

SULIT



First Semester Examination
Academic Session 2019/2020

December 2019/January 2020

**EAS457 – Structural Steel Design
(Rekabentuk Struktur Keluli)**

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of **EIGHTTEEN (18)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **LAPAN BELAS (18)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions : This paper consists of **FOUR (4)** questions. Answer **ALL** questions.

Arahan : Kertas ini mengandungi **EMPAT (4)** soalan. Jawab **SEMUA** soalan.]

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

...2/-

SULIT

- (1). A short span 3 m beam constructed from 406×178×74 UKB with grade S275 steel shown in **Figure 1** is simply supported at both ends where lateral deflections are effectively prevented and rotations are fully restrained. Analyze the adequacy of the beam for a factored concentrated load of 1500 kN at the top flange. Ignore the self-weight of the beam in the calculation.

*Sebatang rasuk pendek 3 m dibina daripada 406×178×74 UKB dengan gred keluli S275 ditunjukkan dalam **Rajah 1** adalah disokong mudah pada kedua-dua hujungnya di mana anjakan sisi dihalang dengan efektif dan putaran adalah dikekang sepenuhnya. Analisa keupayaan rasuk oleh beban tumpu terfaktor 1500 kN di bebibir atas. Abaikan berat diri rasuk dalam pengiraan.*

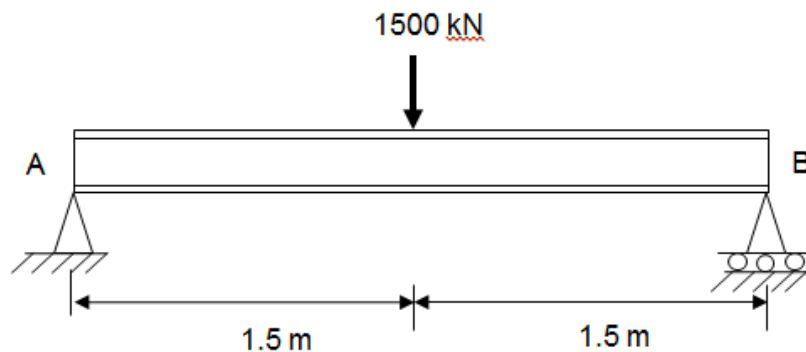


Figure 1/ Rajah 1

[25 marks/markah]

- (2). A tension member consists of a 150×90×10 single unequal leg angle of S275 steel. The ends are connected to gusset plates through the larger leg by a single row of four 22 mm bolts at 60 mm centres. Analyze the member for a design tension force of $N_{t,Ed} = 300$ kN.

Sebatang anggota tegangan yang terdiri daripada satu sesiku tunggal kaki tidak sama 150×90×10 daripada keluli S275. Hujungnya disambungkan kepada plat guset melalui kaki yang terpanjang dengan sebaris empat batang bolt berdiameter 22 mm pada jarak 60 mm pusat ke pusat. Analisa anggota untuk rekabentuk daya tegangan, $N_{t,Ed} = 300$ kN.

[25 marks/markah]

...3/-

- (3). (a). A 6 m long steel column is subjected to a design axial compressive force of 1400 kN applied at the top of the column. The column is pinned at both ends as shown in **Figure 2**. Analyse the suitability of the 203×203×60 UKC section with grade S275 for Class 1.

*Sebatang tiang keluli dengan panjang 6 m menanggung kekuatan rekabentuk mampatan paksi 1400 kN yang dikenakan di bahagian atas tiang. Tiang ini dicematkan di kedua-dua hujung seperti di **Rajah 2**. Analisa kesesuaian keratan UKC 203×203×60 dengan menggunakan gred S275 untuk Kelas 1.*

[12 marks/markah]

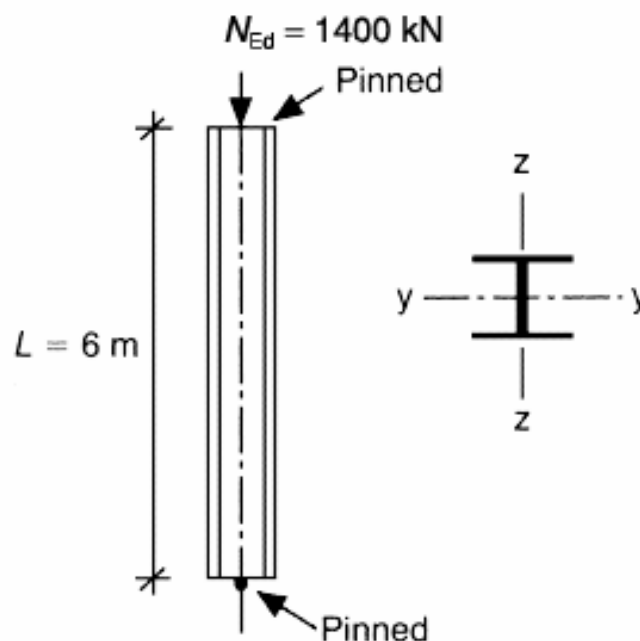


Figure 2/Rajah 2

- (b). By reconsidering the analysed column in part (a), reanalyse the axial compression resistance of the column if a tie-beam is introduced at the mid-height such that in-plane buckling about the z - z axis is prevented, as shown in **Figure 3**.

...4/-

Dengan menimbang semula tiang yang telah dianalisa dalam bahagian (a), analisa semula rintangan mampatan paksi bagi tiang tersebut jika rasuk-ikatan diperkenalkan di pertengahan ketinggian supaya lengkakan satah terhadap paksi z-z dihalang, seperti yang ditunjukkan dalam **Rajah 3**.

