4.4 STEEL (NON-COMPOSITE)

4.4.1 RULES OF THUMB

- **Choice of beam system**

Element	Typical Span/depth	Typical Span (m)
Floor Beams (UB's) (including floor slab)	15-18	up to 12m
Plate girder	10-12	
Slimfloor (steel only)	25-28	6-9m
Castellated UB's*	14-17	12-20m
Lattice girders (RSA's)+	12-15	up to 35m
Lattice girders (Tubular)	15-18	up to 100m
Roof trusses (pitch>20^{O})	14-15	up to 17m
Space Frames	20-24	up to 60m

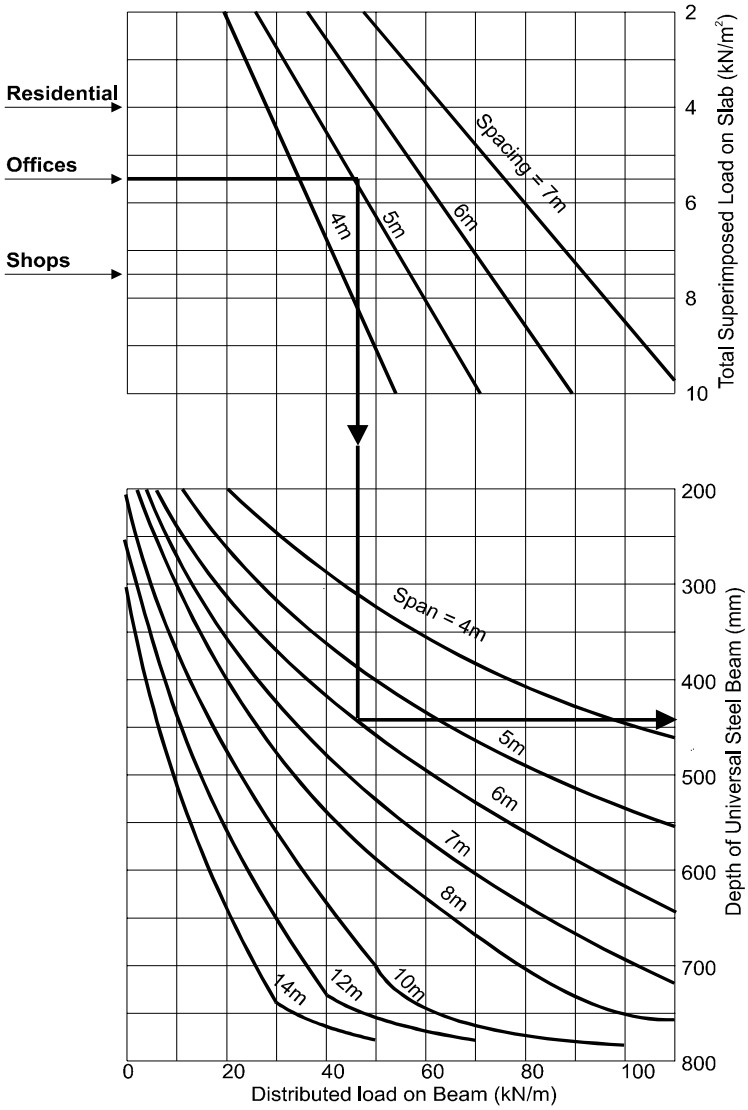
* Avoid if high point loads; increase Ireq by 1.3

\+ Precamber by L/250

- **Initial scheming chart**

One-or-two spans:
Read depth directly from chart

Multiple spans:
Deduct 50mm from depth estimated by chart



4.4.1 Rules of thumb (Cont'd)

- **Steel grades**

Generally grade 50 (Fe 510) (S 355)is most economical for quantities over 40 tonnes.

Note: Grade 50 not readily available from stockholders. Therefore expect a 6 week additional lead in time. Typically, grade 50B sections cost 5% by weight more than grade 43B --- see section 2.3.

- **Columns**

Preliminary design based on a concentric axial load (see section 4.4.4).

For top storey:
Prelim. design axial load = total axial load + 4 × difference in Y-Y axis load
+ 2 × difference in X-X axis load

For intermediate storey:
Prelim. design axial load = total axial load + 2 × difference in Y-Y axis load
+ 1 × difference in X-X axis load

Typical maximum column sizes for braced frames:

- 203 UC for buildings up to 3 storeys high.
- 254 UC for buildings up to 5 storeys high.
- 305 UC for buildings up to 8 storeys high.
- 356 UC for buildings from 8 to 12 storeys high.

- **Struts and ties**

Slenderness limits:

- members resisting load other than wind: $\lambda \leq 180$
- members resisting self weight and wind only: $\lambda \leq 250$
- members normally acting as a tie but subject to load reversal due to wind: $\lambda \leq 350$

Minimum CHS sections which satisfy slenderness limits

Slenderness Limit	Effective Length (m)				
	4	6	8	10	12
180	76.1 x 3.2	114.3 x 3.6	139.7 x 5.0	168.3 x 5.0	193.7 x 5.0
250	60.6 x 3.2	76.1 x 3.2	114.3 x 3.6	139.7 x 5.0	139.7 x 5.0
350	42.2 x 4.6	60.3 x 3.2	76.1 x 3.2	88.9 x 3.2	114.3 x 3.6

- **Portal Frames**

- Hauch length = span / 10
- Haunch depth = rafter depth (same section)
- Minimum rafter slope = 2.5^{O}
- Rafter depth = span / 60 (approx.)
- Stanchion depth = span / 50 (approx. --- not high bay)

4.4.2 LOAD FACTORS

Loadcase	Dead Load		Imposed Load		Wind	Temperature
	adverse	beneficial	adverse	beneficial		
1. Dead + imposed	1.4	1.0	1.6	0	-	(1.2)
2. Dead + Wind	1.4	1.0	-	-	1.4	(1.2)
3. Dead + imposed + Wind	1.2	1.0	1.2	1.0	1.2	(1.2)
4. Dead + imposed + notional horizontal*	1.4	1.4	1.3	1.3	-	-

* Notional horizontal load: 1% of factored dead load at each level or
0.5% of factored dead plus live load at each level, whichever is greater

4.4.3 DESIGN STRENGTH

Grade BS 4360 : 1986 (BS EN 10025 : 1990)	Thickness (mm)	p_y (N/mm²)	Grade BS 4360 : 1986 (BS EN 10025 : 1990)	Thickness (mm)	P_y (N/mm²)
43 (Fe 430) (S 275)	≤ 16	275	50 (Fe 510) (S 355)	≤ 16	355
	≤ 40	265		≤ 40	345
	≤ 63	255		≤ 63	340
	< 100	245		< 100	325

4.4.4 BEAM DESIGN

Ultimate strength in bending

Compression flange restrained

$M_{cx} = p_y S_x \leq 1.2\, p_y S_x$ (plastic & compact)

$M_{cx} = p_y S_x$ (semi-compact)

Requirement :

$M_{cx} \geq M_{max}$

Compression flange unrestrained:

$M_b = p_b S_x \leq M_{cx}$ (see restrained beam)

Note : Mb obtained directly from graph (P.5/23)

Requirement :

$M_b \geq mM_{max}$ (for beam not loaded between restrained points)

where $m = 0.57 + 0.33\beta + 0.1\beta^2 \leq 0.43$

β is positive for single curvature, β is negative for double curvature. Conservatively, (and for non equal flange beams) m = 1.0

