Name:_____ Index No._____

2707/302
STRUCTURES III
Oct./ Nov. 2014
Time: 3 hours

Candidate's Signature:_____

Date:_____

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN CIVIL ENGINEERING
MODULE III

STRUCTURES III

3 hours

INSTRUCTIONS TO CANDIDATES

Write your name and index number in the spaces provided above.
Sign and write the date of examination in the spaces provided above.
You should have a scientific calculator for this examination.
*This paper consists of **EIGHT** questions.*
*Answer **FIVE** questions in the spaces provided in this question paper.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Relevant design tables are attached.
Candidates should answer the questions in English.

For Examiner's Use Only

Question	1	2	3	4	5	6	7	8	TOTAL SCORE
Candidate's Score									

This paper consists of 16 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

Turn over

1. A beam ABC is built in at A and C and supported on rollers at B as shown in figure 1. Analyze the beam using the three moments theorem and draw the bending moment diagram indicating all critical values. (20 marks)

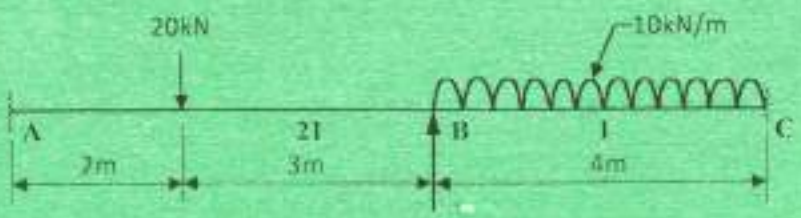


Fig. 1

2. Analyze the frame shown in figure 2 using the moment distribution method and hence sketch the bending moment diagram. (20 marks)

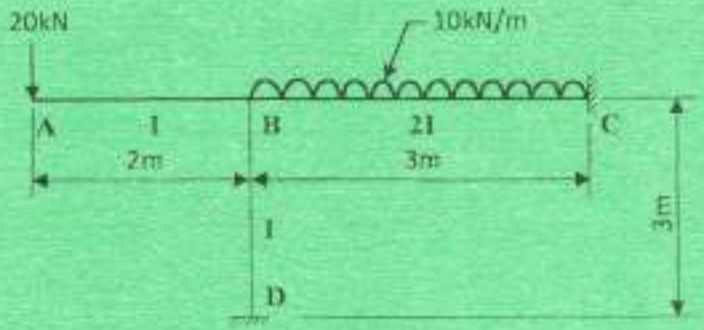


Fig. 2

3. A cantilever beam with effective length 1.5 m is built into a wall as shown in figure 3. It supports unfactored dead and imposed loads of 20 kN/m and 40 kN/m respectively. Select a suitable UB section in grade S275 (grade 43) steel to satisfy bending, shear and deflection criteria given that $E = 205\ kN/mm^2$, $P_y = 275\ N/mm^2$. (20 marks)

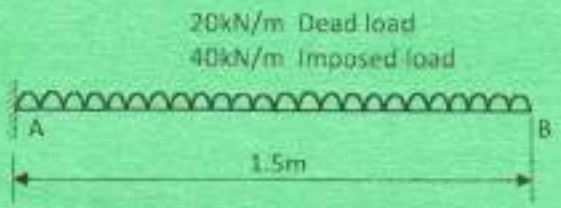


Fig. 3

4. A nailed timber joint is required to carry a long term axial load of 4 kN. The timber is softwood of strength class C16 (SC 3) and sized 50 x 150 mm.

(a) Determine the number of nails required and their spacings if 4.2 mm diameter, 90 mm long, round wire nails are used.

(b) Detail the joint.
Assume all modification factors are equal to 1.00. (20 marks)

5. Design a suitable encased steel column section in grade S275 steel to support a factored axial concentric load of 1200 kN and factored bending moments of 30 kN/m about the major axis and 10 kN/m about the minor axis, applied at the top of the column. Check for strut capacity and cross section capacity. Take the effective length of the column as 4 m. $f_u = 25N/mm^2$.

