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2022/2023 SEMESTER 2

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS 2022/2023 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN BUILDING CONSTRUTION

COURSE CODE: BTB 316

COURSE TITLE: STRUCTURAL DESIGN I

DATE: 27TH APRIL 2023 **TIME:** 8:00 - 10:00

INSTRUCTIONS:

1. This paper contains FOUR questions
2. **Question ONE (1) is Compulsory**
3. **Attempt a total of THREE questions in this booklet.**
4. Marks for each question are indicated in the parenthesis.

Examination duration is **2 Hours**

Commented [MM1]: CHANGE ACCORDINGLY

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 3 Printed Pages. Please Turn Over.

Question 1 **COMPULSORY** **(30 marks)**

a) .Discuss the factors which influence the strength of timber and explain how the strength of timber is assessed in practice **(6 mks)**
b) List and discuss common modes of failure associated with steel beams and joists **(8 mks)**
c) Discuss the following design philosophies **(6 mks)**
   i. Limit State Design
   ii. Load factor Design
   iii. Permissible load Design

Question 2 **(20 marks)**

A timber column of redwood GS grade consists of a 100 mm square section which is restrained at both ends in position but not in direction. Assuming that the actual height of the column is 3.75 m,

a) Calculate the maximum axial long-term load that the column can support. **(10 mks)**
b) Check the adequacy of the column to resist a long-term axial load of 10 kN and a bending moment of 350 kN mm. **(10 mks)**

Question 3 **(20 marks)**

A timber beam with a clear span of 3.2m supports a uniformly distributed load of 10 kN including self-weight of beam. Determine a suitable section for the beam using timber of strength class C16 under service class 1. Assume that the bearing length is 150mm and that the ends of the beam are held in position and compression edge held in line. **(20 mks)**

Question 4 **(20 marks)**

A simply supported beam in Fig. Q4 supports uniformly distributed characteristic dead and imposed loads of 5 kN/m each, as well as a characteristic imposed point load of 30 kN at mid-span. Assuming the beam is fully laterally restrained and there is nominal torsional restrain at supports, select a suitable UB section in S275 steel to satisfy bending and shear considerations. **(20 mks)**

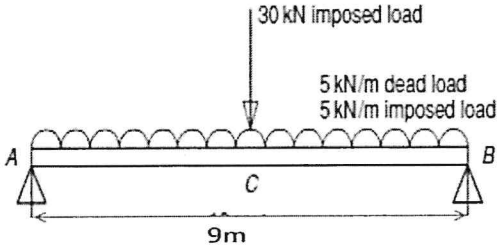


Fig Q4

Useful Information

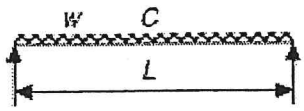
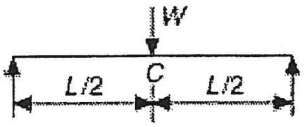
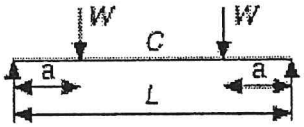
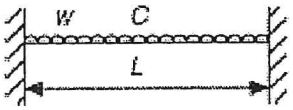
Load distribution and supports	*Deflection at Centre C or end E*	
	Bending	*Shear*
	$\frac{5}{384} \times \frac{wL^4}{EI}$	$\frac{12}{5} \times \frac{wL^2}{EA}$
	$\frac{WL^3}{48EI}$	$\frac{24}{5} \times \frac{WL}{EA}$
	$\frac{Wa}{EI}\left[\frac{L^2}{8} - \frac{a^2}{6}\right]$	$\frac{96}{5} \times \frac{Wa}{EA}$
	$\frac{wL^3}{384EI}$	$\frac{12}{5} \times \frac{wL^2}{EA}$

Table B1 Dimensions and properties of steel universal beams (structural sections to BS 4: Part 1)