ARUP

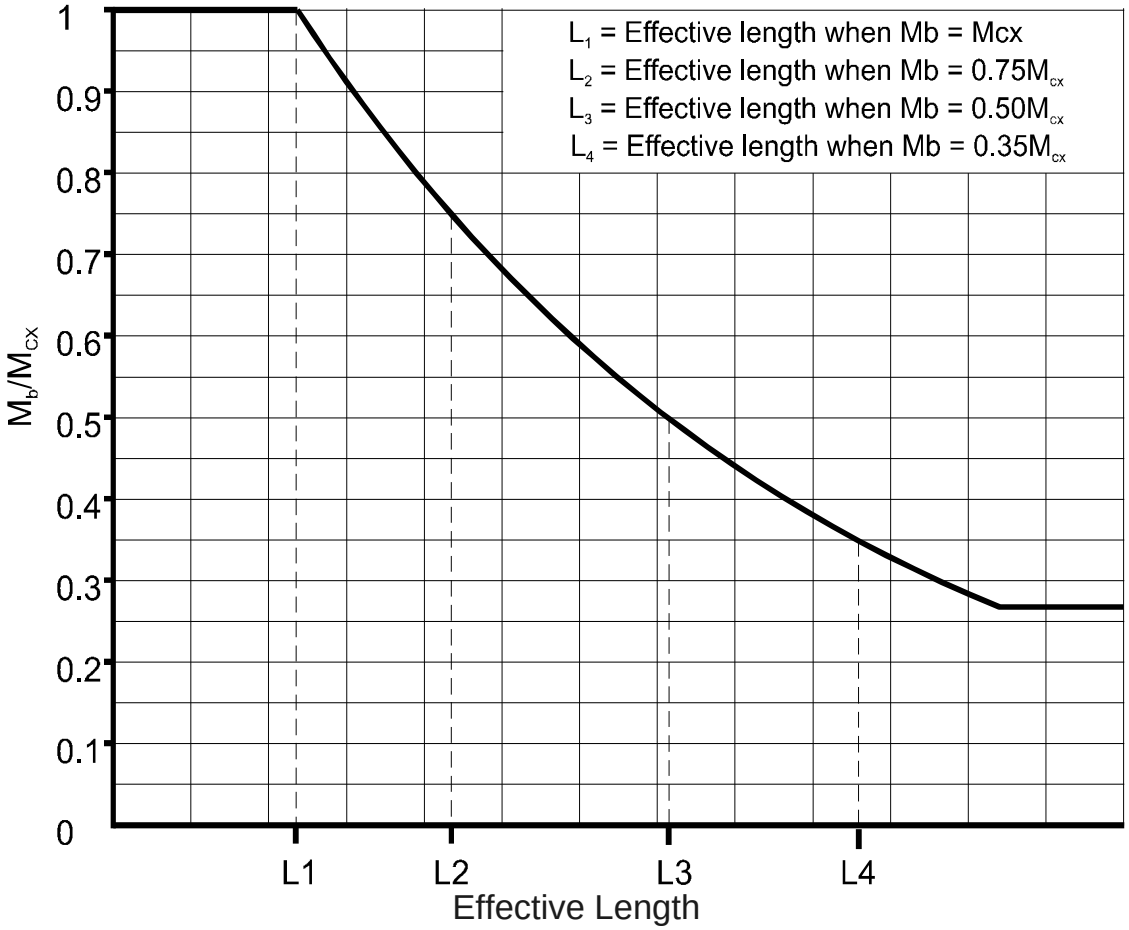
BENDING

Universal Beams	GRADE 43						GRADE 50						
D×b×Mass (mm×mm ×Kg/m)	M_{cx} kNm	L_1 m (1.0)	L_2 m (0.75)	L_3 m (0.5)	L_4 m (0.35)	P_v kN	M_{cx} kNm	L_1 m (1.0)	L_2 m (0.75)	L_3 m (0.5)	L_4 m (0.35)	P_v kN	Intermediate masses (kg/m)
914×419×388	4680	3.9	7.7	12.5	-	3150	6020	3.4	6.8	10.8	15.0	4100	
914×419×343	4100	3.8	7.3	12.0	-	2810	5270	3.4	6.7	10.5	14.4	3660	
914×305×289	3340	2.7	5.1	8.2	11.5	2890	4280	2.4	4.5	7.5	10.1	3760	253, 224
914×305×201	2220	2.5	4.7	7.2	9.7	2180	2840	2.2	4.3	6.4	8.5	2840	
838×292×226	2430	2.5	4.8	7.7	10.7	2180	3110	2.3	4.3	6.8	9.2	2840	194
838×292×176	1800	2.4	4.6	7.0	9.4	1860	2320	2.1	4.2	5.3	8.2	2420	
762×267×197	1900	2.4	4.6	7.1	9.9	1910	2440	2.1	4.0	6.2	8.6	2490	173
762×267×147	1370	2.2	4.3	6.4	8.6	1550	1760	2.0	3.7	5.7	7.8	2010	
686×254×170	1490	2.3	4.3	6.9	9.7	1600	1910	2.0	4.1	6.1	8.4	2080	152, 140
686×254×125	1060	2.1	4.0	6.3	8.3	1260	1360	1.9	3.7	5.6	7.3	1640	
610×305×238	1980	3.0	6.0	10.2	15.0	1870	2540	2.6	5.3	9.0	13.0	2440	179
610×305×149	1460	2.8	5.6	9.0	13.0	1150	1550	2.5	4.9	7.5	10.3	1500	
610×229×140	1100	2.1	3.9	6.3	9.0	1290	1410	1.8	3.5	5.6	7.7	1670	125, 113
610×229×101	794	1.9	3.6	5.5	7.5	1050	1020	1.7	3.3	5.0	6.6	1360	
533×210×122	849	1.9	3.7	6.1	8.1	1110	1090	1.7	3.3	5.3	7.3	1440	109, 101, 92
533×210×82	566	1.8	3.3	5.2	7.0	837	731	1.5	3.0	4.6	6.1	1080	
457×191×98	592	1.8	3.5	5.8	7.6	847	777	1.6	2.9	5.0	7.0	1100	89, 82, 74
457×191×67	405	1.6	3.1	4.9	6.6	636	523	1.4	2.8	4.3	5.8	821	
457×152×82	477	1.3	2.5	4.3	6.3	791	622	1.1	2.4	3.8	5.3	1030	74, 67, 60
457×152×52	301	1.2	2.3	3.7	4.9	564	389	1.1	2.1	3.2	4.3	728	
406×178×74	415	1.6	3.2	5.1	7.3	661	536	1.4	2.8	4.5	6.3	853	67, 60
406×178×54	289	1.5	2.9	4.5	6.2	505	373	1.3	2.6	4.1	5.4	652	
406×140×46	245	1.2	2.3	3.5	4.9	458	316	1.1	2.1	3.2	4.2	591	
406×140×39	198	1.2	2.2	3.3	4.5	413	255	1.0	1.9	3.0	3.9	533	
356×171×67	334	1.6	3.1	5.3	7.7	547	430	1.4	2.8	4.5	6.5	706	57, 51
356×171×45	213	1.5	2.8	4.5	6.1	401	244	1.3	2.4	4.0	5.3	517	
356×127×39	180	1.1	2.0	3.3	4.4	378	232	0.9	1.7	2.9	3.8	488	
356×127×33	148	1.0	2.0	3.0	4.1	339	192	0.9	1.8	2.8	3.6	438	
305×165×54	232	1.6	3.1	5.2	7.8	395	300	1.4	2.8	4.5	6.5	510	46
305×165×40	172	1.5	2.9	4.7	6.5	306	222	1.3	2.6	4.1	5.6	395	
305×127×48	194	1.1	2.3	3.7	5.5	456	251	1.0	2.0	3.2	4.7	588	42
305×127×37	149	1.1	2.1	3.3	4.7	361	192	0.9	1.8	2.9	4.1	466	
305×102×33	132	0.9	1.7	2.7	3.7	341	170	0.8	1.5	2.3	3.3	440	28
305×102×25	92.4	0.8	1.5	2.3	3.2	292	120	0.7	1.3	2.1	2.7	377	
254×146×43	156	1.4	2.8	4.9	7.3	313	202	1.2	2.5	4.2	5.4	404	37
254×146×31	109	1.3	2.5	4.2	5.8	253	125	1.2	2.6	4.1	5.6	327	
254×102×28	97.4	0.9	1.7	2.8	4.0	275	127	0.8	1.6	2.5	3.5	355	25
254×102×22	71.6	0.8	1.6	2.5	3.4	243	93	0.7	1.4	2.3	3.0	314	
203×133×30	86.2	1.3	2.6	4.4	6.6	215	111	1.1	2.4	3.9	5.4	278	
203×133×25	71.2	1.3	2.4	4.1	5.9	194	82	1.1	1.7	2.8	4.0	251	

Universal Columns	GRADE 43						GRADE 50						
D×b×Mass (mm×mm ×Kg/m)	M_{cx} kNm	L_1 m (1.0)	L_2 m (0.75)	L_3 m (0.5)	L_4 m (0.35)	P_v kN	M_{cx} kNm	L_1 m (1.0)	L_2 m (0.75)	L_3 m (0.5)	L_4 m (0.35)	P_v kN	Intermediate masses (kg/m)
356×406×634	3490	8.7	-	-	-	3320	4520	6.8	-	-	-	4410	551, 467, 393,
356×406×235	1240	5.0	12.0	-	-	1120	1620	4.2	16.0	-	-	1460	& 340, 287
356×368×202	1050	4.8	10.5	-	-	1000	1370	3.9	9.0	15.0	-	1300	177, 153
356×368×129	601	4.1	9.8	-	-	605	782	4.8	8.7	14.0	-	788	
305×305×283	1300	4.8	14.0	-	-	1500	1730	4.4	11.5	-	-	2000	240, 198, 158
305×305×97	397	3.2	6.8	12.2	-	503	512	4.0	6.0	10.2	-	649	& 137, 118
254×254×167	641	3.3	10.3	-	-	883	834	3.0	8.7	-	-	1150	132, 107, 89
254×254×73	272	2.3	6.0	11.0	-	360	318	3.4	6.2	10.6	15.0	465	
203×203×86	259	2.7	7.0	14.0	-	459	338	2.2	5.9	12.0	-	598	71, 60, 52
203×203×46	137	2.2	4.8	8.7	13.7	245	159	2.7	5.0	8.2	12.5	316	
152×152×37	85	1.8	4.1	8.1	-	216	110	1.7	3.5	6.8	10.8	279	30
152×152×23	45.4	1.5	3.3	5.6	8.8	153	58.6	2.0	3.5	5.6	8.2	198	

- **Approximate M_b calculation**

Table is to used in conjunction with the table on P. 4/23 to calculate approximate M_b.

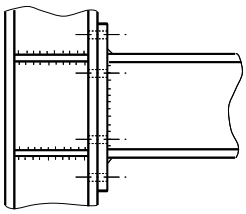


Example : 533x210x82UB (p_y = 275 Mpa) with Le compression flange = 6m.

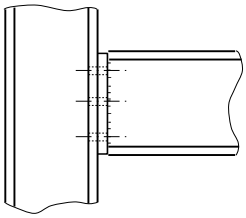
From table	L_4	= 7.0m = $0.35M_{cx}$
	L_3	= 5.2m = $0.50M_{cx}$
	M_{cx}	= 566 kNm
From graph	M_b	= $0.43M_{cx}$ (approx.), for Le = 6m.
		= 243 kNm