[13 marks/markah]

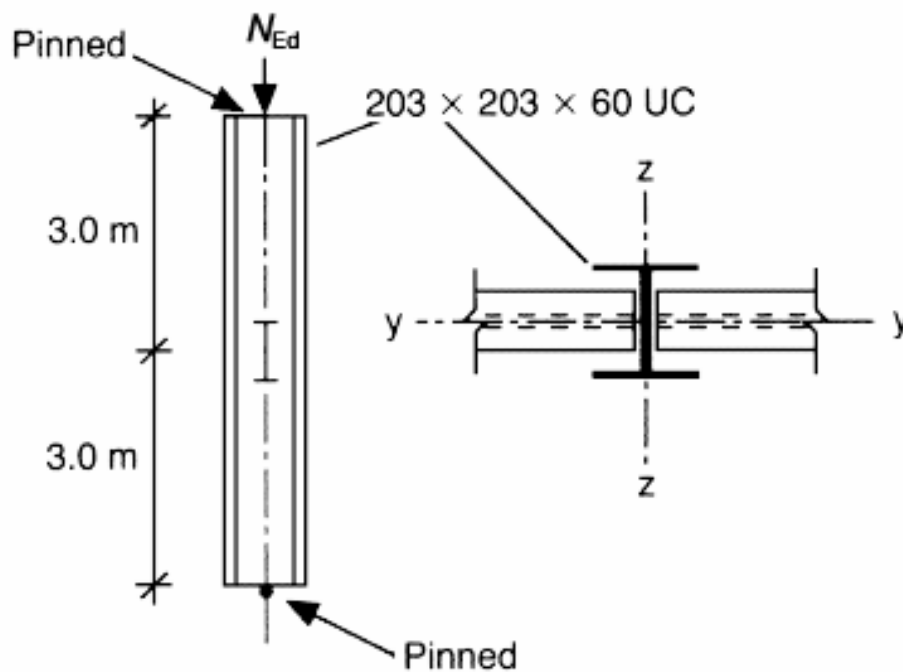


Figure 3/Rajah 3

(4). (a). Sketch the connection elements for
Lakar elemen penyambung untuk

(i). End plates
Plat Hujung

(ii). Cleats
Tetupai

...5/-

- (iii). Splices
Penyambat
- (iv). Beam to Beam
Rasuk ke Rasuk
- (v). Column Bases
Asas Tiang

[5 marks/markah]

- (b). A 356x171x67 UKB is to be connected to a 254x254x89 UKC as shown in **Figure 4** using S275 steel. Several bolts of Class 8.8 M16 are proposed to be the connectors. The beam is welded to the end plate of 10 mm thick. The calculated shear resistance F_{Ed} is 400 kN.

*Satu rasuk UKB 356x171x67 akan disambung ke tiang UKC 254x254x89 seperti dalam **Rajah 4** menggunakan keluli S275. Beberapa bolt Kelas 8.8 M16 dicadangkan sebagai penyambung. Rasuk tersebut dikimpal ke plat hujung setebal 10 mm. Rintangan ricih yang dikira F_{Ed} adalah 400 kN.*

- (i). Determine the number of bolts required.
Tentukan bilangan bolt yang diperlukan.
- (ii). Estimate the bearing and shear resistance of the bolt group shown in **Figure 5**.
*Anggarkan rintangan galas dan ricih kumpulan bolt dalam **Rajah 5**.*
- (iii). Assess the positioning of bolt holes for plate shown in **Figure 5**.
*Nilaikan kedudukan lubang bolt untuk plat dalam **Rajah 5**.*

...6/-

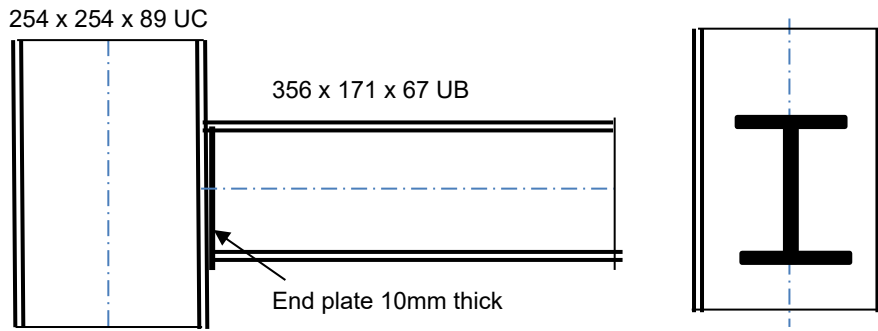


Figure 4/Rajah 4

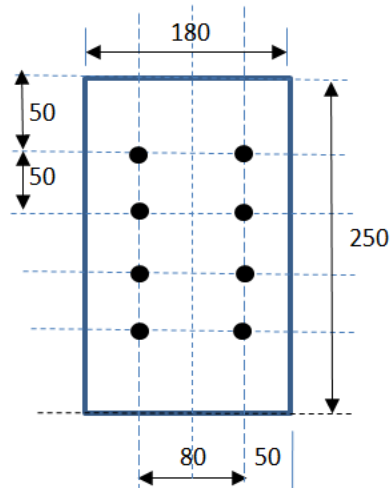


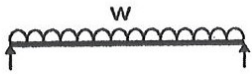

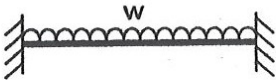

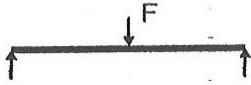

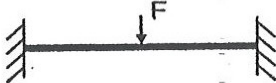

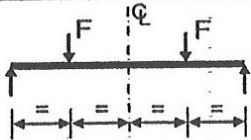

Figure 5 /Rajah 5

[20 marks/markah]

APPENDIX 1/ LAMPIRAN 1

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{L_{cr}^2} \left(\frac{I_w}{I_z} + \frac{L_{cr}^2 GI_T}{\pi^2 EI_z} \right)^{0,5}$$

Values for C_1

Loading and support conditions	Bending moment diagram	Value of C_1
		1.132
		1.285
		1.365
		1.565
		1.046

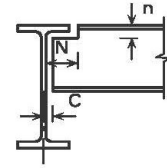
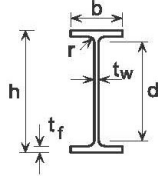
APPENDIX 2/ LAMPIRAN 2

