Design Formulae for Structural Steel Design

1. Steel properties

$E = 205{,}000\ \text{N/mm}^2$ $\qquad \varepsilon = \sqrt{\frac{275}{p_y}}$

2. Design Strength for Steels (Plate, Hot Finished and Cold Formed Sections)

Thickness less than or equal to (mm)	Design strength p_y (N/mm^2)		
	Steel grade S275	Steel grade S355	Steel grade S460
16	275	355	460
40	265	345	440
63	255	335	430
80	245	325	410
100	235	315	400

3. Classification of Sections

Table 7.1- 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
Flange	Outstand element	Compression due to bending	Rolled section	b/T	9ε	10ε	15ε
			Welded section		8ε	9ε	13ε
		Axial compression		b/T	Not applicable		13ε
	Internal element	Compression due to bending		b/T	28ε	32ε	40ε
		Axial compression		b/T	Not applicable		
Web of an I-, H- or Box section [d]	Neutral axis at mid-depth			d/t	80ε	100ε	120ε
	Generally [c]	r_1 is negative		d/t	$\frac{80\varepsilon}{1+r_1}$ but $\geq 40\varepsilon$	$\frac{100\varepsilon}{1+r_1}$	$\frac{120\varepsilon}{1+2r_2}$ but $\geq 40\varepsilon$
		r_1 is positive		d/t		$\frac{100\varepsilon}{1+1.5r_1}$ but $\geq 40\varepsilon$	
	Axial compression [c]			d/t	Not applicable		

where $r_1 = \frac{F_c}{d\,t\,p_{yw}}$ but $-1 \leq r_1 \leq 1$ and $r_2 = \frac{F_c}{A_g p_{yw}}$ for I- and H-sections with equal flanges.

Note: All the terms and symbols bear their usual meanings
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4. Beam Equations

Bending:

$M_{cx} = p_y S_x \leq 1.2\, p_y Z_x \qquad M_{cy} = p_y S_y \leq 1.2\, p_y Z_y$

for Class 1 and Class 2 sections with low shear load

Shear:

$V_c = \frac{p_y A_v}{\sqrt{3}} \qquad A_v = t\, D$ for rolled I, H and channel sections

Deflection of simply supported beams:

$\Delta = \frac{5}{384}\frac{\omega l^4}{EI} \quad for\ UDL, \qquad \Delta = \frac{Pl^4}{48EI} \quad for\ point\ load\ at\ mid-span.$

Table 5.1 – Deflection limits

Vertical deflection of beams due to imposed load	
Cantilevers	Length/180
Beams carrying plaster or other brittle finish	Span/360
Other beams (except purlins and sheeting rails)	Span/200
Purlins and sheeting rails	To suit cladding

5. Buckling Resistance

$\lambda = \frac{L_e}{r_y} \qquad \lambda_{LT} = uv\lambda\sqrt{\beta_w} \qquad \beta_w = 1\ for\ Class\ 1\ and\ Class\ 2\ sections$

$v = \frac{1}{\left(1 + 0.05\left(\frac{\lambda}{x}\right)^2\right)^{0.25}} \qquad M_b = p_b S_x \qquad m_{LT} M_x \leq M_b$

6. Tension Members

$P_t = A_e\, p_y$

$A_e = K_e$ *(net area)* $<=$ *Gross sectional area,* $\qquad K_e = 1.1$ *for Grade S355 steel*

For single angle connected through one leg, single channel through the web or a single T section through the flange,

bolted connections, $P_t = p_y (A_e - 0.5\, a_2)$

welded connections, $P_t = p_y (A_e - 0.3\, a_2)$

For double angle, channels and T-sections connected on both sides of a gusset plate and interconnected by bolts or welds,

bolted connections, $P_t = p_y (A_e - 0.25\, a_2)$

welded connections, $P_t = p_y (A_e - 0.15\, a_2)$

where $a_2 = A_g - a_1$

7. Compression Members

$P_c = A_g p_c \qquad \lambda_x = \frac{L_{ex}}{r_x} \qquad \lambda_y = \frac{L_{ey}}{r_y}$

Note: All the terms and symbols bear their usual meanings

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8. Column Equations

$\lambda = \frac{L_e}{r_y}$ $\lambda_{LT} = uv\lambda\sqrt{\beta_w}$ $M_b = p_b S_x$

Cross Section Capacity Check:

$$\frac{\mathrm{F_c}}{\mathrm{A_g} * \mathrm{p_y}} + \frac{\mathrm{M_x}}{\mathrm{M_{cx}}} + \frac{\mathrm{M_y}}{\mathrm{M_{cy}}} \leq 1$$

Member Buckling Resistance Check:

$$\frac{F_c}{\overline{P_c}} + \frac{m_x \mathrm{M}_x}{M_{\mathrm{cx}}} + \frac{m_y \mathrm{M}_y}{M_{\mathrm{cy}}} \leq 1 \qquad \frac{F_c}{\mathrm{P_{cy}}} + \frac{m_{\mathrm{LT}} \mathrm{M_{LT}}}{M_b} + \frac{m_y \overline{M}_y}{M_{\mathrm{cy}}} \leq 1$$

