2707/302
STRUCTURES III
Oct./Nov. 2022
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN CIVIL ENGINEERING

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 indicated.
Relevant design tables are attached.
Candidates should answer the questions in English.

This paper consists of 11 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) A simply supported beam of effective span 8 m supports unfactored loads of shown in **figure 1**.

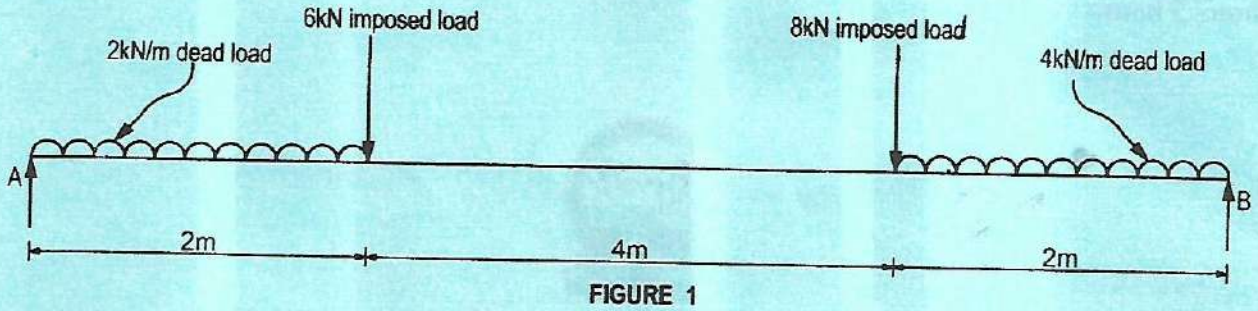

FIGURE 1

Assuming that the beam is fully laterally restrained, select a suitable universal beam section in grade 43 (S 275) steel to satisfy shear and bending. Ignore the self weight of the beam.

(20 marks)

2. **Figure 2** shows a loaded timber truss.

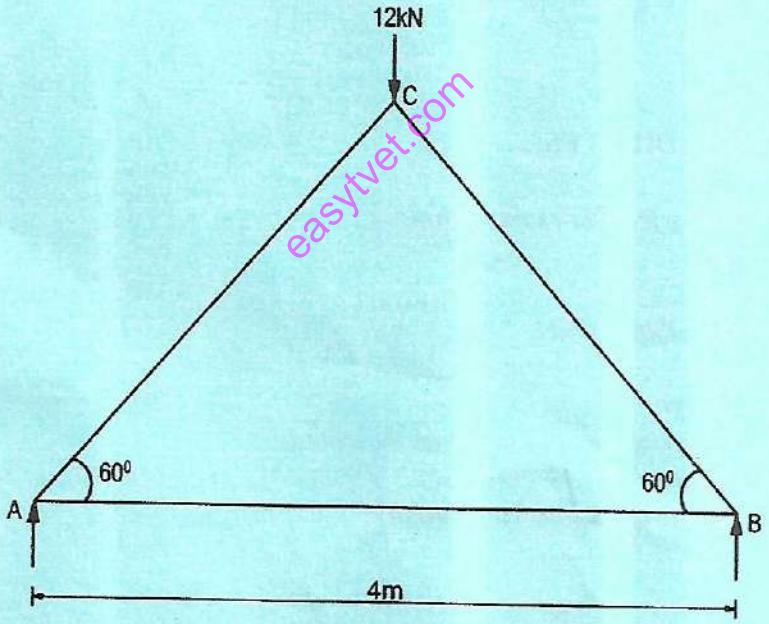

FIGURE 2

Design suitable rectangular timber sections for members AB and AC in softwood timber of strength class C16. Check for buckline and slenderness, assuming that all joints are pinned.
Take: All modification factors as 1.0.
d = 2b

(20 marks)

3. Using the three moments theorem, analyze the beam shown in **figure 3** and hence sketch the bending moment diagram, indicating the values at all critical points. (20 marks)

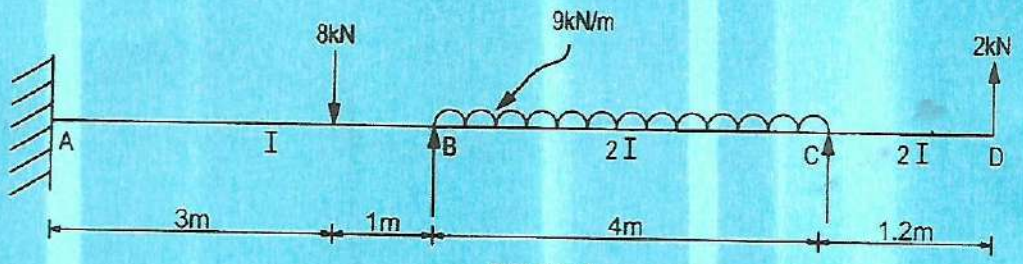

FIGURE 3

4. Analyze the beam shown in **figure 4** using the moment distribution method and hence sketch the bending moment diagram, indicating the values at all critical points. (20 marks)

