2707/302
STRUCTURES III
June/July 2019
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.*
Maximum marks for each part of a question are as indicated.
All relevant tables for this examination 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.

Turn over

1. Using moment distribution method analyse the portal frame shown in **figure 1** and hence draw the bending moment diagram showing all values at critical points. (20 marks)

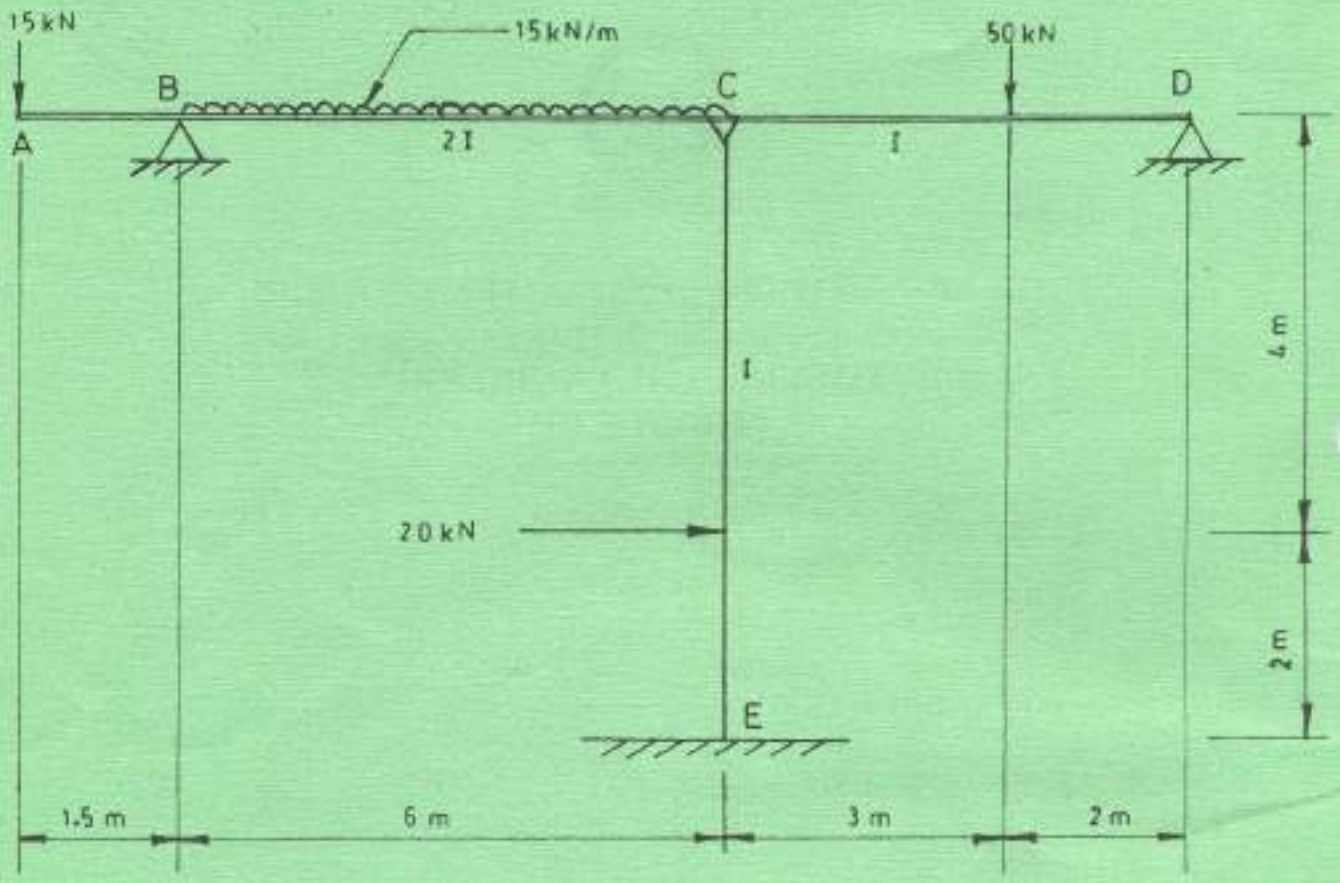

Fig. 1

2. **Figure 2** shows a plan of a timber floor supported on joists. Design the joists types A and B and hence check shear, and deflection using the following data:

Grade C18 timber used
Modification factors:
K3 - 1.25, K7 = 1.04, K8 = 1.1
permissible deflection = $\frac{1}{300}$ of span
depth/ breadth ratio = 3
Loading: Imposed = 2.5 kN/m^2
Finishes = 0.7 kN/m^2
Grade stresses refer to table attached.

(20 marks)

