

2705/302
2709/302
2710/302
STRUCTURES III
Oct./Nov. 2016
Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL

**DIPLOMA IN BUILDING TECHNOLOGY
DIPLOMA IN ARCHITECTURE**

MODULE III

STRUCTURES III

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:

Answer booklet;

Scientific calculator.

*This paper consists of **EIGHT** questions.*

*Answer any **FIVE** questions.*

All questions carry equal marks.

Maximum marks for each part of a question are as shown.

Candidates should answer the questions in English.

This paper consists of 10 printed pages.

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

1. (a) Define the following terms with respect to timber design:

- (i) applied stress;
- (ii) basic stress;
- (iii) modification factors;
- (iv) strength class.

(4 marks)

(b) A suspended timber floor has joists of size 225 x 75 mm, effective length of 4.3 m and spaced at 450 mm c/c. If the total load due to self weight is 1 kN/m², determine the safe intensity of live load on the floor, considering bending only. Use the following data:

- Grade stress in bending parallel to grain = 5.3 N/mm²
- Load duration K₃ medium term = 1.25
- Load sharing factor K₈ = 1.1
- Depth factor K₇ = 1.04

(16 marks)

2. Using three moment theorem analyse the beam shown in figure 1 and hence draw shear force and bending moment diagrams and indicate values at critical points.

(20 marks)

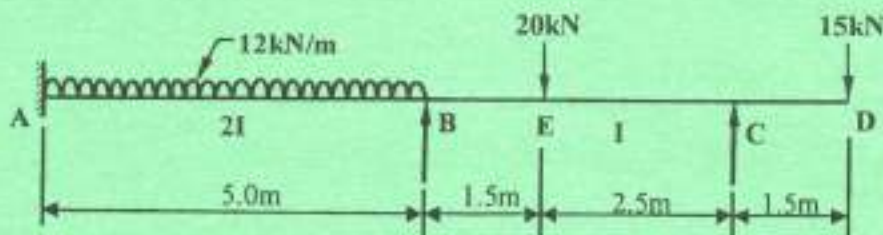


Fig. 1

Handwritten notes:
 $12 \times 5 = 60$
 $20 + 15 = 35$
 $60 + 35 = 95$

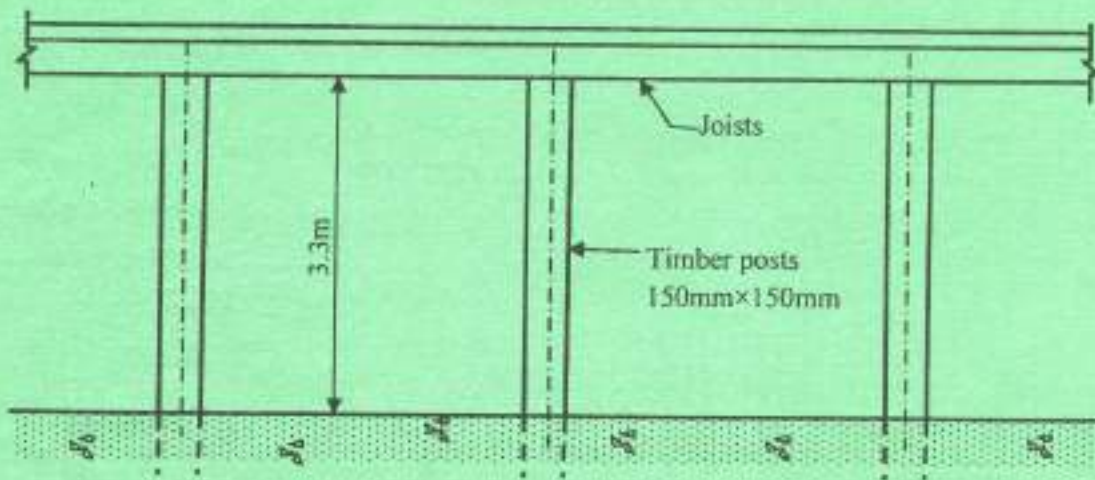
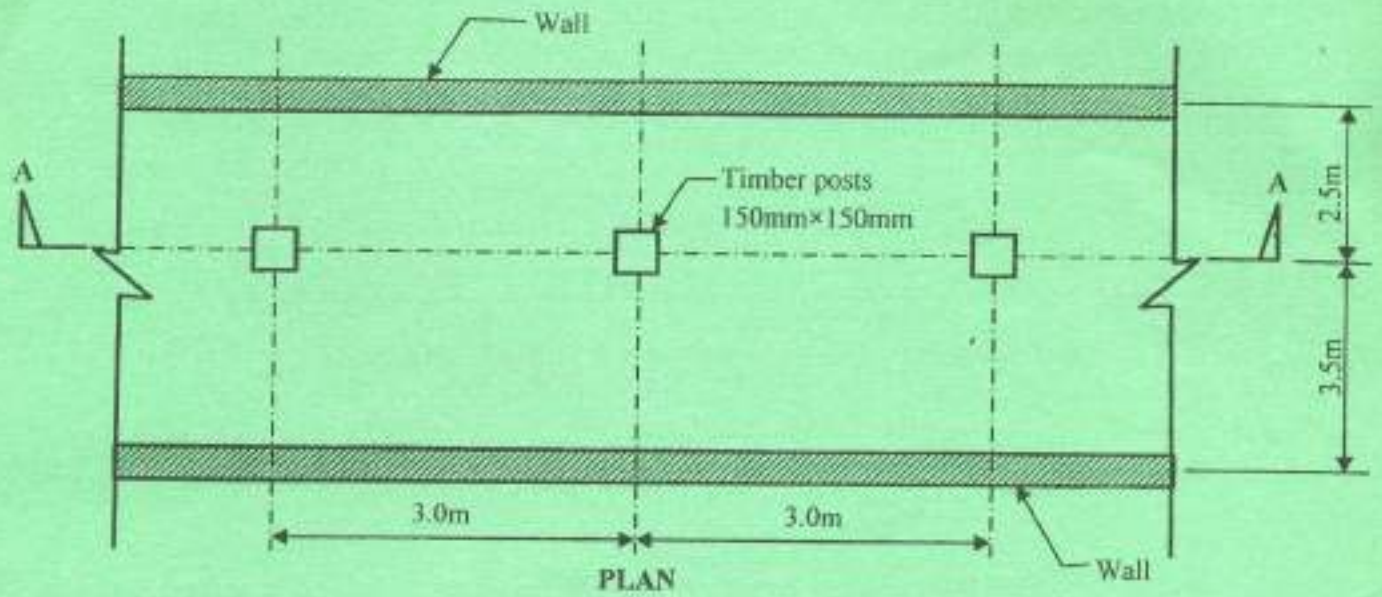
3. (a) State **three** factors which determine the load capacity of a timber post. (3 marks)

