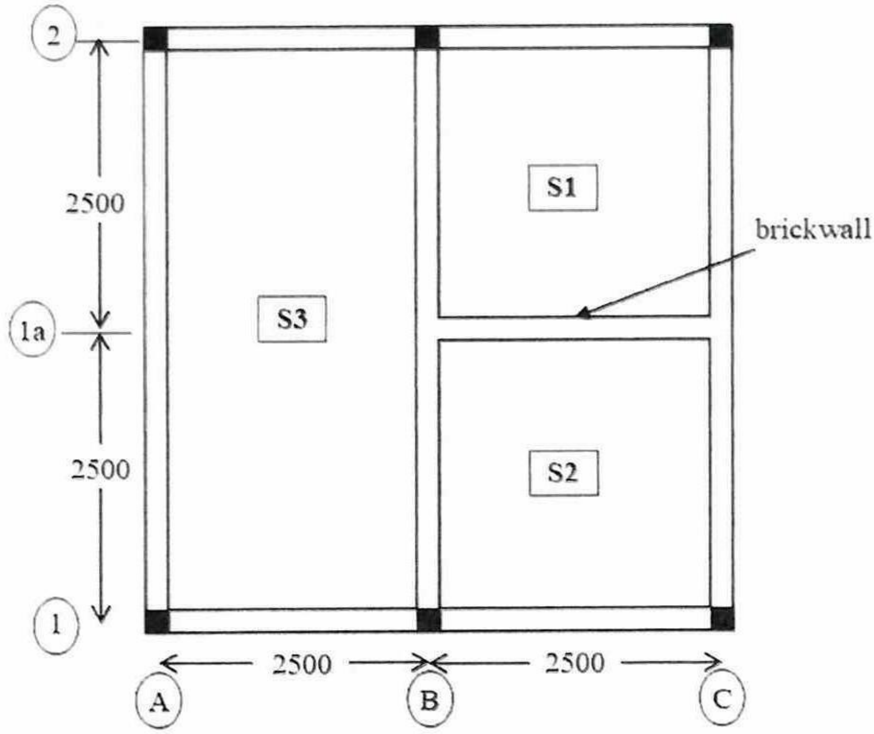

Figure Q2(b)

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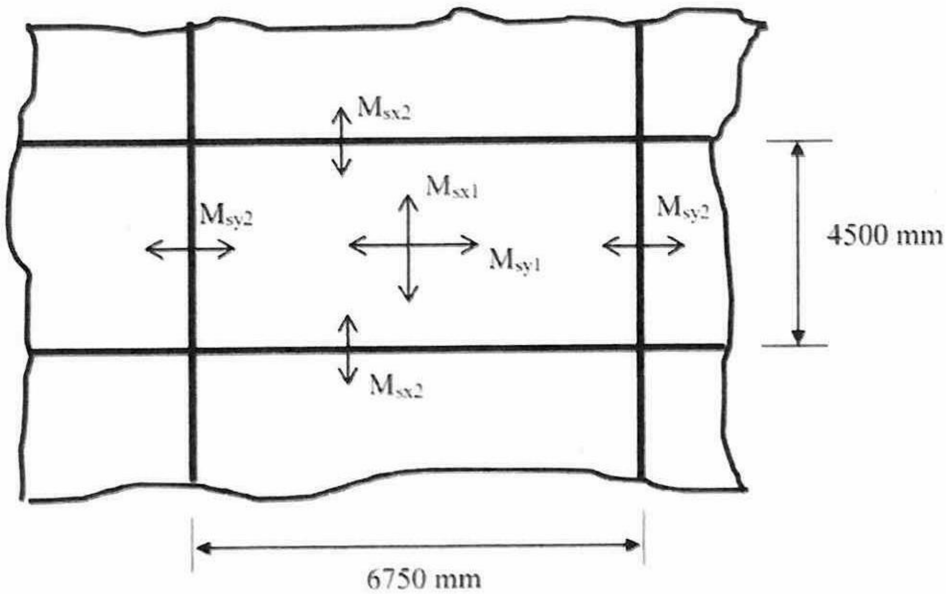

Figure Q3(b)

Table Q3(b)

Location	Bending Moment (kNm/m)	Shear Force (kN/m)	As required (mm^2/m)	Bar provided
Midspan (short span)	Not specified	-	Not specified	H10 – 300 (bot)
Support (short span)	20.20	38.27	337	H10 – 200 (top)
Midspan (long span)	9.10	-	163	H10 – 350 (bot)
Support (long span)	12.25	28.07	220	H10 – 300 (top)

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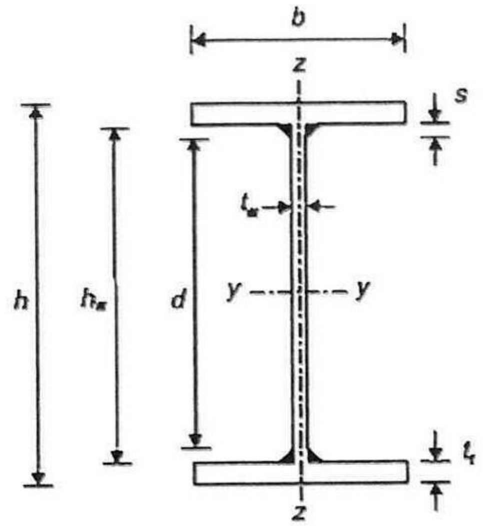

b	= 189.9 mm
t_f	= 12.7 mm
h_w	= 428 mm
h	= 453 mm
t_w	= 8.5 mm
s	= 5.1 mm

Figure Q4(a)

