UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2011/2012 Academic Session

June 2012

EAS 354/3 – Steel and Timber Structural Design

[*Rekabentuk Struktur Kayu dan Keluli*]

Duration : 3 hours
[*Masa : 3 jam*]

Please check that this examination paper consists of **TWENTY THREE (23)** pages of printed material including 7 appendices before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **DUA PULUH TIGA (23)** muka surat yang bercetak termasuk 7 lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.
[***Arahan** : Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan.*]

You may answer the question either in Bahasa Malaysia or English.
[*Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris*].

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) A selected trimmer beam has to be inserted between an opening as shown in **Figure 1**. Check the suitability of a the trimmer beam (100 mm x 300 mm, 2.4 m span supporting four joists spaced equally) subjected to dead load (joist and tonge & groove boarding) and imposed load.

Assume : Dry timber, SG 3, Standard

Imposed load, 4kN/m^2

Tong & frame, 0.07kN/m^2

Weight of timber, 370kg/ m^3

[15 marks]

(b) Beam effective span is defined as the distance between the centre of bearings. With the aid of sketch, indicate the centre of bearing of a beam length.

[5 marks]

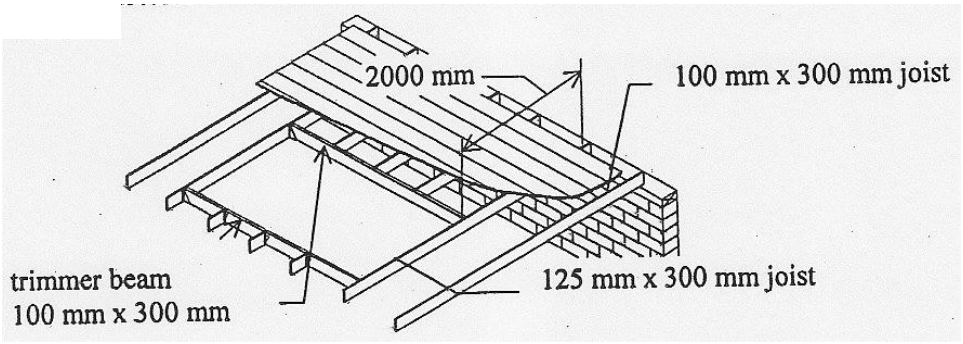


Figure 1

2. A series of solid timber columns is erected to support a covered walkway with a glazed roof as shown in **Figure 2.** Both ends of the columns are restrained in position and direction. Check the suitability of the proposed solid timber sections for a typical column.

Data:-

SG3

Dry condition

Dead load including self-weight of glazing panel = 0.32kN/m^2

Imposed load = 0.75kN/m^2

[15 marks]

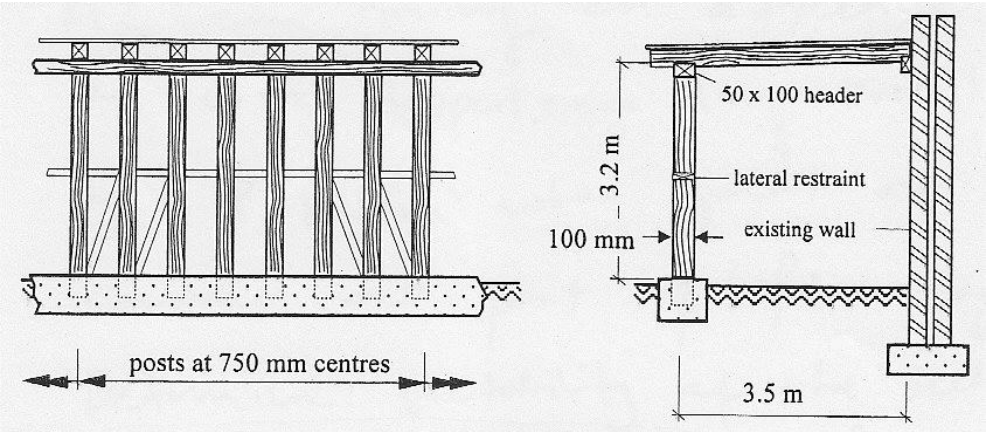


Figure 2

(b) Provide a design for the flanges of a plate girder suitable to counter a moment of 40 MN - Safety Factor already accounted for. The web is 1.0 m in depth and 10 mm in thickness. All steel is from grade S275. Your design should cover thickness and width for top and bottom flanges.

[5 marks]

3. (a) A full depth web section beam having an effective span of 6m supports a long-term load of 1.8 kN/m^2 when spaced at 600 mm centers as part of floor system. Determine suitability of the section shown in **Figure 3,** fabricated from SG3 timber and 12 mm nominal thickness.

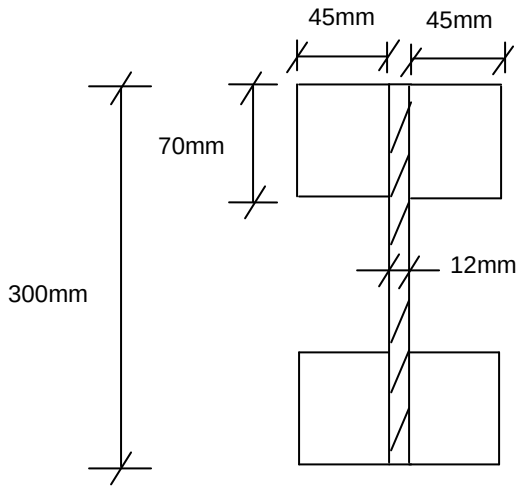


Figure 3

[15 marks]

(b) Provide a design for Member A in **Figure 4**. Safety Factors are already accounted for in the loadings. You may select an equal angle section in grade S275, from Appendix 1. (Note: $\lambda_{maximum} = 180$; for pinned ends, $L_e = L$; use most conservative curve in chart of Figure 5)

[5 marks]

