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THE OPEN UNIVERSITY OF SRI LANKA
Diploma In Technology (Civil) / Bachelor of Technology - Level 3
CEX 3231 - Structural Analysis & Design 1
Final Examination - 2010/2011
Time Allowed 3 hours

Date: 23rd March 2011 Time: 2.00 p.m. - 5.00 p.m.

Answer five questions selecting not less than two questions from each section.
Please write answers clearly showing any derivations required and stating necessary assumptions.

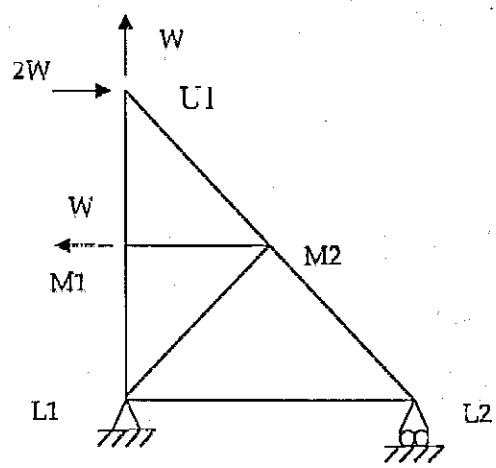


Figure Q1

Q1. i. State three assumptions/idealizations in analysing the Staticaly determinate two dimensional trusses. Discuss their validity comparing with real trusses. (5 Marks)

ii. Figure Q1 shows the geometry of a simply supported plane truss used for the advertising board. Every member of the truss is made out of steel with lengths and cross sectional areas of members as given below.

Member	Length	Cross Sectional Area
U1M1, M1L1,M1M2	l	a
L1L2	$2l$	$2a$
U1M2,M2L2,L1M2	$1.41l$	$3a$

The truss is loaded as shown in the Figure Q1.

a) Find member forces of the truss in the terms of W, using the method of Joints or method of sections. Indicate the sign of each member force clearly. (Use the sign convention. Tension - positive) (8 Marks)

b) Describe with clear diagrams how the graphical method can be applied to analyze the truss. (Calculation of the member forces is not necessary) (7 marks)

Q2. i. Find the displacement of point A due to the horizontal load W using "Williot Diagram" method of displacement calculation. (5 Marks)

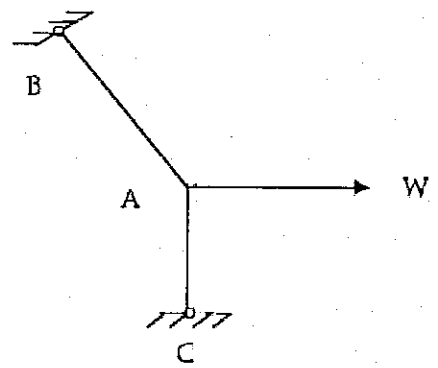


Figure Q2

Data – Length AB = l, Length AC = 0.75 l, Angle BAC = 120^0

ii. Find the displacements of the joint U1 of the truss given in Figure Q1. (Assume constant E for all the members) (9 Marks)

iii. If the horizontal load at the joint U1 is only applied to the truss, find the horizontal displacement of joint U1. (6 Marks)

Q3. Figure Q3 shows a continuous beam ADBC with a hinge.

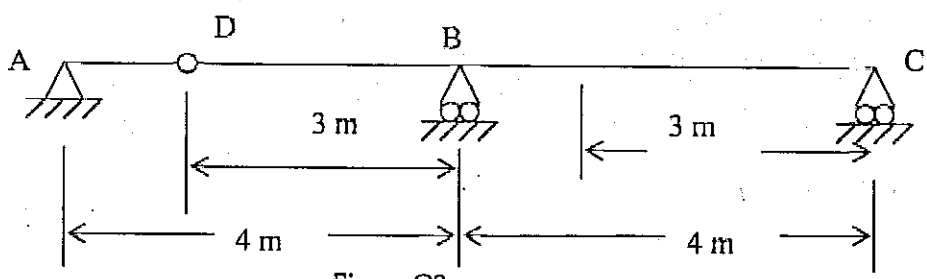


Figure Q3

i. Draw the Influence lines for the following
   a). Vertical Reaction at A
   b). Bending Moment at B
   c). Bending moment at mid span BC

(10 Marks)

ii. If following loads are moving on the beam, find the maximum Bending Moment at mid span BC. when
   a). Two concentrated loads of 5 kN each act at 2 m apart.
   b). A Uniformly distributed load of 2 kN /m and 2 m in length covers the beam.