(3 marks)

(b) Figure 2 shows layout plan and section of a loaded timber floor supported on timber column posts of size 150 mm x 150 mm. Check the adequacy of the posts under the following conditions:

- columns fixed at the bottom and pinned at the top.
- $E_{mean} = 8800 \text{ N/mm}^2$
- Permissible stress in compression parallel to grain 7.33 n/mm²
- Imposed loads on floor (long term) = 2.5 kN/m².

(17 marks)



SECTION A-A

Fig. 2

2705/302

2709/302

2710/302

Oct/Nov. 2016

4. Using moment distribution method analyse the loaded beam shown in figure 3 and hence draw the shear force and bending moment diagrams showing values at critical points. (20 marks)

NB: Make four distributions only.

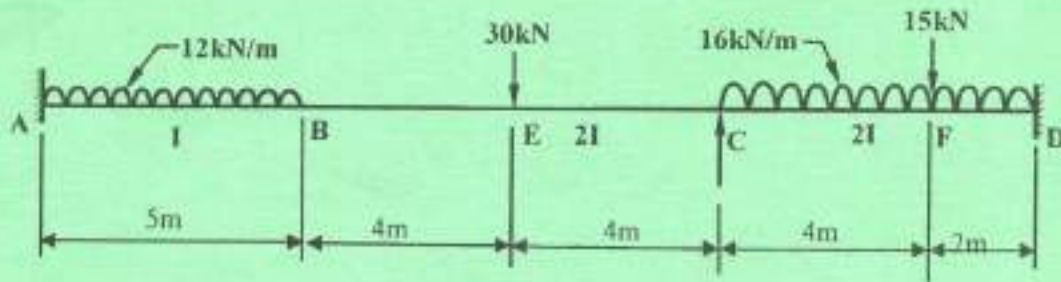


Fig. 3

5. A simply supported floor in a braced industrial frame supports grid flooring and a column as shown in figure 4. Using the design data given, check the suitability of the steel beam with respect to shear and bending. (20 marks)

Data:

- uniformly distributed dead loads (including self weight) = 8 kN/m
- uniformly distributed imposed load = 10 kN/m
- dead load in column = 10 kN
- imposed load in column = 30 kN

