Hong Kong Institute

of

Vocational Education

香港專業教育學院

[redacted]

HD in Civil Engineering

(EG524101)

[redacted]

Steelwork Design

(C O N 4 3 3 4)

[redacted]

AY 2022/23

Semester Seven Examination

XXth Jan 2023

7:00pm – 9:00pm

[redacted]

Notes :

1. The result of this examination will not be counted if you do not meet the minimum attendance requirement governed by the General Academic Regulations of your programme unless approval from the Campus Principal has been granted.
2. This paper consists of **SIX (6)** pages including this cover page.
3. **There are two sections in this paper. Section A contains a compulsory question with a total of 40 marks. Section B is comprised of choice questions and carries a total of 60 marks.**
4. **Answer the compulsory question in Section A. Answer ANY TWO (2) questions in Section B.**
5. All symbols have their usual meaning unless otherwise defined.
6. All dimensions are in millimeter unless otherwise stated.
7. All figures are NOT necessary to scale.
8. Examination Data:
   EIGHTEEN (18) pages of examination data are provided for reference.

SECTION A: COMPULSORY QUESTION (40%)

AQ.1

(a) The floor plan of an office area is shown in **Figure AQ1**. Compression flanges of the steel beams (**Beam B1 and B2**) are fully restrained from lateral torsional buckling by concrete slabs. The concrete slabs are 125 mm thick supporting an additional finishes load of 0.5 kN/m^2. The imposed load on the slabs is 2.5 kN/m^2. All steel beams are **Grade S355** and simply supported at their ends. Unit weight of concrete is assumed to be 24.5 kN/m^3. All the beams are carrying brittle finishes.

(i) Determine the factored load intensity (in kN/m^2) carried by the slabs. (4 marks)

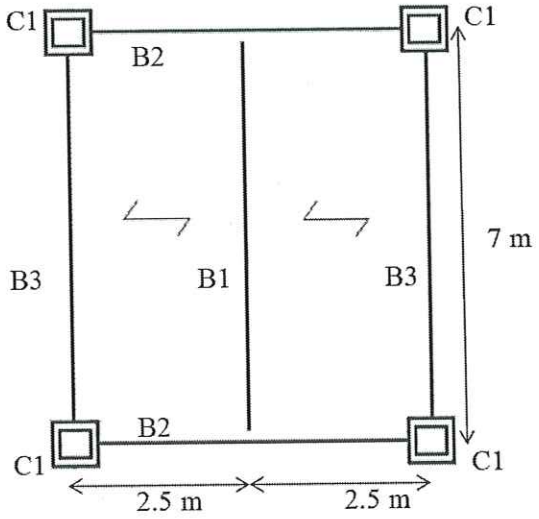
(ii) With consideration of beam self-weight (g = 10 m/s^{-2}), calculate the maximum factored shear forces and bending moments of Beam **B1** and Beam **B2**. (8 marks)

(iii) Find the section classes of the steel beam **B1** and **B2**. (4 marks)

(iv) Check the adequacy of steel beam **B1** against shear, bending and deflection. (10 marks)

(v) Check the adequacy of steel beam **B2** against shear, bending and deflection. (10 marks)

(b) Describe two methods to enhance corrison resistance of structural steel. (4 marks)



Beam **B1**: 356 x 127 x 39 kg/m UB
Beam **B2**: 356 x 171 x 51 kg/m UB

Figure AQ1

Section B – Answer any TWO questions in this Section.

BQ.2

(a) A double unequal angles of size 200×100×12 connected through the long legs as shown in **Figure BQ2(a)** carries a concentric dead load of 150 kN and an imposed load of 160 kN using welded connection. All steel members are of **Grade S355** welded with the **Class 42 electrode**. Assume the weld size of the angle is 8 mm **(checking of gusset plate is not required).**

(i) Check the tensile capacities of the angles. (6 marks)

(ii) Design the final weld length of the angles. (9 marks)

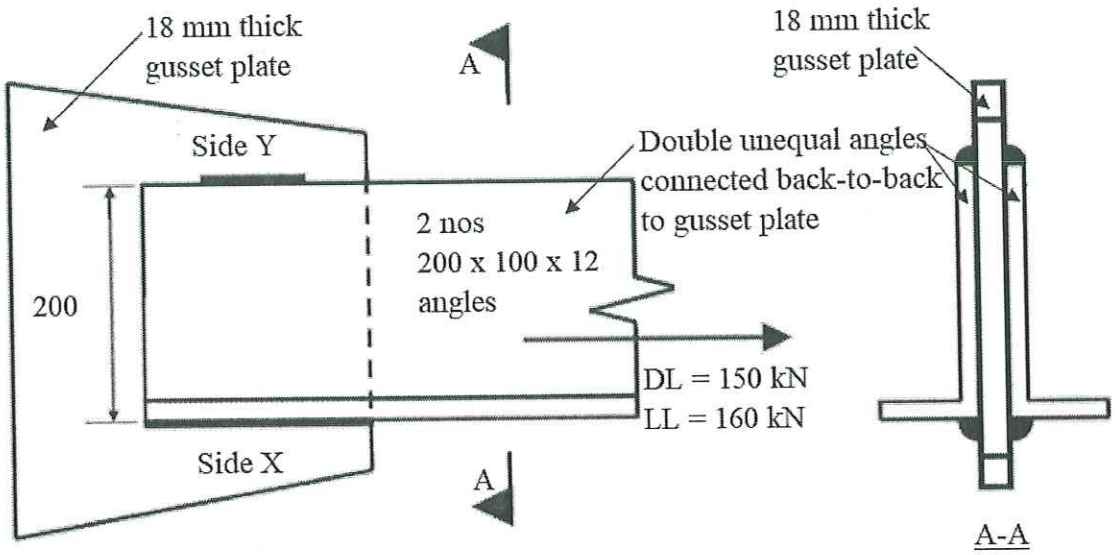


Figure BQ2(a) (dimension in mm)

To be continued…

BQ.2 (Continue)

(b) The steel bracket as shown in **Figure BQ2(b)** is subjected to a designed load of 350 kN. All the bolts are **M20 Grade 8.8** bolts, and steel members are **Grade S355**.