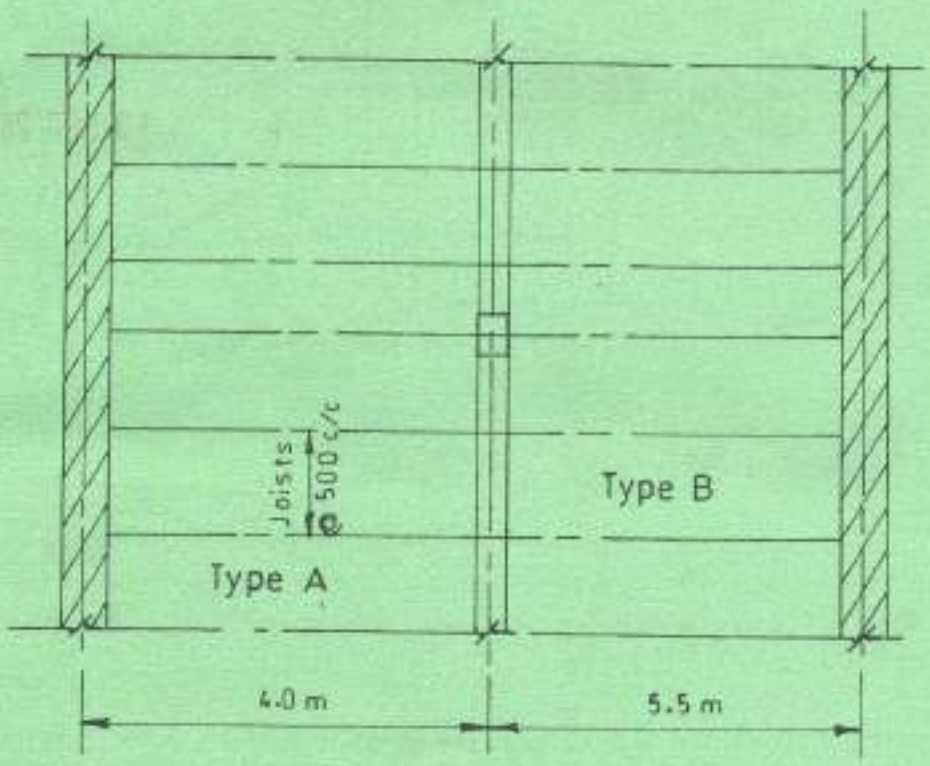

Fig. 2

3. (a) A hollow cast iron column of rectangular section with outer dimensions 600 x 300 mm and inner dimensions 500 x 250 mm carries a load of 165 kN as shown in **figure 3**. Find the extreme intensities of stress, induced in the section if the load is off the geometric axis of 600 mm in the plane as shown. (12 marks)

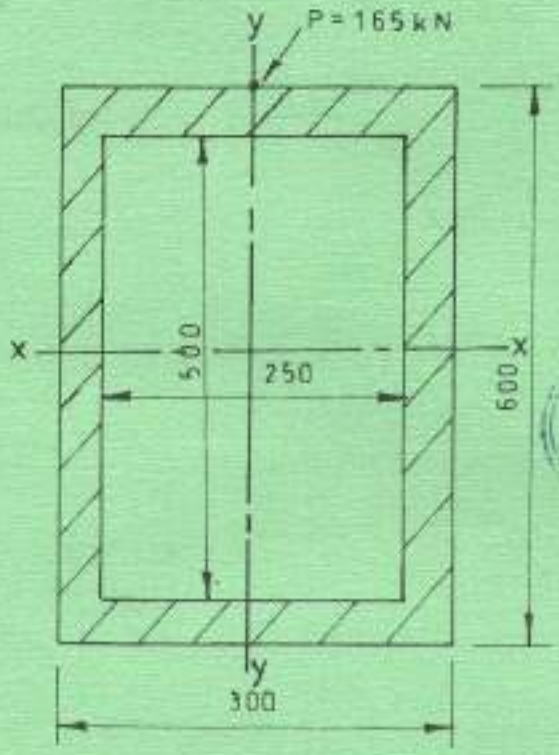

Fig. 3

(b) A hollow steel tube of 45 mm external diameter and 40 mm internal diameter is used as a column 3.5 m long with both ends hinged. Determine the Euler's crippling load, if modulus of elasticity is 205 kN/mm^2. (8 marks)

4. Use the three moment theorem to analyse the beam shown in **figure 4**, hence sketch the shear force and bending moment diagrams indicating values at the critical points. (20 marks)

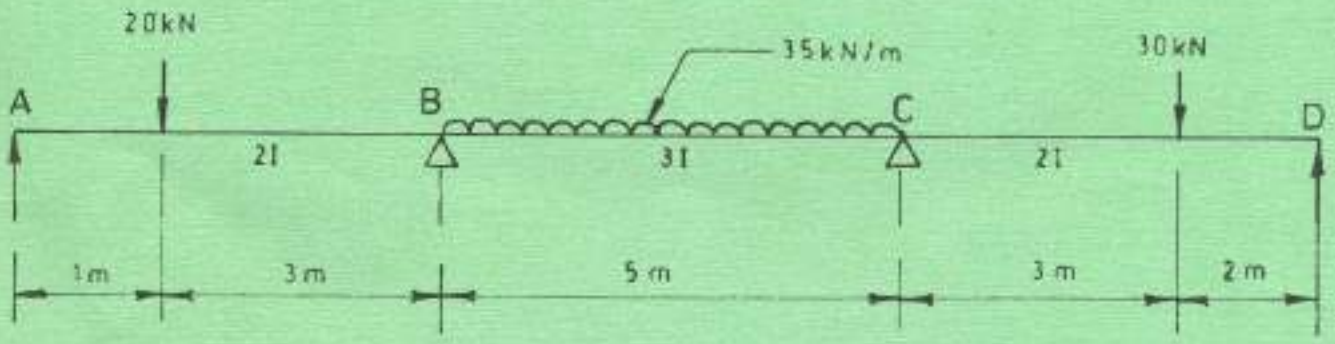

Fig. 4

$R_A = 4.14\,kN$ $R_{C_2} = 22.04$

$R_{B_1} = 15.86$ $R_D = 7.961$

$R_{B_2} = 86.15$

$R_{C_1} = 88.85$

5. **Figure 5** shows a loaded universal beam. Design the beam in Grade S 275 steel and hence check for bending and shear capacities. (20 marks)