P363 Steel Building Design: Design Data, in accordance with Eurocodes and the UK National Annexes

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

UNIVERSAL BEAMS

Advance UKB



Dimensions

Section Designation	Mass per Metre kg/m	Depth of Section h mm	Width of Section b mm	Thickness		Root Radius r mm	Depth between Fillets d mm	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web t _w mm	Flange t _f mm			Flange c _f / t _f	Web c _w / t _w	End Clearance C mm	Notch		Per Metre m ²	Per Tonne m ²
											N mm	n mm		
533x210x138 +	138.3	549.1	213.9	14.7	23.6	12.7	476.5	3.68	32.4	9	110	38	1.90	13.7
533x210x122	122.0	544.5	211.9	12.7	21.3	12.7	476.5	4.08	37.5	8	110	34	1.89	15.5
533x210x109	109.0	539.5	210.8	11.6	18.8	12.7	476.5	4.62	41.1	8	110	32	1.88	17.2
533x210x101	101.0	536.7	210.0	10.8	17.4	12.7	476.5	4.99	44.1	7	110	32	1.87	18.5
533x210x92	92.1	533.1	209.3	10.1	15.6	12.7	476.5	5.57	47.2	7	110	30	1.86	20.2
533x210x82	82.2	528.3	208.8	9.6	13.2	12.7	476.5	6.58	49.6	7	110	26	1.85	22.5
533x165x85 +	84.8	534.9	166.5	10.3	16.5	12.7	476.5	3.96	46.3	7	90	30	1.69	19.9
533x165x75 +	74.7	529.1	165.9	9.7	13.6	12.7	476.5	4.81	49.1	7	90	28	1.68	22.5
533x165x66 +	65.7	524.7	165.1	8.9	11.4	12.7	476.5	5.74	53.5	6	90	26	1.67	25.4
457x191x161 +	161.4	492.0	199.4	18.0	32.0	10.2	407.6	2.52	22.6	11	102	44	1.73	10.7
457x191x133 +	133.3	480.6	196.7	15.3	26.3	10.2	407.6	3.06	26.6	10	102	38	1.70	12.8
457x191x106 +	105.8	469.2	194.0	12.6	20.6	10.2	407.6	3.91	32.3	8	102	32	1.67	15.8
457x191x98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.11	35.8	8	102	30	1.67	17.0
457x191x89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	4.55	38.8	7	102	28	1.66	18.6
457x191x82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.03	41.2	7	102	28	1.65	20.1
457x191x74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	5.55	45.3	7	102	26	1.64	22.1
457x191x67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	6.34	48.0	6	102	24	1.63	24.3
457x152x82	82.1	465.8	155.3	10.5	18.9	10.2	407.6	3.29	38.8	7	84	30	1.51	18.4
457x152x74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	3.66	42.5	7	84	28	1.50	20.2
457x152x67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	4.15	45.3	7	84	26	1.50	22.3
457x152x60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	4.68	50.3	6	84	24	1.49	24.9
457x152x52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	5.71	53.6	6	84	22	1.48	28.3
406x178x85 +	85.3	417.2	181.9	10.9	18.2	10.2	360.4	4.14	33.1	7	96	30	1.52	17.8
406x178x74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	4.68	37.9	7	96	28	1.51	20.4
406x178x67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	5.23	41.0	6	96	26	1.50	22.3
406x178x60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	5.84	45.6	6	96	24	1.49	24.8
406x178x54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	6.86	46.8	6	96	22	1.48	27.3
406x140x53 +	53.3	406.8	143.3	7.9	12.9	10.2	360.4	4.46	45.6	6	78	24	1.35	25.3
406x140x46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	5.13	53.0	5	78	22	1.34	29.1
406x140x39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	6.69	56.3	5	78	20	1.33	34.1
356x171x87	87.1	363.4	173.2	9.1	15.7	10.2	311.6	4.58	34.2	7	94	26	1.38	20.6
356x171x57	57.0	358.0	172.2	8.1	13.0	10.2	311.6	5.53	38.5	6	94	24	1.37	24.1
356x171x51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	6.25	42.1	6	94	22	1.36	26.7
356x171x45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	7.41	44.5	6	94	20	1.36	30.2
356x127x39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	4.63	47.2	5	70	22	1.18	30.2
356x127x33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	5.82	51.9	5	70	20	1.17	35.4
305x165x54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	5.15	33.6	6	90	24	1.26	23.3
305x165x46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	5.98	39.6	5	90	22	1.25	27.1
305x165x40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	6.92	44.2	5	90	20	1.24	30.8

Created on 31 January 2012. This material is copyright - all rights reserved. Use of this document is subject to the terms and conditions of the Steelbiz Licence Agreement.

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

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

FOR EXPLANATION OF TABLES SEE NOTE 2

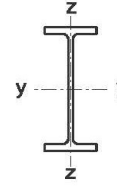
APPENDIX 3/ LAMPIRAN 3

P363 Steel Building Design: Design Data, In accordance with Eurocodes and the UK National Annexes