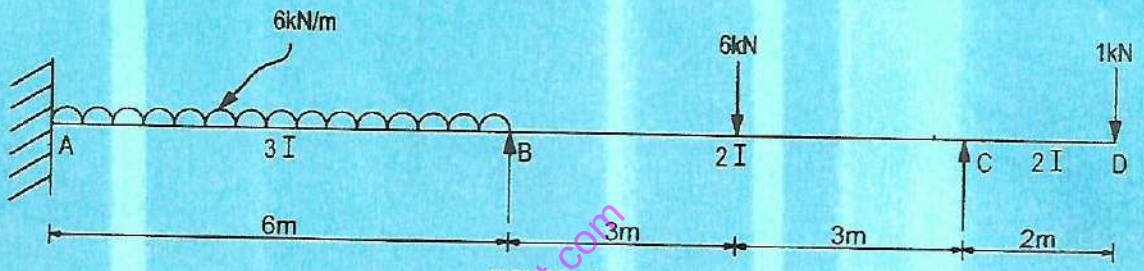

FIGURE 4

5. A strut with an overall length of 3.6 m, is pinned at both ends and used to transmit a load. Using Euler's formula, calculate the critical load that the strut can bear if it has a cross section as shown in **figure 5**. $E = 200\ kN/mm^2$ (20 marks)

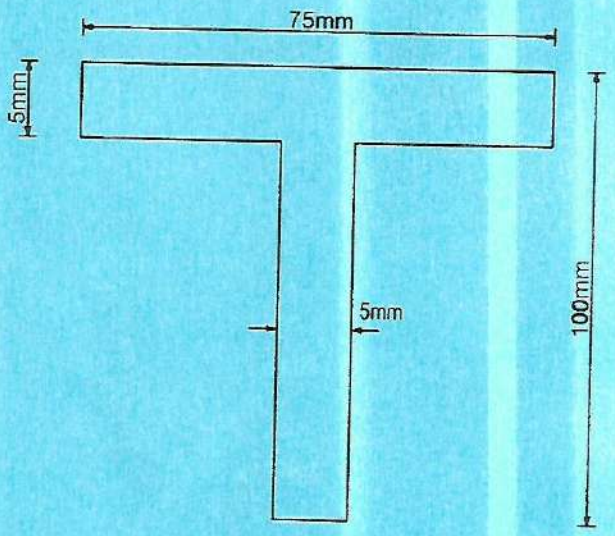

FIGURE 5

6. A rectangular part foundation supports an eccentric vertical load of 800 kN as shown in **figure 6.**

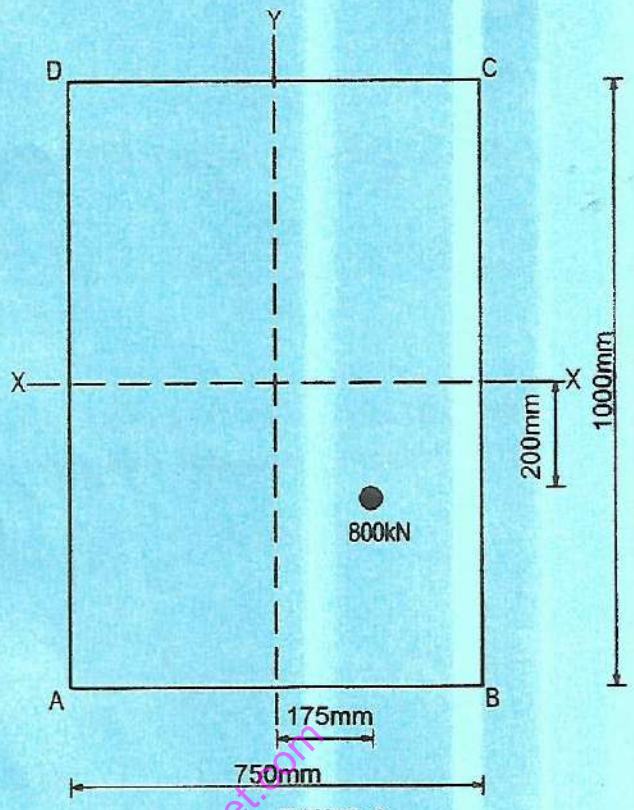

FIGURE 6

(a) Determine the stresses at each corner of the pad foundation. (14 marks)

(b) Calculate the maximum eccentricities about both axes if no tension is to develop anywhere in the foundation. (3 marks)

(c) Using a sketch, show the limits of eccentricity on the foundation. (3 marks)

7. **Figure 7** shows a simply supported beam having a hinge in one span.

