UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2015/2016 Academic Session

June 2016

EAS354 – Steel and Timber Structural Design
[Rekabentuk Struktur Kayu dan Keluli]

Duration : 2 hours
[*Masa : 2 jam*]

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material including **SIX (6)** appendices before you begin the examination.

[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat yang bercetak termasuk **ENAM (6)** lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **FIVE (5)** questions. Answer **FOUR (4)** questions.

[**Arahan** *: Kertas ini mengandungi **LIMA (5)** soalan. Jawab **EMPAT (4)** soalan.*]

All questions **MUST BE** answered on a new page.
[*Semua soalan **MESTILAH** dijawab pada muka surat baru.*]

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

[*Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.*]

1. A short span of 1.4 m beam, 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 twist rotations are fully restrained. Justify the capacity of the beam to carry a total concentrated factored load of 1050 kN (which includes an allowance for self-weight) at mid span. Refer to **APPENDIX 1 & 2** for the section properties of the beam.

   *Sebatang rasuk pendek 1.4 m, 406 × 178 × 74 UKB dengan gred keluli S275 ditunjukkan dalam **Rajah 1** adalah disokong mudah pada kedua hujungnya di mana anjakan sisi dihalang dengan efektif dan sudut putaran adalah dikekang sepenuhnya. Wajarkan keupayaan rasuk untuk membawa jumlah beban tumpu terfaktor 1050 kN (termasuk berat diri sendiri) di tengah rentang. Rujuk **LAMPIRAN 1 & 2** untuk sifat keratan rasuk.*
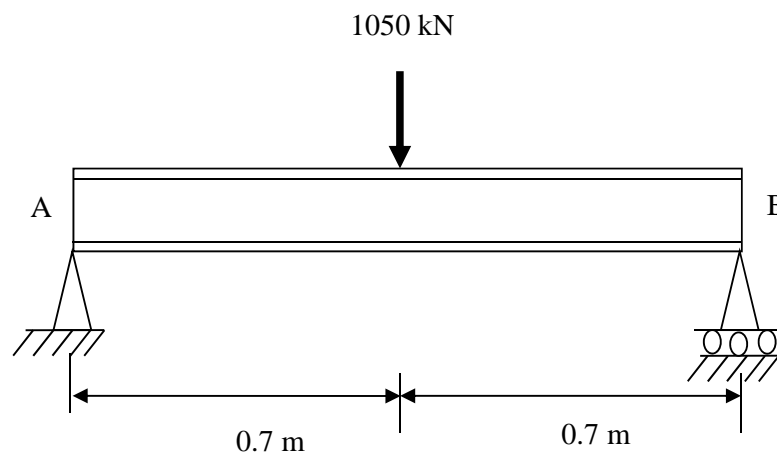
   [25 marks/*markah*]

1050 kN

A

B

0.7 m

0.7 m

Figure 1/ *Rajah 1*

2. A tension member of a truss system consisting of 150 × 75 × 10 single unequal angle is connected to a gusset plate at one end. The connection is made through the larger leg using a single row of four 22 mm bolts in 24 mm holes at 60 mm centres. Justify the adequacy of the angle if the design tension force $N_{t,Ed} = 340$ kN. Assume the steel angle grade as S355. Refer to **APPENDIX 3, 4 & 5** for the section properties of the angle.

Sebatang anggota tegangan bagi sistem kekuda yang terdiri daripada 150 × 75 × 10 sesiku tunggal tidak sama kaki disambungkan kepada plat guset di satu hujung. Sambungan adalah dibuat melalui kaki yang lebih panjang dengan sebaris empat batang bolt berdiameter 22 mm dalam lubang 24 mm pada jarak 60 mm pusat ke pusat. Wajarkan kecukupan anggota sesiku sekiranya daya tegangan rekabentuk, $N_{t,Ed}$ = 340 kN. Anggap sesiku keluli adalah gred S355. Rujuk LAMPIRAN 3,4 & 5 untuk sifat keratan sesiku.