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

UNIVERSAL BEAMS

Advance UKB



Properties

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter U	Torsional Index X	Warping Constant I _w dm ⁶	Torsional Constant I _T cm ⁴	Area of Section A cm ²
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z					
	cm ⁴	cm ⁴	cm	cm	cm ³	cm ³	cm ³	cm ³					
533x210x138 +	86100	3860	22.1	4.68	3140	361	3610	568	0.874	24.9	2.67	250	176
533x210x122	76000	3390	22.1	4.67	2790	320	3200	500	0.878	27.6	2.32	178	155
533x210x109	66800	2940	21.9	4.60	2480	279	2830	436	0.875	30.9	1.99	126	139
533x210x101	61500	2690	21.9	4.57	2290	256	2610	399	0.874	33.1	1.81	101	129
533x210x92	55200	2390	21.7	4.51	2070	228	2360	355	0.873	36.4	1.60	75.7	117
533x210x82	47500	2010	21.3	4.38	1800	192	2060	300	0.863	41.6	1.33	51.5	105
533x165x85 +	48500	1270	21.2	3.44	1820	153	2100	243	0.861	35.5	0.857	73.8	108
533x165x75 +	41100	1040	20.8	3.30	1550	125	1810	200	0.853	41.1	0.691	47.9	95.2
533x165x66 +	35000	859	20.5	3.20	1340	104	1560	166	0.847	47.0	0.566	32.0	83.7
457x191x161 +	79800	4250	19.7	4.55	3240	426	3780	672	0.881	16.5	2.25	515	206
457x191x133 +	63800	3350	19.4	4.44	2660	341	3070	535	0.879	19.6	1.73	292	170
457x191x106 +	48900	2510	19.0	4.32	2080	259	2390	405	0.876	24.4	1.27	146	135
457x191x98	45700	2350	19.1	4.33	1960	243	2230	379	0.881	25.8	1.18	121	125
457x191x89	41000	2090	19.0	4.29	1770	218	2010	338	0.878	28.3	1.04	90.7	114
457x191x82	37100	1870	18.8	4.23	1610	196	1830	304	0.879	30.8	0.922	69.2	104
457x191x74	33300	1670	18.8	4.20	1460	176	1650	272	0.877	33.8	0.818	51.8	94.6
457x191x67	29400	1450	18.5	4.12	1300	163	1470	237	0.873	37.8	0.705	37.1	85.5
457x152x82	36600	1180	18.7	3.37	1570	153	1810	240	0.872	27.4	0.591	89.2	105
457x152x74	32700	1050	18.6	3.33	1410	136	1630	213	0.872	30.1	0.518	65.9	94.5
457x152x67	28900	913	18.4	3.27	1260	119	1450	187	0.868	33.6	0.448	47.7	85.6
457x152x60	25500	795	18.3	3.23	1120	104	1290	163	0.868	37.5	0.387	33.8	76.2
457x152x52	21400	645	17.9	3.11	950	84.6	1100	133	0.859	43.8	0.311	21.4	66.6
406x178x85 +	31700	1830	17.1	4.11	1520	201	1730	313	0.880	24.4	0.728	93.0	109
406x178x74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.5	0.608	62.8	94.5
406x178x67	24300	1360	16.9	3.99	1190	153	1350	237	0.880	30.4	0.533	46.1	85.5
406x178x60	21600	1200	16.8	3.97	1060	135	1200	209	0.880	33.7	0.466	33.3	76.5
406x178x54	18700	1020	16.5	3.85	930	115	1050	178	0.871	38.3	0.392	23.1	69.0
406x140x53 +	18300	635	16.4	3.06	899	88.6	1030	139	0.870	34.1	0.246	29.0	67.9
406x140x46	15700	538	16.4	3.03	778	75.7	888	118	0.871	39.0	0.207	19.0	58.6
406x140x39	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.4	0.155	10.7	49.7
356x171x67	19500	1360	15.1	3.99	1070	157	1210	243	0.886	24.4	0.412	55.7	85.5
356x171x57	16000	1110	14.9	3.91	896	129	1010	199	0.882	28.8	0.330	33.4	72.6
356x171x51	14100	968	14.8	3.86	796	113	896	174	0.881	32.1	0.286	23.8	64.9
356x171x45	12100	811	14.5	3.76	687	94.8	775	147	0.874	36.8	0.237	15.8	57.3
356x127x39	10200	358	14.3	2.68	576	58.8	659	89.0	0.871	35.2	0.105	15.1	49.8
356x127x33	8250	280	14.0	2.58	473	44.7	543	70.2	0.863	42.1	0.081	8.79	42.1
305x165x54	11700	1060	13.0	3.93	754	127	846	196	0.889	23.6	0.234	34.8	68.8
305x165x46	9900	896	13.0	3.90	646	108	720	166	0.890	27.1	0.195	22.2	58.7
305x165x40	8500	764	12.9	3.86	560	92.6	623	142	0.889	31.0	0.164	14.7	51.3

Created on 31 January 2012. This material is copyright - all rights reserved. Use of this document is subject to the terms and conditions of the Steelbiz Licence Agreement.

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

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

FOR EXPLANATION OF TABLES SEE NOTE 3

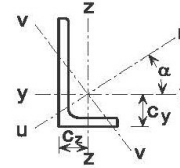
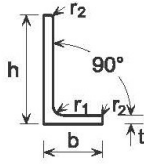
APPENDIX 4/ LAMPIRAN 4

P363 Steel Building Design: Design Data, In accordance with Eurocodes and the UK National Annexes

