UNIVERSAL BEAMS

DORMAN LONG

MIDDLESBROUGH ENGLAND

HANDBOOK SUPPLEMENT FOR CONSTRUCTIONAL ENGINEERS

CONTAINING INFORMATION, PROPERTIES AND SAFE LOADS FOR

UNIVERSAL BEAM AND COLUMN SECTIONS

also

BEARING PILES AND LARGE TEES

Manufactured by

DORMAN LONG (STEEL) LIMITED

MIDDLESBROUGH · ENGLAND

1960

PRINTED AND MADE IN GREAT BRITAIN
BY THE FANFARE PRESS LTD · LONDON WC2

Contents

FOREWORD

DORMAN LONG (STEEL) LTD. is the largest manufacturer of rolled structural steel in Great Britain. The Company has now increased its wide range of structural products by the addition of Universal Beam and Column Sections rolled in the new Mill at Lackenby.

The Mill is designed to include the production of much larger I and H sections and having proportionately wider flanges than any British Standard Beam hitherto available.

From the tables on pages 22 and 24 it will be seen that the range of Beams is divided into 15 Serial Sizes. The Beams in each Serial Size are produced from one set of rolls; the different weights per foot of section result from the capacity of the Mill to vary flange and web thicknesses (see Figs. 1 and 2). From the 15 Serial Sizes of Beams, 45 different weights are available. Similarly, 6 Column Serial Sizes, comprising 28 weights, are available.

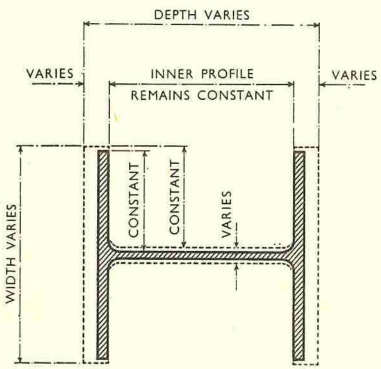
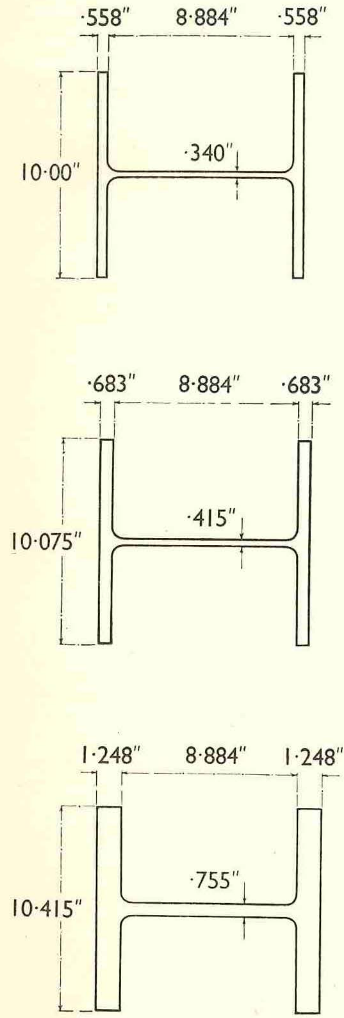


Fig. 1



10" x 10" x 49 lbs. U.B.

10" x 10" x 60 lbs. U.B.

10" x 10" x 112 lbs. U.B.

Fig. 2

Universal Sections will be known by their **Serial Size** and **Weight per Foot,** both of which should be quoted when ordering. For example, a column of 12″ × 12″ serial size required at 133-lbs. per foot, will be known as a 12″ × 12″ × 133-lbs. U.B., regardless of its overall dimensions. Similarly, a column of the same serial size, but 79-lbs. per foot will be known as a 12″ × 12″ × 79-lbs. U.B. Customers will assist the Company greatly by using this method of reference when ordering.

The advantages offered by this new range over the existing British Standard Sections are briefly :

Beams — Better modulus/weight ratio.
Economical modulus increments over the full range.
Much compounding obviated, resulting in economy of fabricating cost and time.
Sections of greater lateral stability included in the range.

Columns—Better radius of gyration.
Greatly increased range of load carrying capacity with consequent reduction in need for compounding and attendant fabricating cost and time.
Simpler and more efficient connections, facilitated by wider flanges and thicker webs.

Universal Sections, used to replace compound sections, are less vulnerable to corrosion owing to the elimination of inaccessible contact surfaces.

The range of sizes and weights has been carefully selected to cover all normal requirements, but sufficiently limited to permit good frequency of rollings.

Special Sections can be rolled differing, within limits, in weight per foot from the weights tabulated under each serial size. Consideration will be given to requests for untabulated sections, provided that the tonnage is sufficient to warrant special rollings.

Equipment for cold cambering Universal Beams has been installed at the mill, and this service is now available. Particulars of the service are given on page 20.

The Universal Mill is readily adaptable to the production of column sections suitable for use as bearing piles. Nine bearing pile sections ranging from 8″ × 8″ to 14″ × 14½″ are tabulated on pages 34–35.

Tees having heavy flanges and long stalks for structural purposes can be obtained by splitting Universal Sections along the web. Shearing equipment to provide this service has been installed at the mill. The sizes of tees available are tabulated on pages 36–41 inclusive.

* * *

QUALITY OF STEEL

All steel supplied by Dorman Long is made in the Company's own Works by the Basic Open Hearth Process which ensures a reliable and uniform product.

Mild Steel, as specified by British Standard 15 : 1948, will be the normal quality used for rolling Universal Sections. High Tensile Structural Steel as specified by British Standards 548 : 1934 and 968 : 1941 will be supplied on special request, provided that a substantial tonnage is required.

* * *

The dimensions and weights of Universal Sections published in this Supplement are theoretical and subject to variations consequent upon rolling tolerances.

In the interests of both manufacturer and customer it has been considered advisable to lay down definite tolerances for Universal Sections as specified on pages 18 and 19. All Universal Sections ordered will be subject to these tolerances which include the usual rolling margin of 2½% over or under the specified weights.

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Preface

THIS SUPPLEMENT to the DORMAN LONG HANDBOOK is an enlarged edition of the Supplement published in 1958 and has been prepared for the use of engineers and designers wishing to take advantage of the Universal Beam and Column Sections now rolled by Dorman Long (Steel) Ltd.

Opportunity has been taken to include safe load tables for Universal Beams carrying uniformly distributed loads and for Universal Columns, uncased and cased, supporting concentric loads, in accordance with the provisions of B.S. 449 : 1959.

In addition to the plastic moduli already published, the reduced plastic moduli are tabulated for each section.

The dimensions and properties of Universal Bearing Piles are tabulated, with notes concerning their use.

The dimensions and properties of Structural Tees are tabulated to facilitate designs in which large Tees form the flanges of plate or braced girders, or are required to function as separate structural members.

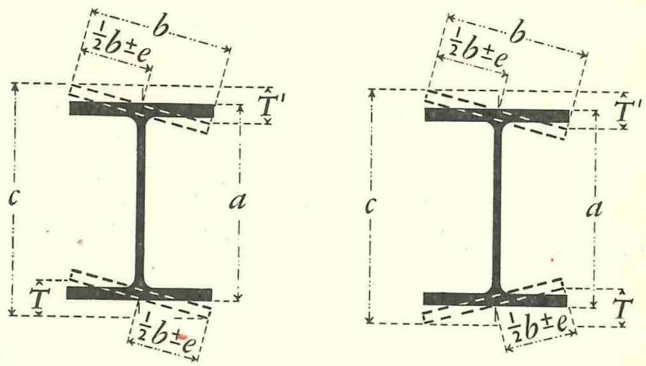
The dimensions and properties of all Universal Products are given in metric units on the pages tinted yellow at the back of the Supplement.

ACKNOWLEDGMENT IS MADE TO THE FOLLOWING:

The Bethlehem Steel Co., Bethlehem, U.S.A., for information regarding the dimensions and properties of Universal Sections.
The British Constructional Steelwork Association and the British Steel Makers for permission to reproduce the tables of safe loads on Universal Beams and Columns.
Dr. M. R. Horne and the British Welding Research Association for information regarding the plastic properties of I *sections.*
The British Standards Institution for abstracts from and references to B.S. 4B : 1959 and B.S. 449 : 1959.

UNIVERSAL BEAMS & COLUMNS

ROLLING AND CUTTING TOLERANCES



Rolling Tolerances - Inches

SECTION Nominal Size	*a* DEPTH OVER theor.	*a* DEPTH UNDER theor.	*b* FLANGE WIDTH OVER theor.	*b* FLANGE WIDTH UNDER theor.	T plus T' FLANGES OUT OF SQUARE	*e* WEB OFF CENTRE	*c* MAX. DEPTH at any Cross Section OVER theor. depth
6″ to 8″ inclusive	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{8}$ max.	$\frac{1}{8}$ max.	$\frac{1}{4}$
8″ to 12″ inclusive	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$ max.	$\frac{1}{8}$ max.	$\frac{1}{4}$
Over 12″	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$ max.	$\frac{3}{16}$ max.	$\frac{1}{4}$

(*a*) is measured at centre line of web
(*b*) is measured parallel to flange
(*c*) is measured parallel to web

Rolling margin over and under specified weight $2\frac{1}{2}\%$

UNIVERSAL BEAMS & COLUMNS

ROLLING AND CUTTING TOLERANCES

CUTTING TOLERANCES

(*a*) ‘*Specified*’ *Lengths.* When a beam or column is specified to be cut to a certain length it shall be cut within a margin of 1 inch (25·40 mm.) under and 1 inch over the specified length, but when a minimum length is specified the margin shall be within 2 inches (50·80 mm.) over.

(*b*) ‘*Exact*’ *Lengths.* When a length is specified to be ‘*Exact*’, the beam or column shall be cold sawn within a margin of $\frac{1}{8}$ inch (3·18 mm.) over and $\frac{1}{8}$ inch under the length specified.

