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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

Study Programme	: Bachelor of Technology Honors in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX3441**
Academic Year	: 2021/2022
Date	: 03rd February 2022
Time	: 1400-1700hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Ten (10)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts / codes are provided.
6. This is a Closed Book Test **(CBT).**
7. Answers should be in clear handwriting.
8. Do not use Red colour pen.
9. Marks are deducted if the instructions are not followed.

PART A

Q1). a). Sketch the three types of supports normally used in structures indicating their reactions clearly. (5 Marks)

b). Figure 1 shows the body diagram of a simply supported plane truss.

i). Find member forces of the truss shown in Figure Q1 using the method of Joints.(10 Marks)

ii). Find member forces of the members BC, CE and CF using the method of Sections. (5 Marks)

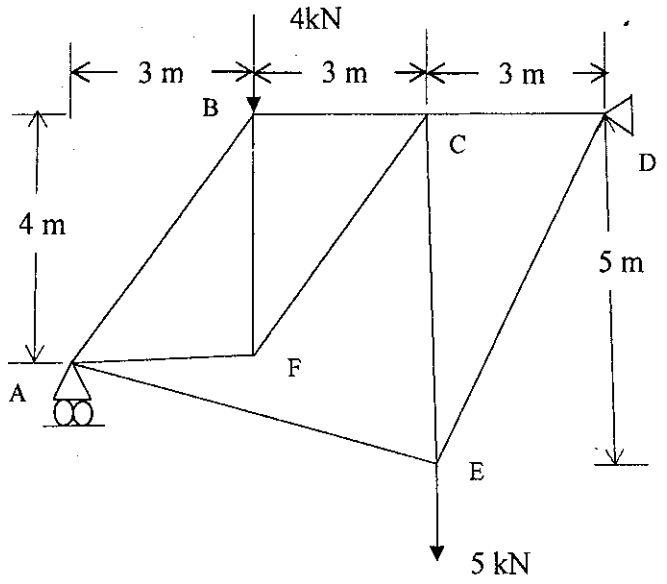


Figure 1

Q2). i). List three methods that can be used in calculation deflection of trusses. Discuss their limitations. (3 Marks)

ii). Find the vertical displacement of the point B of the truss given in Figure 1, if only the load 4kN at joint B is applied to the structure. (Assume AE is constant for all the members) Members are square sections with 25 mm x 25 mm and E = 100 GPa (10 Marks)

iii). Find Horizontal displacement of point F if only 4 kN load at joint B is applied to the structure. (7 Marks)

Q3) a) Figure Q3 shows a continuous beam with internal hinges at B.

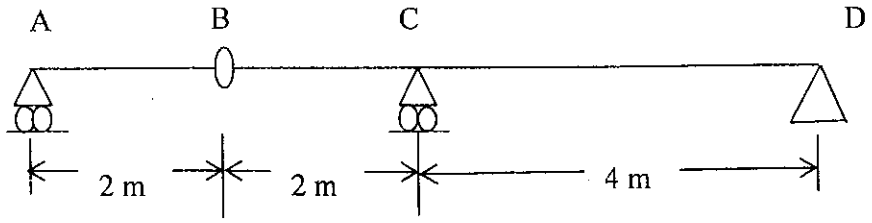


Figure Q3

i). Draw the influence lines of

a). Reaction at A

b). Reaction at C

d). Mid span moment of span CD (14 Marks)

ii). Find the maximum Bending Moment at mid span CD if following loads are moving along the beams.

a). Two concentrated loads of 5 kN each with apart from 4m

b). A udl of 4 kN/m of length 10 m
c). A udl of 5 kN/m of length 4m (6 Marks)