(10 Marks)

SECTION B

Data for Q4 and Q5

The truss given in Figure Q1 in page 1 is to be designed using Gr. 43 steel.

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 to be used for bolted connections.

The properties of a 60 x 60 x 10 equal angle are as follows
Area of Section = 11.1 cm^2, distance to center of gravity c = 1.85 cm,
Second moment of area
relative to xx-axis , y-y axis = 35.3 cm^4
Radius of gyration
relative to x-x axis and y-y axis = 1.78 cm and vv-axis = 1.16 cm

Length of the shortest member (l) = 3 m

Q4. i).Define the term "eccentricity of the connection' and discuss how the eccentricity can be allowed in steel member design. (5 Marks)

ii). Check the capacity of the selected angle section for the outer members which are subjected to tensile stresses. (8 Marks)

iii). If outer members are connected at the supports with three M20 bolts find the strength of the connection. (7 Marks)

The allowable strengths are:
the allowable stress in bolts in clearance holes, in shear = 80 N/mm^2
the allowable stress in bolts in clearance holes, in bearing = 250 N/mm^2
the allowable bearing stresses on connected parts = 250 N/mm^2
the end distance of 20 mm diameter holes =28 mm

Q 5 i). Define the terms radius of gyration and slenderness ratio used in compressive member design. (4 Marks)

ii). Find the capacity of the internal compressive members shown in the truss in figure Q1 in page 1. (members should be connected with at least of two bolts at each end) (10 marks)

iii). If the compressive load of 5 kN and additional 2 kNm bending moment is applied to the particular member mentioned in Q 5. ii). Design the internal member subjected to the given load case. (6 Marks)

Q6. The beam shown in figure Q6 in page number 2 is designed to support a concrete slab of a hotel building.

Loads applied on the Beam

Dead Load

- Load due to the partition and finishing = 1.0 kN/m

Imposed Load

- Load due to the people = 1.0 kN/m

- Load due to the furniture = 0.5 kN/m

Density of the Concrete = 24 kN/m^3, Space between two beams = 3 m,
Self weight of the beam = 15% of the total dead load.

i). Calculate the design load of the beam considering above data. (5 Marks)

ii). Draw the Bending moment diagram and state the maximum sagging BM and hogging BM with their positions. (9 Marks)

iii). If a Universal section(UB) 356 x 171 x45 mm is selected for a given beam check the suitability of the selected T section. (6 Marks)

From the tabulated properties) 356 x 171 x45 mm
Plastic Modulus Z_{xx} = 686 cm^3
Depth of Section, D = 352 mm
Flange Thickness, T = 9.7 mm
Radius of gyration r_y = 3.77 cm

Q7.i)

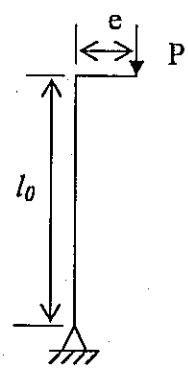


Figure Q7

i). Derive expression for Euler buckling load for the column shown in Figure Q7 (10 Marks)

ii). State five assumptions used in derivation of Euler Buckling load

(5 Marks)

iii). State the differences between basic wind speed and design wind speed used to find total wind load applied to the roof structure. (5 Marks)

TABLE 19. ALLOWABLE STRESS P_t IN AXIAL TENSION

Form	Grade	Thickness	P_t
		mm	N/mm^2
Sections, bars, plates,	43	≤ 40	170
wide flats and hot		over 40 but ≤ 100	155
rolled hollow sections	50	≤ 63	215
		over 63 but ≤ 100	200
	55	≤ 25	265

TENSILE STRESSES FOR ANGLES, TEES AND CHANNELS

42. *a.* Eccentric connections. When eccentricity of loading occurs in connections of angles and tees in tension, the net areas to be used in computing the mean tensile stress shall be as given by the following rules:

1. *Single angles connected through one leg, channel sections connected through the web and T-sections connected only through the flange.* To the net sectional area of the connected leg, add the sectional area of the unconnected leg multiplied by:

$$\frac{3a_1}{3a_1 + a_2}$$

where a_1 = the net sectional area of the connected leg.
a_2 = the sectional area of the unconnected leg.

Where lug angles are used, the net sectional area of the whole of the angle member shall be taken.

2. *A pair of angles, channels or T-sections, connected together along their length,* when attached to the same side of a gusset for the equivalent by only one leg of each component:

(i) in contact or separated, by a distance not exceeding the aggregate thickness of the connected parts, with solid packing pieces.

