UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	STRUCTURAL DESIGN
COURSE CODE	:	DAC 22502
PROGRAMME CODE	:	DAA
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION		1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**. 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHTEEN (18)** PAGES

Q1 (a) To ensure the structural integrity and safety of reinforced concrete structures, designers must consider both permanent and variable actions. With suitable example, explain the differences between permanent and variable actions in the design of reinforced concrete structures.

(4 marks)

(b) The different in failure modes between under-reinforced and over-reinforced flexural is related to the behavior of the steel reinforcement and concrete under loading. List **THREE (3)** factor contribute to the different failure modes for both conditions.

(6 marks)

(c) **Figure Q1(c)** shows a roof plan of a two-storey house. The exposure condition of all beams is considered as XC1, subjected to 1 hour fire resistance and design life of 50 years. Given the followings design data:

All slab thickness	= 150 mm
All beams size.	= 250 mm x 500 mm
Unit weight of reinforced concrete	= 25 kN/m^3
Finishes and services.	= 2.0 kN/m^2
Variable action (all slab)	= 1.5 kN/m^2
Nominal cover	= 35 mm

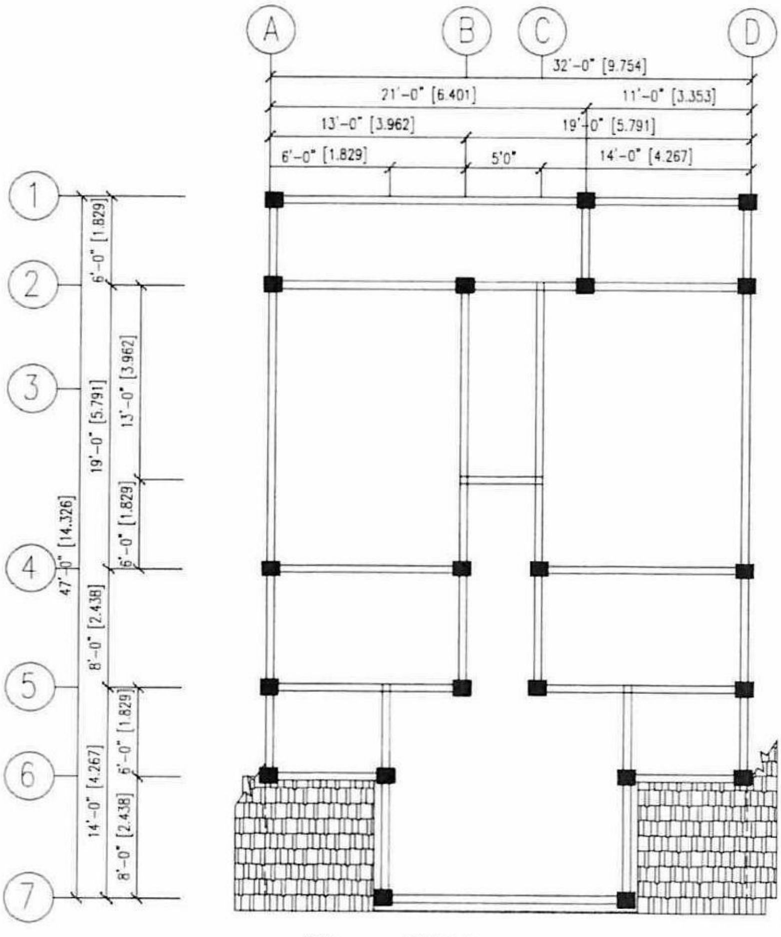

Figure Q1(c)

(i) Calculate permanent and variable actions and determine design action acting on beam 4/A-B. Use shear coefficient, β_{vx} of 0.36 and β_{vy} of 0.51 for slab load distribution to the beam.

(8 marks)

(ii) Determine the area of the reinforcement for beam 4/A-B by assuming the diameter of main bar and link are 16 mm and 8 mm, respectively.

(10 marks)

(iii) Check the deflection for beam 4/A-B.

(7 marks)

Q2 (a) The slenderness and non-slenderness of column can be classified according to the difference failure mode and design considerations. Explain **THREE (3)** possible mechanism of column failure.

(6 marks)

(b) The function of column is to act as vertical load carrying members.

(i) List **FOUR (4)** classification of column.

(4 marks)

(ii) According to Eurocode 2, column may be short or slender. Explain how to determine whether column is short or slender.

(2 marks)

(c) A 300 mm x 400 mm braced rectangular column concrete carries an axial load of 900 kN. The column is classified as non-slender with the bending moment of 55 kNm and 79 kNm about major and minor axes respectively. Using grade C25/30 concrete and f_{yk} = 500 N/mm^2. Assume that the nominal cover for major and minor axes is 70 mm and 60 mm respectively.

(i) Classify biaxial bending moment.

(12 marks)

(ii) Design the area of reinforcement of the column by using the Design Chart.

(7 marks)

(ii) Determine the minimum and maximum area of reinforcement.

(4 marks)

Q3 (a) Names **TWO (2)** types of steel section.

(2 marks)

(b) Steel production can be divided into three stages. Explain these **THREE (3)** stages of production.

(9 marks)

(c) Determine the cross-section classification for a 305x305x97 UC in pure compression, assuming grade S355 steel.

(10 marks)

(d) **Figure Q3(d)** shows two plates in tension connected using 3 bolts with M20 Grade 4.6 bolts and Grade S275.