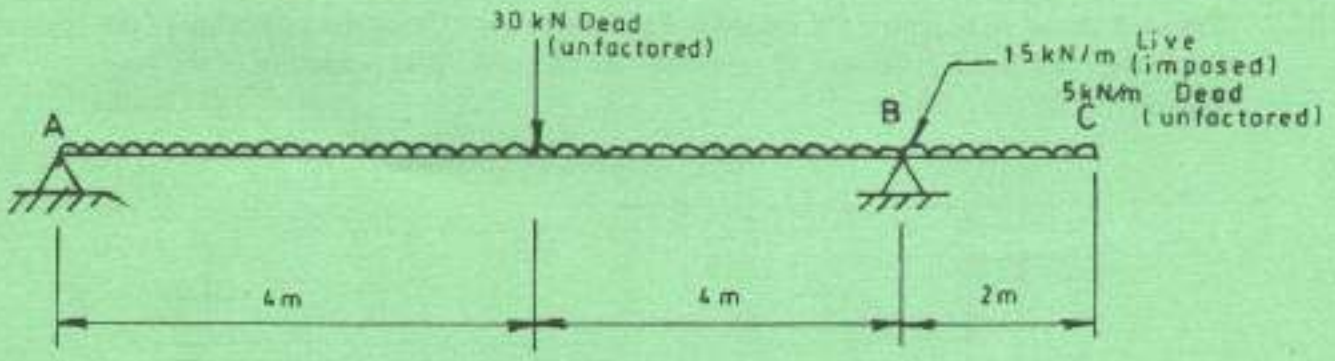

Fig. 5

6. **Figure 6** shows a plan of a reinforced concrete suspended floor on universal beams supported by universal columns. Design column C2 in grade S 275 steel given that:

Imposed loads on floor = 3.5 kN/m^2
R.C floor slab = 120 mm thick
Unit weight of concrete = 24 kN/m^2
Actual height of column = 4.5 m
both ends fixed.

(20 marks)

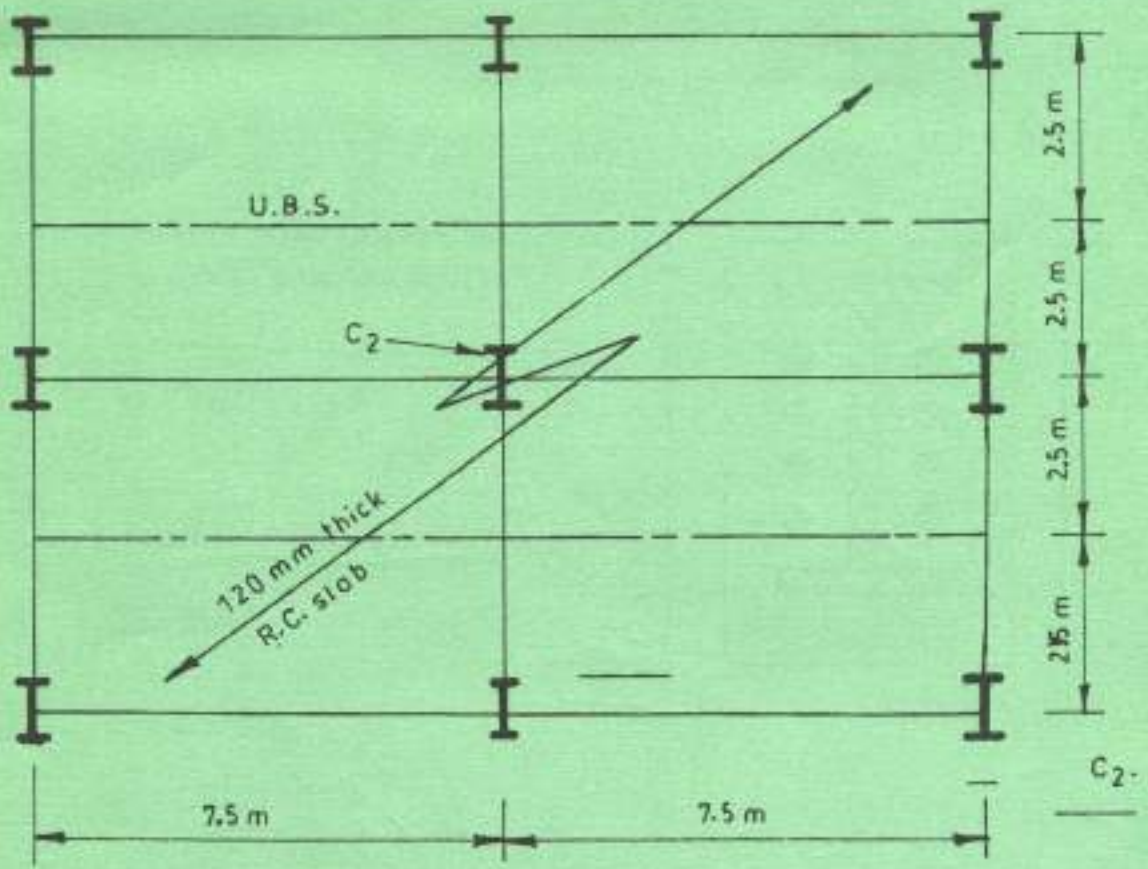

Fig. 6

7. (a) State **two** precautions that are taken when locating positions of bolts in a steel joint. (3 marks)

(b) **Figure 7** shows an eccentrically loaded bolted connection. Check the suitability of the joint given that H.S.F.G bolts of 20 mm diameter are used. Take properties of the bolts as Po = 144 kN, A_t = 245 mm^2 (17 marks)

