

# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 5 Examination in Engineering: December 2020

Module Number: CE5201      Module Name: Design of Steel Structures

Time allowed: Three Hours

Answer all questions, each question carries equal marks

*Code of Practices EN 1993-1-1:2005, EN 1993-1-5:2006, EN 1993-1-8:2005 are provided*

Q1. Fig. Q1(a) shows a part of steel truss bridge. The diagonal members of the truss are unequal single angle section of size 120x120x10 and the top and bottom chords are back-to-back channel sections of size 200x90x30. The back-to-back channel sections are sufficiently interconnected along the member to act together. The connection details of angle sections used for diagonal members are shown in Fig. Q1(c). The grade of steel used is S275.

- If the bottom chord is spliced at joint A on the web with connection details as indicated in Fig Q1(b), determine tensile capacity of back-to-back channel sections. [4.0 Marks]
- If the connection details of angle sections used for diagonal members are as shown in Fig. Q1(c), determine tensile capacity of a diagonal member. [4.0 Marks]
- Check whether the bolted connection shown in Fig. Q1(c) is sufficient to carry the full capacity of tension member obtained in Part (b). Also check the minimum and the maximum spacing, end, and edge distance requirements are satisfied. The bolt are grade 4.6. [7.0 Marks]

Q2. The beam shown in Fig. Q2(a) is used in a multistory steel building at the top most level. The beam has moment resisting connections at its ends and carries concentrated loads due to roof supporting posts at 3m distance from each end. The design values of combined actions at ultimate limits state are calculated and indicated in Fig. Q2(a). The bending moment and shear forces diagrams obtained by analyzing the beam are given in Fig. Q2(b). Universal beam section of size 457x191x67 made in grade S275 steel has been selected as an initial section for the design check. Verify the adequacy of selected beam for the following design criteria.

- Cross section resistance  
  - Local buckling [2.5 Marks]
  - Shear buckling and shear yielding resistance [2.5 Marks]
  - Bending resistance [2.5 Marks]
  - Web bearing and web buckling resistance at support A. Take the stiff bearing length  $s_s=75\text{mm}$  and end distance  $c=0$ . [2.5 Marks]

- b) Lateral torsional buckling resistance of segment AB using Cl. 6.3.2.3 EN 1993-1-1;2005. Use  $M_{cr}=355 \text{ kNm}$  and  $k_e=0.61$ .

[5.0 Marks]

Q3. Square Hollow Section (SHS) steel columns are repropose to be used in a lobby area of a multistory building, mainly for architectural purpose. It is estimated that the ultimate design axial compression force for a typical column is 1300 kN. The end connections are assumed to be pinned. An idealized column and its cross section are as shown in Fig. Q3(a) & (b) respectively. Verify the adequacy of 200x200x6.3 SHS section made in Grade S355 to be used as a column in the above application.

- a) Classify the cross section and hence check the local buckling effect.

[2.0 Marks]

- b) Check whether the cross section resistance in compression is adequate for the selected column section

[4.0 Marks]

- c) Check the flexural buckling resistance of the column.

[6.0 Marks]

- d) If the flexural capacity is not adequate, state with facts on how the flexural capacity can be enhanced. [Hint: Facts may include how the proposed methods are, structurally and economically efficient]

[3.0 Marks]

Q4. A ground floor column of a multi-story building is subjected to axial compression and bending. A universal column section of size 305x305x240 is selected as an initial section for the design check. The height of a column is 4.2 m. The frame is moment resistance in-plane and pinned out-of-plane, with diagonal bracing provided in both directions. Structural analysis was conducted for a column and the resulting bending moment diagrams for major and minor axis are indicated in Fig. Q4. The design axial force at ultimate limit state (ULS) is found as 3440 kN. Grade of steel S275.

- a) Check the cross-section resistance of selected section is sufficient to carry the design forces and moments at ULS.

[6.0 Marks]

- c) Check whether the member resistance against combined action of axial compression and bi-axis moments using Appendix B method in EN1993-1-1:2005.

[9.0 Marks]

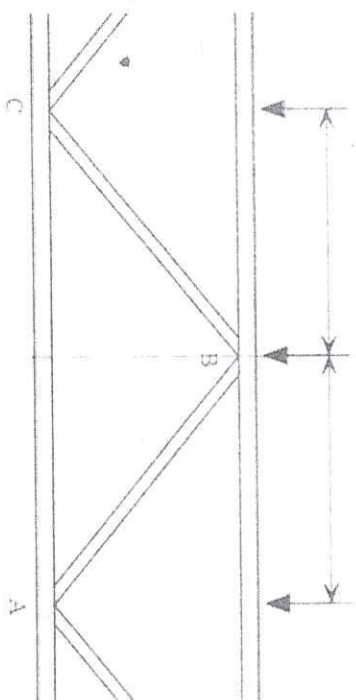


Fig. Q1 (a)

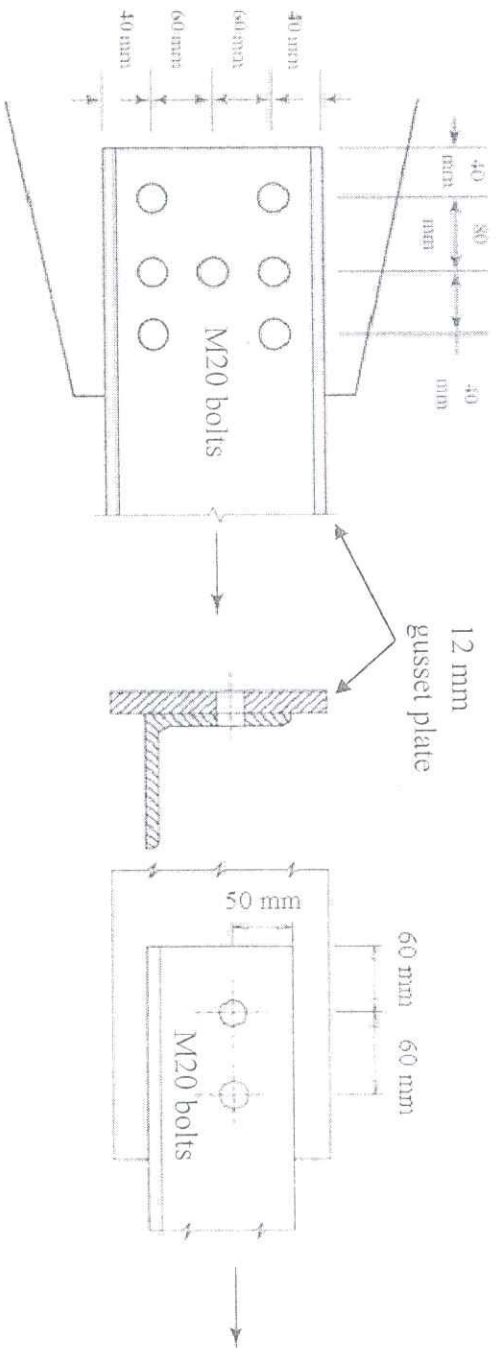


Fig. Q1(b)