Note: The numerical values of the partial factors recommended by MS EN 1993-1-1 are γ_{M0} = 1.00 and γ_{M2} = 1.1. Given value of the β_3 = 0.5.

Nota: Nilai-nilai berangka bagi faktor separa yang disyorkan oleh MS EN 1993-1-1 adalah γ_{M0} = 1.00 dan γ_{M2} = 1.1. Diberikan nilai β_3 = 0.5.

[25 marks/*markah*]

3. [a] Briefly discuss the failure modes of steel columns.

   Bincangkan dengan ringkas mod kegagalan untuk tiang keluli.

   [4 marks/*markah*]

[b] A steel column is proposed to be constructed using 203 × 133 × 30 UKB Grade S275 steel section. The critical length of the column about both axes and the shape of the bending moment diagram is shown in **Figure 2**. The column is subjected to a design axial load (N_{Ed}) = 90 kN, design bending moment about major axis ($M_{y,Ed}$) = 30 kNm and design bending moment about minor axis ($M_{z,Ed}$) = 15 kNm. Justify the suitability of the proposed section for:

   Satu tiang keluli dibina menggunakan keratan 203 x 133 x 25 UKB Gred S275. Panjang kritikal pada kedua-dua paksi dan bentuk gambarajah momen lentur adalah seperti di Rajah 2. Tiang tersebut dikenakan beban paksi rekabentuk (N_{Ed}) = 90 kN, momen lentur rekabentuk pada paksi major ($M_{y,Ed}$) = 30 kNm dan momen lentur pada paksi minor ($M_{x,Ed}$) = 15 kNm. Tentukan kesesuaian cadangan penggunaan keratan tersebut untuk:

[i] compression resistance,

rintangan mampatan,

[ii] buckling resistance about the y-y axis,

rintangan lengkokan pada paksi y-y

[iii] combined bending and compression resistance about the z-z axis

rintangan terhadap gabungan lenturan dan mampatan pada paksi z-z

The section properties for 203 × 133 × 30 UKB Grade S275 are provided in **APPENDIX 6.**

*Sifat keratan untuk 203 × 133 × 30 UKB Gred S275 disediakan dalam **LAMPIRAN 6.***
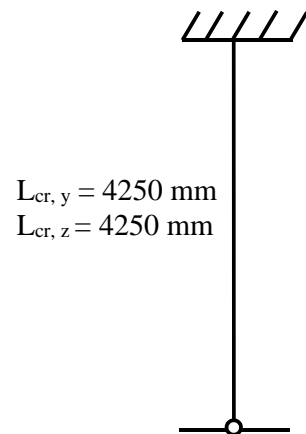
$L_{cr, y} = 4250$ mm
$L_{cr, z} = 4250$ mm

Figure 2 / Rajah 2
Steel column with fixed-pinned end/ *Tiang keluli dengan hujung terikat tegar-tercemat.*

[21 marks*/markah*]

4. A structural engineer has been given a task to design a symmetrically loaded internal column to carry loads from the four connected beams as shown in **Figures 3 (a) and 3 (b)**. Both top and bottom of the column are considered to be held in position but not in the direction. The lateral restraint is provided at the mid-height and also at the top of the column as indicated in the figures. With the given design data, verify the appropriateness of column with the size of 75 mm x 150 mm, solid sawn timber section for the column with respect to compression.

*Seorang jurutera struktur diberi tugas merekabentuk tiang terbeban simetri dalaman untuk membawa beban daripada empat rasuk yang disambung padanya seperti yang ditunjukkan dalam **Rajah 3 (a) dan 3 (b)**. Kedua-dua atas dan bawah tiang dipegang dalam kedudukkannya tetapi tidak dalam arah. Kekangan sisi disediakan pada pertengahan tiang dan juga di bahagian atas tiang seperti yang ditunjukan dalam rajah. Dengan data rekabentuk yang diberi, sahkan kesesuaian tiang bersaiz 75 × 150 mm, keratan kayu pejal bergergaji untuk tiang terhadap mampatan.*

