2705/302
2709/302
2710/302
STRUCTURES III
Oct./Nov. 2021
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;*
- *drawing instruments.*

*This paper consists of **EIGHT** questions.*
*Answer any **FIVE** questions in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are indicated.
Necessary tables for design are provided.
Candidates should answer the questions in English.

This paper consists of 15 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. **Figure 1** shows an overhanging beam.

(a) Plot the influence line diagram for:

(i) reaction at A;
(ii) reaction at B;
(iii) shear force at point E.

(12 marks)

(b) Determine the maximum negative shear force and maximum moment at point E when a uniformly distributed load of 30 kN/m and 6 m long crosses the beam from C to D.

(8 marks)

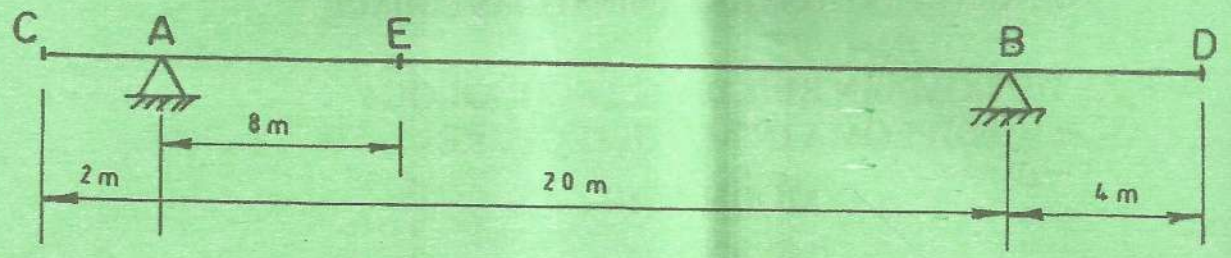


Fig.1

2. **Figure 2** shows a loaded portal frame. Using the method of moment distribution, analyse the frame and hence, sketch the bending moment diagram indicating values at critical points.

(20 marks)

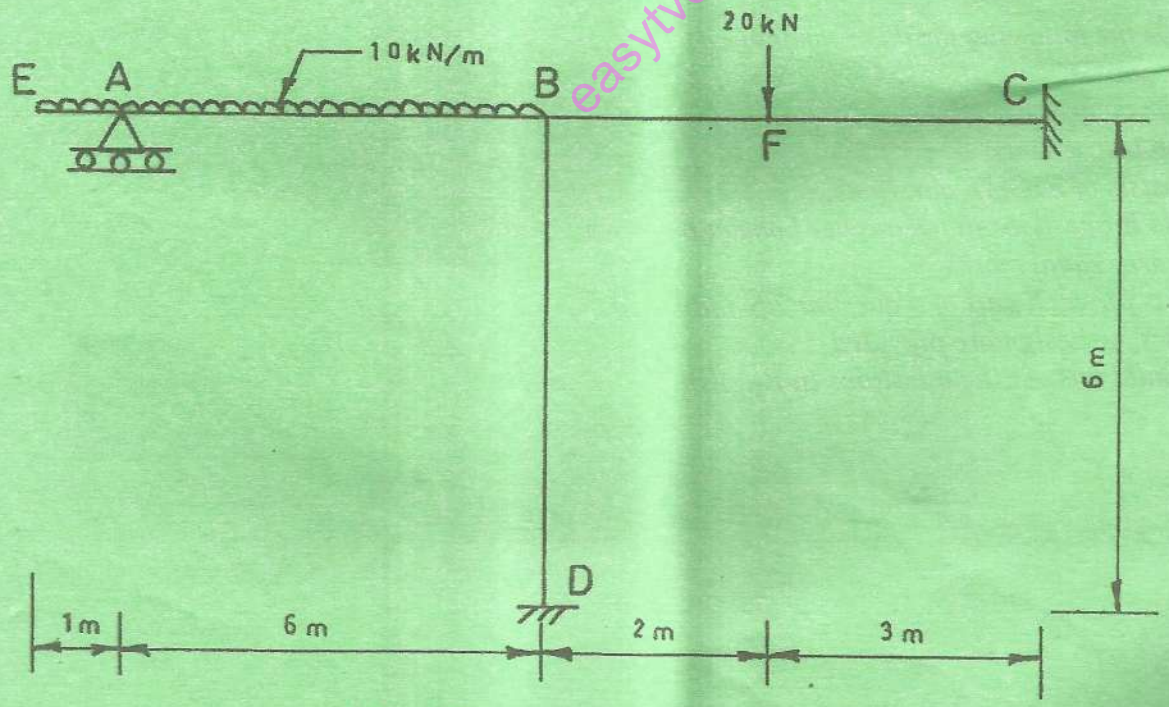


Fig. 2

3. **Figure 3** shows a restrained cantilever universal beam built into a concrete wall. It supports characteristic dead and imposed loads of 300 Kn/m and 250 Kn/m respectively. Select a suitable section in S 275 steel and check for bending, shear and deflection.