Fig. Q1(c)

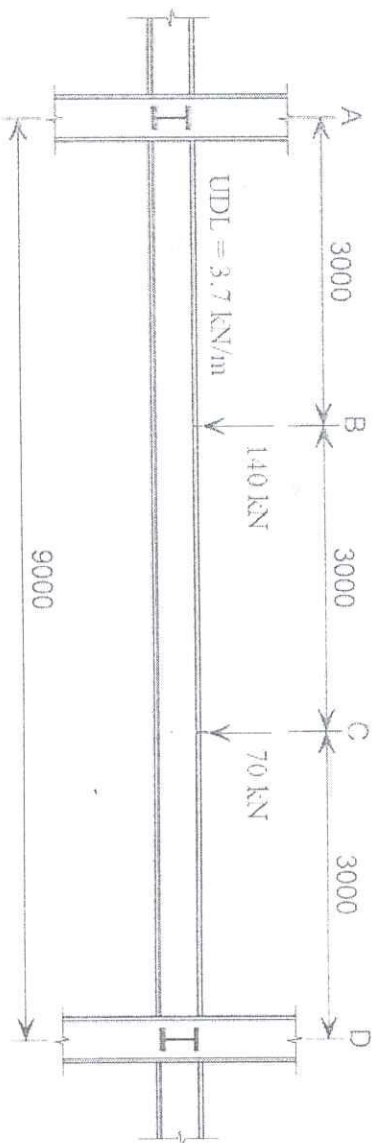


Fig. Q2(a)

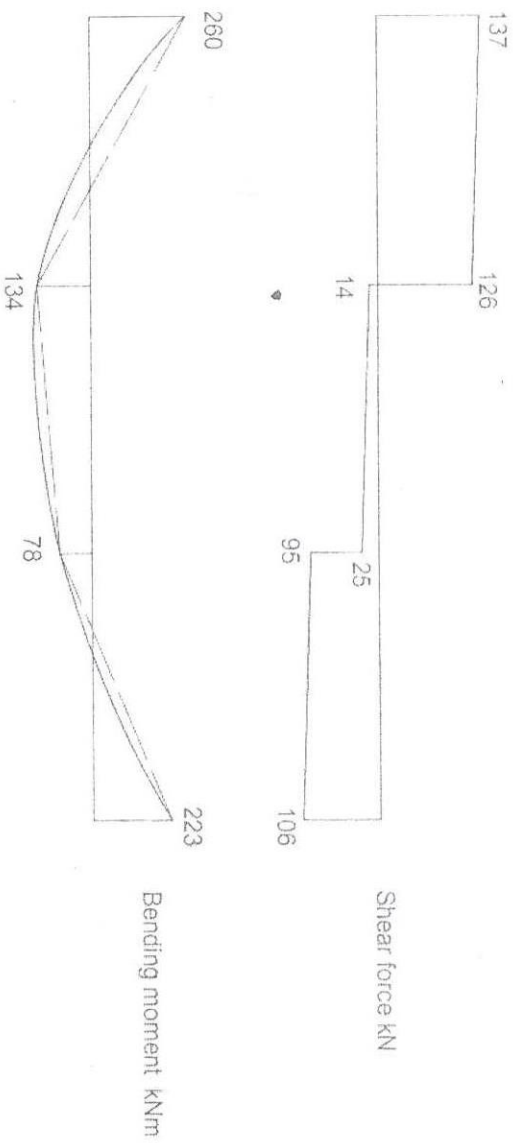


Fig. Q2 (b)

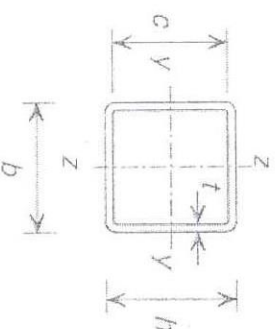
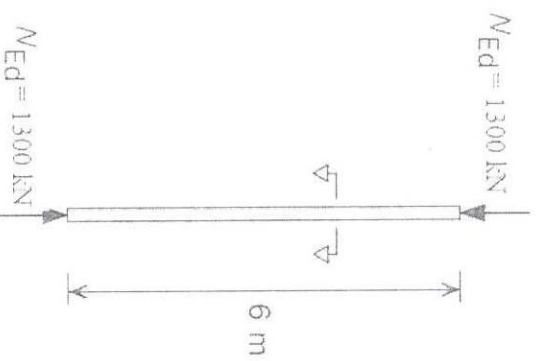


Fig. Q3 (a)

Fig. Q3 (b)

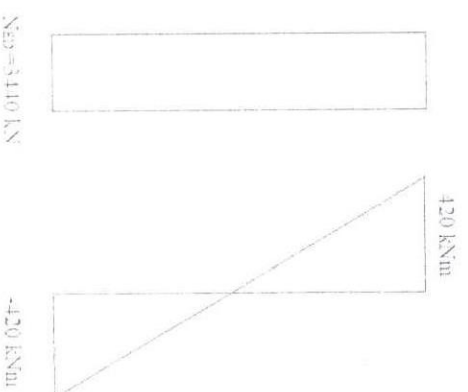
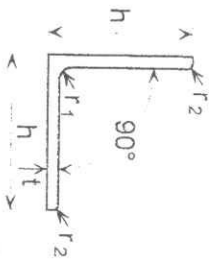


Fig. Q4

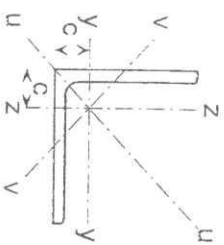
BS EN 1993-1-1:2005  
BS EN 10056-1:1999