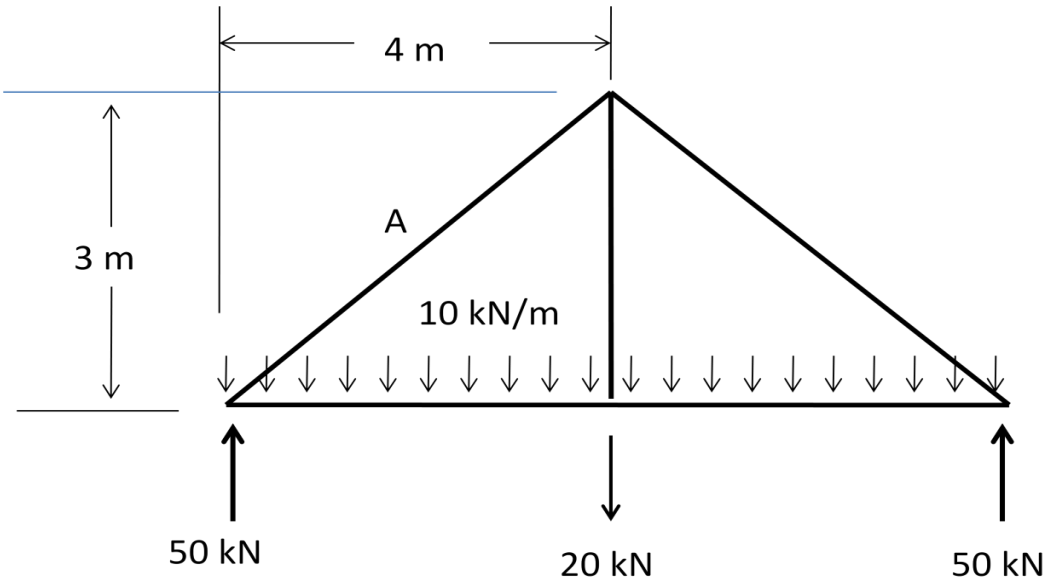


Figure 4

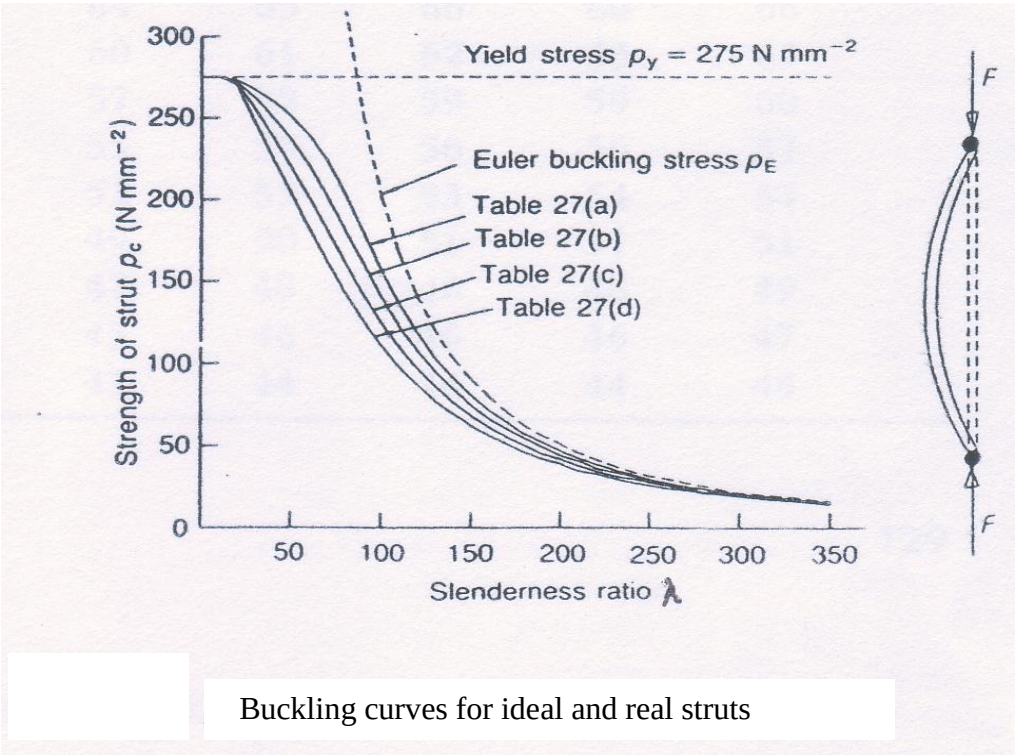


Figure 5

4. (a) A column section of grade S275 is required to support a factored axial concentric load of 2000 kN and factored bending moments of 100 kNm about the major axis, and 20 kNm about the minor axis as shown in **Figure 6** which are applied at both ends of the column. The column is 10 m long and is fully fixed against rotation at both ends, and the floors it supports are braced against sway. Check the suitability of the section if the size is selected as 356 × 368 × 177 UC.

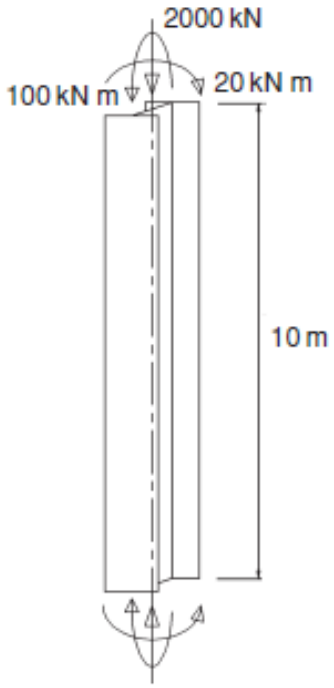


Figure 6

[10 marks]

(b) An internal member of a truss system is subjected to tensile force 270 kN from truss analysis as shown in **Figure 7.** Propose the suitable cross section of the internal tension member if,

(i) the end connections are welded;

[5 marks]

(ii) the end connections are bolted (ϕ = 24 mm bolt)

[5 marks]

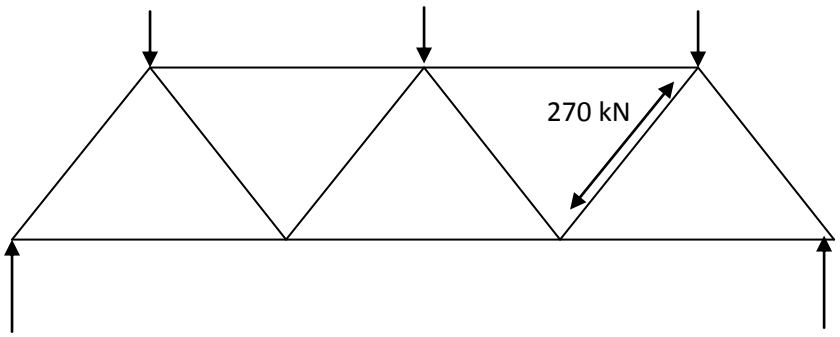


Figure 7

5. (a) The simply supported beam as shown in **Figure 8** carries a uniformly distributed characteristic dead and imposed loads of 5 kN/m each, as well as a characteristic imposed point load of 30 kN at mid-span. Assuming that the beam is fully laterally restrained and there is nominal torsional restraint at supports, select a suitable UB section of S275 to satisfy:

(i) Design bending moment and shear force

[2 marks]

(ii) Section classification

[2 marks]

(iii) Bending

[4 marks]

(iv) Shear

[3 marks]

(v) Deflection

[2 marks]

(vi) Assuming that the beam is located on 100 mm bearings at both ends, calculate web bearing and web buckling at support.

[7 marks]

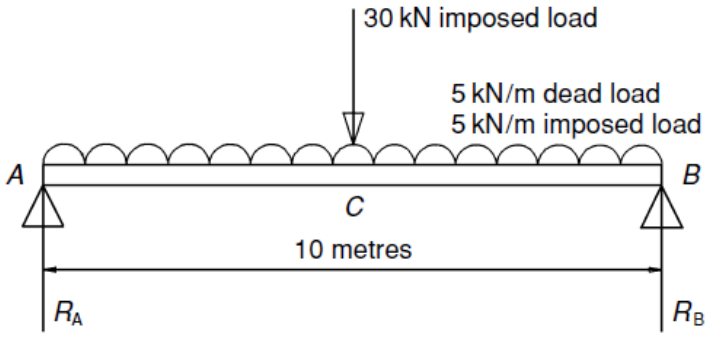
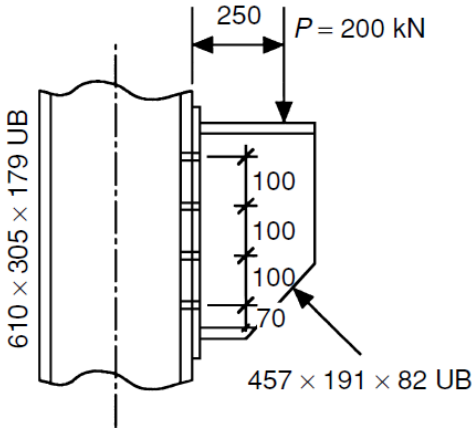


Figure 8

6. (a) **Figure 9** shows a bracket-to-column connection. The connection is subjected to concentrated load of 200 kN. Assume the bolts are all *M*16, grade 8.8. Calculate;