Q4

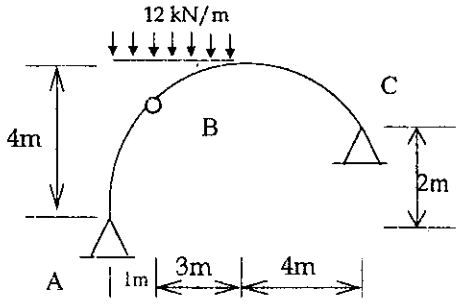


Figure Q4

i). State the difference between two pinned arch and three pinned arch with neat sketches (3 Marks)

ii). 3 Pin Arch (Pins at A,B and C) given in Figure Q 4 is loaded as shown. The general equation of the arches can be given as $y = ax^2 + bx + c$

a). Find the constants a,b and c with the terms of L (Length of the arch) and h (height of the arch (4 Marks)

b). Find the support reactions of the Arch. (7 Marks)

c). Find the Shear Force and Bending Moment of the section when x = 6 m. (x is measured from support A) (6 Marks)

PART B

Description for Q5 and Q6

The truss given in Figure 1 is proposed to design with Gr. 43 steel members.

60 x 60 x 10 EA (Single) angle members are considered for internal members of the truss and 2 x 60 x 60 x 10 EA (Double) angles members for outer members. M 20 bolts are used for bolted connections. All the members are connected with at least two bolts ate each ends.

Q5. a). Define the term eccentricity in connections in steel roof truss and explain how BS codes allow the eccentricity. (5 Marks)

b). If the maximum Tensile member force of the web members is 20 kN. Check the proposed single angle section is suitable for web members. (7 Marks)

c). If a bottom chord member is subjected to 25 kN and 10 kNm. Check the proposed double angle section is suitable for chord members. (8 Marks)

Q6.a). State how the buckling failure in compression members of roof truss can be checked. (4 Marks)

b). If the maximum Compression member force of the web members is 30 kN. Check the proposed single angle section is suitable for web members. Length of the member is 1.5 m (7 marks)

c).) If the maximum Compression member force of the chord members is 30 kN and the length of the member is 2m. Check the proposed double angle section is suitable for chord members. (9 Marks)

Q7 a). Discuss the failure modes of a bolted joint with suitable diagrams. (4 Marks)

b). A single angle member (70 x 70 x 8 EA) is proposed to connect with a gusset plate (12 mm thick) and it was found that 6 number of 18 M bolts are required for the connection.

i). Sketch two arrangements that can be used for this connection. (2 Marks)

ii). Detail each arrangement and state which arrangement is more appropriate with the reasons. (Assume members are cut by machine flame) (6 Marks)

c). A simply supported beam of 4 m effective span is subjected to 10 kN/m dead load and 6 kN/m imposed load.

i). Find the design load and maximum bending moment. (3 marks)

ii). Design the member with 200 x 300 x 10 RHS section considering Bending Moment and Shear Force. (5 Marks)

Breadth = 200 mm, Depth = 300 mm, Thickness = 10 mm

Q8). i). Derive Euler Buckling load of a column with top end is free and bottom end is fixed connected. (7 Marks)

ii). If steel RHS of size 100 mm x 150 mm with thickness 10 mm is proposed for the column discussed in Q8. i) find the suitability of the section if only axial load of 1000 kN is applied. (5 Marks)

The height of the column = 3 m

Elastic Modulus of steel = 200 GPa

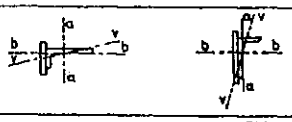
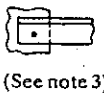
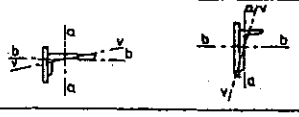
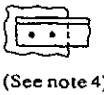
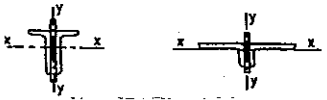
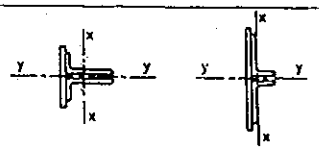
iii). State the difference between Windward slope and Leeward slope used in wind load calculation. (3 Marks)

iv). Briefly explain the method of finding wind load for a building situated in Colombo area. (5 marks)