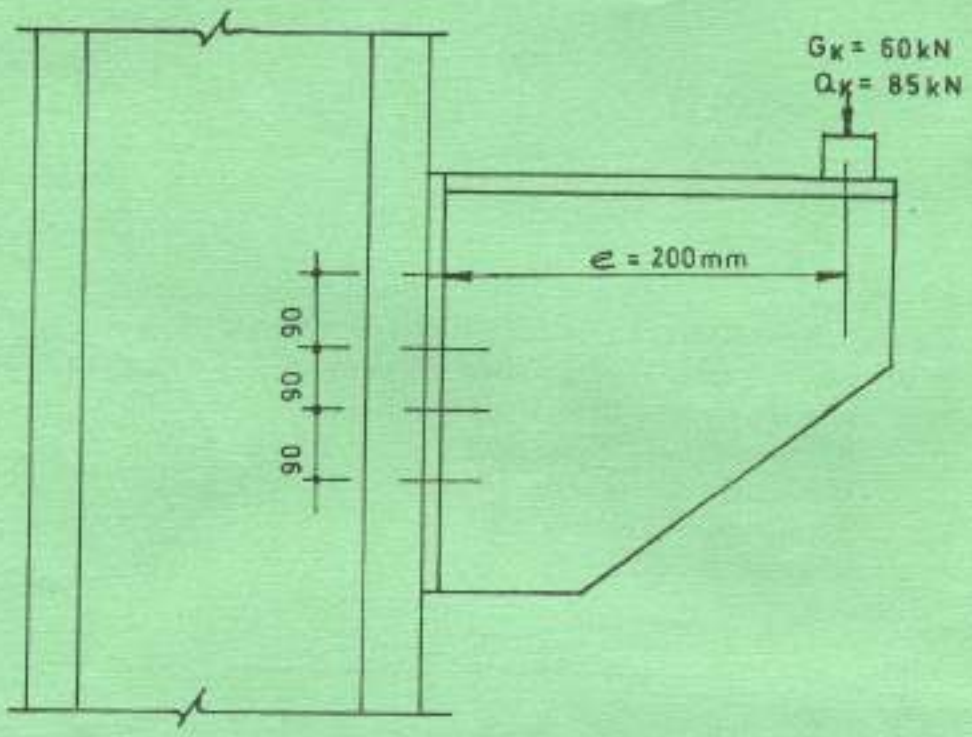

Fig. 7 (a)

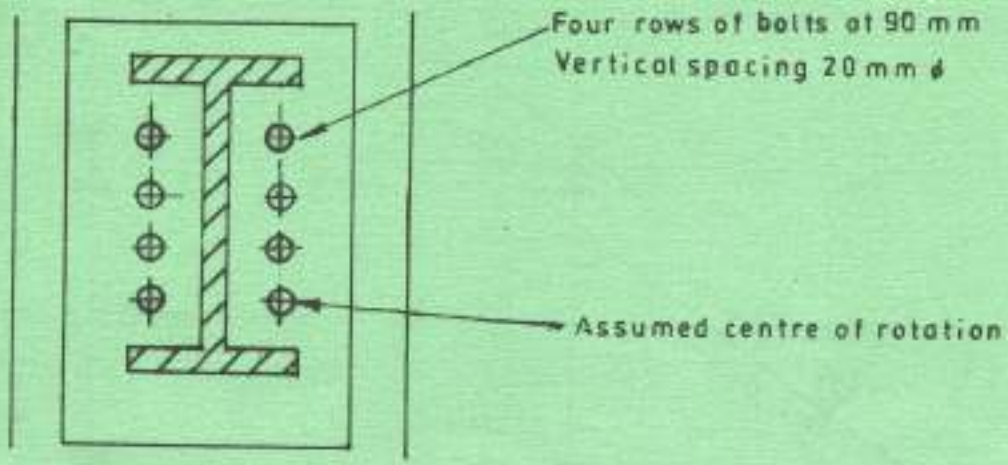

Fig. 7 (b)

8. (a) **Figure 8** shows a continuous beam with a hinge at point B. Plot the influence line diagram for reaction R_C and bending moment at D. (8 marks)

(b) Determine the maximum bending moment at D when a 3 m long uniformly distributed load of 25 kN/m crosses the beam in 8(a) above from A to C. (12 marks)

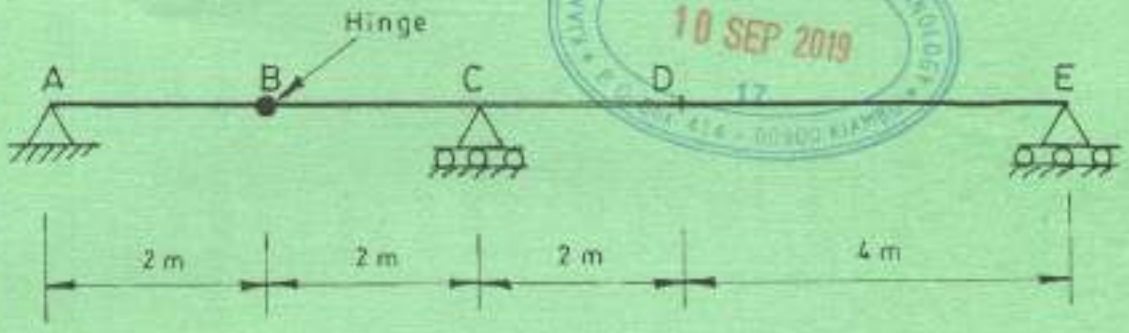

Fig. 8

Grade stresses and moduli of elasticity for various strength classes: for service classes 1 and 2