(i) Determine the shear and tension capacity of the bolts; (5 marks)

(ii) Hence check the adequacy of the bolts for the bracket connection. (10 marks)

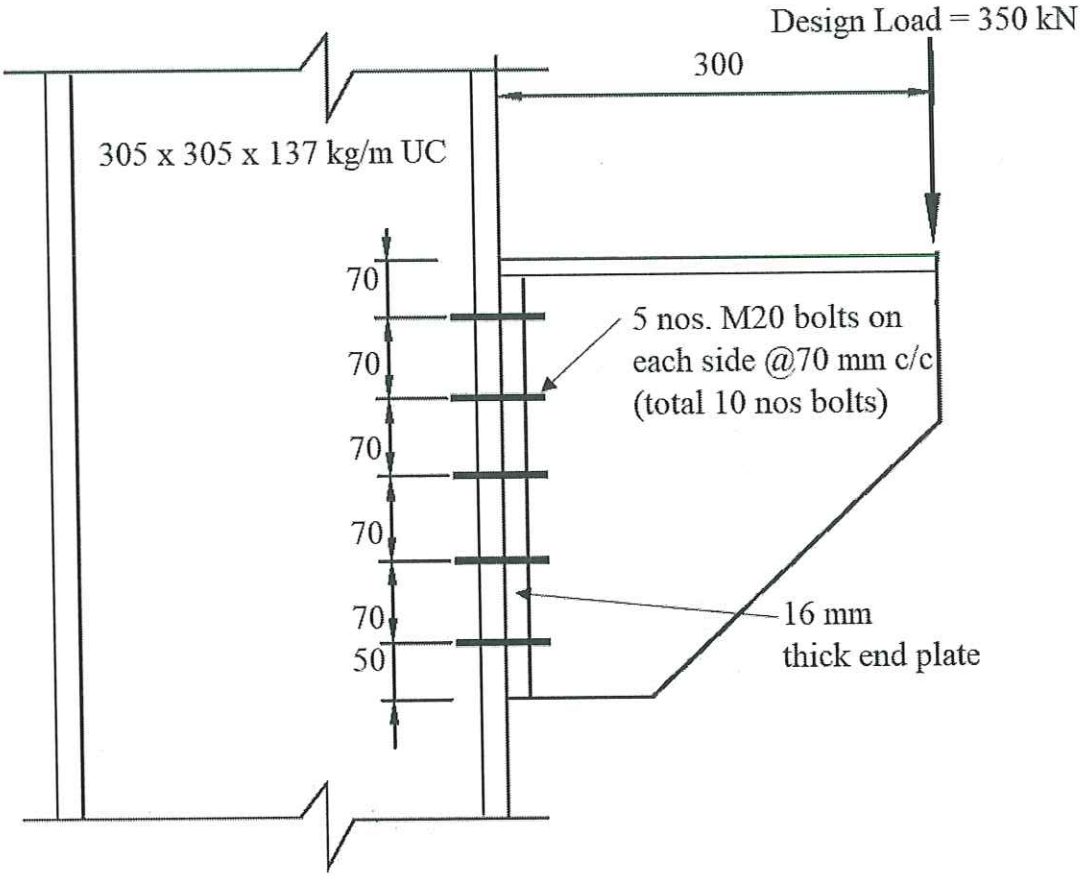


Figure BQ2(b) (dimension in mm)

BQ.3 A braced steel column 305 x 305 x 198 kg/m UC of **Grade S355** in a non-sway frame with 6 m effective height is subjected to factored end loads as shown below:

Factored axial load including self-weight of column = 2300 kN
Factored moment about x-x axis, Mx-x at top of column = +350 kNm
Factored moment about x-x axis, Mx-x at bottom of column = +45 kNm
Amplification factor P-Δ-δ effect in x-x axis = 1.1
Factored moment about y-y axis, My-y at top of column = +90 kNm
Factored moment about y-y axis, My-y at bottom of column = -35 kNm
Amplification factor P-Δ-δ effect in y-y axis = 1.15
Factored moment amplified for P-Δ-δ effect governing Mb
M_{LT} = 110 kNm

(Note: Positive sign for clockwise moment; negative for anti-clockwise moment)

(a) Determine the class of the steel column section. (4 marks)

(b) Check the cross section capacity of the steel column. (6 marks)

(c) Check the buckling resistance of the steel column. (20 marks)

BQ.4 A simply supported steel beam 406 x 140 x 46 kg/m UB (**Class 1 section, Grade S355**) with a span of 6.0 m is as shown in **Figure BQ4** and subjected to a concentrated design load of 110 kN at mid-span. The **self-weight of beam is negligible**.

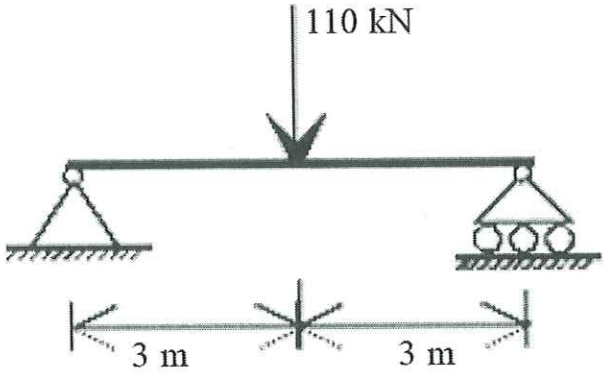


Figure BQ4

(a) Calculate the maximum shear force and moment of the beam. (2 marks)

(b) If lateral restraints on the compression flange of the steel beam are NOT provided along the span and only restraints at end supports are provided, check the adequacy of the beam against buckling moment resistance of the steel beam by using accurate values of parameter u and v in calculation of λ_{LT}. (14 marks)

(c) If lateral restraints on the compression flange of the steel beam are NOT provided along the span and only restraints at end supports and mid-span point load location are provided, check the adequacy of the beam against buckling moment resistance of the steel beam by using accurate values of parameter u and v in calculation of λ_{LT}. (14 marks)

- END OF PAPER -

Design Formulae for Structural Steel Design

Note: ***All the terms and symbols bear their usual meanings***

1. **Steel Properties**

$E = 205{,}000$ N/mm^2 $\qquad \varepsilon = \left(\frac{275}{p_y}\right)^{0.5}$

2. **Bending**

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

Shear

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

Deflection

$\Delta = \frac{5}{384}\frac{wl^4}{EI}$ **for UDL,** $\qquad \Delta = \frac{Pl^3}{48EI}$ **for point load at mid-span.**

Buckling Resistance

$\lambda = L_e / r_y \qquad \lambda_{LT} = uv\lambda\sqrt{\beta_w} \qquad \beta_w = 1$ *for class 1 and 2 sections*

$$v = \frac{1}{\left(1 + 0.05(\frac{\lambda}{x})^2\right)^{0.25}}$$

$M_b = p_b S_x \qquad m_{LT} M_x \leq M_b$

3. **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 $a_2 = A_g - a_1$

4. **Compression Members**

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

5. **Column Equations**

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

Cross Section Capacity Check :