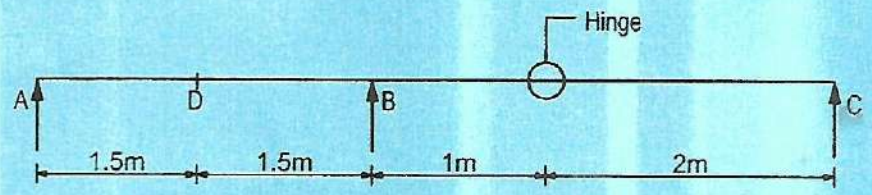

FIGURE 7

Draw the influence line diagrams for each of the following components

(i) reaction at A, B and C;

(ii) shear force at D;

(iii) bending moments at D.

(20 marks)

8. (a) A softwood timber tie, whose ends are held in position, transmits an axial force pf 15 kN. Design a suitble rectangular section of strength class C16 and check for buckling.
Modification factors: $K_2 = 0.8$
$K_3 = 1.0$

(10 marks)

(b) A 203 x 203 x 52 kg/m universal column of grade S275 steel and effective length 4.2 m carries a factored axial load of 800 kN. Check the adequancy of the column.

(10 marks)

6. A rectangular part foundation supports an eccentric vertical load of 800 kN as shown in **figure 6.**

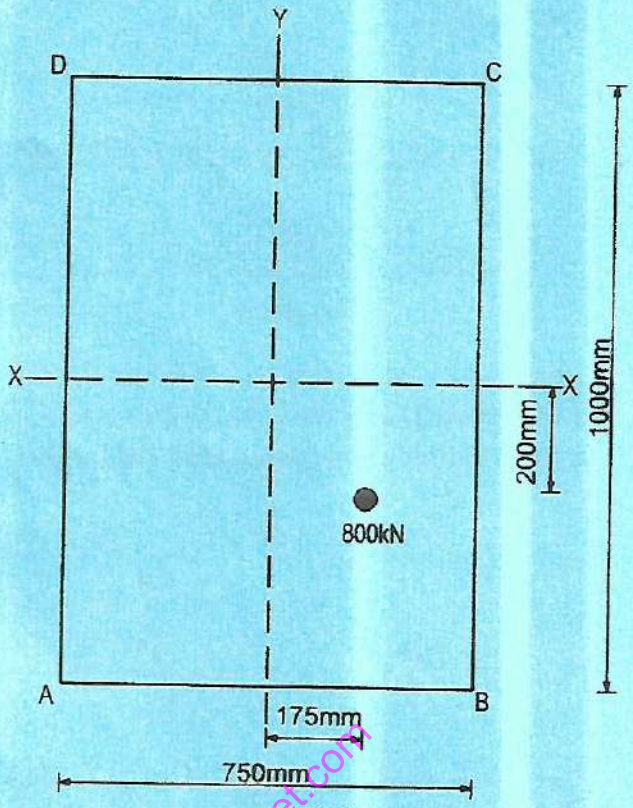

FIGURE 6

(a) Determine the stresses at each corner of the pad foundation. (14 marks)

(b) Calculate the maximum eccentricities about both axes if no tension is to develop anywhere in the foundation. (3 marks)

(c) Using a sketch, show the limits of eccentricity on the foundation. (3 marks)

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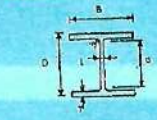
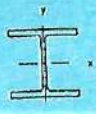
BS 5950-1: 2000
BS 4-1: 1993