Strength class	Bending parallel to grain N/mm²	Tension parallel to grain N/mm²	Compression parallel to grain N/mm²	Compression perpendicular to grain [a] N/mm²		Shear parallel to grain N/mm²	Modulus of elasticity		Characteristic density, ρ_k [b]	Average density, ρ_{mean} [b]
							Mean N/mm²	Minimum 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
C27	10.0	6.0	8.2	2.5	2.0	1.10	12 300	8 200	370	450
C30	11.0	6.6	8.6	2.7	2.2	1.20	12 300	8 200	380	460
C35	12.0	7.2	8.7	2.9	2.4	1.30	13 400	9 000	400	480
C40	13.0	7.8	8.7	3.0	2.6	1.40	14 500	10 000	420	500
D30	9.0	5.4	8.1	2.8	2.2	1.40	9 600	6 000	530	640
D35	11.0	6.6	8.6	3.4	2.6	1.70	10 000	6 500	560	670
D40	12.5	7.5	12.6	3.9	3.0	2.00	10 800	7 500	590	700
D50	16.0	9.6	15.2	4.5	3.5	2.20	15 000	12 600	650	780
D60	18.0	10.8	18.0	5.2	4.0	2.40	18 500	15 600	700	840
D70	23.0	13.8	23.0	6.0	4.6	2.60	21 000	18 000	900	1 080

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 1: Limiting width to thickness ratios

Type of element (all rolled sections)	Class of section		
	(1) Plastic	(2) Compact	(3) Semi-Compact
Outstand element of compression flange	$\frac{b}{T} \leq 8.5\varepsilon$	$\frac{b}{T} \leq 9.5\varepsilon$	$\frac{b}{T} \leq 15\varepsilon$
Web with neutral axis at mid-depth	$\frac{b}{t} \leq 79$	$\frac{b}{t} \leq 98\varepsilon$	$\frac{b}{t} \leq 120\varepsilon$
Web subject to compression throughout	$\frac{b}{t} \leq 39$	$\frac{b}{t} \leq 39$	$\frac{b}{t} \leq 39$
Note: $\varepsilon = (275/py)^{\frac{1}{2}}$			

Table 2: Strut table selection

Type of section	Thickness[a]	Axis of buckling	
		x-x	y-y
Hot- rolled structural hollow section		-	-
Rolled I-section		-	-
Rolled H-section	Up to 40mm	Table 8(a)	Table 8(b)
	Over 40mm	Table 8(b)	-
[a] For thicknesses between 40 and 50mm the value of *pc* may be taken as the average of the values for thicknesses up to 40mm and over 40mm			

Table 3: Strength of bolts in clearance holes

	Bolt grade (N/mm^2)	
	4.6	8.8
Shear strength, p_s	160	375
Bearing, strength, p_{bs}	460	1035
Tension strength, p_t	195	450

Table 4: Tensile stress area, A_s

Nominal size and thread diameter (mm)	Tensile stress area A_s (mm^2)
12	84.3
16	157
20	245
22	303
24	353
27	459
30	561

Table 5: Compressive strength, p_c (N/mm^2) for struts

λ \ Py	225	245	255	265	275	λ \ Py	225	245	255	265	275
15	225	245	255	265	275	96	133	140	143	146	148
20	224	243	253	263	272	98	130	137	139	142	145
25	220	239	248	258	267	100	127	133	136	138	141
30	216	234	243	253	262	102	124	130	132	135	137
35	211	229	238	247	256	104	122	127	129	131	133
40	207	224	233	241	250	106	119	124	126	128	130
42	205	222	231	239	248	108	116	121	123	125	126
44	203	220	228	237	245	110	113	118	120	121	123
46	201	218	226	234	242	112	111	115	117	118	120
48	199	215	223	231	239	114	108	112	114	115	117
50	197	213	221	229	237	116	105	109	111	112	114
52	195	210	218	226	234	118	103	106	108	109	111
54	192	208	215	223	230	120	100	104	105	107	108
56	190	205	213	220	227	122	98	101	103	104	105
58	188	202	210	217	224	124	96	99	100	101	102
60	185	200	207	214	221	126	94	96	97	99	100
62	183	197	204	210	217	128	91	94	95	96	97
64	180	194	200	207	213	130	89	92	93	94	95
66	178	191	197	203	210	135	84	86	87	88	89
68	175	188	194	200	206	140	79	81	82	83	84
70	172	185	190	196	202	145	75	77	78	78	79
72	169	181	187	193	198	150	71	72	73	74	74
74	167	178	183	189	194	155	67	69	69	70	70
76	164	175	180	185	190	160	64	65	66	66	66
78	161	171	176	181	186	165	60	61	62	63	63
80	158	168	172	177	181	170	57	58	59	59	60
82	155	164	169	173	177	175	55	56	56	56	57
84	152	161	165	169	173	180	52	53	53	54	54
86	149	157	161	165	169	185	49	50	51	51	51
88	146	154	158	161	165	190	47	48	48	48	49
90	143	150	154	157	161	195	45	46	46	46	47
92	139	147	150	153	156	200	43	44	44	44	44
94	136	143	147	150	152						

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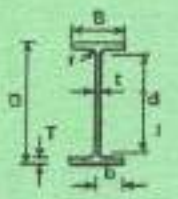