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

Member Buckling Capacity Check :

$$\frac{F_c}{P_c} + \frac{m_x M_x}{M_{cx}} + \frac{m_y M_y}{M_{cy}} \leq 1$$

$$\frac{F_c}{P_{cy}} + \frac{m_{LT} M_{LT}}{M_b} + \frac{m_y \overline{M}_y}{M_{cy}} \leq 1$$

Simple Construction :

$\lambda_{LT} = 0.5L / r_y$

$$\frac{F_c}{P_c} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$$

$$\frac{F_c}{P_{cy}} + \frac{m_{LT} M_{LT}}{M_b} + \frac{\overline{M}_y}{M_{cy}} \leq 1$$

6. **Connection - 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

7. **Bolted Connection - Combined Torsion and Shear**

$F_s = P / (no.\ of\ bolts)$

$F_T = P\ e\ r / (\Sigma x^2 + \Sigma y^2)$

$F_R = [F_s^2 + F_T^2 + 2\ F_T F_s \cos \phi]^{0.5}$

8. **Bolted Connection - Combined Tension and Shear**

$F_s = P / (no.\ of\ bolts)$

$F_T = P\ e\ y_1 / \Sigma y^2$

$F_s \leq P_s \qquad F_T \leq P_T$

$$\frac{F_s}{P_s} + \frac{F_T}{P_{nom}} \leq 1.4$$

9. **Welded Connection - Combined Torsion and Shear**

$F_s = P / (length\ of\ weld)$

$F_T = P\ e\ r / I_p \qquad where\ I_p = I_x + I_y$

$F_R = [F_s^2 + F_T^2 + 2\ F_T F_s \cos \phi]^{0.5}$

10. **Welded Connection - Combined Tension and Shear**

Assume rotation about the bottom flange

$F_s = P / 2a$

$F_T = P\ e / d\ b$

11. **Strength of Weld**

Strength of Weld = 0.7 leg length p_w x 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

Tensile 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

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

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
ISO 10.9	400	1300	700

Design Strength for Steels (Plates, Hot Finished and Cold Formed Hollow 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

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 $r_1 = \dfrac{F_c}{dtp_{yw}}$ but $-1 < r_1 \leq 1$ **and** $r_2 = \dfrac{F_c}{A_g p_{yw}}$ **for I and H sections with equal flanges.**

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

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

Table 8.3a - Bending strength p_b (N/mm2) for rolled sections

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

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

Table 8.4a - Equivalent uniform moment factor m_{LT} for lateral-torsional buckling of beams under end moments and typical loads

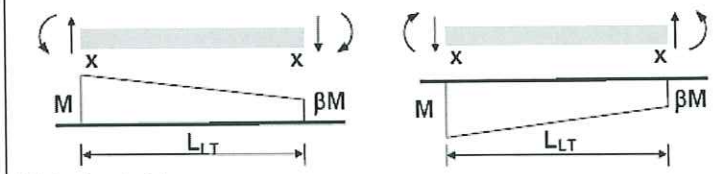
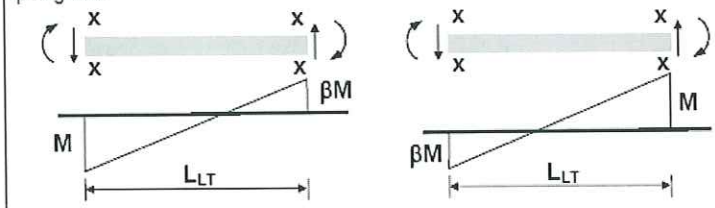
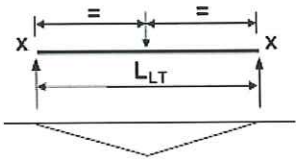
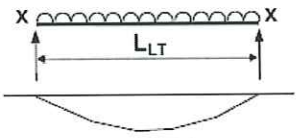
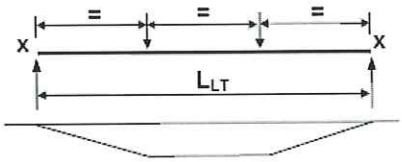
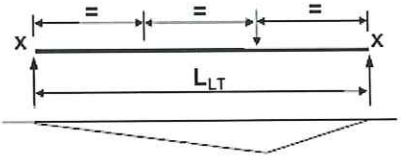
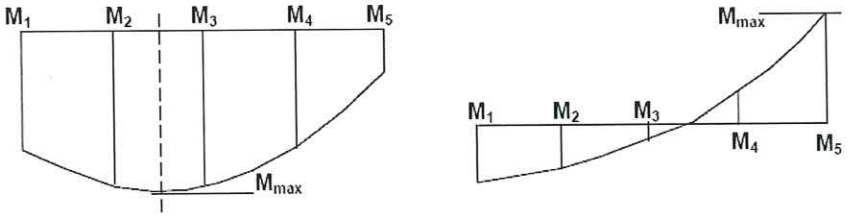
Segment with end moment only (values of m_{LT} from the formula for the general case)	β	m_{LT}
β positive  X lateral restraint	1.0	1.00
	0.9	0.96
	0.8	0.92
	0.7	0.88
	0.6	0.84
	0.5	0.80
	0.4	0.76
	0.3	0.72
	0.2	0.68
	0.1	0.64
β negative  	0.0	0.60
	-0.1	0.56
	-0.2	0.52
	-0.3	0.48
	-0.4	0.46
	-0.5	0.44
	-0.6	0.44
	-0.7	0.44
	-0.8	0.44
	-0.9	0.44
	-1.0	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)



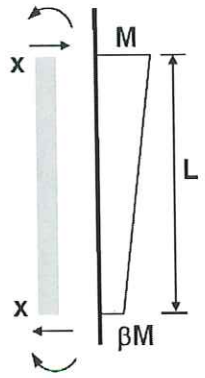
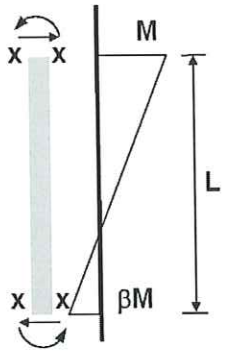
For beams: $m_{LT} = 0.2 + \dfrac{0.15M_2 + 0.5M_3 + 0.15M_4}{M_{max}}$ but $m_{LT} \geq 0.44$

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

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

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 	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
β negative 		
X - lateral restraint		

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
Welded I – or H-section	≤ 40	b	c
	> 40	c	d

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

Table 8.8(a) - Design strength p_c of compression members

1) Values of pc in N/mm² with λ < 110 for strut curve a					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	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