(i) the tension capacity of the connections

(ii) the combined shear and tension of the connections

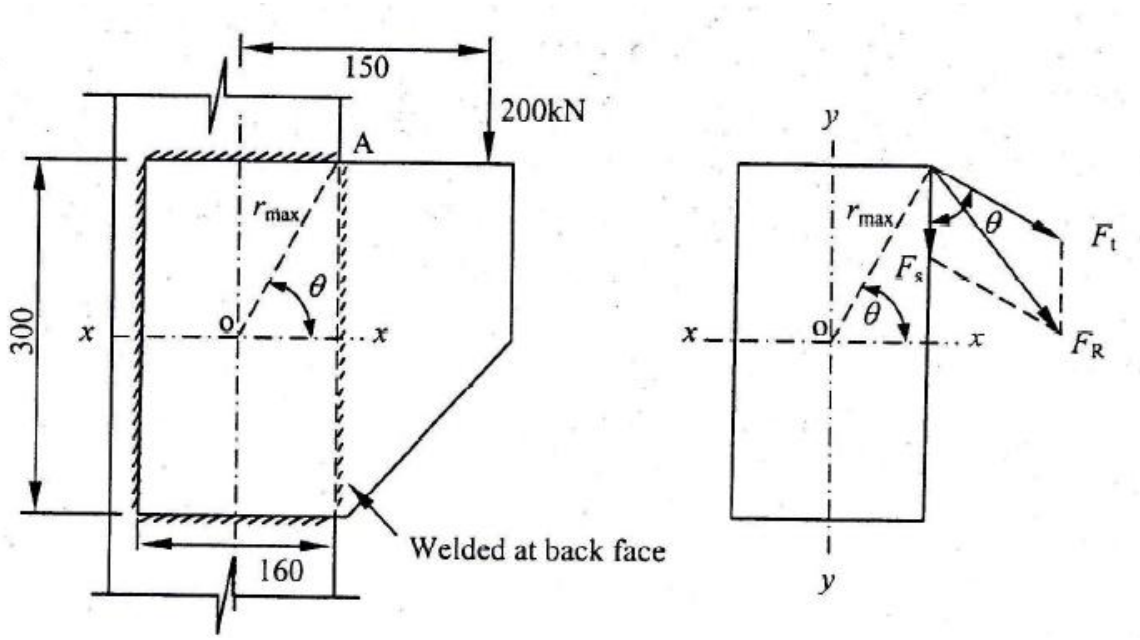


(All dimension in mm)

Figure 9

[6 marks]

(b) Determine the appropriate weld size for the connection shown in **Figure 10.**



(All dimension in mm)

Figure 10

[8 marks]

(c) State **THREE (3)** types of welding and briefly explain each type.

[6 marks]

1. (a) *Rasuk perapi terpilih di letakkan antara bukaan seperti yang ditunjukkan dalam* ***Rajah 1****. Semak kesesuaian rasuk* (100 *mm× 300 mm, 2.4 m rentang menyokong empat gelegar yang mempunyai jarak yang sama) yang dikenakan beban mati (gelegar dan lantai berlidah) dan beban kenaan.*

Anggapkan:-

Kayu kering

SG3

Beban kenaan, 4kN/m^2

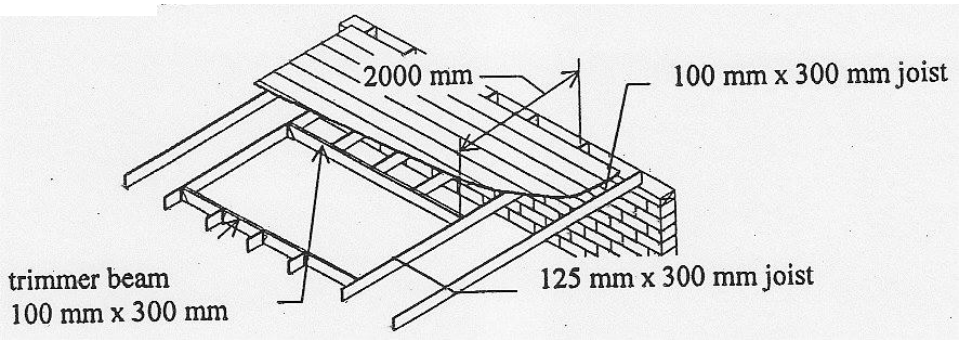
Lantai berlidah, 0.07kN/ m^2

Berat kayu, 370kg/ m^3

[15 markah]

(b) *Rentang effektif rasuk didefinasikan sebagai jarak rasuk antara pusat galas. Dengan berbentukan lakaran, tunjukkan ukuran yang sepatutnya antara pusat galas untuk satu panjang rasuk.*

[5 markah]



Rajah 1

2. *Sebaris tiang kayu didirikan untuk menyokong lakaran rajah menyusul dibumbungi bahan berkaca seperti yang ditunjukkan dalam* ***Rajah 2.*** *Kedua-dua hujung tiang dikekang dalam kedudukan dan arahnya. Semak kesesuaian keratan kayu yang dicadangkan untuk anggota tiang.*

Data:-

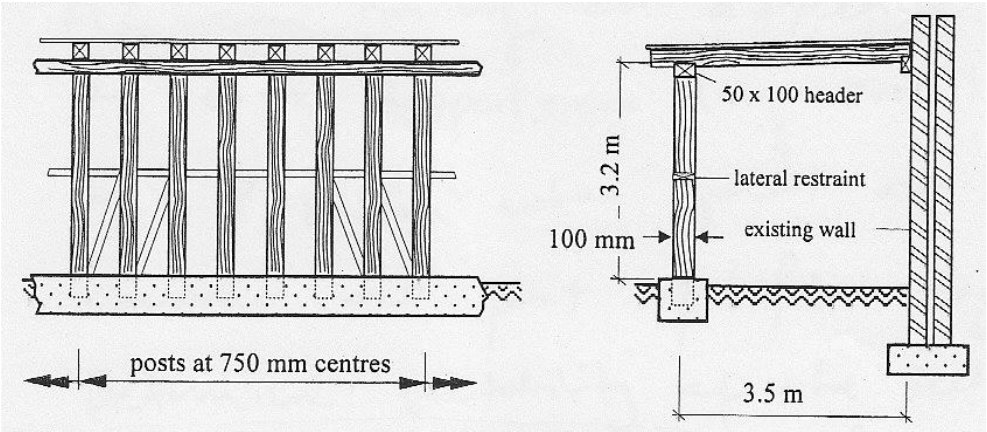
SG3

Keadaan kering

Beban mati termasuk berat sendiri panel berkaca = 0.32kN/m^2

Beban kenaan = 0.75kN/m^2

[15 markah]



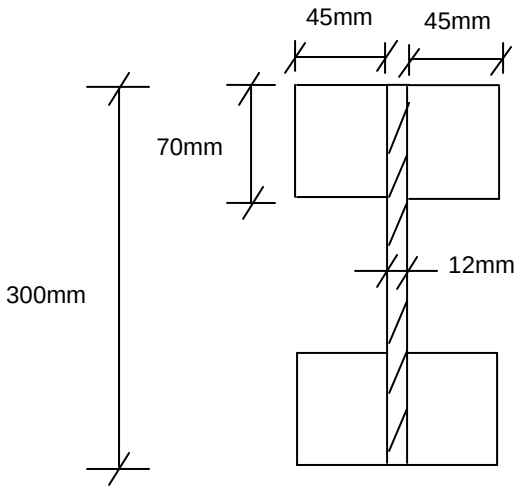
Rajah 2

(b) Berikan rekabentuk bebibir galang plat bagi menampung momen bernilai 40 MN – Faktor Keselamatan sudah diambil kira. Web mempunyai kedalaman 1.0 m dan ketebalan 10 mm. Semua keluli bergred S275. Rekabentuk mestilah meliputi tebal dan lebar bebibir atas dan bawah.