Permissible deflection = length/180
E = 205 kN/mm².

(20 marks)

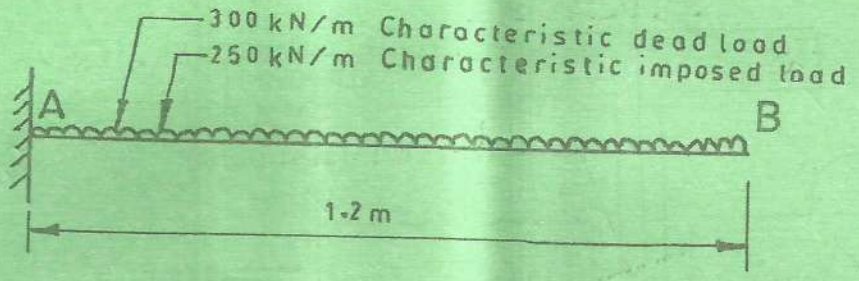


Fig. 3

4. **Figure 4** shows a loaded continuous beam. Using three moments theorem, analyse the beam, and hence sketch the shear force and bending moment diagrams indicating values at critical points.

(20 marks)

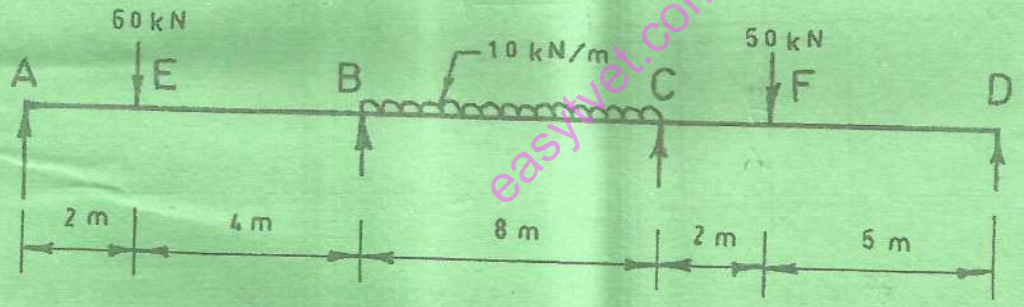


Fig. 4

5. (a) State **four** advantages of casing a stanchion. (2 marks)

(b) **Figure 5** shows a cross section of a loaded universal column. The column is 7 m long, restrained in position and direction at both ends. Check the adequacy of the section. (18 marks)

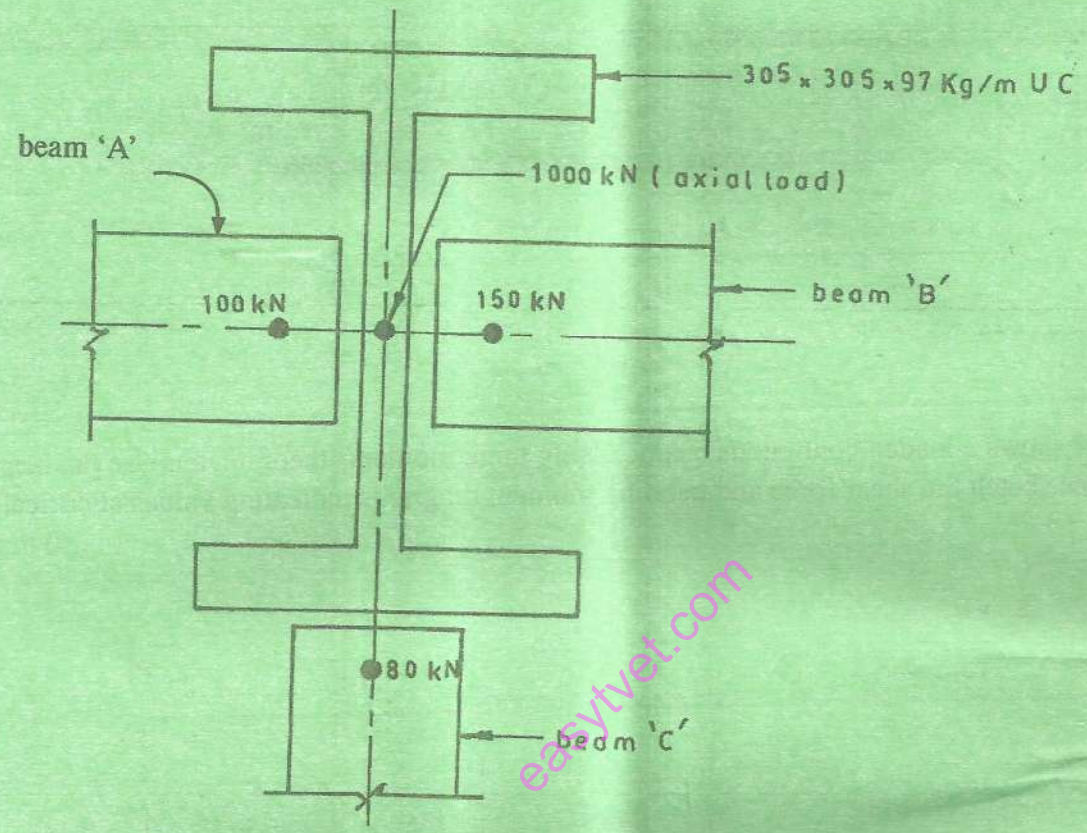


Fig. 5

6. **Figure 6** shows a loaded beam. Using the method of moment distribution, analyse the beam. Hence, sketch the shear force and bending moment diagrams indicating values at critical points. Make four distributions only. (20 marks)