Design data:

Nominal size of sawn timber	75 × 150 mm
Strength Group	SG 4
Condition of timber	Wet
Long-term load	10 kN
Medium-term load	24 kN

Data rekabentuk:

Saiz nominal kayu bergergaji	*75 × 150 mm*
Kumpulan kekuatan kayu	*SG 4*
Kedudukan kayu	*Basah*
Beban jangka panjang	*10 kN*
Beban jangka pertengahan	*24 kN*
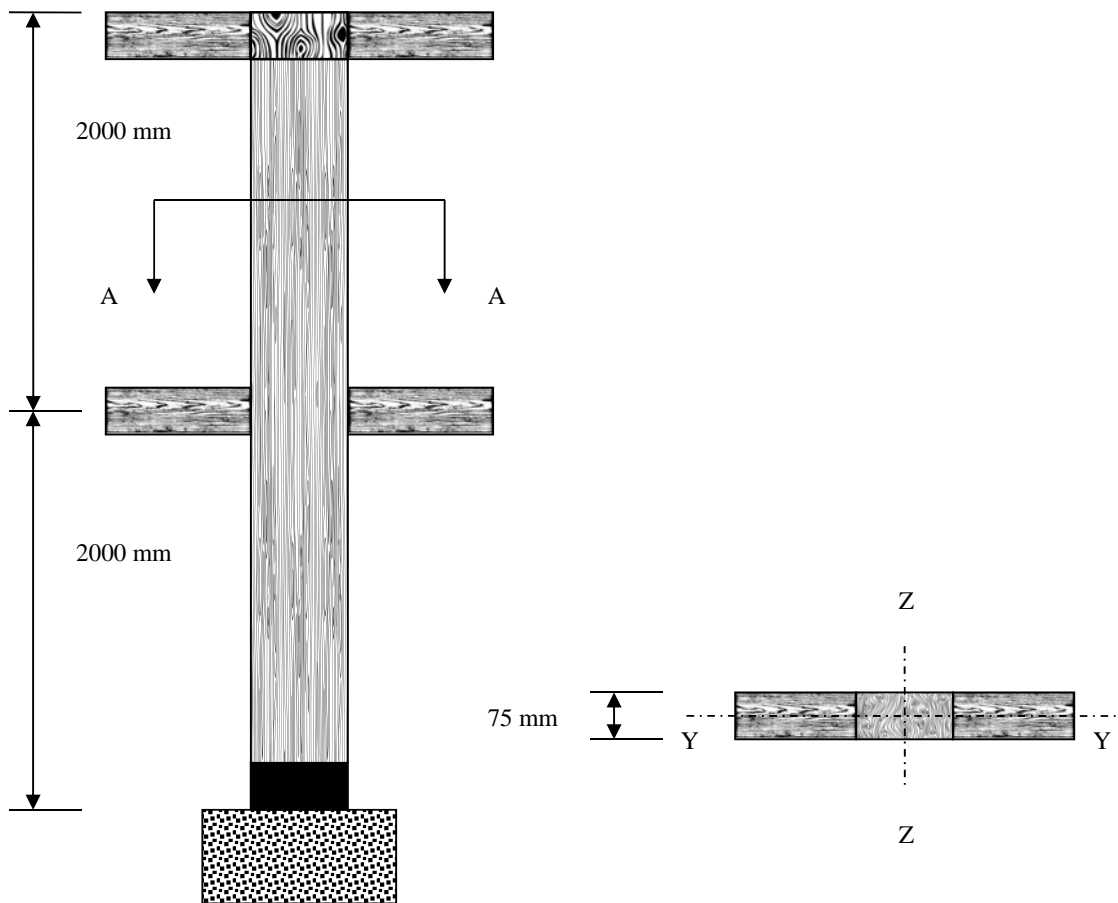
Figure 3 (a) Vertical Column

Figure 3 (b) Cross-section of column

[25 marks/*markah*]

5. A detailed cross-section of a rafter is shown in **Figure 4**. With the given data as shown in the figure, determine the number of bolt and arrangement of the bolt required to resist the loading as indicated.