Simple Construction:

$$\lambda_{LT} = \frac{0.5L}{r_y} \qquad \frac{F_c}{\overline{P_c}} + \frac{\mathrm{M}_x}{M_{\mathrm{cx}}} + \frac{\mathrm{M}_y}{M_{\mathrm{cy}}} \leq 1 \qquad \frac{F_c}{\mathrm{P_{cy}}} + \frac{\mathrm{M_{LT}}}{M_b} + \frac{\overline{M}_y}{M_{\mathrm{cy}}} \leq 1$$

9. Welded Connection

Strength of Weld

Strength of Weld = 0.7 * leg length * p_w * 10^{-3} kN/mm

Design strength for fillet weld p_w for BS-EN standards

Steel grade	Electrode classification		
	35 N/mm^2	42 N/mm^2	50 N/mm^2
S275	220	220	220
S355	220	250	250
S460	220	250	280

Combined Torsion and Shear

Assume rotation about the centroid of weld

$F_s = \frac{P}{length\ of\ weld}$ $F_T = \frac{P\ e\ r}{I_p}$ $where\ I_p = I_x + I_y$

$I_x = \frac{y^3}{6} + \frac{xy^2}{2}$ $I_y = \frac{x^3}{6} + \frac{x^2 y}{2}$ $F_R = \sqrt{{F_s}^2 + {F_T}^2 + 2F_S F_T cos\phi}$

Combined Tension and Shear

Assume rotation about the bottom flange

$F_S = \frac{P}{2a}$ $F_T = \frac{P\ e}{B\ D}$

Note: All the terms and symbols bear their usual meanings

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10. Bolted Connection

Tension Stress Area of Bolt

Nominal diameter (mm)	Shank area (mm^2)	Tensile stress area (mm^2)
12	113	84.3
16	201	157
20	314	245
22	380	303
24	452	353
27	573	459
30	707	561

Design Strength of Bolts

Bolt grade	Design shear strength p_s (N/mm^2)	Design bearing strength p_{bb} (N/mm^2)	Design tension strength p_t (N/mm^2)
ISO 4.6	160	460	240
ISO 8.8	375	1000	560
ISO10.9	400	1300	700

Design Equations for Ordinary Bolts

Shear: $P_s = p_s A_s$

Tension: $P_t = A_s p_t$ or $P_{nom} = 0.8 A_s p_t$

Bolt Bearing: $P_{bb} = d t_p p_{bb}$

Bearing of connected part:

$P_{bs} = k_{bs} d t_p p_{bs}$

$P_{bs} = 0.5 k_{bs} e t_p p_{bs}$

and $P_{bs} = 1.5 I_c t_p U_s \leq 2.0 d t_p U_b$

where e = end distance measured in the direction of load transfer

k_{bs} = 1.0 for standard holes, 0.7 for oversize and short slotted holes

I_c = net distance between the bearing edge of the holes and the near edge of adjacent holes in the direction of load transfer

p_{bs} = bearing strength of connected parts

for steel grade S275, p_{bs} = 460 MPa

for steel grade S355, p_{bs} = 550 MPa

for steel grade S460, p_{bs} = 670 MPa

U_s is the specified minimum tensile strength of parent metal (for S355, U_s = 510 N/mm^2)

U_b is the specified minimum tensile strength of bolts = 800 N/mm^2

Combined Torsion and Shear

$$F_S = \frac{P}{nos.of\ bolts} \qquad F_T = \frac{P\ e\ r}{\sum x^2 + \sum y^2} \qquad F_R = \sqrt{{F_S}^2 + {F_T}^2 + 2F_S F_T cos\phi}$$

Combined Tension and Shear

$$F_S = \frac{P}{nos.of\ bolts} \leq P_S \qquad F_T = \frac{P\ e\ y_1}{\sum y^2} \leq P_T \qquad \frac{F_S}{P_s} + \frac{F_T}{P_{nom}} \leq 1.4$$

Note: All the terms and symbols bear their usual meanings

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Table 8.3a – Bending strength p_b (N/mm^2) for rolled sections

λ_{LT}	Steel grade and design strength p_y (N/mm^2)														
	S275					S355					S460				
	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	125	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	45	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

λ_{L0} is the maximum slenderness ratio of the member having negligible buckling effect.