[5 markah]

*3. Sebuah rasuk web kedalaman penuh mempunyai rentang efektif 6m membawa beban jangka-panjang 1.8kN/m^2 yang mempunyai jarak luang 600 mm sebagai daripada sistem lantai. Tentukan kesesuaian keratan yang ditunjukkan dalam **Rajah 3** dipasang menggunakan SG3 dan ketebalan web 12mm.*

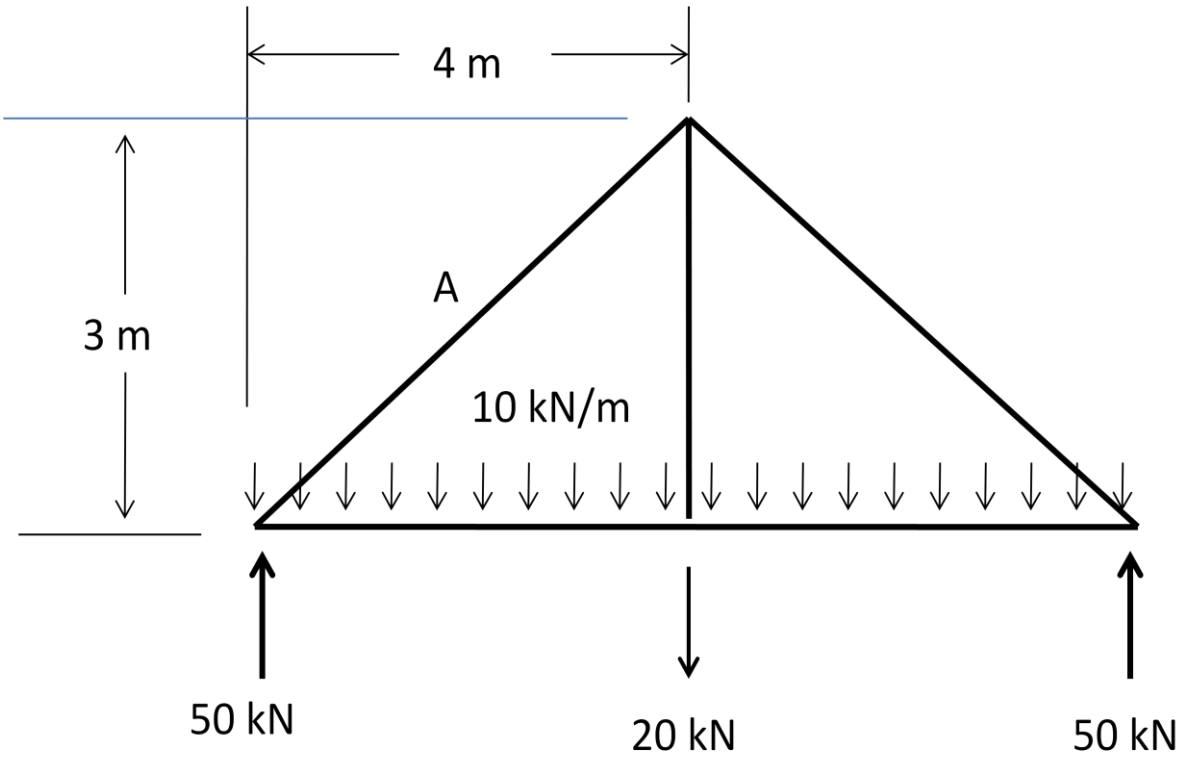
[15 markah]



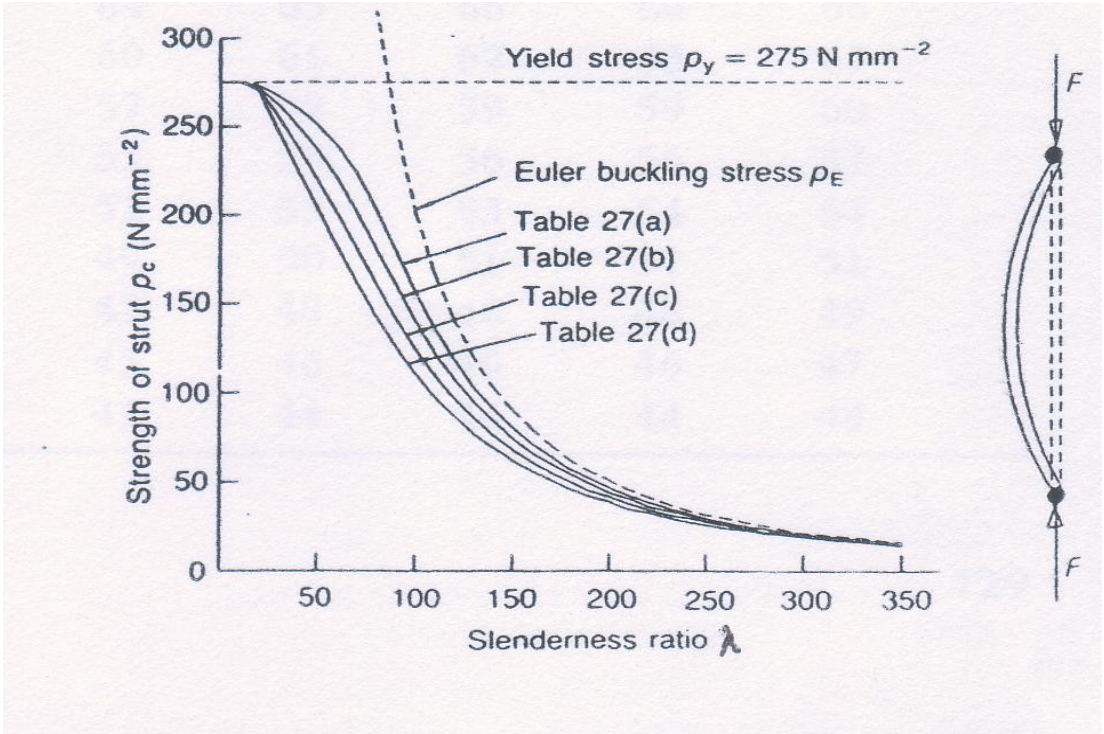
Rajah 3

(b) *Berikan rekabentuk Anggota A dalam **Rajah 4**. Faktor Keselamatan sudah diambil kira dalam bebanan yang ditunjukkan. Anda boleh memilih anggota sesiku bergred S275 daripada jadual Apendix 1. (Nota: $\lambda_{maximum}$ = 180; bagi hujung berpin, L_e = L; gunakan lengkungan paling konservatif dari **Rajah 5**).*

[5 markah]



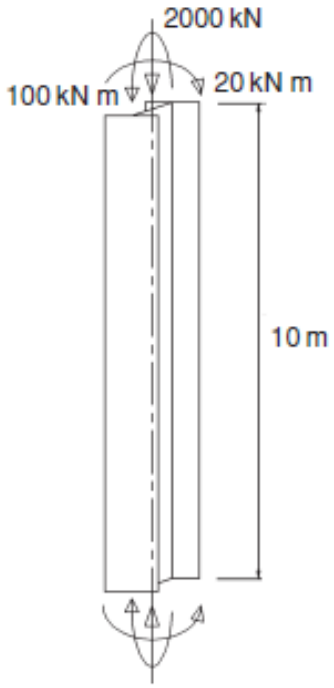
Rajah 4



Buckling curves for ideal and real struts

Rajah 5

4. (a) *Keratan tiang dengan gred keluli S275 perlu menyokong beban tumpu paksi yang terfaktor 2000 kN dan momen lentur terfaktor 100 kNm pada paksi utama dan 20 kNm pada paksi minor seperti yang ditunjukkan dalam* ***Rajah 6,*** *dikenakan pada kedua hujung tiang tersebut. Panjang tiang adalah 10 m dan dikekang sepenuhnya terhadap putaran pada kedua-dua hujung, dan penyokong lantai dikekang bagi terhadap huyung. Periksa kesesuaian keratan sekiranya saiz yang dipilih adalah 356 × 368 × 177 UC.*