(20 marks)

6. A rectangular column carries a load P of 200 kN at an eccentricity of 30 mm to both principal axes as shown in figure 4.

(a) Calculate the stresses at each corner of the column;

(b) Determine the maximum eccentricity of the load from the X-X axis if the eccentricity about the Y-Y axis is maintained at 30 mm and if no tensile stresses are allowed to develop in the section.

(20 marks)

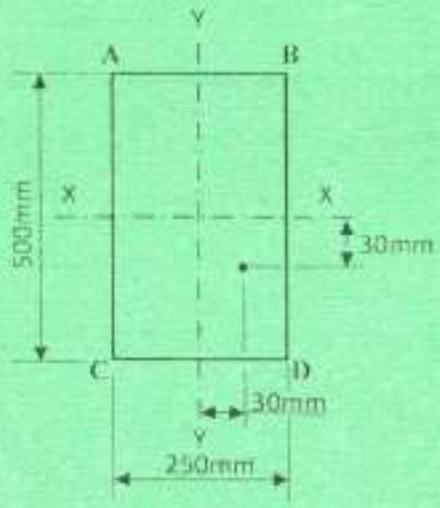


Fig. 4

7. (a) State **five** assumptions made in the analysis of pin-jointed columns and struts.

(5 marks)

(b) With the aid of a sketch, show that a pin-jointed strut, the Euler critical load is:

$$P_E = \frac{\pi^2 EI}{L^2}$$

(15 marks)

8. Figure 5 shows a simply supported beam.

(a) Sketch the influence line diagrams for the following load components:

(i) reaction at A;
(ii) shear at D;
(iii) bending moment at D.

(10 marks)

(b) If the beam is subjected to a single concentrated load of 10 kN and a uniform load of 4 kN/m spread over the entire span of the beam, determine the following values:

(i) maximum reaction at support A;
(ii) maximum shear at point D

(10 marks)

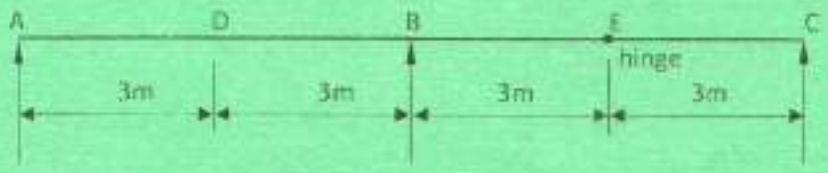
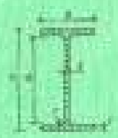


Fig. 5

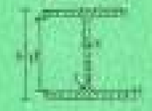
Universal beams – dimensions and properties