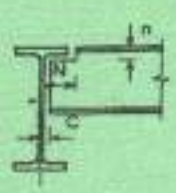

DIMENSIONS

Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
	kg/m	D mm	B mm	t mm	T mm	r mm	d mm	b/T	d/t	C mm	N mm	n mm	m²	m²
457 × 191 × 98	98.3	467.2	192.8	11.4	19.6	10.2	407.8	4.92	35.8	8	102	30	1.67	16.9
457 × 191 × 89	89.3	463.4	191.9	10.5	17.7	10.2	407.8	5.42	38.8	7	102	28	1.66	18.5
457 × 191 × 82	82.0	460.0	191.3	9.9	16.0	10.2	407.8	5.98	41.2	7	102	28	1.65	20.1
457 × 191 × 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	6.57	45.3	7	102	26	1.64	22.1
457 × 191 × 67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	7.48	48.0	6	102	24	1.63	24.3
457 × 152 × 82	82.1	465.8	155.3	10.5	18.9	10.2	407.6	4.11	38.8	7	84	30	1.51	18.4
457 × 152 × 74	74.2	462.0	154.4	9.6	17.0	10.2	407.8	4.54	42.5	7	84	28	1.50	20.3
457 × 152 × 67	67.2	458.0	153.8	9.0	15.0	10.2	407.8	5.13	45.3	7	84	26	1.50	22.3
457 × 152 × 60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	5.75	50.3	6	84	24	1.49	24.9
457 × 152 × 52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	6.99	53.6	6	84	22	1.48	28.2
406 × 178 × 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 × 178 × 67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41.0	6	96	26	1.50	22.3
406 × 178 × 60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	6.95	45.6	6	96	24	1.49	24.8
406 × 178 × 54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	46.8	6	96	22	1.48	27.4
406 × 140 × 46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53.0	5	78	22	1.34	29.2
406 × 140 × 39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	8.24	56.3	5	78	20	1.33	34.2
356 × 171 × 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	7	94	26	1.38	20.6
356 × 171 × 57	57.0	358.0	172.2	8.1	13.0	10.2	311.6	6.62	38.5	6	94	24	1.37	24.1
356 × 171 × 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 × 171 × 45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	8.82	44.5	6	94	20	1.36	30.1
356 × 127 × 39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	5.89	47.2	5	70	22	1.18	30.2
356 × 127 × 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 × 165 × 54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	6.08	33.6	6	90	24	1.26	23.3
305 × 165 × 46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.6	5	90	22	1.25	27.1
305 × 165 × 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 × 127 × 48	48.1	311.0	125.3	9.0	14.0	8.9	265.2	4.47	29.5	7	70	24	1.09	22.7
305 × 127 × 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 × 127 × 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 × 102 × 33	32.8	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	5	58	20	1.01	30.8
305 × 102 × 28	28.2	308.7	101.8	6.0	8.8	7.6	275.9	5.78	46.0	5	58	18	1.00	35.4
305 × 102 × 25	24.8	305.1	101.6	5.8	7.0	7.6	275.9	7.26	47.6	5	58	16	0.992	40.0
254 × 146 × 43	43.0	259.6	147.3	7.2	12.7	7.6	219.0	5.80	30.4	6	82	22	1.08	25.1
254 × 146 × 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 × 146 × 31	31.1	251.4	146.1	6.0	8.6	7.6	219.0	8.49	36.5	5	82	18	1.06	34.2
254 × 102 × 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 × 102 × 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 × 102 × 22	22.0	254.0	101.6	5.7	6.8	7.6	225.2	7.47	39.5	5	58	16	0.890	40.5
203 × 133 × 30	30.0	206.8	133.9	6.4	9.6	7.6	172.4	6.97	26.9	5	74	18	0.923	30.8
203 × 133 × 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 × 102 × 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 × 102 × 19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	4	60	16	0.736	38.8
152 × 89 × 16	16.0	152.4	88.7	4.5	7.7	7.6	121.8	5.78	27.1	4	54	16	0.638	39.8
127 × 76 × 13	13.0	127.0	76.0	4.0	7.6	7.6	96.6	5.00	24.1	4	46	16	0.537	41.3