Effective lengths of beam compression flanges

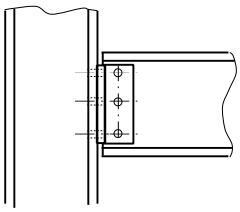
Rotational restraint on plan



1. Flanges fully restrained on plan



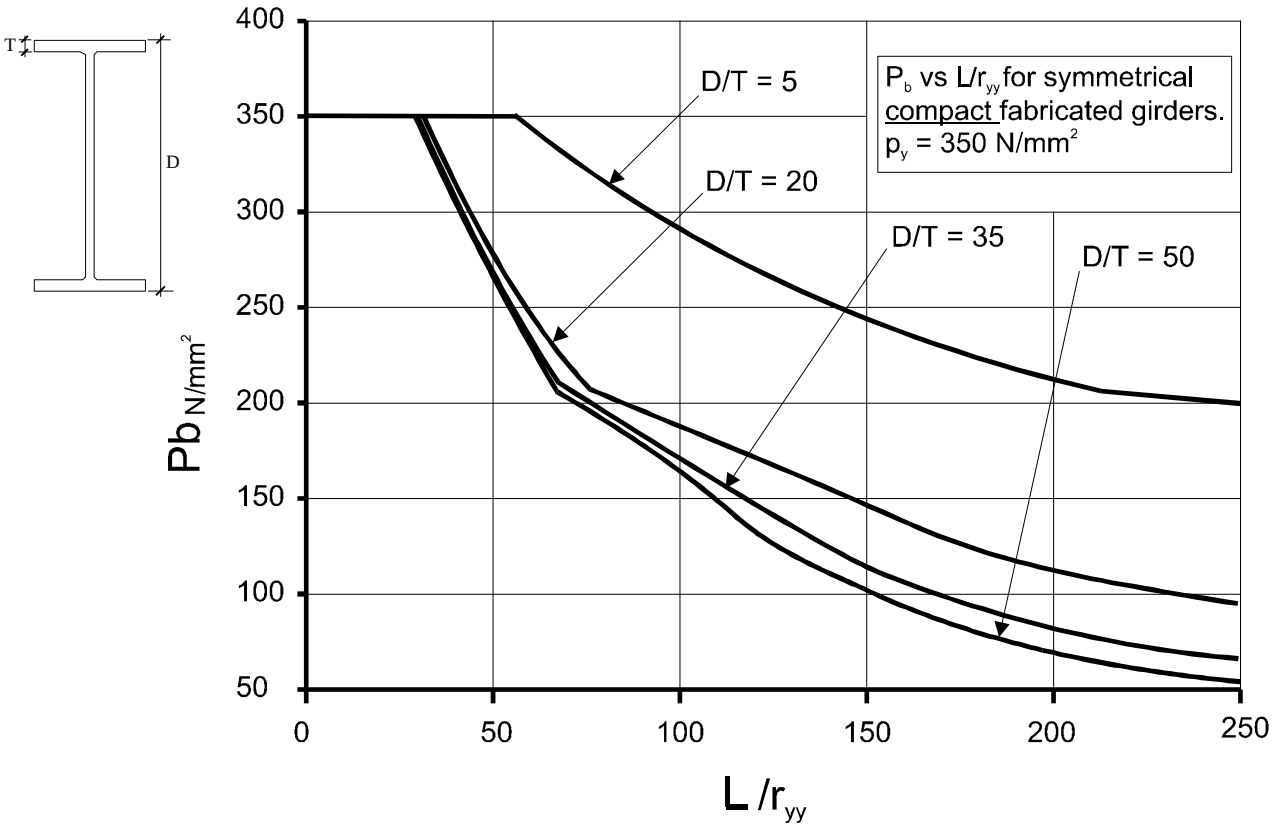
2. Flanges partially restrained on plan



3. Flanges free to rotate on plan

Conditions of restraint at the ends of the beams		Loading conditions	
		Normal	Destabilizing
Compression flange laterally restrained; beam fully restrained against torsion	Both flanges fully restrained against rotation on plan	0.7L	0.85L
	Both flanges partially restrained against rotation on plan	0.85L	1.0L
	Both flanges free to rotate on plan	1.0L	1.2L
Compression flange laterally unrestrained; both flanges free to rotate on plan	Restraint against torsion provided only by positive connection of bottom flange to supports	1.0L+2D	1.2L+2D
	Restraint against torsion provided only by dead bearing of bottom flange on supports.	1.2L+2D	1.4L+2D

Lateral torsional buckling - Stress of fabricated girders



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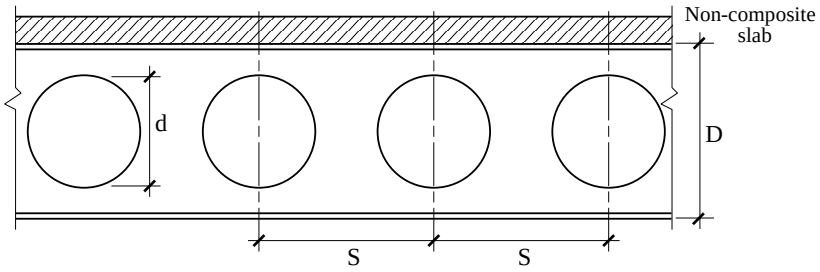
Castellated & cellular beams

Imposed loading 5+1 kN/m²



	SECONDARY BEAM SPAN (m)				
	6	9	12	15	18
Beam Size	**356 x 171 x 45**	**457 x 191 x 67**	**533 x 210 x 92**	**686 x 254 x 125**	**838 x 292 x 176**
Diameter	300	350	450	550	650
Spacing	450	525	675	825	975
0/A Depth	482	605	728	916	1116

	MAIN BEAM SPAN (m)														
	6			9			12			15			18		
Secondary Beam Span (m)	**Beam Size**			**Beam Size**			**Beam Size**			**Beam Size**			**Beam Size**		
	Dia.	Spacing	O/A Depth	Dia.	Spacing	O/A Depth	Dia.	Spacing	O/A Depth	Dia.	Spacing	O/A Depth	Dia.	Spacing	O/A Depth
6	**457 x 191 x 67**			**610 x 229 x 125**			**762 x 267 x 173**			**914 x 305 x 201**			**914 x 305 x 253**		
	400	600	627	500	750	828	700	1000	1078	700	1000	1219	700	1000	1235
9	**610 x 229 x 101**			**762 x 267 x 147**			**914 x 305 x 201**			**914 x 305 x 289**					
	500	750	819	500	750	970	700	1000	1219	700	1000	1243			
12	**610 x 229 x 113**			**838 x 292 x 194**			**914 x 305 x 289**								
	500	750	824	700	1000	1157	700	1000	1243						
15	**686 x 254 x 125**			**914 x 305 x 253**											
	550	750	934	700	1000	1235									
18	**762 x 267 x 173**			**914 x 305 x 289**											
	700	1000	1078	700	1000	1243									

Assumptions

1. Secondary beam spacing 3m
2. 150mm thick concrete slab of normal weight concrete
3. All beams grade Fe 510
4. Beams laterally restrained by concrete slab.

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4.4.5 COLUMNS (AND BEAM COLUMNS)

Local capacity check: $$\frac{P}{P_y} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$$

P_y = squash load

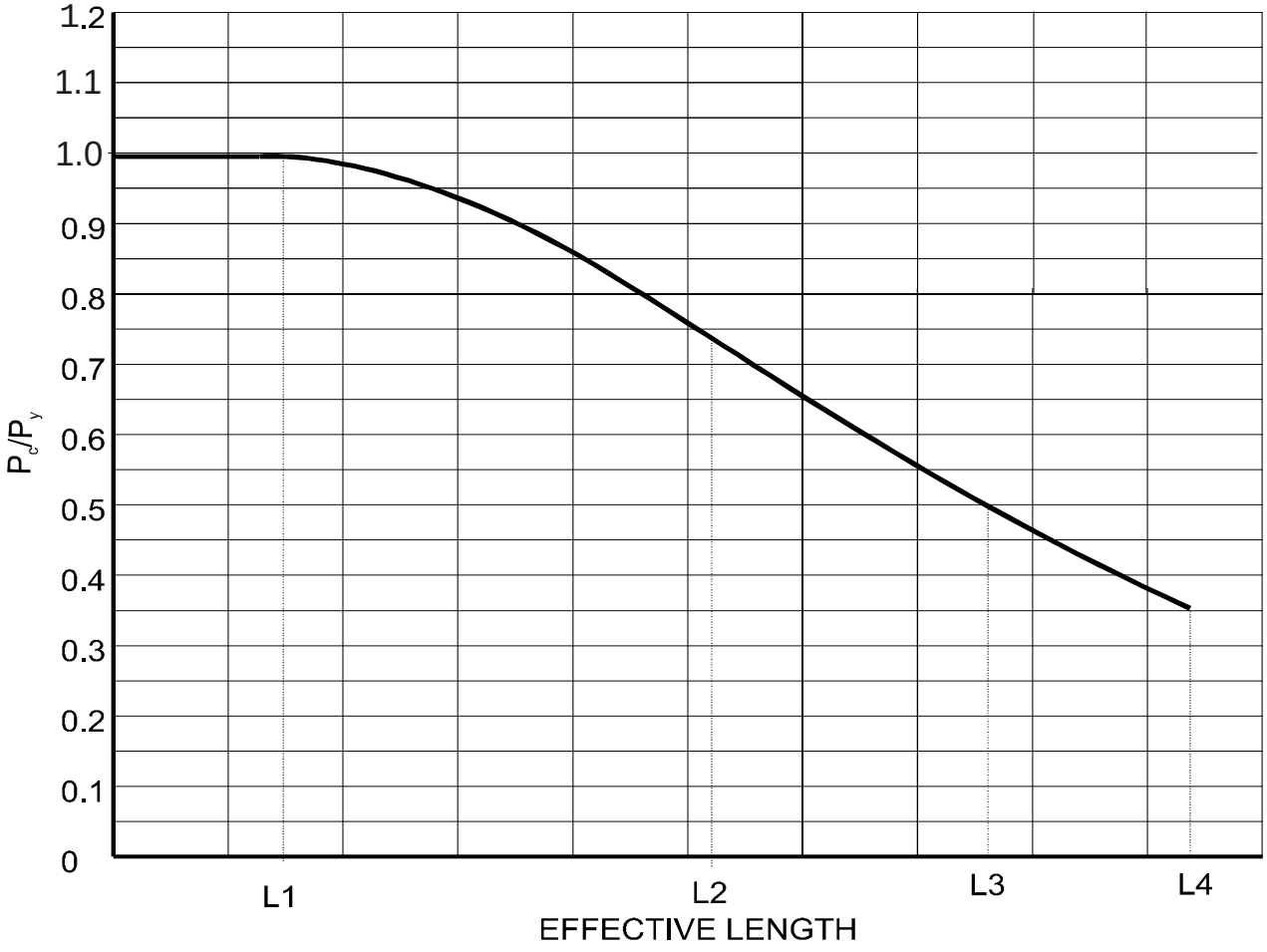
Buckling check: (minor axis failure) $$\frac{P}{P_c} + \frac{m' M_x}{M_b} + \frac{m_y M_y}{p_y Z_y} \leq 1$$

m' is the largest of m_x or m_{LT} from the equation in 4.4.4

M_b is obtained from the graph in 4.4.4 ($\leq 1.2\ p_y Z_x$)

P_c is the buckling capacity from table below

Note: For columns in simple construction use m' = 1.0; when determining M_b use L = 0.5 H , where H = column height



Note

This graph shows the approximate relationship
between axial capacity and effective length. --- see following tables.
L_1 = Effective length when $P_c = P_y$. L_2 = Effective length when $P_c = 0.75P_y$.
L_3 = Effective length when $P_c = 0.50P_y$. L_4 = Effective length when $P_c = 0.35P_y$.