2) Values of pc in N/mm² with λ ≥ 110 for strut curve a					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	315	325	335	345	355
110	142	143	144	144	145
112	137	138	139	140	141
114	133	134	135	136	136
116	129	130	131	132	132
118	126	126	127	128	128
120	122	123	123	123	125
122	119	119	120	120	121
124	115	116	116	117	117
126	112	113	113	114	114
128	109	109	110	110	111
130	106	106	107	107	108
135	99	99	100	100	101
140	93	93	93	94	94
145	87	87	87	88	88
150	82	82	82	82	83
155	77	77	77	77	78
160	72	72	73	73	73
165	68	68	69	69	69
170	64	65	65	65	65
175	61	61	61	61	62
180	58	58	58	58	58
185	55	55	55	55	55
190	52	52	52	53	53
195	50	50	50	50	50
200	47	47	47	48	48
210	43	43	43	43	43
220	39	39	40	40	40
230	36	36	36	36	36
240	33	33	33	33	33
250	31	31	31	31	31
260	28	29	29	29	29
270	26	27	27	27	27
280	25	25	25	25	25
290	23	23	23	23	23
300	22	22	22	22	22
310	20	20	20	20	20
320	19	19	19	19	19
330	18	18	18	18	18
340	17	17	17	17	17
350	16	16	16	16	16

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

Table 8.8(b) - Design strength p_c of compression members

1) Values of pc in N/mm² with λ < 110 for strut curve b					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	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	181
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

2) Values of pc in N/mm² with λ ≥ 110 for strut curve b					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	315	325	335	345	355
110	129	130	131	133	134
112	125	127	128	129	130
114	122	123	124	125	126
116	119	120	121	122	122
118	115	116	117	118	119
120	112	113	114	115	116
122	109	110	111	112	112
124	106	107	108	109	109
126	103	104	105	106	106
128	101	101	102	103	103
130	98	99	99	100	101
135	92	93	93	94	94
140	86	87	87	88	88
145	81	82	82	83	83
150	76	77	77	78	78
155	72	72	73	73	73
160	68	68	69	69	69
165	64	65	65	65	65
170	61	61	61	62	62
175	58	58	58	59	59
180	55	55	55	56	56
185	52	52	53	53	53
190	50	50	50	50	50
195	47	47	48	48	48
200	45	45	45	46	46
210	41	41	41	42	42
220	38	38	38	38	38
230	35	35	35	35	35
240	32	32	32	32	32
250	30	30	30	30	30
260	27	28	28	28	28
270	26	26	26	26	26
280	24	24	24	24	24
290	22	22	22	22	22
300	21	21	21	21	21
310	20	20	20	20	20
320	18	18	19	19	19
330	17	17	17	17	18
340	16	16	16	17	17
350	16	16	16	16	16

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

Table 8.8(c) - Design strength p_c of compression members

1) Values of pc in N/mm² with λ < 110 for strut curve c					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	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

2) Values of pc in N/mm² with λ ≥ 110 for strut curve c					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	315	325	335	345	355
110	116	118	119	120	122
112	113	115	116	117	118
114	110	112	113	114	115
116	108	109	110	111	112
118	105	106	107	108	109
120	102	103	104	105	106
122	99	100	101	102	103
124	97	98	99	100	100
126	94	95	96	97	98
128	92	93	94	95	95
130	90	91	91	92	93
135	84	85	86	87	87
140	79	80	81	81	82
145	75	76	76	77	77
150	71	71	72	72	73
155	67	67	68	68	69
160	63	64	64	65	65
165	60	60	61	61	61
170	57	57	58	58	58
175	54	54	55	55	55
180	51	52	52	52	53
185	49	49	50	50	50
190	47	47	47	47	48
195	45	45	45	45	45
200	43	43	43	43	43
210	39	39	39	40	40
220	36	36	36	36	36
230	33	33	33	33	34
240	30	31	31	31	31
250	28	28	28	29	29
260	26	26	26	27	27
270	24	25	25	25	25
280	23	23	23	23	23
290	21	21	22	22	22
300	20	20	20	20	20
310	19	19	19	19	19
320	18	18	18	18	18
330	17	17	17	17	17
340	16	16	16	16	16
350	15	15	15	15	15

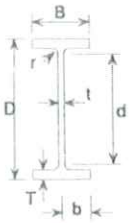
Reproduced from Code of Practice for the Structural Use of Steel 2011[1]

Table 8.8(d) - Design strength p_c of compression members

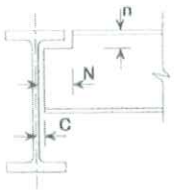
1) Values of pc in N/mm² with λ < 110 for strut curve d					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	315	325	335	345	355
15	315	325	335	345	355
20	305	314	323	332	341
25	292	301	309	318	326
30	279	287	296	304	312
35	267	274	282	290	297
40	254	261	268	275	283
42	249	256	263	270	277
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

2) Values of pc in N/mm² with λ ≥ 110 for strut curve d					
	Steel grade and design strength p_y (N/mm²)				
	S355				
λ	315	325	335	345	355
110	105	106	108	109	110
112	102	103	105	106	107
114	99	101	102	103	104
116	97	98	99	101	102
118	95	96	97	98	99
120	92	93	94	95	96
122	90	91	92	93	94
124	88	89	90	91	92
126	86	87	88	89	89
128	84	85	85	86	87
130	82	83	83	84	85
135	77	78	79	79	80
140	73	73	74	75	75
145	69	69	70	71	71
150	65	66	66	67	67
155	62	62	63	63	64
160	58	59	59	60	60
165	55	56	56	57	57
170	53	53	54	54	54
175	50	51	51	51	52
180	48	48	49	49	49
185	46	46	46	47	47
190	44	44	44	44	45
195	42	42	42	42	43
200	40	40	40	41	41
210	37	37	37	37	37
220	34	34	34	34	34
230	31	31	31	32	32
240	29	29	29	29	29
250	27	27	27	27	27
260	25	25	25	25	25
270	23	23	23	24	24
280	22	22	22	22	22
290	20	21	21	21	21
300	19	19	19	19	20
310	18	18	18	18	18
320	17	17	17	17	17
330	16	16	16	16	16
340	15	15	15	15	15
350	14	14	15	15	15

Reproduced from Code of Practice for the Structural Use of Steel 2011[1]



