



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

DESIGN OF STRUCTURES I

ECW3103

Examination Paper

June 2024

This examination paper consists of 6 pages

Time Allowed: 4 hours

Total Marks: 100

Special Requirements: NONE

Examiner's Name: Dr. Eng. K Mushunje

INSTRUCTIONS

1. Answer ALL questions
2. Each question carries marks as shown
3. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	15
2.	20
3.	35
4.	30
TOTAL	100

QUESTION 1

The design of structures aims to produce a structure which will perform satisfactorily during its design life.

- (a) STATE the three main design philosophies used in design of structures.
(b) EXPLAIN how each of the design philosophies stated in (a) is applied in design in order to increase the margin of safety in structures. [15]

QUESTION 2

- (a) A 200 mm thick reinforced concrete mezzanine floor slab is simply supported on beams and columns as shown in Figure 2.1.

- The floor has to carry an Imposed load of 5 kN/m^2 .
- The weight of concrete may be taken as 2400 kg/m^3 .
- The beams weigh 120 kg/m
- The columns weigh 100 kg/m

Based on the permissible design method, calculate the total design load on:

- (i) Slab between Beam A and Beam B, including self weight
(ii) Beam C, including self weight
(iii) Column 1, including self weight [20]

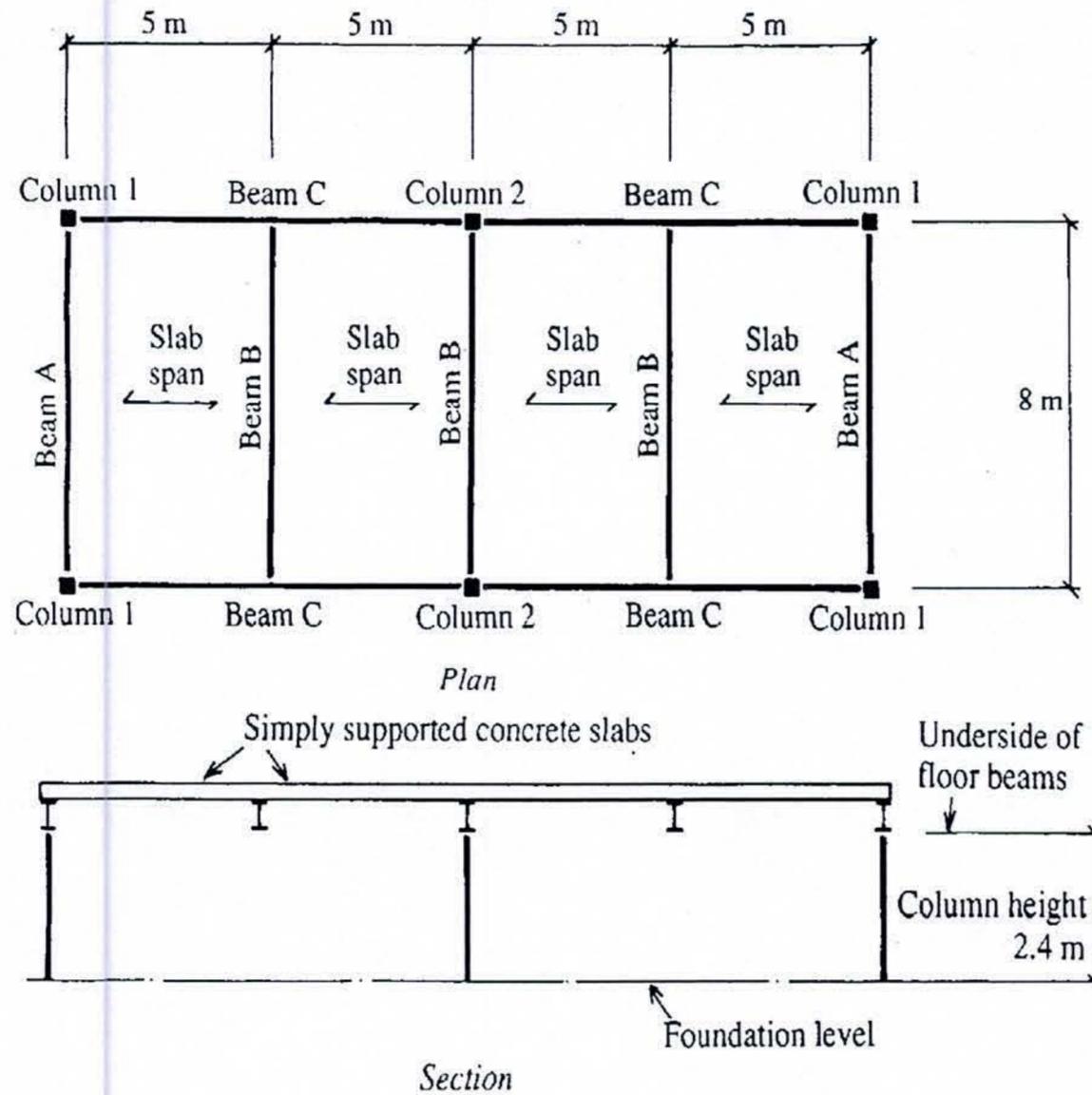


Figure 2.1

QUESTION 3

Design the joists of a timber floor carrying the following loads

- Flooring is tongue and groove 0.05 kN/m^2
- Self-weight of joist 0.10 kN/m^2
- Imposed load (Long term) 2.50 kN/m^2

Assume the following:

Strength Class of timber - C 16;

Modulus of Elasticity, E_{\min} = 5800 N/mm^2

Modulus of Elasticity, E_{mean} = 8800 N/mm^2

Shear stress parallel to grain = 0.67 N/mm^2

Bending stress parallel to grain = 5.3 N/mm^2

Compression perpendicular to grain = 1.7 N/mm^2

Span of Joist = 4.8 m (centre to centre span)

Joists spacing = 400 mm c/c

Bearing length = 115 mm

Perform ALL the necessary checks for to ascertain adequacy of the selected section

[35]

QUESTION 4

- a) Design a suitable grade S275 UC column (C1) 4.5 metres high in a building with shear walls connected to Universal Beams on its flange and web and also supports a vertical concentric load of 150 kN dead and 250kN imposed as shown in Figure 2.1. The connection result in an overall concentric loading. [20]