max allowable deflection
 $\frac{S_{FD} \times 1000}{360}$ - *number*

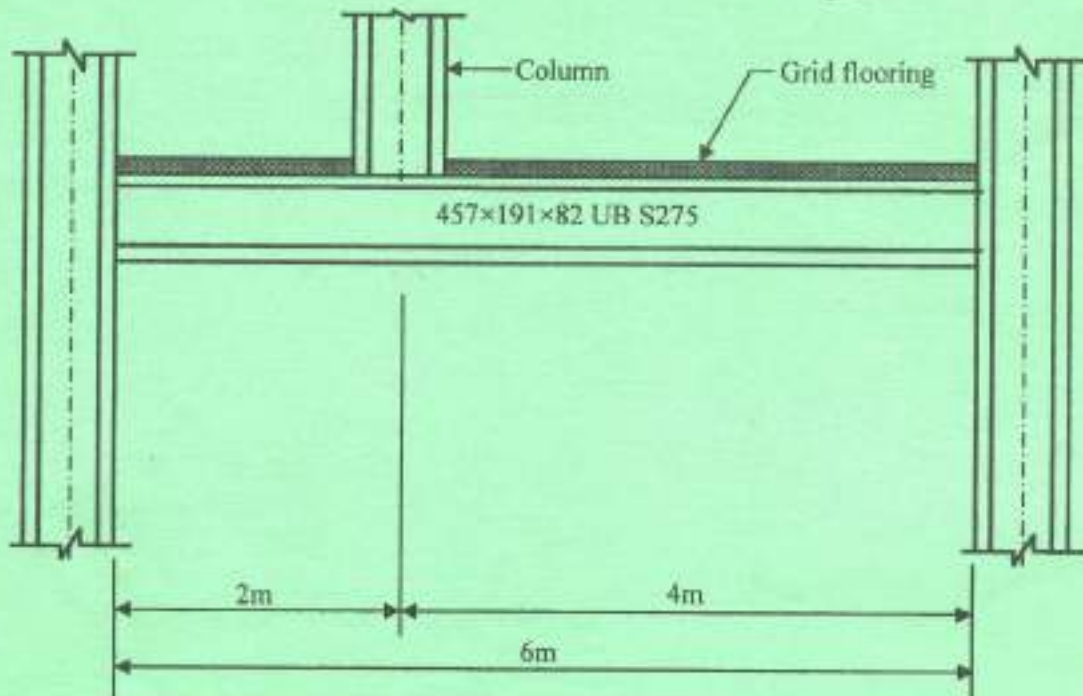


Fig. 4

6. (a) Sketch the influence line diagrams for the reactions at A and B, R_A and R_B for the beam shown in figure 5(a). (6 marks)

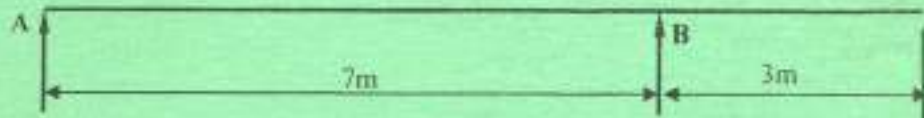


Fig. 5(a)

- (b) Using the influence lines sketched in 6(a) above determine the reactions R_A and R_B when a train of loads as shown in figure 5(b) moves along the beam with the 20 kN load at 3 m from support A. (14 marks)

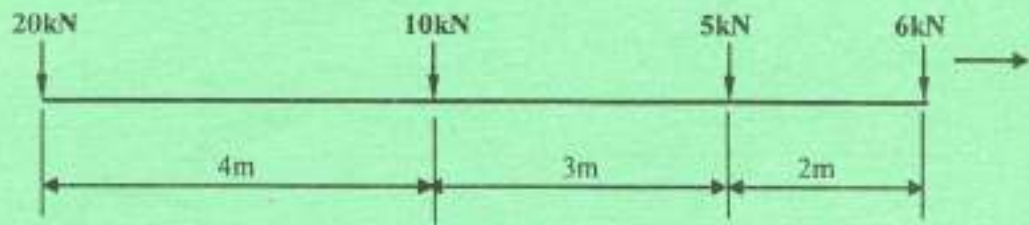


Fig. 5(b)

7. Using moment distribution method analyse the portal frame shown in figure 6 and hence draw the bending moment diagram to show values at critical points. (20 marks)