UB designation	Mass per metre	Depth of section D	Width of section B	Thickness Web t	Thickness Flange T	Root radius r	Depth between fillets d	Ratios for local buckling Flange b/T	Ratios for local buckling Web d/t	Second moment of area Axis x-x I_x	Second moment of area Axis y-y I_y	D/T	Radius of gyration Axis x-x r_x	Radius of gyration Axis y-y r_y	Elastic modulus Axis x-x Z_x	Elastic modulus Axis y-y Z_y	Plastic modulus Axis x-x S_x	Plastic modulus Axis y-y S_y	Buckling parameter u	Torsional index x	Warping constant H	Torsional constant J	Area of section A
	kg/m	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
457 × 152 × 60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	5.75	50.3	25500	795	38	18.3	3.23	1122	104	1287	163	0.868	37.5	0.387	33.8	76.2
457 × 152 × 52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	6.99	53.6	21370	645	41	17.9	3.11	950	84.6	1096	133	0.859	43.9	0.311	21.4	66.6
406 × 178 × 74	74.2	412.8	179.5	9.5	16	10.2	360.4	5.61	37.9	27310	1545	26	17	4.04	1323	172	1501	267	0.882	27.6	0.608	62.8	94.5
406 × 178 × 67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41	24330	1365	29	16.9	3.99	1189	153	1346	237	0.88	30.5	0.533	46.1	85.5
406 × 178 × 60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	6.95	45.6	21600	1203	32	16.8	3.97	1063	135	1199	209	0.88	33.8	0.466	33.3	76.5
406 × 178 × 54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	46.8	18720	1021	37	16.5	3.85	930	115	1055	178	0.871	38.3	0.392	23.1	69
406 × 140 × 46	46	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53	15690	538	36	16.4	3.03	778	75.7	888	118	0.871	38.9	0.207	19	58.6
406 × 140 × 39	39	398	141.8	6.4	8.6	10.2	360.4	8.24	56.3	12510	410	46	15.9	2.87	629	57.8	724	90.8	0.858	47.5	0.155	10.7	49.7
356 × 171 × 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	19460	1362	23	15.1	3.99	1071	157	1211	243	0.886	24.4	0.412	55.7	85.5
356 × 171 × 57	57	358	172.2	8.1	13	10.2	311.6	6.62	38.5	16040	1108	28	14.9	3.91	896	129	1010	199	0.882	28.8	0.33	33.4	72.6
356 × 171 × 51	51	355	171.5	7.4	11.5	10.2	311.6	7.46	42.1	14140	968	31	14.8	3.86	796	113	896	174	0.881	32.1	0.286	23.8	64.9
356 × 171 × 45	45	351.4	171.1	7	9.7	10.2	311.6	8.82	44.5	12070	811	36	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356 × 127 × 39	39.1	353.4	126	6.6	10.7	10.2	311.6	5.89	47.2	10170	358	33	14.3	2.68	576	56.8	659	89.1	0.871	35.2	0.105	15.1	49.8
356 × 127 × 33	33.1	349	125.4	6	8.5	10.2	311.6	7.38	51.9	8249	280	41	14	2.58	473	44.7	543	70.3	0.863	42.2	0.081	8.79	42.1