UNIVERSAL BEAMS



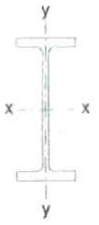
DIMENSIONS

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
914x419x388	388.0	921.0	420.5	21.4	36.6	24.1	799.6	5.74	37.4	13	210	62	3.44	8.87
914x419x343	343.3	911.8	418.5	19.4	32.0	24.1	799.6	6.54	41.2	12	210	58	3.42	9.95
914x305x289	289.1	926.6	307.7	19.5	32.0	19.1	824.4	4.81	42.3	12	156	52	3.01	10.4
914x305x253	253.4	918.4	305.5	17.3	27.9	19.1	824.4	5.47	47.7	11	156	48	2.99	11.8
914x305x224	224.2	910.4	304.1	15.9	23.9	19.1	824.4	6.36	51.8	10	156	44	2.97	13.3
914x305x201	200.9	903.0	303.3	15.1	20.2	19.1	824.4	7.51	54.6	10	156	40	2.96	14.7
838x292x226	226.5	850.9	293.8	16.1	26.8	17.8	761.7	5.48	47.3	10	150	46	2.81	12.4
838x292x194	193.8	840.7	292.4	14.7	21.7	17.8	761.7	6.74	51.8	9	150	40	2.79	14.4
838x292x176	175.9	834.9	291.7	14.0	18.8	17.8	761.7	7.76	54.4	9	150	38	2.78	15.8
762x267x197	196.8	769.8	268.0	15.6	25.4	16.5	686.0	5.28	44.0	10	138	42	2.55	13.0
762x267x173	173.0	762.2	266.7	14.3	21.6	16.5	686.0	6.17	48.0	9	138	40	2.53	14.6
762x267x147	146.9	754.0	265.2	12.8	17.5	16.5	686.0	7.58	53.6	8	138	34	2.51	17.1
762x267x134	133.9	750.0	264.4	12.0	15.5	16.5	686.0	8.53	57.2	8	138	32	2.51	18.7
686x254x170	170.2	692.9	255.8	14.5	23.7	15.2	615.1	5.40	42.4	9	132	40	2.35	13.8
686x254x152	152.4	687.5	254.5	13.2	21.0	15.2	615.1	6.06	46.6	9	132	38	2.34	15.4
686x254x140	140.1	683.5	253.7	12.4	19.0	15.2	615.1	6.68	49.6	8	132	36	2.33	16.6
686x254x125	125.2	677.9	253.0	11.7	16.2	15.2	615.1	7.81	52.6	8	132	32	2.32	18.5
610x305x238	238.1	635.8	311.4	18.4	31.4	16.5	540.0	4.96	29.3	11	158	48	2.45	10.3
610x305x179	179.0	620.2	307.1	14.1	23.6	16.5	540.0	6.51	38.3	9	158	42	2.41	13.5
610x305x149	149.2	612.4	304.8	11.8	19.7	16.5	540.0	7.74	45.8	8	158	38	2.39	16.0
610x229x140	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
610x229x125	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
610x229x113	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
610x229x101	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
533x210x122	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
533x210x109	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
533x210x101	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
533x210x92	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
533x210x82	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
457x191x98	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
457x191x89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	5.42	38.8	7	102	28	1.66	18.5
457x191x82	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
457x191x74	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
457x191x67	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
457x152x82	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
457x152x74	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
457x152x67	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
457x152x60	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
457x152x52	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

FOR EXPLANATION OF TABLES SEE NOTE 2

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"

UNIVERSAL BEAMS

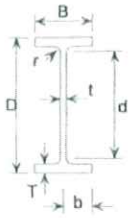


PROPERTIES

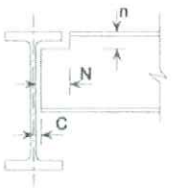
Section Designation	Second Moment Of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area Of Section
	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y					
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	u	x	H dm^6	J cm^4	A cm^2
914x419x388	719600	45440	38.2	9.59	15630	2161	17670	3341	0.885	26.7	88.9	1734	494
914x419x343	625800	39160	37.8	9.46	13730	1871	15480	2890	0.883	30.1	75.8	1193	437
914x305x289	504200	15600	37.0	6.51	10880	1014	12570	1601	0.867	31.9	31.2	926	368
914x305x253	436300	13300	36.8	6.42	9501	871	10940	1371	0.866	36.2	26.4	626	323
914x305x224	376400	11240	36.3	6.27	8269	739	9535	1163	0.861	41.3	22.1	422	286
914x305x201	325300	9423	35.7	6.07	7204	621	8351	982	0.854	46.8	18.4	291	256
838x292x226	339700	11360	34.3	6.27	7985	773	9155	1212	0.870	35.0	19.3	514	289
838x292x194	279200	9066	33.6	6.06	6641	620	7640	974	0.862	41.6	15.2	306	247
838x292x176	246000	7799	33.1	5.90	5893	535	6808	842	0.856	46.5	13.0	221	224
762x267x197	240000	8175	30.9	5.71	6234	610	7167	959	0.869	33.2	11.3	404	251
762x267x173	205300	6850	30.5	5.58	5387	514	6198	807	0.864	38.1	9.39	267	220
762x267x147	168500	5455	30.0	5.40	4470	411	5156	647	0.858	45.2	7.40	159	187
762x267x134	150700	4788	29.7	5.30	4018	362	4644	570	0.854	49.8	6.46	119	171
686x254x170	170300	6630	28.0	5.53	4916	518	5631	811	0.872	31.8	7.42	308	217
686x254x152	150400	5784	27.8	5.46	4374	455	5000	710	0.871	35.5	6.42	220	194
686x254x140	136300	5183	27.6	5.39	3987	409	4558	638	0.868	38.7	5.72	169	178
686x254x125	118000	4383	27.2	5.24	3481	346	3994	542	0.862	43.9	4.80	116	159
610x305x238	209500	15840	26.3	7.23	6589	1017	7486	1574	0.886	21.3	14.5	785	303
610x305x179	153000	11410	25.9	7.07	4935	743	5547	1144	0.886	27.7	10.2	340	228
610x305x149	125900	9308	25.7	7.00	4111	611	4594	937	0.886	32.7	8.17	200	190
610x229x140	111800	4505	25.0	5.03	3622	391	4142	611	0.875	30.6	3.99	216	178
610x229x125	98610	3932	24.9	4.97	3221	343	3676	535	0.873	34.1	3.45	154	159
610x229x113	87320	3434	24.6	4.88	2874	301	3281	469	0.870	38.0	2.99	111	144
610x229x101	75780	2915	24.2	4.75	2515	256	2881	400	0.864	43.1	2.52	77.0	129
533x210x122	76040	3388	22.1	4.67	2793	320	3196	500	0.877	27.6	2.32	178	155
533x210x109	66820	2943	21.9	4.60	2477	279	2828	436	0.875	30.9	1.99	126	139
533x210x101	61520	2692	21.9	4.57	2292	256	2612	399	0.874	33.2	1.81	101	129
533x210x92	55230	2389	21.7	4.51	2072	228	2360	356	0.872	36.5	1.60	75.7	117
533x210x82	47540	2007	21.3	4.38	1800	192	2059	300	0.864	41.6	1.33	51.5	105
457x191x98	45730	2347	19.1	4.33	1957	243	2232	379	0.881	25.7	1.18	121	125
457x191x89	41020	2089	19.0	4.29	1770	218	2014	338	0.880	28.3	1.04	90.7	114
457x191x82	37050	1871	18.8	4.23	1611	196	1831	304	0.877	30.9	0.922	69.2	104
457x191x74	33320	1671	18.8	4.20	1458	176	1653	272	0.877	33.9	0.818	51.8	94.6
457x191x67	29380	1452	18.5	4.12	1296	153	1471	237	0.872	37.9	0.705	37.1	85.5
457x152x82	36590	1185	18.7	3.37	1571	153	1811	240	0.873	27.4	0.591	89.2	105
457x152x74	32670	1047	18.6	3.33	1414	136	1627	213	0.873	30.1	0.518	65.9	94.5
457x152x67	28930	913	18.4	3.27	1263	119	1453	187	0.869	33.6	0.448	47.7	85.6
457x152x60	25500	795	18.3	3.23	1122	104	1287	163	0.868	37.5	0.387	33.8	76.2
457x152x52	21370	645	17.9	3.11	950	84.6	1096	133	0.859	43.9	0.311	21.4	66.6