ENDS OUT OF SQUARE

$\frac{1}{64}''$ per inch of depth, or flange width if greater than depth.

STRAIGHTNESS

Tolerances for Beams: $\frac{1}{8}'' \times \dfrac{\text{Total length in feet}}{10\ \text{feet}}$

Where sections are specified on orders as columns, the following tolerances will apply:

Lengths up to 45 feet: $\frac{1}{8}'' \times \dfrac{\text{Total length in feet}}{10\ \text{feet}}$ $\left\{ \text{but not over } \frac{3}{8}'' \text{ max.} \right.$

Lengths over 45 feet: $\frac{3}{8}'' + \frac{1}{8}'' \times \dfrac{\text{Total length in feet} - 45\ \text{feet}}{10\ \text{feet}}$

COLD CAMBERING

The maximum camber is dependent upon the size of the section and is determined by the ability of the section itself to withstand cambering without distortion.

For general guidance, the maximum camber may be taken as approximately 3 inches in 50 feet. The maximum length which can be cambered is 90 feet.

The curvature of a cambered beam will approximate to the arc of a circle over the majority of its length.

Camber should be specified by the ordinate at mid length.

When cambering less than $1\frac{1}{2}$ inches in 50 feet is contemplated, it will be advisable to seek the advice of the Company, because of the difficulty of giving permanency to small cambers.

DIMENSIONS AND PROPERTIES

(IN ENGLISH UNITS)

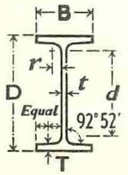
of

UNIVERSAL BEAMS AND COLUMNS

UNIVERSAL BEARING PILES

AND TEES CUT FROM

UNIVERSAL SECTIONS



UNIVERSAL BEAMS

TAPER FLANGES

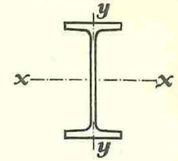
Dimensions and Properties

Serial Size	Weight per foot	Depth of Section D	Width of Section B	Thickness Web t	Thickness Flange T	Root Radius r	Depth between Fillets d	Area of Section
ins	*lbs*	*ins*	*ins*	*ins*	*ins*	*ins*	*ins*	*ins* 2
36×16½	260	36·24	16·555	·845	1·440	·95	31·16	76·56
	230	35·88	16·475	·765	1·260	·95	31·16	67·73
36×12	194	36·48	12·117	·770	1·260	·75	32·25	57·11
	170	36·16	12·027	·680	1·100	·75	32·25	49·98
	150	35·84	11·972	·625	·940	·75	32·25	44·16
33×11½	152	33·50	11·565	·635	1·055	·70	29·78	44·71
	130	33·10	11·510	·580	·855	·70	29·78	38·26
30×10½	132	30·30	10·551	·615	1·000	·65	26·82	38·83
	116	30·00	10·500	·564	·850	·65	26·82	34·13
27×10	114	27·28	10·070	·570	·932	·60	24·04	33·53
	102	27·07	10·018	·518	·827	·60	24·04	30·01
	94	26·91	9·990	·490	·747	·60	24·04	27·65
24×12	160	24·92	12·264	·732	1·235	·65	20·93	47·05
	120	24·31	12·088	·556	·930	·65	20·93	35·29
	100	24·00	12·000	·468	·775	·65	20·93	29·43
24×9	94	24·29	9·061	·516	·872	·50	21·38	27·63
	84	24·09	9·015	·470	·772	·50	21·38	24·71
	76	23·91	8·985	·440	·682	·50	21·38	22·37
21×13	142	21·46	13·132	·659	1·095	·65	17·72	41·78
	127	21·24	13·061	·588	·985	·65	17·72	37·38
	112	21·00	13·000	·527	·865	·65	17·72	32·97

UNIVERSAL BEAMS

TAPER FLANGES

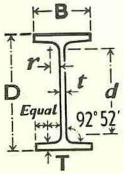
Dimensions and Properties



Serial Size	Moment of Inertia Axis x-x Gross	Moment of Inertia Axis x-x Net	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Ratio D/T
ins	*ins* 4	*ins* 4	*ins* 4	*ins*	*ins*	*ins* 3	*ins* 3	
36×16½	17234	15598	1021	15·00	3·65	951·1	123·3	25·2
	14988	13572	870·9	14·88	3·59	835·5	105·7	28·5
36×12	12103	10637	355·4	14·56	2·49	663·6	58·7	29·0
	10470	9202·0	300·6	14·47	2·45	579·1	50·0	32·9
	9012·1	7938·5	250·4	14·29	2·38	502·9	41·8	38·1
33×11½	8147·6	7626·8	256·1	13·50	2·39	486·4	44·3	31·8
	6699·0	6282·2	201·4	13·23	2·29	404·8	35·0	38·7
30×10½	5753·1	5350·5	185·0	12·17	2·18	379·7	35·1	30·3
	4919·1	4580·4	153·2	12·00	2·12	327·9	29·2	35·3
27×10	4080·5	3777·1	149·6	11·03	2·11	299·2	29·7	29·3
	3604·1	3337·0	129·5	10·96	2·08	266·3	25·9	32·7
	3266·8	3027·1	115·1	10·87	2·04	242·8	23·0	36·0
24×12	4979·2	4329·1	359·7	10·29	2·77	399·6	58·7	20·2
	3635·3	3158·5	254·0	10·15	2·68	299·1	42·0	26·1
	2987·3	2595·2	203·6	10·08	2·63	248·9	33·9	31·0
24×9	2683·0	2458·7	102·2	9·85	1·92	220·9	22·6	27·9
	2364·3	2167·5	88·3	9·78	1·89	196·3	19·6	31·2
	2096·4	1923·9	76·5	9·68	1·85	175·4	17·0	35·1
21×13	3403·9	2977·7	386·0	9·03	3·04	317·2	58·8	19·6
	3018·0	2638·8	338·6	8·99	3·01	284·2	51·8	21·6
	2621·4	2292·4	289·7	8·92	2·96	249·7	44·6	24·3

In calculating the Net Moment of Inertia about x-x, holes have been deducted from each flange in accordance with the table on page 56.

$\frac{D}{T}$ values are tabulated for use when designing members subject to bending and having only intermittent or no adequate lateral support; see notes on pages 56 and 58.



UNIVERSAL BEAMS

TAPER FLANGES

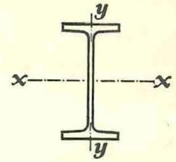
Dimensions and Properties

Serial Size	Weight per foot	Depth of Section D	Width of Section B	Thickness		Root Radius r	Depth between Fillets d	Area of Section
				Web t	Flange T			
ins	lbs	ins	ins	ins	ins	ins	ins	ins^2
21×8¼	82	21.44	8.342	.502	.840	.50	18.61	24.12
	73	21.24	8.295	.455	.740	.50	18.61	21.46
	68	21.13	8.270	.430	.685	.50	18.61	20.02
	62	20.99	8.240	.400	.615	.50	18.61	18.23
18×7½	66	18.40	7.592	.450	.770	.40	15.92	19.40
	60	18.25	7.558	.416	.695	.40	15.92	17.64
	55	18.12	7.532	.390	.630	.40	15.92	16.19
	50	18.00	7.500	.358	.570	.40	15.92	14.71
16×7	50	16.25	7.073	.380	.628	.40	14.07	14.70
	45	16.12	7.039	.346	.563	.40	14.07	13.24
	40	16.00	7.000	.307	.503	.40	14.07	11.77
	36	15.85	6.992	.299	.428	.40	14.07	10.59
14×6¾	45	14.33	6.820	.357	.618	.40	12.17	13.23
	38	14.12	6.776	.313	.513	.40	12.17	11.17
	34	14.00	6.750	.287	.453	.40	12.17	10.00
	30	13.86	6.733	.270	.383	.40	12.17	8.81
12×6½	36	12.24	6.565	.305	.540	.35	10.34	10.59
	31	12.09	6.525	.265	.465	.35	10.34	9.12
	27	11.96	6.500	.240	.400	.35	10.34	7.97
10×5¾	29	10.22	5.799	.289	.500	.30	8.51	8.53
	25	10.08	5.762	.252	.430	.30	8.51	7.35
	21	9.90	5.750	.240	.340	.30	8.51	6.19
8×5¼	20	8.14	5.268	.248	.378	.30	6.69	5.88
	17	8.00	5.250	.230	.308	.30	6.69	5.00

UNIVERSAL BEAMS

TAPER FLANGES

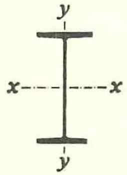
Dimensions and Properties



Serial Size	Moment of Inertia			Radius of Gyration		Elastic Modulus		Ratio D/T
	Axis x-x		Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	$\frac{D}{T}$
	Gross	Net						
ins	ins^4	ins^4	ins^4	ins	ins	ins^3	ins^3	
21×8¼	1827.8	1660.6	77.1	8.70	1.79	170.5	18.5	25.5
	1600.3	1454.5	66.2	8.64	1.76	150.7	16.0	28.7
	1478.3	1344.0	60.4	8.59	1.74	139.9	14.6	30.8
	1326.8	1207.1	53.1	8.53	1.71	126.4	12.9	34.1
18×7½	1096.8	984.5	53.2	7.52	1.66	119.2	14.0	23.9
	984.0	883.5	47.1	7.47	1.63	107.8	12.5	26.3
	889.9	799.5	42.0	7.41	1.61	98.2	11.1	28.8
	800.6	719.4	37.2	7.38	1.59	89.0	9.91	31.6
16×7	655.4	583.5	34.8	6.68	1.54	80.7	9.84	25.9
	583.3	519.4	30.5	6.64	1.52	72.4	8.66	28.6
	515.5	458.9	26.5	6.62	1.50	64.4	7.58	31.8
	446.3	398.6	22.1	6.49	1.45	56.3	6.34	37.0
14×6¾	468.1	413.6	30.7	5.95	1.52	65.3	9.01	23.2
	385.3	340.8	24.6	5.87	1.49	54.6	7.28	27.5
	339.2	300.2	21.3	5.83	1.46	48.5	6.30	30.9
	289.6	257.0	17.5	5.73	1.41	41.8	5.21	36.2
12×6½	280.8	246.1	23.7	5.15	1.50	45.9	7.23	22.7
	238.4	208.9	19.8	5.11	1.47	39.4	6.07	26.0
	204.2	179.1	16.6	5.06	1.44	34.1	5.11	29.9
10×5¾	157.3	138.1	15.2	4.29	1.34	30.8	5.25	20.4
	133.2	116.9	12.7	4.26	1.31	26.4	4.40	23.4
	106.3	93.7	9.74	4.14	1.25	21.5	3.39	29.1
8×5¼	69.2	59.9	8.50	3.43	1.20	17.0	3.23	21.5
	56.4	49.0	6.72	3.36	1.16	14.1	2.56	26.0

In calculating the Net Moment of Inertia about x-x, holes have been deducted from each flange in accordance with the table on page 56.