305 × 165 × 54	54	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	11700	1063	23	13	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305 × 165 × 46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.6	9899	896	26	13	3.9	646	108	720	166	0.891	27.1	0.195	22.2	58.7
305 × 165 × 40	40.3	303.4	165	6	10.2	8.9	265.2	8.09	44.2	8503	764	30	12.9	3.86	560	92.6	623	142	0.889	31	0.164	14.7	51.3
305 × 127 × 48	48.1	311	125.3	9	14	8.9	265.2	4.47	29.5	9575	461	22	12.5	2.74	616	73.6	711	116	0.873	23.3	0.102	31.8	61.2
305 × 127 × 42	41.9	307.2	124.3	8	12.1	8.9	265.2	5.14	33.1	8196	389	25	12.4	2.7	534	62.6	614	98.4	0.872	26.5	0.0846	21.1	53.4
305 × 127 × 37	37	304.4	123.4	7.1	10.7	8.9	265.2	5.77	37.4	7171	336	28	12.3	2.67	471	54.5	539	85.4	0.872	29.7	0.0725	14.8	47.2
305 × 102 × 33	32.8	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	6501	194	29	12.5	2.15	416	37.9	481	60	0.866	31.6	0.0442	12.2	41.8
305 × 102 × 28	28.2	308.7	101.8	6	8.8	7.6	275.9	5.78	46	5366	155	35	12.2	2.08	348	30.5	403	48.5	0.859	37.4	0.0349	7.4	35.9
305 × 102 × 25	24.8	305.1	101.6	5.8	7	7.6	275.9	7.26	47.6	4455	123	44	11.9	1.97	292	24.2	342	38.8	0.846	43.4	0.0273	4.77	31.6
254 × 146 × 43	43	259.6	147.3	7.2	12.7	7.6	219	5.8	30.4	6544	677	20	10.9	3.52	504	92	566	141	0.891	21.2	0.103	23.9	54.8
254 × 146 × 37	37	256	146.4	6.3	10.9	7.6	219	6.72	34.8	5537	571	23	10.8	3.48	433	78	483	119	0.89	24.3	0.0857	15.3	47.2
254 × 146 × 31	31.1	251.4	146.1	6	8.6	7.6	219	8.49	36.5	4413	448	29	10.5	3.36	351	61.3	393	94.1	0.88	29.6	0.066	8.55	39.7
254 × 102 × 28	28.3	260.4	102.2	6.3	10	7.6	225.2	5.11	35.7	4005	179	26	10.5	2.22	308	34.9	353	54.8	0.874	27.5	0.028	9.57	36.1
254 × 102 × 25	25.2	257.2	101.9	6	8.4	7.6	225.2	6.07	37.5	3415	149	31	10.3	2.15	266	29.2	306	46	0.866	31.5	0.0229	6.42	32
254 × 102 × 22	22	254	101.6	5.7	6.8	7.6	225.2	7.47	39.5	2841	119	37	10.1	2.06	224	23.5	259	37.3	0.856	36.4	0.0182	4.15	28
203 × 133 × 30	30	206.8	133.9	6.4	9.6	7.6	172.4	6.97	26.9	2896	385	22	8.71	3.17	280	57.5	314	88.2	0.881	21.5	0.0374	10.3	38.2
203 × 133 × 25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	8.54	30.2	2340	308	26	8.56	3.1	230	46.2	258	70.9	0.877	25.6	0.0294	5.96	32
203 × 102 × 23	23.1	203.2	101.8	5.4	9.3	7.6	169.4	5.47	31.4	2105	164	22	8.46	2.36	207	32.2	234	49.8	0.888	22.5	0.0154	7.02	29.4
178 × 102 × 19	19	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	1356	137	23	7.48	2.37	153	27	171	41.6	0.886	22.6	0.01	4.41	24.3
152 × 89 × 16	16	152.4	88.7	4.5	7.7	7.6	121.8	5.76	27.1	834	89.8	20	6.41	2.1	109	20.2	123	31.2	0.89	19.6	0.005	3.56	20.3
127 × 76 × 13	13	127	76	4	7.6	7.6	96.6	5	24.1	473	55.7	17	5.35	1.84	74.6	14.7	84.2	22.6	0.895	16.3	0.002	2.85	16.5