Note: All the terms and symbols bear their usual meanings
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Table 8.4a - Equivalent uniform moment factor m_{LT} for lateral-torsional buckling of beams under end moments and typical loads

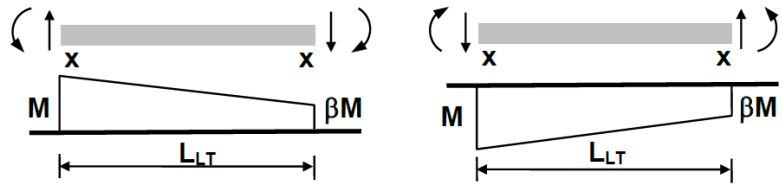
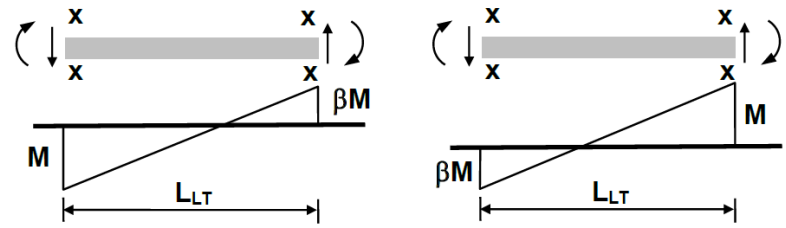
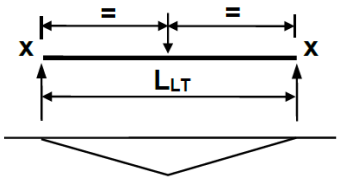
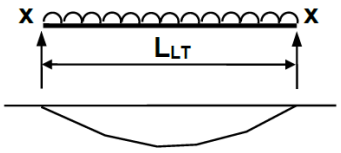
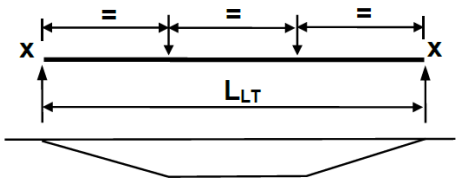
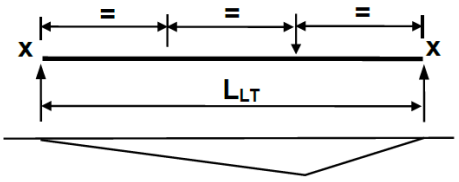
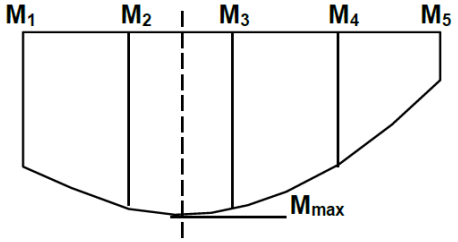
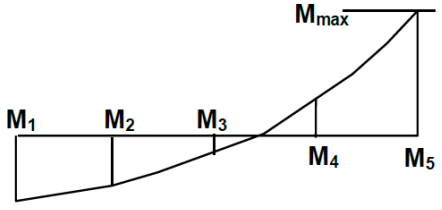
Segment with end moment only (values of m_{LT} from the formula for the general case)	β	m_{LT}
β positive  X lateral restraint	1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1	1.00 0.96 0.92 0.88 0.84 0.80 0.76 0.72 0.68 0.64
β negative  	0.0 -0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7 -0.8 -0.9 -1.0	0.60 0.56 0.52 0.48 0.46 0.44 0.44 0.44 0.44 0.44 0.44
Special case (no intermediate lateral restraint)		
 m_{LT} = 0.85		
 m_{LT} = 0.93		
 m_{LT} = 0.93		
 m_{LT} = 0.74		

Table 8.4b - Equivalent uniform moment factor m_{LT} for lateral-torsional buckling of beams under non-typical loads

General case (segment between intermediate lateral restraint)
      For beams: $m_{LT} = 0.2 + \frac{0.15M_2 + 0.5M_3 + 0.15M_4}{M_{max}}$ but $m_{LT} \geq 0.44$ All moment are taken as positive. The moment M_2 and M_4 are the values at the quarter points, M_3 is the value at mid-length and M_{max} is the maximum moment in the segment.
For cantilevers without intermediate lateral restraint, m_{LT} = 1.00

Note: All the terms and symbols bear their usual meanings
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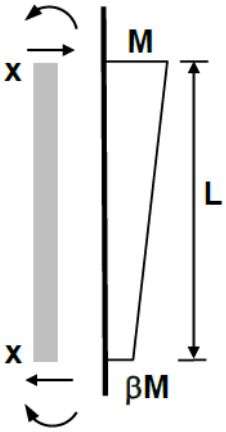
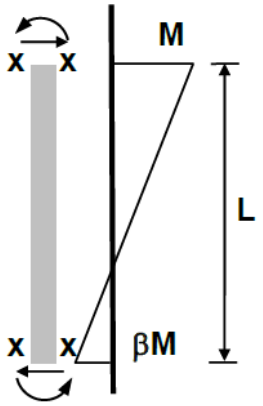
Table 8.7 – Designation of Buckling Curves for Different Section Types

Type of section	Maximum thickness (mm)	Axis of buckling	
		x-x	y-y
Rolled I-section	≤ 40	a	b
	> 40	b	c
Rolled H-section	≤ 40	b	c
	> 40	c	d
Weld I- or H-section	≤ 40	b	c
	> 40	b	d

