
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

EAS 354/3 – Timber and Steel Structural Design
[Rekabentuk Struktur Kayu dan Keluli]

Duration: 3 hours
Masa : 3 jam

Please check that this examination paper consists of **SIXTEEN (16)** pages of printed material including appendices before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM BELAS (16)** muka surat yang bercetak termasuk 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 akan diguna pakai].

1. The frame of Figure 1.1 is a section from a standard truss system. It is required to design members 1, 2, and 3, and bolted connection at A in order to support the given loads which consist of a 20 kN concentrated dead load and a 10 kN/m uniform live load. It has been decided that members 1, 2, and 3 to have the same equal angle section (in grade S275, from Appendix 2) and all connection bolts to have the same diameter (not pre-tensioned, Grade 4.6, from Table 1). This question deals with adequacies of members 1, 2, and 3, and connection bolts at A only therefore neglect all stresses in top horizontal member and connection steel plates assuming they do not govern. Assume pinned joint at B.

(Note: $\lambda_{\text{maximum}} = 180$; for pinned ends, $L_e = L$; use most conservative curve in chart of Figure 1.2)

- a) Determine the required equal angle sections for Member 1, Member 2, and Member 3, citing all requirements. [10 marks]

- b) Determine the size and number of bolts required by each member in the connection at A. Present the details of the connection in a drawing. [10 marks]

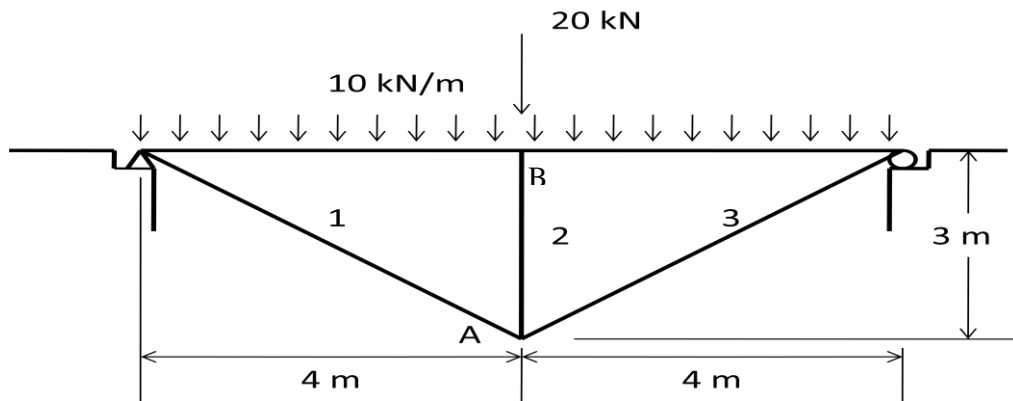


Figure 1.1.

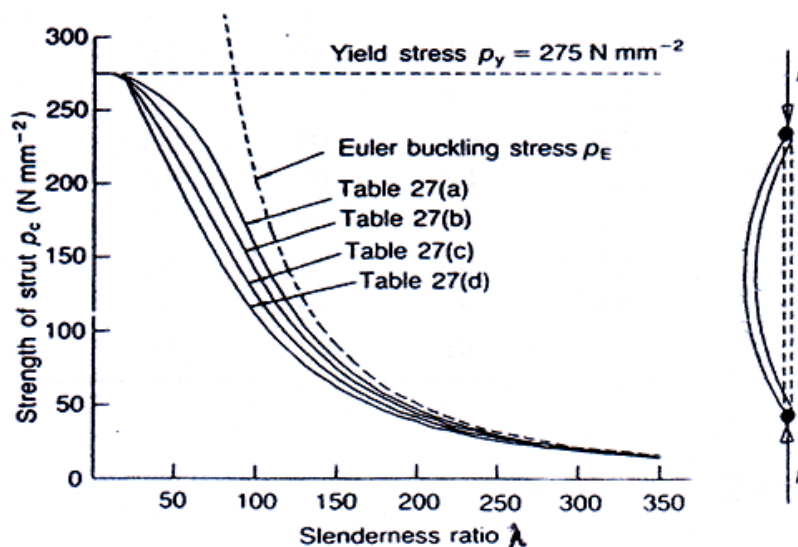


Figure 1.2: Buckling curves for ideal and real struts.

2. The existing outbuildings in an old stable-block are to be modified to provide facilities for a motor vehicle repair workshop. A cross-section of the intended new roof structure is shown in Figure 2. The proposed new beam 406x178x67UB,S275 has been selected with the given properties as in Appendix A.

Using the design data given, check the suitability of the proposed new steel beam with respect to shear and bending.

Design Data:

Characteristics dead load including self-weight (based on the plan area)	2.25 kN/m ²
Characteristics imposed load (based on the plan area)	1.5 kN/m ²
Span of beam between the centres of bearing	6.55 m
Conditions of restraint at supports:	

Compression flange laterally restrained
Beam fully restrained against torsion
Both flanges are free to rotate on plan

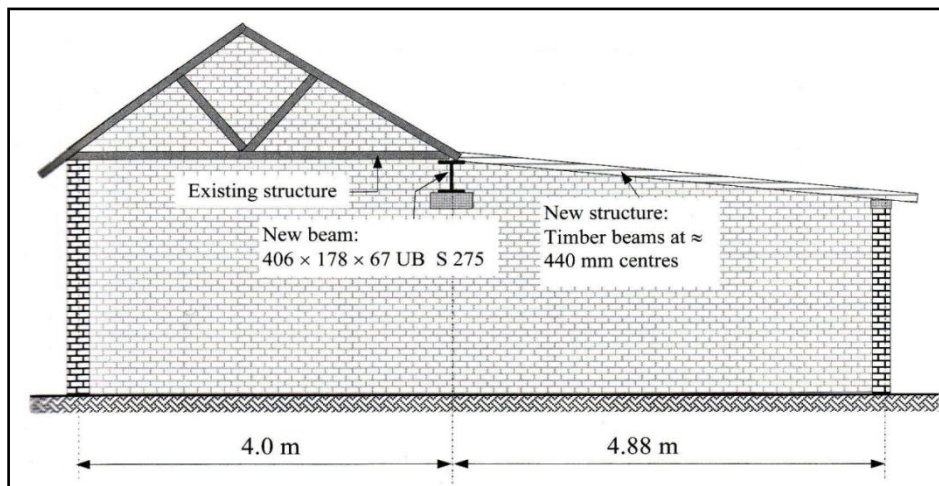


Figure 2

[20 marks]

3. A braced column is supporting symmetrical arrangement of beams in addition to a vertical load from above, as shown in Figure 3. Using the given loads as indicated, check the suitability of a 203 x 203 x 60 UC S 355 section. Use Appendix B for section properties of UC.