†Additional sizes to BS4 available in UK

Universal columns – dimensions and properties



UC designation	Mass per metre	Depth of section	Width of section	Thickness Web	Thickness Flange	Root radius	Depth between fillets	Ratios for local buckling Flange	Ratios for local buckling Web	Second moment of area Axis x-x	Second moment of area Axis y-y	(better known in BS449 as)	Radius of gyration Axis x-x	Radius of gyration Axis y-y	Elastic modulus Axis x-x	Elastic modulus Axis y-y	Plastic modulus Axis x-x	Plastic modulus Axis y-y	Buckling parameter	Torsional index	Warping constant	Torsional constant	Area of section
		h	b	s	t	r	d	$b/2T$	d/s	I_x	I_y	D/T	r_x	r_y	Z_x	Z_y	S_x	S_y	u	x	H	J	A
	kg/m	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
356 x 406 x 634	633.9	474.6	424	47.6	77	15.2	290.2	2.75	6.1	274800	98130	6	18.4	11	11580	4629	14240	7108	0.843	5.46	38.8	13720	808
356 x 406 x 551	551	455.6	418.5	42.1	67.5	15.2	290.2	3.1	6.89	226900	82670	7	18	10.9	9962	3951	12080	6058	0.841	6.05	31.1	9240	702
356 x 406 x 467	467	436.6	412.2	35.8	58	15.2	290.2	3.55	8.11	183000	67830	8	17.5	10.7	8383	3291	10000	5034	0.839	6.86	24.9	5809	595
356 x 406 x 393	393	419	407	30.6	49.2	15.2	290.2	4.14	9.48	146600	55370	9	17.1	10.5	6998	2721	8222	4154	0.837	7.86	18.5	3545	501
356 x 406 x 340	339.9	406.4	403	26.6	42.9	15.2	290.2	4.7	10.9	122500	46850	9	16.8	10.4	6031	2325	6999	3544	0.836	8.85	15.5	2343	433
356 x 406 x 287	287.1	393.6	399	22.6	36.5	15.2	290.2	5.47	12.8	99880	38680	11	16.5	10.3	5075	1939	5812	2949	0.835	10.2	12.3	1441	366
356 x 406 x 235	235.1	381	394.8	18.4	30.2	15.2	290.2	6.54	15.8	79080	30990	13	16.3	10.2	4151	1570	4687	2383	0.834	12.1	9.54	812	299
356 x 368 x 202	201.9	374.6	374.7	16.5	27	15.2	290.2	6.94	17.6	66260	23690	14	16.1	9.6	3538	1264	3972	1920	0.844	13.4	7.16	558	257
356 x 368 x 177	177	368.2	372.6	14.4	23.8	15.2	290.2	7.83	20.2	57120	20530	15	15.9	9.54	3103	1102	3455	1671	0.844	15	6.09	381	226
356 x 368 x 153	152.9	362	370.5	12.3	20.7	15.2	290.2	8.95	23.6	48590	17550	17	15.8	9.49	2684	948	2965	1435	0.844	17	5.11	251	195
356 x 368 x 129	129	355.6	368.6	10.4	17.5	15.2	290.2	10.5	27.9	40250	14610	20	15.6	9.43	2264	793	2479	1199	0.844	19.9	4.18	153	164
305 x 305 x 283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.65	9.21	78870	24630	8	14.8	8.27	4318	1529	5105	2342	0.855	7.65	6.35	2034	360
305 x 305 x 240	240	352.5	318.4	23	37.7	15.2	246.7	4.22	10.7	64200	20310	9	14.5	8.15	3643	1276	4247	1951	0.854	8.74	5.03	1271	306
305 x 305 x 198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	5.01	12.9	50900	16300	11	14.2	8.04	2995	1037	3440	1581	0.854	10.2	3.88	734	252
305 x 305 x 158	158.1	327.1	311.2	15.8	25	15.2	246.7	6.22	15.6	38750	12570	13	13.9	7.9	2369	808	2680	1230	0.851	12.5	2.87	378	201
305 x 305 x 137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	7.12	17.9	32810	10700	15	13.7	7.83	2048	692	2297	1053	0.851	14.2	2.39	249	174
305 x 305 x 118	117.9	314.5	307.4	12	18.7	15.2	246.7	8.22	20.6	27670	9059	17	13.6	7.77	1760	589	1958	895	0.85	16.2	1.98	161	150
305 x 305 x 97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	9.91	24.9	22250	7308	20	13.4	7.69	1445	479	1592	726	0.85	19.3	1.56	91.2	123
254 x 254 x 167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	4.18	10.4	30000	9870	9	11.9	6.81	2075	744	2424	1137	0.851	8.49	1.63	626	213
254 x 254 x 132	132	276.3	261.3	15.3	25.3	12.7	200.3	5.16	13.1	22530	7531	11	11.6	6.69	1631	576	1869	878	0.85	10.3	1.19	319	168
254 x 254 x 107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	6.31	15.6	17510	5928	13	11.3	6.59	1313	458	1484	697	0.848	12.4	0.898	172	136
254 x 254 x 89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	7.41	19.4	14270	4857	15	11.2	6.55	1096	379	1224	575	0.85	14.5	0.717	102	113
254 x 254 x 73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	8.96	23.3	11410	3908	18	11.1	6.48	898	307	992	465	0.849	17.3	0.562	57.6	93.1
203 x 203 x 86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	5.1	12.7	9449	3127	11	9.28	5.34	850	299	977	456	0.85	10.2	0.318	137	110
203 x 203 x 71	71	215.8	206.4	10	17.3	10.2	160.8	5.97	16.1	7618	2537	12	9.18	5.3	706	246	799	374	0.853	11.9	0.25	80.2	90.4
203 x 203 x 60	60	209.6	205.8	9.4	14.2	10.2	160.8	7.25	17.1	6125	2065	15	8.96	5.2	584	201	656	305	0.846	14.1	0.197	47.2	76.4
203 x 203 x 52	52	206.2	204.3	7.9	12.5	10.2	160.8	8.17	20.4	5259	1778	16	8.91	5.18	510	174	567	264	0.848	15.8	0.167	31.8	66.3
203 x 203 x 46	46.1	203.2	203.6	7.2	11	10.2	160.8	9.25	22.3	4568	1548	18	8.82	5.13	450	152	497	231	0.847	17.7	0.143	22.2	58.7
152 x 152 x 37	37	161.8	154.4	8	11.5	7.6	123.6	6.71	15.5	2210	706	14	6.85	3.87	273	91.5	309	140	0.848	13.3	0.04	19.2	47.1
152 x 152 x 30	30	157.6	152.9	6.5	9.4	7.6	123.6	8.13	19	1748	560	17	6.76	3.83	222	73.3	248	112	0.849	14	0.031	10.5	38.3
152 x 152 x 23	23	152.4	152.2	5.8	6.8	7.6	123.6	11.2	21.3	1250	400	22	6.54	3.7	164	52.6	182	80.2	0.84	20.7	0.021	4.63	29.2