Designation		*Dimensions*								*Properties*													
		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*	*Web*	*Flange*	*r*	*d*	*Flange bT*	*Web dt*	*Axis x-x*	*Axis y-y*	*Axis x-x*	*Axis y-y*	*Axis x-x*	*Axis y-y*	*Axis x-x*	*Axis y-y*					
(mm)	*(kg)*	*(mm)*	*(mm)*	*t (mm)*	*T (mm)*	*(mm)*	*(mm)*			*(cm⁴)*	*(cm⁴)*	*(cm)*	*(cm)*	*(cm³)*	*(cm³)*	*(cm³)*	*(cm³)*	*u*	*x*	*H (dm⁶)*	*J (cm⁴)*	*A (cm²)*
914×419	388	920.5	420.5	21.5	36.6	24.1	790.1	5.74	37.2	719 000	35 400	38.1	9.58	15 600	2460	17 700	3 540	0.884	26.7	88.7	1 730	494
	343	911.4	418.5	19.4	32.0	24.1	790.1	6.54	41.2	625 000	30 200	37.8	9.46	13 700	1870	15 500	2 890	0.885	30.1	75.7	1 100	437
914×305	289	926.6	307.8	19.6	32.0	19.1	824.5	4.81	42.1	505 000	15 600	37.0	6.51	10 900	1010	12 600	1 600	0.867	31.9	31.2	929	369
	253	918.5	305.5	17.3	27.9	19.1	824.5	5.47	47.7	437 000	13 500	36.8	6.42	9 510	872	10 900	1 370	0.866	36.2	25.4	627	323
	224	918.3	304.1	15.9	23.9	19.1	824.5	6.36	51.9	376 000	11 200	36.3	6.37	8 160	738	9 520	1 160	0.863	41.3	22.0	421	285
	201	903.0	303.4	15.2	20.2	19.1	824.5	7.51	54.2	326 000	9 430	35.6	6.06	7 210	621	8 360	983	0.853	46.8	18.4	295	256
838×292	226	850.9	293.8	16.1	26.8	17.8	761.7	5.48	47.3	340 000	11 400	34.5	6.27	7 990	773	9 160	1 210	0.87	35.0	19.3	514	289
	194	840.7	292.4	14.7	21.7	17.8	761.7	6.74	51.8	279 000	9 070	33.6	6.06	6 650	620	7 650	974	0.862	41.6	15.2	307	247
	176	834.9	291.6	14.0	18.8	17.8	761.7	7.76	54.4	246 000	7 790	33.1	5.90	5 890	534	6 816	842	0.856	46.5	13.0	222	224
762×267	197	769.6	268.0	15.6	25.4	16.5	685.8	5.28	44.0	240 000	8 170	30.9	5.71	6 230	610	7 170	959	0.869	35.2	11.5	405	251
	173	762.0	266.7	14.3	21.6	16.5	685.8	6.17	48.0	205 000	6 850	30.5	5.57	5 390	513	6 300	807	0.864	38.1	9.38	267	220
	147	753.9	265.3	12.9	17.5	16.5	685.8	7.58	53.2	169 000	5 470	30.0	5.39	4 480	412	5 376	646	0.857	45.1	7.41	161	188
686×254	170	692.9	255.8	14.5	23.7	15.2	615.1	5.40	42.4	170 000	6 620	28.8	5.53	4 910	518	5 620	810	0.872	31.8	7.41	307	217
	152	687.6	254.5	13.2	21.0	15.2	615.1	6.06	46.6	150 000	5 780	27.8	5.46	4 370	454	5 008	710	0.873	35.5	6.42	219	194
	140	683.5	253.7	12.4	19.0	15.2	615.1	6.68	49.6	136 000	5 180	27.6	5.38	3 990	408	4 568	638	0.868	38.7	5.72	169	179
	125	677.9	253.0	11.7	16.2	15.2	615.1	7.81	52.6	118 000	4 380	27.2	5.21	3 480	346	4 030	542	0.862	45.9	4.39	116	160
610×305	238	633.0	311.5	18.6	31.4	16.5	537.2	4.96	28.9	208 000	15 800	26.1	7.22	6 560	1020	7 450	1 570	0.886	21.1	14.3	768	304
	179	617.5	307.0	14.1	23.6	16.5	537.2	6.50	38.1	15 200	11 400	25.8	7.08	4 910	743	5 520	1 140	0.886	27.5	10.1	341	228
	149	609.6	304.8	11.9	19.7	16.5	537.2	7.74	45.1	125 000	9 300	25.6	6.99	4 090	610	4 578	937	0.886	32.5	8.00	203	190
610×229	140	617.0	230.1	13.1	22.1	12.7	547.3	5.21	41.8	112 000	4 510	25.0	5.85	3 630	392	4 150	612	0.875	30.5	3.99	237	178
	125	611.9	229.0	11.9	19.6	12.7	547.3	5.84	46.0	98 600	3 930	24.9	4.96	3 220	344	3 680	536	0.873	34.6	3.45	155	160
	113	607.3	228.2	11.2	17.3	12.7	547.3	6.60	48.9	87 400	3 440	24.6	4.88	2 880	301	3 290	470	0.87	37.9	2.99	132	144
	101	602.2	227.6	10.6	14.8	12.7	547.3	7.69	51.6	75 700	2 910	24.2	4.75	2 510	256	2 860	400	0.863	43.6	2.51	77.2	129
533×210	122	544.6	211.9	12.8	21.3	12.7	476.5	4.97	37.2	76 200	3 390	22.1	4.67	2 800	320	3 200	501	0.876	27.6	2.32	180	156
	109	539.5	210.7	11.6	18.8	12.7	476.5	5.66	41.1	66 700	2 940	21.9	4.60	2 470	279	2 820	435	0.875	30.9	1.99	126	139
	101	536.7	210.1	10.9	17.4	12.7	476.5	6.04	43.7	61 700	2 690	21.8	4.56	2 300	257	2 620	400	0.874	33.1	1.82	102	129
	92	533.1	209.3	10.2	15.6	12.7	476.5	6.71	46.7	55 400	2 390	21.7	4.51	2 080	229	2 370	356	0.872	36.4	1.68	76.2	118
	82	528.3	208.7	9.6	13.2	12.7	476.5	7.91	49.6	47 500	2 010	21.5	4.38	1 800	192	2 060	300	0.865	41.6	1.33	51.3	104
457×191	98	467.4	192.8	11.4	19.6	10.2	407.9	4.92	35.8	45 700	2 340	19.1	4.33	1 960	243	2 230	378	0.88	25.8	1.17	121	125
	89	463.6	192.0	10.6	17.7	10.2	407.9	5.42	38.5	41 000	2 090	19.0	4.28	1 770	217	2 010	336	0.879	28.5	1.04	90.5	114
	82	460.2	191.3	9.9	16.0	10.2	407.9	5.98	41.2	37 100	1 870	18.8	4.23	1 610	196	1 830	304	0.877	30.9	0.923	69.2	105
	74	457.2	190.5	9.1	14.5	10.2	407.9	6.57	44.8	33 300	1 670	18.7	4.19	1 460	175	1 660	272	0.876	33.9	0.819	52.9	95.0
	67	453.6	189.9	8.5	12.7	10.2	407.9	7.48	48.0	29 400	1 450	18.5	4.12	1 300	153	1 470	233	0.873	37.9	0.706	37.1	85.4

