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Name _____ Index No. _____/_____

2707/302
STRUCTURES III
Oct./Nov. 2015
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 the examination in the spaces provided above.
You should have scientific calculator for this examination.
*This paper consists of **EIGHT** questions.*
*Answer any **FIVE** of the following **EIGHT** questions in the spaces provided in this question paper.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Answers should be written in the spaces provided in this question paper.
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 150 mm thick reinforced concrete slab is supported on simply supported beams of effective length 6 m, spaced at 3 m centres. Select a suitable UB section for the internal beams in grade 5275 (grade 43) steel and check for shear, bending and deflection given the following information:

   - Characteristic loads:
     - imposed load = 3.0 kN/m²
     - Finishes = 0.8 kN/m²
     - Unit weight of concrete = 24 kN/m³
   - E = 210 kN/mm²

   Ignore the self weight of the beam. (20 marks)

2. (a) With the aid of labelled sectional sketches, describe the following types of riveted joints:
   (i) lap joint
   (ii) double cover butt joint. (6 marks)

   (b) A single unequal angle section, 100 x 75 x 10 mm is welded to a gusset plate as shown in figure 1. It transmits a load P of 150 kN through its centroid. Design the joint using 8 mm fillet welds.
   Permissible stress in weld = 100 N/mm². (14 marks)

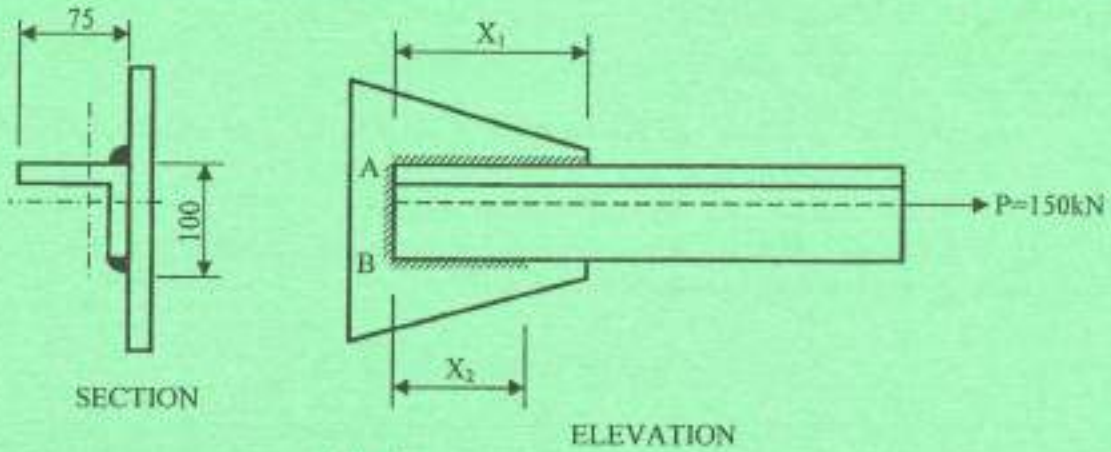


Fig. 1

3. A timber section 150 x 150 mm of strength class C 16 and effective span 3.0 m is used as a a simply supported beam. Assuming the beam is fully laterally restrained, check the adequacy of the timber beam in bearing, shear, bending and deflection given the following information:

   - dead load = 0.5 kN/m
   - imposed load = 1.5 kN/m
   - bearing length = 100 mm
   - take all k factors to be 1.0 (20 marks)

4. Using the three moments theorem, analyze the beam shown in figure 2 and hence sketch the bending moment and shear force diagrams indicating the values at the critical points. (20 marks)

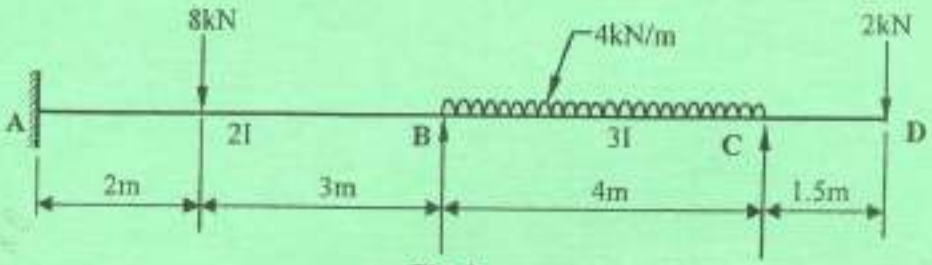


Fig. 2

5. Using the moment distribution method, analyze the beam shown in figure 3 and hence sketch the bending moment diagram indicating the values at the critical points. (20 marks)