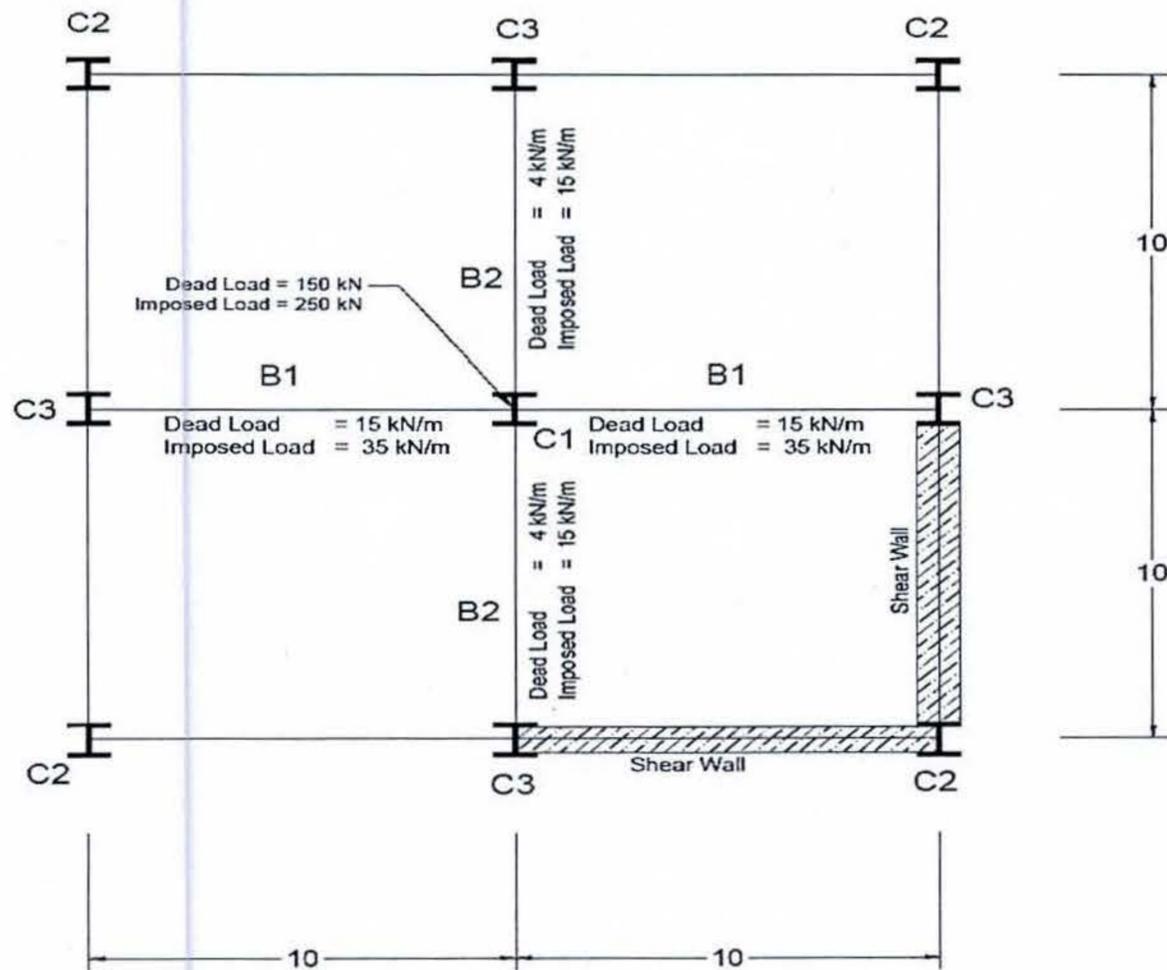


Figure 2.1

- b) Design a suitable slab baseplate for the column section designed in (a) if the foundation is formed from grade 35 concrete. [10]

Geometrical properties of sawn softwoods

Customary target size*	Area 10^3mm^2	Section Modulus		Second of moment area		Radius of gyration	
		About x-x 10^3mm^3	About y-y 10^3mm^3	About x-x 10^6mm^4	About y-y 10^6mm^4	About x-x mm	About y-y mm
22 × 100	2.20	36.6	8.1	1.83	0.089	28.9	6.35
38 × 100	3.80	63.3	24.1	3.17	0.457	28.9	11.0
38 × 150	5.70	143	36.1	10.7	0.686	43.3	11.0
38 × 175	6.54	194	42.1	17.0	0.800	50.5	11.0
38 × 200	7.60	253	48.1	25.3	0.915	57.7	11.0
38 × 225	8.55	321	54.2	36.1	1.03	65.0	11.0
47 × 75	3.53	44.1	27.6	1.65	0.649	21.7	13.6
47 × 100	4.70	78.3	36.8	3.92	0.865	28.9	13.6
47 × 125	5.88	122	46.0	7.65	1.08	36.1	13.6
47 × 150	7.05	176	55.2	13.2	1.30	43.3	13.6
47 × 175	8.23	240	64.4	21.0	1.51	50.5	13.6
47 × 200	9.40	313	73.6	31.3	1.73	57.7	13.6
