UNIVERSITY OF LONDON

B.Sc. (ENGINEERING EXAMINATION) 1963

PART II

for Internal and External Students

(9) THEORY OF STRUCTURES

Wednesday 12 June: 10 to 1

Answer FIVE questions.

1. Calculate and draw the bending moment and shear force diagrams for the column, shown in Figure 1, which is position-fixed only at the lower end, and position-and-direction-fixed at the upper end. The column is of uniform section throughout. $AB = 15$ ft, $AE = 8$ ft, $AC = 10$ ft and $CD = 2$ ft. CDE is a bracket which is pin-jointed at D and pin-jointed, without directional restraint, to the continuous column at E and C.

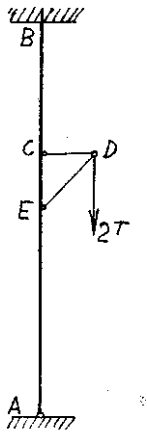

Figure 1

2. A reinforced concrete beam is of rectangular section, 12 in wide by 30 in deep overall. It has five 1 in bars as tensile reinforcement in one layer with 1 in cover and three 1 in bars as compression reinforcement also in one layer with 1 in cover. Find the moment of resistance of the section if the allowable stresses are 1100 and 18 000 lbf/in^2 respectively in concrete and steel, and the modular ratio is 16.

3. Verify the statical determinacy of the symmetrical frame shown in Figure 2, and calculate all the reactions when a load W acts on the upper chord, at a distance x from A, x being less than AC. All inclined bars are of length a and make an angle of 45° with the horizontal. The truss is on rollers at K and F and pinned to the ground at H; all joints are pin-joints. Reactions at K and F can act either upwards or downwards. Explain the situation which would arise in the above case if the distance of H vertically below the horizontal $KJGF$ were altered from $a\sqrt{2}/2$ to $a\sqrt{2}/4$, all other points being unchanged.

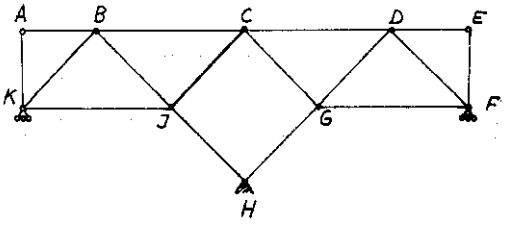

Figure 2

4. A 6 in deep channel beam is connected to a stanchion by being placed with its back to the flange of the stanchion and a $\frac{1}{2}$ in fillet weld run around the edges AB, BC, CD. Find the greatest stress in the weld under the loading shown in Figure 3.

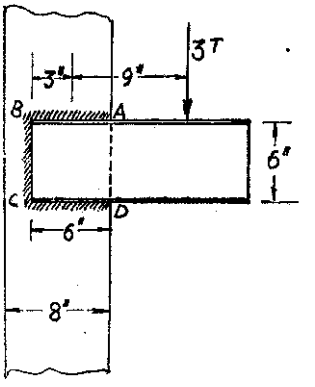

Figure 3

5. Calculate and sketch the bending moment and shear force diagrams for the continuous beam AE shown in Figure 4. The beam is built-in at A; B, C and D are simple supports and all remain at the same level. The beam is of uniform cross section. The distributed load stretches from C to E.

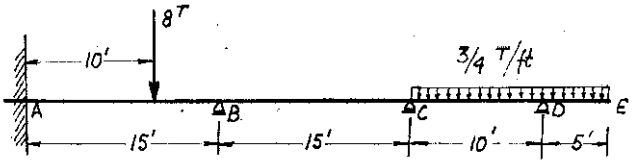

Figure 4

6. The beam shown in Figure 5 is pinned to the ground at A and supported on rollers at B. Draw the influence lines for bending moment at the mid-point of AB and for bending moment at B. Any number of 2 ton concentrated loads will be placed on the beam but they cannot be closer together than 4 ft. Find the worst position of the loads and the greatest values for the bending moments (a) at B and (b) at the mid-point of AB.

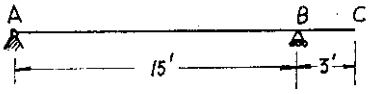

Figure 5

7. The plan of a three-dimensional frame is shown in Figure 6. The members are pinned to the ground at A, B, C and D which are in the horizontal plane. E is a pin-joint 12 ft above ground and F a pin-joint 16 ft above ground. $ABCD$ is a rectangle. Find the forces in all members when a load of 3 tons hangs from E.