*Perincian keratan rentas kekuda ditunjukkan dalam **Rajah 4**. Dengan data yang diberikan seperti dalam rajah, tentukan bilangan bolt dan susunan bolt yang diperlukan untuk merintangi beban seperti yang ditunjukkan.*

Given data:

Joint group J3

Bolt grade M12

Dry timber

Diberi data:

Kumpulan sambungan J3

Gred bolt M12

Kayu Kering

2/47 x 120 @ 47 mm apart

5.50 kN

30^0

4.76 kN

47 x 95 mm

2.75 kN

Figure 4 / *Rajah 4*
Rafters connection

[25 marks/*markah*]

APPENDIX 1/ *LAMPIRAN 1*

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

UNIVERSAL BEAMS

Advance UKB

Dimensions

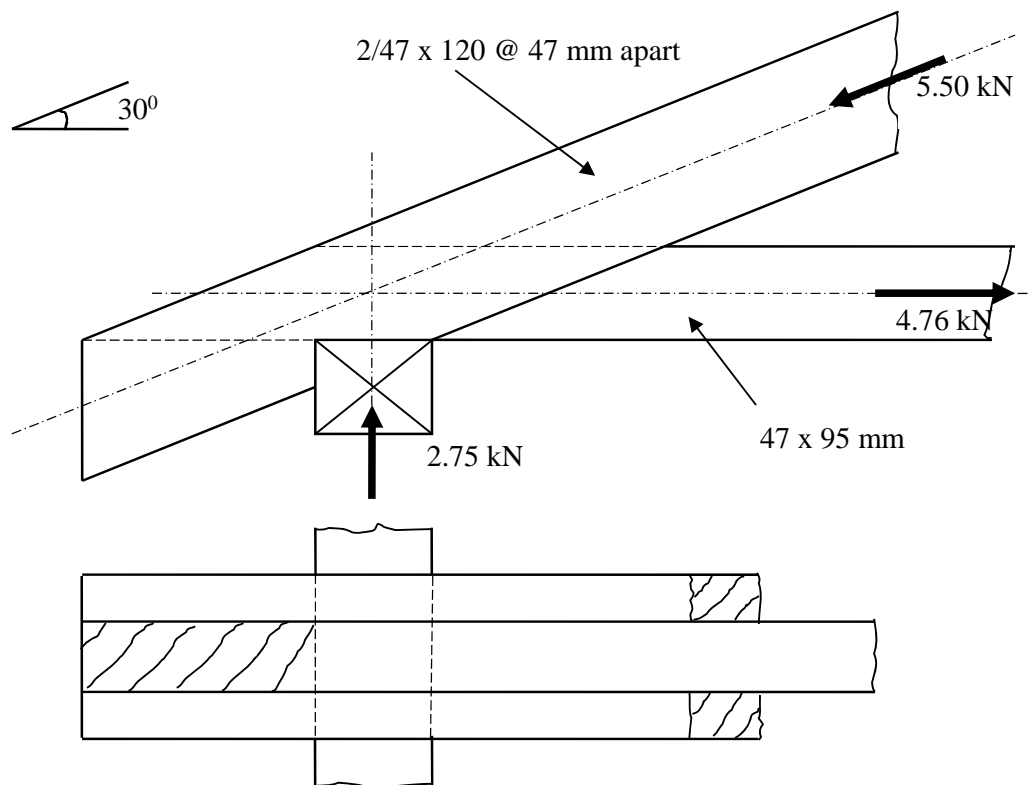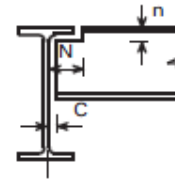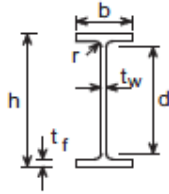| Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		h	b	t_w	t_f	r	d	c_f/t_f	c_w/t_w	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
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	406.6	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
356x171x67	67.1	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

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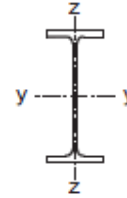
+ These sections are in addition to the range of BS 4 sections.