$\frac{D}{T}$ values are tabulated for use when designing members subject to bending and having only intermittent or no adequate lateral support; see notes on pages 56 and 58.



UNIVERSAL BEAMS

TAPER FLANGES

Plastic Moduli — Major Axis

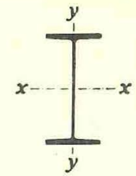
Serial Size	Weight per foot	Plastic Modulus Axis x-x	Reduced Values of Plastic Modulus under Axial Load: Lower Values of n	Change formula at $n =$	Higher Values of n
ins	lbs	ins³	ins³		ins³
36 × 16½	260	1076	$1076 - 1734\,n^2$	.367	$89.12\,(1-n)\,(14.57+n)$
	230	942.5	$942.5 - 1499\,n^2$	.376	$71.01\,(1-n)\,(16.11+n)$
36 × 12	194	766.8	$766.8 - 1059\,n^2$	.457	$67.82\,(1-n)\,(14.36+n)$
	170	667.0	$667.0 - 918.4\,n^2$	.461	$52.45\,(1-n)\,(16.23+n)$
	150	580.0	$580.0 - 780.0\,n^2$	.480	$41.50\,(1-n)\,(18.07+n)$
33 × 11½	152	558.0	$558.0 - 787.0\,n^2$	.445	$43.77\,(1-n)\,(16.11+n)$
	130	465.9	$465.9 - 631.0\,n^2$	.475	$32.26\,(1-n)\,(18.63+n)$
30 × 10½	132	436.7	$436.7 - 612.9\,n^2$	.447	$36.24\,(1-n)\,(15.23+n)$
	116	377.5	$377.5 - 516.3\,n^2$	.467	$28.08\,(1-n)\,(17.23+n)$
27 × 10	114	342.7	$342.7 - 493.1\,n^2$	.431	$28.20\,(1-n)\,(15.22+n)$
	102	304.5	$304.5 - 434.7\,n^2$	.438	$22.67\,(1-n)\,(16.91+n)$
	94	277.8	$277.8 - 390.1\,n^2$	.450	$19.19\,(1-n)\,(18.39+n)$
24 × 12	160	454.4	$454.4 - 756.0\,n^2$	.348	$45.61\,(1-n)\,(11.85+n)$
	120	336.3	$336.3 - 560.0\,n^2$	.353	$26.30\,(1-n)\,(15.31+n)$
	100	278.4	$278.4 - 462.7\,n^2$	.356	$18.50\,(1-n)\,(18.09+n)$
24 × 9	94	252.7	$252.7 - 369.9\,n^2$	.420	$21.33\,(1-n)\,(14.73+n)$
	84	224.1	$224.1 - 324.8\,n^2$	.428	$17.24\,(1-n)\,(16.27+n)$
	76	200.3	$200.3 - 284.3\,n^2$	.442	$14.37\,(1-n)\,(17.61+n)$
21 × 13	142	356.9	$356.9 - 662.2\,n^2$	.303	$33.68\,(1-n)\,(12.31+n)$
	127	318.1	$318.1 - 594.1\,n^2$	.302	$27.03\,(1-n)\,(13.68+n)$
	112	278.3	$278.3 - 515.7\,n^2$	.307	$21.25\,(1-n)\,(15.29+n)$

Let p = mean axial stress, Y_s = yield stress, then $n = \frac{p}{Y_s}$

UNIVERSAL BEAMS

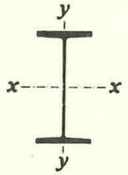
TAPER FLANGES

Plastic Moduli — Minor Axis



Serial Size	Weight per foot	Plastic Modulus Axis y-y	Reduced Values of Plastic Modulus under Axial Load: Lower Values of n	Change formula at $n =$	Higher Values of n
ins	lbs	ins³	ins³		ins³
36 × 16½	260	195.6	$195.6 - 40.43\,n^2$	.400	$471.5\,(1-n)\,(0.269+n)$
	230	168.2	$168.2 - 31.96\,n^2$	.405	$417.2\,(1-n)\,(0.252+n)$
36 × 12	194	94.7	$94.7 - 22.35\,n^2$	.492	$302.6\,(1-n)\,(0.089+n)$
	170	80.7	$80.7 - 17.27\,n^2$	.492	$263.0\,(1-n)\,(0.081+n)$
	150	67.8	$67.8 - 13.60\,n^2$	.507	$236.8\,(1-n)\,(0.044+n)$
33 × 11½	152	71.2	$71.2 - 14.92\,n^2$	.476	$219.7\,(1-n)\,(0.113+n)$
	130	56.7	$56.7 - 11.06\,n^2$	.502	$195.0\,(1-n)\,(0.053+n)$
30 × 10½	132	56.4	$56.4 - 12.44\,n^2$	.480	$174.9\,(1-n)\,(0.109+n)$
	116	47.2	$47.2 - 9.71\,n^2$	.496	$157.2\,(1-n)\,(0.070+n)$
27 × 10	114	47.6	$47.6 - 10.30\,n^2$	.464	$140.0\,(1-n)\,(0.141+n)$
	102	41.5	$41.5 - 8.32\,n^2$	.467	$125.3\,(1-n)\,(0.128+n)$
	94	37.1	$37.1 - 7.10\,n^2$	.477	$116.8\,(1-n)\,(0.104+n)$
24 × 12	160	92.9	$92.9 - 22.21\,n^2$	.388	$210.7\,(1-n)\,(0.306+n)$
	120	66.6	$66.6 - 12.81\,n^2$	.383	$154.1\,(1-n)\,(0.298+n)$
	100	54.0	$54.0 - 9.02\,n^2$	.382	$126.6\,(1-n)\,(0.291+n)$
24 × 9	94	36.1	$36.1 - 7.86\,n^2$	.454	$102.5\,(1-n)\,(0.162+n)$
	84	31.4	$31.4 - 6.34\,n^2$	.458	$91.72\,(1-n)\,(0.147+n)$
	76	27.4	$27.4 - 5.23\,n^2$	.470	$84.23\,(1-n)\,(0.118+n)$
21 × 13	142	92.6	$92.6 - 20.34\,n^2$	.338	$185.5\,(1-n)\,(0.397+n)$
	127	81.8	$81.8 - 16.45\,n^2$	.334	$163.8\,(1-n)\,(0.399+n)$
	112	70.5	$70.5 - 12.94\,n^2$	.336	$143.4\,(1-n)\,(0.389+n)$

For explanation of tables, see notes on pages 62 to 64.



UNIVERSAL BEAMS

TAPER FLANGES

Plastic Moduli — Major Axis

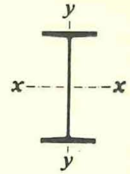
Serial Size	Weight per foot	Plastic Modulus Axis x-x	Reduced Values of Plastic Modulus under Axial Load		
			Lower Values of n	Change formula at $n =$	Higher Values of n
ins	*lbs*	*ins*³	*ins*³		*ins*³
21×8¼	82	195·2	$195·2 - 289·7\,n^2$	·411	$17·40\,(1-n)\,(13·86+n)$
	73	172·1	$172·1 - 253·0\,n^2$	·418	$14·03\,(1-n)\,(15·24+n)$
	68	159·6	$159·6 - 233·0\,n^2$	·423	$12·43\,(1-n)\,(16·02+n)$
	62	144·1	$144·1 - 207·7\,n^2$	·432	$10·34\,(1-n)\,(17·51+n)$
18×7½	66	136·0	$136·0 - 209·1\,n^2$	·390	$12·56\,(1-n)\,(13·21+n)$
	60	122·8	$122·8 - 187·0\,n^2$	·397	$10·27\,(1-n)\,(14·67+n)$
	55	111·7	$111·7 - 168·0\,n^2$	·405	$8·857\,(1-n)\,(15·56+n)$
	50	100·9	$100·9 - 151·1\,n^2$	·409	$7·500\,(1-n)\,(16·65+n)$
16×7	50	91·6	$91·6 - 142·2\,n^2$	·387	$7·736\,(1-n)\,(14·44+n)$
	45	82·0	$82·0 - 126·7\,n^2$	·391	$6·345\,(1-n)\,(15·82+n)$
	40	72·7	$72·7 - 112·8\,n^2$	·390	$5·096\,(1-n)\,(17·48+n)$
	36	63·8	$63·8 - 93·78\,n^2$	·422	$4·114\,(1-n)\,(19·40+n)$
14×6¾	45	73·9	$73·9 - 122·6\,n^2$	·353	$6·461\,(1-n)\,(13·67+n)$
	38	61·5	$61·5 - 99·66\,n^2$	·366	$4·594\,(1-n)\,(16·16+n)$
	34	54·5	$54·5 - 87·11\,n^2$	·374	$3·839\,(1-n)\,(17·24+n)$
	30	47·1	$47·1 - 71·87\,n^2$	·401	$2·863\,(1-n)\,(20·33+n)$
12×6½	36	51·5	$51·5 - 91·93\,n^2$	·321	$4·292\,(1-n)\,(14·10+n)$
	31	44·0	$44·0 - 78·47\,n^2$	·323	$3·294\,(1-n)\,(15·74+n)$
	27	38·0	$38·0 - 66·17\,n^2$	·335	$2·533\,(1-n)\,(17·82+n)$
10×5¾	29	34·6	$34·6 - 62·94\,n^2$	·311	$3·202\,(1-n)\,(12·61+n)$
	25	29·6	$29·6 - 53·59\,n^2$	·316	$2·329\,(1-n)\,(14·91+n)$
	21	24·1	$24·1 - 39·91\,n^2$	·357	$1·666\,(1-n)\,(17·40+n)$
8×5¼	20	19·1	$19·1 - 34·85\,n^2$	·312	$1·601\,(1-n)\,(13·95+n)$
	17	15·8	$15·8 - 27·17\,n^2$	·338	$1·242\,(1-n)\,(15·10+n)$