Given:
For end bolts, $\alpha_b = 0.61$
For inner bolts, $\alpha_b = 0.66$

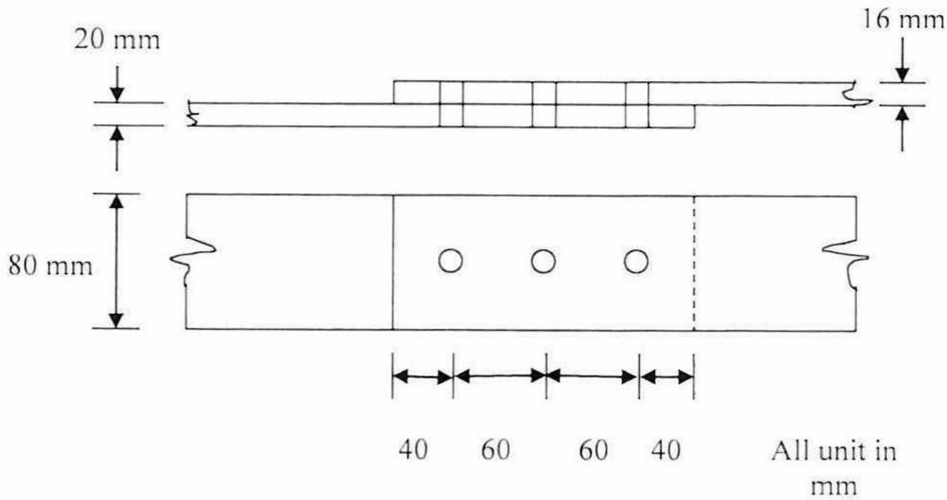

Figure Q3(d)

(i) Check whether the end distance, edge distance and distance between bolts are sufficient.

(3 marks)

(ii) Calculate the shear resistance per bolt in single shear.

(2 marks)

(iii) Calculate the bearing resistance per bolt for end bolts and inner bolts.

(4 marks)

END OF QUESTIONS

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Formula for Design of Flexure for Rectangular Beam

Ultimate moment resistance	: Mbal = 0.167fckbd^2
Area of compression reinforcement	: As' = (M-Mbal)/0.87fyk(d-d')
Neutral axis depth	: M = 0.454 (fckbx)(d-0.4x)
Lever arm	: z = d – 0.4x
Area of tension reinforcement	: As = (Mbal/0.87fykZ) + As'

Formula for Deflection

$$\frac{l}{d} = K\left[11 + 1.5\sqrt{f_{ck}}\frac{\rho_o}{\rho} + 3.2\sqrt{f_{ck}}\left(\frac{\rho_o}{\rho} - 1\right)^{3/2}\right] \quad \text{if } \rho \le \rho_o$$

$$\frac{l}{d} = K\left[11 + 1.5\sqrt{f_{ck}}\frac{\rho_o}{\rho - \rho'} + \frac{1}{12}\sqrt{f_{ck}}\sqrt{\frac{\rho'}{\rho}}\right] \quad \text{if } \rho > \rho_o$$

Table 7.4N: Basic span/effective depth ratio (typical values for rectangular section for steel grade f_{yk} = 500 N/mm^2 and concrete class C30/35)

Structural System	K	Basic span-effective depth ratio	
		Concrete highly stressed, ρ = 1.5%	**Concrete lightly stressed, ρ = 0.5%**
1. Simply supported beam, one/two way simply supported slab	1.0	14	20
2. End span of continuous beam or one-way continuous slab or two way spanning slab continuous over one long side	1.3	18	26
3. Interior span of beam or one way or two way spanning slab	1.5	20	30
4. Slab supported on columns without beam (flat slab) based on longer span	1.2	17	24
5. Cantilever	0.4	6	8

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Shear force coefficients for restrained two-way slab.

Type of panel and location	β_{vx} for values of l_y/l_x								β_{vy}
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
Four edges continuous									
Continuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33
One short edge discontinuous									
Continuous edge	0.36	0.39	0.42	0.44	0.45	0.47	0.50	0.52	0.36
Discontinuous edge	–	–	–	–	–	–	–	–	0.24
One long edge discontinuous									
Continuous edge	0.36	0.40	0.44	0.47	0.49	0.51	0.55	0.59	0.36
Discontinuous edge	0.24	0.27	0.29	0.31	0.32	0.34	0.36	0.38	–
Two adjacent edges discontinuous									
Continuous edge	0.40	0.44	0.47	0.50	0.52	0.54	0.57	0.60	0.40
Discontinuous edge	0.26	0.29	0.31	0.33	0.34	0.35	0.38	0.40	0.26
Two short edges discontinuous									
Continuous edge	0.40	0.43	0.45	0.47	0.48	0.49	0.52	0.54	–
Discontinuous edge	–	–	–	–	–	–	–	–	0.26
Two long edges discontinuous									
Continuous edge	–	–	–	–	–	–	–	–	0.40
Discontinuous edge	0.26	0.30	0.33	0.36	0.38	0.40	0.44	0.47	–
Three edges discontinuous (one long edge discontinuous)									
Continuous edge	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.63	–
Discontinuous edge	0.30	0.32	0.34	0.35	0.36	0.37	0.39	0.41	0.29
Three edges discontinuous (one short edge discontinuous)									
Continuous edge	–	–	–	–	–	–	–	–	0.45
Discontinuous edge	0.29	0.33	0.36	0.38	0.40	0.42	0.45	0.48	0.30
Four edges discontinuous									
Discontinuous edge	0.33	0.36	0.39	0.41	0.43	0.45	0.48	0.50	0.33

Sectional areas of groups of bars (mm^2)

Bar size (mm)	Number of bars									
	1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.8	113	141	170	198	226	255	283
8	50.3	101	151	201	251	302	352	402	452	503
10	78.6	157	236	314	393	471	550	628	707	786
12	113	226	339	452	566	679	792	905	1018	1131
16	201	402	603	804	1005	1207	1408	1609	1810	2011
20	314	628	943	1257	1571	1885	2199	2514	2828	3142
25	491	982	1473	1964	2455	2946	3437	3928	4418	4909
32	804	1609	2413	3217	4022	4826	5630	6435	7239	8044
40	1257	2514	3770	5027	6284	7541	8798	10054	11311	12568

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The Value of Coefficient β

$\frac{N_{ED}}{bhf_{ck}}$	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	≥0.75
β	1.00	0.91	0.81	0.72	0.63	0.53	0.44	0.35	0.3