47 × 225	10.6	397	82.8	44.6	1.95	65.0	13.6
47 × 250	11.8	490	92.0	61.2	2.16	72.2	13.6
47 × 300	14.1	705	110	106	2.60	86.6	13.6
63 × 150	9.45	236	99.2	17.7	3.13	43.3	18.2
63 × 175	11.0	322	116	28.1	3.65	50.5	18.2
63 × 200	12.6	420	132	42.0	4.17	57.7	18.2
63 × 225	14.2	532	149	59.8	4.69	65.0	18.2
75 × 100	7.50	125	93.8	6.25	3.52	28.9	21.7
75 × 150	11.3	281	141	21.1	5.27	43.3	21.7
75 × 175	13.1	383	164	33.5	6.15	50.5	21.7
75 × 200	15.0	500	188	50.0	7.03	57.7	21.7
75 × 225	16.9	633	211	71.2	7.91	65.0	21.7
75 × 250	18.8	781	234	97.7	8.79	72.2	21.7
75 × 300	22.5	1130	281	169	10.5	86.6	21.7
100 × 100	10.0	167	167	8.33	8.33	28.9	28.9
100 × 150	15.0	375	250	28.1	12.5	43.3	28.9
100 × 200	20.0	667	333	66.7	16.7	57.7	28.9
100 × 225	22.5	844	375	94.9	18.8	65.0	28.9
100 × 250	25.0	1010	417	130	20.8	72.2	28.9
100 × 300	30.0	1500	500	225	25.0	86.6	28.9
150 × 150	20.0	563	563	42.2	42.2	43.3	43.3
150 × 300	30.0	2250	1130	338	84.4	86.6	43.3
300 × 300	90.0	4500	4500	675	675	86.6	86.6