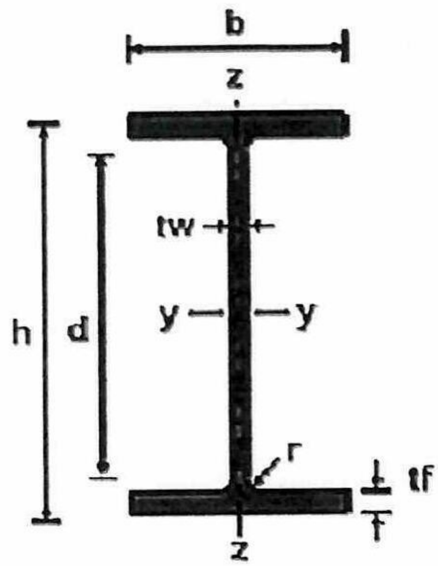

Figure Q4(b)

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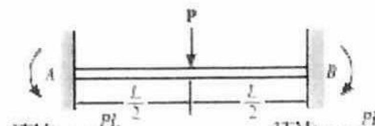
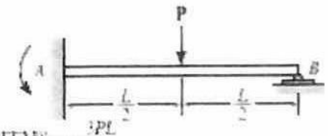
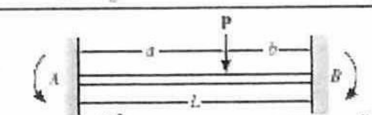
APPENDIX A



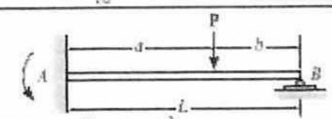
$(FEM)_{AB} = \frac{PL}{8}$ $(FEM)_{BA} = \frac{PL}{8}$



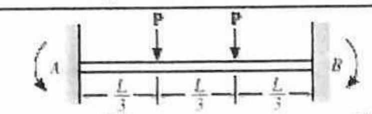
$(FEM)'_{AB} = \frac{3PL}{16}$



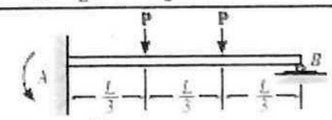
$(FEM)_{AB} = \frac{Pb^2a}{L^2}$ $(FEM)_{BA} = \frac{Pa^2b}{L^2}$



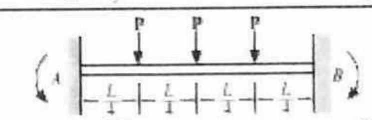
$(FEM)'_{AB} = (\frac{P}{L^2})(b^2a + \frac{a^2b}{2})$



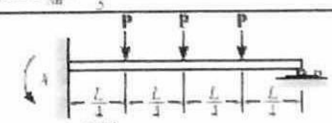
$(FEM)_{AB} = \frac{2PL}{9}$ $(FEM)_{BA} = \frac{2PL}{9}$



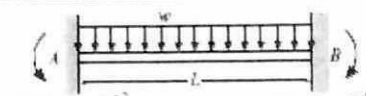
$(FEM)'_{AB} = \frac{PL}{3}$



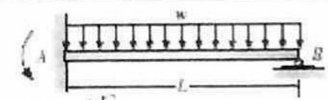
$(FEM)_{AB} = \frac{5PL}{16}$ $(FEM)_{BA} = \frac{5PL}{16}$



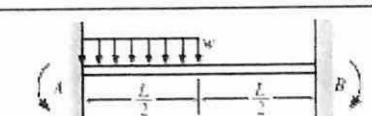
$(FEM)'_{AB} = \frac{45PL}{96}$



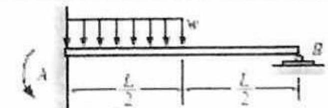
$(FEM)_{AB} = \frac{wL^2}{12}$ $(FEM)_{BA} = \frac{wL^2}{12}$



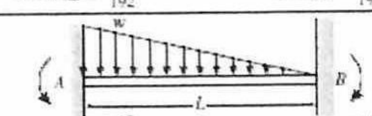
$(FEM)'_{AB} = \frac{wL^2}{8}$



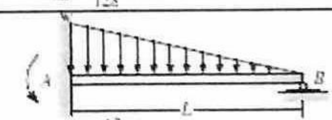
$(FEM)_{AB} = \frac{11wL^2}{192}$ $(FEM)_{BA} = \frac{5wL^2}{192}$



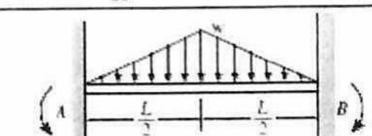
$(FEM)'_{AB} = \frac{9wL^2}{128}$



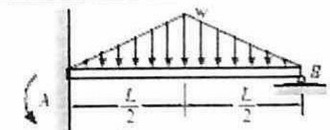
$(FEM)_{AB} = \frac{wL^2}{20}$ $(FEM)_{BA} = \frac{wL^2}{30}$



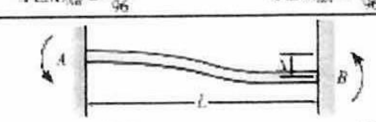
$(FEM)'_{AB} = \frac{wL^2}{15}$



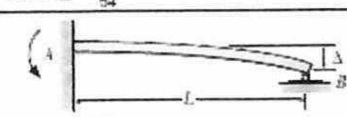
$(FEM)_{AB} = \frac{5wL^2}{96}$ $(FEM)_{BA} = \frac{5wL^2}{96}$



$(FEM)'_{AB} = \frac{5wL^2}{64}$



$(FEM)_{AB} = \frac{6EI\Delta}{L^2}$ $(FEM)_{BA} = \frac{6EI\Delta}{L^2}$



$(FEM)'_{AB} = \frac{3EI\Delta}{L^2}$

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APPENDIX B

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

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APPENDIX C

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