Chart No. 1

Column design chart for rectangular columns $d_2/h = 0.05$

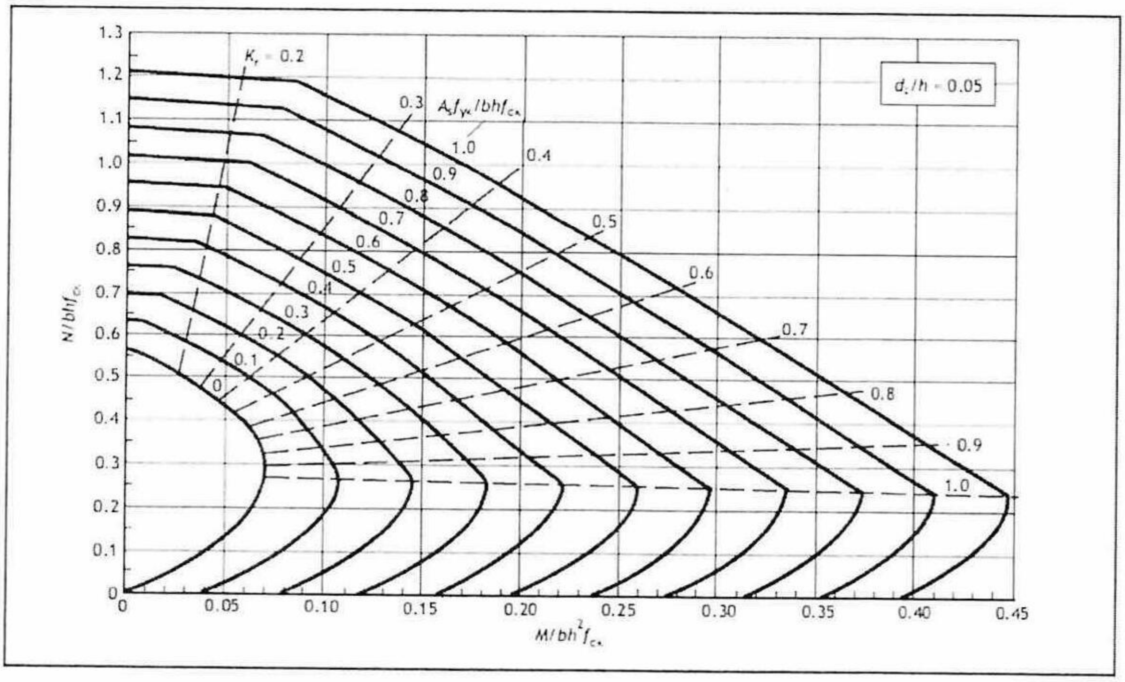

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Chart No. 2

Column design chart for rectangular columns $d_2/h = 0.10$

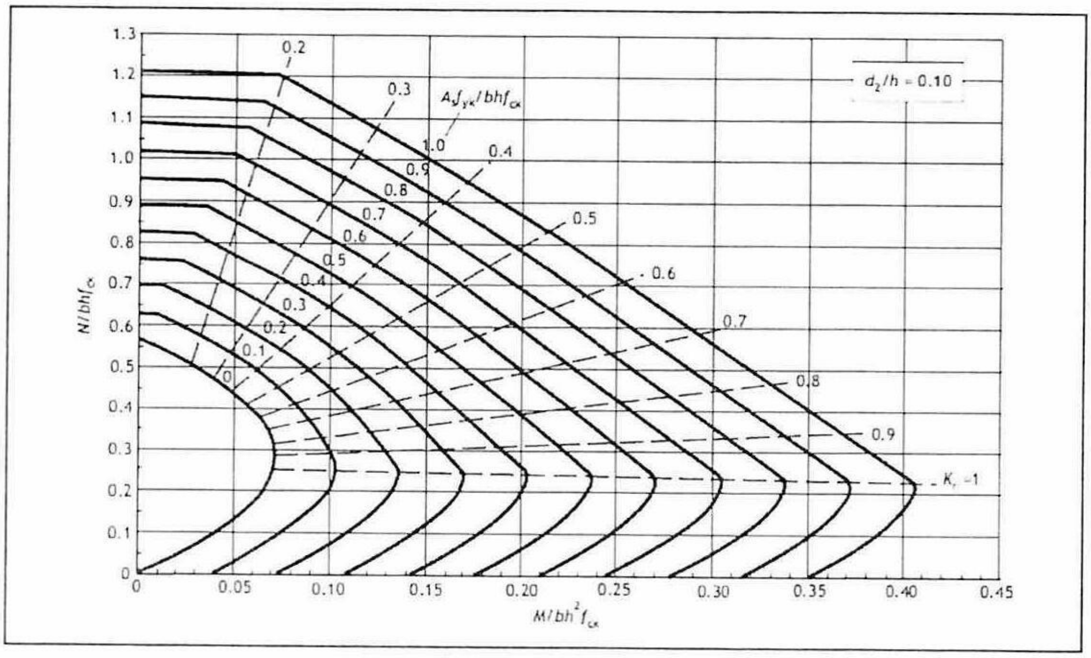

Chart No. 3

Column design chart for rectangular columns $d_2/h = 0.15$

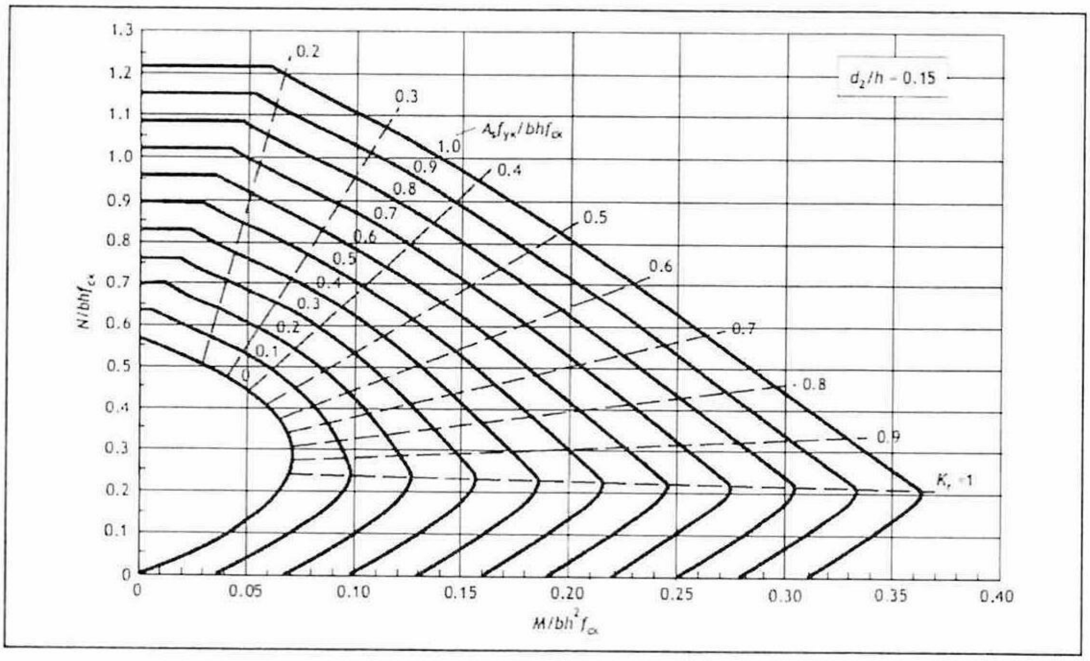

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Chart No. 4