Let p = mean axial stress, Y_s = yield stress, then $n = \frac{p}{Y_s}$

UNIVERSAL BEAMS

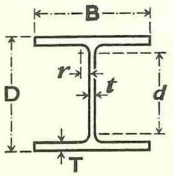
TAPER FLANGES

Plastic Moduli — Minor Axis



Serial Size	Weight per foot	Plastic Modulus Axis y-y	Reduced Values of Plastic Modulus under Axial Load		
			Lower Values of n	Change formula at $n =$	Higher Values of n
ins	*lbs*	*ins*³	*ins*³		*ins*³
21×8¼	82	29·5	$29·5 - 6·78\,n^2$	·446	$80·86\,(1-n)\,(0·182+n)$
	73	25·5	$25·5 - 5·42\,n^2$	·450	$71·87\,(1-n)\,(0·167+n)$
	68	23·4	$23·4 - 4·74\,n^2$	·454	$67·29\,(1-n)\,(0·156+n)$
	62	20·7	$20·7 - 3·96\,n^2$	·461	$61·50\,(1-n)\,(0·138+n)$
18×7½	66	22·3	$22·3 - 5·11\,n^2$	·427	$57·41\,(1-n)\,(0·222+n)$
	60	19·9	$19·9 - 4·26\,n^2$	·430	$52·46\,(1-n)\,(0·209+n)$
	55	17·8	$17·8 - 3·62\,n^2$	·436	$48·28\,(1-n)\,(0·192+n)$
	50	15·8	$15·8 - 3·01\,n^2$	·438	$43·52\,(1-n)\,(0·184+n)$
16×7	50	15·7	$15·7 - 3·32\,n^2$	·420	$40·12\,(1-n)\,(0·229+n)$
	45	13·8	$13·8 - 2·72\,n^2$	·421	$35·80\,(1-n)\,(0·221+n)$
	40	12·1	$12·1 - 2·16\,n^2$	·417	$31·43\,(1-n)\,(0·223+n)$
	36	10·2	$10·2 - 1·77\,n^2$	·447	$29·39\,(1-n)\,(0·159+n)$
14×6¾	45	14·3	$14·3 - 3·05\,n^2$	·387	$32·95\,(1-n)\,(0·298+n)$
	38	11·6	$11·6 - 2·21\,n^2$	·396	$27·93\,(1-n)\,(0·271+n)$
	34	10·1	$10·1 - 1·79\,n^2$	·402	$25·02\,(1-n)\,(0·254+n)$
	30	8·38	$8·38 - 1·40\,n^2$	·425	$22·49\,(1-n)\,(0·203+n)$
12×6½	36	11·4	$11·4 - 2·29\,n^2$	·353	$24·02\,(1-n)\,(0·362+n)$
	31	9·60	$9·60 - 1·72\,n^2$	·351	$20·45\,(1-n)\,(0·357+n)$
	27	8·12	$8·12 - 1·33\,n^2$	·360	$17·92\,(1-n)\,(0·333+n)$
10×5¾	29	8·27	$8·27 - 1·78\,n^2$	·346	$16·97\,(1-n)\,(0·380+n)$
	25	6·95	$6·95 - 1·34\,n^2$	·346	$14·44\,(1-n)\,(0·373+n)$
	21	5·42	$5·42 - 0·97\,n^2$	·384	$12·70\,(1-n)\,(0·291+n)$
8×5¼	20	5·11	$5·11 - 1·06\,n^2$	·343	$10·45\,(1-n)\,(0·383+n)$
	17	4·09	$4·09 - 0·78\,n^2$	·368	$9·065\,(1-n)\,(0·327+n)$

For explanation of tables, see notes on pages 62 to 64.



UNIVERSAL COLUMNS

PARALLEL FLANGES

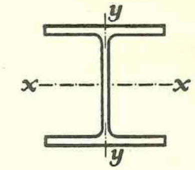
Dimensions and Properties

Serial Size	Weight per foot	Depth of Section D	Width of Section B	Thickness Web t	Thickness Flange T	Root Radius r	Depth between Fillets d	Area of Section
ins	lbs	ins	ins	ins	ins	ins	ins	ins²
14×16	426	18·69	16·695	1·875	3·033	·60	11·42	125·25
	264	16·50	16·025	1·205	1·938	·60	11·42	77·63
	202	15·63	15·750	·930	1·503	·60	11·42	59·39
	158	15·00	15·550	·730	1·188	·60	11·42	46·47
Column Core	320	16·81	16·710	1·890	2·093	·60	11·42	94·12
14×14½	136	14·75	14·740	·660	1·063	·60	11·42	39·98
	119	14·50	14·650	·570	·938	·60	11·42	34·99
	103	14·25	14·575	·495	·813	·60	11·42	30·26
	87	14·00	14·500	·420	·688	·60	11·42	25·56
12×12	190	14·38	12·670	1·060	1·736	·60	9·71	55·86
	161	13·88	12·515	·905	1·486	·60	9·71	47·38
	133	13·38	12·365	·755	1·236	·60	9·71	39·11
	106	12·88	12·230	·620	·986	·60	9·71	31·19
	92	12·62	12·155	·545	·856	·60	9·71	27·06
	79	12·38	12·080	·470	·736	·60	9·71	23·22
	65	12·12	12·000	·390	·606	·60	9·71	19·11
10×10	112	11·38	10·415	·755	1·248	·50	7·88	32·92
	89	10·88	10·275	·615	·998	·50	7·88	26·19
	72	10·50	10·170	·510	·808	·50	7·88	21·18
	60	10·25	10·075	·415	·683	·50	7·88	17·66
	49	10·00	10·000	·340	·558	·50	7·88	14·40
8 × 8	48	8·50	8·117	·405	·683	·40	6·33	14·11
	40	8·25	8·077	·365	·558	·40	6·33	11·76
	35	8·12	8·027	·315	·493	·40	6·33	10·30
	31	8·00	8·000	·288	·433	·40	6·33	9·12
6 × 6	25	6·37	6·080	·320	·454	·30	4·86	7·35
	20	6·20	6·018	·258	·369	·30	4·86	5·93
	15·7	6·00	6·000	·240	·269	·30	4·86	4·62

UNIVERSAL COLUMNS

PARALLEL FLANGES

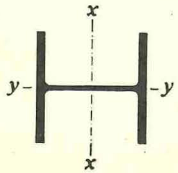
Dimensions and Properties



Serial Size	Moment of Inertia Axis x-x Gross	Moment of Inertia Axis x-x Net	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Ratio $\frac{D}{T}$
ins	ins⁴	ins⁴	ins⁴	ins	ins	ins³	ins³	
14×16	6610·3	5904·5	2359·5	7·26	4·34	707·4	282·7	6·2
	3526·0	3138·5	1331·2	6·74	4·14	427·4	166·1	8·5
	2538·8	2256·5	979·7	6·54	4·06	324·9	124·4	10·4
	1900·6	1687·6	745·0	6·40	4·00	253·4	95·8	12·6
Column Core	4141·7	3713·8	1635·1	6·63	4·17	492·8	195·7	8·0
14×14½	1593·0	1405·9	567·8	6·31	3·77	216·0	77·0	13·9
	1373·1	1211·1	491·8	6·26	3·75	189·4	67·1	15·5
	1165·8	1028·0	419·7	6·21	3·72	163·6	57·6	17·5
	966·9	852·5	349·7	6·15	3·70	138·1	48·2	20·3
12×12	1892·6	1630·8	589·7	5·82	3·25	263·2	93·1	8·3
	1541·9	1326·9	486·3	5·70	3·20	222·2	77·7	9·3
	1221·3	1049·8	389·9	5·59	3·16	182·5	63·1	10·8
	930·7	799·6	300·9	5·46	3·11	144·5	49·2	13·1
	788·9	677·6	256·4	5·40	3·08	125·0	42·2	14·7
	663·1	569·4	216·4	5·34	3·05	107·1	35·8	16·8
	533·4	458·0	174·6	5·28	3·02	88·0	29·1	20·0
10×10	718·7	658·3	235·4	4·67	2·67	126·3	45·2	9·1
	542·4	496·6	180·6	4·55	2·63	99·7	35·2	10·9
	420·7	385·0	141·8	4·46	2·59	80·1	27·9	13·0
	343·7	314·3	116·5	4·41	2·57	67·1	23·1	15·0
	272·9	249·6	93·0	4·35	2·54	54·6	18·6	17·9
8 × 8	183·7	164·1	60·9	3·61	2·08	43·2	15·0	12·4
	146·3	130·8	49·0	3·53	2·04	35·5	12·1	14·8
	126·5	113·0	42·5	3·50	2·03	31·1	10·6	16·5
	109·7	98·1	37·0	3·47	2·01	27·4	9·24	18·5
6 × 6	53·3	46·8	17·0	2·69	1·52	16·7	5·60	14·0
	41·9	36·8	13·4	2·66	1·50	13·5	4·46	16·8
	30·3	26·7	9·69	2·56	1·45	10·1	3·23	22·3

In calculating the Net Moment of Inertia about x-x, holes have been deducted from each flange in accordance with the table on page 56.