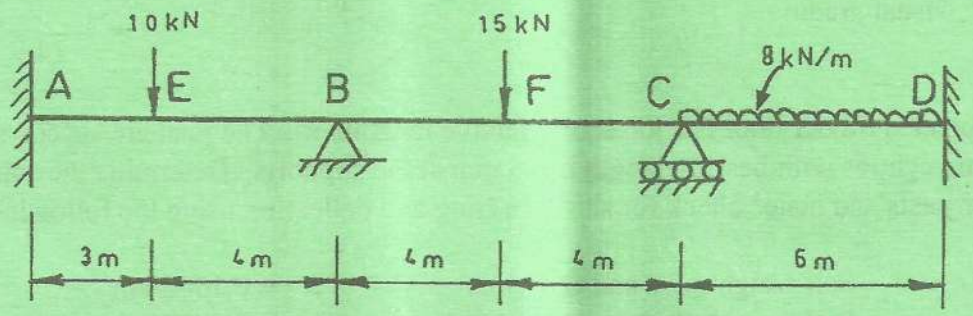


Fig. 6

7. (i) State **two** disadvantages and **two** disadvantages of welded connections.

(ii) **Figure 7** shows an accentrically welded connection. Determine the size of fillet weld required if the permissible shear stress is 115 N/mm^2. (20 marks)

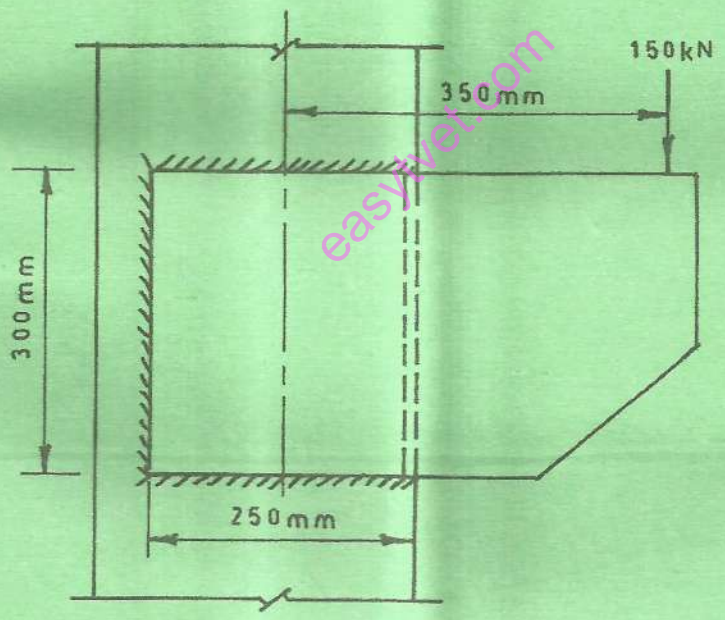


Fig. 7

8. (a) Define the following terms with respect to structural timber:

(i) strength class;
(ii) machine grading;
(iii) visual grading.

($4\frac{1}{2}$ marks)

(b) A suspended timber floor has joists of effective length 5 m. The joist are spaced at 450 mm centres with bearing length of 75 mm at the supports. Determine the suitable size of joists and hence check for shear, bearing and deflection using the following data:

Loading:	Self weight of T and G boards	= 0.15 kN/m²
	Self weight of plaster board ceiling	= 0.2 kN/m²
	Imposed load on floor	= 1.75 kN/m²
Depth of joist limited to 250 mm.		
Grade stresses: Bending		= 7 N/mm²
	Shear parallel to the grain	= 0.9 N/mm²
	Compression perpendicular to the grain	= 2.0 N/mm²
Mean modulus of elasticity		= 10 kN/mm²
Assume medium term loading		= 1.25
Permissible deflection		= 0.003 span

($15\frac{1}{2}$ marks)

Table 1 — Design strength p_y

Steel grade	Thickness[a] less than or equal to mm	Design strength p_y N/mm²
S 275	16	275
	40	265
	63	255
	80	245
	100	235
	150	225
S 355	16	355
	40	345
	63	335
	80	325
	100	315
	150	295
S 460	16	460
	40	440
	63	430
	80	410
	100	400

[a] For rolled sections, use the specified thickness of the thickest element of the cross-section.