Table 8.9 - Moment equivalent factor m for flexural buckling

Segment with end moment only (value of m from the formula of general case)		β	m
β positive  X - lateral restraint	β negative 	1.0	1.00
		0.9	0.96
		0.8	0.92
		0.7	0.88
		0.6	0.84
		0.5	0.80
		0.4	0.76
		0.3	0.72
		0.2	0.68
		0.1	0.64
		0.0	0.60
		-0.1	0.58
		-0.2	0.56
		-0.3	0.54
		-0.4	0.52
		-0.5	0.50
		-0.6	0.48
		-0.7	0.46
		-0.8	0.44
		-0.9	0.42
		-1.0	0.40

Note: All the terms and symbols bear their usual meanings
Tables are reproduced from Code of Practice for the Structural Use of Steel 2011

Table 8.8(a) to 8.8(d) – Design strength p_c of compression members

Table 8.8(a)

Values of p_c in N/mm^2 for strut curve a					
λ	Steel grade and design strength p_y (N/mm^2)				
	S355				
	315	325	335	345	355
15	315	325	335	345	355
20	312	322	332	342	351
25	309	318	328	338	347
30	305	315	324	333	343
35	301	310	320	329	338
40	296	305	315	324	333
42	294	303	312	321	330
44	292	301	310	319	327
46	280	299	307	316	325
48	288	296	305	313	322
50	285	293	302	310	318
52	282	291	299	307	315
54	279	287	295	303	311
56	276	284	292	300	307
58	273	281	288	295	303
60	269	277	284	291	298
62	266	273	280	286	293
64	262	268	275	281	288
66	257	264	270	276	282
68	253	259	265	270	276
70	248	254	259	265	270
72	243	248	253	258	263
74	238	243	247	252	256
76	232	237	241	245	249
78	227	231	235	239	242
80	221	225	229	232	235
82	215	219	222	225	228
84	209	213	216	219	221
86	204	207	209	212	214
88	198	200	203	205	208
90	192	195	197	199	201
92	186	189	191	193	194
94	181	183	185	187	188
96	175	177	179	181	182
98	170	172	173	175	176
100	165	167	168	169	171
102	160	161	163	164	165
104	155	156	158	159	160
106	150	152	153	154	155
108	146	147	148	149	150

Table 8.8(b)

Values of p_c in N/mm^2 for strut curve b					
λ	Steel grade and design strength p_y (N/mm^2)				
	S355				
	315	325	335	345	355
15	315	325	335	345	355
20	310	320	330	339	349
25	304	314	323	332	342
30	298	307	316	325	335
35	291	300	309	318	327
40	284	293	301	310	318
42	281	289	298	306	314
44	278	286	294	302	310
46	275	283	291	298	306
48	271	279	287	294	302
50	267	275	283	290	298
52	264	271	278	286	293
54	260	267	274	281	288
56	256	263	269	276	283
58	252	258	265	271	278
60	247	254	260	266	272
62	243	249	255	261	266
64	238	244	249	255	261
66	233	239	244	249	255
68	228	233	239	244	249
70	223	228	233	238	242
72	218	223	227	232	236
74	213	217	222	226	230
76	208	212	216	220	223
78	203	206	210	214	217
80	197	201	204	208	211
82	192	196	199	202	205
84	187	190	193	196	199
86	182	185	188	190	193
88	177	180	182	185	187
90	172	175	177	179	18
92	167	170	172	174	176
94	162	165	167	169	171
96	158	160	162	164	165
98	153	155	157	159	160
100	149	151	152	154	155
102	145	146	148	149	151
104	141	142	144	145	146
106	137	138	139	141	142
108	133	134	135	137	138

Table 8.8(c)

Values of p_c in N/mm^2 for strut curve c					
λ	Steel grade and design strength p_y (N/mm^2)				
	S355				
	315	325	335	345	355
15	315	325	335	345	355
20	308	317	326	336	345
25	299	308	317	326	335
30	289	298	307	315	324
35	280	288	296	305	313
40	270	278	285	293	301
42	266	273	281	288	296
44	261	269	276	284	291
46	257	264	271	279	286
48	253	260	267	274	280
50	248	255	262	268	275
52	244	250	257	263	270
54	239	245	252	258	264
56	234	240	246	252	258
58	229	235	241	247	252
60	225	230	236	241	247
62	220	225	230	236	241
64	215	220	225	230	235
66	210	215	220	224	229
68	205	210	214	219	223
70	200	204	209	213	217
72	195	199	203	207	211
74	190	194	198	202	205
76	185	189	193	196	200
78	180	184	187	191	194
80	176	179	182	185	188
82	171	174	177	180	183
84	167	169	172	175	178
86	162	165	168	170	173
88	158	160	163	165	168
90	153	156	158	161	163
92	149	152	154	156	158
94	145	147	149	151	153
96	141	143	145	147	149
98	137	139	141	143	145
100	134	135	137	139	140
102	130	132	133	135	136
104	126	128	130	131	133
106	123	125	126	127	129
108	120	121	123	124	125

Table 8.8(d)