F_1 :
Dead load = 75 kN
Imposed load = 175 kN

F_2 :
Dead load = 20 kN
Imposed load = 75 kN

F_3 :
Dead load = 150 kN
Imposed load = 250 kN

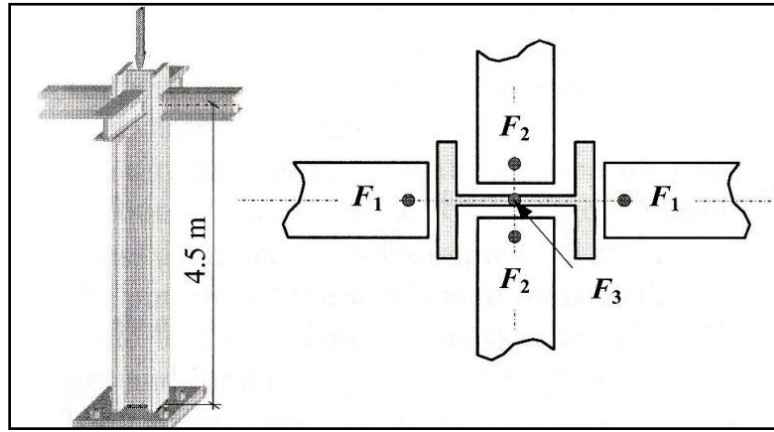


Figure 3

[20 marks]

4. In a load-sharing system, lateral distribution of the load will reduce the effect on any member. The effect can spread or share through the other member of four or more joists of solid member spaced at not more than 610 mm centres. The load-sharing factor ($k_2 = 1.1$) is applied to all stresses. Check the suitability of 38×225 joisting spaced at 0.6 m centres over a clear span of 3.3 m to be used for domestic floor.

Data : Dead load (including the self-weight of joists) 0.35 kN/m^2
Imposed load 1.5 kN/m^2
Being length 50 mm – at each end
Effective span = 3.35 m
SG 4, Dry Timber

[20 marks]

5. a) In timber structures, mechanical is connector is used to transfer the forces from one structural member to another. With the aid of sketches, briefly describe FOUR (4) types of mechanical connector for structural timber.
- b) Figure 4 shows the bolted joints with load parallel to the grain direction. With the data provided, determine the permissible medium-term loads for the member joints.

[10 marks]

Data : M 12 , 4.6 grade bolt
Dry timber
SG 4

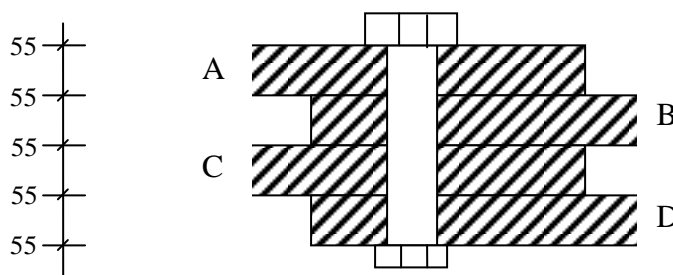


Figure 4

[10 marks]

6. The spaced column in the temporary timber frame comprise of at least two or more equal rectangular shafts connected and spaced a part by end and intermediate packing blocks adequately the column is required to support long-term and medium-term loads of 80 kN and 140 kN, respectively. Check the suitability of the proposed section as indicated in Figure 5.

Data : SG 4, Dry timber
Glued strength, 0.71 N/mm^2

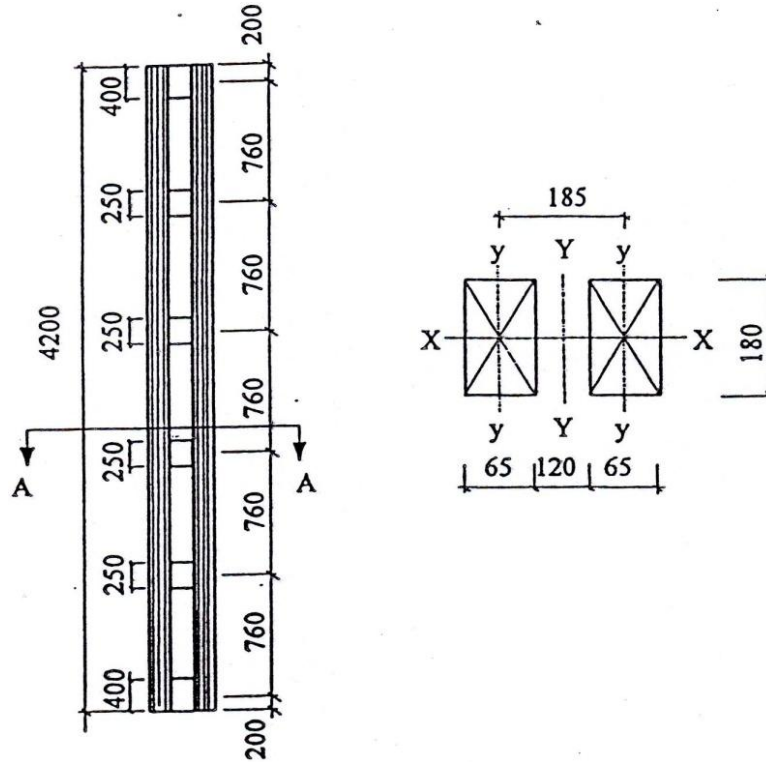


Figure 5

[20 marks]

1. Rajah 1.1 menunjukkan suatu bahagian daripada kekuda biasa. Anda dikehendaki memilih anggota 1, 2, dan 3, dan bolt bagi sambungan di A bagi menanggung bebanan diberi iaitu suatu bebanan mati tumpu 20 kN dan suatu beban kenaan seragam 10 kN/m. Anggota 1, 2, dan 3, (dari gred S275, Jadual 1) dikehendaki mempunyai saiz yang sama begitu juga dengan semua bolt sambungan (tak-tertegas, Gred 4.6, Lampiran 2), juga dikehendaki mempunyai saiz yang sama. Soalan ini mengenai cukup tidaknya saiz anggota 1, 2, dan 3, dan bolt-bolt di A, oleh itu abaikan semua tegasan pada anggota mendatar teratas dan plet penyambung.