Table 2 — 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	9ε	10ε	15ε
		Welded section	b/T	8ε	9ε	13ε
Internal element of compression flange		Compression due to bending	b/T	28ε	32ε	40ε
		Axial compression	b/T	Not applicable		
Web of an I-, H- or box section[c]	Neutral axis at mid-depth		d/t	80ε	100ε	120ε
	Generally[d]	If r_1 is negative:	d/t		$\frac{100\varepsilon}{1+r_1}$	
		If r_1 is positive:	d/t	$\frac{80\varepsilon}{1+r_1}$ but $\geq 40\varepsilon$	$\frac{100\varepsilon}{1+1.5r_1}$ but $\geq 40\varepsilon$	$\frac{120\varepsilon}{1+2r_2}$ but $\geq 40\varepsilon$
	Axial compression[d]		d/t	Not applicable		
Web of a channel			d/t	40ε	40ε	40ε
Angle, compression due to bending (Both criteria should be satisfied)			b/t	9ε	10ε	15ε
			d/t	9ε	10ε	15ε
Single angle, or double angles with the components separated, axial compression (All three criteria should be satisfied)			b/t	Not applicable		15ε
			d/t			15ε
			$(b+d)/t$			24ε
Outstand leg of an angle in contact back-to-back in a double angle member			b/t	9ε	10ε	15ε
Outstand leg of an angle with its back in continuous contact with another component						
Stem of a T-section, rolled or cut from a rolled I- or H-section			D/t	8ε	9ε	18ε

[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 $\varepsilon = (275/p_y)^{0.5}$.
[c] For the web of a hybrid section ε 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 3 — Bending strength p_b (N/mm²) for rolled sections

λ_{LT}	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
25	235	245	255	265	275	315	325	335	345	355	400	410	430	440	460
30	235	245	255	265	275	315	325	335	345	355	395	403	421	429	446
35	235	245	255	265	273	307	316	324	332	341	378	386	402	410	426
40	229	238	246	254	262	294	302	309	317	325	359	367	382	389	404
45	219	227	235	242	250	280	287	294	302	309	340	347	361	367	381
50	210	217	224	231	238	265	272	279	285	292	320	326	338	344	356
55	199	206	213	219	226	251	257	263	268	274	299	305	315	320	330
60	189	195	201	207	213	236	241	246	251	257	278	283	292	296	304
65	179	185	190	196	201	221	225	230	234	239	257	261	269	272	279
70	169	174	179	184	188	206	210	214	218	222	237	241	247	250	256
75	159	164	168	172	176	192	195	199	202	205	219	221	226	229	234
80	150	154	158	161	165	178	181	184	187	190	201	203	208	210	214
85	140	144	147	151	154	165	168	170	173	175	185	187	190	192	195
90	132	135	138	141	144	153	156	158	160	162	170	172	175	176	179
95	124	126	129	131	134	143	144	146	148	150	157	158	161	162	164
100	116	118	121	123	126	132	134	136	137	139	145	146	148	149	151
105	109	111	113	115	117	123	125	126	128	129	134	135	137	138	140
110	102	104	106	107	109	115	116	117	119	120	124	125	127	128	129
115	96	97	99	101	102	107	108	109	110	111	115	116	118	118	120
120	90	91	93	94	96	100	101	102	103	104	107	108	109	110	111
125	85	86	87	89	90	94	95	96	96	97	100	101	102	103	104
130	80	81	82	83	84	88	89	90	90	91	94	94	95	96	97
135	75	76	77	78	79	83	83	84	85	85	88	88	89	90	90
140	71	72	73	74	75	78	78	79	80	80	82	83	84	84	85
145	67	68	69	70	71	73	74	74	75	75	77	78	79	79	80
150	64	64	65	66	67	69	70	70	71	71	73	73	74	74	75
155	60	61	62	62	63	65	66	66	67	67	69	69	70	70	71
160	57	58	59	59	60	62	62	63	63	63	65	65	66	66	67
165	54	55	56	56	57	59	59	59	60	60	61	62	62	62	63
170	52	52	53	53	54	56	56	56	57	57	58	58	59	59	60
175	49	50	50	51	51	53	53	53	54	54	55	55	56	56	56
180	47	47	48	48	49	50	51	51	51	51	52	53	53	53	54
185	45	46	46	46	46	48	48	48	49	49	50	50	50	51	51
190	43	43	44	44	44	46	46	46	46	47	48	48	48	48	48
195	41	41	42	42	42	43	44	44	44	44	45	45	46	46	46
200	39	39	40	40	40	42	42	42	42	42	43	43	44	44	44
210	36	36	37	37	37	38	38	38	39	39	39	40	40	40	40
220	33	33	34	34	34	35	35	35	35	36	36	36	37	37	37
230	31	31	31	31	31	32	32	33	33	33	33	33	34	34	34
240	28	29	29	29	29	30	30	30	30	30	31	31	31	31	31
250	26	27	27	27	27	28	28	28	28	28	29	29	29	29	29
λ_{L0}	37.1	36.3	35.6	35.0	34.3	32.1	31.6	31.1	30.6	30.2	28.4	28.1	27.4	27.1	26.5