EQUAL ANGLES

Advance UKA - Equal Angles



Dimensions and properties



Section Designation	Thickness t	Mass per metre	Radius		Area of section	Distance to centroid c	Second Moment of Area			Radius of Gyration			Elastic Modulus $E$	Torsional Constant $I_t$	Equivalent Slenderness Coefficient $\phi_s$
			Root $r_1$	Toe $r_2$			Axis	Axis	Axis	Axis	Axis	Axis			
200x200	24	71.1	18.0	9.00	90.6	5.84	3330	5280	1380	6.06	7.64	3.90	235	182	2.50
	20	59.9	18.0	9.00	76.3	5.68	2850	4530	1170	6.11	7.70	3.92	199	107	3.05
	18	54.3	18.0	9.00	69.1	5.60	2600	4150	1050	6.13	7.75	3.90	181	78.9	3.43
	16	48.5	18.0	9.00	61.8	5.52	2340	3720	960	6.16	7.76	3.94	162	56.1	3.85
150x150	18+	40.1	16.0	8.00	51.2	4.38	1060	1680	440	4.55	5.73	2.93	99.8	58.6	2.48
	15	33.8	16.0	8.00	43.0	4.25	898	1430	370	4.57	5.76	2.93	83.5	34.6	3.01
	12	27.3	16.0	8.00	34.8	4.12	737	1170	303	4.60	5.80	2.95	67.7	18.2	3.77
	10	23.0	16.0	8.00	29.3	4.03	624	990	258	4.62	5.82	2.97	56.9	10.8	4.51
120x120	15+	26.6	13.0	6.50	34.0	3.52	448	710	186	3.63	4.57	2.34	52.8	27.0	2.37
	12	21.6	13.0	6.50	27.5	3.40	368	584	152	3.65	4.60	2.35	42.7	14.2	2.99
	10	18.2	13.0	6.50	23.2	3.31	313	497	129	3.67	4.63	2.36	36.0	8.41	3.61
	8+	14.7	13.0	6.50	18.8	3.24	259	411	107	3.71	4.67	2.38	29.5	4.44	4.56
100x100	15+	21.9	12.0	6.00	28.0	3.02	250	395	105	2.99	3.76	1.94	35.8	22.3	1.92
	12	17.8	12.0	6.00	22.7	2.90	207	328	85.7	3.02	3.80	1.94	29.1	11.8	2.44
	10	15.0	12.0	6.00	19.2	2.82	177	280	73.0	3.04	3.83	1.95	24.6	6.97	2.94
	8	12.2	12.0	6.00	15.5	2.74	145	230	59.9	3.06	3.85	1.96	19.9	3.68	3.70
90x90	12+	15.9	11.0	5.50	20.3	2.66	149	235	62.0	2.71	3.40	1.75	23.5	10.5	2.17
	10	13.4	11.0	5.50	17.1	2.58	127	201	52.6	2.72	3.42	1.75	19.8	6.20	2.64
	8	10.9	11.0	5.50	13.9	2.50	104	166	43.1	2.74	3.45	1.76	16.1	3.28	3.33
	7	9.61	11.0	5.50	12.2	2.45	92.6	147	38.3	2.75	3.46	1.77	14.1	2.24	3.80
80x80	10	11.9	10.0	5.00	15.1	2.34	87.5	139	36.4	2.41	3.03	1.55	15.4	5.45	2.33
	8	9.63	10.0	5.00	12.3	2.26	72.2	115	29.9	2.43	3.06	1.56	12.6	2.88	2.94
	6	6.85	9.00	4.50	11.4	2.14	59.1	93.8	24.5	2.27	2.86	1.46	11.0	2.65	2.76
	4	4.57	8.00	4.00	8.73	2.05	45.8	72.7	18.9	2.29	2.89	1.47	8.41	1.17	3.70
70x70	7	7.38	9.00	4.50	9.40	1.97	42.3	67.1	17.5	2.12	2.67	1.36	8.41	1.69	2.92
	6	6.38	9.00	4.50	8.13	1.93	36.9	58.5	15.3	2.13	2.68	1.37	7.27	1.09	3.41
	4	4.57	8.00	4.00	6.83	1.82	33.4	53.0	13.8	1.96	2.47	1.26	7.18	1.58	2.67
	3	3.89	7.00	3.50	6.06	1.77	29.2	46.1	12.2	1.80	2.26	1.16	6.89	2.09	2.14
60x60	8	7.09	8.00	4.00	9.03	1.77	29.2	46.1	12.2	1.80	2.26	1.16	6.89	2.09	2.14
	6	5.42	8.00	4.00	6.91	1.69	22.8	36.1	9.44	1.82	2.29	1.17	5.29	0.922	2.90
	5	4.57	8.00	4.00	5.82	1.64	19.4	30.7	8.03	1.82	2.30	1.17	4.45	0.550	3.48
	4	3.77	7.00	3.50	4.80	1.40	12.8	20.3	5.34	1.50	1.89	0.968	3.61	0.755	2.38
45x45	5	3.06	7.00	3.50	3.89	1.36	8.97	14.2	3.73	1.52	1.91	0.979	2.46	0.240	3.57
	4	2.42	6.00	3.00	3.08	1.12	4.47	7.09	1.86	1.21	1.52	0.777	1.55	0.188	2.83
	3	1.78	5.00	2.50	2.27	0.878	1.80	2.85	0.754	0.892	1.12	0.577	0.850	0.137	2.07
	2	1.36	5.00	2.50	1.74	0.835	1.40	2.22	0.585	0.899	1.13	0.581	0.649	0.0613	2.75
30x30	4	2.09	5.00	2.50	2.67	1.00	2.95	4.68	1.23	1.05	1.32	0.678	1.18	0.158	2.50
	3	1.45	3.50	1.75	1.85	0.762	1.02	1.61	0.430	0.741	0.931	0.482	0.586	0.1070	1.75
	2	1.12	3.50	1.75	1.42	0.723	0.803	1.27	0.334	0.751	0.945	0.484	0.452	0.0472	2.38
	1	0.882	3.50	1.75	1.12	0.599	0.392	0.618	0.165	0.590	0.742	0.383	0.279	0.0382	1.81

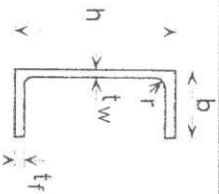
Advance and UKA are trademarks of Corus. A fuller description of the relationship between Angles and the Advance range of sections manufactured by Corus is given in section 12.