Section 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	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				
		D	B	t	T	r	d	b/T	d/t									u	x	H	A
	kg/m	mm	mm	mm	mm	mm	mm			cm⁴	cm⁴	cm	cm	cm³	cm³	cm³	cm³			dm⁶	cm²
356x406x634	633.9	474.6	424	47.6	77	15.2	290.2	2.75	6.1	275000	98100	18.4	11	11600	4630	14200	7110	0.843	5.46	38.8	808
356x406x551	551	455.6	418.5	42.1	67.5	15.2	290.2	3.1	6.89	227000	82700	18	10.9	9960	3950	12100	6060	0.841	6.05	31.1	702
356x406x467	467	436.6	412.2	35.8	58	15.2	290.2	3.55	8.11	183000	67800	17.5	10.7	8380	3290	10000	5030	0.839	6.86	24.3	595
356x406x393	393	419	407	30.6	49.2	15.2	290.2	4.14	9.48	147000	55400	17.1	10.5	7000	2720	8220	4150	0.837	7.86	18.9	501
356x406x340	339.9	406.4	403	26.6	42.9	15.2	290.2	4.7	10.9	123000	46900	16.8	10.4	6030	2330	7000	3540	0.836	8.85	15.5	433
356x406x287	287.1	393.6	399	22.6	36.5	15.2	290.2	5.47	12.8	99900	38700	16.5	10.3	5070	1940	5810	2950	0.835	10.2	12.3	366
356x406x235	235.1	381	394.8	18.4	30.2	15.2	290.2	6.54	15.8	79100	31000	16.3	10.2	4150	1570	4690	2380	0.834	12.1	9.54	299
356x368x202	201.9	374.6	374.7	16.5	27	15.2	290.2	6.94	17.6	66300	23700	16.1	9.6	3540	1260	3970	1920	0.844	13.4	7.16	257
356x368x177	177	368.2	372.6	14.4	23.8	15.2	290.2	7.83	20.2	57100	20500	15.9	9.54	3100	1100	3460	1670	0.844	15	6.09	226
356x368x153	152.9	362	370.5	12.3	20.7	15.2	290.2	8.95	23.6	48600	17600	15.8	9.49	2680	948	2960	1430	0.844	17	5.11	195
356x368x129	129	355.6	368.6	10.4	17.5	15.2	290.2	10.5	27.9	40200	14600	15.6	9.43	2260	793	2480	1200	0.844	19.9	4.18	164
305x305x283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.65	9.21	78900	24600	14.8	8.27	4320	1530	5110	2340	0.865	7.65	6.35	360
305x305x240	240	352.5	318.4	23	37.7	15.2	246.7	4.22	10.7	64200	20300	14.5	8.15	3640	1280	4250	1950	0.854	8.74	5.03	306
305x305x198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	5.01	12.9	50900	16300	14.2	8.04	3000	1040	3440	1580	0.854	10.2	3.88	252
305x305x158	158.1	327.1	311.2	15.8	25	15.2	246.7	6.22	15.6	38700	12600	13.9	7.9	2370	808	2680	1230	0.851	12.5	2.87	201
305x305x137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	7.12	17.9	32800	10700	13.7	7.83	2050	692	2300	1050	0.851	14.2	2.39	174
305x305x118	117.9	314.5	307.4	12	18.7	15.2	246.7	8.22	20.6	27700	9060	13.6	7.77	1760	589	1960	895	0.85	16.2	1.98	150
305x305x97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	9.91	24.9	22200	7310	13.4	7.69	1450	479	1590	726	0.85	19.3	1.56	123
254x254x167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	4.18	10.4	30000	9870	11.9	6.81	2080	744	2420	1140	0.851	8.49	1.63	213
254x254x132	132	276.3	261.3	15.3	25.3	12.7	200.3	5.16	13.1	22500	7530	11.6	6.69	1630	576	1870	878	0.85	10.3	1.19	169
254x254x107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	6.31	15.6	17500	5930	11.3	6.59	1310	458	1480	697	0.848	12.4	0.898	136
254x254x89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	7.41	19.4	14300	4860	11.2	6.55	1100	379	1220	575	0.85	14.5	0.717	113
254x254x73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	8.96	23.3	11400	3910	11.1	6.48	898	307	992	465	0.849	17.3	0.562	93.1
203x203x86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	5.1	12.7	9450	3130	9.28	5.34	850	299	977	459	0.85	10.2	0.318	110
203x203x71	71	215.8	206.4	10	17.3	10.2	160.8	5.97	16.1	7620	2540	9.18	5.3	706	246	799	374	0.853	11.9	0.25	90.4
203x203x60	60	209.6	205.8	9.4	14.2	10.2	160.8	7.25	17.1	6120	2060	8.98	5.2	584	201	656	305	0.846	14.1	0.197	76.4
203x203x52	52	206.2	204.3	7.9	12.5	10.2	160.8	8.17	20.4	5260	1780	8.91	5.18	510	174	567	264	0.848	15.8	0.167	66.3
203x203x46	46.1	203.2	203.6	7.2	11	10.2	160.8	9.25	22.3	4570	1550	8.82	5.13	450	152	497	231	0.847	17.7	0.143	58.7
152x152x37	37	161.8	154.4	8	11.5	7.6	123.6	6.71	15.5	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.3	0.04	47.1
152x152x30	30	157.6	152.9	6.5	9.4	7.6	123.6	8.13	19	1750	560	6.78	3.83	222	73.3	248	112	0.849	16	0.031	38.3
152x152x23	23	152.4	152.2	5.8	6.8	7.6	123.6	11.2	21.3	1250	400	6.54	3.7	164	52.6	182	80.1	0.84	20.7	0.021	29.2

Table 24 — Compressive strength p_c (N/mm²) (*continued*)