Column design chart for rectangular columns $d_2/h = 0.20$

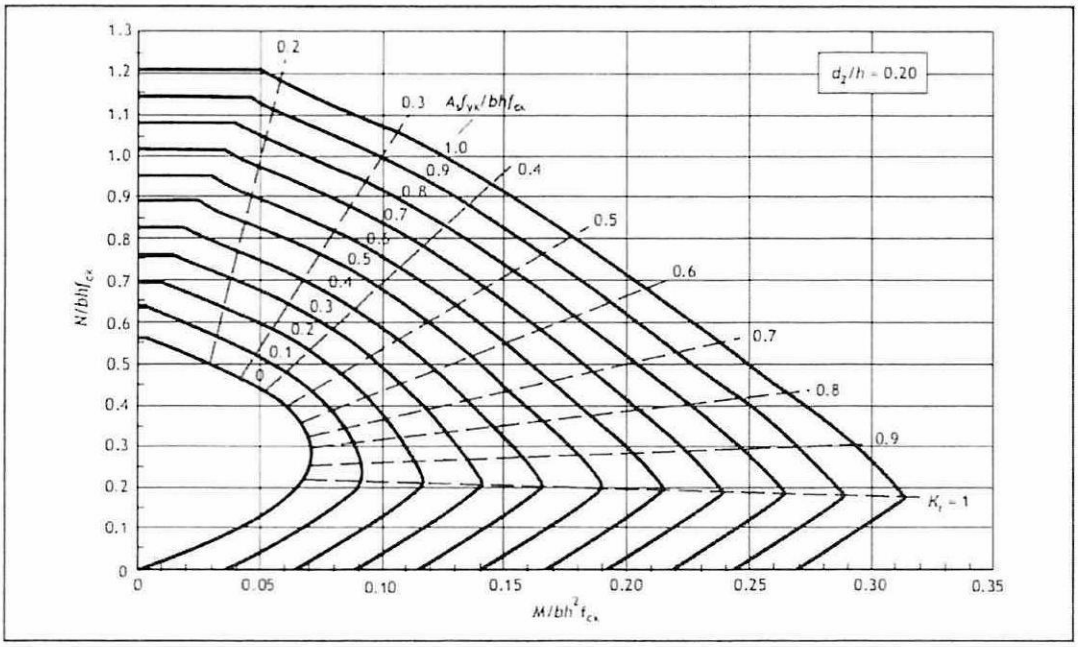
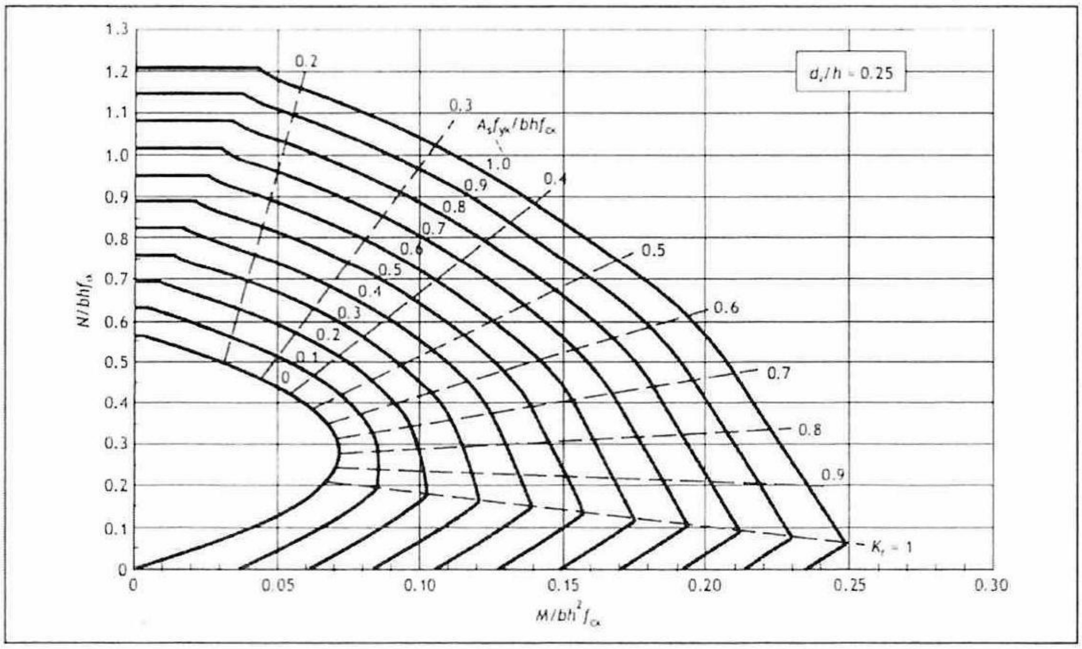


Chart No. 5

Column design chart for rectangular columns $d_2/h = 0.25$



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APPENDIX 1

Table 3.1: Nominal values of yield strength f_y and ultimate tensile strength f_u for hot rolled structural steel