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PROPERTIES

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis x-x cm^4	Axis y-y cm^4	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	A cm^2
457 × 191 × 98	45700	2350	18.1	4.33	1990	243	2230	379	0.862	25.7	1.18	121	125
457 × 191 × 89	41000	2090	18.0	4.29	1770	218	2010	338	0.879	28.3	1.04	90.7	114
457 × 191 × 82	37100	1870	18.8	4.23	1610	196	1830	304	0.879	30.8	0.922	69.2	104
457 × 191 × 74	33300	1670	18.8	4.20	1460	176	1650	272	0.877	33.8	0.818	51.8	94.6
457 × 191 × 67	29400	1450	18.5	4.12	1300	153	1470	237	0.872	37.9	0.705	37.1	85.5
457 × 152 × 82	38600	1100	18.7	3.37	1570	153	1810	240	0.871	27.4	0.591	89.2	105
457 × 152 × 74	33700	1050	18.6	3.33	1410	136	1630	213	0.873	30.2	0.518	65.9	94.5
457 × 152 × 67	29900	913	18.4	3.27	1260	119	1450	187	0.868	33.6	0.448	47.7	85.6
457 × 152 × 60	25500	795	18.3	3.23	1120	104	1290	163	0.868	37.5	0.387	33.8	76.2
457 × 152 × 52	21400	645	17.9	3.11	960	84.6	1100	133	0.859	43.8	0.311	21.4	66.6
406 × 178 × 74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.8	0.936	62.8	94.5
406 × 178 × 67	24300	1370	16.9	3.99	1190	153	1350	237	0.880	30.5	0.833	46.1	85.5
406 × 178 × 60	21600	1200	16.9	3.97	1060	135	1200	209	0.880	33.8	0.466	33.3	76.5
406 × 178 × 54	18700	1020	16.8	3.85	930	115	1060	178	0.871	38.3	0.392	23.1	69.0
406 × 140 × 46	15700	538	16.4	3.03	778	76.7	898	118	0.872	39.0	0.207	19.0	58.8
406 × 140 × 39	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.5	0.155	10.7	49.7
356 × 171 × 67	19500	1360	15.1	3.99	1070	157	1210	243	0.886	24.4	0.412	55.7	85.5
356 × 171 × 57	16000	1110	14.8	3.91	896	129	1010	199	0.882	29.8	0.330	33.4	72.6
356 × 171 × 51	14100	968	14.8	3.88	798	113	898	174	0.881	32.1	0.286	23.8	64.9
356 × 171 × 45	12100	811	14.5	3.79	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356 × 127 × 39	10200	358	14.3	2.68	576	56.8	659	89.1	0.871	35.2	0.105	15.1	49.8
356 × 127 × 33	8250	280	14.0	2.58	473	44.7	543	70.3	0.863	42.2	0.081	8.79	42.1
305 × 165 × 54	11700	1090	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305 × 165 × 46	9900	896	13.0	3.90	646	108	720	166	0.891	27.1	0.195	22.2	58.7
305 × 165 × 40	8500	764	12.9	3.86	569	92.6	623	142	0.889	31.0	0.164	14.7	51.3
305 × 127 × 48	9560	461	12.5	2.74	616	73.6	711	116	0.874	23.3	0.102	31.8	61.2
305 × 127 × 42	8200	389	12.4	2.70	534	62.6	614	98.4	0.872	26.5	0.0848	21.1	53.4
305 × 127 × 37	7170	336	12.3	2.67	471	54.5	539	85.4	0.871	29.7	0.0725	14.8	47.2
305 × 102 × 33	6500	194	12.5	2.15	416	37.9	481	60.0	0.867	31.6	0.0442	12.2	41.8
305 × 102 × 28	6370	155	12.2	2.08	348	30.5	403	48.5	0.859	37.4	0.0349	7.40	35.9
305 × 102 × 25	4460	123	11.9	1.97	292	24.2	342	38.8	0.846	43.4	0.0273	4.77	31.8
254 × 146 × 43	6540	577	10.9	3.52	504	82.0	566	141	0.890	21.2	0.103	23.9	54.8
254 × 146 × 37	5540	571	10.8	3.48	433	78.0	483	119	0.889	24.4	0.0857	15.3	47.2
254 × 146 × 31	4410	448	10.5	3.36	351	61.3	393	94.1	0.879	29.6	0.0690	8.55	39.7
254 × 102 × 28	4010	179	10.5	2.22	308	34.9	353	54.8	0.874	27.5	0.0280	9.57	36.1
254 × 102 × 25	3420	149	10.3	2.15	266	29.2	306	46.0	0.867	31.4	0.0230	6.42	32.0
254 × 102 × 22	2840	119	10.1	2.06	224	23.5	259	37.3	0.856	36.3	0.0182	4.15	28.0
203 × 133 × 30	2900	385	8.71	3.17	290	57.5	314	88.2	0.881	21.5	0.0374	10.3	38.2
203 × 133 × 25	2340	308	8.58	3.10	230	46.2	258	70.9	0.877	25.6	0.0294	5.96	32.0
203 × 102 × 23	2110	164	8.46	2.36	207	32.2	234	49.8	0.868	22.5	0.0154	7.02	29.4
178 × 102 × 19	1360	137	7.48	2.37	153	27.0	171	41.6	0.886	22.5	0.00967	4.41	24.3
152 × 89 × 16	834	89.8	6.41	2.10	109	20.2	123	31.2	0.889	19.6	0.00479	3.56	20.3
127 × 76 × 13	473	55.7	5.35	1.84	74.6	14.7	84.2	22.6	0.896	19.3	0.00199	2.85	16.5

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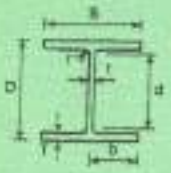

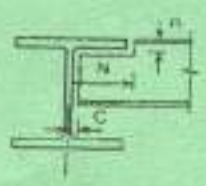

DIMENSIONS

Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
	kg/m	D mm	B mm	t mm	T mm	r mm	d mm	b/T	d/t	C mm	N mm	n mm	m^2	m^2
356 × 406 × 634 #	633.9	474.6	424.0	47.6	77.0	15.2	290.2	2.75	6.10	26	200	94	2.52	3.98
356 × 406 × 551 #	551.0	455.6	418.5	42.1	67.5	15.2	290.2	3.10	6.89	23	200	84	2.47	4.49
356 × 406 × 467 #	467.0	436.6	412.2	35.8	58.0	15.2	290.2	3.55	8.11	20	200	74	2.42	5.19
356 × 406 × 393 #	393.0	419.0	407.0	30.6	49.2	15.2	290.2	4.14	9.48	17	200	66	2.38	6.06
356 × 406 × 340 #	339.9	406.4	403.0	26.6	42.9	15.2	290.2	4.70	10.9	15	200	60	2.35	6.90
356 × 406 × 287 #	287.1	393.6	399.0	22.6	36.5	15.2	290.2	5.47	12.8	13	200	52	2.31	8.05
356 × 406 × 235 #	235.1	381.0	394.8	18.4	30.2	15.2	290.2	6.54	15.8	11	200	46	2.28	9.69
356 × 368 × 202 #	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.94	17.6	10	190	44	2.19	10.8
356 × 368 × 177 #	177.0	368.2	372.6	14.4	23.8	15.2	290.2	7.83	20.2	9	190	40	2.17	12.3
356 × 368 × 153 #	152.9	362.0	370.5	12.3	20.7	15.2	290.2	8.95	23.6	8	190	36	2.16	14.1
356 × 368 × 129 #	129.0	355.6	368.6	10.4	17.5	15.2	290.2	10.50	27.9	7	190	34	2.14	16.6
305 × 305 × 283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.65	9.21	15	158	60	1.94	6.86
305 × 305 × 240	240.0	352.5	318.4	23.0	37.7	15.2	246.7	4.22	10.7	14	158	54	1.91	7.94
305 × 305 × 198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	5.01	12.9	12	158	48	1.87	9.46
305 × 305 × 158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	6.22	15.6	10	158	42	1.84	11.6
305 × 305 × 137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	7.12	17.9	9	158	38	1.82	13.3
305 × 305 × 118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	8.22	20.6	8	158	34	1.81	15.3
305 × 305 × 97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	9.91	24.9	7	158	32	1.79	18.5
254 × 254 × 167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	4.18	10.4	12	134	48	1.58	9.45
254 × 254 × 132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	5.16	13.1	10	134	38	1.55	11.7
254 × 254 × 107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	6.31	15.6	8	134	34	1.52	14.2
254 × 254 × 89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	7.41	19.4	7	134	30	1.50	16.9
254 × 254 × 73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	8.96	23.3	6	134	28	1.49	20.4
203 × 203 × 86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	5.10	12.7	8	110	32	1.24	14.4
203 × 203 × 71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.97	16.1	7	110	28	1.22	17.2
203 × 203 × 60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	7.25	17.1	7	110	26	1.21	20.1
203 × 203 × 52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	8.17	20.4	6	110	24	1.20	23.0
203 × 203 × 46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	9.25	22.3	6	110	22	1.19	25.8
152 × 152 × 37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	6.71	15.5	6	84	20	0.912	24.7
152 × 152 × 30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	8.13	19.0	5	84	18	0.901	30.0
152 × 152 × 23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	11.2	21.3	5	84	16	0.889	38.7