Table 4 — 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 $0.25 < t/B < 0.8$ as shown in Figure 14a)	≤40 mm	a)	b)
	>40 mm	b)	c)
Rolled H-section with welded flange cover plates with $0.25 < t/B < 0.8$ as shown in Figure 14a)	≤40 mm	b)	c)
	>40 mm	c)	d)
Rolled I or H-section with welded flange cover plates with $t/B \geq 0.8$ as shown in Figure 14b)	≤40 mm	b)	a)
	>40 mm	c)	b)
Rolled I or H-section with welded flange cover plates with $t/B \leq 0.25$ 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 5 — Compressive strength p_c (N/mm²) (*continued*)

3) Values of p_c (N/mm²) with $\lambda < 110$ 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	296	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

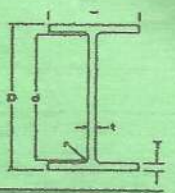
Table 6 — Compressive strength p_c (N/mm²) (*continued*)

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

Universal beams

Dimensions and properties to BS 4: Part 1: 1993



Designation Serial Size	Mass per metre kg/m	Depth of Section D mm	Width of Section B mm	Thickness of Web t mm	Thickness of Flange T mm	Root Radius r mm	Depth between fillets d mm	Ratios for Local Buckling Flange B/2T	Ratios for Local Buckling Web d/t	Second Moment of Area Axis x-x cm⁴	Second Moment of Area Axis y-y cm⁴
† 1016 x 305 x 487	486.6	1036.1	308.5	30.0	54.1	30.0	867.9	2.85	28.9	1021400	26720
† 1016 x 305 x 437	436.9	1025.9	305.4	26.9	49.0	30.0	867.9	3.12	32.3	909900	23450
† 1016 x 305 x 393	392.7	1016.0	303.0	24.4	43.9	30.0	868.2	3.45	35.6	807700	20500
† 1016 x 305 x 349	349.4	1008.1	302.0	21.1	40.0	30.0	868.1	3.78	41.1	723100	18460
† 1016 x 305 x 314	314.3	1000.0	300.0	19.1	35.9	30.0	868.2	4.18	45.5	644200	16230
† 1016 x 305 x 272	272.3	990.1	300.0	16.5	31.0	30.0	868.1	4.84	52.6	554000	14000
† 1016 x 305 x 249	248.7	980.2	300.0	16.5	26.0	30.0	868.2	5.77	52.6	481300	11750
† 1016 x 305 x 222	222.0	970.3	300.0	16.0	21.1	30.0	868.1	7.11	54.3	408000	9546
914 x 419 x 388	388.0	921.0	420.5	21.4	36.6	24.1	799.6	5.74	37.4	719600	45440
914 x 419 x 343	343.3	911.8	418.5	19.4	32.0	24.1	799.6	6.54	41.2	625800	39160
914 x 305 x 289	289.1	926.6	307.7	19.5	32.0	19.1	824.4	4.81	42.3	504200	15800
914 x 305 x 253	253.4	918.4	305.5	17.3	27.9	19.1	824.4	5.47	47.7	436300	13300
914 x 305 x 224	224.2	910.4	304.1	15.9	23.9	19.1	824.4	6.36	51.8	376400	11240
914 x 305 x 201	200.9	903.0	303.3	15.1	20.2	19.1	824.4	7.51	54.6	325300	9423
838 x 292 x 226	226.5	850.9	293.8	16.1	26.8	17.8	761.7	5.48	47.3	339700	11360
838 x 292 x 194	193.8	840.7	292.4	14.7	21.7	17.8	761.7	6.74	51.8	279200	9066
838 x 292 x 176	175.9	834.9	291.7	14.0	18.8	17.8	761.7	7.76	54.4	246000	7799
762 x 267 x 197	196.8	769.8	268.0	15.6	25.4	16.5	686.0	5.28	44.0	240000	8175
762 x 267 x 173	173.0	762.2	266.7	14.3	21.6	16.5	686.0	6.17	48.0	205300	6850
762 x 267 x 147	146.9	754.0	265.2	12.8	17.5	16.5	686.0	7.58	53.6	168500	5455
762 x 267 x 134	133.9	750.0	264.4	12.0	15.5	16.5	686.0	8.53	57.2	150700	4788
686 x 254 x 170	170.2	692.9	255.8	14.5	23.7	15.2	615.1	5.40	42.4	170900	6630
686 x 254 x 152	152.4	687.5	254.5	13.2	21.0	15.2	615.1	6.06	46.6	150400	5784
686 x 254 x 140	140.1	683.5	253.7	12.4	19.0	15.2	615.1	6.68	49.6	136300	5183
686 x 254 x 125	125.2	677.9	253.0	11.7	16.2	15.2	615.1	7.81	52.6	118000	4383
610 x 305 x 238	238.1	635.8	311.4	18.4	31.4	16.5	540.0	4.96	29.3	209500	15840
610 x 305 x 179	179.0	620.2	307.1	14.1	23.6	16.5	540.0	6.51	38.3	153000	11410
610 x 305 x 149	149.2	612.4	304.8	11.8	19.7	16.5	540.0	7.74	45.8	125900	9308
610 x 229 x 140	139.9	617.2	230.2	13.1	22.1	12.7	547.6	5.21	41.8	111800	4505
610 x 229 x 125	125.1	612.2	229.0	11.9	19.6	12.7	547.6	5.84	46.0	98610	3932
610 x 229 x 113	113.0	607.6	228.2	11.1	17.3	12.7	547.6	6.60	49.3	87320	3434
610 x 229 x 101	101.2	602.6	227.6	10.5	14.8	12.7	547.6	7.69	52.2	75780	2915
533 x 210 x 122	122.0	544.5	211.9	12.7	21.3	12.7	476.5	4.97	37.5	76040	3388
533 x 210 x 109	109.0	539.5	210.8	11.6	18.8	12.7	476.5	5.61	41.1	66820	2943
533 x 210 x 101	101.0	536.7	210.0	10.8	17.4	12.7	476.5	6.03	44.1	61520	2692
533 x 210 x 92	92.1	533.1	209.3	10.1	15.6	12.7	476.5	6.71	47.2	55230	2389
533 x 210 x 82	82.2	528.3	208.8	9.6	13.2	12.7	476.5	7.91	49.6	47540	2007
457 x 191 x 98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.92	35.8	45730	2347
457 x 191 x 89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	5.42	38.8	41020	2089
457 x 191 x 82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.98	41.2	37050	1871
457 x 191 x 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	6.57	45.3	33320	1671
457 x 191 x 67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	7.48	48.0	29380	1452