Standard and steel grade	Nominal thickness of the element t [mm]			
	$t \leq 40$ mm		40 mm $< t \leq 80$ mm	
	f_y [N/mm²]	f_u [N/mm²]	f_y [N/mm²]	f_u [N/mm²]
EN 10025-2				
S 235	235	360	215	360
S 275	275	430	255	410
S 355	355	AC2) 490 (AC2	335	470
S 450	440	550	410	550
EN 10025-3				
S 275 N/NL	275	390	255	370
S 355 N/NL	355	490	335	470
S 420 N/NL	420	520	390	520
S 460 N/NL	460	540	430	540
EN 10025-4				
S 275 M/ML	275	370	255	360
S 355 M/ML	355	470	335	450
S 420 M/ML	420	520	390	500
S 460 M/ML	460	540	430	530
EN 10025-5				
S 235 W	235	360	215	340
S 355 W	355	AC2) 490 (AC2	335	490
EN 10025-6				
S 460 Q/QL/QL1	460	570	440	550

$$\varepsilon = \sqrt{\frac{235}{f_y}}$$

Table 3.1 Bolt area

d (mm)	8	10	12	14	16	18	20	22	24	27	30
A (mm²)	50	78	113	154	201	254	314	380	452	573	707
A_s (mm²)	36	58	84	115	157	192	245	303	353	459	561

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APPENDIX 2

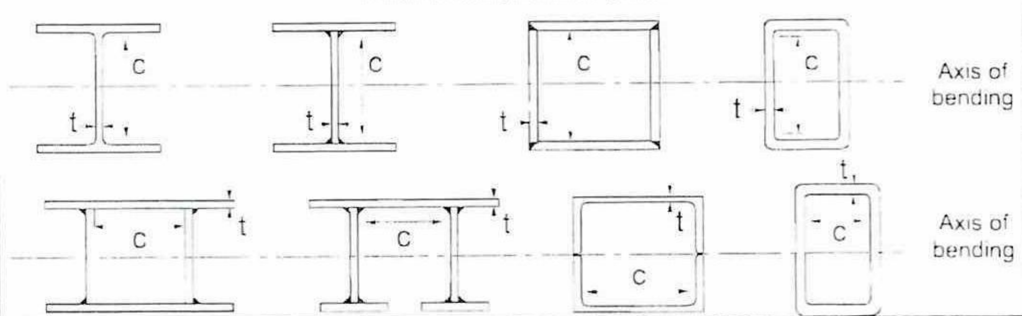
Table 3.1 Nominal value of the yield strength f_{yb} and ultimate tensile strength f_{ub} for bolts (EC3-1-8)

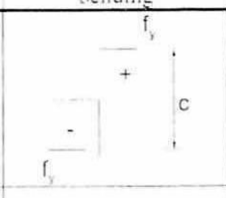
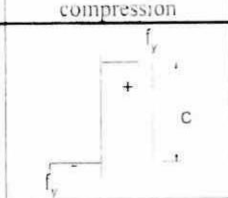
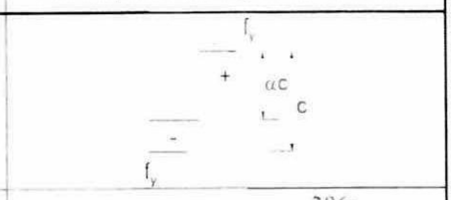
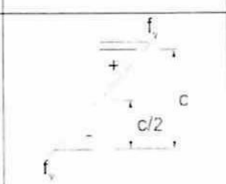
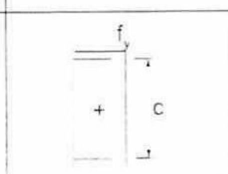
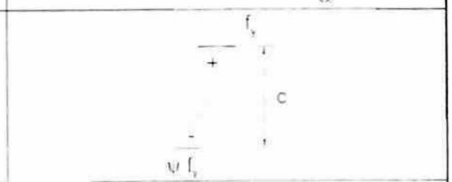
Bolt class	**4.6**	**4.8**	**5.6**	**5.8**	**6.8**	**8.8**	**10.9**
f_{yb} (N/mm^2)	240	320	300	400	480	640	900
f_{ub} (N/mm^2)	400	400	500	500	600	800	1000

BS EN 1993-1-1:2005
EN 1993-1-1:2005 (E)

Table 5.2 (sheet 1 of 3): Maximum width-to-thickness ratios for compression parts

Internal compression parts



Class	Part subject to bending	Part subject to compression	Part subject to bending and compression
Stress distribution in parts (compression positive)			
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$	when $\alpha > 0,5$: $c/t \le \frac{396\varepsilon}{13\alpha - 1}$ when $\alpha \le 0,5$: $c/t \le \frac{36\varepsilon}{\alpha}$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$	when $\alpha > 0,5$: $c/t \le \frac{456\varepsilon}{13\alpha - 1}$ when $\alpha \le 0,5$: $c/t \le \frac{41,5\varepsilon}{\alpha}$
Stress distribution in parts (compression positive)			
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$	when $\psi > -1$: $c/t \le \frac{42\varepsilon}{0,67 + 0,33\psi}$ when $\psi \le -1^{*)}$: $c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

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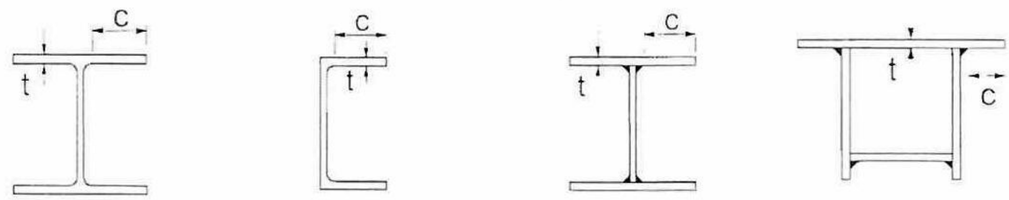
APPENDIX 3