FOR EXPLANATION OF TABLES SEE NOTE 3

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"



UNIVERSAL BEAMS



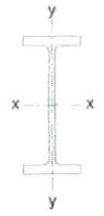
DIMENSIONS

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
406x178x74	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
406x178x67	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
406x178x60	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
406x178x54	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
406x140x46	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
406x140x39	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
356x171x67	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
356x171x57	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
356x171x51	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
356x171x45	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
356x127x39	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
356x127x33	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
305x165x54	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
305x165x46	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
305x165x40	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
305x127x48	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
305x127x42	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
305x127x37	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
305x102x33	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
305x102x28	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
305x102x25	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
254x146x43	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
254x146x37	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
254x146x31	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
254x102x28	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
254x102x25	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
254x102x22	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
203x133x30	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
203x133x25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	8.54	30.2	5	74	16	0.915	36.4
203x102x23	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
178x102x19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	4	60	16	0.738	38.8
152x89x16	16.0	152.4	88.7	4.5	7.7	7.6	121.8	5.76	27.1	4	54	16	0.638	39.8
127x76x13	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

FOR EXPLANATION OF TABLES SEE NOTE 2

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"

UNIVERSAL BEAMS

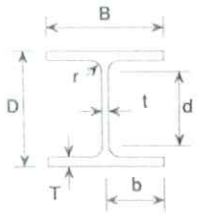


PROPERTIES

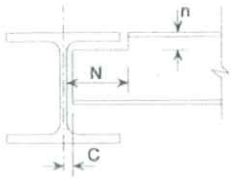
Section Designation	Second Moment Of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area Of Section
	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y					
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	u	x	H dm^6	J cm^4	A cm^2
406x178x74	27310	1545	17.0	4.04	1323	172	1501	267	0.882	27.6	0.608	62.8	94.5
406x178x67	24330	1365	16.9	3.99	1189	153	1346	237	0.880	30.5	0.533	46.1	85.5
406x178x60	21600	1203	16.8	3.97	1063	135	1199	209	0.880	33.8	0.466	33.3	76.5
406x178x54	18720	1021	16.5	3.85	930	115	1055	178	0.871	38.3	0.392	23.1	69.0
406x140x46	15690	538	16.4	3.03	778	75.7	888	118	0.871	38.9	0.207	19.0	58.6
406x140x39	12510	410	15.9	2.87	629	57.8	724	90.8	0.858	47.5	0.155	10.7	49.7
356x171x67	19460	1362	15.1	3.99	1071	157	1211	243	0.886	24.4	0.412	55.7	85.5
356x171x57	16040	1108	14.9	3.91	896	129	1010	199	0.882	28.8	0.330	33.4	72.6
356x171x51	14140	968	14.8	3.86	796	113	896	174	0.881	32.1	0.286	23.8	64.9
356x171x45	12070	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356x127x39	10170	358	14.3	2.68	576	56.8	659	89.1	0.871	35.2	0.105	15.1	49.8
356x127x33	8249	280	14.0	2.58	473	44.7	543	70.3	0.863	42.2	0.0812	8.79	42.1
305x165x54	11700	1063	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305x165x46	9899	896	13.0	3.90	646	108	720	166	0.891	27.1	0.195	22.2	58.7
305x165x40	8503	764	12.9	3.86	560	92.6	623	142	0.889	31.0	0.164	14.7	51.3
305x127x48	9575	461	12.5	2.74	616	73.6	711	116	0.873	23.3	0.102	31.8	61.2
305x127x42	8196	389	12.4	2.70	534	62.6	614	98.4	0.872	26.5	0.0846	21.1	53.4
305x127x37	7171	336	12.3	2.67	471	54.5	539	85.4	0.872	29.7	0.0725	14.8	47.2
305x102x33	6501	194	12.5	2.15	416	37.9	481	60.0	0.866	31.6	0.0442	12.2	41.8
305x102x28	5366	155	12.2	2.08	348	30.5	403	48.5	0.859	37.4	0.0349	7.40	35.9
305x102x25	4455	123	11.9	1.97	292	24.2	342	38.8	0.846	43.4	0.0273	4.77	31.6
254x146x43	6544	677	10.9	3.52	504	92.0	566	141	0.891	21.2	0.103	23.9	54.8
254x146x37	5537	571	10.8	3.48	433	78.0	483	119	0.890	24.3	0.0857	15.3	47.2
254x146x31	4413	448	10.5	3.36	351	61.3	393	94.1	0.880	29.6	0.0660	8.55	39.7
254x102x28	4005	179	10.5	2.22	308	34.9	353	54.8	0.874	27.5	0.0280	9.57	36.1
254x102x25	3415	149	10.3	2.15	266	29.2	306	46.0	0.866	31.5	0.0230	6.42	32.0
254x102x22	2841	119	10.1	2.06	224	23.5	259	37.3	0.856	36.4	0.0182	4.15	28.0
203x133x30	2896	385	8.71	3.17	280	57.5	314	88.2	0.881	21.5	0.0374	10.3	38.2
203x133x25	2340	308	8.56	3.10	230	46.2	258	70.9	0.877	25.6	0.0294	5.96	32.0
203x102x23	2105	164	8.46	2.36	207	32.2	234	49.8	0.888	22.5	0.0154	7.02	29.4
178x102x19	1356	137	7.48	2.37	153	27.0	171	41.6	0.888	22.6	0.00987	4.41	24.3
152x89x16	834	89.8	6.41	2.10	109	20.2	123	31.2	0.890	19.6	0.00470	3.56	20.3
127x76x13	473	55.7	5.35	1.84	74.6	14.7	84.2	22.6	0.895	16.3	0.00199	2.85	16.5