+ These sections are in addition to the range of BS EN 10056-1 sections  
c is the distance from the back of the leg to the centre of gravity.  
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

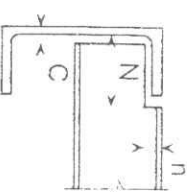
BS EN 1993-1-1:2005  
BS 4-1:2005

## PARALLEL FLANGE CHANNELS

Advance UKPFC



Dimensions



Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Distance $e_0$	Dimensions for Detailing			Surface Area	
				Web $t_w$	Flange $t_f$			Flange $c_f/t_f$	Web $c_w/l_w$		End Clearance C	Notch		Per Metre $m^2$	Per Tonne $m^2$
430x100x64	64.4	430	100	11.0	19.0	15	362	3.89	32.9	3.27	13	96	36	1.23	19.0
380x100x54	54.0	380	100	9.5	17.5	15	315	4.31	33.2	3.48	12	98	34	1.13	20.9
300x100x46	45.5	300	100	9.0	16.5	15	237	4.61	26.3	3.68	11	98	32	0.969	21.3
300x90x41	41.4	300	90	9.0	15.5	12	245	4.45	27.2	3.18	11	88	28	0.932	22.5
260x90x35	34.8	260	90	8.0	14.0	12	208	5.00	26.0	3.32	10	88	28	0.854	24.5
260x75x28	27.6	260	75	7.0	12.0	12	212	4.67	30.3	2.62	9	74	26	0.796	28.8
230x90x32	32.2	230	90	7.5	14.0	12	178	5.04	23.7	3.46	10	90	28	0.795	24.7
230x75x26	25.7	230	75	6.5	12.5	12	181	4.52	27.8	2.78	9	76	26	0.737	28.7
200x90x30	29.7	200	90	7.0	14.0	12	148	5.07	21.1	3.60	9	90	28	0.736	24.8
200x75x23	23.4	200	75	6.0	12.5	12	151	4.56	25.2	2.91	8	76	26	0.678	28.9
180x90x26	26.1	180	90	6.5	12.5	12	131	5.72	20.2	3.64	9	90	26	0.697	26.7
180x75x20	20.3	180	75	6.0	10.5	12	135	5.43	22.5	2.87	8	76	24	0.638	31.4
150x90x24	23.9	150	90	6.5	12.0	12	102	5.96	15.7	3.71	9	90	26	0.637	26.7
150x75x18	17.9	150	75	5.5	10.0	12	106	5.75	19.3	2.99	8	76	24	0.579	32.4
125x65x15	14.8	125	65	5.5	9.5	12	82.0	5.00	14.9	2.56	8	66	22	0.489	33.1
100x50x10	10.2	100	50	5.0	8.5	9	65.0	4.24	13.0	1.94	7	52	18	0.382	37.5

Advance and UKPFC are trademarks of Corus. A fuller description of the relationship between Parallel Flange Channels (PFC) and the Advance range of sections manufactured by Corus is given in section 12.

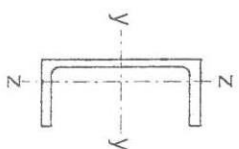
$e_0$  is the distance from the centre of the web to the shear centre

FOR EXPLANATION OF TABLES SEE NOTE 2

BS EN 1993-1-1:2005  
BS 4-1:2005

## PARALLEL FLANGE CHANNELS

### Advance UKPFC



### Properties

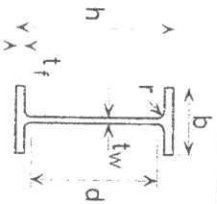
Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis Y-Y	Axis Z-Z	Axis Y-Y	Axis Z-Z	Axis Y-Y	Axis Z-Z	Axis Y-Y	Axis Z-Z					
430x100x64	21900	722	16.3	2.97	1020	97.9	1220	176	0.917	22.5	0.219	63.0	82.1
360x100x54	15000	643	14.8	3.06	791	89.2	933	161	0.933	21.2	0.150	45.7	68.7
300x100x46	8230	568	11.9	3.13	549	81.7	641	148	0.944	17.0	0.0813	36.8	58.0
300x90x41	7220	404	11.7	2.77	481	63.1	568	114	0.934	18.3	0.0581	28.8	52.7
260x90x35	4730	353	10.3	2.82	364	56.3	425	102	0.943	17.2	0.0379	20.6	44.4
260x75x28	3620	185	10.1	2.30	278	34.4	328	62.0	0.932	20.5	0.0203	11.7	35.1
230x90x32	3520	334	9.27	2.86	306	55.0	355	98.9	0.949	15.1	0.0279	19.3	41.0
230x75x26	2750	181	9.17	2.35	239	34.8	278	63.2	0.945	17.3	0.0153	11.8	32.7
200x90x30	2520	314	8.16	2.88	252	53.4	291	94.5	0.952	12.9	0.0197	18.3	37.9
200x75x23	1960	170	8.11	2.39	196	33.8	227	60.6	0.956	14.7	0.0107	11.1	29.9
180x90x26	1820	277	7.40	2.89	202	47.4	232	83.5	0.950	12.8	0.0141	13.3	33.2
180x75x20	1370	146	7.27	2.38	152	28.8	176	51.8	0.945	15.3	0.00754	7.34	25.9
150x90x24	1160	253	6.18	2.89	155	44.4	179	76.9	0.937	10.8	0.00890	11.8	30.4
150x75x18	861	131	6.15	2.40	115	26.6	132	47.2	0.945	13.1	0.00467	6.10	22.8
125x65x15	483	80.0	5.07	2.06	77.3	18.8	89.9	33.2	0.942	11.1	0.00194	4.72	18.8
100x50x10	208	32.3	4.00	1.58	41.5	9.89	48.9	17.5	0.942	10.0	0.000491	2.53	13.0

Advance and UKPFC are trademarks of Corus. A fuller description of the relationship between Parallel Flange Channels (PFC) and the Advance range of sections manufactured by Corus is given in section 12.  
FOR EXPLANATION OF TABLES SEE NOTE 3