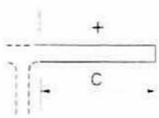
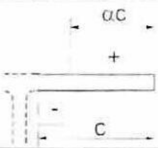
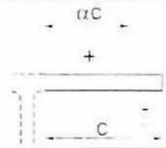
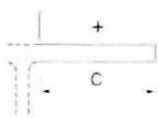
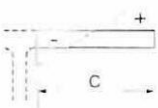
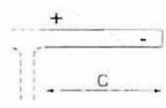
BS EN 1993-1-1:2005
EN 1993-1-1:2005 (E)

Table 5.2 (sheet 2 of 3): Maximum width-to-thickness ratios for compression parts

Outstand flanges



Rolled sections Welded sections

Class	Part subject to compression	Part subject to bending and compression: Tip in compression	Part subject to bending and compression: Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \le 9\varepsilon$	$c/t \le \frac{9\varepsilon}{\alpha}$	$c/t \le \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \frac{10\varepsilon}{\alpha}$	$c/t \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \le 14\varepsilon$	$c/t \le 21\varepsilon\sqrt{k_\sigma}$ For k_σ see EN 1993-1-5	

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

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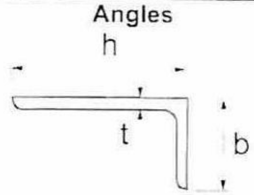
APPENDIX 4

BS EN 1993-1-1:2005
EN 1993-1-1:2005 (E)

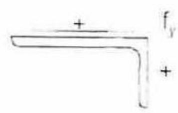
Table 5.2 (sheet 3 of 3): Maximum width-to-thickness ratios for compression parts

Angles

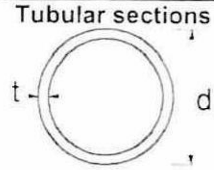


Refer also to "Outstand flanges" (see sheet 2 of 3)

Does not apply to angles in continuous contact with other components

Class	Section in compression
Stress distribution across section (compression positive)	
3	AC2 $h/t \le 15\varepsilon$ and $\frac{b+h}{2t} \le 11{,}5\varepsilon$ AC2

Tubular sections



Class	Section in bending and/or compression
1	$d/t \le 50\varepsilon^2$
2	$d/t \le 70\varepsilon^2$
3	$d/t \le 90\varepsilon^2$ **NOTE** For $d/t > 90\varepsilon^2$ see EN 1993-1-6.

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71
	ε^2	1,00	0,85	0,66	0,56	0,51

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APPENDIX 5

Table 2.1: Partial safety factors for joints

Resistance of members and cross-sections	γ_{M0} , γ_{M1} and γ_{M2} see EN 1993-1-1
Resistance of bolts	γ_{M2}
Resistance of rivets	
Resistance of pins	
Resistance of welds	
Resistance of plates in bearing	
Slip resistance - at ultimate limit state (Category C) - at serviceability limit state (Category B)	 γ_{M3} $\gamma_{M3,ser}$
Bearing resistance of an injection bolt	γ_{M4}
Resistance of joints in hollow section lattice girder	γ_{M5}
Resistance of pins at serviceability limit state	$\gamma_{M6,ser}$
Preload of high strength bolts	γ_{M7}
Resistance of concrete	γ_c see EN 1992

NOTE: Numerical values for γ_M may be defined in the National Annex. Recommended values are as follows: $\gamma_{M2} = 1,25$; $\gamma_{M3} = 1,25$ and $\gamma_{M3,ser} = 1,1$; $\gamma_{M4} = 1,0$; $\gamma_{M5} = 1,0$; $\gamma_{M6,ser} = 1,0$; $\gamma_{M7} = 1,1$.

Table 3.3: Minimum and maximum spacing, end and edge distances

Distances and spacings, see Figure 3.1	Minimum	Maximum[1)2)3)]		
		Structures made from steels conforming to EN 10025 except steels conforming to EN 10025-5		Structures made from steels conforming to EN 10025-5
		Steel exposed to the weather or other corrosive influences	Steel not exposed to the weather or other corrosive influences	Steel used unprotected
End distance e_1	$1,2d_0$	$4t + 40$ mm		The larger of $8t$ or 125 mm
Edge distance e_2	$1.2d_0$	$4t + 40$ mm		The larger of $8t$ or 125 mm
Distance e_3 in slotted holes	$1,5d_0$ [4)]			
Distance e_4 in slotted holes	$1.5d_0$ [4)]			
Spacing p_1	$2.2d_0$	The smaller of $14t$ or 200 mm	The smaller of $14t$ or 200 mm	The smaller of $14t_{min}$ or 175 mm
Spacing $p_{1,0}$		The smaller of $14t$ or 200 mm		
Spacing $p_{1,i}$		The smaller of $28t$ or 400 mm		
Spacing p_2 [5)]	$2.4d_0$	The smaller of $14t$ or 200 mm	The smaller of $14t$ or 200 mm	The smaller of $14t_{min}$ or 175 mm

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APPENDIX 6

BS EN 1993-1-8:2005
EN 1993-1-8:2005 (E)

Table 3.4: Design resistance for individual fasteners subjected to shear and/or tension