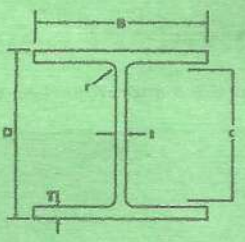
Universal beams

Dimensions and properties to BS 4: Part 1: 1993

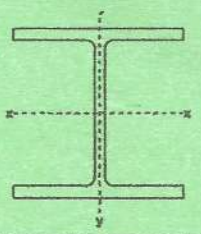
Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section	Mass per metre	Designation
Axis x-x cm	Axis y-y cm	Axis x-x cm³	Axis y-y cm³	Axis x-x cm³	Axis y-y cm³	u	x	H dm⁶	J cm⁴	cm²	kg/m	Serial Size
40.6	6.57	19720	1732	23200	2800	0.857	21.1	64.4	4209	620	486.6	1016 x 305 x 487
40.4	6.49	17740	1535	20760	2469	0.866	23.1	55.9	3185	557	436.9	1016 x 305 x 437
40.2	6.40	15900	1353	18540	2168	0.868	25.5	48.4	2330	500	392.7	1016 x 305 x 393
40.3	6.44	14350	1223	16590	1941	0.872	27.9	43.3	1716	445	349.4	1016 x 305 x 349
40.1	6.37	12880	1082	14850	1713	0.872	30.7	37.7	1264	400	314.3	1016 x 305 x 314
40.0	6.35	11190	934	12830	1470	0.873	35.0	32.2	835	347	272.3	1016 x 305 x 272
39.0	6.09	9821	764	11350	1245	0.861	39.9	26.8	582	317	248.7	1016 x 305 x 249
38.0	5.81	8409	636	9807	1020	0.850	45.7	21.5	390	283	222.0	1016 x 305 x 222
38.2	9.59	15630	2161	17670	3341	0.885	26.7	68.8	1734	494	388.0	914 x 419 x 388
37.8	9.46	13730	1871	15480	2890	0.883	30.1	75.8	1193	437	343.3	914 x 419 x 343
37.0	8.51	10880	1014	12570	1601	0.867	31.9	31.2	926	368	289.1	914 x 305 x 289
36.8	8.42	9501	871	10940	1371	0.866	36.2	26.4	626	323	253.4	914 x 305 x 253
36.3	8.27	8269	739	9535	1163	0.861	41.3	22.1	422	286	224.2	914 x 305 x 224
35.7	8.07	7204	621	8351	982	0.854	46.8	18.4	291	256	200.9	914 x 305 x 201
34.3	6.27	7985	773	9155	1212	0.870	35.0	19.3	514	289	226.5	838 x 292 x 226
33.6	6.06	6641	620	7640	974	0.862	41.6	15.2	306	247	193.8	838 x 292 x 194
33.1	5.90	5893	535	6808	842	0.856	46.5	13.0	221	224	175.9	838 x 292 x 176
30.9	5.71	6234	610	7167	959	0.869	33.2	11.3	404	251	196.8	762 x 267 x 197
30.5	5.58	5387	514	6198	807	0.864	38.1	8.59	287	220	173.0	762 x 267 x 173
30.0	5.40	4470	411	5156	647	0.858	45.2	7.40	159	187	146.9	762 x 267 x 147
29.7	5.30	4018	362	4644	570	0.854	49.5	6.46	119	171	133.9	762 x 267 x 134
28.0	5.53	4916	618	5631	811	0.872	31.8	7.42	308	217	170.2	686 x 254 x 170
27.8	5.46	4374	455	5000	710	0.871	35.5	6.42	220	194	152.4	686 x 254 x 152
27.6	5.39	3987	409	4558	638	0.868	38.7	5.72	169	178	140.1	686 x 254 x 140
27.2	5.24	3481	346	3994	542	0.862	43.9	4.80	116	159	125.2	686 x 254 x 125
26.3	7.23	6589	1017	7486	1574	0.886	21.3	14.5	785	303	238.1	610 x 305 x 238
25.9	7.07	4935	743	5547	1144	0.886	27.7	10.2	340	228	179.0	610 x 305 x 179
25.7	7.00	4111	611	4594	937	0.886	32.7	8.17	200	190	149.2	610 x 305 x 149
25.0	5.03	3622	391	4142	611	0.875	30.6	3.99	216	178	139.9	610 x 229 x 140
24.9	4.97	3221	343	3676	535	0.873	34.1	3.45	154	159	125.1	610 x 229 x 125
24.6	4.88	2674	301	3281	469	0.870	38.0	2.99	111	144	113.0	610 x 229 x 113
24.2	4.75	2515	256	2881	400	0.864	43.1	2.52	77.0	129	101.2	610 x 229 x 101
22.1	4.67	2793	320	3196	500	0.877	27.6	2.32	178	155	122.0	533 x 210 x 122
21.9	4.60	2477	279	2828	436	0.875	30.9	1.99	126	139	109.0	533 x 210 x 109
21.9	4.57	2292	256	2612	399	0.874	33.2	1.81	101	129	101.0	533 x 210 x 101
21.7	4.51	2072	228	2360	356	0.872	36.5	1.60	76.7	117	92.1	533 x 210 x 92
21.3	4.38	1800	192	2059	300	0.864	41.6	1.33	51.5	105	82.2	533 x 210 x 82
19.1	4.33	1957	243	2232	379	0.881	25.7	1.18	121	125	98.3	457 x 191 x 98
19.0	4.29	1770	218	2014	338	0.880	28.3	1.04	90.7	114	89.3	457 x 191 x 89
18.8	4.23	1611	198	1831	304	0.877	30.9	0.922	69.2	104	82.0	457 x 191 x 82
18.8	4.20	1458	176	1653	272	0.877	33.9	0.816	51.8	94.6	74.3	457 x 191 x 74
18.5	4.12	1296	153	1471	237	0.872	37.9	0.705	37.1	85.5	67.1	457 x 191 x 67