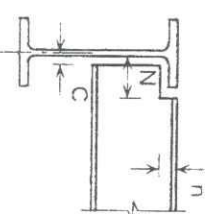
**BS EN 1993-1-1:2005**  
BS 4-1:2005

**UNIVERSAL BEAMS**

**Advance UKB**



Dimensions



Section Designation	Mass per metre	Depth of section h	Width of section b	Thickness		Root radius r	Depth between fillics d	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web lw	Flange lf			Flange c/t	Web cw / tw	End Clearance C	Notch		Per Metre	Per Tonne
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m <sup>2</sup>	m <sup>2</sup>
533x210x138 +	138.3	549.1	213.9	14.7	23.6	12.7	476.5	3.68	32.4	9	110	38	1.90	13.7
533x210x122	122.0	544.5	211.9	12.7	21.3	12.7	476.5	4.08	37.5	8	110	34	1.89	15.5
533x210x109	109.0	539.5	210.8	11.6	18.8	12.7	476.5	4.62	41.1	8	110	32	1.88	17.2
533x210x101	101.0	536.7	210.0	10.8	17.4	12.7	476.5	4.99	44.1	7	110	32	1.87	18.5
533x210x92	92.1	533.1	209.3	10.1	15.6	12.7	476.5	5.57	47.2	7	110	30	1.86	20.2
533x210x82	82.2	528.3	208.8	9.6	13.2	12.7	476.5	6.58	49.6	7	110	26	1.85	22.5
533x165x85 +	84.8	534.9	166.5	10.3	16.5	12.7	476.5	3.96	46.3	7	90	30	1.69	19.9
533x165x75 +	74.7	529.1	165.9	9.7	13.6	12.7	476.5	4.81	49.1	7	90	28	1.68	22.5
533x165x66 +	65.7	524.7	165.1	8.9	11.4	12.7	476.5	5.74	53.5	6	90	26	1.67	25.4
457x191x161 +	161.4	492.0	199.4	18.0	32.0	10.2	407.6	2.52	22.6	11	102	44	1.73	10.7
457x191x133 +	133.3	480.6	196.7	15.3	26.3	10.2	407.6	3.06	26.6	10	102	38	1.70	12.8
457x191x106 +	105.8	469.2	194.0	12.6	20.6	10.2	407.6	3.91	32.3	8	102	32	1.67	15.8
457x191x88	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.11	35.8	8	102	30	1.67	17.0
457x191x89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	4.55	38.8	7	102	28	1.66	18.6
457x191x82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.03	41.2	7	102	28	1.65	20.1
457x191x74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	5.55	45.3	7	102	26	1.64	22.1
457x191x67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	6.34	48.0	6	102	24	1.63	24.3
457x152x82	82.1	465.8	155.3	10.5	18.9	10.2	407.6	3.29	38.8	7	84	30	1.51	18.4
457x152x74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	3.66	42.5	7	84	28	1.50	20.2
457x152x67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	4.15	45.3	7	84	26	1.50	22.3
457x152x60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	4.68	50.3	6	84	24	1.49	24.9
457x152x52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	5.71	53.6	6	84	22	1.48	28.3
406x178x85 +	85.3	417.2	181.9	10.9	18.2	10.2	360.4	4.14	33.1	7	96	30	1.52	17.8
406x178x74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	4.68	37.9	7	96	28	1.51	20.4
406x178x67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	5.23	41.0	6	96	26	1.50	22.3
406x178x60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	5.84	45.6	6	96	24	1.49	24.8
406x178x54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	6.86	48.8	6	96	22	1.48	27.3
406x140x53 +	53.3	406.6	143.3	7.9	12.9	10.2	360.4	4.46	45.6	6	78	22	1.35	25.3
406x140x46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	5.13	53.0	5	78	22	1.34	29.1
406x140x39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	6.69	56.3	5	78	20	1.33	34.1
356x171x67	67.1	383.4	173.2	9.1	15.7	10.2	311.6	4.58	34.2	7	94	26	1.38	20.6
356x171x57	57.0	368.0	172.2	8.1	13.0	10.2	311.6	5.53	38.5	6	94	24	1.37	24.1
356x171x51	51.0	365.0	171.5	7.4	11.5	10.2	311.6	6.25	42.1	6	94	22	1.36	26.7
356x171x45	45.0	361.4	171.1	7.0	9.7	10.2	311.6	7.41	44.5	6	94	20	1.36	30.2
356x127x39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	4.63	47.2	5	70	22	1.18	30.2
356x127x33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	5.82	51.9	5	70	20	1.17	35.4
305x165x54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	5.15	33.6	6	90	24	1.26	23.3
305x165x46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	5.98	39.6	5	90	22	1.25	27.1
305x165x40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	6.92	44.2	5	90	20	1.24	30.8

Advance and UKB are trademarks of Corus. A fuller description of the relationship between Universal Beams (UB) and the Advance range of sections manufactured by Corus is given in section 12.

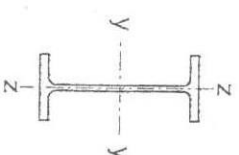
+ These sections are in addition to the range of BS 4 sections.  
FOR EXPLANATION OF TABLES SEE NOTE 2