FOR EXPLANATION OF TABLES SEE NOTE 3

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"



UNIVERSAL COLUMNS



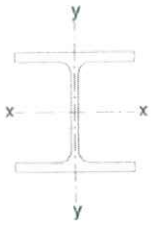
DIMENSIONS

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
356x406x634	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
356x406x551	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
356x406x467	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
356x406x393	393.0	419.0	407.0	30.6	49.2	15.2	290.2	4.14	9.48	17	200	66	2.38	6.05
356x406x340	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
356x406x287	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
356x406x235	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
356x368x202	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
356x368x177	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
356x368x153	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
356x368x129	129.0	355.6	368.6	10.4	17.5	15.2	290.2	10.5	27.9	7	190	34	2.14	16.6
305x305x283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.65	9.21	15	158	60	1.94	6.86
305x305x240	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
305x305x198	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
305x305x158	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
305x305x137	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
305x305x118	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
305x305x97	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
254x254x167	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
254x254x132	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
254x254x107	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
254x254x89	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
254x254x73	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
203x203x86	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
203x203x71	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
203x203x60	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
203x203x52	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
203x203x46	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
152x152x37	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
152x152x30	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
152x152x23	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

FOR EXPLANATION OF TABLES SEE NOTE 2

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"

UNIVERSAL COLUMNS

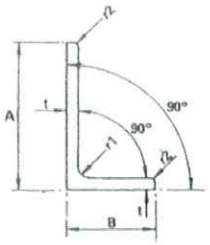


PROPERTIES

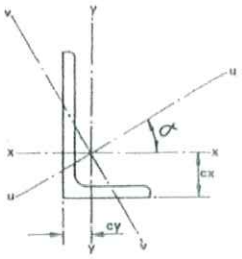
Section Designation	Second Moment Of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area Of Section
	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	u	x	H	J	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
356x406x634	274800	98130	18.4	11.0	11580	4629	14240	7108	0.843	5.46	38.8	13720	808
356x406x551	226900	82670	18.0	10.9	9962	3951	12080	6058	0.841	6.05	31.1	9240	702
356x406x467	183000	67830	17.5	10.7	8383	3291	10000	5034	0.839	6.86	24.3	5809	595
356x406x393	146600	55370	17.1	10.5	6998	2721	8222	4154	0.837	7.86	18.9	3545	501
356x406x340	122500	46850	16.8	10.4	6031	2325	6999	3544	0.836	8.85	15.5	2343	433
356x406x287	99880	38680	16.5	10.3	5075	1939	5812	2949	0.835	10.2	12.3	1441	366
356x406x235	79080	30990	16.3	10.2	4151	1570	4687	2383	0.834	12.1	9.54	812	299
356x368x202	66260	23690	16.1	9.60	3538	1264	3972	1920	0.844	13.4	7.16	558	257
356x368x177	57120	20530	15.9	9.54	3103	1102	3455	1671	0.844	15.0	6.09	381	226
356x368x153	48590	17550	15.8	9.49	2684	948	2965	1435	0.844	17.0	5.11	251	195
356x368x129	40250	14610	15.6	9.43	2264	793	2479	1199	0.844	19.9	4.18	153	164
305x305x283	78870	24630	14.8	8.27	4318	1529	5105	2342	0.855	7.65	6.35	2034	360
305x305x240	64200	20310	14.5	8.15	3643	1276	4247	1951	0.854	8.74	5.03	1271	306
305x305x198	50900	16300	14.2	8.04	2995	1037	3440	1581	0.854	10.2	3.88	734	252
305x305x158	38750	12570	13.9	7.90	2369	808	2680	1230	0.851	12.5	2.87	378	201
305x305x137	32810	10700	13.7	7.83	2048	692	2297	1053	0.851	14.2	2.39	249	174
305x305x118	27670	9059	13.6	7.77	1760	589	1958	895	0.850	16.2	1.98	161	150
305x305x97	22250	7308	13.4	7.69	1445	479	1592	726	0.850	19.3	1.56	91.2	123
254x254x167	30000	9870	11.9	6.81	2075	744	2424	1137	0.851	8.49	1.63	626	213
254x254x132	22530	7531	11.6	6.69	1631	576	1869	878	0.850	10.3	1.19	319	168
254x254x107	17510	5928	11.3	6.59	1313	458	1484	697	0.848	12.4	0.898	172	136
254x254x89	14270	4857	11.2	6.55	1096	379	1224	575	0.850	14.5	0.717	102	113
254x254x73	11410	3908	11.1	6.48	898	307	992	465	0.849	17.3	0.562	57.6	93.1
203x203x86	9449	3127	9.28	5.34	850	299	977	456	0.850	10.2	0.318	137	110
203x203x71	7618	2537	9.18	5.30	706	246	799	374	0.853	11.9	0.250	80.2	90.4
203x203x60	6125	2065	8.96	5.20	584	201	656	305	0.846	14.1	0.197	47.2	76.4
203x203x52	5259	1778	8.91	5.18	510	174	567	264	0.848	15.8	0.167	31.8	66.3
203x203x46	4568	1548	8.82	5.13	450	152	497	231	0.847	17.7	0.143	22.2	58.7
152x152x37	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.3	0.0399	19.2	47.1
152x152x30	1748	560	6.76	3.83	222	73.3	248	112	0.849	16.0	0.0308	10.5	38.3
152x152x23	1250	400	6.54	3.70	164	52.6	182	80.2	0.840	20.7	0.0212	4.63	29.2

FOR EXPLANATION OF TABLES SEE NOTE 3

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"