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COMPRESSION

Circular Hollow Sections (CHS)		GRADE 43 (S275)					GRADE 50 (S355)					
Outside diameter (mm)	Thickness (mm)	$P_{c\,max}$ kN	L_{y1} m (1.0)	L_{y2} m (0.75)	L_{y3} m (0.5)	L_{y4} m (0.35)	$P_{c\,max}$ kN	L_{y1} m (1.0)	L_{y2} m (0.75)	L_{y3} m (0.5)	L_{y4} m (0.35)	Intermediate thicknesses * (mm)
88.9	3.2	237	0.4	2.3	3.3	4.1	306	0.4	2.1	3.0	3.7	4.0
	5.0	363	0.4	2.2	3.2	4.0	469	0.4	2.1	2.9	3.6	
114.3	3.6	344	0.6	3.1	4.3	5.3	444	0.6	2.8	3.8	4.8	5.0
	6.3	589	0.6	3.0	4.3	5.2	760	0.6	2.7	3.7	4.6	
139.7	5.0	583	0.7	3.7	5.2	6.4	753	0.7	3.4	4.6	5.8	6.3, 8.0
	10.0	1120	0.7	3.6	5.0	6.2	1440	0.7	3.3	4.5	5.7	
168.3	5.0	707	0.8	4.5	6.3	7.9	912	0.8	4.2	5.6	7.0	6.3, 8.0
	10.0	1370	0.8	4.4	6.1	7.5	1760	0.8	4.0	5.7	6.7	
193.7	5.0	814	1.0	5.2	7.3	9.0	1050	1.0	4.8	6.7	8.0	6.3, 8.0, 10.0
	12.5	1960	0.9	5.0	7.0	8.6	2530	0.9	4.5	6.3	7.7	
219.1	5.0	924	1.1	6.0	8.3	10.0	1190	1.1	5.4	7.3	9.1	6.3, 8.0, 10.0
	12.5	2230	1.1	5.7	8.0	9.9	2880	1.1	5.1	7.1	8.7	
244.5	6.3	1300	1.2	6.7	9.3	11.4	1670	1.2	6.0	8.2	10.1	8.0, 10.0, 12.5
	16.0	3160	1.2	6.5	8.9	11.0	4080	1.2	5.8	7.9	9.7	
273.0	6.3	1450	1.4	7.6	10.3	12.7	1870	1.4	6.8	9.2	11.3	8.0, 10.0, 12.5
	16.0	3550	1.3	7.2	9.9	12.3	4580	1.3	6.5	8.9	10.9	
323.9	6.3	1730	1.7	8.8	12.3	-	2230	1.7	8.0	11.0	13.5	8.0, 10.0, 12.5
	16.0	4260	1.6	8.6	12.0	-	5500	1.6	7.7	10.6	13.0	
355.6	8.0	2400	1.8	9.7	13.5	-	3100	1.8	8.7	12.0	-	10.0, 12.5
	16.0	4700	1.8	9.5	13.1	-	6070	1.8	8.5	11.7	-	

* Only part of the range is given. For the larger sections thicker tubes may be available.

Universal Columns	GRADE 43					GRADE 50				
D×b×Mass (mm×mm×Kg/m)	$P_{c\,max}$ kN	L_{y1} m (1.0)	L_{y2} m (0.75)	L_{y3} m (0.5)	L_{y4} m (0.35)	$P_{c\,max}$ kN	L_{y1} m (1.0)	L_{y2} m (0.75)	L_{y3} m (0.5)	L_{y4} m (0.35)
356×406×634	19800	2.0	5.5	9.2	12.8	26300	1.7	5.1	8.6	11.6
356×406×551	17200	2.0	5.4	9.3	12.7	22800	1.7	4.9	8.6	11.6
356×406×467	15200	1.9	5.3	9.1	12.3	20200	1.7	4.9	8.3	11.0
356×406×393	12800	1.9	5.6	9.5	12.6	17000	1.8	4.8	8.2	10.8
356×406×340	11000	1.9	5.6	9.4	12.5	14700	1.9	4.8	8.1	10.7
356×406×287	9690	1.8	5.9	9.6	12.7	12600	1.7	5.4	8.5	11.2
356×406×235	7950	1.8	5.9	9.6	12.5	10300	1.9	5.4	8.6	11.3
356×368×202	6840	1.8	5.6	9.0	11.8	89000	1.6	5.0	8.2	10.5
356×368×177	5980	1.7	5.7	8.9	11.7	7780	1.7	5.0	8.1	10.5
356×368×153	5180	1.8	5.5	8.9	11.6	6750	1.6	5.0	8.0	10.4
356×368×129	4380	1.9	5.7	8.8	11.5	5700	1.5	4.9	8.0	10.3
305×305×283	9190	1.5	4.6	7.5	9.9	12300	1.3	3.8	6.4	8.7
305×305×240	8090	1.5	4.7	7.7	10.0	10500	1.3	4.2	6.9	8.9
305×305×198	6690	1.5	4.7	7.6	9.8	8710	1.3	4.2	6.8	8.8
305×305×158	5320	1.4	4.7	7.4	9.7	6930	1.3	4.1	6.7	8.7
305×305×137	4620	1.4	4.5	7.3	9.6	6010	1.2	4.1	6.6	8.6
305×305×118	3970	1.4	4.5	7.3	9.6	5160	1.2	4.1	6.6	8.6
305×305×97	3390	1.3	4.4	7.2	9.4	4380	1.1	4.0	6.5	8.4
254×254×167	5630	1.3	3.9	6.3	8.3	7330	1.1	3.6	5.8	7.5
254×254×132	4470	1.2	3.9	6.3	8.3	5820	1.1	3.5	5.7	7.4
254×254×107	3620	1.2	3.8	6.2	8.1	4710	1.1	3.5	5.6	7.3
254×254×89	3010	1.2	3.8	6.2	8.1	3920	1.0	3.5	5.6	7.2
254×254×73	2560	1.1	3.7	6.0	7.9	3300	1.0	3.5	5.5	7.0
203×203×86	2920	0.9	3.1	5.0	6.6	3800	0.9	2.8	4.5	5.8
203×203×71	2410	0.9	3.1	4.9	6.4	3140	0.9	2.7	4.5	5.7
203×203×60	2090	0.9	3.0	4.8	6.3	2700	0.9	2.7	4.4	5.6
203×203×52	1830	0.9	2.9	4.7	6.2	2360	0.8	2.7	4.4	5.6
203×203×46	1620	0.9	2.9	4.7	6.2	2090	0.8	2.7	4.3	5.5
152×152×37	1300	0.7	2.1	3.5	4.7	1680	0.6	2.0	3.3	4.2
152×152×30	1060	0.7	2.2	3.5	4.6	1360	0.6	2.0	3.2	4.2
152×152×23	816	0.7	2.1	3.4	4.5	1050	0.6	2.0	3.1	4.0

NOTE: $L_x \approx 1.15 \left(\frac{I_x}{I_y}\right)^{½} L_y$

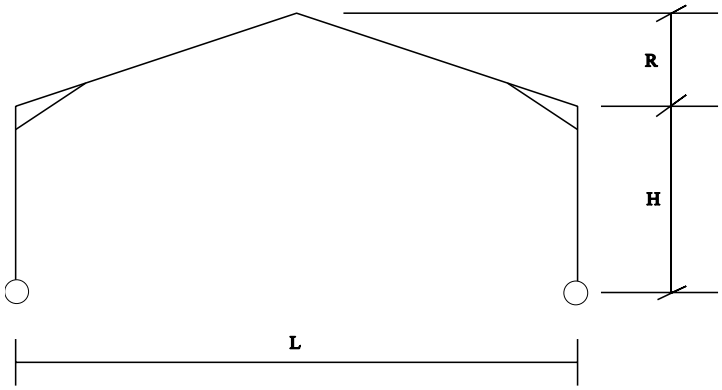
4.4.6 Portal Frame Sizing

The following are simple charts for the sizing of pinned base portals.

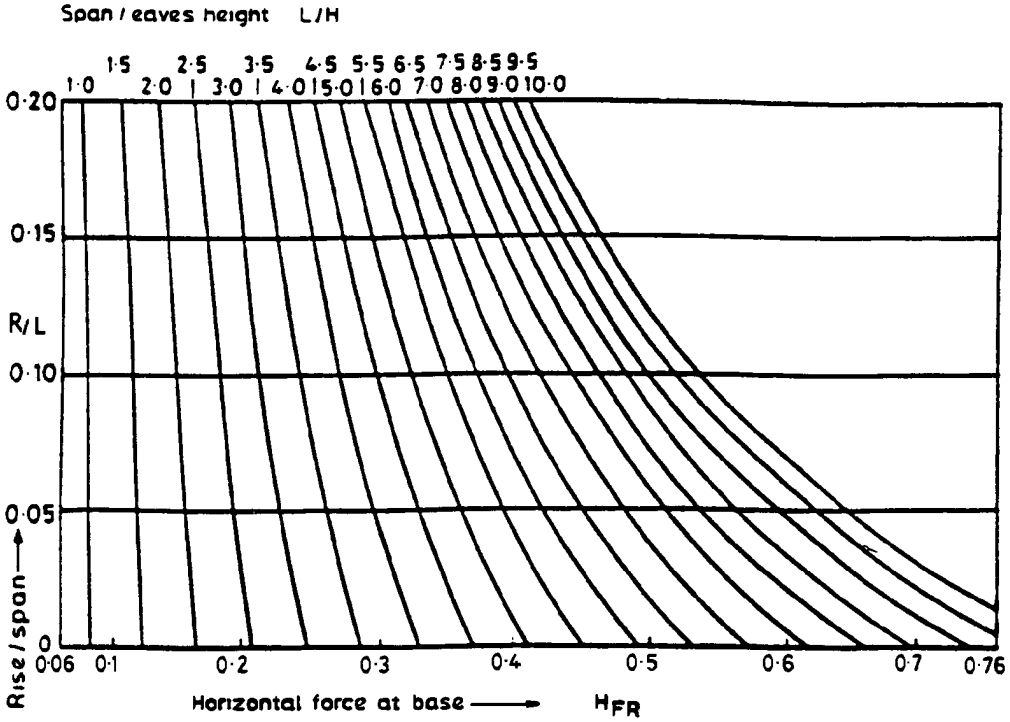
Assumptions :