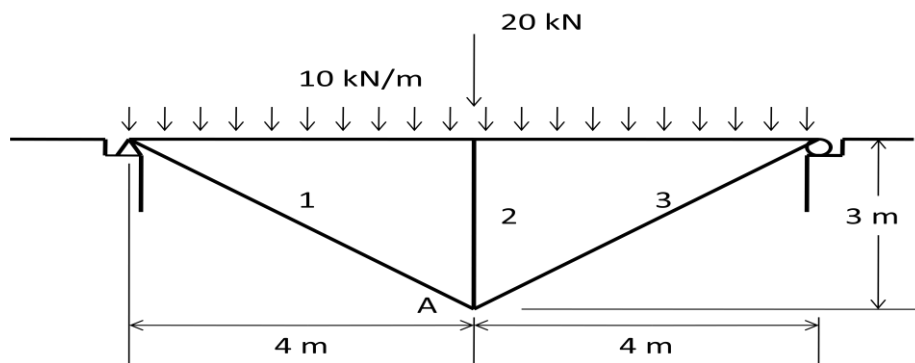
(Nota: $\lambda_{maksimum} = 180$; Bagi hujung berpilin, $L_e = L$; gunakan lengkung paling selamat di Rajah 1.2)

- b) Tentukan anggota sesiku yang sesuai bagi Anggota 1, Anggota 2, dan Anggota 3, dengan 6omest 6omesti rekabentuknya.

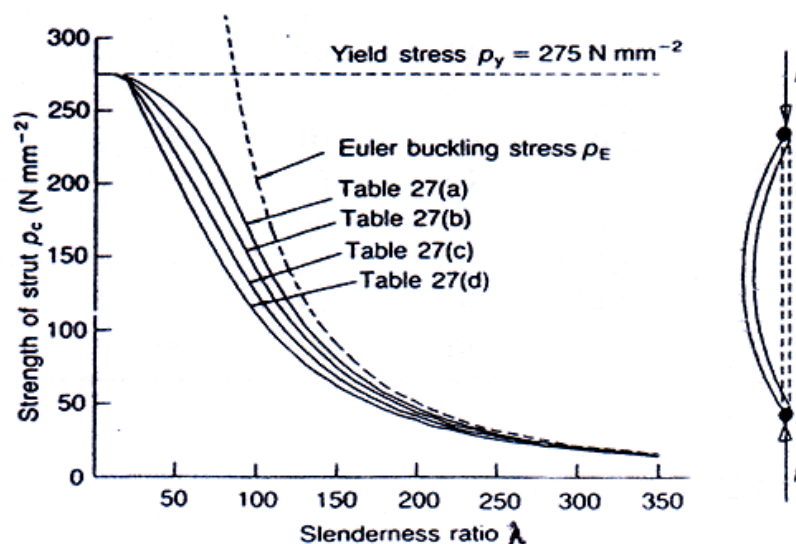
[10 markah]

- b) Tentukan saiz dan bilangan bolt yang diperlukan bagi setiap anggota pada sambungan di A dan lakarkan susun aturnya dengan jelas.

[10 markah]



Rajah 1.1.



Rajah 1.2: Buckling curves for ideal and real struts.

2. Bahagian luar sebuah bangunan lama sedia ada akan diubahsuai untuk menyediakan kemudahan bagi sebuah kedai baik pulih kenderaan. Keratan rentas bagi penambahan struktur bumbung baru ditunjukkan dalam Rajah 2. Cadangan rasuk baru 406x178x67UB,S275 telah dipilih dengan diberi sifat-sifat seperti dalam.

Gunakan data rekabentuk yang diberi, periksa kesesuaian cadangan rasuk keluli yang baru berkaitan dengan ricih dan lenturan.

Data rekabentuk:

Beban ciri mati termasuk berat sendiri rasuk 2.25 kN/m^2

(berdasarkan pada pandangan plan)

Beban ciri kenaan (berdasarkan pada pandangan plan) 1.5 kN/m^2

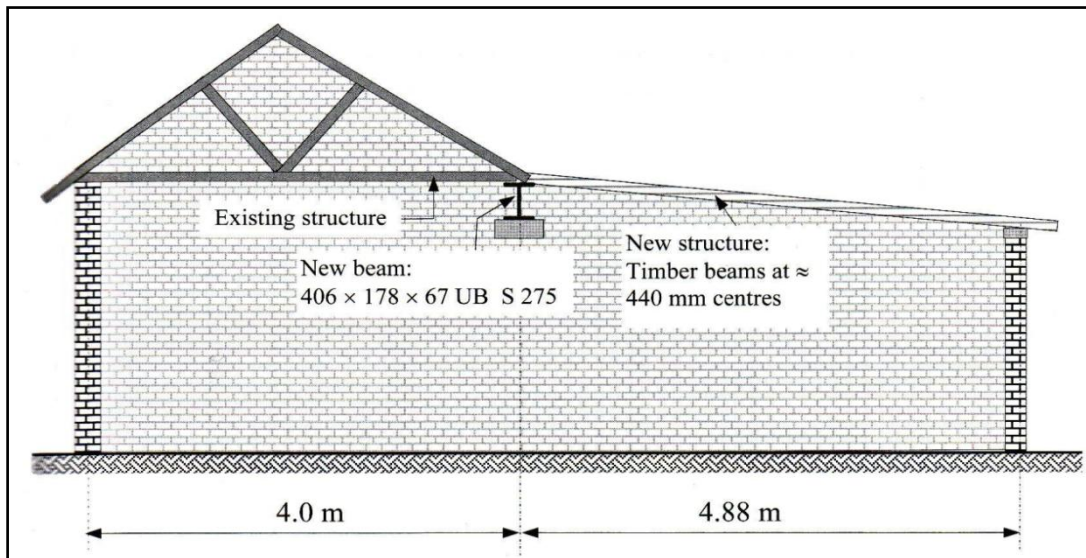
Rentang rasuk antara dua penyokong 6.55 m

Keadaan kekangan di penyokong:

Compression flange laterally restrained

Beam fully restrained against torsion

Both flanges are free to rotate on plan



Rajah 2

[20 markah]

3. Sebuah tiang dalam bangunan yang dirembat, menyokong susunan rasuk yang simetri termasuk beban pugak daripada bahagian atas, sepertimana yang ditunjukkan dalam Rajah 3. Dengan menggunakan beban yang diberi, periksa kesesuaian keratan 203 x 203 x 60 UC S 355 . Gunakan Appendix B untuk ciri-ciri keratan untuk UC.