Rajah 6

[10 markah]

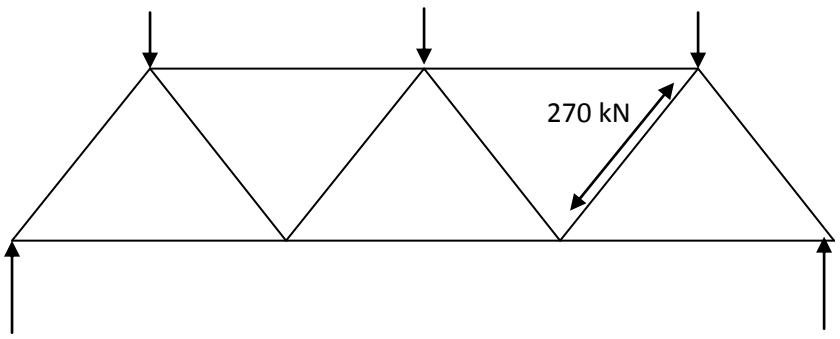
(b) *Anggota dalaman sebuah sistem kekuda menanggung daya tegangan 270 kN daripada analisis kekuda seperti yang ditunjukkan dalam* ***Rajah 7.*** *Cadangkan keratan yang sesuai untuk anggota tegangan dalaman tersebut sekiranya:*

(i) *Sambungan hujungnya adalah kimpalan;*

[5 markah]

(ii) *Sambungan hujungnya adalah bolt (ϕ bolt = 24 mm)*

[5 markah]



Rajah 7

5. (a) *Rasuk sokong mudah seperti dalam* ***Rajah 8*** *menanggung beban mati ciri teragih seragam 5 kN/m, beban kenaan sebanyak 5 kN/m dan juga beban tumpu kenaan ciri 30 kN pada tengah rentang. Anggap rasuk adalah dikekang sisi sepenuhnya dan terdapat kekangan kilasan nominal pada penyokong. Pilih keratan UB yang sesuai dalam keluli gred S275 untuk memenuhi:*

(i) Rekabentuk momen lentur dan daya ricih

[2 markah]

(ii) Pengelasan keratan

[2 markah]

(iii) Lenturan

[4 markah]

(iv) Ricih

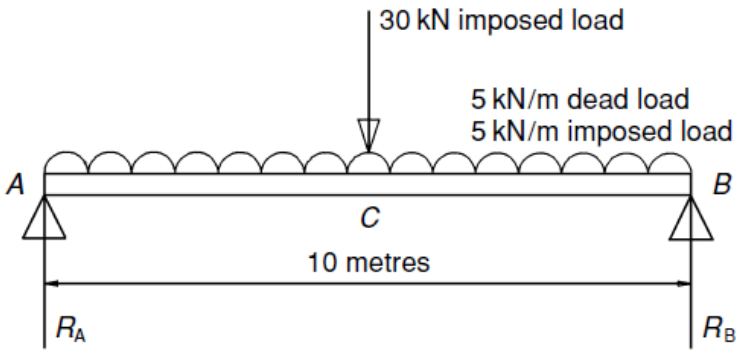
[3 markah]

(v) Anjakan

[2 markah]

(v) Anggap rasuk tersebut terletak di atas galas pada setiap hujung dengan saiz 100 m. Kirakan galas web dan lengkukan web pada penyokong.

[7 markah]

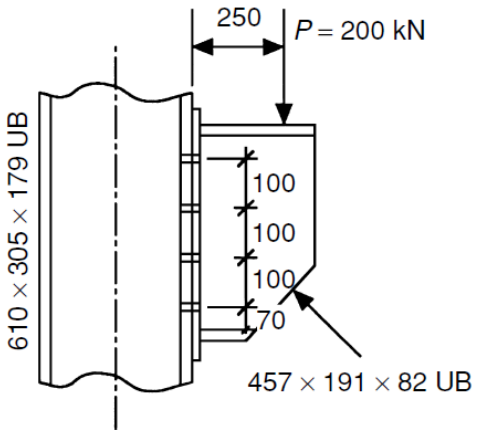


Rajah 8

6. (a) ***Rajah 9*** *menunjukkan sambungan pendakap pada tiang. Sambungan dikenakan beban tumpu sebanyak 200 kN. Anggap semua bolt adalah M16, gred 8.8. Kirakan,*

(i) kekuatan tegangan bagi sambungan

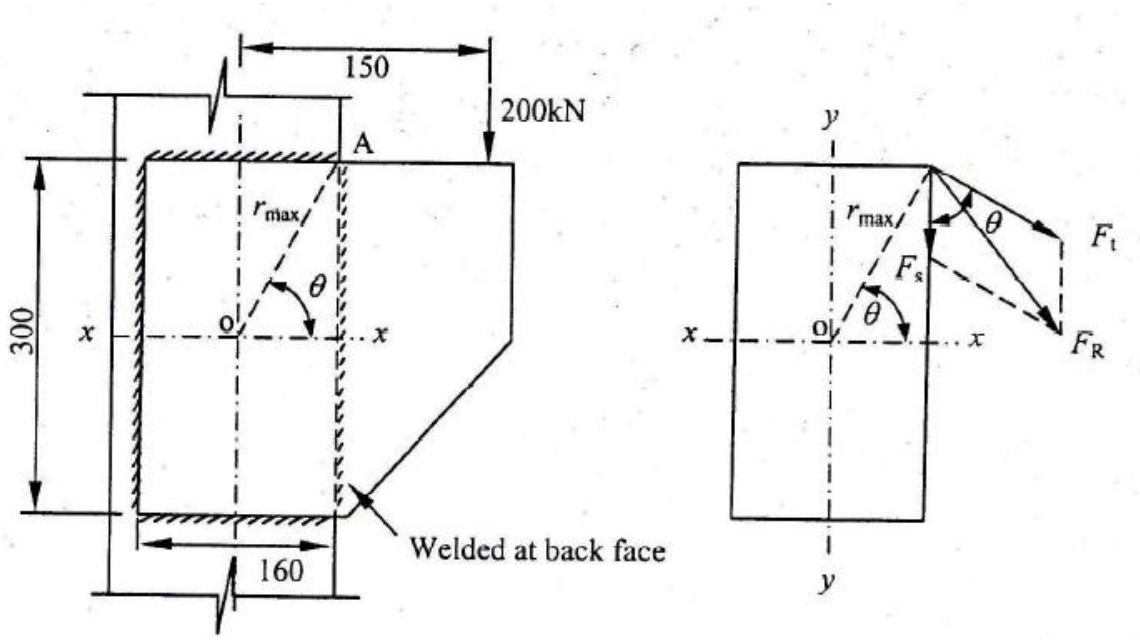
(ii) Gabungan ricih dan tegangan bagi sambungan



Rajah 9

[6 markah]

(b) *Tentukan saiz yang sesuai untuk sambungan yang ditunjukkan di dalam* ***Rajah 10.***



Rajah 10

[8 markah]

*(c) Nyatakan **TIGA (3)** jenis kimpalan dan terangkan secara ringkas setiap jenis.*

[6 markah]

<u>Appendix 1</u>
<u>*Lampiran 1*</u>

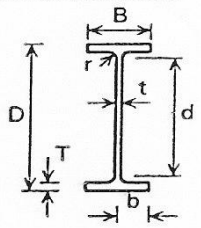
Table B2 Dimensions and properties of steel universal columns (structural sections to BS 4: Part 1)