5) Values of p_c (N/mm²) with $\lambda < 110$ for strut curve c															
λ	Steel grade and design strength p_y (N/mm²)														
	S 275					S 355					S 460				
	235	245	255	265	275	315	325	335	345	355	400	410	430	440	460
15	235	245	255	265	275	315	325	335	345	355	398	408	427	436	455
20	233	242	252	261	271	308	317	326	336	345	387	396	414	424	442
25	226	235	245	254	263	299	308	317	326	335	375	384	402	410	428
30	220	228	237	246	255	289	298	307	315	324	363	371	388	396	413
35	213	221	230	238	247	280	288	296	305	313	349	357	374	382	397
40	206	214	222	230	238	270	278	285	293	301	335	343	358	365	380
42	203	211	219	227	235	266	273	281	288	296	329	337	351	358	373
44	200	208	216	224	231	261	269	276	284	291	323	330	344	351	365
46	197	205	213	220	228	257	264	271	279	286	317	324	337	344	357
48	195	202	209	217	224	253	260	267	274	280	311	317	330	337	349
50	192	199	206	213	220	248	255	262	268	275	304	310	323	329	341
52	189	196	203	210	217	244	250	257	263	270	297	303	315	321	333
54	186	193	199	206	213	239	245	252	258	264	291	296	308	313	324
56	183	189	196	202	209	234	240	246	252	258	284	289	300	305	315
58	179	186	192	199	205	229	235	241	247	252	277	282	292	297	306
60	176	183	189	195	201	225	230	236	241	247	270	274	284	289	298
62	173	179	185	191	197	220	225	230	236	241	262	267	276	280	289
64	170	176	182	188	193	215	220	225	230	235	255	260	268	272	280
66	167	173	178	184	189	210	215	220	224	229	248	252	260	264	271
68	164	169	175	180	185	205	210	214	219	223	241	245	252	256	262
70	161	166	171	176	181	200	204	209	213	217	234	238	244	248	254
72	157	163	168	172	177	195	199	203	207	211	227	231	237	240	246
74	154	159	164	169	173	190	194	198	202	205	220	223	229	232	238
76	151	156	160	165	169	185	189	193	196	200	214	217	222	225	230
78	148	152	157	161	165	180	184	187	191	194	207	210	215	217	222
80	145	149	153	157	161	176	179	182	185	188	201	203	208	210	215
82	142	146	150	154	157	171	174	177	180	183	195	197	201	203	207
84	139	142	146	150	154	167	169	172	175	178	189	191	195	197	201
86	135	139	143	146	150	162	165	168	170	173	183	185	189	190	194
88	132	136	139	143	146	158	160	163	165	168	177	179	183	184	187
90	129	133	136	139	142	153	156	158	161	163	172	173	177	178	181
92	126	130	133	136	139	149	152	154	156	158	166	168	171	173	175
94	124	127	130	133	135	145	147	149	151	153	161	163	166	167	170
96	121	124	127	129	132	141	143	145	147	149	156	158	160	162	164
98	118	121	123	126	129	137	139	141	143	145	151	153	155	157	159
100	115	118	120	123	125	134	135	137	139	140	147	148	151	152	154
102	113	115	118	120	122	130	132	133	135	136	143	144	146	147	149
104	110	112	115	117	119	126	128	130	131	133	138	139	142	142	144
106	107	110	112	114	116	123	125	126	127	129	134	135	137	138	140
108	105	107	109	111	113	120	121	123	124	125	130	131	133	134	136

Table 24 — Compressive strength p_c (N/mm²) (*continued*)

3) Values of p_c (N/mm²) with λ < 110 for strut curve b															
λ	Steel grade and design strength p_y (N/mm²)														
	S 275					S 355					S 460				
	235	245	255	265	275	315	325	335	345	355	400	410	430	440	460
15	235	245	255	265	275	315	325	335	345	355	399	409	428	438	457
20	234	243	253	263	272	310	320	330	339	349	391	401	420	429	448
25	229	239	248	258	267	304	314	323	332	342	384	393	411	421	439
30	225	234	243	253	262	298	307	316	325	335	375	384	402	411	429
35	220	229	238	247	256	291	300	309	318	327	366	374	392	400	417
40	216	224	233	241	250	284	293	301	310	318	355	364	380	388	404
42	213	222	231	239	248	281	289	298	306	314	351	359	375	383	399
44	211	220	228	237	245	278	286	294	302	310	346	354	369	377	392
46	209	218	226	234	242	275	283	291	298	306	341	349	364	371	386
48	207	215	223	231	239	271	279	287	294	302	336	343	358	365	379
50	205	213	221	229	237	267	275	283	290	298	330	337	351	358	372
52	203	210	218	226	234	264	271	278	286	293	324	331	344	351	364
54	200	208	215	223	230	260	267	274	281	288	318	325	337	344	356
56	198	205	213	220	227	256	263	269	276	283	312	318	330	336	347
58	195	202	210	217	224	252	258	265	271	278	305	311	322	328	339
60	193	200	207	214	221	247	254	260	266	272	298	304	314	320	330
62	190	197	204	210	217	243	249	255	261	266	291	296	306	311	320
64	187	194	200	207	213	238	244	249	255	261	284	289	298	302	311
66	184	191	197	203	210	233	239	244	249	255	276	281	289	294	301
68	181	188	194	200	206	228	233	239	244	249	269	273	281	285	292
70	178	185	190	196	202	223	228	233	238	242	261	265	272	276	282
72	175	181	187	193	198	218	223	227	232	236	254	257	264	267	273
74	172	178	183	189	194	213	217	222	226	230	246	249	255	258	264
76	169	175	180	185	190	208	212	216	220	223	238	241	247	250	255
78	166	171	176	181	186	203	206	210	214	217	231	234	239	241	246
80	163	168	172	177	181	197	201	204	208	211	224	226	231	233	237
82	160	164	169	173	177	192	196	199	202	205	217	219	223	225	229
84	156	161	165	169	173	187	190	193	196	199	210	212	216	218	221
86	153	157	161	165	169	182	185	188	190	193	203	205	208	210	213
88	150	154	158	161	165	177	180	182	185	187	196	198	201	203	206
90	146	150	154	157	161	172	175	177	179	181	190	192	195	196	199
92	143	147	150	153	156	167	170	172	174	176	184	185	188	189	192
94	140	143	147	150	152	162	165	167	169	171	178	179	182	183	185
96	137	140	143	146	148	158	160	162	164	165	172	173	176	177	179
98	134	137	139	142	145	153	155	157	159	160	167	168	170	171	173
100	130	133	136	138	141	149	151	152	154	155	161	162	164	165	167
102	127	130	132	135	137	145	146	148	149	151	156	157	159	160	162
104	124	127	129	131	133	141	142	144	145	146	151	152	154	155	156
106	121	124	126	128	130	137	138	139	141	142	147	148	149	150	151
108	118	121	123	125	126	133	134	135	137	138	142	143	144	145	147