Universal columns

Dimensions and properties to BS 4: Part 1: 1993



Designation	Mass per metre	Depth of Section	Width of Section	Thickness of Web	Thickness of Flange	Root Radius	Depth between fillets	Ratios for Local Buckling		Second Moment of Area	
Serial Size	kg/m	D mm	B mm	t mm	T mm	r mm	d mm	Flange B/2T	Web d/t	Axis x-x cm⁴	Axis y-y cm⁴
356 x 406 x 634	633.9	474.6	424.0	47.6	77.0	15.2	290.2	2.75	6.10	274800	98130
356 x 406 x 551	551.0	455.6	418.5	42.1	67.5	15.2	290.2	3.10	6.89	226900	82670
356 x 406 x 467	467.0	436.6	412.2	35.8	58.0	15.2	290.2	3.55	8.11	183000	67830
356 x 406 x 393	393.0	419.0	407.0	30.6	49.2	15.2	290.2	4.14	9.48	146600	55370
356 x 406 x 340	339.9	406.4	403.0	26.6	42.9	15.2	290.2	4.70	10.9	122500	46850
356 x 406 x 287	287.1	393.6	399.0	22.6	36.5	15.2	290.2	5.47	12.8	99880	38680
356 x 406 x 235	235.1	381.0	394.8	18.4	30.2	15.2	290.2	6.54	15.8	79060	30990
356 x 368 x 202	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.94	17.6	66260	23690
356 x 368 x 177	177.0	368.2	372.6	14.4	23.8	15.2	290.2	7.83	20.2	57120	20530
356 x 368 x 153	152.9	362.0	370.5	12.3	20.7	15.2	290.2	8.95	23.6	48590	17550
356 x 368 x 129	129.0	355.6	368.6	10.4	17.5	15.2	290.2	10.5	27.9	40250	14610
305 x 305 x 283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.65	9.21	78870	24630
305 x 305 x 240	240.0	352.5	318.4	23.0	37.7	15.2	246.7	4.22	10.7	64200	20310
305 x 305 x 198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	5.01	12.9	50900	16300
305 x 305 x 158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	6.22	15.6	38750	12570
305 x 305 x 137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	7.12	17.9	32810	10700
305 x 305 x 118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	8.22	20.6	27670	9059
305 x 305 x 97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	9.91	24.9	22250	7308
254 x 254 x 167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	4.18	10.4	30000	9870
254 x 254 x 132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	5.16	13.1	22530	7531
254 x 254 x 107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	6.31	15.6	17510	5928
254 x 254 x 89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	7.41	19.4	14270	4857
254 x 254 x 73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	8.96	23.3	11410	3908
203 x 203 x 86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	5.10	12.7	9449	3127
203 x 203 x 71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.97	16.1	7618	2537
203 x 203 x 60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	7.25	17.1	6125	2065
203 x 203 x 52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	8.17	20.4	5259	1778
203 x 203 x 46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	9.25	22.3	4568	1548
152 x 152 x 37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	6.71	15.5	2210	706
152 x 152 x 30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	8.13	19.0	1748	560
152 x 152 x 23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	11.2	21.3	1250	400