Values of p_c in N/mm^2 for strut curve d					
λ	Steel grade and design strength p_y (N/mm^2)				
	S355				
	315	325	335	345	355
15	315	325	335	345	355
20	305	314	323	332	341
25	292	301	309	318	326
30	279	287	296	304	312
35	267	274	282	290	297
40	254	261	268	275	283
42	249	256	263	270	277
44	244	251	257	264	271
46	239	245	252	258	265
48	234	240	246	252	259
50	228	235	241	247	253
52	223	229	235	241	246
54	218	224	229	235	240
56	213	219	224	229	234
58	208	213	218	224	229
60	203	208	213	218	223
62	198	203	208	212	217
64	193	198	202	207	211
66	188	193	197	201	205
68	184	188	192	196	200
70	179	183	187	190	194
72	174	178	182	185	189
74	170	173	177	180	183
76	165	169	172	175	178
78	161	164	167	170	173
80	156	160	163	165	168
82	152	155	158	161	163
84	148	151	154	156	159
86	144	147	149	152	154
88	140	143	145	148	150
90	137	139	141	144	146
92	133	135	137	139	142
94	129	132	134	136	138
96	126	128	130	132	134
98	123	125	126	128	130
100	119	121	123	125	126
102	116	118	120	121	123
104	113	115	116	118	120
106	110	112	113	115	116
108	107	109	110	112	113

Values of p_c for steel grade S275 and S460 refer to Code of Practice
Values of p_c with $110 < \lambda < 350$ refer to Code of Practice

Note: All the terms and symbols bear their usual meanings
Tables are reproduced from Code of Practice for the Structural Use of Steel 2011
HD in Civil Engineering

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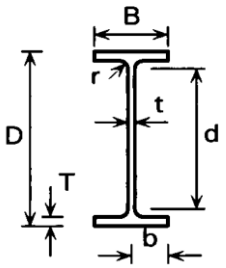
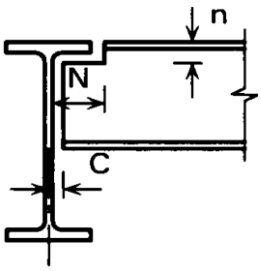
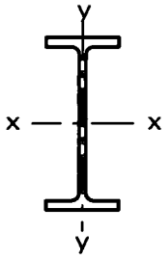




DIMENSIONS

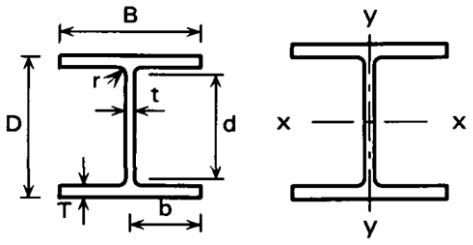
Section Designation	Mass Per Metre	Depth Of Section	Width Of Section	Thickness		Root Radius	Depth Between Fillets	Ratios For Local Buckling		Dimensions For Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		D	B	t	T	r	d	b/T	d/t	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
610 x 229 x 140	139.9	617.2	230.2	13.1	22.1	12.7	547.6	5.21	41.8	9	120	36	2.11	15.1
610 x 229 x 125	125.1	612.2	229.0	11.9	19.6	12.7	547.6	5.84	46.0	8	120	34	2.09	16.7
610 x 229 x 113	113.0	607.6	228.2	11.1	17.3	12.7	547.6	6.60	49.3	8	120	30	2.08	18.4
610 x 229 x 101	101.2	602.6	227.6	10.5	14.8	12.7	547.6	7.69	52.2	7	120	28	2.07	20.5
533 x 210 x 122	122.0	544.5	211.9	12.7	21.3	12.7	476.5	4.97	37.5	8	110	34	1.89	15.5
533 x 210 x 109	109.0	539.5	210.8	11.6	18.8	12.7	476.5	5.61	41.1	8	110	32	1.88	17.2
533 x 210 x 101	101.0	536.7	210.0	10.8	17.4	12.7	476.5	6.03	44.1	7	110	32	1.87	18.5
533 x 210 x 92	92.1	533.1	209.3	10.1	15.6	12.7	476.5	6.71	47.2	7	110	30	1.86	20.2
533 x 210 x 82	82.2	528.3	208.8	9.6	13.2	12.7	476.5	7.91	49.6	7	110	26	1.85	22.5
457 x 191 x 98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.92	35.8	8	102	30	1.67	16.9
457 x 191 x 89	89.3	483.4	191.9	10.5	17.7	10.2	407.6	5.42	38.8	7	102	28	1.66	18.5
457 x 191 x 82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.98	41.2	7	102	28	1.65	20.1
457 x 191 x 74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	6.57	45.3	7	102	26	1.64	22.1
457 x 191 x 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 x 152 x 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 x 152 x 74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	4.54	42.5	7	84	28	1.50	20.3
457 x 152 x 67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	5.13	45.3	7	84	26	1.50	22.3
457 x 152 x 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 x 152 x 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 x 178 x 74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	5.61	37.9	7	96	28	1.51	20.3
406 x 178 x 67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41.0	6	96	26	1.50	22.3
406 x 178 x 60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	6.95	45.6	6	96	24	1.49	24.8
406 x 178 x 54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	46.8	6	96	22	1.48	27.4
406 x 140 x 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 x 140 x 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 x 171 x 67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	7	94	26	1.38	20.6
356 x 171 x 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 x 171 x 51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	7.46	42.1	6	94	22	1.36	26.7
356 x 171 x 45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	8.82	44.5	6	94	20	1.36	30.1
356 x 127 x 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 x 127 x 33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	7.38	51.9	5	70	20	1.17	35.4
305 x 165 x 54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	6	90	24	1.26	23.3
305 x 165 x 46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.6	5	90	22	1.25	27.1
305 x 165 x 40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	8.09	44.2	5	90	20	1.24	30.8
305 x 127 x 48	48.1	311.0	125.3	9.0	14.0	8.9	265.2	4.47	29.5	7	70	24	1.09	22.7
305 x 127 x 42	41.9	307.2	124.3	8.0	12.1	8.9	265.2	5.14	33.2	6	70	22	1.08	25.8
305 x 127 x 37	37.0	304.4	123.4	7.1	10.7	8.9	265.2	5.77	37.4	6	70	20	1.07	29.0
305 x 102 x 33	32.8	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	5	58	20	1.01	30.8
305 x 102 x 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 x 102 x 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