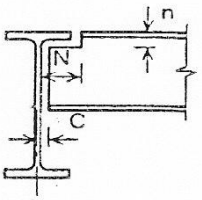
Designation: Serial size (mm)	Designation: Mass per metre (kg)	Depth of section D (mm)	Width of section B (mm)	Thickness: Web t (mm)	Thickness: Flange T (mm)	Root radius r (mm)	Depth between fillets d (mm)	Ratios for local buckling: Flange b/T	Ratios for local buckling: Web d/t	Second moment of area: Axis x–x (cm^4)	Second moment of area: Axis y–y (cm^4)	Radius of gyration: Axis x–x (cm)	Radius of gyration: Axis y–y (cm)	Elastic modulus: Axis x–x (cm^3)	Elastic modulus: Axis y–y (cm^3)	Plastic modulus: Axis x–x (cm^3)	Plastic modulus: Axis y–y (cm^3)	Buckling parameter u	Torsional index x	Warping constant H (dm^6)	Torsional constant J (cm^4)	Area of section A (cm^2)
356×406	634	474.7	424.1	47.6	77.0	15.2	290.2	2.75	6.10	275 000	98 200	18.5	11.0	11 600	4630	14 200	7110	0.843	5.46	38.8	13 700	808
	551	455.7	418.5	42.0	67.5	15.2	290.2	3.10	6.91	227 000	82 700	18.0	10.9	9 960	3950	12 100	6060	0.841	6.05	31.1	9 240	702
	467	436.6	412.4	35.9	58.0	15.2	290.2	3.56	8.08	183 000	67 900	17.5	10.7	8 390	3290	10 000	5040	0.839	6.86	24.3	5 820	595
	393	419.1	407.0	30.6	49.2	15.2	290.2	4.14	9.48	14 700	55 400	17.1	10.5	7 000	2720	8 230	4160	0.837	7.86	19.0	3 550	501
	340	406.4	403.0	26.5	42.9	15.2	290.2	4.70	11.0	12 200	46 800	16.8	10.4	6 030	2320	6 990	3540	0.836	8.85	15.5	2 340	433
	287	393.7	399.0	22.6	36.5	15.2	290.2	5.47	12.8	100 000	38 700	16.5	10.3	5 080	1940	5 820	2950	0.835	10.2	12.3	1 440	366
	235	381.0	395.0	18.5	30.2	15.2	290.2	6.54	15.7	79 100	31 000	16.2	10.2	4 150	1570	4 690	2380	0.834	12.1	9.54	812	300
COLCORE	477	427.0	424.4	48.0	53.2	15.2	290.2	3.99	6.05	172 000	68 100	16.8	10.6	8 080	3210	9 700	4980	0.815	6.91	23.8	5 700	607
356×368	202	374.7	374.4	16.8	27.0	15.2	290.2	6.93	17.3	66 300	23 600	16.0	9.57	3 540	1260	3 980	1920	0.844	13.3	7.14	560	258
	177	368.3	372.1	14.5	23.8	15.2	290.2	7.82	20.0	57 200	20 500	15.9	9.52	3 100	1100	3 460	1670	0.844	15.0	6.07	383	226
	153	362.0	370.2	12.6	20.7	15.2	290.2	8.94	23.0	48 500	17 500	15.8	9.46	2 680	944	2 960	1430	0.844	17.0	5.09	251	195
	129	355.6	368.3	10.7	17.5	15.2	290.2	10.5	27.1	40 200	14 600	15.6	9.39	2 260	790	2 480	1200	0.843	19.9	4.16	153	165
305×305	283	365.3	321.8	26.9	44.1	15.2	246.6	3.65	9.17	78 800	24 500	14.8	8.25	4 310	1530	5 100	2340	0.855	7.65	6.33	2 030	360
	240	352.6	317.9	23.0	37.7	15.2	246.6	4.22	10.7	64 200	20 200	14.5	8.14	3 640	1270	4 250	1950	0.854	8.73	5.01	1 270	306
	198	339.9	314.1	19.2	31.4	15.2	246.6	5.00	12.8	50 800	16 200	14.2	8.02	2 990	1030	3 440	1580	0.854	10.2	3.86	734	252
	158	327.2	310.6	15.7	25.0	15.2	246.6	6.21	15.7	38 700	12 500	13.9	7.89	2 370	806	2 680	1230	0.852	12.5	2.86	379	201
	137	320.5	308.7	13.8	21.7	15.2	246.6	7.11	17.9	32 800	10 700	13.7	7.82	2 050	691	2 300	1050	0.851	14.1	2.38	250	175
	118	314.5	306.8	11.9	18.7	15.2	246.6	8.20	20.7	27 600	9 010	13.6	7.75	1 760	587	1 950	892	0.851	16.2	1.97	160	150
	97	307.8	304.8	9.9	15.4	15.2	246.6	9.90	24.9	22 200	7 270	13.4	7.68	1 440	477	1 590	723	0.85	19.3	1.55	91.1	123
254×254	167	289.1	264.5	19.2	31.7	12.7	200.3	4.17	10.4	29 900	9 800	11.9	6.79	2 070	741	2 420	1130	0.852	8.49	1.62	625	212
	132	276.4	261.0	15.6	25.3	12.7	200.3	5.16	12.8	22 600	7 520	11.6	6.67	1 630	576	1 870	879	0.85	10.3	1.18	322	169
	107	266.7	258.3	13.0	20.5	12.7	200.3	6.30	15.4	17 500	5 900	11.3	6.57	1 310	457	1 490	695	0.848	12.4	0.894	173	137
	89	260.4	255.9	10.5	17.3	12.7	200.3	7.40	19.1	14 300	4 850	11.2	6.52	1 100	379	1 230	575	0.849	14.4	0.716	104	114
	73	254.0	254.0	8.6	14.2	12.7	200.3	8.94	23.3	11 400	3 870	11.1	6.46	894	305	989	462	0.849	17.3	0.557	57.3	92.9
203×203	86	222.3	208.8	13.0	20.5	10.2	160.9	5.09	12.4	9 460	3 120	9.27	5.32	851	299	979	456	0.85	10.2	0.317	138	110
	71	215.9	206.2	10.3	17.3	10.2	160.9	5.96	15.6	7 650	2 540	9.16	5.28	708	246	802	374	0.852	11.9	0.25	81.5	91.1
	60	209.6	205.2	9.3	14.2	10.2	160.9	7.23	17.3	6 090	2 040	8.96	5.19	581	199	652	303	0.847	14.1	0.195	46.6	75.8
	52	206.2	203.9	8.0	12.5	10.2	160.9	8.16	20.1	5 260	1 770	8.90	5.16	510	174	568	264	0.848	15.8	0.166	32.0	66.4
	46	203.2	203.2	7.3	11.0	10.2	160.9	9.24	22.0	4 560	1 540	8.81	5.11	449	151	497	230	0.846	17.7	0.142	22.2	58.8
152×152	37	161.8	154.4	8.1	11.5	7.6	123.5	6.71	15.2	2 220	709	6.84	3.87	274	91.8	310	140	0.848	13.3	0.04	19.5	47.4
	30	157.5	152.9	6.6	9.4	7.6	123.5	8.13	18.7	1 740	558	6.75	3.82	221	73.1	247	111	0.848	16.0	0.0306	10.5	38.2
	23	152.4	152.4	6.1	6.8	7.6	123.5	11.2	20.2	1 260	403	6.51	3.68	166	52.9	184	80.9	0.837	20.4	0.0214	4.87	29.8