$\frac{D}{T}$ values are tabulated for use when designing members subject to bending and having only intermittent or no adequate lateral support; see notes on pages 56 and 58.



UNIVERSAL COLUMNS

PARALLEL FLANGES

Plastic Moduli — Major Axis

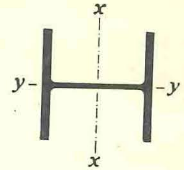
Serial Size	Weight per foot	Plastic Modulus Axis x-x	Reduced Values of Plastic Modulus under Axial Load: Lower Values of n	Change formula at n =	Reduced Values of Plastic Modulus under Axial Load: Higher Values of n
ins	lbs	ins³	ins³		ins³
14×16	426	869·4	869·4 − 2092 n^2	·189	235·0 (1 − n) (3·981 + n)
	264	502·2	502·2 − 1250 n^2	·196	93·98 (1 − n) (5·815 + n)
	202	373·4	373·4 − 948·2 n^2	·197	55·98 (1 − n) (7·291 + n)
	158	286·1	286·1 − 739·5 n^2	·198	34·84 ([illegible]3 + n)
Column Core	320	591·9	591·9 − 1172 n^2	·253	132·7 (1 − n) (4·962 + n)
14×14½	136	242·7	242·7 − 605·5 n^2	·208	27·13 (1 − n) (9·868 + n)
	119	211·0	211·0 − 537·0 n^2	·205	20·95 (1 − n) (11·11 + n)
	103	180·9	180·9 − 462·5 n^2	·206	15·72 (1 − n) (12·71 + n)
	87	151·4	151·4 − 388·9 n^2	·207	11·36 (1 − n) (14·74 + n)
12×12	190	311·3	311·3 − 735·9 n^2	·207	61·59 (1 − n) (5·521 + n)
	161	259·1	259·1 − 620·1 n^2	·208	44·88 (1 − n) (6·326 + n)
	133	209·7	209·7 − 506·5 n^2	·210	30·98 (1 − n) (7·445 + n)
	106	163·5	163·5 − 392·3 n^2	·216	19·98 (1 − n) (9·055 + n)
	92	140·3	140·3 − 335·9 n^2	·219	15·02 (1 − n) (10·36 + n)
	79	119·2	119·2 − 286·8 n^2	·220	11·16 (1 − n) (11·88 + n)
	65	97·0	97·0 − 234·1 n^2	·222	7·657 (1 − n) (14·12 + n)
10×10	112	147·5	147·5 − 358·9 n^2	·203	26·10 (1 − n) (6·177 + n)
	89	114·4	114·4 − 278·8 n^2	·208	16·74 (1 − n) (7·509 + n)
	72	90·6	90·6 − 219·9 n^2	·213	11·12 (1 − n) (9·000 + n)
	60	75·0	75·0 − 187·9 n^2	·209	7·668 (1 − n) (10·80 + n)
	49	60·3	60·3 − 152·5 n^2	·209	5·293 (1 − n) (12·60 + n)
8 × 8	48	49·0	49·0 − 122·9 n^2	·205	6·074 (1 − n) (8·873 + n)
	40	39·8	39·8 − 94·72 n^2	·221	4·310 (1 − n) (10·25 + n)
	35	34·7	34·7 − 84·20 n^2	·218	3·276 (1 − n) (11·77 + n)
	31	30·4	30·4 − 72·20 n^2	·225	2·542 (1 − n) (13·35 + n)
6 × 6	25	18·9	18·9 − 42·21 n^2	·236	2·288 (1 − n) (9·230 + n)
	20	15·1	15·1 − 34·07 n^2	·237	1·443 (1 − n) (11·74 + n)
	15·7	11·2	11·2 − 22·20 n^2	·283	0·8979 (1 − n) (14·42 + n)

Let p = mean axial stress, Y_s = yield stress, then $n = \frac{p}{Y_s}$

UNIVERSAL COLUMNS

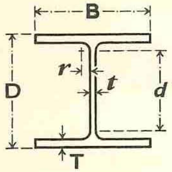
PARALLEL FLANGES

Plastic Moduli — Minor Axis



Serial Size	Weight per foot	Plastic Modulus Axis y-y	Reduced Values of Plastic Modulus under Axial Load: Lower Values of n	Change formula at n =	Reduced Values of Plastic Modulus under Axial Load: Higher Values of n
ins	lbs	ins³	ins³		ins³
14×16	426	434·1	434·1 − 209·8 n^2	·280	642·2 (1 − n) (0·623 + n)
	264	253·7	253·7 − 91·31 n^2	·256	384·8 (1 − n) (0·609 + n)
	202	189·3	189·3 − 56·42 n^2	·245	289·4 (1 − n) (0·606 + n)
	158	145·5	145·5 − 35·99 n^2	·236	223·4 (1 − n) (0·605 + n)
Column Core	320	303·8	303·8 − 131·7 n^2	·338	523·8 (1 − n) (0·495 + n)
14×14½	136	117·0	117·0 − 27·09 n^2	·243	184·2 (1 − n) (0·585 + n)
	119	101·8	101·8 − 21·11 n^2	·236	159·4 (1 − n) (0·590 + n)
	103	87·2	87·2 − 16·06 n^2	·233	137·0 (1 − n) (0·588 + n)
	87	73·0	73·0 − 11·67 n^2	·230	115·1 (1 − n) (0·587 + n)
12×12	190	142·6	142·6 − 54·25 n^2	·273	221·4 (1 − n) (0·588 + n)
	161	118·8	118·8 − 40·43 n^2	·265	185·5 (1 − n) (0·585 + n)
	133	96·2	96·2 − 28·58 n^2	·258	151·5 (1 − n) (0·581 + n)
	106	74·9	74·9 − 18·88 n^2	·256	120·1 (1 − n) (0·568 + n)
	92	64·2	64·2 − 14·52 n^2	·254	103·8 (1 − n) (0·563 + n)
	79	54·4	54·4 − 10·89 n^2	·251	88·37 (1 − n) (0·561 + n)
	65	44·1	44·1 − 7·53 n^2	·247	72·08 (1 − n) (0·557 + n)
10×10	112	69·1	69·1 − 23·81 n^2	·261	106·7 (1 − n) (0·594 + n)
	89	53·6	53·6 − 15·76 n^2	·256	84·03 (1 − n) (0·585 + n)
	72	42·4	42·4 − 10·68 n^2	·253	67·50 (1 − n) (0·574 + n)
	60	35·1	35·1 − 7·61 n^2	·241	55·32 (1 − n) (0·585 + n)
	49	28·2	28·2 − 5·18 n^2	·236	44·63 (1 − n) (0·583 + n)
8 × 8	48	22·8	22·8 − 5·86 n^2	·244	35·50 (1 − n) (0·593 + n)
	40	18·5	18·5 − 4·19 n^2	·256	30·05 (1 − n) (0·559 + n)
	35	16·1	16·1 − 3·27 n^2	·248	25·98 (1 − n) (0·566 + n)
	31	14·0	14·0 − 2·60 n^2	·253	23·01 (1 − n) (0·552 + n)
6 × 6	25	8·55	8·55 − 2·12 n^2	·277	14·43 (1 − n) (0·527 + n)
	20	6·79	6·79 − 1·42 n^2	·270	11·49 (1 − n) (0·527 + n)
	15·7	4·94	4·94 − 0·888 n^2	·312	9·437 (1 − n) (0·435 + n)

For explanation of tables, see notes on pages 62 to 64.



UNIVERSAL BEARING PILES

PARALLEL FLANGES

Dimensions and Properties

Serial Size	Weight per foot	Depth of Section D	Width of Section B	Thickness: Web t	Thickness: Flange T	Root Radius r	Depth between Fillets d	Ratio D/T
ins	lbs	ins	ins	ins	ins	ins	ins	
14 × 14½	117	14·234	14·885	·805	·805	·60	11·42	17·7
	102	14·032	14·784	·704	·704	·60	11·42	19·9
	89	13·856	14·696	·616	·616	·60	11·42	22·5
	73	13·636	14·586	·506	·506	·60	11·42	26·9
12 × 12	74	12·122	12·217	·607	·607	·60	9·71	20·0
	53	11·780	12·046	·436	·436	·60	9·71	27·0
10 × 10	57	10·012	10·224	·564	·564	·50	7·88	17·8
	42	9·720	10·078	·418	·418	·50	7·88	23·3
8 × 8	36	8·026	8·158	·446	·446	·40	6·33	18·0

THE SECTIONS listed above are known all over the world and have been used in many varied types of structures; as foundations for bridges, buildings and heavy machinery; for wharves, steamship piers and mooring dolphins; and in numerous other situations.

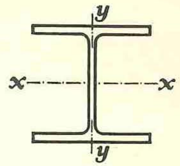
Briefly, their advantages arise from the ability to withstand extremely hard driving and to develop a high bearing value.