Table 23 — Allocation of strut curve

Type of section	Maximum thickness (see note 1)	Axis of buckling	
		x-x	y-y
Hot-finished structural hollow section		a)	a)
Cold-formed structural hollow section		c)	c)
Rolled I-section	≤40 mm	a)	b)
	>40 mm	b)	c)
Rolled H-section	≤40 mm	b)	c)
	>40 mm	c)	d)
Welded I or H-section (see note 2 and 4.7.5)	≤40 mm	b)	c)
	>40 mm	b)	d)
Rolled I-section with welded flange cover plates with $0.25 < U/B < 0.8$ as shown in Figure 14a)	≤40 mm	a)	b)
	>40 mm	b)	c)
Rolled H-section with welded flange cover plates with $0.25 < U/B < 0.8$ as shown in Figure 14a)	≤40 mm	b)	c)
	>40 mm	c)	d)
Rolled I or H-section with welded flange cover plates with $U/B \geq 0.8$ as shown in Figure 14b)	≤40 mm	b)	a)
	>40 mm	c)	b)
Rolled I or H-section with welded flange cover plates with $U/B \leq 0.25$ as shown in Figure 14c)	≤40 mm	b)	c)
	>40 mm	b)	d)
Welded box section (see note 3 and 4.7.5)	≤40 mm	b)	b)
	>40 mm	c)	c)
Round, square or flat bar	≤40 mm	b)	b)
	>40 mm	c)	c)
Rolled angle, channel or T-section		Any axis: c)	
Two rolled sections laced, battened or back-to-back			
Compound rolled sections			

NOTE 1 For thicknesses between 40 mm and 50 mm the value of p_c may be taken as the average of the values for thicknesses up to 40 mm and over 40 mm for the relevant value of p_y.

NOTE 2 For welded I or H-sections with their flanges thermally cut by machine without subsequent edge grinding or machining, for buckling about the y-y axis, strut curve b) may be used for flanges up to 40 mm thick and strut curve c) for flanges over 40 mm thick.

NOTE 3 The category "welded box section" includes any box section fabricated from plates or rolled sections, provided that all of the longitudinal welds are near the corners of the cross-section. Box sections with longitudinal stiffeners are NOT included in this category.

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 [a]		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

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

[a] 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.

Table 11 — Limiting width-to-thickness ratios for sections other than CHS and RHS

Compression element			Ratio[a]	Limiting value[b]		
				Class 1 plastic	Class 2 compact	Class 3 semi-compact
Outstand element of compression flange		Rolled section	b/T	9E	10E	15E
		Welded section	b/T	8E	9E	13E
Internal element of compression flange		Compression due to bending	b/T	28E	32E	40E
		Axial compression	b/T	Not applicable		
Web of an I-, H- or box section[c]	Neutral axis at mid-depth		d/t	80E	100E	120E
	Generally[d]	If r_1 is negative:	d/t	$\frac{80E}{1+r_1}$ but 40E	$\frac{100E}{1+r_1}$	$\frac{120E}{1+2r_2}$ but 40E
		If r_1 is positive:	d/t		$\frac{100E}{1+1.5r_1}$ but 40E	
	Axial compression[d]		d/t	Not applicable		

[a] Dimensions b, D, d, T and t are defined in Figure 5. For a box section b and T are flange dimensions and d and t are web dimensions, where the distinction between webs and flanges depends upon whether the box section is bent about its major axis or its minor axis, see 3.5.1.
[b] The parameter $E = (275/p_y)^{0.5}$.
[c] For the web of a hybrid section E should be based on the design strength p_{yf} of the flanges.
[d] The stress ratios r_1 and r_2 are defined in 3.5.5.