UNIVERSAL BEAMS



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	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y					
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	u	x	H dm^6	J cm^4	A cm^2
610 x 229 x 140	111800	4505	25.0	5.03	3622	391	4142	611	0.875	30.6	3.99	216	178
610 x 229 x 125	98610	3932	24.9	4.97	3221	343	3676	535	0.873	34.1	3.45	154	159
610 x 229 x 113	87320	3434	24.6	4.88	2874	301	3281	469	0.870	38.0	2.99	111	144
610 x 229 x 101	75780	2915	24.2	4.75	2515	256	2881	400	0.864	43.1	2.52	77.0	129
533 x 210 x 122	76040	3388	22.1	4.67	2793	320	3196	500	0.877	27.6	2.32	178	155
533 x 210 x 109	66820	2943	21.9	4.60	2477	279	2828	436	0.875	30.9	1.99	126	139
533 x 210 x 101	61520	2692	21.9	4.57	2292	256	2612	399	0.874	33.2	1.81	101	129
533 x 210 x 92	55230	2389	21.7	4.51	2072	228	2360	356	0.872	36.5	1.60	75.7	117
533 x 210 x 82	47540	2007	21.3	4.38	1800	192	2059	300	0.864	41.6	1.33	51.5	105
457 x 191 x 98	45730	2347	19.1	4.33	1957	243	2232	379	0.881	25.7	1.18	121	125
457 x 191 x 89	41020	2089	19.0	4.29	1770	218	2014	338	0.880	28.3	1.04	90.7	114
457 x 191 x 82	37050	1871	18.8	4.23	1611	196	1831	304	0.877	30.9	0.922	69.2	104
457 x 191 x 74	33320	1671	18.8	4.20	1458	176	1653	272	0.877	33.9	0.818	51.8	94.6
457 x 191 x 67	29380	1452	18.5	4.12	1296	153	1471	237	0.872	37.9	0.705	37.1	85.5
457 x 152 x 82	36590	1185	18.7	3.37	1571	153	1811	240	0.873	27.4	0.591	89.2	105
457 x 152 x 74	32670	1047	18.6	3.33	1414	136	1627	213	0.873	30.1	0.518	65.9	94.5
457 x 152 x 67	28930	913	18.4	3.27	1263	119	1453	187	0.869	33.6	0.448	47.7	85.6
457 x 152 x 60	25500	795	18.3	3.23	1122	104	1287	163	0.868	37.5	0.387	33.8	76.2
457 x 152 x 52	21370	645	17.9	3.11	950	84.6	1096	133	0.859	43.9	0.311	21.4	66.6
406 x 178 x 74	27310	1545	17.0	4.04	1323	172	1501	267	0.882	27.6	0.608	62.8	94.5
406 x 178 x 67	24330	1365	16.9	3.99	1189	153	1346	237	0.880	30.5	0.533	46.1	85.5
406 x 178 x 60	21600	1203	16.8	3.97	1063	135	1199	209	0.880	33.8	0.466	33.3	76.5
406 x 178 x 54	18720	1021	16.5	3.85	930	115	1055	178	0.871	38.3	0.392	23.1	69.0
406 x 140 x 46	15690	538	16.4	3.03	778	75.7	888	118	0.871	38.9	0.207	19.0	58.6
406 x 140 x 39	12510	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	19460	1362	15.1	3.99	1071	157	1211	243	0.886	24.4	0.412	55.7	85.5
356 x 171 x 57	16040	1108	14.9	3.91	896	129	1010	199	0.882	28.8	0.330	33.4	72.6
356 x 171 x 51	14140	968	14.8	3.86	796	113	896	174	0.881	32.1	0.286	23.8	64.9
356 x 171 x 45	12070	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356 x 127 x 39	10170	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	8249	280	14.0	2.58	473	44.7	543	70.3	0.863	42.2	0.0812	8.79	42.1
305 x 165 x 54	11700	1063	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305 x 165 x 46	9899	896	13.0	3.90	646	108	720	166	0.891	27.1	0.195	22.2	58.7
305 x 165 x 40	8503	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	9575	461	12.5	2.74	616	73.6	711	116	0.873	23.3	0.102	31.8	61.2
305 x 127 x 42	8196	389	12.4	2.70	534	62.6	614	98.4	0.872	26.5	0.0846	21.1	53.4
305 x 127 x 37	7171	336	12.3	2.67	471	54.5	539	85.4	0.872	29.7	0.0725	14.8	47.2
305 x 102 x 33	6501	194	12.5	2.15	416	37.9	481	60.0	0.866	31.6	0.0442	12.2	41.8
305 x 102 x 28	5366	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	4455	123	11.9	1.97	292	24.2	342	38.8	0.846	43.4	0.0273	4.77	31.6