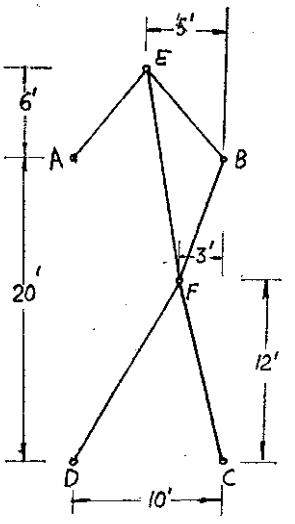

Figure 6

8. Figure 7 shows the section of an angle purlin for which the following have been calculated

$$I_{xx} = 10{\cdot}45 \text{ in}^4$$
$$I_{yy} = 5{\cdot}96 \text{ in}^4$$
$$\bar{x} = 1{\cdot}07 \text{ in}$$
$$\bar{y} = 1{\cdot}57 \text{ in}$$

Find the product moment with reference to the axes xx, yy and hence the position of the principal axes and the values of the principal second moments of area. If the loading is vertically through the centroid, find the neutral axis position.

A construction employing the Mohr circle is permissible.

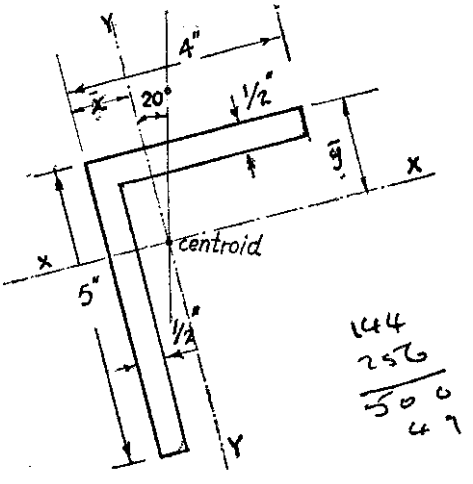

Figure 7

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J. WALKER

For Candidate's Use.

Not to be taken away.

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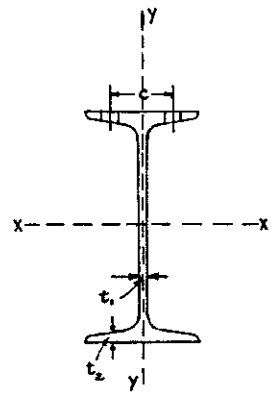
Properties of British Standard Sections

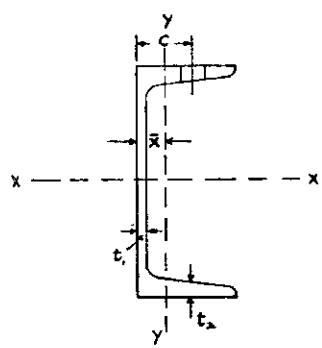
BEAMS

Ref. No.	Size in Inches	Wt./ft. lb.	Thickness		c in.	Area sq. in.	Mom. of Inertia	
			t_1	t_2			XX in.^{4}	YY in.^{4}
N.B.S.B.								
18	$24 \times 7\frac{1}{2}$	90	·52	·984	4·5	26·47	2443	60·44
16	$20 \times 6\frac{1}{2}$	65	·45	·82	3·75	19·12	1226	32·56
15	18×6	55	·42	·757	3·50	16·18	841·8	23·64
14	16×6	50	·40	·726	3·50	14·71	618·1	22·47
13	15×6	45	·38	·655	3·50	13·24	491·9	19·87
12	$14 \times 5\frac{1}{2}$	40	·37	·627	3·25	11·77	377·1	14·79
11	13×5	35	·35	·604	2·75	10·30	283·5	10·82
10	12×5	30	·33	·507	2·75	8·83	206·9	8·77
9	$10 \times 4\frac{1}{2}$	25	·30	·505	2·50	7·35	122·3	6·49
8	9×4	21	·30	·457	2·25	6·18	81·13	4·15
7	8×4	18	·28	·398	2·25	5·30	55·63	3·51
6	$7 \times 3\frac{1}{2}$	15	·25	·398	2·00	4·42	35·90	2·41
5	6×3	12	·23	·377	1·50	3·53	20·99	1·46
N.B.S.H.B.								
7	10×8	55	·40	·783	4·75	16·18	288·7	54·74
6	10×6	40	·36	·709	3·50	11·77	204·8	21·76
5	9×7	50	·40	·825	4·00	14·71	208·1	40·17
4	8×6	35	·35	·648	3·50	10·30	115·1	19·54
3	6×5	25	·33	·561	2·75	7·35	45·2	9·88