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

UNEQUAL ANGLES

Advance UKA - Unequal Angles



Dimensions and properties

Section Designation		Mass per Metre	Radius		Dimension		Second Moment of Area				Radius of Gyration			
Size	Thickness		Root	Toe			Axis y-y	Axis z-z	Axis u-u	Axis v-v	Axis y-y	Axis z-z	Axis u-u	Axis v-v
h x b mm	t mm	kg/m	r ₁ mm	r ₂ mm	c _y cm	c _z cm	cm ⁴	cm ⁴	cm ⁴	cm ⁴	cm	cm	cm	cm
200x150	18 +	47.1	15.0	7.50	6.33	3.85	2380	1150	2920	623	6.29	4.37	6.97	3.22
	15	39.6	15.0	7.50	6.21	3.73	2020	979	2480	526	6.33	4.40	7.00	3.23
	12	32.0	15.0	7.50	6.08	3.61	1650	803	2030	430	6.36	4.44	7.04	3.25
200x100	15	33.8	15.0	7.50	7.16	2.22	1760	299	1860	193	6.40	2.64	6.59	2.12
	12	27.3	15.0	7.50	7.03	2.10	1440	247	1530	159	6.43	2.67	6.63	2.14
	10	23.0	15.0	7.50	6.93	2.01	1220	210	1290	135	6.46	2.68	6.65	2.15
150x90	15	33.9	12.0	6.00	5.21	2.23	761	205	841	126	4.74	2.46	4.98	1.93
	12	21.6	12.0	6.00	5.08	2.12	627	171	694	104	4.77	2.49	5.02	1.94
	10	18.2	12.0	6.00	5.00	2.04	533	146	591	88.3	4.80	2.51	5.05	1.95
150x75	15	24.8	12.0	6.00	5.52	1.81	713	119	753	78.6	4.75	1.94	4.88	1.58
	12	20.2	12.0	6.00	5.40	1.69	588	99.6	623	64.7	4.78	1.97	4.92	1.59
	10	17.0	12.0	6.00	5.31	1.61	501	85.6	531	55.1	4.81	1.99	4.95	1.60
125x75	12	17.8	11.0	5.50	4.31	1.84	354	95.5	391	58.5	3.95	2.05	4.15	1.61
	10	15.0	11.0	5.50	4.23	1.76	302	82.1	334	49.9	3.97	2.07	4.18	1.61
	8	12.2	11.0	5.50	4.14	1.68	247	67.6	274	40.9	4.00	2.09	4.21	1.63
100x75	12	15.4	10.0	5.00	3.27	2.03	189	90.2	230	49.5	3.10	2.14	3.42	1.59
	10	13.0	10.0	5.00	3.19	1.95	162	77.6	197	42.2	3.12	2.16	3.45	1.59
	8	10.6	10.0	5.00	3.10	1.87	133	64.1	162	34.6	3.14	2.18	3.47	1.60
100x65	10 +	12.3	10.0	5.00	3.36	1.63	154	51.0	175	30.1	3.14	1.81	3.35	1.39
	8 +	9.94	10.0	5.00	3.27	1.55	127	42.2	144	24.8	3.16	1.83	3.37	1.40
	7 +	8.77	10.0	5.00	3.23	1.51	113	37.6	128	22.0	3.17	1.83	3.39	1.40
100x50	8	8.97	8.00	4.00	3.60	1.13	116	19.7	123	12.8	3.19	1.31	3.28	1.06
	6	6.84	8.00	4.00	3.51	1.05	89.9	15.4	95.4	9.92	3.21	1.33	3.31	1.07
80x60	7	7.36	8.00	4.00	2.51	1.52	59.0	28.4	72.0	15.4	2.51	1.74	2.77	1.28
80x40	8	7.07	7.00	3.50	2.94	0.963	57.6	9.61	60.9	6.34	2.53	1.03	2.60	0.838
	6	5.41	7.00	3.50	2.85	0.884	44.9	7.59	47.6	4.93	2.55	1.05	2.63	0.845
75x50	8	7.39	7.00	3.50	2.52	1.29	52.0	18.4	59.6	10.8	2.35	1.40	2.52	1.07
	6	5.65	7.00	3.50	2.44	1.21	40.5	14.4	46.6	8.36	2.37	1.42	2.55	1.08
70x50	6	5.41	7.00	3.50	2.23	1.25	33.4	14.2	39.7	7.92	2.20	1.43	2.40	1.07
65x50	5	4.35	6.00	3.00	1.99	1.25	23.2	11.9	28.8	6.32	2.05	1.47	2.28	1.07
60x40	6	4.46	6.00	3.00	2.00	1.01	20.1	7.12	23.1	4.16	1.88	1.12	2.02	0.855
	5	3.76	6.00	3.00	1.96	0.972	17.2	6.11	19.7	3.54	1.89	1.13	2.03	0.860
60x30	5	3.36	5.00	2.50	2.17	0.684	15.6	2.63	16.5	1.71	1.91	0.784	1.97	0.633
50x30	5	2.96	5.00	2.50	1.73	0.741	9.36	2.51	10.3	1.54	1.57	0.816	1.65	0.639
45x30	4	2.25	4.50	2.25	1.48	0.740	5.78	2.05	6.65	1.18	1.42	0.850	1.52	0.640
40x25	4	1.93	4.00	2.00	1.36	0.623	3.89	1.16	4.35	0.700	1.26	0.687	1.33	0.534
40x20	4	1.77	4.00	2.00	1.47	0.480	3.59	0.600	3.80	0.393	1.26	0.514	1.30	0.417
30x20	4	1.46	4.00	2.00	1.03	0.541	1.59	0.553	1.81	0.330	0.925	0.546	0.988	0.421
	3	1.12	4.00	2.00	0.990	0.502	1.25	0.437	1.43	0.256	0.935	0.553	1.00	0.424

Created on 31 January 2012. This material is copyright - all rights reserved. Use of this document is subject to the terms and conditions of the Steelbiz Licence Agreement.

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

+ These sections are in addition to the range of BS EN 10056-1 sections.

c_y is the distance from the back of the short leg to the centre of gravity.

c_z is the distance from the back of the long leg to the centre of gravity.

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

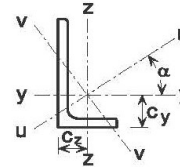
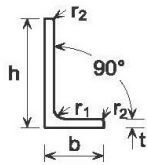
APPENDIX 5/LAMPIRAN 5

P363 Steel Building Design: Design Data, in accordance with Eurocodes and the UK National Annexes

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

UNEQUAL ANGLES

Advance UKA - Unequal Angles



Dimensions and properties (continued)