BS EN 1993-1-1:2005  
BS 4-1:2005

UNIVERSAL BEAMS

Advance UKB



Properties

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter U	Torsional Index X	Warping Constant $I_w$ dm <sup>6</sup>	Torsional Constant $I_T$ cm <sup>4</sup>	Area of Section A cm <sup>2</sup>
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z					
533x210x138 +	86100	3860	22.1	4.68	3140	361	3610	568	0.874	24.9	2.67	250	176
533x210x122	76000	3390	22.1	4.67	2790	320	3200	500	0.878	27.6	2.32	178	155
533x210x109	66800	2940	21.9	4.60	2480	279	2830	436	0.875	30.9	1.99	126	136
533x210x101	61500	2690	21.9	4.57	2290	256	2610	399	0.874	33.1	1.81	101	126
533x210x92	55200	2390	21.7	4.51	2070	228	2360	355	0.873	36.4	1.60	75.7	117
533x210x82	47500	2010	21.3	4.38	1800	192	2060	300	0.863	41.6	1.33	51.5	105
533x165x85 +	48500	1270	21.2	3.44	1820	153	2100	243	0.861	35.5	0.857	73.8	108
533x165x75 +	41100	1040	20.8	3.30	1550	125	1810	200	0.853	41.1	0.691	47.9	95.2
533x165x66 +	35000	859	20.5	3.20	1340	104	1560	166	0.847	47.0	0.566	32.0	83.7
457x191x161 +	79800	4250	19.7	4.55	3240	426	3780	672	0.881	16.5	2.25	515	206
457x191x133 +	63800	3350	19.4	4.44	2660	341	3070	535	0.879	19.6	1.73	292	170
457x191x106 +	48900	2510	19.0	4.32	2080	259	2390	405	0.876	24.4	1.27	146	135
457x191x98	45700	2350	19.1	4.33	1960	243	2230	379	0.881	25.8	1.18	121	125
457x191x89	41000	2090	19.0	4.29	1770	218	2010	338	0.878	28.3	1.04	90.7	114
457x191x82	37100	1870	18.8	4.23	1610	196	1830	304	0.879	30.8	0.922	69.2	104
457x191x74	33300	1670	18.8	4.20	1460	176	1650	272	0.877	33.8	0.818	51.8	94.6
457x191x67	29400	1450	18.5	4.12	1300	153	1470	237	0.873	37.8	0.705	37.1	85.5
457x152x82	36600	1180	18.7	3.37	1570	153	1810	240	0.872	27.4	0.591	89.2	105
457x152x74	32700	1050	18.6	3.33	1410	136	1630	213	0.872	30.1	0.518	65.9	94.5
457x152x67	28900	913	18.4	3.27	1260	119	1450	187	0.868	33.6	0.448	47.7	85.6
457x152x60	25500	795	18.3	3.23	1120	104	1290	163	0.868	37.5	0.387	33.8	76.2
457x152x52	21400	645	17.9	3.11	950	84.6	1100	133	0.859	43.8	0.311	21.4	66.6
406x178x85 +	31700	1830	17.1	4.11	1520	201	1730	313	0.880	24.4	0.728	93.0	105
406x178x74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.5	0.608	62.8	94.5
406x178x67	24300	1380	16.9	3.99	1190	153	1350	237	0.880	30.4	0.533	46.1	85.5
406x178x60	21500	1200	16.8	3.97	1060	135	1200	209	0.880	33.7	0.466	33.3	76.5
406x178x54	18700	1020	16.5	3.85	930	115	1050	178	0.871	38.3	0.392	23.1	69.0
406x140x53 +	18300	635	16.4	3.06	899	88.6	1030	139	0.870	34.1	0.246	29.0	67.9
406x140x46	15700	538	16.4	3.03	778	75.7	888	118	0.871	39.0	0.207	19.0	58.6
406x140x39	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.4	0.155	10.7	49.7
356x171x67	19500	1360	15.1	3.99	1070	157	1210	243	0.886	24.4	0.412	55.7	85.5
356x171x57	16000	1110	14.9	3.91	896	129	1010	199	0.882	28.8	0.330	33.4	72.6
356x171x51	14100	968	14.8	3.86	796	113	896	174	0.881	32.1	0.286	23.8	64.9
356x171x45	12100	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356x127x39	10200	358	14.3	2.68	576	56.8	659	89.0	0.871	35.2	0.105	15.1	49.8
356x127x33	8250	280	14.0	2.58	473	44.7	543	70.2	0.863	42.1	0.081	8.79	42.1
305x165x54	11700	1060	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305x165x46	9900	896	13.0	3.90	646	108	720	166	0.890	27.1	0.195	22.2	58.7
305x165x40	8500	764	12.9	3.86	560	92.6	623	142	0.889	31.0	0.164	14.7	51.3

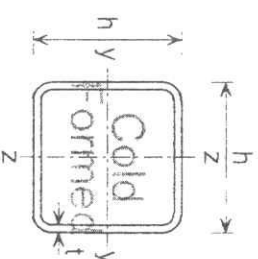
Advance and UKB are trademarks of Corus. A fuller description of the relationship between Universal Beams (UB) and the Advance range of sections manufactured by Corus is given in section 12.

+ These sections are in addition to the range of BS 4 sections  
FOR EXPLANATION OF TABLES SEE NOTE 3