(ii) connected by bolts or welding as specified in Subclauses 51*e* or 54*g* so that the maximum ratio of slenderness of each member between connections is not greater than 80.

To the net sectional area of the connect part, add the sectional area of the unconnected part multiplied by:

$$\frac{5a_1}{5a_1 + a_2}$$

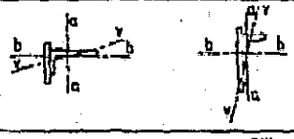
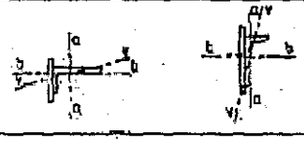
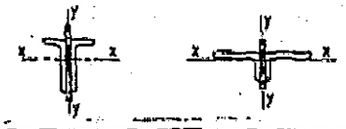
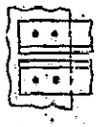
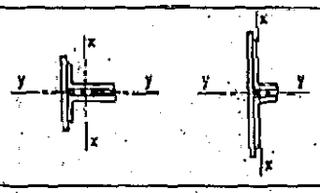
where a_1 = the net sectional area of the connected part.
a_2 = the sectional area of the unconnected part.

Where the components are widely spaced, this rule does not apply, and the member shall be specially designed.

b. Double angles, tees or channels placed back-to-back and connected to each side of a gusset or to each side of part of a rolled section. For computing the mean tensile stress the net sectional area of the pair shall be taken, provided the members are connected together along their length as specified in Subclause 51 *e* or 54*g*.

NOTE. The area of the leg of an angle shall be taken as the product of the thickness by the length from the outer corner minus half the thickness, and the area of the leg of a tee as the product of the thickness by the depth minus the thickness of the table.

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

As altered Dec. 1989

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 30*a*.

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	43	≤ 40	180
		>40 but ≤ 100	165
Compound beams composed of rolled sections plated, with thickness of plate	50	≤ 63	230
		>63 but ≤ 100	215
Double channel sections forming a symmetrical I-section which acts as an integral unit	55	≤ 25	280
Plate girders with single or multiple webs	43	≤ 40	170
		>40 but ≤ 100	155
	50	≤ 63	215
		>63 but ≤ 100	200
	55	≤ 25	265
Slab bases	All steels		185

TABLE 3 *a*—ALLOWABLE STRESS p_{bc} IN BENDING (N/mm²) FOR CASE A OF CLAUSE 19*a*(2) FOR GRADE 43 STEEL

l/r_y	D/T									
	5	10	15	20	25	30	35	40	45	50
40	180	180	180	180	180	180	180	180	180	180
45	180	180	180	180	180	180	180	180	180	180
50	180	180	180	180	180	180	180	180	180	180
55	180	180	180	178	176	175	174	174	173	173
60	180	180	176	172	170	169	168	167	167	166
65	180	180	172	167	164	163	162	161	160	160
70	180	177	167	162	159	157	156	155	154	154
75	180	174	163	157	154	151	150	149	148	147
80	180	171	159	153	148	146	144	143	142	141
85	180	168	156	148	143	140	138	137	136	135
90	180	165	152	144	139	135	133	131	130	129
95	180	162	148	140	134	130	127	125	124	123
100	180	160	145	136	129	125	122	119	118	117
105	180	157	142	132	125	120	116	114	112	111
110	180	155	139	128	120	115	111	108	106	105
115	178	152	136	124	116	110	106	103	101	99
120	177	150	133	120	112	106	101	98	96	95
130	174	146	127	113	104	97	94	91	89	88
140	171	142	121	107	97	92	88	85	83	81
150	168	138	116	100	92	87	82	79	77	75
160	166	134	111	96	88	82	77	74	72	70
170	163	130	106	92	84	77	73	69	67	65
180	161	126	102	89	80	73	69	65	63	60
190	158	123	97	85	76	70	65	61	59	56
200	156	119	95	82	73	66	62	58	55	53
210	154	116	92	79	70	63	58	55	52	50
220	151	113	90	77	67	61	56	52	49	47
230	149	110	87	74	65	58	53	49	47	44
240	147	107	85	72	62	56	51	47	44	42
250	145	104	83	69	60	53	48	45	42	40
260	143	101	80	67	58	51	46	43	40	38
270	141	98	78	65	56	49	45	41	38	36
280	139	96	76	63	54	48	43	39	37	35
290	137	94	75	61	52	46	41	38	35	33
300	135	93	73	60	51	44	40	36	34	32