APPENDIX 2/ *LAMPIRAN 2*

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	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
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	153	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	56.8	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

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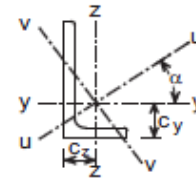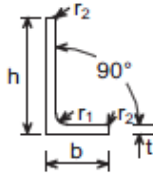
+ These sections are in addition to the range of BS 4 sections.

APPENDIX 3/ *LAMPIRAN* 3

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

UNEQUAL ANGLES

Advance UKA - Unequal Angles

Dimensions and properties

Section Designation		Mass per	Radius		Dimension		Second Moment of Area				Radius of Gyration			
Size	Thickness	Metre	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
$h \times b$	t		r_1	r_2	c_y	c_z								
mm	mm	kg/m	mm	mm	cm	cm	cm⁴	cm⁴	cm⁴	cm⁴	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

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.

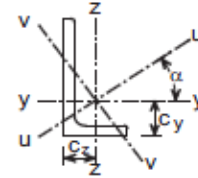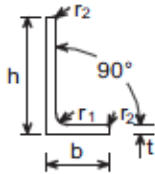+ These sections are in addition to the range of BS EN 10056-1 sections.

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

APPENDIX 4/ LAMPIRAN 4

UNEQUAL ANGLES

Advance UKA - Unequal Angles

Dimensions and properties (continued)

Section Designation		Elastic Modulus		Angle Axis y-y to Axis u-u	Torsional Constant	Equivalent Slenderness Coefficient		Mono-symmetry Index	Area of Section
Size h x b mm	Thickness t mm	Axis y-y cm³	Axis z-z cm³	Tan α	I_T cm⁴	Min ϕ_a	Max ϕ_a	ψ_a	cm²
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	4.25	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
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

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

APPENDIX 5/ *LAMPIRAN 5*

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

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

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

a) 1 bolt
b) 2 bolts
c) 3 bolts
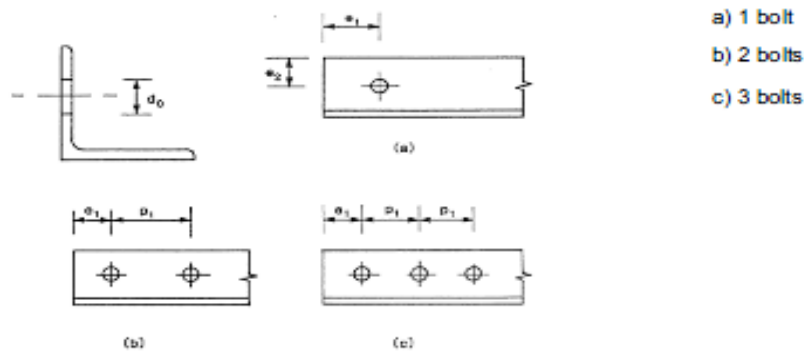
Figure 3.9: Angles connected by one leg

33

...13/-

APPENDIX 6/ *LAMPIRAN 6*

Steel Grade (S275)

E = 210000 N/mm^2

G = 81000 N/mm^2

Section	Depth of Section	Width of Section	Thickness		Depth between Fillets	Ratios for Local Buckling	
			Web	Flange		Flange	Web
	h	b	t_w	t_f	d	c_f/t_f	c_w/t_w
	mm	mm	mm	mm	mm	mm	mm
203 x 133 x 30	206.8	133.9	6.4	9.6	172.4	5.85	26.9

Section	Second Moment Of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		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	
									A
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^2
203 x 133 x 30	2900	385	8.71	3.17	280	57.5	314	88.2	38.2

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