F_1 :

Beban Mati = 75 kN

Beban Kenaan = 175 kN

F_2 :

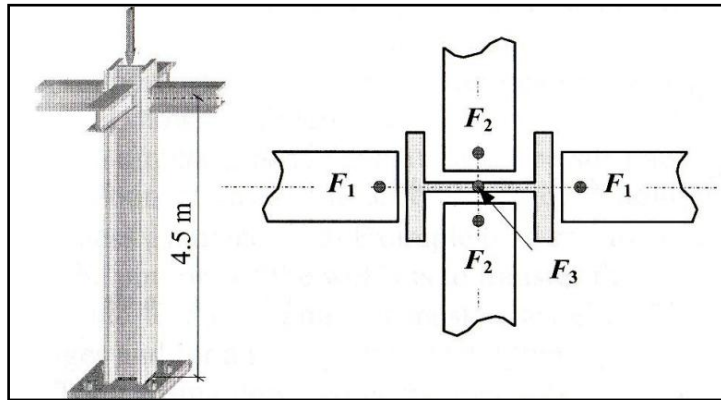
Beban Mati = 20 kN

Beban Kenaan = 75 kN

F_3 :

Beban Mati = 150 kN

Beban Kenaan = 250 kN



Rajah 3

[20 markah]

4. Dalam sistem kongsi beban, penghasilan beban secara disisi akan mengurangkan kesan ke atas setiap anggota. Kesan ini boleh disebar atau dikongsi melalui empat atau lebih anggota gelegar pada jarak tidak lebih 610 mm pusat ke pusat. **The load-sharing factor ($k_2 = 1.1$) is applied to all stresses.** Semak kesesuaian anggota gelegar 38×225 mm yang di jarakkan pada 0.6 m pusat ke pusat bagi satu rentangan bersih 3.3 m untuk kegunaan lantai domestic.

Data : Beban Mati (termasuk berat sendiri gelegar) 0.35 kN/m^2
 Beban kenaan 1.5 kN/m^2
 Panjang gelas 50 mm – dikedua-dua hujung
 Rentang berkesan = 3.35 m
 SG 4, kayu kering

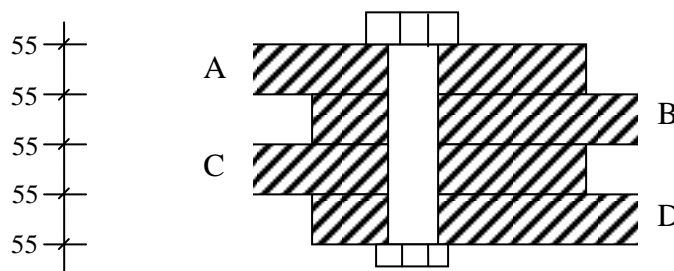
[20 markah]

5. a) Bagi struktur kayu, penyambung mekanikal digunakan untuk memindahkan daya-daya daripada satu anggota kepada yang lain. Dengan berbantuan lakaran, perihalkan dengan ringkas EMPAT (4) jenis penyambung mekanikal untuk struktur kayu.

[10 markah]

- b) Rajah 4 menunjukkan sambungan bolt dikenakan beban selari dengan arah lain. Dengan data yang dibekalkan, tentukan beban jangka-sederhana izin untuk sambungan anggota.

Data : M 12 , Bolt gred 4.6
 Kayu kering, SG 4

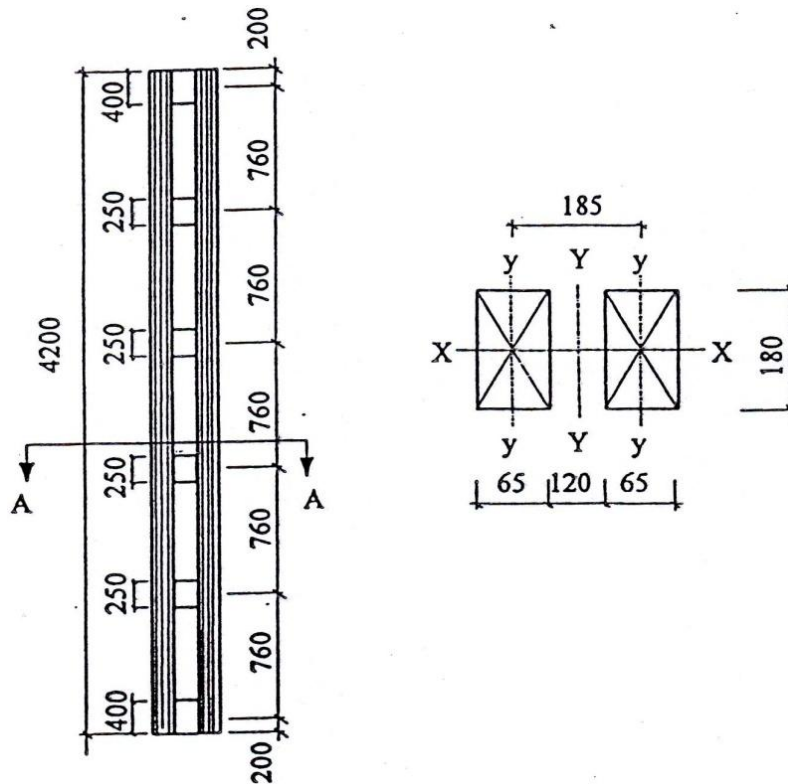


Rajah 4

[10 markah]

6. *Tiang luang dalam kerangka kayu sementara mempunyai sekurang-kurangnya dua atau lebih ac segiempat sama yang disambung dan luang dihujung dan dipertengahan dijarakan dengan blok penyendal secukupnya secara bersambung. Tiang luang dalaman diperlukan untuk menyokong beban jangka-panjang dan jangka-sederhana, 80 kN dan 140 kN. Semak kesesuaian keratan yang dicadangkan seperti yang ditunjukkan dalam Rajah 5.*