DATA SHEETS

a	T	M	r1	r2	A	C of G	Moment Of Inertia			Radius Of Gyration			Z
						Cx, Cy	X-X, Y-Y	U-U	V-V	X-X, Y-Y	U-U	V-V	
mm	mm	kg	mm	mm	cm^2	cm	cm^4	cm^4	cm^4	cm	cm	cm	cm^3
50 x 50	5	3.77	7,0	2,4	4.80	1.40	11.0	17.4	4.54	1.51	1.90	0.97	3.05
	6	4.47	7,0	2,4	5.69	1.45	12.8	20.4	5.33	1.50	1.89	0.97	3.61
	7	5.82	7,0	2,4	7.41	1.52	16.3	25.7	6.87	1.48	1.86	0.96	4.68
60 x 60	5	4.57	8,0	2,4	5.82	1.64	19.4	30.7	8.02	1.82	2.30	1.17	4.45
	6	5.42	8,0	2,4	6.91	1.69	22.8	36.2	9.43	1.82	2.29	1.17	5.29
	8	7.09	8,0	2,4	9.03	1.77	29.2	46.2	12.1	1.80	2.26	1.16	6..89
	10	8.69	8,0	2,4	11.1	1.85	34.9	55.1	14.8	1.78	2.23	1.16	8.41
70 x 70	6	6.38	9,0	2,4	8.13	1.93	36.9	58.5	15.2	2.13	2.68	1.37	7.27
	8	8.36	9,0	2,4	10.6	2.01	47.5	75.3	19.7	2.11	2.66	1.36	9.52
	10	10.3	9,0	2,4	13.1	2.09	57.2	90.5	23.9	2.09	2.63	1.35	11.7
80 x 80	6	7.34	10,0	4,8	9.35	2.17	55.8	88.5	23.1	2.44	3.08	1.57	9.57
	8	9.63	10,0	4,8	12.3	2.26	72.2	115	29.8	2.43	3.06	1.56	12.6
	10	11.9	10,0	4,8	15.1	2.34	87.5	139	36.3	2.41	3.03	1.55	15.4
90 x 90	6	8.3	11,0	4,8	10.6	2.41	80.3	127	33.3	2.76	3.47	1.78	12.2
	8	10.9	11,0	4,8	13.9	2.50	104	166	43.1	2.74	3.45	1.76	16.1
	10	13.4	11,0	4,8	17.1	2.58	127	201	52.6	2.72	3.42	1.76	19.8
	12	15.9	11,0	4,8	20.3	2.66	148	234	61.7	2.70	3.40	1.75	23.3
100x100	8	12.2	12,0	4,8	15.5	2.74	145	230	59.8	3.06	3.85	1.96	19.9
	12	17.8	12,0	4,8	22.7	2.90	207	328	85.7	3.02	3.80	1.94	29.1
	15	21.9	12,0	4,8	27.9	3.02	249	393	104	2.98	3.75	1.93	35.6

TABLE 18. ANGLE STRUTS

Connection	Sections and axes	Slenderness ratios (see notes 1 and 2)
		*vv axis:* $0.85L_{vv}/r_{vv}$ but $\geq 0.7L_{vv}/r_{vv} + 15$ *aa axis:* $1.0L_{aa}/r_{aa}$ but $\geq 0.7L_{aa}/r_{aa} + 30$ *bb axis:* $0.85L_{bb}/r_{bb}$ but $\geq 0.7L_{bb}/r_{bb} + 30$
 (See note 3)		*vv axis:* $1.0L_{vv}/r_{vv}$ but $\geq 0.7L_{vv}/r_{vv} + 15$ *aa axis:* $1.0L_{aa}/r_{aa}$ but $\geq 0.7L_{aa}/r_{aa} + 30$ *bb axis:* $1.0L_{bb}/r_{bb}$ but $\geq 0.7L_{bb}/r_{bb} + 30$ (See note 3)
 (See note 4)		*xx axis:* $0.85L_{xx}/r_{xx}$ but $\geq 0.7L_{xx}/r_{xx} + 30$ *yy axis:* $1.0L_{yy}/r_{yy} + 10$
 (See note 4)		*xx axis:* $1.0L_{xx}/r_{xx}$ but $\geq 0.7L_{xx}/r_{xx} + 30$ *yy axis:* $0.85L_{yy}/r_{yy}$ but $\geq 0.7L_{yy}/r_{yy} + 10$

NOTE 1. The length L is taken between the intersections of the centroidal axes or the intersections of the setting out lines of the bolts, irrespective of whether the strut is connected to a gusset or directly to another member.