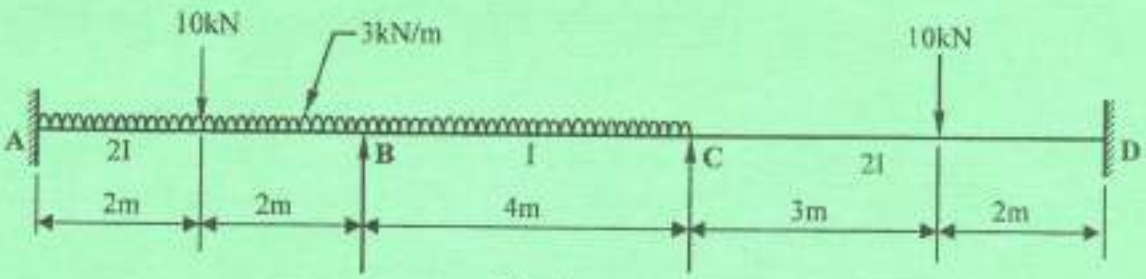


Fig. 3

6. (a) Using Rankines formula, calculate the crippling load that a solid steel rod 4 m long and 50 mm diameter can carry when used as a column with both ends pinned.

Take
- $E = 200\ kN/mm^2$
- rankines constant, $a = 1/7500$
- crushing stress, $\sigma cs = 320\ N/mm^2$ (6 marks)

(b) An equal angle section 100 x 100 x 8 mm is used as a strut of 3 m length with both ends fixed.
Calculate the crippling load using Euler's formula.
Take $E = 200\ kN/mm^2$ (14 marks)

7. Figure 4 shows the section of a short rectangular column with a square hole. The column carries an eccentric load P of 150 kN. Calculate the stresses at the four extreme corners of the column. (20 marks)

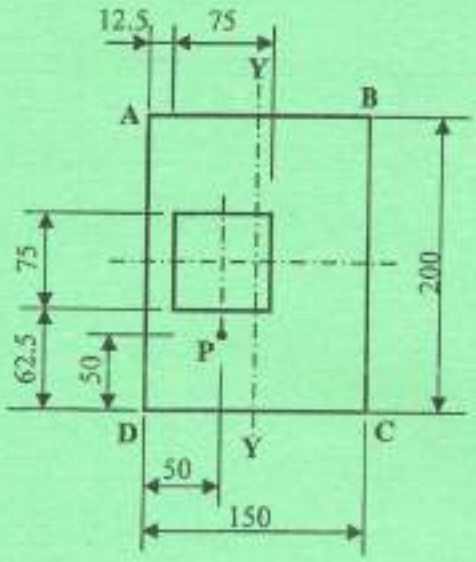


Fig. 4

8. (a) Figure 5 shows a simply supported girder of 8 m span. Using equilibrium conditions, sketch the influence line diagrams for the following load components, calculating values at every 2 m intervals:

(i) reaction at A
(ii) shear force at C
(iii) bending moment at C (14 marks)

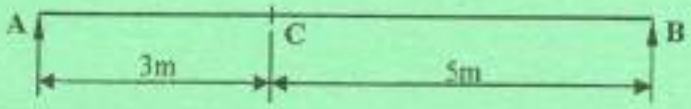
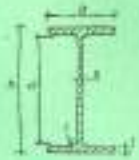


Fig. 5

(b) If a point load of 60 KN moves across the girder shown in figure 5 from the left to the right, determine the following values using the influence line diagrams.

(i) maximum reaction at A.
(ii) maximum positive and negative shear forces at C
(iii) maximum bending moment at C. (6 marks)