Table 19 — Maximum depth to breadth ratios (solid and laminated members)

Degree of lateral support	Maximum depth to breadth ratio
No lateral support	2
Ends held in position	3
Ends held in position and member held in line as by purlins or tie rods at centres not more than 30 times breadth of the member	4
Ends held in position and compression edge held in line, as by direct connection of sheathing, deck or joists	5
Ends held in position and compression edge held in line, as by direct connection of sheathing, deck or joists, together with adequate bridging or blocking spaced at intervals not exceeding six times the depth	6
Ends held in position and both edges held firmly in line	7

Selected Softwood Timber Sizes (BS 5268)

Geometrical properties of sawn softwoods based on timber with a 20% moisture content

Target Sizes	Area	Section Modulus		Section Moment of Area		Radius of Gyration	
		About x-x	About y-y	About x-x	About y-y	y-y	x-x
mm	10^3mm^2	10^3mm^3	10^3mm^3	10^6mm^4	10^6mm^4	mm	mm
25x50	1.25	10.4	5.2	0.26	0.065	14.4	7.2
25x75	1.88	23.5	7.8	0.88	0.098	21.6	7.2
50x75	3.75	46.9	31.3	1.76	0.781	21.7	14.4
50x100	5.00	83.3	41.7	4.17	1.04	28.9	14.4
50x150	7.50	188	62.5	14.1	1.56	43.3	14.4
50x200	10.0	333	83.3	33.3	2.08	57.7	14.4
75x100	7.50	125	93.8	6.25	3.52	28.9	21.7
75x150	11.3	281	141	21.1	5.27	43.3	21.7
75x200	15.0	500	188	50.0	7.03	57.7	21.7
100x100	10.0	167	167	8.33	8.33	28.9	28.9
100x150	15.0	375	250	28.1	12.5	43.3	28.9
100x200	20.0	667	333	66.7	16.7	57.7	28.9
100x250	25.0	1010	417	130	20.8	72.2	28.9
100x300	30.0	1500	500	225	25.0	86.6	28.9
150x150	20.0	563	563	42.2	42.2	43.3	43.3
150x200	25.5	1000	750	100	56.3	57.7	43.3
150x300	30.0	2250	1130	338	84.4	86.6	43.3

UNIVERSAL BEAMS

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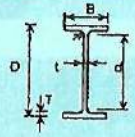