	Dimensions										Properties											
Designation	Depth of section	Width of section	Thickness		Root radius	Depth between fillets	Ratios for local buckling		Second moment of area		Radius of gyration		Elastic modulus		Plastic modulus		Buckling parameter	Torsional index	Warping constant	Torsional constant	Area of section	
Serial size	Mass per metre	D	B	t	T	r	d	Flange b/T	Web d/t	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	u	x	H	J	A
(mm)	(kg)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)	(cm ³)	(cm ³)			(dm ⁶)	(cm ⁴)	(cm ²)
356x406	634	474.7	424.1	47.6	77.0	15.2	290.2	2.75	6.10	275 000	98 200	18.5	11.0	11 600	4630	14 200	7110	0.843	5.46	38.8	13 700	808
	551	455.7	418.5	42.0	67.5	15.2	290.2	3.10	6.91	227 000	82 700	18.0	10.9	9 960	3950	12 100	6060	0.841	6.05	31.1	9 240	702
	467	436.6	412.4	35.9	58.0	15.2	290.2	3.56	8.08	183 000	67 900	17.5	10.7	8 390	3290	10 000	5040	0.839	6.86	24.3	5 820	595
	393	419.1	407.0	30.6	49.2	15.2	290.2	4.14	9.48	14 700	55 400	17.1	10.5	7 000	2720	8 230	4160	0.837	7.86	19.0	3 550	501
	340	406.4	403.0	26.5	42.9	15.2	290.2	4.70	11.0	12 200	46 800	16.8	10.4	6 030	2320	6 990	3540	0.836	8.85	15.5	2 340	433
	287	393.7	399.0	22.6	36.5	15.2	290.2	5.47	12.8	100 000	38 700	16.5	10.3	5 080	1940	5 820	2950	0.835	10.2	12.3	1 440	366
	235	381.0	395.0	18.5	30.2	15.2	290.2	6.54	15.7	79 100	31 000	16.2	10.2	4 150	1570	4 690	2380	0.834	12.1	9.54	812	300
	COLCORE 477	427.0	424.4	48.0	53.2	15.2	290.2	3.99	6.05	172 000	68 100	16.8	10.6	8 080	3210	9 700	4980	0.815	6.91	23.8	5 700	607
356x368	202	374.7	374.4	16.8	27.0	15.2	290.2	6.93	17.3	66 300	23 600	16.0	9.57	3 540	1260	3 980	1920	0.844	13.3	7.14	560	258
	177	368.3	372.1	14.5	23.8	15.2	290.2	7.82	20.0	57 200	20 500	15.9	9.52	3 100	1100	3 460	1670	0.844	15.0	6.07	383	226
	153	362.0	370.2	12.6	20.7	15.2	290.2	8.94	23.0	48 500	17 500	15.8	9.46	2 680	944	2 960	1430	0.844	17.0	5.09	251	195
305x305	129	355.6	368.3	10.7	17.5	15.2	290.2	10.5	27.1	40 200	14 600	15.6	9.39	2 260	790	2 480	1200	0.843	19.9	4.16	153	165
	283	365.3	321.8	26.9	44.1	15.2	246.6	3.65	9.17	78 800	24 500	14.8	8.25	4 310	1530	5 100	2340	0.855	7.65	6.33	2 030	360