*Data : SG 4, Kayu kering
Kekuatan glu, 0.71 N/mm²*



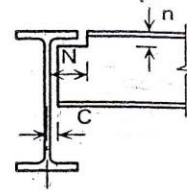
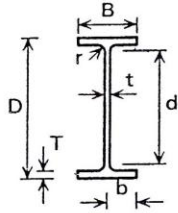
Rajah 5

[20 markah]

Appendix 1
Lampiran 1

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

UNIVERSAL BEAMS



DIMENSIONS

Section Designation	Mass per Metre kg/m	Depth of Section D 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 mm	Flange T mm			Flange b/T	Web d/t	End Clearance C mm	Notch		Per Metre m ²	Per Tonne m ²
											N mm	n mm		
1016x305x487 # +	486.6	1036.1	308.5	30.0	54.1	30.0	867.9	2.85	28.9	17	150	86	3.19	6.57
1016x305x437 # +	436.9	1025.9	305.4	26.9	49.0	30.0	867.9	3.12	32.3	16	150	80	3.17	7.25
1016x305x393 # +	392.7	1016.0	303.0	24.4	43.9	30.0	868.2	3.45	35.6	14	150	74	3.14	8.01
1016x305x349 # +	349.4	1008.1	302.0	21.1	40.0	30.0	868.1	3.77	41.1	13	150	70	3.13	8.96
1016x305x314 # +	314.3	1000.0	300.0	19.1	35.9	30.0	868.2	4.18	45.5	12	150	66	3.11	9.90
1016x305x272 # +	272.3	990.1	300.0	16.5	31.0	30.0	868.1	4.84	52.6	10	152	63	3.10	11.4
1016x305x249 # +	248.7	980.2	300.0	16.5	26.0	30.0	868.2	5.77	52.6	10	152	56	3.08	12.4
1016x305x222 # +	222.0	970.3	300.0	16.0	21.1	30.0	868.1	7.11	54.3	10	152	52	3.06	13.8
914x419x388 #	388.0	921.0	420.5	21.4	36.6	24.1	799.6	5.74	37.4	13	210	62	3.44	8.87
914x419x343 #	343.3	911.8	418.5	19.4	32.0	24.1	799.6	6.54	41.2	12	210	58	3.42	9.95
914x305x289 #	289.1	926.6	307.7	19.5	32.0	19.1	824.4	4.81	42.3	12	156	52	3.01	10.4
914x305x253 #	253.4	918.4	305.5	17.3	27.9	19.1	824.4	5.47	47.7	11	156	48	2.99	11.8
914x305x224 #	224.2	910.4	304.1	15.9	23.9	19.1	824.4	6.36	51.8	10	156	44	2.97	13.3
914x305x201 #	200.9	903.0	303.3	15.1	20.2	19.1	824.4	7.51	54.6	10	156	40	2.96	14.7
838x292x226 #	226.5	850.9	293.8	16.1	26.8	17.8	761.7	5.48	47.3	10	150	46	2.81	12.4
838x292x194 #	193.8	840.7	292.4	14.7	21.7	17.8	761.7	6.74	51.8	9	150	40	2.79	14.4
838x292x176 #	175.9	834.9	291.7	14.0	18.8	17.8	761.7	7.76	54.4	9	150	38	2.78	15.8
762x267x197	196.8	769.8	268.0	15.6	25.4	16.5	686.0	5.28	44.0	10	138	42	2.55	13.0
762x267x173	173.0	762.2	266.7	14.3	21.6	16.5	686.0	6.17	48.0	9	138	40	2.53	14.6
762x267x147	146.9	754.0	265.2	12.8	17.5	16.5	686.0	7.58	53.6	8	138	34	2.51	17.1
762x267x134	133.9	750.0	264.4	12.0	15.5	16.5	686.0	8.53	57.2	8	138	32	2.51	18.7
686x254x170	170.2	692.9	255.8	14.5	23.7	15.2	615.1	5.40	42.4	9	132	40	2.35	13.8
686x254x152	152.4	687.5	254.5	13.2	21.0	15.2	615.1	6.06	46.6	9	132	38	2.34	15.4
686x254x140	140.1	683.5	253.7	12.4	19.0	15.2	615.1	6.68	49.6	8	132	36	2.33	16.6
686x254x125	125.2	677.9	253.0	11.7	16.2	15.2	615.1	7.81	52.6	8	132	32	2.32	18.5
610x305x238	238.1	635.8	311.4	18.4	31.4	16.5	540.0	4.96	29.3	11	158	48	2.45	10.3
610x305x179	179.0	620.2	307.1	14.1	23.6	16.5	540.0	6.51	38.3	9	158	42	2.41	13.5
610x305x149	149.2	612.4	304.8	11.8	19.7	16.5	540.0	7.74	45.8	8	158	38	2.39	16.0
610x229x140	139.9	617.2	230.2	13.1	22.1	12.7	547.6	5.21	41.8	9	120	36	2.11	15.1
610x229x125	125.1	612.2	229.0	11.9	19.6	12.7	547.6	5.84	46.0	8	120	34	2.09	16.7
610x229x113	113.0	607.6	228.2	11.1	17.3	12.7	547.6	6.60	49.3	8	120	30	2.08	18.4
610x229x101	101.2	602.6	227.5	10.5	14.8	12.7	547.6	7.69	52.2	7	120	28	2.07	20.5
533x210x122	122.0	544.5	211.9	12.7	21.3	12.7	476.5	4.97	37.5	8	110	34	1.89	15.5
533x210x109	109.0	539.5	210.8	11.6	18.8	12.7	476.5	5.61	41.1	8	110	32	1.88	17.2
533x210x101	101.0	536.7	210.0	10.8	17.4	12.7	476.5	6.03	44.1	7	110	32	1.87	18.5
533x210x92	92.1	533.1	209.3	10.1	15.6	12.7	476.5	6.71	47.2	7	110	30	1.86	20.2
533x210x82	82.2	528.3	208.8	9.6	13.2	12.7	476.5	7.91	49.6	7	110	26	1.85	22.5

+ Section is not given in BS 4-1: 1993.