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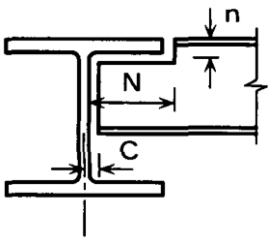


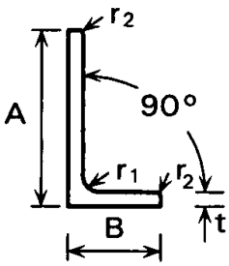
DIMENSIONS

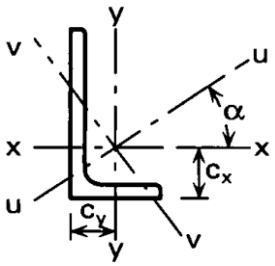
Section Designation	Mass Per Metre	Depth Of Section	Width Of Section	Thickness		Root Radius	Depth Between Fillets	Ratios For Local Buckling		Dimensions For Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		D	B	t	T	r	d	b/T	d/t	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
305 x 305 x 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 x 305 x 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 x 305 x 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 x 305 x 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 x 305 x 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 x 305 x 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 x 305 x 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 x 254 x 167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	4.18	10.4	12	134	46	1.58	9.45
254 x 254 x 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 x 254 x 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 x 254 x 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 x 254 x 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 x 203 x 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 x 203 x 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 x 203 x 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 x 203 x 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 x 203 x 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 x 152 x 37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	6.71	15.4	6	84	20	0.912	24.7
152 x 152 x 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 x 152 x 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

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	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y					
									u	x	H	J	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
305 x 305 x 283	78870	24630	14.8	8.27	4318	1529	5105	2342	0.855	7.65	6.35	2034	360
305 x 305 x 240	64200	20310	14.5	8.15	3643	1276	4247	1951	0.854	8.74	5.03	1271	306
305 x 305 x 198	50900	16300	14.2	8.04	2995	1037	3440	1581	0.854	10.2	3.88	734	252
305 x 305 x 158	38750	12570	13.9	7.90	2369	808	2680	1230	0.851	12.5	2.87	378	201
305 x 305 x 137	32810	10700	13.7	7.83	2048	692	2297	1053	0.851	14.2	2.39	249	174
305 x 305 x 118	27670	9059	13.6	7.77	1760	589	1958	895	0.850	16.2	1.98	161	150
305 x 305 x 97	22250	7308	13.4	7.69	1445	479	1592	726	0.850	19.3	1.56	91.2	123
254 x 254 x 167	30000	9870	11.9	6.81	2075	744	2424	1137	0.851	8.49	1.63	626	213
254 x 254 x 132	22530	7531	11.6	6.69	1631	576	1869	878	0.850	10.3	1.19	319	168
254 x 254 x 107	17510	5928	11.3	6.59	1313	458	1484	697	0.848	12.4	0.898	172	136
254 x 254 x 89	14270	4857	11.2	6.55	1096	379	1224	575	0.850	14.5	0.717	102	113
254 x 254 x 73	11410	3908	11.1	6.48	898	307	992	465	0.849	17.3	0.562	57.6	93.1
203 x 203 x 86	9449	3127	9.28	5.34	850	299	977	456	0.850	10.2	0.318	137	110
203 x 203 x 71	7618	2537	9.18	5.30	706	246	799	374	0.853	11.9	0.250	80.2	90.4
203 x 203 x 60	6125	2065	8.96	5.20	584	201	656	305	0.846	14.1	0.197	47.2	76.4
203 x 203 x 52	5259	1778	8.91	5.18	510	174	567	264	0.848	15.8	0.167	31.8	66.3
203 x 203 x 46	4568	1548	8.82	5.13	450	152	497	231	0.847	17.7	0.143	22.2	58.7
152 x 152 x 37	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.3	0.0399	19.2	47.1
152 x 152 x 30	1748	560	6.76	3.83	222	73.3	248	112	0.849	16.0	0.0308	10.5	38.3
152 x 152 x 23	1250	400	6.54	3.70	164	52.6	182	80.2	0.840	20.7	0.0212	4.63	29.2