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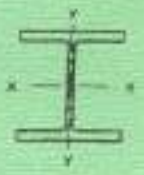

PROPERTIES

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis x-x cm^4	Axis y-y cm^4	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	A cm^2
356 × 406 × 634 #	275000	98100	18.4	11.0	11600	4830	14200	7110	0.843	5.46	38.5	13700	808
356 × 406 × 551 #	227000	82700	18.0	10.9	9960	3950	12100	6060	0.841	6.05	31.1	9240	702
356 × 406 × 467 #	183000	67900	17.5	10.7	8380	3290	10000	5030	0.839	6.86	24.3	5810	595
356 × 406 × 393 #	147000	55400	17.1	10.5	7000	2720	8320	4150	0.837	7.87	18.9	3550	501
356 × 406 × 340 #	123000	46900	16.8	10.4	6030	2330	7000	3540	0.836	8.84	15.5	2340	433
356 × 406 × 287 #	99900	38700	16.5	10.3	5080	1940	5810	2950	0.834	10.2	12.3	1440	366
356 × 406 × 235 #	79100	31000	16.3	10.2	4150	1570	4690	2380	0.835	12.0	9.54	812	299
356 × 368 × 202 #	56300	23700	16.1	9.69	3540	1260	3970	1920	0.844	13.4	7.16	556	257
356 × 368 × 177 #	47100	20500	15.9	9.54	3100	1100	3480	1670	0.843	15.0	6.09	381	226
356 × 368 × 153 #	40500	17600	15.8	9.49	2680	948	2970	1440	0.844	17.0	5.11	251	195
356 × 368 × 129 #	34000	14600	15.6	9.40	2260	790	2480	1200	0.845	19.3	4.16	153	164
305 × 305 × 283	78900	24800	14.8	8.27	4320	1530	5110	2340	0.855	7.65	8.35	2030	360
305 × 305 × 240	64200	20300	14.5	8.15	3640	1280	4250	1950	0.854	8.74	5.03	1270	306
305 × 305 × 198	50900	16300	14.2	8.04	3000	1040	3440	1580	0.854	10.2	3.86	734	252
305 × 305 × 158	38800	12600	13.9	7.90	2370	808	2680	1230	0.852	12.5	2.87	378	201
305 × 305 × 137	32900	10700	13.7	7.83	2060	692	2300	1050	0.852	14.1	2.39	249	174
305 × 305 × 118	27700	9060	13.6	7.77	1780	589	1960	895	0.851	16.2	1.98	161	150
305 × 305 × 97	22300	7010	13.4	7.69	1450	479	1590	726	0.852	19.2	1.56	91.2	123
254 × 254 × 167	30000	9870	11.9	6.81	2360	744	2620	1140	0.851	8.50	1.83	626	213
254 × 254 × 132	22500	7530	11.8	6.69	1830	576	1870	878	0.850	10.3	1.19	319	168
254 × 254 × 107	17500	5930	11.3	6.59	1310	456	1480	697	0.849	12.4	0.898	172	136
254 × 254 × 89	14300	4860	11.2	6.55	1100	379	1220	575	0.851	14.5	0.717	102	113
254 × 254 × 73	11400	3910	11.1	6.48	898	307	992	465	0.849	17.3	0.562	57.6	93.1
203 × 203 × 86	9450	3130	9.28	5.34	850	289	977	456	0.849	10.2	0.318	137	110
203 × 203 × 71	7620	2540	9.16	5.36	706	246	799	374	0.853	11.9	0.250	80.2	90.4
203 × 203 × 60	6130	2070	8.96	5.20	584	201	656	305	0.846	14.1	0.197	47.2	76.4
203 × 203 × 52	5260	1780	8.91	5.18	510	174	567	264	0.848	15.8	0.167	31.8	66.3
203 × 203 × 46	4570	1550	8.82	5.13	450	152	497	231	0.846	17.7	0.143	22.2	58.7
152 × 152 × 37	2210	706	6.85	3.87	273	91.5	309	140	0.849	13.3	0.0399	13.2	47.1
152 × 152 × 30	1750	560	6.76	3.83	222	73.9	248	112	0.849	16.0	0.0308	10.5	38.3
152 × 152 × 23	1250	400	6.54	3.70	164	52.6	182	80.2	0.840	20.7	0.0212	4.83	29.2

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