Appendix 2
Lampiran 2

BS 5950-1: 2000
BS 4-1: 1993

UNIVERSAL BEAMS





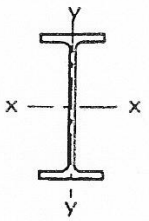
DIMENSIONS

Section Designation	Mass per Metre	Depth of Section	Width of Section	Thickness		Root Radius	Depth between Fillets	Ratios for Local Buckling		Dimensions for Detailing			Surface Area	
				Web	Flange			Flange	Web	End Clearance	Notch		Per Metre	Per Tonne
		D	B	t	T	r	d	b/T	d/t	C	N	n		
	kg/m	mm	mm	mm	mm	mm	mm			mm	mm	mm	m^2	m^2
457x191x98	98.3	467.2	192.8	11.4	19.6	10.2	407.6	4.92	35.8	8	102	30	1.67	16.9
457x191x89	89.3	463.4	191.9	10.5	17.7	10.2	407.6	5.42	38.8	7	102	28	1.66	18.5
457x191x82	82.0	460.0	191.3	9.9	16.0	10.2	407.6	5.98	41.2	7	102	28	1.65	20.1
457x191x74	74.3	457.0	190.4	9.0	14.5	10.2	407.6	6.57	45.3	7	102	26	1.64	22.1
457x191x67	67.1	453.4	189.9	8.5	12.7	10.2	407.6	7.48	48.0	6	102	24	1.63	24.3
457x152x82	82.1	465.8	155.3	10.5	18.9	10.2	407.6	4.11	38.8	7	84	30	1.51	18.4
457x152x74	74.2	462.0	154.4	9.6	17.0	10.2	407.6	4.54	42.5	7	84	28	1.50	20.3
457x152x67	67.2	458.0	153.8	9.0	15.0	10.2	407.6	5.13	45.3	7	84	26	1.50	22.3
457x152x60	59.8	454.6	152.9	8.1	13.3	10.2	407.6	5.75	50.3	6	84	24	1.49	24.9
457x152x52	52.3	449.8	152.4	7.6	10.9	10.2	407.6	6.99	53.6	6	84	22	1.48	28.2
406x178x74	74.2	412.8	179.5	9.5	16.0	10.2	360.4	5.61	37.9	7	96	28	1.51	20.3
406x178x67	67.1	409.4	178.8	8.8	14.3	10.2	360.4	6.25	41.0	6	96	26	1.50	22.3
406x178x60	60.1	406.4	177.9	7.9	12.8	10.2	360.4	6.95	45.6	6	96	24	1.49	24.8
406x178x54	54.1	402.6	177.7	7.7	10.9	10.2	360.4	8.15	46.8	6	96	22	1.48	27.4
406x140x46	46.0	403.2	142.2	6.8	11.2	10.2	360.4	6.35	53.0	5	78	22	1.34	29.2
406x140x39	39.0	398.0	141.8	6.4	8.6	10.2	360.4	8.24	56.3	5	78	20	1.33	34.2
356x171x67	67.1	363.4	173.2	9.1	15.7	10.2	311.6	5.52	34.2	7	94	26	1.38	20.6
356x171x57	57.0	358.0	172.2	8.1	13.0	10.2	311.6	6.62	38.5	6	94	24	1.37	24.1
356x171x51	51.0	355.0	171.5	7.4	11.5	10.2	311.6	7.46	42.1	6	94	22	1.36	26.7
356x171x45	45.0	351.4	171.1	7.0	9.7	10.2	311.6	8.82	44.5	6	94	20	1.36	30.1
356x127x39	39.1	353.4	126.0	6.6	10.7	10.2	311.6	5.89	47.2	5	70	22	1.18	30.2
356x127x33	33.1	349.0	125.4	6.0	8.5	10.2	311.6	7.38	51.9	5	70	20	1.17	35.4
305x165x54	54.0	310.4	166.9	7.9	13.7	8.9	265.2	6.09	33.6	6	90	24	1.26	23.3
305x165x46	46.1	306.6	165.7	6.7	11.8	8.9	265.2	7.02	39.6	5	90	22	1.25	27.1
305x165x40	40.3	303.4	165.0	6.0	10.2	8.9	265.2	8.09	44.2	5	90	20	1.24	30.8
305x127x48	48.1	311.0	125.3	9.0	14.0	8.9	265.2	4.47	29.5	7	70	24	1.09	22.7
305x127x42	41.9	307.2	124.3	8.0	12.1	8.9	265.2	5.14	33.1	6	70	22	1.08	25.8
305x127x37	37.0	304.4	123.4	7.1	10.7	8.9	265.2	5.77	37.4	6	70	20	1.07	29.0
305x102x33	32.8	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	5	58	20	1.01	30.8
305x102x28	28.2	308.7	101.8	6.0	8.8	7.6	275.9	5.78	46.0	5	58	18	1.00	35.4
305x102x25	24.8	305.1	101.6	5.8	7.0	7.6	275.9	7.26	47.6	5	58	16	0.992	40.0
254x146x43	43.0	259.6	147.3	7.2	12.7	7.6	219.0	5.80	30.4	6	82	22	1.08	25.1
254x146x37	37.0	256.0	146.4	6.3	10.9	7.6	219.0	6.72	34.8	5	82	20	1.07	29.0
254x146x31	31.1	251.4	146.1	6.0	8.6	7.6	219.0	8.49	36.5	5	82	18	1.06	34.2
254x102x28	28.3	260.4	102.2	6.3	10.0	7.6	225.2	5.11	35.7	5	58	18	0.904	31.9
254x102x25	25.2	257.2	101.9	6.0	8.4	7.6	225.2	6.07	37.5	5	58	16	0.897	35.6
254x102x22	22.0	254.0	101.6	5.7	6.8	7.6	225.2	7.47	39.5	5	58	16	0.890	40.5
203x133x30	30.0	206.8	133.9	6.4	9.6	7.6	172.4	6.97	26.9	5	74	18	0.923	30.8
203x133x25	25.1	203.2	133.2	5.7	7.8	7.6	172.4	8.54	30.2	5	74	16	0.915	36.4
203x102x23	23.1	203.2	101.8	5.4	9.3	7.6	169.4	5.47	31.4	5	60	18	0.790	34.2
178x102x19	19.0	177.8	101.2	4.8	7.9	7.6	146.8	6.41	30.6	4	60	16	0.738	38.8
152x89x16	16.0	152.4	88.7	4.5	7.7	7.6	121.6	5.76	27.1	4	54	16	0.638	39.8
127x76x13	13.0	127.0	76.0	4.0	7.6	7.6	96.6	5.00	24.1	4	46	16	0.537	41.3