Table B2 Dimensions and properties of steel universal columns (structural sections to BS 4: Part 1)

Designation		Dimensions						Properties												
				Thickness				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	Depth of section	Width of section	Web	Flange	Root radius	Depth between fillets	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)	D (mm)	B (mm)	t (mm)	T (mm)	r (mm)	d (mm)			(cm⁴)	(cm⁴)	(cm)	(cm)	(cm³)	(cm³)	(cm³)	(cm³)			(dm⁶)	(cm⁴)	(cm²)
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	18.9	10.9	9 960	3956	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	5048	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	144 000	55 400	17.1	10.5	7 000	2720	8 330	4168	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	119 000	46 800	16.8	10.4	5 850	2320	6 980	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	2958	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	2369	0.834	12.1	9.54	813	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	4960	0.815	6.91	23.8	5 740	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	1928	0.844	13.3	7.14	560	258
	177	368.5	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	1679	0.844	15.0	6.07	381	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
	129	355.6	368.3	10.7	17.5	15.2	290.2	10.5	27.1	40 250	14 600	15.6	9.39	2 260	790	2 480	1200	0.843	19.9	4.16	153	165
305x305	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	2343	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	1958	0.854	8.73	5.03	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	1238	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	2 360	1052	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	862	0.851	16.2	1.97	160	150
	97	307.8	304.2	9.8	15.4	15.2	246.6	9.90	24.9	22 200	7 270	13.4	7.68	1 440	477	1 590	725	0.85	19.3	1.55	98.1	125
254x254	167	289.1	264.5	19.2	31.7	12.7	200.3	4.17	10.4	29 000	9 800	11.8	6.79	2 010	741	2 420	1138	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	1.16	322	169
	107	266.7	258.5	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	0.736	104	114
	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
203x203	86	222.3	208.8	13.0	20.5	10.2	168.9	5.09	12.4	9 460	3 120	9.27	5.32	851	299	979	456	0.85	10.2	0.357	138	110
	71	215.9	206.2	10.3	17.3	10.2	168.9	5.96	15.6	7 650	2 540	9.16	5.28	708	246	802	374	0.852	11.9	0.25	81.5	91.3
	60	209.6	205.2	9.3	14.2	10.2	168.9	7.23	17.3	6 090	2 040	8.96	5.19	581	199	652	305	0.847	14.3	0.195	46.6	75.8
	52	206.2	203.9	8.0	12.5	10.2	168.9	8.16	20.1	5 260	1 770	8.98	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	168.9	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
152x152	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	10.5	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	0.0305	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

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