Failure mode	Bolts	Rivets
Shear resistance per shear plane	$F_{v,Rd} = \dfrac{\alpha_v\, f_{ub}\, A}{\gamma_{M2}}$ - where the shear plane passes through the threaded portion of the bolt (A is the tensile stress area of the bolt A_s): - for classes 4.6, 5.6 and 8.8: $\alpha_v = 0,6$ - for classes 4.8, 5.8, 6.8 and 10.9: $\alpha_v = 0,5$ - where the shear plane passes through the unthreaded portion of the bolt (A is the gross cross section of the bolt): $\alpha_v = 0,6$	$F_{v,Rd} = \dfrac{0,6\, f_{ur}\, A_0}{\gamma_{M2}}$
Bearing resistance [1), 2), 3)]	(AC2) $F_{b,Rd} = \dfrac{k_1\, \alpha_b\, f_u\, d\, t}{\gamma_{M2}}$ (AC2) where α_b is the smallest of α_d; $\dfrac{f_{ub}}{f_u}$ or 1,0; in the direction of load transfer: - for end bolts: $\alpha_d = \dfrac{e_1}{3d_0}$; for inner bolts: $\alpha_d = \dfrac{p_1}{3d_0} - \dfrac{1}{4}$ perpendicular to the direction of load transfer: (AC2)- for edge bolts: k_1 is the smallest of $2,8\dfrac{e_2}{d_0} - 1,7$, $1,4\dfrac{p_2}{d_0} - 1,7$ and 2,5 (AC2) - for inner bolts: k_1 is the smallest of $1,4\dfrac{p_2}{d_0} - 1,7$ or 2,5	
Tension resistance [2)]	$F_{t,Rd} = \dfrac{k_2\, f_{ub}\, A_s}{\gamma_{M2}}$ where $k_2 = 0,63$ for countersunk bolt, otherwise $k_2 = 0,9$.	$F_{t,Rd} = \dfrac{0,6\, f_{ur}\, A_0}{\gamma_{M2}}$
Punching shear resistance	$B_{p,Rd} = 0,6\, \pi\, d_m\, t_p\, f_u / \gamma_{M2}$	No check needed
Combined shear and tension	$\dfrac{F_{v,Ed}}{F_{v,Rd}} + \dfrac{F_{t,Ed}}{1,4\, F_{t,Rd}} \le 1,0$	

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APPENDIX 7

Table 10.2 Load capacity table (ordinary non-preloaded bolts Grade 4.6 in S275 steel)

Diameter of Bolt	*Tensile Stress Area*	*Tension Capacity*		*Shear Capacity*		*Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) End distance equal to 2× bolt diameter*										
		Nominal $0.8A_tp_t$ P_{nom}	*Exact* A_tp_t P_t	*Single Shear* P_s	*Double Shear* $2P_s$	*Thickness in mm of ply passed through*										
mm	A_t *mm²*	*kN*	*kN*	*kN*	*kN*	5	6	7	8	9	10	12	15	20	25	30
12	84.3	16.2	20.2	13.5	27.0	*27.6*	*33.1*	*38.6*	*44.2*	*49.7*	*55.2*	*66.2*	*82.8*	*110*	*138*	*166*
16	157	30.1	37.7	25.1	50.2	36.8	44.2	*51.5*	*58.9*	*66.2*	*73.6*	*88.3*	*110*	*147*	*184*	*221*
20	245	47.0	58.8	39.2	78.4	46.0	55.2	64.4	73.6	*82.8*	*92.0*	*110*	*138*	*184*	*230*	*276*
22	303	58.2	72.7	48.5	97.0	50.6	60.7	70.8	81.0	91.1	*101*	*121*	*152*	*202*	*253*	*304*
24	353	67.8	84.7	56.5	113	**55.2**	66.2	77.3	88.3	99.4	110	*132*	*166*	*221*	*276*	*331*
27	459	88.1	110	73.4	147	**62.1**	74.5	86.9	99.4	112	124	*149*	*186*	*248*	*311*	*373*
30	561	108	135	89.8	180	**69.0**	**82.8**	96.6	110	124	138	166	*207*	*276*	*345*	*414*

Values in **bold** are less than the single shear capacity of the bolt.
Values in *italic* are greater than the double shear capacity of the bolt.
Bearing values assume standard clearance holes.
If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.
If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.
If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.

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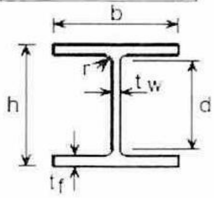
APPENDIX 8

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



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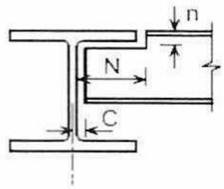

Dimensions

Section Designation	Mass per Metre	Depth of Section h	Width of Section b	Thickness Web t_w	Thickness Flange t_f	Root Radius r	Depth between Fillets d	Ratios for Local Buckling Flange c_f / t_f	Ratios for Local Buckling Web c_w / t_w	Dimensions for Detailing End Clearance C	Notch N	Notch n	Surface Area Per Metre	Surface Area Per Tonne
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
356x406x634	633.9	474.6	424.0	47.6	77.0	15.2	290.2	2.25	6.10	26	200	94	2.52	3.98
356x406x551	551.0	455.6	418.5	42.1	67.5	15.2	290.2	2.56	6.89	23	200	84	2.47	4.48
356x406x467	467.0	436.6	412.2	35.8	58.0	15.2	290.2	2.98	8.11	20	200	74	2.42	5.18
356x406x393	393.0	419.0	407.0	30.6	49.2	15.2	290.2	3.52	9.48	17	200	66	2.38	6.06
356x406x340	339.9	406.4	403.0	26.6	42.9	15.2	290.2	4.03	10.9	15	200	60	2.35	6.91
356x406x287	287.1	393.6	399.0	22.6	36.5	15.2	290.2	4.74	12.8	13	200	52	2.31	8.05
356x406x235	235.1	381.0	394.8	18.4	30.2	15.2	290.2	5.73	15.8	11	200	46	2.26	9.70
356x368x202	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.07	17.6	10	190	44	2.19	10.8
356x368x177	177.0	368.2	372.6	14.4	23.8	15.2	290.2	6.89	20.2	9	190	40	2.17	12.3
356x368x153	152.9	362.0	370.5	12.3	20.7	15.2	290.2	7.92	23.6	8	190	36	2.16	14.1
356x368x129	129.0	355.6	368.6	10.4	17.5	15.2	290.2	9.4	27.9	7	190	34	2.14	16.6
305x305x283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.00	9.21	15	158	60	1.94	6.86
305x305x240	240.0	352.5	318.4	23.0	37.7	15.2	246.7	3.51	10.7	14	158	54	1.91	7.96
305x305x198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	4.22	12.9	12	158	46	1.87	9.44
305x305x158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	5.30	15.6	10	158	42	1.84	11.6
305x305x137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	6.11	17.90	9	158	38	1.82	13.3
305x305x118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	7.09	20.6	8	158	34	1.81	15.4
305x305x97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	8.60	24.9	7	158	32	1.79	18.5
254x254x167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	3.48	10.4	12	134	46	1.58	9.46
254x254x132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	4.36	13.1	10	134	38	1.55	11.7
254x254x107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	5.38	15.6	8	134	34	1.52	14.2
254x254x89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	6.38	19.4	7	134	30	1.50	16.9
254x254x73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	7.77	23.3	6	134	28	1.49	20.4
203x203x127 +	127.5	241.4	213.9	18.1	30.1	10.2	160.8	2.91	8.88	11	108	42	1.28	10.0
203x203x113 +	113.5	235.0	212.1	16.3	26.9	10.2	160.8	3.26	9.87	10	108	38	1.27	11.2
203x203x100 +	99.6	228.6	210.3	14.5	23.7	10.2	160.8	3.70	11.1	9	108	34	1.25	12.6
203x203x86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	4.29	12.7	8	110	32	1.24	14.4
203x203x71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.09	16.1	7	110	28	1.22	17.2
203x203x60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	6.20	17.1	7	110	26	1.21	20.2
203x203x52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	7.04	20.4	6	110	24	1.20	23.1
203x203x46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	8.00	22.3	6	110	22	1.19	25.8
152x152x51 +	51.2	170.2	157.4	11.0	15.7	7.6	123.6	4.18	11.2	8	84	24	0.935	18.3
152x152x44 +	44.0	166.0	155.9	9.5	13.6	7.6	123.6	4.62	13.0	7	84	22	0.924	21.0
152x152x37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	5.70	15.5	6	84	20	0.912	24.7
152x152x30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	6.98	19.0	5	84	16	0.901	30.0
152x152x23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	9.65	21.3	5	84	16	0.889	38.7