Appendix 3
Lampiran 3

BS 5950-1: 2000
BS 4-1: 1993

UNIVERSAL BEAMS



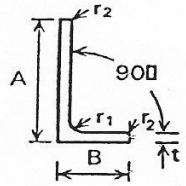
PROPERTIES

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y					
	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	u	x	H dm^6	J cm^4	A cm^2
457x191x98	45700	2350	19.1	4.33	1960	243	2230	379	0.882	25.7	1.18	121	125
457x191x89	41000	2090	19.0	4.29	1770	218	2010	338	0.879	26.3	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	0.872	37.9	0.705	37.1	85.5
457x152x82	36600	1190	18.7	3.37	1570	153	1810	240	0.871	27.4	0.591	89.2	105
457x152x74	32700	1050	18.6	3.33	1410	136	1630	213	0.873	30.2	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
406x178x74	27300	1550	17.0	4.04	1320	172	1500	267	0.882	27.6	0.608	62.8	94.5
406x178x67	24300	1370	16.9	3.99	1190	153	1350	237	0.880	30.5	0.533	46.1	85.5
406x178x60	21600	1200	16.8	3.97	1060	135	1200	209	0.880	33.6	0.466	33.3	76.5
406x178x54	18700	1020	16.5	3.85	930	115	1060	178	0.871	38.3	0.392	23.1	69.0
406x140x46	15700	538	16.4	3.03	778	75.7	888	118	0.872	39.0	0.207	19.0	58.6
406x140x39	12500	410	15.9	2.87	629	57.8	724	90.8	0.858	47.5	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	89.1	0.871	35.2	0.105	15.1	49.8
356x127x33	8250	280	14.0	2.58	473	44.7	543	70.3	0.863	42.2	0.081	8.79	42.1
305x165x54	11700	1060	13.0	3.93	754	127	845	196	0.889	23.6	0.234	34.8	68.8
305x165x46	9900	896	13.0	3.90	646	108	720	166	0.891	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
305x127x48	9580	461	12.5	2.74	616	73.6	711	116	0.874	23.3	0.102	31.6	61.2
305x127x42	8200	389	12.4	2.70	534	62.6	614	98.4	0.872	26.6	0.0846	21.1	53.4
305x127x37	7170	336	12.3	2.67	471	54.5	539	85.4	0.871	29.7	0.0725	14.6	47.2
305x102x33	6500	194	12.5	2.15	416	37.9	481	60.0	0.867	31.6	0.0442	12.2	41.8
305x102x28	5370	155	12.2	2.08	348	30.5	403	48.5	0.859	37.4	0.0349	7.40	35.9
305x102x25	4460	123	11.9	1.97	292	24.2	342	38.8	0.846	43.4	0.0273	4.77	31.6
254x146x43	6540	677	10.9	3.52	504	92.0	566	141	0.890	21.2	0.103	23.9	54.8
254x146x37	5540	571	10.8	3.48	433	78.0	483	119	0.889	24.4	0.0857	15.3	47.2
254x146x31	4410	448	10.5	3.36	351	61.3	393	94.1	0.879	29.6	0.0660	8.55	39.7
254x102x28	4010	179	10.5	2.22	308	34.9	353	54.8	0.874	27.5	0.0280	9.57	36.1
254x102x25	3420	149	10.3	2.15	266	29.2	306	46.0	0.867	31.4	0.0230	6.42	32.0
254x102x22	2840	119	10.1	2.06	224	23.5	259	37.3	0.856	36.3	0.0182	4.15	28.0
203x133x30	2900	385	8.71	3.17	280	57.5	314	88.2	0.881	21.5	0.0374	10.3	38.2
203x133x25	2340	308	8.56	3.10	230	46.2	258	70.9	0.877	25.6	0.0294	5.96	32.0
203x102x23	2110	164	8.46	2.36	207	32.2	234	49.8	0.888	22.5	0.0154	7.02	29.4
178x102x19	1360	137	7.48	2.37	153	27.0	171	41.6	0.886	22.6	0.00987	4.41	24.3
152x89x16	834	89.8	6.41	2.10	109	20.2	123	31.2	0.889	19.6	0.00470	3.56	20.3
127x76x13	473	55.7	5.35	1.84	74.6	14.7	84.2	22.6	0.896	16.3	0.00199	2.85	16.5

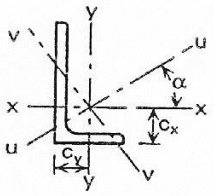
Appendix 4
Lampiran 4

BS 5950-1: 2000
BS EN 10056-1: 1999

UNEQUAL ANGLES



DIMENSIONS AND PROPERTIES



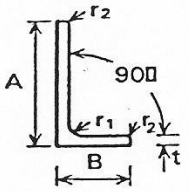
Section Designation		Mass per	Radius		Dimension		Second Moment of Area				Radius of Gyration			
Size	Thickness	Metre	Root	Toe			Axis x-x	Axis y-y	Axis u-u	Axis v-v	Axis x-x	Axis y-y	Axis u-u	Axis v-v
A x B	t		r_1	r_2	c_x	c_y								
mm	mm	kg/m	mm	mm	cm	cm	cm^4	cm^4	cm^4	cm^4	cm	cm	cm	cm
200x150	18 #	47.1	15.0	7.50	6.34	3.86	2390	1160	2920	623	6.30	4.38	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	4.85	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	12.6	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	26.4	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	6.00	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

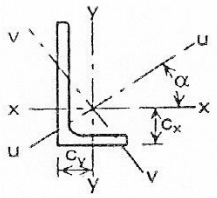
? Not available from some leading producers. Check availability.
Check availability.
c_x is the distance from the back of the short leg to the centre of gravity.
c_y is the distance from the back of the long leg to the centre of gravity.
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

Appendix 5
Lampiran 5

BS 5950-1: 2000
BS EN 10056-1: 1999

UNEQUAL ANGLES





DIMENSIONS AND PROPERTIES (CONTINUED)

Section Designation		Elastic Modulus		Angle Axis x-x to Axis u-u Tan α	Torsional Constant	Equivalent Slenderness Coefficient		Mono-symmetry Index	Area of Section
Size	Thickness	Axis x-x	Axis y-y			Min	Max		
A x B mm	t mm	cm^3	cm^3		J cm^4	ϕ_a	ϕ_a	ψ_a	cm^2
200x150	18 #	175	104	0.549	67.9	2.93	3.72	4.60	60.1
	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	3.69	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	2.65	3.87	5.92	2.87
40x25	4 □	1.47	0.619	0.360	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

? Not available from some leading producers. Check availability.
Check availability.
FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

Appendix 6
Lampiran 6

Tensile stress area, A_t

Nominal size and thread diameter (mm)	*Tensile stress area, A_t (mm^2)*
12	84.3
16	157
20	245
22	303
24	353
27	459
30	561

Appendix 7
Lampiran 7

BS 5950-1 :2000
BS EN 440
BS EN 499
BS EN 756
BS EN 758
BS EN 1668

FILLET WELDS

WELD CAPACITIES WITH E35 ELECTRODE WITH S275

Leg Length s mm	Throat Thickness a mm	Longitudinal Capacity P_L kN/mm	Transverse Capacity P_T kN/mm
3.0	2.1	0.462	0.577
4.0	2.8	0.616	0.770
5.0	3.5	0.770	0.963
6.0	4.2	0.924	1.155
8.0	5.6	1.232	1.540
10.0	7.0	1.540	1.925
12.0	8.4	1.848	2.310
15.0	10.5	2.310	2.888
18.0	12.6	2.772	3.465
20.0	14.0	3.080	3.850
22.0	15.4	3.388	4.235
25.0	17.5	3.850	4.813

Welds are between two elements at 90° to each other.
$P_L = p_w a$
$P_T = K p_w a$
$p_w = 220$ N/mm^2
K = 1.25 for elements at 90° to each other.

BS 5950-1 :2000
BS EN 440
BS EN 499
BS EN 756
BS EN 758
BS EN 1668

FILLET WELDS

WELD CAPACITIES WITH E42 ELECTRODE WITH S355

Leg Length s mm	Throat Thickness a mm	Longitudinal Capacity P_L kN/mm	Transverse Capacity P_T kN/mm
3.0	2.1	0.525	0.656
4.0	2.8	0.700	0.875
5.0	3.5	0.875	1.094
6.0	4.2	1.050	1.312
8.0	5.6	1.400	1.750
10.0	7.0	1.750	2.188
12.0	8.4	2.100	2.625
15.0	10.5	2.625	3.281
18.0	12.6	3.150	3.938
20.0	14.0	3.500	4.375
22.0	15.4	3.850	4.813
25.0	17.5	4.375	5.469

Welds are between two elements at 90° to each other.
$P_L = p_w a$
$P_T = K p_w a$
$p_w = 250$ N/mm^2
K = 1.25 for elements at 90° to each other.

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