UNEQUAL ANGLES





DIMENSIONS AND PROPERTIES

Designation		Mass Per Metre	Radius		Area Of Section	Distance Centre Of Gravity		Second Moment Of Area		Radius Of Gyration		Elastic Modulus	
Size A B	Thickness t		Root r1	Toe r2		cx	cy	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y
mm	mm	kg	mm	mm	cm^2	cm	cm	cm^4	cm^4	cm	cm	cm^3	cm^3
200 x 150	18	47.1	15.0	4.8	60.1	6.34	3.86	2390	1155	6.30	4.38	175	104
	15	39.6	15.0	4.8	50.6	6.22	3.75	2037	989	6.34	4.42	148	87.8
	12	32.0	15.0	4.8	40.9	6.10	3.63	1667	812	6.38	4.45	120	71.4
200 x 100	15	33.7	15.0	4.8	43.1	7.17	2.23	1772	303	6.40	2.65	138	39.0
	12	27.3	15.0	4.8	34.9	7.04	2.11	1454	252	6.45	2.68	112	31.9
	10	23.0	15.0	4.8	29.4	6.95	2.03	1233	215	6.48	2.70	94.5	26.9
150 x 90	15	26.6	12.0	4.8	34.0	5.21	2.24	764	207	4.74	2.47	78.0	30.6
	12	21.6	12.0	4.8	27.6	5.09	2.12	630	172	4.78	2.50	63.6	25.0
	10	18.2	12.0	4.8	23.2	5.00	2.04	536	147	4.81	2.52	53.6	21.2
150 x 75	15	24.8	11.0	4.8	31.7	5.53	1.81	715	120	4.75	1.95	75.5	21.1
	12	20.2	11.0	4.8	25.7	5.41	1.70	591	100	4.79	1.98	61.6	17.3
	10	17.0	11.0	4.8	21.7	5.32	1.62	503	86.3	4.82	2.00	52.0	14.7
137 x 102	9.5+	17.3	11.0	4.8	22.0	4.23	2.50	415	198	4.35	3.00	43.8	25.7
	7.9+	14.5	11.0	4.8	18.4	4.16	2.44	351	168	4.36	3.02	36.8	21.6
	6.4+	11.7	11.0	4.8	15.0	4.09	2.37	289	138	4.38	3.03	30.0	17.6
125 x 75	8	17.8	11.0	4.8	22.7	4.31	1.84	355	96.0	3.95	2.06	43.4	17.0
	12	15.0	11.0	4.8	19.2	4.23	1.76	303	82.5	3.98	2.08	36.7	14.4
	10	12.2	11.0	4.8	15.5	4.14	1.68	249	68.1	4.00	2.10	29.7	11.7
	6.5+	9.98	11.0	4.8	12.7	4.07	1.62	206	56.6	4.02	2.11	24.4	9.62
100 x 75	12	15.4	10.0	4.8	19.7	3.27	2.03	189	90.3	3.10	2.14	28.1	16.5
	10	13.0	10.0	4.8	16.6	3.19	1.95	162	77.7	3.12	2.16	23.8	14.0
	8	10.6	10.0	4.8	13.5	3.10	1.87	133	64.2	3.14	2.18	19.3	11.4
100 x 65	10	12.3	10.0	4.8	15.6	3.36	1.63	154	51.1	3.14	1.81	23.2	10.5
	8	9.94	10.0	4.8	12.7	3.28	1.56	127	42.3	3.17	1.83	18.9	8.56
	7	8.77	10.0	4.8	11.2	3.23	1.51	113	37.7	3.18	1.84	16.6	7.56
80 x 60	8	8.34	8.0	4.8	10.6	2.55	1.56	65.8	31.5	2.49	1.72	12.1	7.09
	7	7.36	8.0	4.8	9.35	2.50	1.52	58.5	28.1	2.50	1.73	10.6	6.26
	6	6.37	8.0	4.8	8.08	2.46	1.48	50.9	24.5	2.51	1.74	9.19	5.41
75 x 50	8	7.39	7.0	2.4	9.44	2.53	1.29	52.4	18.6	2.36	1.40	10.5	5.00
	6	5.65	7.0	2.4	7.22	2.44	1.21	40.9	14.6	2.38	1.42	8.10	3.87
65 x 50	8	6.75	6.0	2.4	8.61	2.12	1.37	34.9	17.8	2.01	1.44	7.97	4.92
	6	5.16	6.0	2.4	6.59	2.04	1.30	27.4	14.1	2.04	1.46	6.14	3.80
	5	4.35	6.0	2.4	5.55	2.00	1.26	23.3	12.0	2.05	1.47	5.18	3.21
60 x 30	6	3.99	6.0	2.4	5.09	2.20	0.724	18.3	3.05	1.90	0.774	4.82	1.34
	5	3.37	6.0	2.4	4.30	2.16	0.684	15.7	2.64	1.91	0.783	4.08	1.14
40 x 25	4	1.93	4.0	2.4	2.45	1.36	0.621	3.86	1.15	1.26	0.685	1.46	0.612

+ Section marked thus are not included in BS4848: Part 4

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