NOTE 2. Intermediate lateral restraints reduce the value of L for buckling about the relevant axes. For single angle members, L_{vv} is taken between lateral restraints perpendicular to either aa or bb.

NOTE 3. For single angles connected by one bolt, the allowable stress is also reduced to 80 per cent of that for an axially loaded member.

NOTE 4. Double angles are interconnected back-to-back to satisfy Clause 37.

TABLE 2. ALLOWABLE STRESS p_{bc} OR p_{bt} IN BENDING
(See also Clauses 19 and 20 and Tables 3 and 4)

Form	Grade	Thickness of material	p_{bc} or p_{bt}
Sections, bars, plates, wide flats and hot rolled hollow sections. Compound beams composed of rolled sections plated, with thickness of plate. Double channel sections forming a symmetrical I-section which acts as an integral unit.	43	≤ 40 >40 but ≤ 100	180 165
	50	≤ 63 >63 but ≤ 100	230 215
	55	≤ 25	280
Plate girders with single or multiple webs	43	≤ 40 >40 but ≤ 100	170 155
	50	≤ 63 >63 but ≤ 100	215 200
	55	≤ 25	265
Slab bases	All steels		185

Altered Dec. 1989

TABLE 17a. ALLOWABLE STRESS p_c ON GROSS SECTION FOR AXIAL COMPRESSION

l/r	p_c (N/mm²) for grade 43 steel									
	0	1	2	3	4	5	6	7	8	9
0	170	169	169	168	168	167	167	166	166	165
10	165	164	164	163	163	162	162	161	160	160
20	159	159	158	158	157	157	156	156	155	155
30	154	154	153	153	153	152	152	151	151	150
40	150	149	149	148	148	147	146	146	145	144
50	144	143	142	141	140	139	139	138	137	136
60	135	134	133	131	130	129	128	127	126	124
70	123	122	120	119	118	116	115	114	112	111
80	109	108	107	105	104	102	101	100	98	97
90	95	94	93	91	90	89	87	86	85	84
100	82	81	80	79	78	77	75	74	73	72
110	71	70	69	68	67	66	65	64	63	62
120	62	61	60	59	58	57	57	56	55	54
130	54	53	52	51	51	50	49	49	48	47
140	47	46	46	45	45	44	43	43	42	42
150	41	41	40	40	39	39	38	38	38	37
160	37	36	36	35	35	35	34	34	33	33
170	33	32	32	32	31	31	31	30	30	30
180	29	29	29	28	28	28	28	27	27	27
190	26	26	26	26	25	25	25	25	24	24
200	24	24	24	23	23	23	23	22	22	22
210	22	22	21	21	21	21	21	20	20	20
220	20	20	20	19	19	19	19	19	19	18
230	18	18	18	18	18	18	17	17	17	17
240	17	17	17	16	16	16	16	16	16	16
250	16	15	15	15	15	15	15	15	15	15
300	11	11	11	11	11	11	10	10	10	10
350	8	8	8	8	8	8	8	8	8	8

NOTE 1. Intermediate values may be obtained by linear interpolation.
NOTE 2. For material over 40 mm thick refer to subclause 30b.

Appendix - BS 449: Part2: 1969 Tables & Clause

from BS 449 Table 10: Allowable maximum shear stress p_q

Allowable maximum shear stress p_q for sections, bars, plates, wide flats and hot rolled sections of grade 43 steel:

For thickness ≤ 40 mm: 125 N/mm²
For 40 < thickness ≤ 100 mm: 115 N/mm²

BS 449 Table 20: Allowable stresses in Rivets and Bolts (N/mm²)

Description of fasteners	Axial tension	Shear	Bearing
Power-driven rivets	100	100	300
Hand-driven rivets	80	80	250
Close tolerance and turned bolts	120	100	300
Bolts in clearance holes	120	80	250