Section Designation		Elastic Modulus		Angle Axis y-y to Axis u-u Tan α	Torsional Constant I _T cm ⁴	Equivalent Slenderness Coefficient		Mono-symmetry Index ψ _a	Area of Section cm ²
Size h x b mm	Thickness t mm	Axis y-y cm ³	Axis z-z cm ³			Min φ _e	Max φ _e		
200x150	18 +	174	103	0.549	67.9	2.93	3.72	4.60	60.0
	15	147	86.9	0.551	39.9	3.53	4.50	5.55	50.5
	12	119	70.5	0.552	20.9	4.43	5.70	6.97	40.8
200x100	15	137	38.5	0.260	34.3	3.54	5.17	9.19	43.0
	12	111	31.3	0.262	18.0	4.42	6.57	11.5	34.8
	10	93.2	26.3	0.263	10.66	5.26	7.92	13.9	29.2
150x90	15	77.7	30.4	0.354	26.8	2.58	3.59	5.96	33.9
	12	63.3	24.8	0.358	14.1	3.24	4.58	7.50	27.5
	10	53.3	21.0	0.360	8.30	3.89	5.56	9.03	23.2
150x75	15	75.2	21.0	0.253	25.1	2.62	3.74	6.84	31.7
	12	61.3	17.1	0.258	13.2	3.30	4.79	8.60	25.7
	10	51.6	14.5	0.261	7.80	3.95	5.83	10.4	21.7
125x75	12	43.2	16.9	0.354	11.6	2.66	3.73	6.23	22.7
	10	36.5	14.3	0.357	6.87	3.21	4.55	7.50	19.1
	8	29.6	11.6	0.360	3.62	4.00	5.75	9.43	15.5
100x75	12	28.0	16.5	0.540	10.05	2.10	2.64	3.46	19.7
	10	23.8	14.0	0.544	5.95	2.54	3.22	4.17	16.6
	8	19.3	11.4	0.547	3.13	3.18	4.08	5.24	13.5
100x65	10 +	23.2	10.5	0.410	5.61	2.52	3.43	5.45	15.6
	8 +	18.9	8.54	0.413	2.96	3.14	4.35	6.86	12.7
	7 +	16.6	7.53	0.415	2.02	3.58	5.00	7.85	11.2
100x50	8	18.2	5.08	0.258	2.61	3.30	4.80	8.61	11.4
	6	13.8	3.89	0.262	1.14	4.38	6.52	11.6	8.71
80x60	7	10.7	6.34	0.546	1.66	2.92	3.72	4.78	9.38
80x40	8	11.4	3.16	0.253	2.05	2.61	3.73	6.85	9.01
	6	8.73	2.44	0.258	0.899	3.48	5.12	9.22	6.89
75x50	8	10.4	4.95	0.430	2.14	2.36	3.18	4.92	9.41
	6	8.01	3.81	0.435	0.935	3.18	4.34	6.60	7.19
70x50	6	7.01	3.78	0.500	0.899	2.96	3.89	5.44	6.89
65x50	5	5.14	3.19	0.577	0.498	3.38	4.26	5.08	5.54
60x40	6	5.03	2.38	0.431	0.735	2.51	3.39	5.26	5.68
	5	4.26	2.02	0.434	0.435	3.02	4.11	6.34	4.79
60x30	5	4.07	1.14	0.257	0.382	3.15	4.56	8.26	4.28
50x30	5	2.86	1.11	0.352	0.340	2.51	3.52	5.99	3.78
45x30	4	1.91	0.910	0.436	0.166	2.85	3.87	5.92	2.87
40x25	4	1.47	0.619	0.380	0.142	2.51	3.48	5.75	2.46
40x20	4	1.42	0.393	0.252	0.131	2.57	3.68	6.86	2.26
	3	0.807	0.379	0.421	0.1096	1.79	2.39	3.95	1.86
30x20	4	0.807	0.379	0.421	0.1096	1.79	2.39	3.95	1.86
	3	0.621	0.292	0.427	0.0486	2.40	3.28	5.31	1.43

Created on 31 January 2012. This material is copyright - all rights reserved. Use of this document is subject to the terms and conditions of the Steelbiz Licence Agreement.

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

+ These sections are in addition to the range of BS EN 10056-1 sections.

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

APPENDIX 6/LAMPIRAN 6

EN 1993-1-8 : 2005 (E)

3.10.3 Angles connected by one leg and other unsymmetrically connected members in tension

- (1) The eccentricity in joints, see 2.7(1), and the effects of the spacing and edge distances of the bolts, should be taken into account in determining the design resistance of:
 - unsymmetrical members;
 - symmetrical members that are connected unsymmetrically, such as angles connected by one leg.
- (2) A single angle in tension connected by a single row of bolts in one leg, see Figure 3.9, may be treated as concentrically loaded over an effective net section for which the design ultimate resistance should be determined as follows:

with 1 bolt:
$$N_{u,Rd} = \frac{2,0(e_2 - 0,5d_0)t f_u}{\gamma_{M2}} \dots (3.11)$$

with 2 bolts:
$$N_{u,Rd} = \frac{\beta_2 A_{net} f_u}{\gamma_{M2}} \dots (3.12)$$

with 3 or more bolts:
$$N_{u,Rd} = \frac{\beta_3 A_{net} f_u}{\gamma_{M2}} \dots (3.13)$$

where:

β_2 and β_3 are reduction factors dependent on the pitch p_1 as given in Table 3.8. For intermediate values of p_1 the value of β may be determined by linear interpolation;

A_{net} is the net area of the angle. For an unequal-leg angle connected by its smaller leg, A_{net} should be taken as equal to the net section area of an equivalent equal-leg angle of leg size equal to that of the smaller leg.