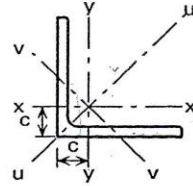
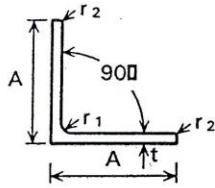
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FOR EXPLANATION OF TABLES SEE NOTE 2

Appendix 2
Lampiran 2

EN 10056-1: 2000
EN 10056-1: 1999

EQUAL ANGLES



DIMENSIONS AND PROPERTIES

Section Designation		Mass per Metre	Radius		Area of Section	Dimension c	Second Moment of Area			Radius of Gyration			Elastic Modulus Axis x-x, y-y	Torsional Constant J	Equivalent Slenderness Coefficient ϕ_e
Size	Thickness		Root	Toe			Axis x-x, y-y	Axis u-u	Axis v-v	Axis x-x, y-y	Axis u-u	Axis v-v			
A x A mm	t mm	kg/m	r ₁ mm	r ₂ mm	cm ²	cm	cm ⁴	cm ⁴	cm ⁴	cm	cm	cm	cm ³	cm ⁴	
200x200	24 #	71.1	18.0	9.00	90.6	5.84	3330	5280	1380	6.06	7.64	3.90	235	182	2.50
	20	59.9	18.0	9.00	76.3	5.68	2850	4530	1170	6.11	7.70	3.92	199	107	3.05
	18	54.3	18.0	9.00	69.1	5.60	2600	4150	1050	6.13	7.75	3.90	181	78.9	3.43
	16	48.5	18.0	9.00	61.8	5.52	2340	3720	960	6.16	7.76	3.94	162	56.1	3.85
150x150	18 #	40.1	16.0	8.00	51.2	4.38	1060	1680	440	4.55	5.73	2.93	99.8	58.6	2.48
	15	33.8	16.0	8.00	43.0	4.25	898	1430	370	4.57	5.76	2.93	83.5	34.6	3.01
	12	27.3	16.0	8.00	34.8	4.12	737	1170	303	4.60	5.80	2.95	67.7	18.2	3.77
	10	23.0	16.0	8.00	29.3	4.03	624	990	258	4.62	5.82	2.97	56.9	10.80	4.51
120x120	15 #	26.6	13.0	6.50	34.0	3.52	448	710	186	3.63	4.57	2.34	52.8	27.0	2.37
	12	21.6	13.0	6.50	27.5	3.40	368	584	152	3.65	4.60	2.35	42.7	14.2	2.99
	10	18.2	13.0	6.50	23.2	3.31	313	497	129	3.67	4.63	2.36	36.0	8.41	3.61
	8 #	14.7	13.0	6.50	18.8	3.24	259	411	107	3.71	4.67	2.38	29.5	4.44	4.56
100x100	15 #	21.9	12.0	6.00	28.0	3.02	250	395	105	2.99	3.76	1.94	35.8	22.3	1.92
	12	17.8	12.0	6.00	22.7	2.90	207	328	85.7	3.02	3.80	1.94	29.1	11.8	2.44
	10	15.0	12.0	6.00	19.2	2.82	177	280	73.0	3.04	3.83	1.95	24.6	6.97	2.94
	8	12.2	12.0	6.00	15.5	2.74	145	230	59.9	3.06	3.85	1.96	19.9	3.68	3.70
90x90	12 #	15.9	11.0	5.50	20.3	2.66	149	235	62.0	2.71	3.40	1.75	23.5	10.46	2.17
	10	13.4	11.0	5.50	17.1	2.58	127	201	52.6	2.72	3.42	1.75	19.8	6.20	2.64
	8	10.9	11.0	5.50	13.9	2.50	104	166	43.1	2.74	3.45	1.76	16.1	3.28	3.33
	7 #	9.61	11.0	5.50	12.2	2.45	92.6	147	38.3	2.75	3.46	1.77	14.1	2.24	3.80
80x80	10 □	11.9	10.0	5.00	15.1	2.34	87.5	139	36.4	2.41	3.03	1.55	15.4	5.45	2.33
	8 □	9.63	10.0	5.00	12.3	2.26	72.2	115	29.9	2.43	3.06	1.56	12.6	2.88	2.94
75x75	8 □	8.99	9.00	4.50	11.4	2.14	59.1	93.8	24.5	2.27	2.86	1.46	11.0	2.65	2.76
	6 □	6.85	9.00	4.50	8.73	2.05	45.8	72.7	18.9	2.29	2.89	1.47	8.41	1.17	3.70
70x70	7 □	7.38	9.00	4.50	9.40	1.97	42.3	67.1	17.5	2.12	2.67	1.36	8.41	1.69	2.92
	6 □	6.38	9.00	4.50	8.13	1.93	36.9	58.5	15.3	2.13	2.68	1.37	7.27	1.093	3.41
65x65	7 □	6.83	9.00	4.50	8.73	2.05	33.4	53.0	13.8	1.96	2.47	1.26	7.18	1.58	2.67
60x60	8 □	7.09	8.00	4.00	9.03	1.77	29.2	46.1	12.2	1.80	2.26	1.16	6.89	2.09	2.14
	6 □	5.42	8.00	4.00	6.91	1.69	22.8	36.1	9.44	1.82	2.29	1.17	5.29	0.922	2.90
	5 □	4.57	8.00	4.00	5.82	1.64	19.4	30.7	8.03	1.82	2.30	1.17	4.45	0.550	3.48
50x50	6 □	4.47	7.00	3.50	5.69	1.45	12.8	20.3	5.34	1.50	1.89	0.968	3.61	0.755	2.38
	5 □	3.77	7.00	3.50	4.80	1.40	11.0	17.4	4.55	1.51	1.90	0.973	3.05	0.450	2.88
	4 □	3.06	7.00	3.50	3.89	1.36	8.97	14.2	3.73	1.52	1.91	0.979	2.46	0.240	3.57
45x45	4.5 □	3.06	7.00	3.50	3.90	1.25	7.14	11.4	2.94	1.35	1.71	0.870	2.20	0.304	2.84
40x40	5 □	2.97	6.00	3.00	3.79	1.16	5.43	8.60	2.26	1.20	1.51	0.773	1.91	0.352	2.26
	4 □	2.42	6.00	3.00	3.08	1.12	4.47	7.09	1.86	1.21	1.52	0.777	1.55	0.188	2.83
35x35	4 □	2.09	5.00	2.50	2.67	1.00	2.95	4.68	1.23	1.05	1.32	0.678	1.18	0.158	2.50
30x30	4 □	1.78	5.00	2.50	2.27	0.878	1.80	2.85	0.754	0.892	1.12	0.577	0.850	0.137	2.07
	3 □	1.36	5.00	2.50	1.74	0.835	1.40	2.22	0.585	0.899	1.13	0.581	0.649	0.0613	2.75
25x25	4 □	1.45	3.50	1.75	1.85	0.762	1.02	1.61	0.430	0.741	0.931	0.482	0.586	0.1070	1.75
	3 □	1.12	3.50	1.75	1.42	0.723	0.803	1.27	0.334	0.751	0.945	0.484	0.452	0.0472	2.38
20x20	3 □	0.882	3.50	1.75	1.12	0.598	0.392	0.618	0.165	0.590	0.742	0.383	0.279	0.0382	1.81

? Not available from some leading producers. Check availability.