- wind loading does not control design
- hinges formed at the eaves (in the stanchion) and near the apex.
- Moment at the end of the haunch is $0.87M_p$
- Stability of sections is not addressed

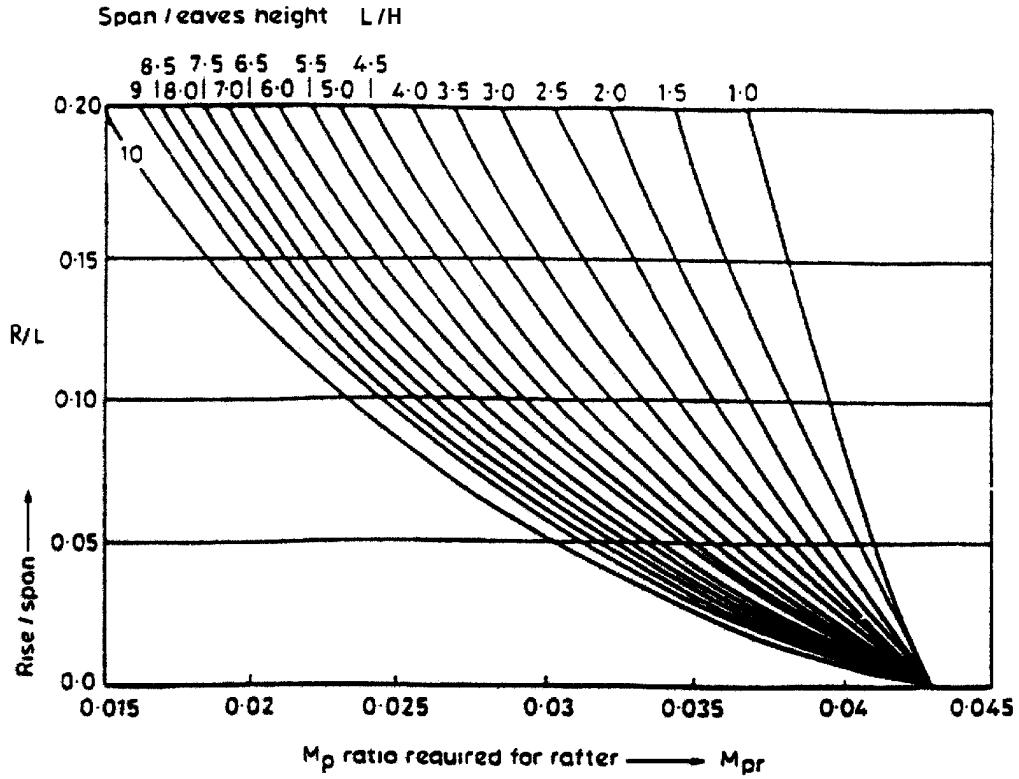
Load W = vertical load on rafter per meter



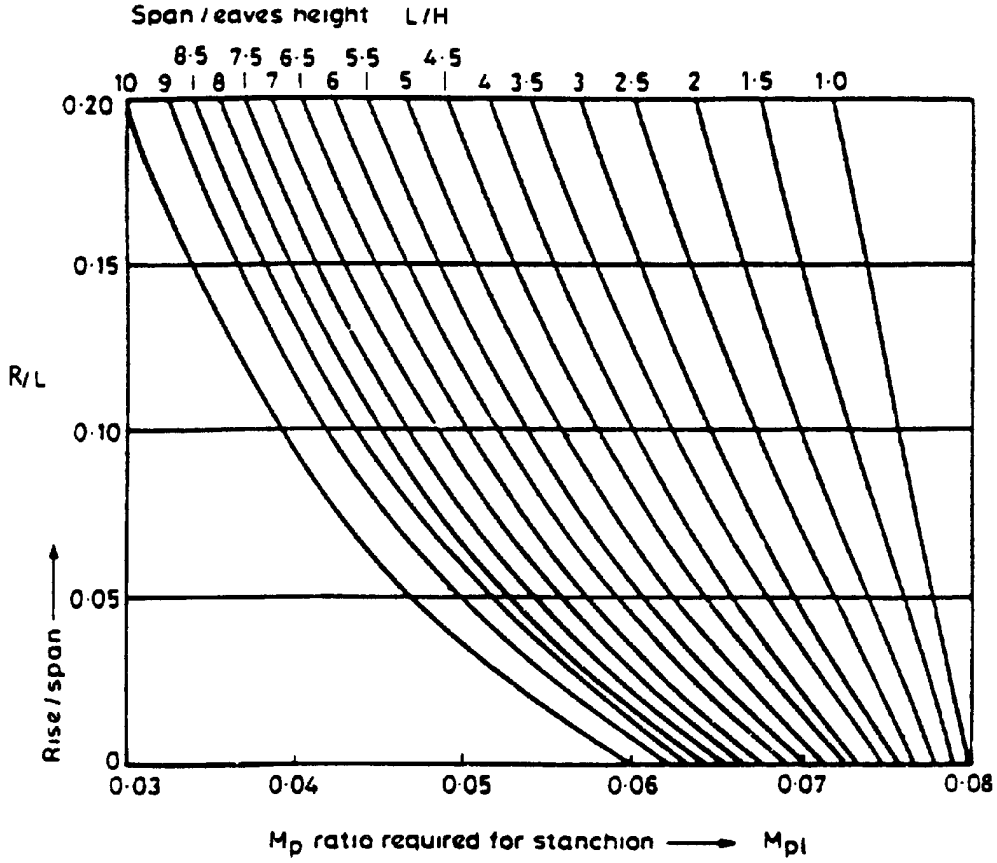
Horizontal base reaction $H = H_{FR}\ WL$



M_p required for rafter : $M_{prafter} = M_{pr}\ WL^2$



M_p required for stanchion : $M_{pstanchion} = M_{pl}\ WL^2$



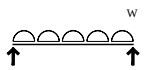
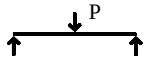
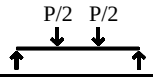
4.4.7 ELEMENT STIFFNESS

Serviceability check: unfactored dead + imposed
unfactored dead + 0.8 × (imposed + wind)

Deflection limits under imposed load:

Element	Limit
● Cantilever	L/180
● Beam supporting plaster or brittle finish	L/360
● Beams supporting masonry	L/500
● Other beams	L/200
● Crane beams	L/500
● Columns	H/300
● Columns in multi-storey construction with movement sensitive cladding.	H/500
Portal frames	
● Lateral at eaves	H/100 - H/300 *
● Vertical at apex	L/250 - L/500 *

* Depends on cladding system

Load case	Minimum I to satisfy deflection limit		
	L/200	L/360	L/500
	1.27 WL^2	2.29 WL^2	3.18 WL^2
	2.03 PL^2	3.66 PL^2	5.08 PL^2
	3.46 PL^2	6.23 PL^2	8.66 PL^2

Note: For castellated beams, assume a 30% increase in deflection due to presence of web openings.
L in metres; W, P in kN; I in cm^4

4.4.8 CONNECTIONS

Bolted

- Assume S 275 fittings.
- Simple connections - use grade 8.8, 20mm diameter bolts
  fin plates} t = 8mm for UB's < 457mm deep
  partial depth end plates} t = 10mm for UB's > 457mm deep
  web cleats}
- Moment connections -use grade 8.8, 20mm or 24mm diameter. Assume end plate thickness equal to bolt diameter (25 thick with M24)
- Holding down bolts - assume grade 4.6 where possible.
  Standard sizes: M16 x 300
  M20 x 450, 600
  M24 x 450, 600
  M30 x 450, 600
  M36 x 450, 600, 750

See Appendices C12, C13, C14 for more information on bolts and fastening.
When carrying out design, it is important to consult new SCI/BCSA guidelines (Ref 3.4.5)

Bolts

Dia of Bolt mm	Tensile Stress Area mm2	Tensile Cap kN	Shear Value		Bearing Value of plate at 460N/mm2 and end distance equal to 2xbolt diameter Thickness in mm of Plate Passed Through											Bearing Value of plate at 550N/mm2 and end distance equal to 2xbolt diameter Thickness in mm of Plate Passed Through										
			Single Shear kN	Double Shear kN	5	6	7	8	9	10	12.5	15	20	25	30	5	6	7	8	9	10	12.5	15	20	25	30
12	84.3	37.9	31.6	63.2	27.6	33.1	38.6	44.2	49.7	55.2	69.0	-	-	-	-	33.0	39.6	46.2	52.8	59.4	66.0	-	-	-	-	-
16	157	70.7	58.9	118	36.8	44.2	51.5	58.9	66.2	73.6	92.0	110	147	-	-	44.0	52.8	61.6	70.4	79.2	88.0	110	132	-	-	-
20	245	110	91.9	184	46.0	55.2	64.4	73.6	82.8	92.0	115	138	184	230	-	55.0	66.0	77.0	88.0	99.0	110	138	165	220	-	-
22	303	136	114	227	50.6	60.7	70.8	81.0	91.1	101	126	152	202	253	-	60.5	72.6	84.7	96.8	109	121	151	182	242	-	-
24	353	159	132	265	55.2	66.2	77.3	88.3	99.4	110	138	166	221	276	-	66.0	79.2	92.4	106	119	132	165	198	264	330	-
27	459	207	172	344	62.1	74.5	86.9	99.4	112	124	155	186	248	310	373	74.2	89.1	104	119	134	148	186	223	297	371	-
30	561	252	210	421	69.0	82.8	96.6	110	124	138	172	207	276	345	414	82.5	99.0	116	132	148	165	206	248	330	412	495

Dia of Bolt mm	Proof Load of Bolt kN	Tensile Cap kN	Slip Value		Bearing Value of Plate at 825N/mm2 and end distance equal to 3xbolt diameter Thickness in mm of Plate Passed Through											Bearing Value of Plate at 1065N/mm2 and end distance equal to 2xbolt diameter Thickness in mm of Plate Passed Though										
			Single Shear kN	Double Shear kN	5	6	7	8	9	10	12.5	15	20	25	30	5	6	7	8	9	10	12.5	15	20	25	30
12	49.4	44.5	24.5	48.9	49.5	-	-	-	-	-	-	-	-	-	-	63.9	-	-	-	-	-	-	-	-	-	-
16	92.1	82.9	45.6	91.2	66.0	79.2	92.4	-	-	-	-	-	-	-	-	85.2	102	-	-	-	-	-	-	-	-	-
20	144	130	71.3	143	82.5	99.0	116	132	148	-	-	-	-	-	-	106	128	149	-	-	-	-	-	-	-	-
22	177	159	87.6	175	90.7	109	127	145	163	182	-	-	-	-	-	117	141	164	187	-	-	-	-	-	-	-
24	207	186	102	205	99	119	139	158	178	198	248	-	-	-	-	128	153	179	204	230	-	-	-	-	-	-
27	234	211	116	232	111	134	156	178	200	223	278	-	-	-	-	144	173	201	230	259	-	-	-	-	-	-
30	286	257	142	283	124	148	173	198	223	248	309	-	-	-	-	160	192	224	256	288	-	-	-	-	-	-

ARUP

Welded

Use 6mm fillet where possible.