Table 3.8: Reduction factors β_2 and β_3

Pitch	p_1	$\leq 2,5 d_0$	$\geq 5,0 d_0$
2 bolts	β_2	0,4	0,7
3 bolts or more	β_3	0,5	0,7

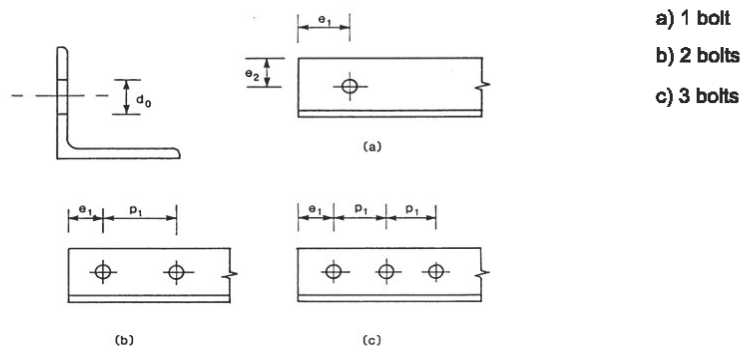
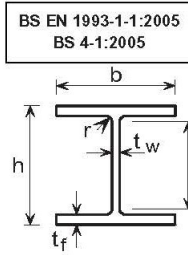


Figure 3.9: Angles connected by one leg

Licensed Copy: :FULLNAME, : DATE, Uncontrolled Copy, (c) BSI

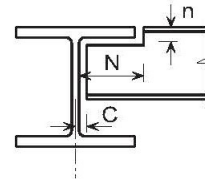
APPENDIX 7/LAMPIRAN 7

P363 Steel Building Design: Design Data, In accordance with Eurocodes and the UK National Annexes



UNIVERSAL COLUMNS

Advance UKC



Dimensions

Section Designation	Mass per Metre kg/m	Depth of Section h mm	Width of Section b mm	Thickness		Root Radius r mm	Depth between Fillets d mm	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web tw mm	Flange tf mm			Flange Cf / tf	Web Cw / tw	End Clearance C mm	Notch		Per Metre m ²	Per Tonne m ²
											N mm	n mm		
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	2.28	9.70
356x368x202	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.07	17.6	10	190	44	2.19	10.8
356x368x177	177.0	368.2	372.6	14.4	23.8	15.2	290.2	6.89	20.2	9	190	40	2.17	12.3
356x368x153	152.9	362.0	370.5	12.3	20.7	15.2	290.2	7.92	23.6	8	190	36	2.16	14.1
356x368x129	129.0	355.6	368.6	10.4	17.5	15.2	290.2	9.4	27.9	7	190	34	2.14	16.6
305x305x283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.00	9.21	15	158	60	1.94	6.86
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	48	1.87	9.44
305x305x158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	5.30	15.6	10	158	42	1.84	11.6
305x305x137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	6.11	17.90	9	158	38	1.82	13.3
305x305x118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	7.09	20.6	8	158	34	1.81	15.4
305x305x97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	8.60	24.9	7	158	32	1.79	18.5
254x254x167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	3.48	10.4	12	134	46	1.58	9.46
254x254x132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	4.36	13.1	10	134	38	1.55	11.7
254x254x107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	5.38	15.6	8	134	34	1.52	14.2
254x254x89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	6.38	19.4	7	134	30	1.50	16.9
254x254x73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	7.77	23.3	6	134	28	1.49	20.4
203x203x127 +	127.5	241.4	213.9	18.1	30.1	10.2	160.8	2.91	8.88	11	108	42	1.28	10.0
203x203x113 +	113.5	235.0	212.1	16.3	26.9	10.2	160.8	3.26	9.87	10	108	38	1.27	11.2
203x203x100 +	99.6	228.6	210.3	14.5	23.7	10.2	160.8	3.70	11.1	9	108	34	1.25	12.6
203x203x86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	4.29	12.7	8	110	32	1.24	14.4
203x203x71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.09	16.1	7	110	28	1.22	17.2
203x203x60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	6.20	17.1	7	110	26	1.21	20.2
203x203x52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	7.04	20.4	6	110	24	1.20	23.1
203x203x46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	8.00	22.3	6	110	22	1.19	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	4.82	13.0	7	84	22	0.924	21.0
152x152x37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	5.70	15.5	6	84	20	0.912	24.7
152x152x30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	6.98	19.0	5	84	18	0.901	30.0
152x152x23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	9.65	21.3	5	84	16	0.889	38.7

Created on 31 January 2012. This material is copyright - all rights reserved. Use of this document is subject to the terms and conditions of the Steelbiz Licence Agreement.

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

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

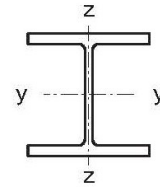
FOR EXPLANATION OF TABLES SEE NOTE 2

APPENDIX 8/LAMPIRAN 8

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

UNIVERSAL COLUMNS

Advance UKC



Properties

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter U	Torsional Index X	Warping Constant I _w dm ⁶	Torsional Constant I _T cm ⁴	Area of Section A cm ²
	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z	Axis y-y	Axis z-z					
	cm ⁴	cm ⁴	cm	cm	cm ³	cm ³	cm ³	cm ³					
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	808	2680	1230	0.851	12.46	2.87	378	201
305x305x137	32800	10700	13.7	7.83	2050	692	2300	1050	0.851	14.13	2.39	249	174
305x305x118	27700	9060	13.6	7.77	1760	589	1960	895	0.850	16.14	1.98	161	150
305x305x97	22200	7310	13.4	7.69	1450	479	1590	726	0.850	19.19	1.56	91.2	123
254x254x167	30000	9870	11.9	6.81	2080	744	2420	1140	0.851	8.48	1.63	626	213
254x254x132	22500	7530	11.6	6.69	1630	576	1870	878	0.850	10.32	1.19	319	168
254x254x107	17500	5930	11.3	6.59	1310	458	1480	697	0.848	12.38	0.898	172	136
254x254x89	14300	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	9.28	5.34	850	299	977	456	0.850	10.20	0.318	137	110
203x203x71	7620	2540	9.18	5.30	706	246	799	374	0.853	11.90	0.250	80.2	90.4
203x203x60	6120	2060	8.96	5.20	584	201	656	305	0.846	14.10	0.197	47.2	76.4
203x203x52	5260	1780	8.91	5.18	510	174	567	264	0.848	15.80	0.167	31.8	66.3
203x203x46	4570	1550	8.82	5.13	450	152	497	231	0.847	17.70	0.143	22.2	58.7
152x152x51 +	3230	1020	7.04	3.96	379	130	438	199	0.848	10.10	0.061	48.8	65.2
152x152x44 +	2700	860	6.94	3.92	326	110	372	169	0.848	11.50	0.050	31.7	56.1
152x152x37	2210	706	6.85	3.87	273	91.5	309	140	0.848	13.30	0.040	19.2	47.1
152x152x30	1750	560	6.76	3.83	222	73.3	248	112	0.849	16.00	0.031	10.5	38.3
152x152x23	1250	400	6.54	3.70	164	52.6	182	80.1	0.840	20.70	0.021	4.63	29.2

Created on 31 January 2012. This material is copyright - all rights reserved. Use of this document is subject to the terms and conditions of the Steelbiz Licence Agreement.