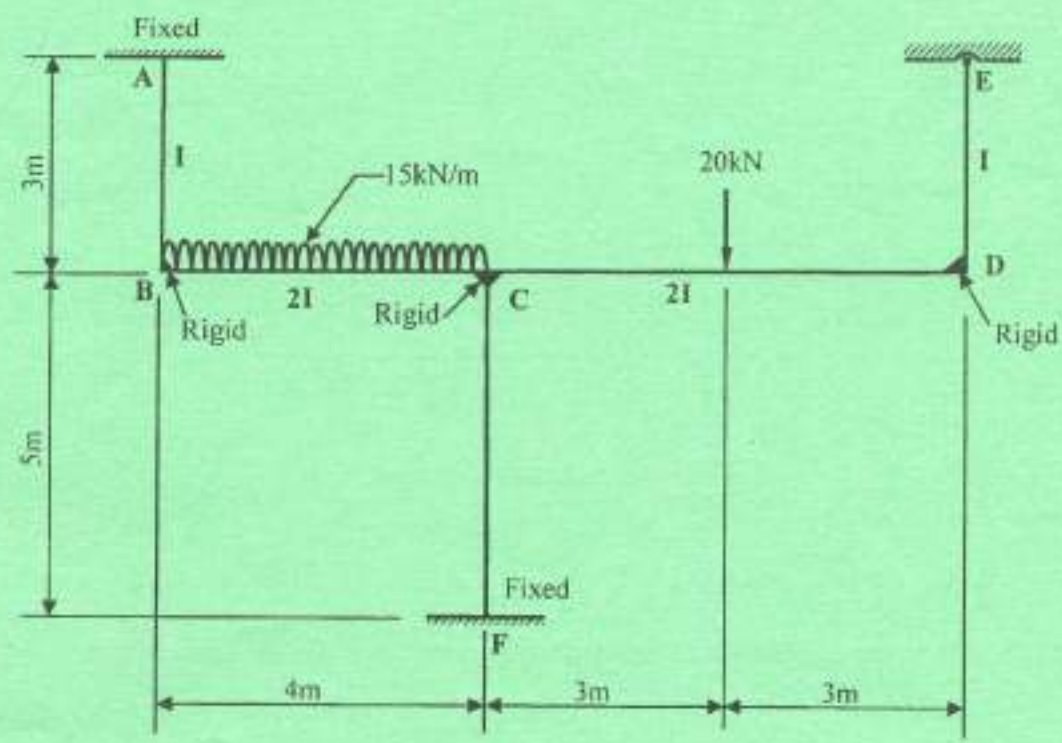


Fig. 6

8. (a) A 100 mm x 25 mm strap is spliced as shown in figure 7. The bolts are 25 mm in diameter. Check the load capacity of the connection with respect to:
- bolt shear;
 - bolt bearing;
 - plate bearing and
 - plate tension capacity.

Take:

- shear strength on bolts (P_s) = 375 N/mm²
- bearing strength (P_{bb}) = 1000 N/mm²
- tension strength P_t = 560 N/mm²

(10 marks)