Relative costs:	6mm fillet in downhand position	1.0
	6mm fillet in vertical position	2.0
	6mm fillet in overhead position	3.0

For each additional run multiply above by 1.75.

Note:	6mm weld	1 run
	8mm weld	2 runs
	10mm weld	3 runs

Single V butt weld in 10mm plate	6.0
Double V butt weld in 20mm plate	12.0
Single U butt weld in 20mm plate	10.0
Double U butt weld in 40mm plate	20.0
Single J butt weld in 20mm plate	9.0
Double J butt weld in 40mm plate	18.0
Single level butt weld in 10mm plate	5.0
Double level butt weld in 20mm plate	10.0

For each 5mm of plate thickness multiply above by 4.0.

Weld design

Fillet welds - **Grade 43 (Fe 430) (S 275) steel**, Grade E43 Electrodes

Leg length mm	Throat thickness mm	Capacity at 215 N/mm² kN/mm	Leg length mm	Throat thickness mm	Capacity at 215 N/mm² kN/mm
3.0	2.1	0.452	**12.0**	**8.4**	**1.81**
4.0	2.8	0.602	15.0	10.5	2.26
5.0	3.5	0.753	18.0	12.6	2.71
6.0	**4.2**	**0.903**	20.0	14.0	3.01
8.0	**5.6**	**1.2**	22.0	15.4	3.31
10.0	**7.0**	**1.51**	25.0	17.5	3.76

Fillet welds - **Grade 50 (Fe 510) (S 355) steel**, Grade E51 Electrodes

Leg length mm	Throat thickness mm	Capacity at 255 N/mm² kN/mm	Leg length mm	Throat thickness mm	Capacity at 255 N/mm² kN/mm
3.0	2.1	0.535	**12.0**	**8.4**	**2.14**
4.0	2.8	0.714	15.0	10.5	2.68
5.0	3.5	0.893	18.0	12.6	3.21
6.0	**4.2**	**1.07**	20.0	14.0	3.57
8.0	**5.6**	**1.43**	22.0	15.4	3.93
10.0	**7.0**	**1.79**	25.0	17.5	4.46

4.4.9 Corrosion protection

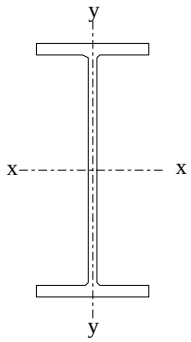
Notes : Define the environment correctly.
The information given is typical. There are many alternatives depending on the individual situations.
Avoid specifying too many schemes for any one job.
The table takes no account of fire resistance.
For further details, see Structural Guidance Note 5.1 (1992)

Environment		Typical protection solution
External	All	E-2 (three coat scheme)
Internal	Controlled (e.g. office)	Do nothing
	Cavity and perimeter	Galvanise to BS729
	Uncontrolled (e.g. warehouses)	Zinc rich primer to BS 4652
	Specials (e.g. swimming pools kitchens)	1-2

	External scheme E-2	Internal scheme I-2
Preparation	Blast clean to Sa 2.5 of BS7079 Pt A1	
Primer	Zinc rich epoxy 75µm DFT	2 pack epoxy zinc phosphate primer 50µm DFT
Barrier	Two pack Epoxy Micaceous Iron Oxide 75µm DFT	
Undercoat	Silicone Alkyd Enamel 35µm DFT	Acrylated rubber undrecoat 40µm DFT
Finish	Silicone Alkyd Enamel 35µm DFT	Acrylated rubber finish 25µm DFT

SECTION PROPERTIES

Universal Beams (1 of 2)

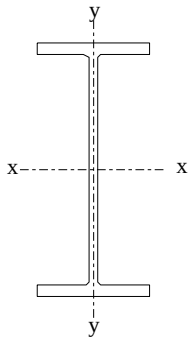


PROPERTIES

Designation		Moment of		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buck. Para.	Tors. Index	Warp. Const	Tors. Const	Area
Serial Size mm	**Mass per Metre**	Axis x-x cm^4	Axis y-y cm^4	Axis x-x cm	Axis y-y cm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	u	x	H dm^6	J cm^4	A cm^2
914x419	**388**	719300	45440	38.1	9.58	15630	2161	17670	3342	0.884	26.7	88.8	1739	495
	343	625200	39160	37.8	9.46	13720	1871	15470	2890	0.883	30.1	75.7	1193	437
914x305	**289**	504800	15610	37.0	6.50	10900	1015	12590	1603	0.866	31.9	31.2	930	369
	253	436400	13300	36.8	6.42	9503	871	10940	1371	0.866	36.2	26.4	626	323
	224	376300	1240	36.3	6.27	8268	739	9533	1163	0.861	41.3	22.1	422	286
	201	325900	9433	35.6	6.06	7217	622	8372	983	0.853	46.7	18.4	294	257
838x292	**226**	339700	11360	34.3	6.27	7985	773	9155	1212	0.870	35.0	19.3	514	289
	194	279200	9066	33.6	6.06	6641	620	7640	974	0.862	41.6	15.2	306	247
	176	246000	7791	33.1	5.90	5892	534	6806	841	0.856	46.5	13.0	221	224
762x267	**197**	239800	8175	30.9	5.71	6232	610	7164	959	0.869	33.2	11.3	404	251
	173	205200	6850	30.5	5.58	5385	514	6195	807	0.864	38.1	9.39	267	220
	147	168800	5462	30.0	5.39	4478	412	5169	648	0.857	45.1	7.40	160	188
686x254	**170**	170300	6630	28.0	5.53	4916	518	5631	811	0.872	31.8	7.42	308	217
	152	150400	5784	27.8	5.46	4375	455	5001	710	0.871	35.5	6.43	220	194
	140	136300	5183	27.6	5.39	3987	409	4558	638	0.868	38.7	5.72	169	178
	125	118000	4383	27.2	5.24	3481	346	3994	542	0.862	43.9	4.80	116	159
610x305	**238**	207700	15850	26.1	7.22	6564	1018	7462	1576	0.886	21.1	14.3	790	304
	179	151500	11400	25.8	7.08	4907	742	5515	1143	0.886	27.5	10.0	340	228
	149	124700	9308	25.6	6.99	4093	611	4575	938	0.886	32.5	8.10	201	190
610x229	**140**	111700	4499	25.0	5.03	3619	391	4139	611	0.875	30.6	3.98	216	178
	125	98500	3932	24.9	4.97	3219	343	3673	535	0.873	34.1	3.45	154	159
	113	87380	3434	24.6	4.88	2878	301	3287	470	0.869	37.9	2.99	112	144
	101	75820	2915	24.2	4.75	2518	256	2887	401	0.863	42.9	2.51	77.6	129
533x210	**122**	76180	3388	22.1	4.66	2798	320	3203	500	0.876	27.6	2.32	179	156
	109	66800	2939	21.9	4.60	2476	279	2827	435	0.875	30.9	1.99	126	139
	101	61650	2696	21.8	4.57	2297	257	2619	400	0.874	33.1	1.82	102	129
	92	55330	2389	21.7	4.50	2076	228	2366	356	0.871	36.4	1.60	76.3	118
	82	47520	2004	21.3	4.38	1799	192	2058	300	0.864	41.6	1.33	51.5	105
457x191	**98**	45770	2347	19.1	4.33	1959	243	2234	379	0.881	25.8	1.18	121	125
	89	41140	2093	19.0	4.28	1775	218	2020	339	0.879	28.2	1.04	91.3	114
	82	37090	1871	18.8	4.23	1612	196	1832	304	0.877	30.9	0.923	69.2	105
	74	33430	1674	18.7	4.20	1462	176	1659	273	0.876	33.8	0.820	52.2	95.1
	67	29410	1452	18.5	4.12	1297	153	1472	237	0.872	37.9	0.706	37.1	85.5
457x152	**82**	36250	1144	18.6	3.31	1559	149	1802	236	0.872	27.3	0.570	89.5	105
	74	32470	1013	18.5	3.26	1408	133	1624	209	0.870	30.0	0.500	66.8	95.1
	67	28600	879	18.3	3.21	1251	116	1442	183	0.867	33.5	0.430	47.6	85.3
	60	25450	795	18.3	3.24	1119	104	1283	163	0.869	37.6	0.387	33.5	75.8
	52	21370	645	17.9	3.11	950	84.6	1096	133	0.859	43.9	0.311	21.4	66.6

ARUP

Universal Beams (2 of 2)