Check availability.

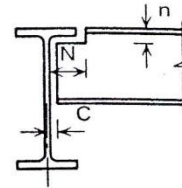
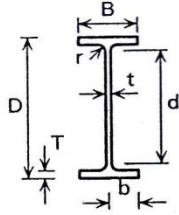
c is the distance from the back of the leg to the centre of gravity.

FOR EXPLANATION OF TABLES SEE NOTES 2 AND 3

Appendix A1
Lampiran A1

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

UNIVERSAL BEAMS



DIMENSIONS

Section Designation	Mass per Metre kg/m	Depth of Section D 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 mm	Flange T mm			Flange b/T	Web d/t	End Clearance C mm	Notch		Per Metre m ²	Per Tonne m ²
											N mm	n mm		
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	121.8	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

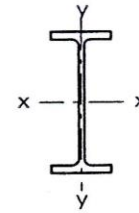
FOR EXPLANATION OF TABLES SEE NOTE 2

Appendix A2

Lampiran A2

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

UNIVERSAL BEAMS



PROPERTIES

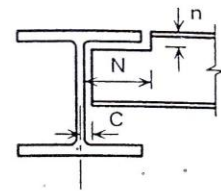
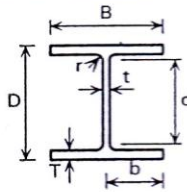
Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter u	Torsional Index x	Warping Constant H dm ⁶	Torsional Constant J cm ⁴	Area of Section A cm ²
	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y					
	cm ⁴	cm ⁴	cm	cm	cm ³	cm ³	cm ³	cm ³					
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	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	0.872	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	33.8	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	846	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	31.8	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	14.8	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

FOR EXPLANATION OF TABLES SEE NOTE 3

Appendix B1
Lampiran B1

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

UNIVERSAL COLUMNS



DIMENSIONS

Section Designation	Mass per Metre kg/m	Depth of Section D 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 mm	Flange T mm			Flange b/T	Web d/t	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	2.75	6.10	26	200	94	2.52	3.98
356x406x551 #	551.0	455.6	418.5	42.1	67.5	15.2	290.2	3.10	6.89	23	200	84	2.47	4.49
356x406x467 #	467.0	436.6	412.2	35.8	58.0	15.2	290.2	3.55	8.11	20	200	74	2.42	5.19
356x406x393 #	393.0	419.0	407.0	30.6	49.2	15.2	290.2	4.14	9.48	17	200	66	2.38	6.05
356x406x340 #	339.9	406.4	403.0	26.6	42.9	15.2	290.2	4.70	10.9	15	200	60	2.35	6.90
356x406x287 #	287.1	393.6	399.0	22.6	36.5	15.2	290.2	5.47	12.8	13	200	52	2.31	8.05
356x406x235 #	235.1	381.0	394.8	18.4	30.2	15.2	290.2	6.54	15.8	11	200	46	2.28	9.69
356x368x202 #	201.9	374.6	374.7	16.5	27.0	15.2	290.2	6.94	17.6	10	190	44	2.19	10.8
356x368x177 #	177.0	368.2	372.6	14.4	23.8	15.2	290.2	7.83	20.2	9	190	40	2.17	12.3
356x368x153 #	152.9	362.0	370.5	12.3	20.7	15.2	290.2	8.95	23.6	8	190	36	2.16	14.1
356x368x129 #	129.0	355.6	368.6	10.4	17.5	15.2	290.2	10.50	27.9	7	190	34	2.14	16.6
305x305x283	282.9	365.3	322.2	26.8	44.1	15.2	246.7	3.65	9.21	15	158	60	1.94	6.86
305x305x240	240.0	352.5	318.4	23.0	37.7	15.2	246.7	4.22	10.7	14	158	54	1.91	7.94
305x305x198	198.1	339.9	314.5	19.1	31.4	15.2	246.7	5.01	12.9	12	158	48	1.87	9.46
305x305x158	158.1	327.1	311.2	15.8	25.0	15.2	246.7	6.22	15.6	10	158	42	1.84	11.6
305x305x137	136.9	320.5	309.2	13.8	21.7	15.2	246.7	7.12	17.9	9	158	38	1.82	13.3
305x305x118	117.9	314.5	307.4	12.0	18.7	15.2	246.7	8.22	20.6	8	158	34	1.81	15.3
305x305x97	96.9	307.9	305.3	9.9	15.4	15.2	246.7	9.91	24.9	7	158	32	1.79	18.5
254x254x167	167.1	289.1	265.2	19.2	31.7	12.7	200.3	4.18	10.4	12	134	46	1.58	9.45
254x254x132	132.0	276.3	261.3	15.3	25.3	12.7	200.3	5.16	13.1	10	134	38	1.55	11.7
254x254x107	107.1	266.7	258.8	12.8	20.5	12.7	200.3	6.31	15.6	8	134	34	1.52	14.2
254x254x89	88.9	260.3	256.3	10.3	17.3	12.7	200.3	7.41	19.4	7	134	30	1.50	16.9
254x254x73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	8.96	23.3	6	134	28	1.49	20.4
203x203x86	86.1	222.2	209.1	12.7	20.5	10.2	160.8	5.10	12.7	8	110	32	1.24	14.4
203x203x71	71.0	215.8	206.4	10.0	17.3	10.2	160.8	5.97	16.1	7	110	28	1.22	17.2
203x203x60	60.0	209.6	205.8	9.4	14.2	10.2	160.8	7.25	17.1	7	110	26	1.21	20.1
203x203x52	52.0	206.2	204.3	7.9	12.5	10.2	160.8	8.17	20.4	6	110	24	1.20	23.0
203x203x46	46.1	203.2	203.6	7.2	11.0	10.2	160.8	9.25	22.3	6	110	22	1.19	25.8
152x152x37	37.0	161.8	154.4	8.0	11.5	7.6	123.6	6.71	15.5	6	84	20	0.912	24.7
152x152x30	30.0	157.6	152.9	6.5	9.4	7.6	123.6	8.13	19.0	5	84	18	0.901	30.0
152x152x23	23.0	152.4	152.2	5.8	6.8	7.6	123.6	11.2	21.3	5	84	16	0.889	38.7

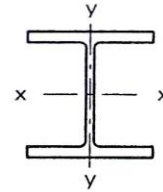
Check availability.