BS 449 Table 20A : Allowable Bearing stresses on connected parts (N/mm²)

Description of fasteners	Material of connected part		
	Grade 43	Grade 50	Grade 55
Power-driven rivets Close tolerance and turned bolts	300	420	480
Hand-driven rivets Bolts in clearance holes	250	350	400

BS 449 Table 21: Edge distance of Holes

Diameter of hole	Distance to sheared or hand flame cut edge	Distance to rolled, machine flame cut, sawn or planed edge
Mm	mm	mm
39	68	62
36	62	56
33	56	50
30	50	44
26	42	36
24	38	32
22	34	30
20	30	28

18	28	26
16	26	24
14	24	22

Spacing of Bolts

The BS 449 clause 52 gives the following parameters for positioning of bolts, based on clause 51 pertaining to rivets.

Minimum *pitch* (BS clause 51 b):
A minimum clearance should be available between adjacent bolts; this is specified in terms of the *pitch* i.e. distance between bolts as follows:

Minimum distance between centres of the bolts shall
$\not<$ [2.5 x nominal diameter of bolt].

Maximum pitch (BS clause 51 c):
There are a number of conditions given about the maximum distance between adjacent bolts. The main conditions are as follows: (please refer the BS for the complete specifications).

(i) The distance between centres of any two adjacent bolts that connect together elements of compression or tension members, shall
$\not>$ $32t$ or 300 mm, where t is the thickness of the thinner outside plate.

(ii) The distance between centres of two adjacent bolts in a line lying in the direction of stress, shall
$\not>$ 16 t or 200 mm in tension members, and
$\not>$ 12 $t$or 200 mm in the case of compression members.

(iii) The distance between any two consecutive bolts in a line adjacent or parallel to an edge of an outside plate
$\not>$ [100 mm + 4 t] or 200 mm in compression or tension members.

(iv) When bolts are staggered at equal intervals and the gauge does not exceed 75 mm, the distances between centres of bolts as specified in (ii) and (iii) above may be increased by 50 %.

TABLE 7 — ALLOWABLE STRESS p_{bc} IN BENDING (N/mm²) FOR CASE A OF CLAUSE 19(2) FOR GRADE 43 STEEL

L/T	D/T 10	15	20	25	30	35	40	45	50
40	180	180	180	180	180	180	180	180	180
45	180	180	180	180	180	180	180	180	180
50	180	180	180	180	180	180	180	180	180
60	180	180	178	176	175	174	174	173	173
70	180	176	172	170	169	168	167	167	166
80	180	172	167	164	163	162	161	160	160
90	177	167	162	159	157	156	155	154	154
100	174	163	157	154	151	150	149	148	147
110	170	159	153	148	146	144	143	142	141
120	166	156	148	143	140	138	137	136	135
130	162	152	144	139	135	133	131	130	129
140	158	148	140	134	130	127	125	124	123
150	160	145	136	129	125	122	119	118	117
160	157	142	132	125	120	116	114	112	111
170	155	139	128	120	115	111	108	106	105
180	152	136	124	116	110	106	103	101	99
190	150	133	120	112	106	101	98	96	95
200	147	130	117	108	102	97	94	91	89	88
210	145	127	113	104	97	92	88	85	83	81
220	142	124	110	100	92	87	82	79	77	75
230	140	121	107	96	88	82	77	74	72	70
240	137	118	104	92	84	77	73	69	67	65
250	135	115	101	89	80	73	69	65	63	60
260	132	113	98	85	76	70	65	61	59	56
270	130	110	95	82	73	66	62	58	55	53
280	127	107	92	79	70	63	58	55	52	50
290	125	104	89	76	67	61	56	52	49	47
300	122	101	86	74	63	58	53	49	47	44
310	120	98	83	71	62	56	51	47	44	42
320	117	95	80	68	60	54	48	45	42	40
330	115	92	77	65	58	51	46	43	40	38
340	112	89	74	63	56	49	45	41	38	36
350	110	86	71	60	54	48	43	39	37	35
360	107	83	68	58	52	46	41	38	35	33
370	105	80	65	55	51	44	40	36	34	32