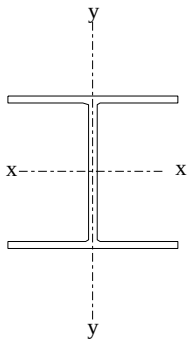


PROPERTIES

Designation		Second Moment of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buck. Para.	Tors. Index	Warp. Const	Tors. Const	Area
Serial Size mm	Mass per Metre kg	Axis x-x cm^4	Axis y-y cm^4	Axis x-x cm	Axis y-y cm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	u	x	H dm^6	J cm^4	A cm^2
406x178	**74**	27430	1551	17.0	4.03	1329	173	1509	268	0.880	27.5	0.610	63.7	95.3
	67	24330	1365	16.9	3.99	1189	153	1346	237	0.880	30.5	0.533	46.1	85.5
	60	21540	1201	16.8	3.97	1060	135	1195	209	0.881	33.8	0.465	33.0	76.1
	54	18670	1019	16.5	3.86	927	115	1051	178	0.872	38.4	0.391	22.9	68.6
406x140	**46**	15670	540	16.3	3.03	779	75.9	889	119	0.870	38.8	0.207	19.2	59.0
	39	12410	410	15.9	2.89	625	57.8	718	90.7	0.859	47.6	0.155	10.5	49.2
356x171	**67**	19540	1362	15.1	3.99	1073	157	1213	243	0.886	24.4	0.413	55.7	85.5
	57	16060	1106	14.9	3.91	896	129	1009	198	0.883	28.9	0.330	33.1	72.2
	51	14160	968	14.8	3.87	796	113	895	174	0.882	32.2	0.287	23.6	64.6
	45	12080	810	14.6	3.77	686	94.7	773	146	0.875	37.0	0.237	15.7	57.0
356x127	**39**	10100	358	14.3	2.69	573	56.8	654	88.9	0.872	35.2	0.105	14.9	49.4
	33	8192	280	14.0	2.59	470	44.7	539	70.2	0.864	42.3	0.0810	8.65	41.8
305x165	**54**	11690	1061	13.1	3.94	752	127	843	195	0.891	23.7	0.234	34.3	68.2
	46	9935	896	13.0	3.90	647	108	722	166	0.891	27.2	0.195	22.2	58.8
	40	8551	766	12.9	3.85	563	92.8	626	142	0.888	31.0	0.165	14.9	51.6
305x127	**48**	9507	460	12.5	2.75	613	73.5	706	116	0.874	23.3	0.101	31.5	60.9
	42	8159	389	12.4	2.70	532	62.6	612	98.4	0.872	26.5	0.0843	21.1	53.4
	37	7162	337	12.3	2.67	471	54.6	540	85.6	0.871	29.6	0.0724	14.9	47.4
305x102	**33**	6501	194	12.5	2.15	416	37.9	481	60.0	0.866	31.6	0.0442	12.2	41.8
	28	5439	158	12.2	2.08	352	30.9	408	49.2	0.859	36.9	0.0355	7.69	36.4
	25	4364	119	11.8	1.96	286	23.5	336	37.8	0.844	44.1	0.0265	4.57	31.2
254x146	**43**	6554	677	10.9	3.51	505	92.0	568	141	0.890	21.1	0.103	24.0	55.0
	37	5547	571	10.8	3.47	433	78.0	435	119	0.889	24.3	0.0857	15.4	47.4
	31	4428	448	10.5	3.35	352	61.3	395	94.2	0.879	29.5	0.0660	8.65	39.9
254x102	**28**	4013	178	10.5	2.2l	308	34.9	354	54.8	0.873	27.4	0.0279	9.68	36.3
	25	3420	149	10.3	2.15	266	29.2	307	46.1	0.865	31.3	0.0230	6.52	32.3
	22	2853	119	10.0	2.06	225	23.5	260	37.3	0.854	36.1	0.0182	4.23	28.3
203x133	**30**	2888	384	8.72	3.18	279	57.4	313	88.0	0.882	21.5	0.0373	10.2	38.0
	25	2349	309	8.54	3.10	231	46.3	259	71.2	0.876	25.5	0.0295	6.05	32.2
203x102	**23**	2091	163	8.49	2.37	206	32.1	232	49.5	0.890	22.5	0.0153	6.87	29.0
178x102	**19**	1357	138	7.49	2.39	153	27.2	171	41.9	0.889	22.6	0.00998	4.37	24.2
152x89	**16**	838	90.4	6.40	2.10	110	20.3	124	31.4	0.889	19.5	0.00473	3.61	20.5
127x76	**13**	477	56.2	5.33	1.83	75.1	14.7	85.0	22.7	0.893	16.2	0.00200	2.92	16.8

ARUP

Universal Columns



PROPERTIES

Designation		Second Moment of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buck. Para.	Tors. Index	Warp. Const	Tors. Const	Area
Serial Size mm	**Mass per Metre** kg	Axis x-x cm^4	Axis y-y cm^4	Axis x-x cm	Axis y-y cm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	u	x	H dm^6	J cm^4	A cm^2
356x406	**634**	275000	98190	18.5	11.0	11590	4631	14240	7112	0.843	5.46	38.8	13730	808
	551	227000	82670	18.0	10.9	9964	3951	12080	6057	0.841	6.06	31.1	9232	702
	467	183100	67930	17.5	10.7	8388	3295	10010	5040	0.839	6.86	24.3	5817	595
	393	146700	55370	17.1	10.5	7001	2721	8225	4154	0.837	7.87	18.9	3545	501
	340	122500	46850	16.8	10.4	6029	2325	6997	3543	0.836	8.85	15.5	2340	433
	287	99930	38680	16.5	10.3	5077	1939	5814	2949	0.835	10.2	12.3	1441	366
	235	79150	31040	16.2	10.2	4155	1572	4691	2386	0.834	12.1	9.55	813	300
COLCORE	**477**	172500	68090	16.9	10.6	8078	3209	9704	4981	0.815	6.90	23.8	5705	607
356x368	**202**	66330	23630	16.0	9.57	3541	1262	3978	1917	0.843	13.4	7.14	561	258
	177	57110	20450	15.9	9.52	3101	1099	3455	1667	0.844	15.0	6.07	382	226
	153	48640	17510	15.8	9.46	2687	946	2970	1433	0.844	17.0	5.10	252	196
	129	40300	14580	15.6	9.39	2266	792	2485	1198	0.843	19.8	4.17	154	165
305x305	**283**	78800	24540	14.8	8.25	4314	1525	5101	2337	0.855	7.65	6.33	2034	360
	240	64150	20220	14.5	8.14	3639	1272	4243	1945	0.854	8.74	5.01	1270	305
	198	50860	16240	14.2	8.02	2993	1034	3438	1577	0.854	10.2	3.86	735	252
	158	38690	12500	13.9	7.89	2365	805	2675	1225	0.852	12.5	2.85	376	201
	137	32770	10650	13.7	7.82	2045	690	2293	1049	0.851	14.2	2.38	249	174
	118	27610	9006	13.6	7.76	1756	587	1952	892	0.851	16.2	1.97	160	150
	97	22200	7272	13.4	7.68	1443	477	1589	724	0.850	19.3	1.55	91.1	123
254x254	**167**	29920	9792	11.9	6.79	2070	740	2418	1131	0.852	8.49	1.62	625	212
	132	22550	7506	11.6	6.67	1632	575	1872	877	0.850	10.3	1.18	321	169
	10 7	17500	5894	11.3	6.57	1312	456	1484	695	0.848	12.4	0.893	173	137
	89	14280	4835	11.2	6.52	1097	378	1225	574	0.849	14.5	0.714	103	114
	73	11370	3880	11.1	6.46	895	306	990	463	0.849	17.3	0.558	57.5	92.9
203x203	**86**	9461	3114	9.27	5.32	851	298	979	455	0.849	10.2	0.317	138	110
	71	7634	2530	9.16	5.28	707	245	801	373	0.852	11.9	0.249	81.0	90.9
	60	6103	2047	8.96	5.19	582	199	654	303	0.847	14.1	0.195	46.9	76.0
	52	5254	1767	8.90	5.16	510	173	567	263	0.848	15.8	0.166	31.9	66.4
	46	4565	1539	8.81	5.12	449	151	497	230	0.846	17.7	0.142	22.2	58.8
152x152	**37**	2213	706	6.84	3.87	274	91.5	309	140	0.848	13.3	0.0399	19.3	47.3
	30	1748	560	6.75	3.82	222	73.3	248	112	0.848	16.0	0.0307	10.6	38.4
	23	1258	402	6.51	3.68	165	52.7	184	80.5	0.837	20.5	0.0213	4.82	29.7