The cost of driving is low, because no secondary operations are required and extremely

UNIVERSAL BEARING PILES

PARALLEL FLANGES

Dimensions and Properties

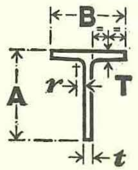


Area of Section	Moment of Inertia: Axis x-x	Moment of Inertia: Axis y-y	Radius of Gyration: Axis x-x	Radius of Gyration: Axis y-y	Elastic Modulus: Axis x-x	Elastic Modulus: Axis y-y	Serial Size
ins2	ins4	ins4	ins	ins	ins3	ins3	ins
34·44	1228·5	443·1	5·97	3·59	172·6	59·5	14 × 14½
30·01	1055·1	379·6	5·93	3·56	150·4	51·4	
26·19	909·1	326·2	5·89	3·53	131·2	44·4	
21·46	733·1	261·9	5·85	3·49	107·5	35·9	
21·76	566·5	184·7	5·10	2·91	93·5	30·2	12 × 12
15·57	394·0	127·1	5·03	2·86	66·9	21·1	
16·76	294·7	100·6	4·19	2·45	58·9	19·7	10 × 10
12·35	210·8	71·4	4·13	2·40	43·4	14·2	
10·60	119·8	40·4	3·36	1·95	29·9	9·9	8 × 8

long lengths can be pitched and driven as single pieces. Lengths up to 90 ft. are available from the mill, which reduces the number of splices required. Splicing by welding is quickly and easily carried out and develops the full strength of the section.

In special circumstances where minimum soil displacement is desirable, these sections are admirable and in normal conditions the life far exceeds requirements.

Standard tolerances and size extras as for Universal Beams and Columns are applicable.



STRUCTURAL TEES

CUT FROM UNIVERSAL BEAMS

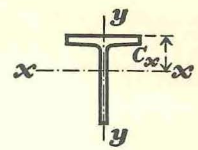
Dimensions and Properties

Serial Size	Weight per foot	Width of Section B	Depth of Section A	Thickness: Web t	Thickness: Flange T	Root Radius r	Slope inside Flange	Area of Section
ins	lbs	ins	ins	ins	ins	ins	per cent	ins²
12×18	85	12·027	18·080	·680	1·100	·75	5·0	24·99
	75	11·972	17·920	·625	·940	·75	5·0	22·08
$11\frac{1}{2} \times 16\frac{1}{2}$	76	11·565	16·750	·635	1·055	·70	5·0	22·35
	65	11·510	16·550	·580	·855	·70	5·0	19·13
$10\frac{1}{2} \times 15$	66	10·551	15·150	·615	1·000	·65	5·0	19·41
	58	10·500	15·000	·564	·850	·65	5·0	17·07
$10 \times 13\frac{1}{2}$	57	10·070	13·640	·570	·932	·60	5·0	16·77
	51	10·018	13·535	·518	·827	·60	5·0	15·01
	47	9·990	13·455	·490	·747	·60	5·0	13·83
12×12	80	12·264	12·460	·732	1·235	·65	5·0	23·52
	60	12·088	12·155	·556	·930	·65	5·0	17·64
	50	12·000	12·000	·468	·775	·65	5·0	14·71
9×12	47	9·061	12·145	·516	·872	·50	5·0	13·81
	42	9·015	12·045	·470	·772	·50	5·0	12·35
	38	8·985	11·955	·440	·682	·50	5·0	11·18
$13 \times 10\frac{1}{2}$	71	13·132	10·730	·659	1·095	·65	5·0	20·89
	63·5	13·061	10·620	·588	·985	·65	5·0	18·69
	56	13·000	10·500	·527	·865	·65	5·0	16·48
$8\frac{1}{4} \times 10\frac{1}{2}$	41	8·342	10·720	·502	·840	·50	5·0	12·06
	36·5	8·295	10·620	·455	·740	·50	5·0	10·73
	34	8·270	10·565	·430	·685	·50	5·0	10·01
	31	8·240	10·495	·400	·615	·50	5·0	9·12

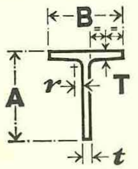
STRUCTURAL TEES

CUT FROM UNIVERSAL BEAMS

Dimensions and Properties



Gravity Centre Distance C_x	Moment of Inertia: Axis x-x	Moment of Inertia: Axis y-y	Radius of Gyration: Axis x-x	Radius of Gyration: Axis y-y	Elastic Modulus: Axis x-x	Elastic Modulus: Axis y-y	Nominal Size	Cut from Universal Beam
ins	ins⁴	ins⁴	ins	ins	ins³	ins³	ins	ins × ins × lbs
4·74	784·8	150·3	5·60	2·45	58·8	25·0	$12 \times 18\frac{1}{16}$	$36 \times 12 \times 170$
4·79	696·7	125·2	5·62	2·38	53·0	20·9	$12 \times 17\frac{15}{16}$	150
4·27	591·9	128·1	5·15	2·39	47·4	22·1	$11\frac{9}{16} \times 16\frac{3}{4}$	$33 \times 11\frac{1}{2} \times 152$
4·37	513·0	100·7	5·18	2·29	42·1	17·5	$11\frac{1}{2} \times 16\frac{9}{16}$	130
3·90	420·7	92·5	4·66	2·18	37·4	17·5	$10\frac{9}{16} \times 15\frac{1}{8}$	$30 \times 10\frac{1}{2} \times 132$
3·94	371·8	76·6	4·67	2·12	33·6	14·6	$10\frac{1}{2} \times 15$	116
3·42	288·9	74·8	4·15	2·11	28·3	14·9	$10\frac{1}{16} \times 13\frac{5}{8}$	$27 \times 10 \times 114$
3·39	257·7	64·8	4·14	2·08	25·4	12·9	$10 \times 13\frac{9}{16}$	102
3·41	238·5	57·5	4·15	2·04	23·7	11·5	$10 \times 13\frac{7}{16}$	94
2·80	295·1	179·9	3·54	2·77	30·6	29·3	$12\frac{1}{4} \times 12\frac{7}{16}$	$24 \times 12 \times 160$
2·62	214·8	127·0	3·49	2·68	22·5	21·0	$12\frac{1}{16} \times 12\frac{1}{8}$	120
2·54	176·7	101·8	3·47	2·63	18·7	17·0	12×12	100
3·00	185·9	51·1	3·67	1·92	20·3	11·3	$9\frac{1}{16} \times 12\frac{1}{8}$	$24 \times 9 \times 94$
2·97	165·9	44·2	3·66	1·89	18·3	9·80	$9 \times 12\frac{1}{16}$	84
3·00	151·1	38·3	3·68	1·85	16·9	8·51	$9 \times 11\frac{15}{16}$	76
2·19	177·3	193·0	2·91	3·04	20·8	29·4	$13\frac{1}{8} \times 10\frac{3}{4}$	$21 \times 13 \times 142$
2·11	155·8	169·3	2·89	3·01	18·3	25·9	$13\frac{1}{16} \times 10\frac{5}{8}$	127
2·06	136·4	144·8	2·88	2·96	16·2	22·3	$13 \times 10\frac{1}{2}$	112
2·63	124·4	38·5	3·21	1·79	15·4	9·24	$8\frac{5}{16} \times 10\frac{3}{4}$	$21 \times 8\frac{1}{4} \times 82$
2·60	110·2	33·1	3·21	1·76	13·7	7·98	$8\frac{5}{16} \times 10\frac{5}{8}$	73
2·59	102·8	30·2	3·20	1·74	12·9	7·30	$8\frac{1}{4} \times 10\frac{9}{16}$	68
2·59	93·7	26·6	3·21	1·71	11·9	6·45	$8\frac{1}{4} \times 10\frac{1}{2}$	62



STRUCTURAL TEES

CUT FROM UNIVERSAL BEAMS

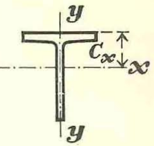
Dimensions and Properties

Serial Size	Weight per foot	Width of Section B	Depth of Section A	Thickness Web t	Thickness Flange T	Root Radius r	Slope inside Flange	Area of Section
ins	lbs	ins	ins	ins	ins	ins	per cent	ins 2
$7\frac{1}{2} \times 9$	33	7·592	9·200	·450	·770	·40	5·0	9·70
	30	7·558	9·125	·416	·695	·40	5·0	8·82
	27·5	7·532	9·060	·390	·630	·40	5·0	8·09
	25	7·500	9·000	·358	·570	·40	5·0	7·35
7×8	25	7·073	8·125	·380	·628	·40	5·0	7·35
	22·5	7·039	8·060	·346	·563	·40	5·0	6·62
	20	7·000	8·000	·307	·503	·40	5·0	5·88
	18	6·992	7·925	·299	·428	·40	5·0	5·30
$6\frac{3}{4} \times 7$	22·5	6·820	7·165	·357	·618	·40	5·0	6·61
	19	6·776	7·060	·313	·513	·40	5·0	5·59
	17	6·750	7·000	·287	·453	·40	5·0	5·00
	15	6·733	6·930	·270	·383	·40	5·0	4·41
$6\frac{1}{2} \times 6$	18	6·565	6·120	·305	·540	·35	5·0	5·29
	15·5	6·525	6·045	·265	·465	·35	5·0	4·56
	13·5	6·500	5·980	·240	·400	·35	5·0	3·99
$5\frac{3}{4} \times 5$	14·5	5·799	5·110	·289	·500	·30	5·0	4·27
	12·5	5·762	5·040	·252	·430	·30	5·0	3·67
	10·5	5·750	4·950	·240	·340	·30	5·0	3·10
$5\frac{1}{4} \times 4$	10	5·268	4·070	·248	·378	·30	5·0	2·94
	8·5	5·250	4·000	·230	·308	·30	5·0	2·50