Table 60 — Minimum nail spacings

Spacing	Timber-to-timber joints		Steel plate-to-timber joints	Joints between timber and plywood or particleboard
	Without pre-drilled holes	With pre-drilled holes	Without pre-drilled holes	Without pre-drilled holes
End distance parallel to grain	20*d*	14*d*	14*d*	14*d*
Edge distance perpendicular to grain	5*d*	5*d*	5*d*	— [a]
Distance between lines of nails, perpendicular to grain	10*d*	3*d*	7*d*	7*d*
Distance between adjacent nails in any one line, parallel to grain	20*d*	10*d*	14*d*	14*d*

NOTE *d* is the nail diameter.

[a] The loaded edge distance in the timber should be not less than 5*d*. The loaded edge distance in the plywood should be not less than 3*d*. The loaded edge distance in the particleboard should be not less than 6*d*. In all other cases the edge distance should be not less than 3*d*.

Table 61 — Basic single shear lateral load for round wire nails in a timber-to-timber joint

Softwoods (not pre-drilled)						Hardwoods (pre-drilled)		
Nail diameter	Standard penetration [a]	Basic single shear lateral load N				Minimum penetration [a]	Basic single shear lateral load N	
		Strength class					Strength class	
		C14	C16/18/20 TR20/C22	C24	TR26/C27 C30/35/40		D35/40/45	D50/60/70
mm	mm					mm		
2.7	32	249	258	274	281	22	386	427
3	36	296	306	326	335	24	465	515
3.4	41	364	377	400	412	27	582	644
3.8	46	438	453	481	495	30	709	785
4.2	50	516	534	567	583	34	897	939
4.6	55	600	620	659	678	37	996	1 103
5	60	689	712	756	778	40	1 155	1 279
5.5	66	806	833	885	910	44	1 368	1 515
6	72	930	962	1 022	1 051 [b]	48	1 595	1 767
7	84	1 200	1 240	1 318	1 355 [b]	56	2 094	2 319
8	96	1 495	1 546	1 643	1 689 [b]	64	2 649	2 933

[a] These values apply to both the headside and pointside penetration.
[b] Holes should be pre-drilled.