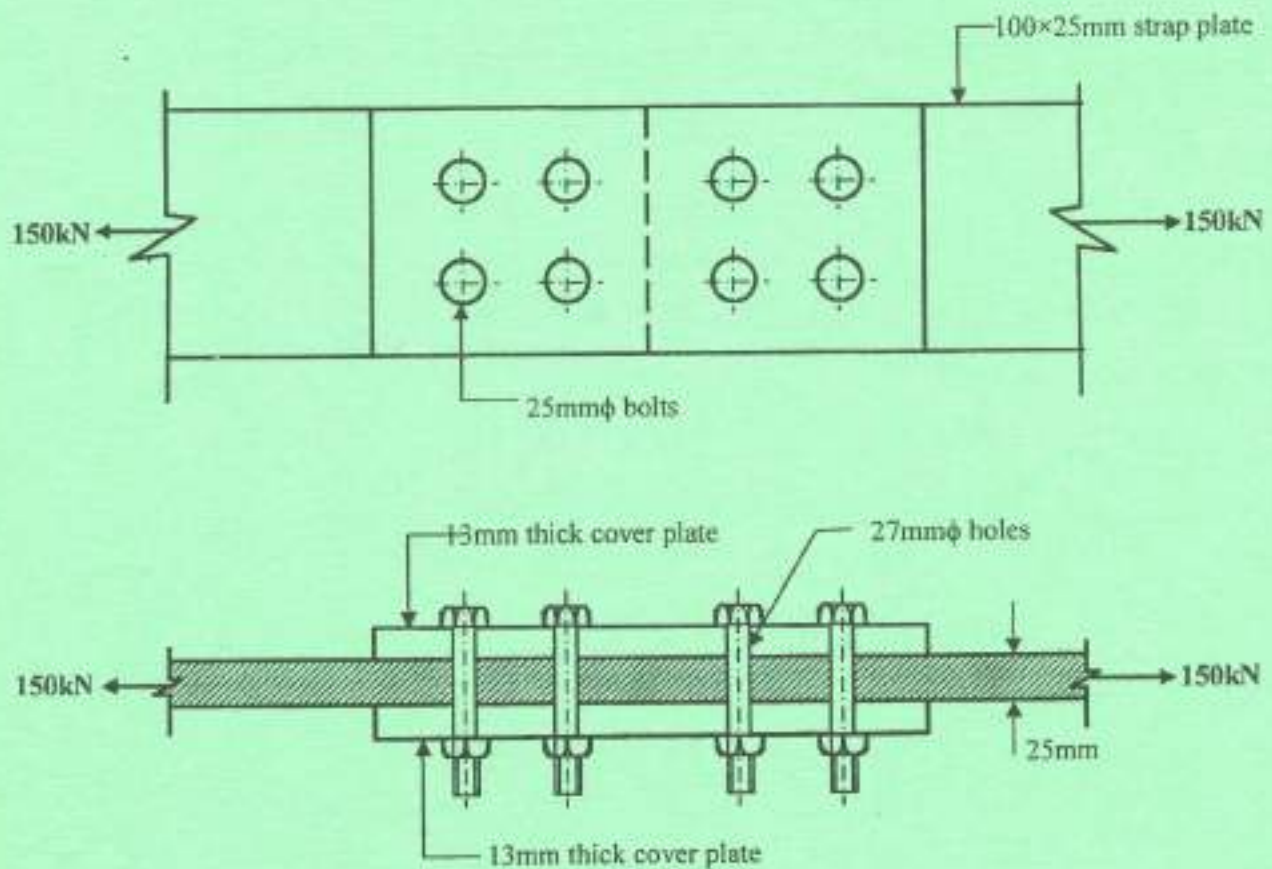


Fig. 7

- (b) State **three** advantages of welded connections over bolted connections. (3 marks)

- (c) Find the length of side fillet welds required for the connection shown in figure 8. The capacity of 6 mm fillet weld = 924 N/mm run. (7 marks)

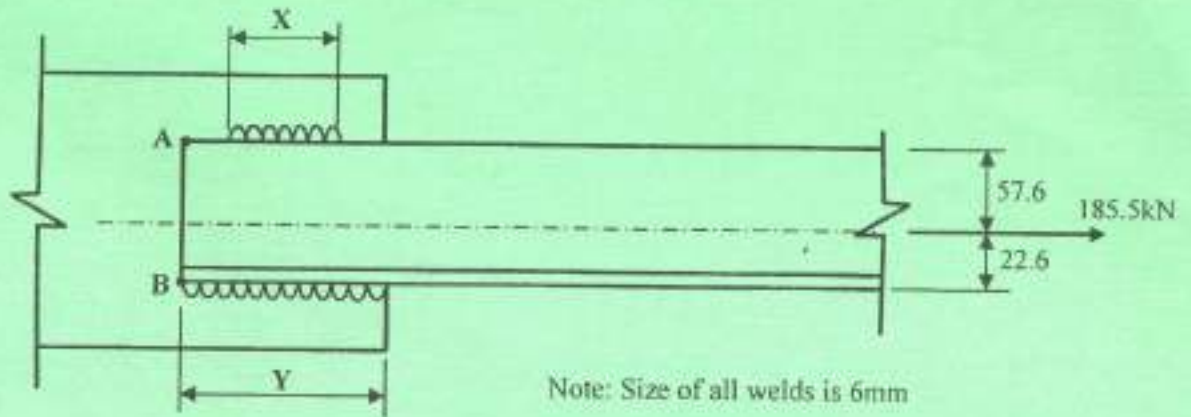
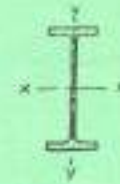