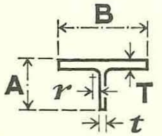
STRUCTURAL TEES

CUT FROM UNIVERSAL BEAMS

Dimensions and Properties



Gravity Centre Distance C_x	Moment of Inertia Axis x-x	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Nominal Size	Cut from Universal Beam
ins	ins 4	ins 4	ins	ins	ins 3	ins 3	ins	ins × ins × lbs
2·19	71·5	26·6	2·72	1·66	10·2	7·01	$7\frac{9}{16} \times 9\frac{3}{16}$	$18 \times 7\frac{1}{2} \times 66$
2·17	64·8	23·5	2·71	1·63	9·32	6·23	$7\frac{9}{16} \times 9\frac{1}{8}$	60
2·16	59·6	21·0	2·71	1·61	8·63	5·57	$7\frac{9}{16} \times 9\frac{1}{16}$	55
2·14	53·9	18·6	2·71	1·59	7·85	4·96	$7\frac{1}{2} \times 9$	50
1·89	42·2	17·4	2·40	1·54	6·77	4·92	$7\frac{1}{16} \times 8\frac{1}{8}$	$16 \times 7 \times 50$
1·87	37·8	15·2	2·39	1·52	6·10	4·33	$7\frac{1}{16} \times 8\frac{1}{16}$	45
1·82	33·2	13·3	2·37	1·50	5·37	3·79	7×8	40
1·90	30·7	11·1	2·41	1·45	5·10	3·17	$7 \times 7\frac{15}{16}$	36
1·58	27·8	15·4	2·05	1·52	4·98	4·50	$6\frac{13}{16} \times 7\frac{3}{16}$	$14 \times 6\frac{3}{4} \times 45$
1·56	23·5	12·3	2·05	1·49	4·27	3·64	$6\frac{3}{4} \times 7\frac{1}{16}$	38
1·55	21·1	10·6	2·05	1·46	3·86	3·15	$6\frac{3}{4} \times 7$	34
1·59	19·0	8·77	2·08	1·41	3·55	2·61	$6\frac{3}{4} \times 6\frac{15}{16}$	30
1·26	15·3	11·9	1·70	1·50	3·14	3·62	$6\frac{9}{16} \times 6\frac{1}{8}$	$12 \times 6\frac{1}{2} \times 36$
1·22	13·0	9·91	1·69	1·47	2·69	3·04	$6\frac{1}{2} \times 6\frac{1}{16}$	31
1·21	11·4	8·30	1·69	1·44	2·39	2·55	$6\frac{1}{2} \times 6$	27
1·05	8·38	7·61	1·40	1·34	2·07	2·62	$5\frac{13}{16} \times 5\frac{1}{8}$	$10 \times 5\frac{3}{4} \times 29$
1·02	7·12	6·34	1·39	1·31	1·77	2·20	$5\frac{3}{4} \times 5\frac{1}{16}$	25
1·06	6·31	4·87	1·43	1·25	1·62	1·69	$5\frac{3}{4} \times 4\frac{15}{16}$	21
·83	3·66	4·25	1·12	1·20	1·13	1·61	$5\frac{1}{4} \times 4\frac{1}{16}$	$8 \times 5\frac{1}{4} \times 20$
·84	3·21	3·36	1·13	1·16	1·01	1·28	$5\frac{1}{4} \times 4$	17



STRUCTURAL TEES

CUT FROM UNIVERSAL COLUMNS

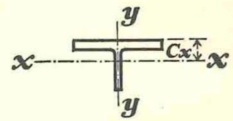
Dimensions and Properties

Serial Size	Weight per foot	Width of Section B	Depth of Section A	Thickness: Web t	Thickness: Flange T	Root Radius r	Slope inside Flange	Area of Section
ins	lbs	ins	ins	ins	ins	ins	per cent	ins²
16 × 7	79	15·550	7·500	·730	1·188	·60	0	23·24
14½ × 7	68	14·740	7·375	·660	1·063	·60	0	19·99
	59·5	14·650	7·250	·570	·938	·60	0	17·49
	51·5	14·575	7·125	·495	·813	·60	0	15·13
	43·5	14·500	7·000	·420	·688	·60	0	12·78
12 × 6	53	12·230	6·440	·620	·986	·60	0	15·59
	46	12·155	6·310	·545	·856	·60	0	13·53
	39·5	12·080	6·190	·470	·736	·60	0	11·61
	32·5	12·000	6·060	·390	·606	·60	0	9·55
10 × 5	44·5	10·275	5·440	·615	·998	·50	0	13·09
	36	10·170	5·250	·510	·808	·50	0	10·59
	30	10·075	5·125	·415	·683	·50	0	8·83
	24·5	10·000	5·000	·340	·558	·50	0	7·20
8 × 4	24	8·117	4·250	·405	·683	·40	0	7·06
	20	8·077	4·125	·365	·558	·40	0	5·88
	17·5	8·027	4·060	·315	·493	·40	0	5·15
	15·5	8·000	4·000	·288	·433	·40	0	4·56
6 × 3	12·5	6·080	3·185	·320	·454	·30	0	3·67
	10	6·018	3·100	·258	·369	·30	0	2·96
	7·85	6·000	3·000	·240	·269	·30	0	2·31

STRUCTURAL TEES

CUT FROM UNIVERSAL COLUMNS

Dimensions and Properties



Gravity Centre Distance C_x	Moment of Inertia: Axis x-x	Moment of Inertia: Axis y-y	Radius of Gyration: Axis x-x	Radius of Gyration: Axis y-y	Elastic Modulus: Axis x-x	Elastic Modulus: Axis y-y	Nominal Size	Cut from Universal Column
ins	ins⁴	ins⁴	ins	ins	ins³	ins³	ins	ins × ins × lbs
1·34	69·3	372·5	1·73	4·00	11·3	47·9	$15\frac{9}{16} \times 7\frac{1}{2}$	14 × 16 × 158
1·31	60·1	283·9	1·73	3·77	9·89	38·5	$14\frac{3}{4} \times 7\frac{3}{8}$	14 × 14½ × 136
1·22	50·4	245·9	1·70	3·75	8·36	33·6	$14\frac{5}{8} \times 7\frac{1}{4}$	119
1·15	42·4	209·9	1·67	3·72	7·10	28·8	$14\frac{9}{16} \times 7\frac{1}{8}$	103
1·08	34·9	174·8	1·65	3·70	5·88	24·1	$14\frac{1}{2} \times 7$	87
1·20	36·7	150·4	1·53	3·11	7·01	24·6	$12\frac{1}{4} \times 6\frac{7}{16}$	12 × 12 × 106
1·13	31·0	128·2	1·51	3·08	5·99	21·1	$12\frac{1}{8} \times 6\frac{5}{16}$	92
1·06	25·8	108·2	1·49	3·05	5·03	17·9	$12\frac{1}{16} \times 6\frac{3}{16}$	79
·98	20·6	87·3	1·47	3·02	4·06	14·6	$12 \times 6\frac{1}{16}$	65
1·07	21·3	90·3	1·28	2·63	4·88	17·6	$10\frac{1}{4} \times 5\frac{7}{16}$	10 × 10 × 89
·97	16·4	70·9	1·24	2·59	3·83	13·9	$10\frac{3}{16} \times 5\frac{1}{4}$	72
·88	12·8	58·2	1·21	2·57	3·03	11·6	$10\frac{1}{16} \times 5\frac{1}{8}$	60
·81	9·99	46·5	1·18	2·54	2·38	9·30	10×5	49
·78	6·92	30·5	·99	2·08	2·00	7·51	$8\frac{1}{8} \times 4\frac{1}{4}$	8 × 8 × 48
·74	5·80	24·5	·99	2·04	1·71	6·07	$8\frac{1}{16} \times 4\frac{1}{8}$	40
·69	4·88	21·3	·97	2·03	1·45	5·30	$8 \times 4\frac{1}{16}$	35
·67	4·32	18·5	·97	2·01	1·30	4·62	8×4	31
·61	2·27	8·51	·79	1·52	·88	2·80	$6\frac{1}{16} \times 3\frac{3}{16}$	6 × 6 × 25
·56	1·75	6·71	·77	1·50	·69	2·23	$6 \times 3\frac{1}{8}$	20
·56	1·47	4·85	·80	1·45	·60	1·62	6×3	15·7

SAFE LOAD TABLES

for

UNIVERSAL BEAMS AND COLUMNS

with

EXPLANATORY NOTES

BASED ON B.S. 449 : 1959

UNIVERSAL BEAMS

Web Capacities in Tons

BASED ON B.S. 449 1959

Serial Size	Weight per foot	Web thickness t inches	Depth between fillets d inches	Buckling Value in Tons for Unstiffened Web: Simply supported on End Bearing — Beam Component	Simply supported on End Bearing — Stiff Bearing or Flange Pl. Component per inch	Continuous over Intermediate Bearing — Beam Component	Continuous over Intermediate Bearing — Stiff Bearing Component per linear inch	Continuous over Intermediate Bearing — Flange Pl. Component per inch of thickness
ins	lbs							
21×8¼	82	·502	18·61	32·99	3·08	65·98	3·08	6·15
	73	·455	18·61	27·93	2·63	55·87	2·63	5·26
	68	·430	18·61	25·28	2·39	50·56	2·39	4·79
	62	·400	18·61	22·12	2·11	44·24	2·11	4·22
18×7½	66	·450	15·92	26·01	2·83	52·02	2·83	5·65
	60	·416	15·92	22·86	2·51	45·72	2·51	5·01
	55	·390	15·92	20·45	2·26	40·91	2·26	4·52
	50	·358	15·92	17·58	1·95	35·16	1·95	3·91
16×7	50	·380	14·07	18·94	2·33	37·88	2·33	4·66
	45	·346	14·07	16·18	2·01	32·37	2·01	4·02
	40	·307	14·07	13·10	1·64	26·20	1·64	3·27
	36	·299	14·07	12·37	1·56	24·74	1·56	3·12
14×6¾	45	·357	12·17	16·37	2·29	32·75	2·29	4·57
	38	·313	12·17	13·18	1·87	26·36	1·87	3·73
	34	·287	12·17	11·34	1·62	22·68	1·62	3·24
	30	·270	12·17	10·11	1·46	20·22	1·46	2·92
12×6½	36	·305	10·34	11·98	1·96	23·96	1·96	3·91
	31	·265	10·34	9·54	1·58	19·07	1·58	3·15
	27	·240	10·34	8·01	1·34	16·03	1·34	2·68
10×5¾	29	·289	8·51	10·08	1·97	20·15	1·97	3·94
	25	·252	8·51	8·17	1·62	16·33	1·62	3·24
	21	·240	8·51	7·46	1·51	14·91	1·51	3·01
8×5¼	20	·248	6·69	7·11	1·75	14·23	1·75	3·50
	17	·230	6·69	6·31	1·58	12·61	1·58	3·15

For explanation of tables, see notes on pages 57 and 58.