UNEQUAL ANGLES



DIMENSIONS AND PROPERTIES

Designation		Mass	Radius		Area	Distance		Second Moment Of Area				Radius Of Gyration				Elastic Modulus		Angle x-x Axis to u-u Axis
Size	Thick-ness	Per Metre	Root	Toe	Of Section	Centre Of Gravity		Axis	Axis	Axis	Axis	Axis	Axis	Axis	Axis	Axis	Axis	
A B	t		r1	r2		cx	cy	x-x	y-y	u-u	v-v	x-x	y-y	u-u	v-v	x-x	y-y	
mm	mm	kg	mm	mm	cm^2	cm	cm	cm^4	cm^4	cm^4	cm^4	cm	cm	cm	cm	cm^3	cm^3	Tanα
200x150	18	47.1	15.0	4.8	60.1	6.34	3.86	2390	1155	2922	623	6.30	4.38	6.97	3.22	175	104	0.549
	15	39.6	15.0	4.8	50.6	6.22	3.75	2037	989	2495	531	6.34	4.42	7.02	3.24	148	87.8	0.551
	12	32.0	15.0	4.8	40.9	6.10	3.63	1667	812	2045	435	6.38	4.45	7.07	3.26	120	71.4	0.553
200x100	15	33.7	15.0	4.8	43.1	7.17	2.23	1772	303	1879	197	6.41	2.65	6.60	2.13	138	39.0	0.260
	12	27.3	15.0	4.8	34.9	7.04	2.11	1454	252	1544	162	6.45	2.68	6.65	2.15	112	31.9	0.263
	10	23.0	15.0	4.8	29.4	6.95	2.03	1233	215	1310	138	6.48	2.70	6.68	2.17	94.5	26.9	0.265
150x90	15	26.6	12.0	4.8	34.0	5.21	2.24	764	207	844	127	4.74	2.47	4.99	1.93	78.0	30.6	0.354
	12	21.6	12.0	4.8	27.6	5.09	2.12	630	172	698	104	4.78	2.50	5.03	1.95	63.6	25.0	0.359
	10	18.2	12.0	4.8	23.2	5.00	2.04	536	147	595	89.1	4.81	2.52	5.06	1.96	53.6	21.2	0.361
150x75	15	24.8	11.0	4.8	31.7	5.53	1.81	715	120	756	79.2	4.75	1.95	4.89	1.58	75.5	21.1	0.254
	12	20.2	11.0	4.8	25.7	5.41	1.70	591	100	626	65.2	4.79	1.98	4.93	1.59	61.6	17.3	0.259
	10	17.0	11.0	4.8	21.7	5.32	1.62	503	86.3	534	55.7	4.82	2.00	4.96	1.60	52.0	14.7	0.262
137x102	9.5+	17.3	11.0	4.8	22.0	4.23	2.50	415	198	506	107	4.35	3.00	4.80	2.20	43.8	25.7	0.543
	7.9+	14.5	11.0	4.8	18.4	4.16	2.44	351	168	428	90.4	4.36	3.02	4.82	2.22	36.8	21.6	0.544
	6.4+	11.7	11.0	4.8	15.0	4.09	2.37	289	138	352	74.7	4.38	3.03	4.84	2.23	30.0	17.6	0.544
125x75	12	17.8	11.0	4.8	22.7	4.31	1.84	355	96.0	392	58.8	3.95	2.06	4.16	1.61	43.4	17.0	0.354
	10	15.0	11.0	4.8	19.2	4.23	1.76	303	82.5	336	50.2	3.98	2.08	4.19	1.62	36.7	14.4	0.358
	8	12.2	11.0	4.8	15.5	4.14	1.68	249	68.1	275	41.2	4.00	2.10	4.21	1.63	29.7	11.7	0.360
	6.5+	9.98	11.0	4.8	12.7	4.07	1.62	206	56.6	228	34.3	4.02	2.11	4.23	1.64	24.4	9.62	0.361
100x75	12	15.4	10.0	4.8	19.7	3.27	2.03	189	90.3	230	49.5	3.10	2.14	3.42	1.59	28.1	16.5	0.540
	10	13.0	10.0	4.8	16.6	3.19	1.95	162	77.7	198	42.2	3.12	2.16	3.45	1.59	23.8	14.0	0.544
	8	10.6	10.0	4.8	13.5	3.10	1.87	133	64.2	163	34.7	3.14	2.18	3.48	1.61	19.3	11.4	0.547
100x65	10	12.3	10.0	4.8	15.6	3.36	1.63	154	51.1	175	30.2	3.14	1.81	3.35	1.39	23.2	10.5	0.410
	8	9.94	10.0	4.8	12.7	3.28	1.56	127	42.3	144	24.9	3.17	1.83	3.38	1.40	18.9	8.56	0.414
	7	8.77	10.0	4.8	11.2	3.23	1.51	113	37.7	128	22.1	3.18	1.84	3.39	1.41	16.6	7.56	0.415
80x60	8	8.34	8.0	4.8	10.6	2.55	1.56	65.8	31.5	80.2	17.1	2.49	1.72	2.75	1.27	12.1	7.09	0.544
	7	7.36	8.0	4.8	9.35	2.50	1.52	58.5	28.1	71.4	15.2	2.50	1.73	2.76	1.27	10.6	6.26	0.545
	6	6.37	8.0	4.8	8.08	2.46	1.48	50.9	24.5	62.2	13.2	2.51	1.74	2.77	1.28	9.19	5.41	0.546
75x50	8	7.39	7.0	2.4	9.44	2.53	1.29	52.4	18.6	60.1	10.9	2.36	1.40	2.52	1.07	10.5	5.00	0.430
	6	5.65	7.0	2.4	7.22	2.44	1.21	40.9	14.6	47.1	8.48	2.38	1.42	2.55	1.08	8.10	3.87	0.436
65x50	8	6.75	6.0	2.4	8.61	2.12	1.37	34.9	17.8	43.1	9.62	2.01	1.44	2.24	1.06	7.97	4.92	0.569
	6	5.16	6.0	2.4	6.59	2.04	1.30	27.4	14.1	34.0	7.49	2.04	1.46	2.27	1.07	6.14	3.80	0.575
	5	4.35	6.0	2.4	5.55	2.00	1.26	23.3	12.0	29.0	6.38	2.05	1.47	2.28	1.07	5.18	3.21	0.577
60x30	6	3.99	6.0	2.4	5.09	2.20	0.724	18.3	3.05	19.3	2.01	1.90	0.774	1.95	0.629	4.82	1.34	0.252
	5	3.37	6.0	2.4	4.30	2.16	0.684	15.7	2.64	16.6	1.72	1.91	0.783	1.96	0.632	4.08	1.14	0.256
40x25	4	1.93	4.0	2.4	2.45	1.36	0.621	3.86	1.15	4.32	0.692	1.26	0.685	1.33	0.532	1.46	0.612	0.380

+ Sections marked thus are not included in BS4848: Part4
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

Reproduced from "Design Guide to BS 5950: Part 1: 1990, Volume 1, 5th Edition, SCI"