	240	352.6	317.9	23.0	37.7	15.2	246.6	4.22	10.7	64 200	20 200	14.5	8.14	3 640	1270	4 250	1950	0.854	8.73	5.01	1 270	306
	198	339.9	314.1	19.2	31.4	15.2	246.6	5.00	12.8	50 800	16 200	14.2	8.02	2 990	1030	3 440	1580	0.854	10.2	3.86	734	252
	158	327.2	310.6	15.7	25.0	15.2	246.6	6.21	15.7	38 700	12 500	13.9	7.89	2 370	806	2 680	1230	0.852	12.5	2.86	379	201
	137	320.5	308.7	13.8	21.7	15.2	246.6	7.11	17.9	32 800	10 700	13.7	7.82	2 050	691	2 300	1050	0.851	14.1	2.38	250	175
	118	314.5	306.8	11.9	18.7	15.2	246.6	8.20	20.7	27 600	9 010	13.6	7.75	1 760	587	1 950	892	0.851	16.2	1.97	160	150
254x254	97	307.8	304.8	9.9	15.4	15.2	246.6	9.90	24.9	22 200	7 270	13.4	7.68	1 440	477	1 590	723	0.85	19.3	1.55	91.1	123
	167	289.1	264.5	19.2	31.7	12.7	200.3	4.17	10.4	29 900	9 800	11.9	6.79	2 070	741	2 420	1130	0.852	8.49	1.62	625	212
	132	276.4	261.0	15.6	25.3	12.7	200.3	5.16	12.8	22 600	7 520	11.6	6.67	1 630	576	1 870	879	0.85	10.3	1.18	322	169
	107	266.7	258.3	13.0	20.5	12.7	200.3	6.30	15.4	17 500	5 900	11.3	6.57	1 310	457	1 490	695	0.848	12.4	0.894	173	137
	89	260.4	255.9	10.5	17.3	12.7	200.3	7.40	19.1	14 300	4 850	11.2	6.52	1 100	379	1 230	575	0.849	14.4	0.716	104	114
203x203	73	254.0	254.0	8.6	14.2	12.7	200.3	8.94	23.3	11 400	3 870	11.1	6.46	894	305	989	462	0.849	17.3	0.557	57.3	92.9
	86	222.3	208.8	13.0	20.5	10.2	160.9	5.09	12.4	9 460	3 120	9.27	5.32	851	299	979	456	0.85	10.2	0.317	138	110
	71	215.9	206.2	10.3	17.3	10.2	160.9	5.96	15.6	7 650	2 540	9.16	5.28	708	246	802	374	0.852	11.9	0.25	81.5	91.1
	60	209.6	205.2	9.3	14.2	10.2	160.9	7.23	17.3	6 090	2 040	8.96	5.19	581	199	652	303	0.847	14.1	0.195	46.6	75.8
152x152	52	206.2	203.9	8.0	12.5	10.2	160.9	8.16	20.1	5 260	1 770	8.90	5.16	510	174	568	264	0.848	15.8	0.166	32.0	66.4
	46	203.2	203.2	7.3	11.0	10.2	160.9	9.24	22.0	4 560	1 540	8.81	5.11	449	151	497	230	0.846	17.7	0.142	22.2	58.8
	37	161.8	154.4	8.1	11.5	7.6	123.5	6.71	15.2	2 220	709	6.84	3.87	274	91.8	310	140	0.848	13.3	0.04	19.5	47.4
	30	157.5	152.9	6.6	9.4	7.6	123.5	8.13	18.7	1 740	558	6.75	3.82	221	73.1	247	111	0.848	16.0	0.0306	10.5	38.2
	23	152.4	152.4	6.1	6.8	7.6	123.5	11.2	20.2	1 260	403	6.51	3.68	166	52.9	184	80.9	0.837	20.4	0.0214	4.87	29.8