FOR EXPLANATION OF TABLES SEE NOTE 2

Appendix B2
Lampiran B2

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

UNIVERSAL COLUMNS



PROPERTIES

Section Designation	Second Moment of Area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter u	Torsional Index x	Warping Constant H dm ⁶	Torsional Constant J cm ⁴	Area of Section A cm ²
	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					
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	6.86	24.3	5810	595
356x406x393 #	147000	55400	17.1	10.5	7000	2720	8220	4150	0.837	7.87	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	5080	1940	5810	2950	0.834	10.2	12.3	1440	366
356x406x235 #	79100	31000	16.3	10.2	4150	1570	4690	2380	0.835	12.0	9.54	812	299
356x368x202 #	66300	23700	16.1	9.60	3540	1260	3970	1920	0.844	13.4	7.16	558	257
356x368x177 #	57100	20500	15.9	9.54	3100	1100	3460	1670	0.843	15.0	6.09	381	226
356x368x153 #	48600	17600	15.8	9.49	2680	948	2970	1440	0.844	17.0	5.11	251	195
356x368x129 #	40300	14600	15.6	9.43	2260	793	2480	1200	0.845	19.8	4.18	153	164
305x305x283	78900	24600	14.8	8.27	4320	1530	5110	2340	0.856	7.65	6.35	2030	360
305x305x240	64200	20300	14.5	8.15	3640	1280	4250	1950	0.854	8.74	5.03	1270	306
305x305x198	50900	16300	14.2	8.04	3000	1040	3440	1580	0.854	10.2	3.88	734	252
305x305x158	38800	12600	13.9	7.90	2370	808	2680	1230	0.852	12.5	2.87	378	201
305x305x137	32800	10700	13.7	7.83	2050	692	2300	1050	0.852	14.1	2.39	249	174
305x305x118	27700	9060	13.6	7.77	1760	589	1960	895	0.851	16.2	1.98	161	150
305x305x97	22300	7310	13.4	7.69	1450	479	1590	726	0.852	19.2	1.56	91.2	123
254x254x167	30000	9870	11.9	6.81	2080	744	2420	1140	0.851	8.50	1.63	626	213
254x254x132	22500	7530	11.6	6.69	1630	576	1870	878	0.850	10.3	1.19	319	168
254x254x107	17500	5930	11.3	6.59	1310	458	1480	697	0.849	12.4	0.898	172	136
254x254x89	14300	4860	11.2	6.55	1100	379	1220	575	0.851	14.5	0.717	102	113
254x254x73	11400	3910	11.1	6.48	898	307	992	465	0.849	17.3	0.562	57.6	93.1
203x203x86	9450	3130	9.28	5.34	850	299	977	456	0.849	10.2	0.318	137	110
203x203x71	7620	2540	9.18	5.30	706	246	799	374	0.853	11.9	0.250	80.2	90.4
203x203x60	6130	2070	8.96	5.20	584	201	656	305	0.846	14.1	0.197	47.2	76.4
203x203x52	5260	1780	8.91	5.18	510	174	567	264	0.848	15.8	0.167	31.8	66.3
203x203x46	4570	1550	8.82	5.13	450	152	497	231	0.846	17.7	0.143	22.2	58.7
152x152x37	2210	706	6.85	3.87	273	91.5	309	140	0.849	13.3	0.0399	19.2	47.1
152x152x30	1750	560	6.76	3.83	222	73.3	248	112	0.849	16.0	0.0308	10.5	38.3
152x152x23	1250	400	6.54	3.70	164	52.6	182	80.2	0.840	20.7	0.0212	4.63	29.2

: Check availability.

: OR EXPLANATION OF TABLES SEE NOTE 3

Table 1
Jadual 1

1242 Bolt data

BS 5950-1: 2000
BS 4190: 2001

BOLT CAPACITIES
NON-PRELOADED ORDINARY BOLTS
GRADE 4.6 BOLTS IN S275

Diameter of Bolt mm	Tensile Stress Area A_t mm ²	Tension Capacity			Shear Capacity		Bearing Capacity in kN (Minimum of P_{bb} and P_{bs}) End distance equal to 2 x bolt diameter.										
		Nominal		Exact	Single Shear P_s kN	Double Shear $2P_s$ kN	5	6	7	8	9	10	12	15	20	25	30
		$0.8A_{p1}$	P_{nom} kN	A_{p1} P_t kN	Thickness in mm of ply passed through.												
12	84.3	16.2	20.2	13.5	27.0	27.6	33.1	38.6	44.2	49.7	55.2	66.2	82.8	110	138	166	
16	157	30.1	37.7	25.1	50.2	36.8	44.2	51.5	58.9	66.2	73.6	88.3	110	147	184	221	
20	245	47.0	58.8	39.2	78.4	46.0	55.2	64.4	73.6	82.8	92.0	110	138	184	230	276	
22	303	58.2	72.7	48.5	87.0	50.6	60.7	70.8	81.0	91.1	101	121	152	202	253	304	
24	353	67.8	84.7	56.5	113	55.2	66.2	77.3	88.3	99.4	110	132	166	221	276	331	
27	459	88.1	110	73.4	147	62.1	74.5	86.9	99.4	112	124	149	188	248	311	373	
30	561	108	135	89.8	180	69.0	82.8	96.6	110	124	138	166	207	276	345	414	

Values in bold are less than the single shear capacity of the bolt.

Values in *italic* are greater than the double shear capacity of the bolt.

Bearing values assume standard clearance holes.

If oversize or short slotted holes are used, bearing values should be multiplied by 0.7.

If long slotted or kidney shaped holes are used, bearing values should be multiplied by 0.5.

If appropriate, shear capacity must be reduced for large packings, large grip lengths and long joints.