Universal columns

Dimensions and properties to BS 4: Part 1: 1993

Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section	Mass per metre	Designation
Axis x-x cm	Axis y-y cm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	u	x	H dm^6	J cm^4	cm^2	kg/m	Serial Size
18.4	11.0	11580	4629	14240	7108	0.843	5.46	36.8	13720	808	633.9	356 x 406 x 634
18.0	10.9	9962	3951	12080	6058	0.841	6.05	31.1	9240	702	551.0	356 x 406 x 551
17.5	10.7	8383	3291	10000	5034	0.839	6.86	24.3	5809	595	467.0	356 x 406 x 467
17.1	10.5	6998	2721	8222	4154	0.837	7.86	18.9	3545	501	393.0	356 x 406 x 393
16.8	10.4	6031	2325	6999	3544	0.836	8.85	15.5	2343	433	339.9	356 x 406 x 340
16.5	10.3	5075	1939	5812	2949	0.835	10.2	12.3	1441	366	287.1	356 x 406 x 287
16.3	10.2	4151	1570	4687	2383	0.834	12.1	9.54	812	299	235.1	356 x 406 x 235
16.1	9.60	3538	1264	3972	1920	0.844	13.4	7.16	558	257	201.9	356 x 368 x 202
15.9	9.54	3103	1102	3455	1671	0.844	15.0	6.09	381	226	177.0	356 x 368 x 177
15.8	9.49	2684	948	2965	1435	0.844	17.0	5.11	251	195	152.9	356 x 368 x 153
15.6	9.43	2264	793	2479	1199	0.844	19.9	4.18	153	164	129.0	356 x 368 x 129
14.8	8.27	4318	1529	5105	2342	0.855	7.65	6.35	2034	360	282.9	305 x 305 x 283
14.5	8.15	3643	1276	4247	1951	0.854	8.74	5.03	1271	306	240.0	305 x 305 x 240
14.2	8.04	2995	1037	3440	1581	0.854	10.2	3.88	734	252	198.1	305 x 305 x 198
13.9	7.90	2389	808	2680	1230	0.851	12.5	2.87	378	201	158.1	305 x 305 x 158
13.7	7.83	2048	692	2297	1053	0.851	14.2	2.39	249	174	136.9	305 x 305 x 137
13.6	7.77	1760	589	1958	895	0.850	16.2	1.98	161	150	117.9	305 x 305 x 118
13.4	7.69	1445	479	1592	726	0.850	19.3	1.56	91.2	123	96.9	305 x 305 x 97
11.9	6.61	2075	744	2424	1137	0.851	8.49	1.63	626	213	167.1	254 x 254 x 167
11.6	6.69	1631	576	1869	878	0.850	10.3	1.19	319	168	132.0	254 x 254 x 132
11.3	6.59	1313	458	1484	697	0.848	12.4	0.898	172	136	107.1	254 x 254 x 107
11.2	6.55	1096	379	1224	575	0.850	14.5	0.717	102	113	88.9	254 x 254 x 89
11.1	6.48	898	307	992	465	0.849	17.3	0.562	57.6	93.1	73.1	254 x 254 x 73
9.28	5.34	850	299	977	456	0.850	10.2	0.318	137	110	86.1	203 x 203 x 86
9.18	5.30	706	246	799	374	0.853	11.9	0.250	80.2	90.4	71.0	203 x 203 x 71
8.96	5.20	584	201	656	305	0.846	14.1	0.197	47.2	76.4	60.0	203 x 203 x 60
8.91	5.18	510	174	567	264	0.848	15.8	0.167	31.8	66.3	52.0	203 x 203 x 52
8.82	5.13	450	152	497	231	0.847	17.7	0.143	22.2	58.7	46.1	203 x 203 x 46
6.85	3.87	273	91.5	309	140	0.846	13.3	0.0399	19.2	47.1	37.0	152 x 152 x 37
6.76	3.83	222	73.3	248	112	0.849	16.0	0.0308	10.5	38.3	30.0	152 x 152 x 30
6.54	3.70	164	52.6	182	80.2	0.840	20.7	0.0212	4.63	29.2	23.0	152 x 152 x 23

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