Section Designation	Mass per Metre kg/m	Depth of Section D mm	Width of Section B mm	Thickness Web t mm	Thickness Flange T mm	Root Radius r mm	Depth between Fillets d mm	Ratios for Local Buckling Flange b/T	Ratios for Local Buckling Web d/t	Second Moment of Area Axis x-x cm⁴	Second Moment of Area Axis y-y cm⁴	Radius of Gyration Axis x-x cm	Radius of Gyration Axis y-y cm	Elastic Modulus Axis x-x cm³	Elastic Modulus Axis y-y cm³	Plastic Modulus Axis x-x cm³	Plastic Modulus Axis y-y cm³	Buckling Parameter u	Torsional Index x	Warping Constant H dm⁶	Torsional Constant J cm⁴	Area of Section A cm²
457 x 191 x 98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.92	35.8	45700	2350	19.1	4.33	1960	243	2230	379	0.882	25.7	1.18	121	125
457 x 191 x 89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	5.42	38.8	41000	2090	19.0	4.29	1770	218	2010	338	0.879	28.3	1.04	90.7	114
457 x 191 x 82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.96	41.2	37100	1870	18.8	4.23	1610	196	1830	304	0.879	30.8	0.922	69.2	104
457 x 191 x 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	6.57	45.3	33300	1670	18.8	4.20	1460	176	1650	272	0.877	33.9	0.818	51.8	94.6
457 x 191 x 67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	7.48	48.0	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	82.1	465.8	155.3	10.5	19.0	10.2	407.6	4.11	38.8	36600	1190	18.7	3.37	1570	153	1810	240	0.871	27.4	0.591	89.2	105
457 x 152 x 74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	4.54	42.5	32700	1050	18.6	3.33	1410	136	1630	213	0.873	30.2	0.518	65.9	94.5
457 x 152 x 67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	5.13	45.3	28900	913	18.4	3.27	1260	119	1450	187	0.868	33.6	0.448	47.7	85.6
457 x 152 x 60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	5.75	50.3	25500	795	18.3	3.23	1120	104	1290	163	0.868	37.5	0.387	33.8	76.2
457 x 152 x 52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	6.99	53.6	21400	645	17.9	3.11	950	84.6	1100	133	0.859	43.8	0.311	21.4	66.6
406 x 178 x 74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	5.61	37.9	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	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41.0	24300	1370	16.9	3.99	1190	153	1350	237	0.880	30.5	0.533	46.1	85.5
406 x 178 x 60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	6.95	45.6	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	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	46.8	18700	1020	16.5	3.85	930	115	1060	178	0.871	38.3	0.392	23.1	69.0
406 x 140 x 46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53.0	15700	538	16.4	3.03	778	75.7	888	118	0.872	39.0	0.207	19.0	58.6
406 x 140 x 39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	8.24	56.3	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.5	0.155	10.7	49.7
356 x 171 x 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	19500	1360	15.1	3.99	1070	157	1210	243	0.886	24.4	0.412	55.7	85.5
356 x 171 x 57	57.0	358.0	172.2	8.1	13.0	10.2	311.6	6.62	38.5	16000	1110	14.9	3.91	896	129	1010	199	0.882	26.8	0.330	33.4	72.6
356 x 171 x 51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	7.48	42.1	14100	968	14.8	3.86	796	113	896	174	0.881	32.1	0.288	23.8	64.9
356 x 171 x 45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	8.82	44.5	12100	811	14.5	3.78	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356 x 127 x 39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	5.89	47.2	10200	358	14.3	2.68	576	56.8	659	89.1	0.871	35.2	0.105	15.1	49.8
356 x 127 x 33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	7.38	51.9	8250	280	14.0	2.55	473	44.7	543	70.3	0.863	42.2	0.081	8.79	42.1
305 x 165 x 54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	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	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.6	9900	896	13.0	3.90	646	108	720	166	0.891	27.1	0.195	22.2	58.7
305 x 165 x 40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	8.09	44.2	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	48.1	311.0	125.3	9.0	14.0	8.9	265.2	4.47	29.5	9560	461	12.5	2.74	616	73.6	711	116	0.874	23.3	0.102	31.8	61.2
305 x 127 x 42	41.9	307.2	124.3	8.0	12.1	8.9	265.2	5.14	33.1	8200	389	12.4	2.70	534	62.6	614	98.4	0.872	26.6	0.0846	21.1	53.4
305 x 127 x 37	37.0	304.4	123.4	7.1	10.7	8.9	265.2	5.77	37.4	7170	336	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	32.8	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	6500	194	12.5	2.15	416	37.9	481	60.0	0.887	31.6	0.0442	12.2	41.8
305 x 102 x 28	28.2	308.7	101.8	6.0	8.8	7.6	275.9	5.78	46.0	5370	155	12.2	2.08	348	30.5	403	48.5	0.859	37.4	0.0349	7.40	35.9
305 x 102 x 25	24.8	305.1	101.6	5.8	7.0	7.6	275.9	7.25	47.6	4460	123	11.9	1.97	292	24.2	342	38.6	0.848	43.4	0.0273	4.77	31.6
254 x 146 x 43	43.0	259.6	147.3	7.2	12.7	7.6	219.0	5.80	30.4	6540	677	10.9	3.52	504	92.0	586	141	0.890	21.2	0.103	23.9	54.8
254 x 146 x 37	37.0	256.0	146.4	6.3	10.9	7.6	219.0	6.72	34.8	5540	571	10.8	3.48	433	78.0	493	119	0.889	24.4	0.0857	15.3	47.2
254 x 146 x 31	31.1	251.4	146.1	6.0	8.6	7.6	219.0	8.49	36.5	4410	448	10.5	3.36	351	61.3	393	94.1	0.879	29.6	0.0660	8.55	39.7
254 x 102 x 28	28.3	260.4	102.2	6.3	10.0	7.6	225.2	5.11	35.7	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	25.2	257.2	101.9	6.0	8.4	7.6	225.2	6.07	37.5	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	22.0	254.0	101.6	5.7	6.8	7.6	225.2	7.47	39.5	2840	119	10.1	2.06	224	23.5	259	37.3	0.856	36.3	0.0182	4.15	28.0
203 x 133 x 30	30.0	206.8	133.9	6.4	9.6	7.6	172.4	6.97	26.9	2900	385	8.71	3.17	280	57.5	314	88.2	0.881	21.5	0.0374	10.3	38.2
203 x 133 x 25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	8.54	30.2	2340	308	8.56	3.10	230	46.2	258	70.9	0.877	25.6	0.0294	5.96	32.0
203 x 102 x 23	23.1	203.2	101.8	5.4	9.3	7.6	169.4	5.47	31.4	2110	164	8.46	2.36	207	32.2	234	49.8	0.888	22.5	0.0154	7.02	29.4
178 x 102 x 19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	1360	137	7.48	2.37	153	27.0	171	41.6	0.886	22.6	0.00967	4.41	24.3
152 x 89 x 16	16.0	152.4	88.7	4.5	7.7	7.6	121.8	5.76	27.1	834	89.8	6.41	2.10	109	20.2	123	31.2	0.889	19.6	0.00470	3.58	20.3
127 x 76 x 13	13.0	127.0	76.0	4.0	7.6	7.6	96.6	5.00	24.1	473	55.7	5.35	1.84	74.6	14.7	84.2	22.6	0.893	16.3	0.00199	2.85	16.5

PROPERTIES

DIMENSIONS

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