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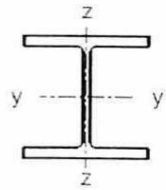

Properties

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	U	X	I_w	I_T	A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3			dm^6	cm^4	cm^2
356x406x634	275000	98100	18.4	11.0	11600	4630	14200	7110	0.843	5.46	38.8	13700	808
356x406x551	227000	82700	18.0	10.9	9960	3950	12100	6060	0.841	6.05	31.1	9240	702
356x406x467	183000	67800	17.5	10.7	8380	3290	10000	5030	0.839	6.85	24.3	5810	595
356x406x393	147000	55400	17.1	10.5	7000	2720	8220	4150	0.837	7.86	18.9	3550	501
356x406x340	123000	46900	16.8	10.4	6030	2330	7000	3540	0.836	8.84	15.5	2340	433
356x406x287	99900	38700	16.5	10.3	5070	1940	5810	2950	0.835	10.17	12.3	1440	366
356x406x235	79100	31000	16.3	10.2	4150	1570	4690	2380	0.834	12.04	9.54	812	299
356x368x202	66300	23700	16.1	9.60	3540	1260	3970	1920	0.844	13.35	7.16	558	257
356x368x177	57100	20500	15.9	9.54	3100	1100	3460	1670	0.844	15.00	6.09	381	226
356x368x153	48600	17600	15.8	9.49	2680	948	2960	1430	0.844	17.01	5.11	251	195
356x368x129	40200	14600	15.6	9.43	2260	793	2480	1200	0.844	19.81	4.18	153	164
305x305x283	78900	24600	14.8	8.27	4320	1530	5110	2340	0.855	7.64	6.35	2030	360
305x305x240	64200	20300	14.5	8.15	3640	1280	4250	1950	0.854	8.73	5.03	1270	306
305x305x198	50900	16300	14.2	8.04	3000	1040	3440	1580	0.854	10.23	3.88	734	252
305x305x158	38700	12600	13.9	7.90	2370	809	2680	1230	0.851	12.46	2.87	378	201
305x305x137	32800	10700	13.7	7.83	2050	692	2300	1050	0.851	14.13	2.39	249	174
305x305x118	27700	9060	13.6	7.77	1760	589	1960	895	0.850	16.14	1.98	161	150
305x305x97	22200	7310	13.4	7.69	1450	479	1590	726	0.850	19.19	1.56	91.2	123
254x254x167	30000	9870	11.9	6.81	2080	744	2420	1140	0.851	8.48	1.63	626	213
254x254x132	22500	7530	11.6	6.69	1630	576	1870	878	0.850	10.32	1.19	319	168
254x254x107	17500	5930	11.3	6.59	1310	458	1480	697	0.848	12.38	0.898	172	136
254x254x89	14300	4860	11.2	6.55	1100	379	1220	575	0.850	14.46	0.717	102	113
254x254x73	11400	3910	11.1	6.48	898	307	992	465	0.849	17.24	0.562	57.6	93.1
203x203x127 +	15400	4920	9.75	5.50	1280	460	1520	704	0.854	7.38	0.549	427	162
203x203x113 +	13300	4290	9.59	5.45	1130	404	1330	618	0.853	8.11	0.464	305	145
203x203x100 +	11300	3680	9.44	5.39	988	350	1150	534	0.852	9.02	0.386	210	127
203x203x86	9450	3130	9.26	5.34	850	299	977	456	0.850	10.20	0.318	137	110
203x203x71	7620	2540	9.18	5.30	706	246	799	374	0.853	11.90	0.250	80.2	90.4
203x203x60	6120	2060	8.96	5.20	584	201	656	305	0.846	14.10	0.197	47.2	76.4
203x203x52	5260	1780	8.91	5.18	510	174	567	264	0.848	15.80	0.167	31.8	66.3
203x203x46	4570	1550	8.82	5.13	450	152	497	231	0.847	17.70	0.143	22.2	58.7
152x152x51 +	3230	1020	7.04	3.96	379	130	438	199	0.848	10.10	0.061	48.8	65.2
152x152x44 +	2700	860	6.94	3.92	326	110	372	169	0.848	11.50	0.050	31.7	56.1
152x152x37	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.30	0.040	19.2	47.1
152x152x30	1750	560	6.76	3.83	222	73.3	248	112	0.849	16.00	0.031	10.5	38.3
152x152x23	1250	400	6.54	3.70	164	52.6	182	80.1	0.840	20.70	0.021	4.63	29.2