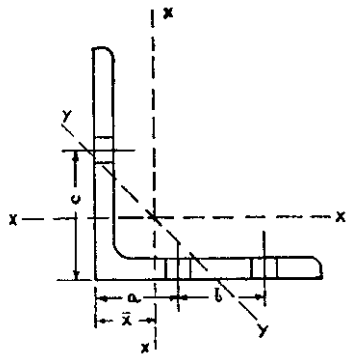
CHANNELS

Ref. No.	Size in Inches	Wt./ft. lb.	Dimensions, ins.			Area sq. in.	Mom. of Inertia		$\bar{x}$ in.
			t_1	t_2	c		XX in.^{4}	YY in.^{4}	
N.B.S.C.									
18	17×4	44·34	·48	·68	$2\frac{1}{4}$	13·04	520·2	15·26	·92
17	15×4	36·37	·41	·62	$2\frac{1}{4}$	10·70	349·1	13·34	·967
16	12×4	31·33	·40	·60	$2\frac{1}{4}$	9·21	200·1	12·12	1·055
15	$12 \times 3\frac{1}{2}$	29·23	·40	·60	2	8·60	180·3	8·44	·901
14	$12 \times 3\frac{1}{2}$	25·35	·35	·50	2	7·43	156·4	7·07	·841
13	$10 \times 3\frac{1}{2}$	24·46	·36	·56	2	7·19	109·5	7·42	·965
12	10×3	19·28	·32	·45	$1\frac{3}{4}$	5·67	82·66	3·98	·742
11	$9 \times 3\frac{1}{2}$	22·27	·34	·54	2	6·55	82·62	6·90	1·003
10	9×3	17·46	·30	·44	$1\frac{3}{4}$	5·14	62·52	3·75	·781
9	$8 \times 3\frac{1}{2}$	20·21	·32	·52	2	5·94	60·57	6·37	1·045
8	8×3	15·96	·28	·44	$1\frac{3}{4}$	4·69	46·72	3·58	·834
7	$7 \times 3\frac{1}{2}$	18·28	·30	·50	2	5·38	42·83	5·83	1·092
6	7×3	14·22	·26	·42	$1\frac{3}{4}$	4·18	32·75	3·26	·875
5	$6 \times 3\frac{1}{2}$	16·48	·28	·48	2	4·85	28·88	5·29	1·143
4	6×3	12·41	·25	·38	$1\frac{3}{4}$	3·65	21·27	2·83	·890



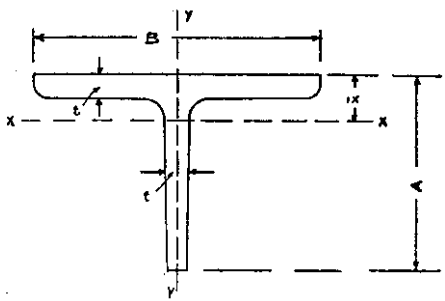
EQUAL ANGLES

Ref. No.	Size in Inches	Wt. /ft. lb.	Dimensions, ins. a	b	c	Area sq. in.	Mom. of Inertia XX in.⁴	YY in.⁴	$\bar{x}$ in.
N.B.S.E.A									
16	9 × 9 × $\frac{3}{4}$	44·0	3	4	..	12·94	99·02	40·42	2·50
15	8 × 8 × $\frac{3}{4}$	38·89	3	3	$4\frac{1}{2}$	11·44	68·58	28·06	2·25
14	6 × 6 × $\frac{5}{8}$	24·17	$2\frac{1}{4}$	$2\frac{1}{4}$	$3\frac{1}{2}$	7·11	23·73	9·74	1·71
13	5 × 5 × $\frac{1}{2}$	16·16	2	$1\frac{3}{4}$	3	4·75	11·04	4·53	1·42
12	4 × 4 × $\frac{1}{2}$	12·75	..	..	$2\frac{1}{4}$	3·75	5·46	2·26	1·17
11	$3\frac{1}{2}$ × $3\frac{1}{2}$ × $\frac{1}{2}$	11·05	..	..	2	3·25	3·57	1·49	1·05
10	3 × 3 × $\frac{3}{8}$	7·17	..	..	$1\frac{3}{4}$	2·11	1·72	·71	·88
9	$2\frac{3}{4}$ × $2\frac{3}{4}$ × $\frac{1}{4}$	4·46	..	..	$1\frac{5}{8}$	1·31	·92	·38	·76
8	$2\frac{1}{2}$ × $2\frac{1}{2}$ × $\frac{1}{4}$	4·04	..	..	$1\frac{3}{8}$	1·19	·68	·28	·70



TEES

Ref. No.	Size in Inches B × A × t	Wt./ft. lb.	Area sq. in.	Mom. of Inertia XX in.⁴	YY in.⁴	$\bar{x}$ in.
N.B.S.T.						
10	6 × 6 × $\frac{1}{2}$	19·62	5·77	19·04	8·56	1·630
9	6 × 4 × $\frac{1}{2}$	16·22	4·77	6·07	8·62	·968
8	5 × 4 × $\frac{1}{2}$	14·50	4·27	5·77	5·02	1·052
6	4 × 3 × $\frac{3}{8}$	8·49	2·50	1·86	1·91	·767
5	3 × 3 × $\frac{3}{8}$	7·20	2·12	1·71	·81	·869
4	$2\frac{1}{2}$ × $2\frac{1}{2}$ × $\frac{1}{4}$	4·07	1·20	·68	·31	·697



T 2533 21/9/50 Sir J. C & S.