**BS EN 1993-1-1:2005**  
**BS EN 10219-2:2006**

**COLD-FORMED**  
**SQUARE HOLLOW SECTIONS**

**Hybox® SHS**



Dimensions and properties

Section Designation	Thickness	Mass per Metre	Area of Section	Ratio for local Buckling $c/t$ (1)	Second Moment of Area	Radius of Gyration	Elastic Modulus	Plastic Modulus	Torsional Constants		Surface Area	
									$I_T$	$W_t$	Per Metre	Per Tonne
h x h mm	t mm	kg/m	A cm <sup>2</sup>		$I$ cm <sup>4</sup>	i cm	$W_{el}$ cm <sup>3</sup>	$W_{pl}$ cm <sup>3</sup>	$I_T$ cm <sup>4</sup>	$W_t$ cm <sup>3</sup>	m <sup>2</sup>	m <sup>2</sup>
140x140	4.0	16.8	21.3	32.0	662	5.52	93.1	108	1020	140	0.546	32.6
	5.0	20.7	26.4	25.0	791	5.48	113	132	1260	170	0.543	26.2
	6.0	24.5	31.2	20.3	920	5.43	131	155	1480	198	0.539	22.0
	8.0	31.4	40.0	14.5	1130	5.30	161	194	1900	248	0.526	16.7
150x150	10.0	38.1	48.6	11.0	1310	5.20	187	230	2270	291	0.517	13.6
	4.0	18.0	22.9	34.5	808	5.93	108	125	1270	162	0.566	32.5
	5.0	22.3	28.4	27.0	982	5.89	131	153	1550	197	0.563	26.2
	6.0	26.4	33.6	22.0	1150	5.84	153	180	1830	230	0.579	21.9
160x160	8.0	33.9	43.2	15.8	1410	5.71	188	226	2360	289	0.566	16.7
	10.0	41.3	52.6	12.0	1650	5.61	220	269	2840	341	0.557	13.5
	4.0	19.3	24.5	37.0	987	6.34	123	143	1540	185	0.626	32.5
	5.0	23.8	30.4	29.0	1200	6.29	150	175	1900	226	0.623	26.1
180x180	6.0	32.1	40.8	27.0	2040	7.06	226	264	3220	340	0.699	21.8
	8.0	41.5	52.8	19.5	2550	6.94	283	336	4190	432	0.666	16.5
	10.0	50.7	64.6	15.0	3020	6.84	335	404	5070	515	0.677	13.4
	12.0	58.5	74.5	12.0	3320	6.68	369	454	5870	584	0.658	11.3
200x200	12.5	60.5	77.0	11.4	3410	6.65	378	467	6050	600	0.656	10.8
	5.0	30.1	38.4	37.0	2410	7.93	241	279	3760	362	0.783	26.0
	6.0	35.8	45.6	30.3	2830	7.88	283	330	4460	426	0.779	21.8
	8.0	46.5	59.2	22.0	3570	7.76	357	421	5620	544	0.766	16.5
250x250	10.0	57.0	72.6	17.0	4250	7.66	425	508	7070	651	0.757	13.3
	12.0	66.0	84.1	13.7	4730	7.50	473	576	8230	743	0.738	11.2
	12.5	68.3	87.0	13.0	4860	7.47	486	594	8500	765	0.736	10.8
	6.0	45.2	57.6	38.7	5670	9.92	454	524	8840	681	0.979	21.3
300x300	8.0	59.1	75.2	28.3	7230	9.80	578	676	11600	878	0.966	16.3
	10.0	72.7	92.6	22.0	8710	9.70	697	822	14200	1060	0.957	13.2
	12.0	84.8	108	17.8	9860	9.55	789	944	16700	1230	0.938	11.1
	12.5	88.0	112	17.0	10200	9.52	813	975	17300	1270	0.936	10.5
350x350	6.0	54.7	69.6	47.0	9960	12.0	664	764	15400	997	1.18	21.5
	8.0	71.6	91.2	34.5	12800	11.8	853	991	20300	1290	1.17	16.3
	10.0	88.4	113	27.0	15500	11.7	1040	1210	25000	1570	1.16	13.1
	12.0	104	132	22.0	17800	11.6	1180	1400	29500	1830	1.14	11.0
400x400	12.5	108	137	21.0	18300	11.6	1220	1450	30600	1890	1.14	10.5
	8.0	84.2	107	40.8	20700	13.9	1180	1370	32600	1790	1.37	16.2
	10.0	104	133	32.0	25200	13.8	1440	1680	40100	2180	1.36	13.0
	12.0	123	156	26.2	29100	13.6	1660	1950	47600	2550	1.34	10.9
400x400	12.5	127	162	25.0	30000	13.6	1720	2020	49400	2640	1.34	10.5
	8.0	96.7	123	47.0	31300	15.9	1560	1800	48900	2360	1.57	16.2
	10.0	120	153	37.0	38200	15.8	1910	2210	60400	2890	1.56	13.0
	12.0	141	180	30.3	44300	15.7	2220	2590	71800	3400	1.54	10.9
12.5	147	187	29.0	45900	15.7	2290	2680	74600	3520	1.54	10.5	

Hybox® is a trademark of Corus. A fuller description of the relationship between Cold Formed Square Hollow Sections (Cf-SHS) and the Hybox® range of sections manufactured by Corus is given in section 12.

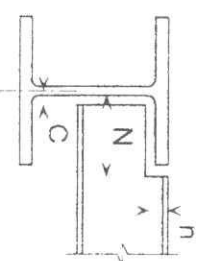
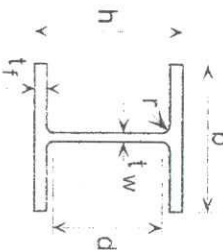
(1) For local buckling calculation  $c = h - 3t$ .

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

## UNIVERSAL COLUMNS

### Advance UKC

BS EN 1993-1-1:2005  
BS 4-1:2005



### 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 $t_w$	Flange $t_f$			Flange $c/t_f$	Web $c_w/t_w$	End Clearance C	Notch N	Notch n	Per Metre $m^2$	Per Tonne $m^2$
356x406x634	633.9	474.6	424.0	47.6	77.0	15.2	290.2	2.25	6.10	26	200	94	2.52	3.38
356x406x551	551.0	455.6	418.5	42.1	67.5	15.2	290.2	2.56	6.89	23	200	84	2.47	4.48
356x406x467	467.0	436.6	412.2	35.8	58.0	15.2	290.2	2.98	8.11	20	200	74	2.42	5.18
356x406x393	393.0	419.0	407.0	30.6	49.2	15.2	290.2	3.52	9.48	17	200	66	2.38	6.06
356x406x340	339.9	406.4	403.0	26.6	42.9	15.2	290.2	4.03	10.9	15	200	60	2.35	6.91
356x406x287	287.1	393.6	399.0	22.6	36.5	15.2	290.2	4.74	12.8	13	200	52	2.31	8.05
356x406x235	235.1	381.0	394.8	18.4	30.2	15.2	290.2	5.73	15.8	11	200	46	2.28	9.70
356x368x202	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.07	17.6	10	190	44	2.19	10.8
356x368x177	177.0	368.2	372.6	14.4	23.8	15.2	290.2	6.89	20.2	9	190	40	2.17	12.3
356x368x153	152.9	362.0	370.5	12.3	20.7	15.2	290.2	7.92	23.6	8	190	36	2.16	14.1
356x368x129	129.0	355.6	368.6	10.4	17.5	15.2	290.2	9.4	27.9	7	190	34	2.14	16.6
305x305x283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.00	9.21	15	158	60	1.94	6.36
305x305x240	240.0	352.5	318.4	23.0	37.7	15.2	246.7	3.51	10.7	14	158	54	1.91	7.96
305x305x198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	4.22	12.9	12	158	48	1.87	9.44
305x305x158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	5.30	15.6	10	158	42	1.84	11.6
305x305x137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	6.11	17.90	9	158	38	1.82	13.3
305x305x118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	7.09	20.6	8	158	34	1.81	15.4
305x305x97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	8.60	24.9	7	158	32	1.79	18.5
254x254x167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	3.48	10.4	12	134	46	1.58	9.46
254x254x132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	4.36	13.1	10	134	38	1.55	11.7
254x254x107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	5.38	15.6	8	134	34	1.52	14.2
254x254x89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	6.38	19.4	7	134	30	1.50	16.9
254x254x73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	7.77	23.3	6	134	28	1.49	20.4
203x203x127 +	127.5	241.4	213.9	18.1	30.1	10.2	160.8	2.91	8.88	11	108	42	1.28	10.0
203x203x113 +	113.5	235.0	212.1	16.3	26.9	10.2	160.8	3.26	9.87	10	108	38	1.27	11.2
203x203x100 +	99.6	228.6	210.3	14.5	23.7	10.2	160.8	3.70	11.1	9	108	34	1.25	12.6
203x203x86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	4.29	12.7	8	110	32	1.24	14.4
203x203x71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.09	16.1	7	110	28	1.22	17.2
203x203x60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	6.20	17.1	7	110	26	1.21	20.2
203x203x52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	7.04	20.4	6	110	24	1.20	23.1
203x203x46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	8.00	22.3	6	110	22	1.19	26.8
152x152x51 +	51.2	170.2	157.4	11.0	15.7	7.6	123.6	4.18	11.2	8	84	24	0.935	18.3
152x152x44 +	44.0	166.0	155.9	9.5	13.6	7.6	123.6	4.82	13.0	7	84	22	0.924	21.0
152x152x37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	5.70	15.5	6	84	20	0.912	24.7
152x152x30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	6.98	19.0	5	84	18	0.901	30.0
152x152x23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	9.65	21.3	5	84	16	0.889	38.7