Fig. 8

Modification factor K_{12} for compression members

E (N/mm ²)	Value of K_{12}																				
	Values of slenderness ratio $\lambda = L_e/i$																				
	< 5	5	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	250	
	Equivalent L_e/i (for rectangular sections)																				
	< 1.4	1.4	2.9	5.8	8.7	11.6	14.5	17.3	20.2	23.1	26.0	28.9	34.7	40.5	46.2	52.0	57.8	63.6	69.4	72.3	
400	1.000	0.975	0.951	0.896	0.827	0.735	0.621	0.506	0.408	0.330	0.271	0.225	0.167	0.121	0.094	0.075	0.061	0.051	0.043	0.040	
500	1.000	0.975	0.951	0.899	0.837	0.759	0.664	0.562	0.466	0.385	0.320	0.269	0.195	0.148	0.115	0.092	0.076	0.063	0.053	0.049	
600	1.000	0.975	0.951	0.901	0.843	0.774	0.692	0.601	0.511	0.430	0.363	0.307	0.226	0.172	0.135	0.109	0.089	0.074	0.063	0.058	
700	1.000	0.975	0.951	0.902	0.848	0.784	0.711	0.629	0.545	0.467	0.399	0.341	0.254	0.195	0.154	0.124	0.102	0.085	0.072	0.067	
800	1.000	0.975	0.952	0.903	0.851	0.792	0.724	0.649	0.572	0.497	0.430	0.371	0.280	0.217	0.172	0.139	0.115	0.096	0.082	0.076	
900	1.000	0.975	0.952	0.904	0.853	0.797	0.734	0.665	0.593	0.522	0.456	0.397	0.304	0.237	0.188	0.153	0.127	0.106	0.091	0.084	
1000	1.000	0.976	0.952	0.904	0.855	0.801	0.742	0.677	0.609	0.542	0.478	0.420	0.325	0.255	0.204	0.167	0.138	0.116	0.099	0.092	
1100	1.000	0.976	0.952	0.905	0.856	0.804	0.748	0.687	0.623	0.559	0.497	0.440	0.344	0.272	0.219	0.179	0.149	0.126	0.107	0.100	
1200	1.000	0.976	0.952	0.905	0.857	0.807	0.753	0.695	0.634	0.573	0.513	0.457	0.362	0.288	0.233	0.192	0.160	0.135	0.116	0.107	
1300	1.000	0.976	0.952	0.905	0.858	0.809	0.757	0.701	0.643	0.584	0.527	0.472	0.378	0.303	0.247	0.203	0.170	0.144	0.123	0.115	
1400	1.000	0.976	0.952	0.906	0.859	0.811	0.760	0.707	0.651	0.595	0.539	0.486	0.392	0.317	0.259	0.214	0.180	0.153	0.131	0.122	
1500	1.000	0.976	0.952	0.906	0.860	0.813	0.763	0.712	0.658	0.603	0.550	0.498	0.405	0.330	0.271	0.225	0.189	0.161	0.139	0.129	
1600	1.000	0.976	0.952	0.906	0.861	0.814	0.766	0.716	0.664	0.611	0.559	0.508	0.417	0.342	0.282	0.235	0.198	0.169	0.145	0.135	
1700	1.000	0.976	0.952	0.906	0.861	0.815	0.768	0.719	0.669	0.618	0.567	0.516	0.428	0.353	0.292	0.245	0.207	0.177	0.152	0.142	
1800	1.000	0.976	0.952	0.905	0.862	0.816	0.770	0.722	0.673	0.624	0.574	0.526	0.438	0.363	0.302	0.254	0.215	0.184	0.159	0.148	
1900	1.000	0.976	0.952	0.907	0.862	0.817	0.772	0.726	0.677	0.629	0.581	0.534	0.447	0.373	0.312	0.262	0.223	0.191	0.165	0.154	
2000	1.000	0.976	0.952	0.907	0.863	0.818	0.773	0.728	0.681	0.634	0.587	0.541	0.455	0.382	0.320	0.271	0.230	0.198	0.172	0.160	