Universal beams – dimensions and properties



UB designation	Mass per metre	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
				Web	Flange			Flange	Web	Axis x–x	Axis y–y	Axis x–x	Axis y–y	Axis x–x	Axis y–y	Axis x–x	Axis y–y					
		h	b	s	t	r	d	$b/2t$	d/s	I_x	I_y	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			cm⁴	cm⁴	cm	cm	cm³	cm³	cm³	cm³			dm⁶	cm⁴	cm²
457 × 152 × 60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	5.75	50.3	25500	795	18.3	3.24	1122	104	1287	162	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	17.9	3.11	950	84.6	1096	132	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	1540	17	4.04	1323	172	1501	267	0.882	37.6	0.638	63.8	94.5
406 × 178 × 67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41	24300	1365	16.9	3.98	1188	153	1346	237	0.86	38.5	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	16.8	3.97	1063	135	1199	209	0.858	38.9	0.466	33.2	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	16.5	3.89	930	115	1055	178	0.871	38.9	0.392	23.1	69
406 × 140 × 46	46	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53	15840	538	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	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	15.1	3.99	1071	157	1211	240	0.886	34.4	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	14.9	3.91	896	129	1010	198	0.882	38.8	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	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	14.5	3.79	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	14.3	2.68	576	56.8	658	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	14	2.58	473	44.7	543	70.3	0.863	42.2	0.081	8.78	42.1
305 × 165 × 54	54	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	11700	1063	13	3.99	754	127	846	196	0.899	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	13	3.9	646	108	720	165	0.891	27.1	0.165	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	12.9	3.88	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	9573	481	12.9	2.74	616	73.6	711	116	0.873	33.3	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	12.4	2.7	534	62.6	614	93.4	0.872	36.5	0.085	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	12.3	2.67	471	54.5	539	65.4	0.872	39.7	0.072	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	12.5	2.15	416	37.9	481	60	0.856	31.8	0.044	12.2	41.8
305 × 102 × 28	28.2	308.7	101.8	6	8.8	7.6	275.9	5.78	46	5388	155	12.2	2.08	349	30.5	402	48.5	0.859	37.4	0.035	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	11.9	1.97	292	24.2	342	38.8	0.848	43.4	0.027	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	10.9	3.52	504	92	566	141	0.891	31.2	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	10.8	3.48	433	78	492	119	0.89	24.2	0.086	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	10.1	3.36	351	61.3	393	94.1	0.88	29.6	0.068	8.99	39.7
254 × 102 × 28	28.3	260.4	102.2	6.3	10	7.6	225.2	5.11	35.7	4005	179	10.5	2.23	308	34.9	355	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	10.3	2.19	266	29.2	306	46	0.866	31.5	0.023	6.42	32
254 × 102 × 22	22	254	101.6	5.7	6.8	7.6	225.2	7.47	39.5	2841	113	10.1	2.06	224	23.5	259	37.3	0.856	36.4	0.018	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	8.71	3.17	280	57.5	314	88.2	0.881	21.5	0.037	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	8.55	3.1	230	46.2	258	70.9	0.877	25.8	0.029	5.96	32
203 × 102 × 23	23.1	203.2	101.8	5.4	9.3	7.6	160.4	5.47	31.4	2105	164	8.46	2.36	207	32.2	234	49.8	0.868	22.5	0.015	7.07	29.4
178 × 102 × 19	19	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	1356	137	7.48	2.37	153	27	171	41.6	0.868	22.6	0.01	4.41	24.3
152 × 89 × 16	16	152.4	88.7	4.5	7.7	7.6	121.8	5.78	27.1	834	89.8	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	98.6	5	24.7	473	55.7	5.35	1.94	74.6	14.7	84.2	22.9	0.895	16.5	0.002	2.35	16.5

Turn over

Table 8 — Grade stresses and moduli of elasticity for various strength classes: for service classes 1 and 2

Strength class	Bending parallel to grain	Tension parallel to grain	Compression parallel to grain	Compression perpendicular to grain *		Shear parallel to grain	Modulus of elasticity		Characteristic density, ρ_k [b]	Average density, ρ_{mean} [b]
							Mean	Minimum		
	N/mm²	N/mm²	N/mm²	N/mm²		N/mm²	N/mm²	N/mm²	kg/m³	kg/m³
C14	4.1	2.5	5.2	2.1	1.6	0.60	6 800	4 600	290	350
C16	5.3	3.2	6.8	2.2	1.7	0.67	8 800	5 800	310	370
C18	5.8	3.5	7.1	2.2	1.7	0.67	9 100	6 000	320	380
C22	6.8	4.1	7.5	2.3	1.7	0.71	9 700	6 500	340	410
C24	7.5	4.5	7.9	2.4	1.9	0.71	10 800	7 200	350	420
C27	10.0	6.0	8.2	2.5	2.0	1.10	12 300	8 200	370	450
C30	11.0	6.6	8.6	2.7	2.2	1.20	12 300	8 200	380	460
C35	12.0	7.2	8.7	2.9	2.4	1.30	13 400	9 000	400	480
C40	13.0	7.8	8.7	3.0	2.6	1.40	14 500	10 000	420	500
D30	9.0	5.4	8.1	2.8	2.2	1.40	9 500	6 000	530	640
D35	11.0	6.6	8.6	3.4	2.6	1.70	10 000	6 500	560	670
D40	12.5	7.5	12.6	3.9	3.0	2.00	10 800	7 500	590	700
D50	16.0	9.6	15.2	4.5	3.5	2.20	15 000	12 600	650	780
D60	18.0	10.8	18.0	5.2	4.0	2.40	18 500	15 600	700	840
D70	23.0	13.8	23.0	6.0	4.6	2.60	21 000	18 000	900	1 080

NOTE Strength classes C14 to C40 are for softwoods and D30 to D70 are for hardwoods.

* When the specification specifically prohibits wane at bearing areas, the higher values of compression perpendicular to grain stress may be used, otherwise the lower values apply.

[b] The values of characteristic density given above are for use when designing joints. For the calculation of dead load, the average density should be used.