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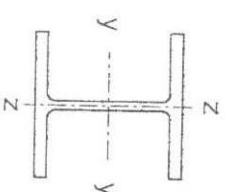
+ These sections are in addition to the range of BS 4 sections.

FOR EXPLANATION OF TABLES SEE NOTE 2

BS EN 1993-1-1:2005  
BS 4-1:2005

## UNIVERSAL COLUMNS

### Advance UKC



### 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 Y-Y	Axis Z-Z	Axis Y-Y	Axis Z-Z									
356x406x634	275000	98100	18.4	11.0	11600	4630	14200	7110	0.843	5.46	38.8	13700	808
356x406x551	227000	82700	18.0	10.9	9960	3950	12100	6060	0.841	6.05	31.1	9240	702
356x406x467	183000	67800	17.5	10.7	8380	3290	10000	5030	0.839	6.85	24.3	5810	595
356x406x393	147000	55400	17.1	10.5	7000	2720	8220	4150	0.837	7.86	18.9	3550	501
356x406x340	123000	46900	16.8	10.4	6030	2330	7000	3540	0.836	8.84	15.5	2340	433
356x406x287	99900	38700	16.5	10.3	5070	1940	5810	2950	0.835	10.17	12.3	1440	366
356x406x235	79100	31000	16.3	10.2	4150	1570	4890	2380	0.834	12.04	9.54	812	299
356x366x202	66300	23700	16.1	9.60	3540	1260	3970	1920	0.844	13.35	7.16	558	257
356x366x177	57100	20500	15.9	9.54	3100	1100	3460	1670	0.844	15.00	6.09	381	226
356x366x153	48600	17600	15.8	9.49	2680	948	2960	1430	0.844	17.01	5.11	251	195
356x366x129	40200	14600	15.6	9.43	2260	793	2480	1200	0.844	19.81	4.18	153	164
305x305x283	78900	24600	14.8	8.27	4320	1530	5110	2340	0.855	7.64	6.35	2030	360
305x305x240	64200	20300	14.5	8.15	3640	1280	4250	1950	0.854	8.73	5.03	1270	306
305x305x198	50900	16300	14.2	8.04	3000	1040	3440	1580	0.854	10.23	3.88	734	252
305x305x158	38700	12600	13.9	7.90	2370	808	2680	1230	0.851	12.46	2.87	378	201
305x305x137	32800	10700	13.7	7.83	2050	692	2300	1050	0.851	14.13	2.39	249	174
305x305x118	27700	9060	13.6	7.77	1760	589	1960	895	0.850	16.14	1.98	161	150
305x305x97	22200	7310	13.4	7.69	1450	479	1590	726	0.850	19.19	1.56	91.2	123
254x254x167	30000	9870	11.9	6.81	2080	744	2420	1140	0.851	8.48	1.63	626	213
254x254x132	22500	7530	11.6	6.69	1630	576	1870	878	0.850	10.32	1.19	319	168
254x254x107	17500	5930	11.3	6.59	1310	458	1480	697	0.848	12.38	0.898	172	136
254x254x89	14300	4880	11.2	6.55	1100	379	1220	575	0.850	14.46	0.717	102	113
254x254x73	11400	3910	11.1	6.48	898	307	992	465	0.849	17.24	0.562	57.6	93.1
203x203x127 +	15400	4920	9.75	5.50	1280	460	1520	704	0.854	7.38	0.549	427	162
203x203x113 +	13300	4290	9.59	5.45	1130	404	1330	618	0.853	8.11	0.464	305	145
203x203x100 +	11300	3680	9.44	5.39	988	350	1150	534	0.852	9.02	0.386	210	127
203x203x86	9450	3130	9.28	5.34	850	299	977	456	0.850	10.20	0.318	137	110
203x203x71	7620	2540	9.18	5.30	706	246	799	374	0.853	11.90	0.250	80.2	90.4
203x203x60	6120	2060	8.96	5.20	584	201	656	305	0.846	14.10	0.197	47.2	76.4
203x203x52	5260	1780	8.91	5.18	510	174	567	264	0.848	15.80	0.167	31.8	66.3
203x203x46	4570	1550	8.82	5.13	450	152	497	231	0.847	17.70	0.143	22.2	58.7
152x152x51 +	3230	1020	7.04	3.96	379	130	438	199	0.848	10.10	0.061	48.8	65.2
152x152x44 +	2700	860	6.94	3.92	326	110	372	169	0.848	11.50	0.050	31.7	56.1
152x152x37	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.30	0.040	19.2	47.1
152x152x30	1750	560	6.76	3.83	222	73.3	248	112	0.849	16.00	0.031	10.5	38.3
152x152x23	1250	400	6.54	3.70	164	52.6	182	80.1	0.840	20.70	0.021	4.63	29.2

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+ These sections are in addition to the range of BS 4 sections.

+ FOR EXPLANATION OF TABLES SEE NOTE 3