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

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

FOR EXPLANATION OF TABLES SEE NOTE 3

APPENDIX 9/LAMPIRAN 9

MS EN 1993-1-1:2010

EUROCODE 3: DESIGN OF STEELSTRUCTURES –

PART 1-1: GENERAL RULES AND RULES FOR BUILDINGS

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		$40 \text{ mm} < t \leq 80$ mm	
	f_y [N/mm ²]	f_u [N/mm ²]	f_y [N/mm ²]	f_u [N/mm ²]
EN 10025-2				
S 235	235	360	215	360
S 275	275	430	255	410
S 355	355	510	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	510	335	490
EN 10025-6				
S 460 Q/QL/QL1	460	570	440	550

APPENDIX 10/LAMPIRAN 10

BS EN 1993-1-8:2005
Eurocode 3: Design of steel structures — Part 1-8: Design of joints

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 3.1: Nominal values of the yield strength f_{yb} and the ultimate tensile strength f_{ub} for bolts

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

NOTE: The National Annex may exclude certain bolt classes.

...17/-

APPENDIX 11/LAMPIRAN 11

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
<p>¹⁾ Maximum values for spacings, edge and end distances are unlimited, except in the following cases:</p> <ul style="list-style-type: none"> - for compression members in order to avoid local buckling and to prevent corrosion in exposed members and; - for exposed tension members to prevent corrosion. <p>²⁾ The local buckling resistance of the plate in compression between the fasteners should be calculated according to EN 1993-1-1 using $0,6 p_1$ as buckling length. Local buckling between the fasteners need not to be checked if p_1/t is smaller than 9ε. The edge distance should not exceed the local buckling requirements for an outstand element in the compression members, see EN 1993-1-1. The end distance is not affected by this requirement.</p> <p>³⁾ t is the thickness of the thinner outer connected part.</p> <p>⁴⁾ The dimensional limits for slotted holes are given in 1.2.7 Reference Standards: Group 7.</p> <p>⁵⁾ For staggered rows of fasteners a minimum line spacing of $p_2 = 1,2d_0$ may be used, provided that the minimum distance, L, between any two fasteners is greater or equal than $2,4d_0$, see Figure 3.1b).</p>				

APPENDIX 12/LAMPIRAN 12

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

Failure mode	Bolts	Rivets
Shear resistance per shear plane	$F_{v,Rd} = \frac{\alpha_v f_{ub} A}{\gamma_{M2}}$ <p>- where the shear plane passes through the threaded portion of the bolt (A is the tensile stress area of the bolt A_s):</p> <ul style="list-style-type: none"> - for classes 4.6, 5.6 and 8.8: $\alpha_v = 0,6$ - for classes 4.8, 5.8, 6.8 and 10.9: $\alpha_v = 0,5$ <p>- where the shear plane passes through the unthreaded portion of the bolt (A is the gross cross section of the bolt): $\alpha_v = 0,6$</p>	$F_{v,Rd} = \frac{0,6 f_{wr} A_0}{\gamma_{M2}}$
Bearing resistance ^{1), 2), 3)}	$F_{b,Rd} = \frac{k_1 a_b f_u d t}{\gamma_{M2}}$ <p>where a_b is the smallest of a_d; $\frac{f_{ub}}{f_u}$ or 1,0; in the direction of load transfer:</p> <ul style="list-style-type: none"> - for end bolts: $a_d = \frac{e_1}{3d_0}$; for inner bolts: $a_d = \frac{p_1}{3d_0} - \frac{1}{4}$ <p>perpendicular to the direction of load transfer:</p> <ul style="list-style-type: none"> - for edge bolts: k_1 is the smallest of $2,8 \frac{e_2}{d_0} - 1,7$ or 2,5 - for inner bolts: k_1 is the smallest of $1,4 \frac{p_2}{d_0} - 1,7$ or 2,5 	
Tension resistance ²⁾	$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}}$ <p>where $k_2 = 0,63$ for countersunk bolt, otherwise $k_2 = 0,9$.</p>	$F_{t,Rd} = \frac{0,6 f_{wr} A_0}{\gamma_{M2}}$
Punching shear resistance	$B_{p,Rd} = 0,6 \pi d_m t_p f_u / \gamma_{M2}$	No check needed
Combined shear and tension	$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} \leq 1,0$	
<p>¹⁾ The bearing resistance $F_{b,Rd}$ for bolts</p> <ul style="list-style-type: none"> - in oversized holes is 0,8 times the bearing resistance for bolts in normal holes. - in slotted holes, where the longitudinal axis of the slotted hole is perpendicular to the direction of the force transfer, is 0,6 times the bearing resistance for bolts in round, normal holes. <p>²⁾ For countersunk bolt:</p> <ul style="list-style-type: none"> - the bearing resistance $F_{b,Rd}$ should be based on a plate thickness t equal to the thickness of the connected plate minus half the depth of the countersinking. - for the determination of the tension resistance $F_{t,Rd}$ the angle and depth of countersinking should conform with 1.2.4 Reference Standards: Group 4, otherwise the tension resistance $F_{t,Rd}$ should be adjusted accordingly. <p>³⁾ When the load on a bolt is not parallel to the edge, the bearing resistance may be verified separately for the bolt load components parallel and normal to the end.</p>		