UNIVERSAL BEAMS



PROPERTIES

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter λ	Torsional Index λ	Warping Constant H cm ⁶	Torsional Constant J cm ⁴	Area of Section A cm ²
	Axis x-x cm ⁴	Axis y-y cm ⁴	Axis x-x cm	Axis y-y cm	Axis x-x cm ²	Axis y-y cm ²	Axis x-x cm ³	Axis y-y cm ³					
457 x 151 x 95	45700	2350	19.1	4.33	1860	243	2230	379	0.862	25.7	1.18	121	125
457 x 151 x 85	41000	2090	19.0	4.29	1770	218	2010	338	0.879	25.3	1.04	90.7	114
457 x 151 x 82	37100	1870	18.8	4.23	1610	196	1830	304	0.879	32.8	0.922	69.2	104
457 x 151 x 74	33300	1670	18.8	4.20	1490	176	1650	272	0.877	33.8	0.818	51.8	94.8
457 x 151 x 67	29400	1450	18.5	4.12	1300	153	1470	237	0.872	37.9	0.705	37.1	85.5
457 x 152 x 82	36900	1160	18.7	3.37	1570	153	1810	240	0.871	37.4	0.591	89.2	105
457 x 152 x 74	32700	1050	18.6	3.33	1410	136	1630	213	0.873	30.2	0.518	66.9	94.5
457 x 152 x 67	29900	913	18.4	3.27	1260	119	1490	187	0.868	33.6	0.448	47.2	85.8
457 x 152 x 60	25500	795	18.3	3.23	1120	104	1390	163	0.868	37.5	0.387	33.8	75.2
457 x 152 x 52	21400	645	17.9	3.11	950	84.6	1100	133	0.859	43.8	0.311	21.4	66.8
406 x 178 x 74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.8	0.608	62.8	94.5
406 x 178 x 67	24300	1370	16.9	3.99	1190	153	1350	237	0.880	30.5	0.533	46.1	85.3
406 x 178 x 60	21600	1200	16.8	3.97	1060	135	1200	209	0.880	33.8	0.466	33.3	76.5
406 x 178 x 54	18700	1020	16.5	3.85	930	115	1080	178	0.871	38.3	0.392	23.1	69.0
406 x 140 x 46	15700	536	16.4	3.00	778	75.7	889	118	0.872	39.0	0.207	19.0	56.6
406 x 140 x 39	12500	410	15.9	2.87	629	57.8	724	90.9	0.858	47.5	0.155	10.7	49.7
356 x 171 x 67	19500	1360	15.1	3.89	1070	157	1210	243	0.856	24.4	0.412	55.7	85.5
356 x 171 x 57	16000	1110	14.9	3.81	896	129	1010	199	0.862	28.8	0.350	33.4	72.5
356 x 171 x 51	14100	988	14.8	3.85	796	113	896	174	0.861	32.1	0.299	23.8	64.9
356 x 171 x 45	12100	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.6	57.3
356 x 127 x 39	10200	356	14.3	2.98	576	66.8	659	89.1	0.871	35.2	0.105	15.1	49.8
356 x 127 x 33	8250	290	14.0	2.92	473	44.7	543	70.3	0.863	42.2	0.081	8.79	42.1
305 x 165 x 54	11700	1060	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305 x 165 x 46	9900	896	13.0	3.90	648	108	720	166	0.891	27.1	0.195	22.2	58.7
305 x 165 x 40	8500	764	12.9	3.86	560	92.6	623	142	0.889	31.0	0.164	14.7	51.3
305 x 127 x 48	9580	461	12.5	2.74	618	73.6	711	116	0.874	23.3	0.102	31.8	61.2
305 x 127 x 42	8200	389	12.4	2.70	534	62.8	614	98.4	0.872	26.8	0.0846	21.1	53.4
305 x 127 x 37	7170	306	12.3	2.67	471	54.5	539	85.4	0.871	29.7	0.0725	14.8	47.2
305 x 102 x 33	8500	194	12.5	2.15	416	37.9	481	60.0	0.867	31.6	0.0442	12.2	41.8
305 x 102 x 28	6370	158	12.2	2.08	348	30.5	403	48.5	0.863	37.4	0.0349	7.40	35.9
305 x 102 x 25	4480	123	11.9	1.97	292	24.2	340	38.8	0.848	43.4	0.0273	4.77	31.6
254 x 146 x 43	8540	677	10.9	3.52	504	92.0	568	141	0.890	21.2	0.103	23.9	54.8
254 x 146 x 37	5540	571	10.8	3.45	433	78.0	483	119	0.889	24.4	0.0857	15.3	47.2
254 x 146 x 31	4410	448	10.5	3.36	361	61.3	390	94.1	0.879	29.6	0.0660	8.55	39.7
254 x 102 x 28	4010	179	10.5	2.22	308	34.9	353	54.8	0.874	27.5	0.0280	9.57	36.1
254 x 102 x 25	3420	149	10.3	2.15	266	29.2	306	46.0	0.867	31.4	0.0230	6.42	32.0
254 x 102 x 22	2940	119	10.1	2.06	224	23.5	259	37.3	0.856	36.3	0.0182	4.15	29.0
203 x 133 x 30	2900	385	8.71	3.17	280	57.5	314	88.2	0.861	21.5	0.0374	10.3	38.2
203 x 133 x 25	2340	308	8.56	3.10	230	48.2	258	70.9	0.877	25.6	0.0294	5.96	32.0
203 x 102 x 23	2110	164	8.46	2.36	207	32.2	234	49.8	0.868	22.5	0.0154	7.02	29.4
178 x 102 x 18	1360	137	7.48	2.37	153	27.0	171	41.6	0.866	22.6	0.00987	4.41	24.3
152 x 89 x 15	834	89.8	6.41	2.10	109	20.2	123	31.2	0.889	19.6	0.00470	3.56	20.3
127 x 76 x 13	473	55.7	5.35	1.84	74.8	14.7	84.2	22.8	0.896	16.3	0.00199	2.85	16.5

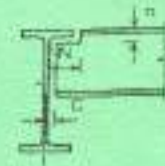
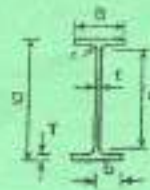
2705/302