ARUP

Circular Hollow Sections

DIMENSIONS AND PROPERTIES

Designation		Mass Per Metre	Area	Ratio For Local Buck.	Second Moment of Area	Radius Of Gyration	Elastic Modulus	Plastic Modulus	Tors. Const		Surf. Area Per Metre
Outside Dia. D(mm)	Thickness t mm	kg	A cm^2	D/t	I cm^4	r cm	Z cm^3	S cm^3	J cm^4	C cm^3	m^2
244.5	**6.3**	37.0	47.1	38.8	3346	8.42	274	358	6692	548	0.768
	8.0	46.7	59.4	30.6	4160	8.37	340	448	8320	680	0.768
	10.0	57.8	73.7	24.5	5073	8.30	415	550	10150	830	0.768
	12.5	71.5	91.1	19.6	6147	8.21	503	673	12290	1006	0.768
	I6.0	90.2	115	15.3	7533	8.10	616	837	15070	1232	0.768
	20.0@◆	111	141	12.2	8957	7.97	733	1011	17910	1466	0.768
	25.0+@◆	135	172	9.78	10520	7.81	860	1210	21040	1720	0.768
273.0	**6.3**	41.4	52.8	43.3	4696	9.43	344	448	9392	688	0.858
	8.0	52.3	66.6	34.1	5852	9.37	429	562	11700	858	0.858
	10.0	64.9	82.6	27.3	7154	9.31	524	692	14310	1048	0.858
	12.5	80.3	102	21.8	8697	9.22	637	849	17390	1274	0.858
	16.0	101	129	17.I	10710	9.10	784	1058	21420	1568	0.858
	20.0 @◆	125	159	13.6	12800	8.97	938	1283	25600	1876	0.858
	25.0 @◆	153	195	10.9	15130	8.81	1108	1543	30260	2216	0.858
323.9	**6.3**	49.3	62.9	51.4	7929	11.2	490	636	15860	980	1.02
	8.0	62.3	79.4	40.5	9910	11.2	612	799	19820	1224	1.02
	10.0	77.4	98.6	32.4	12160	11.1	751	986	24320	1502	1.02
	12.5	96.0	122	25.9	14850	11.0	917	1213	29700	1834	1.02
	16.0	121	155	20.2	18390	10.9	1136	1518	36780	2272	1.02
	20.0@ ◆	150	191	16.2	22140	10.8	1367	1850	44280	2734	1.02
	25.0@ ◆	184	235	13.0	26400	10.6	1630	2239	52800	3260	1.02
355.6	**8.0**	68.6	87.4	44.5	13200	12.3	742	967	26400	1484	1.12
	10.0	85.2	109	35.6	16220	12.2	912	1195	32440	1824	1.12
	12.5	106	135	28.4	19850	12.1	1117	1472	39700	2234	1.12
	16.0	134	171	22.2	24660	12.0	1387	1847	49320	2774	1.12
	20.0 @◆	166	211	17.8	29790	11.9	1676	2255	59580	3352	1.12
	25.0 @◆	204	260	14.2	35680	11.7	2007	2738	71360	4014	1.12
406.4	**10.0**	97.8	125	40.6	24480	14.0	1205	1572	48960	2410	1.28
	12.5	121	155	32.5	30030	13.9	1478	1940	60060	2956	1.28
	16.0	154	196	25.4	37450	I3.8	1843	2440	74900	3686	1.28
	20.0 @◆	191	243	20.3	45430	13.7	2236	2989	90860	4472	1.28
	25.0 @◆	235	300	16.3	54700	13.5	2692	3642	109400	5384	1.28
	32.0 @◆	295	376	12.7	66430	13.3	3269	4497	132900	6538	1.28
457.0	**10.0**	110	140	45.7	35090	15.8	1536	1998	70180	3072	1.44
	12.5	137	175	36.6	43140	15.7	1888	2470	86280	3776	1.44
	16.0	174	222	28.6	53960	15.6	2361	3113	107900	4722	1.44
	20.0@ ◆	216	275	22.9	65680	15.5	2874	3822	131400	5748	1.44
	25.0@ ◆	266	339	18.3	79420	15.3	3475	4671	158800	6950	1.44
	32.0 @◆	335	427	14.3	97010	15.1	4246	5791	194000	8492	1.44
	40.0@ ◆	411	524	11.4	114900	14.8	5031	6977	229800	10060	1.44
508.0	**10.0**	123	156	50.8	48520	17.6	1910	2480	97040	3820	1. 60
	12.5	153	195	40.6	59760	17.5	2353	3070	119500	4706	1.60
	16.0	194	247	31.7	74910	17.4	2949	3874	149800	5898	1.60
	20.0@◆	241	307	25.4	91430	17.3	3600	4766	182900	7200	1.60
	25.0@ ◆	298	379	20.3	110900	17.1	4367	5837	221800	8734	1.60
	32.0@ ◆	376	479	15.9	136100	16.9	5360	7261	272200	10720	1.60
	40.0@◆	462	588	12.7	162200	16.6	6385	8782	324400	12770	1.60
	50.0@ ◆	565	719	10.2	190900	16.3	75I5	10530	381800	15030	1.60

\+ Sections marked thus are not ncluded in BS4848: Part 2

@ Sections marked thus are seamless and rolled in grade 50B only

◆ Check availability of section

Rectangular Hollow Sections

DIMENSIONS AND PROPERTIES

Designation		Mass Per Metre	Area	Ratios for Local Buck.		Second Moment of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Tors. Const		Surf. Area
Size D B mm	Thickness kg	kg	A cm^2	d/t	b/t	Axis x-x cm^4	Axis y-y cm^4	Axis x-x cm	Axis y-y cm	Axis x-x cm^3	Axis y-y cm^3	Axis x-x cm^3	Axis y-y cm^3	J cm^4	C cm^3	m^2
150x100	**5.0**	18.7	23.9	27.0	17.0	747	396	5.59	4.07	99.5	79.1	121	90.8	806	127	0.489
	6.3	23.3	29.7	20.8	12.9	910	479	5.53	4.02	121	95.9	148	111	985	153	0.486
	8.0	29.1	37.1	15.7	9.50	1106	577	5.46	3.94	147	115	183	137	1202	184	0.483
	10.0	35.7	45.5	12.0	7.00	1312	678	5.37	3.86	175	136	220	164	1431	215	0.479
	12.5	43.6	55.5	9.00	5.00	1532	781	5.25	3.75	204	156	263	194	1680	246	0.473
160x80	**5.0**	18.0	22.9	29.0	13.0	753	251	5.74	3.31	94.1	62.8	117	71.7	599	106	0.469
	6.3	22.3	28.5	22.4	9.70	917	302	5.68	3.26	115	75.6	144	87.7	729	127	0. 466
	8.0	27.9	35.5	17.0	7.00	1113	361	5.60	3.19	139	90.2	177	107	882	151	0. 463
	10.0	34.2	43.5	13.0	5.00	1318	419	5.50	3.10	165	105	213	127	1041	175	0.459
	12.5	41.6	53.0	9.80	3.40	1536	476	5.38	3.00	192	119	254	150	1206	199	0.453
200x100	**5.0**	22.7	28.9	37.0	17.0	1509	509	7.23	4.20	151	102	186	115	1202	172	0.589
	6.3	28.3	36.0	28.7	12.9	1851	618	7.17	4.14	185	124	231	1473	1473	208	0.586
	8.0	35.4	45.1	22.0	9.50	2269	747	7.09	4.07	227	149	286	1802	1802	251	0.583
	10.0	43.6	55.5	17.0	7.00	2718	881	7.00	3.98	272	176	346	2154	2154	296	0.579
	12.5	53.4	68.0	13.0	5.00	3218	1022	6.88	3.88	322	204	417	2541	2541	342	0.573
	16.0	66.4	84.5	9.50	3.25	3808	1175	6.71	3.73	381	235	505	2988	2988	393	0.566
200x120	**5.0+**	24.2	30.9	37.0	21.0	1699	767	7.42	4.98	170	128	206	144	1646	210	0.629
	6.0+	28.9	36.8	30.3	17.0	2000	899	7.37	4.94	200	150	244	171	1940	245	0.627
	6.3 +	30.3	38.5	28.7	16.0	2087	937	7.36	4.93	209	156	255	178	2025	256	0.626
	8.0+	37.9	48.3	22.0	12.0	2564	1140	7.28	4.86	256	190	316	220	2491	310	0.623
	10.0+	46.7	59.5	17.0	9.00	3079	1356	7.19	4.77	308	226	384	266	2997	367	0.619
	12.5+	57.3	73.0	13.0	6.60	3658	1589	7.08	4.67	366	265	464	319	3567	429	0.613
250x150	**5.0+**	30.5	38.9	47.0	27.0	3382	1535	9.33	6.28	271	205	326	229	3275	337	0.789
	6.3	38.2	48.6	36.7	20.8	4178	1886	9.27	6.23	334	252	405	284	4049	413	0. 786
	8.0	48.0	61.1	28.2	15.7	5167	2317	9.19	6.16	413	309	505	353	5014	506	0. 783
	10.0	59.3	75.5	22.0	12.0	6259	2784	9.10	6.07	501	371	618	430	6082	606	0.779
	12.5	73.0	93.0	17.0	9.00	7518	3310	8.99	5.97	601	441	751	520	7317	717	0.773
	16.0	91.5	117	12.6	6.38	9089	3943	8.83	5.82	727	526	924	635	8863	851	0.766
300x200	**6.3**	48.1	61.2	44.6	28.7	7880	4216	11.3	8.30	525	422	627	475	8468	681	0. 986
	8.0	60.5	77.1	34.5	22.0	9798	5219	11.3	8.23	653	522	785	593	10550	840	0. 983
	10.0	75.0	95.5	27.0	17.0	11940	6331	11.2	8.14	796	633	964	726	12890	1016	0.979
	12.5	92.6	118	21.0	13.0	14460	7619	11.1	8.04	964	762	1179	886	15650	1217	0. 973
	16.0	117	149	15.7	9.50	17700	9239	10.9	7.89	1180	924	1462	1094	19230	1469	0.966
400x200	**8.0**	73.1	93.1	47.0	22.0	19710	6695	14.5	8.48	985	669	1210	746	15720	1135	1.18
	10.0	90.7	116	37.0	17.0	24140	8138	14.5	8.39	1207	814	1492	916	19240	1377	1.18
	12.5	112	143	29.0	13.0	29410	9820	14.3	8.29	1471	982	1831	1120	23410	1657	1.17
	16.0	142	181	22.0	9.50	36300	11950	14.2	8.14	1815	1195	2285	1388	28840	2011	1.17
450x250	**8.0+**	85.7	109	53.2	28.2	30270	12200	16.7	10.6	1345	976	1630	1086	27060	1629	1.38
	10.0	106	136	42.0	22.0	37180	14900	16.6	10.5	1653	1192	2013	1338	33250	1986	1.38
	12.5	132	168	33.0	17.0	45470	18100	16.5	10.4	2021	1448	2478	1642	40670	2407	1.37
	16.0	167	213	25.1	12.6	56420	22250	16.3	10.2	2508	1780	3103	2047	50480	2948	1.37
500x200	**8.0+**	85.7	109	59.5	22.0	34270	8170	17.7	8.65	1371	817	1716	900	21100	1430	1.38
	10.0+	106	136	47.0	17.0	42110	9945	17.6	8.57	1684	994	2119	1106	25840	1738	1.38
	12.5+	132	168	37.0	13.0	51510	12020	17.5	8.46	2060	1202	2609	1354	31480	2097	1.37
	16.0+	167	213	28.2	9.50	63930	14670	17.3	8.31	2557	1467	3267	1683	38830	2554	1.37
500x300	**10.0**	122	156	47.0	27.0	54120	24560	18.7	12.6	2165	1638	2609	1834	52400	2696	1.58
	12.5	152	193	37.0	21.0	66360	29970	18.5	12.5	2655	1998	3218	2257	64310	3282	1.57
	16.0	192	245	28.2	15.7	82670	37080	18.4	12.3	3307	2472	4042	2825	80220	4046	1.57
	20.0@	237	302	22.0	12.0	100100	44550	18.2	12.1	4006	2970	4942	3442	97310	4845	1.56

\+ Sections marked thus are not ncluded in BS4848: Part 2

@ Sections marked thus are seamless and rolled in grade 50B only

◆ Check availability of section

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4.4.11 References

4. SCI, Guide to BS 5950: Part 1: 1990, Volume 1

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