2709/302

2710/302

Oct./Nov. 2016

UNIVERSAL BEAMS



DIMENSIONS

Section Designation	Mass per Metre kg/m	Depth of Section D mm	Width of Section B mm	Thickness		Root Radius r mm	Depth between Fllets d mm	Radii for Local Buckling		Dimensions for Drilling			Surface Area	
				Web t mm	Flange T mm			Flange b/T	Web d/t	End Clearance C mm	Notch		Per Metre m ²	Per Tonne m ²
											N mm	n mm		
457 x 191 x 98	98.3	457.2	192.8	11.4	19.6	10.2	407.6	4.92	35.8	5	102	30	1.67	16.9
457 x 191 x 82	82.3	453.4	191.9	10.3	17.7	10.2	407.6	5.42	38.8	7	102	28	1.66	18.5
457 x 191 x 67	67.0	450.0	191.3	9.9	16.0	10.2	407.6	5.99	41.2	7	102	28	1.65	20.1
457 x 191 x 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	5.57	45.3	7	102	28	1.54	22.1
457 x 191 x 57	57.1	453.4	189.9	8.5	12.7	10.2	407.6	7.48	48.0	6	102	24	1.63	24.3
457 x 152 x 82	82.1	455.8	155.3	10.5	18.9	10.2	407.6	4.11	38.8	7	84	30	1.51	18.4
457 x 152 x 74	74.2	452.0	154.4	9.6	17.0	10.2	407.6	4.54	42.5	7	84	28	1.50	20.3
457 x 152 x 67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	5.13	45.3	7	84	28	1.50	22.3
457 x 152 x 60	60.8	454.8	152.5	8.1	13.2	10.2	407.6	5.75	50.3	6	84	24	1.49	24.9
457 x 152 x 52	52.0	449.8	152.4	7.6	10.9	10.2	407.6	6.99	53.6	6	84	22	1.48	28.2
406 x 178 x 74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	5.61	37.9	7	96	28	1.51	20.3
406 x 178 x 67	67.1	409.4	176.8	8.8	14.3	10.2	360.4	6.25	41.0	6	96	26	1.50	22.3
406 x 178 x 60	60.1	405.4	177.9	7.9	12.9	10.2	360.4	6.95	45.6	6	96	24	1.49	24.8
406 x 178 x 54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	48.8	6	96	22	1.48	27.4
406 x 140 x 48	48.0	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53.0	5	78	22	1.34	29.2
406 x 140 x 39	39.0	396.0	141.8	6.4	9.6	10.2	360.4	8.24	56.3	5	78	20	1.33	34.2
356 x 171 x 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	7	94	26	1.36	20.8
356 x 171 x 57	57.0	368.0	172.2	8.1	13.0	10.2	311.6	6.62	38.5	6	94	24	1.37	24.1
356 x 171 x 51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	7.46	42.1	6	94	22	1.36	26.7
356 x 171 x 45	45.0	361.4	171.1	7.0	9.7	10.2	311.6	8.90	44.5	6	94	20	1.36	30.1
356 x 127 x 39	39.1	353.4	126.0	6.8	10.7	10.2	311.6	5.89	47.2	5	70	22	1.18	30.2
356 x 127 x 33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	7.38	51.9	5	70	20	1.17	35.4
305 x 165 x 54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	6	90	24	1.26	23.3
305 x 165 x 46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.8	5	90	22	1.25	27.1
305 x 165 x 40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	8.09	44.2	5	90	20	1.24	30.8
305 x 127 x 48	48.1	311.0	125.3	9.0	14.0	8.9	265.2	4.47	29.5	7	70	24	1.08	22.7
305 x 127 x 42	41.9	307.2	124.3	8.0	12.1	8.9	265.2	5.14	33.1	6	70	22	1.08	25.8
305 x 127 x 37	37.0	304.4	123.4	7.1	10.7	8.9	265.2	5.77	37.4	6	70	20	1.07	29.0
305 x 102 x 33	32.8	312.7	102.4	6.4	10.8	7.6	275.9	4.74	41.8	5	58	20	1.01	33.8
305 x 102 x 28	28.2	308.7	101.9	6.0	8.8	7.6	275.9	5.78	46.0	5	58	18	1.00	35.4
305 x 102 x 25	24.8	305.1	101.5	5.8	7.0	7.6	275.9	7.26	47.8	5	58	16	0.992	40.0
254 x 148 x 43	43.0	259.6	147.3	7.2	12.7	7.6	219.0	5.80	39.4	6	82	22	1.08	25.1
254 x 148 x 37	37.0	256.0	146.4	6.3	10.9	7.6	219.0	6.72	34.8	5	82	20	1.07	29.0
254 x 148 x 31	31.1	251.4	146.1	6.0	8.8	7.6	219.0	8.49	38.5	5	82	18	1.06	34.2
254 x 102 x 28	28.3	260.4	102.2	6.3	10.0	7.6	225.2	5.11	35.7	5	58	18	0.904	31.9
254 x 102 x 25	25.2	257.2	101.9	6.0	8.4	7.6	225.2	6.07	37.5	5	58	16	0.897	35.6
254 x 102 x 22	22.0	254.0	101.8	5.7	6.8	7.6	225.2	7.47	39.5	5	58	16	0.890	40.3
203 x 130 x 30	30.6	206.8	133.9	6.4	9.6	7.6	172.4	6.97	26.9	5	74	18	0.923	30.8
203 x 130 x 25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	8.54	30.2	5	74	18	0.915	36.4
203 x 102 x 23	23.1	203.2	101.8	5.4	9.3	7.6	169.4	5.47	31.4	5	60	18	0.790	34.2
178 x 102 x 19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	4	60	18	0.738	38.8
152 x 69 x 10	10.0	152.4	68.7	4.5	7.7	7.6	121.8	5.76	27.1	4	54	16	0.638	39.8
127 x 79 x 13	13.0	127.0	76.0	4.0	7.6	7.6	96.8	9.00	24.1	4	46	16	0.537	41.3

THIS IS THE LAST PRINTED PAGE.

2705/302

2709/302

2710/302

Oct/Nov. 2016