BASED ON B.S. 449 1959

UNIVERSAL BEAMS

Web Capacities in Tons

Serial Size	Weight per foot	Direct Bearing Value in Tons: Simply supported on End Bearing — Beam Component	Simply supported on End Bearing — Stiff Bearing Component per linear inch	Simply supported on End Bearing — Flange Pl. Component per inch of thickness	Continuous over Intermediate Bearing — Beam Component	Continuous over Intermediate Bearing — Stiff Bearing Component per linear inch	Continuous over Intermediate Bearing — Flange Pl. Component per inch of thickness	Shear Value in Tons
ins	lbs							
21×8¼	82	14·76	6·02	10·43	29·53	6·02	20·87	64·58
	73	12·44	5·46	9·46	24·87	5·46	18·91	57·99
	68	11·26	5·16	8·94	22·52	5·16	17·87	54·52
	62	9·89	4·80	8·31	19·79	4·80	16·63	50·38
18×7½	66	11·60	5·40	9·35	23·19	5·40	18·71	49·68
	60	10·07	4·99	8·65	20·15	4·99	17·29	45·55
	55	8·92	4·68	8·11	17·83	4·68	16·21	42·40
	50	7·74	4·30	7·44	15·48	4·30	14·88	38·66
16× 7	50	8·61	4·56	7·90	17·22	4·56	15·80	37·05
	45	7·37	4·15	7·19	14·74	4·15	14·38	33·47
	40	6·16	3·68	6·38	12·31	3·68	12·76	29·47
	36	5·53	3·59	6·21	11·06	3·59	12·43	28·43
14×6¾	45	8·01	4·28	7·42	16·03	4·28	14·84	30·69
	38	6·34	3·76	6·51	12·69	3·76	13·01	26·52
	34	5·46	3·44	5·97	10·92	3·44	11·93	24·11
	30	4·74	3·24	5·61	9·48	3·24	11·22	22·45
12×6½	36	6·02	3·66	6·34	12·04	3·66	12·68	22·40
	31	4·82	3·18	5·51	9·64	3·18	11·02	19·22
	27	4·04	2·88	4·99	8·08	2·88	9·98	17·22
10×5¾	29	5·14	3·47	6·01	10·27	3·47	12·01	17·72
	25	4·11	3·02	5·24	8·22	3·02	10·48	15·24
	21	3·47	2·88	4·99	6·93	2·88	9·98	14·26
8×5¼	20	3·74	2·98	5·15	7·47	2·98	10·31	12·11
	17	3·13	2·76	4·78	6·26	2·76	9·56	11·04

Let W = web value in tons, Cj = beam component, Cp = flange plate component, Cb = stiff bearing component, tp = thickness, in inches, of flange plates between beam and support and lb = length, in inches, of stiff bearing; then, for web buckling or direct bearing, either at end or intermediate bearings, $W = Cj + tp \cdot Cp + lb \cdot Cb$.

UNIVERSAL BEAMS

BASED ON B.S. 449 1959

Safe Loads

Serial Size	Weight per foot	SAFE DISTRIBUTED LOADS IN TONS FOR SPANS IN FEET									
ins	*lbs*	12	14	16	18	20	22	24	26	28	32
36 × 16½	260						288	264	244	226	198
	230						253	232	214	199	174
36 × 12	194				246	221	201	184	170	158	138
	170					203	184	169	156	145	127
	150						160	147	135	126	110
33 × 11½	152					170	155	142	131	122	106
	130					142	129	118	109	101	88·6
30 × 10½	132				148	133	121	111	102	94·9	83·1
	116				128	115	104	95·6	88·3	82·0	71·7
27 × 10	114			131	116	105	95·2	87·3	80·6	74·8	65·5
	102				104	93·2	84·7	77·7	71·7	66·6	58·3
	94				94·4	85·0	77·3	70·8	65·4	60·7	53·1
24 × 12	160			175	155	140	127	117	108	99·9	87·4
	120				116	105	95·2	87·2	80·5	74·8	65·4
	100					87·1	79·2	72·6	67·0	62·2	54·4
24 × 9	94		110	96·6	85·9	77·3	70·3	64·4	59·5	55·2	48·3
	84			85·9	76·3	68·7	62·5	57·3	52·8	49·1	42·9
	76			76·7	68·2	61·4	55·8	51·2	47·2	43·8	38·4
21 × 13	142			139	123	111	101	92·5	85·4	79·3	69·4
	127			124	111	99·5	90·4	82·9	76·5	71·0	62·2
	112				97·1	87·4	79·4	72·8	67·2	62·4	54·6
21 × 8¼	82	99·5	85·3	74·6	66·3	59·7	54·2	49·7	45·9	42·6	37·3
	73	87·9	75·3	65·9	58·6	52·7	47·9	44·0	40·6	37·7	33·0
	68	81·6	70·0	61·2	54·4	49·0	44·5	40·8	37·7	35·0	30·6
	62	73·7	63·2	55·3	49·2	44·2	40·2	36·9	34·0	31·6	27·6

Generally, tabular loads are based on the following flexural stresses, assuming adequate lateral support: (*a*) 10·5 tons/inch² for beams having webs up to and including ¾ in. thick, (*b*) 10·0 tons/inch² for beams having webs over ¾ in. thick.

Tabular loads to left of dotted zig-zag line exceed the load buckling capacity of the unstiffened web without allowance for actual length of bearing. The load bearing capacity should also be checked; see page 58.

BASED ON B.S. 449 1959

UNIVERSAL BEAMS

Safe Loads

SAFE DISTRIBUTED LOADS IN TONS FOR SPANS IN FEET										Serial Size	Weight per foot
36	40	44	48	52	56	60	64	68	72	*ins*	*lbs*
176	159	144	132	122	113	102	89·8	79·5	70·9	36 × 16½	260
155	139	127	116	107	99·5	88·8	78·1	69·1	61·7		230
123	111	101	92·2	85·1	79·0	71·7	63·0	55·8	49·8	36 × 12	194
113	101	92·1	84·5	78·0	71·2	62·0	54·5	48·3	43·1		170
97·8	88·0	80·0	73·3	67·7	61·3	53·4	46·9	41·6	37·1		150
94·6	85·1	77·4	70·9	64·3	55·4	48·3	42·4	37·6	33·5	33 × 11½	152
78·7	70·8	64·4	59·0	52·9	45·6	39·7	34·9	30·9	27·6		130
73·8	66·4	60·4	53·3	45·4	39·1	34·1	30·0			30 × 10½	132
63·8	57·4	52·2	45·5	38·8	33·5	29·2	25·6				116
58·2	52·4	45·0	37·8	32·2	27·8	24·2	21·3			27 × 10	114
51·8	46·6	39·7	33·4	28·4	24·5	21·4	18·8				102
47·2	42·5	36·0	30·2	25·8	22·2	19·4	17·0				94
77·7	66·4	54·9	46·1	39·3	33·9					24 × 12	160
58·2	48·5	40·1	33·7	28·7	24·7						120
48·4	39·8	32·9	27·7	23·6	20·3						100
43·0	35·8	29·6	24·8	21·2	18·3					24 × 9	94
38·2	31·5	26·1	21·9	18·7	16·1						84
34·1	28·0	23·1	19·4	16·5	14·3						76
56·0	45·4	37·5	31·5	26·9						21 × 13	142
49·7	40·2	33·3	27·9	23·8							127
43·2	35·0	28·9	24·3	20·7							112
30·1	24·4	20·1	16·9	14·4						21 × 8¼	82
26·3	21·3	17·6	14·8	12·6							73
24·3	19·7	16·3	13·7	11·7							68
21·8	17·7	14·6	12·3	10·5							62

Tabular loads to right of full zig-zag line are reduced so that the deflection will equal 1/325 th of the span.

For explanation of tables see notes on pages 56 to 59 inclusive.

Beams with limited, or without adequate lateral support should be designed to reduced stresses in accordance with clause 19a, B.S. 449 : 1959.

UNIVERSAL BEAMS

BASED ON B.S. 449 1959

Safe Loads

Serial Size	Weight per foot	SAFE DISTRIBUTED LOADS IN TONS FOR SPANS IN FEET									
ins	lbs	5	6	7	8	9	10	12	14	16	18
18×7½	66						83·4	69·5	59·6	52·2	46·4
	60						75·5	62·9	53·9	47·2	41·9
	55						68·7	57·3	49·1	43·0	38·2
	50						62·3	51·9	44·5	38·9	34·6
16×7	50					62·8	56·5	47·1	40·3	35·3	31·4
	45					56·3	50·7	42·2	36·2	31·7	28·2
	40						45·1	37·6	32·2	28·2	25·0
	36					43·8	39·4	32·8	28·1	24·6	21·9
14×6¾	45				57·1	50·8	45·7	38·1	32·6	28·6	25·4
	38					42·5	38·2	31·8	27·3	23·9	21·2
	34					37·7	33·9	28·3	24·2	21·2	18·9
	30					32·5	29·3	24·4	20·9	18·3	16·3
12×6½	36				40·2	35·7	32·1	26·8	22·9	20·1	17·9
	31					30·6	27·6	23·0	19·7	17·2	15·3
	27					26·5	23·9	19·9	17·0	14·9	13·3
10×5¾	29			30·8	27·0	24·0	21·6	18·0	15·4	13·1	10·4
	25			26·4	23·1	20·5	18·5	15·4	13·2	11·1	8·7
	21			21·5	18·8	16·7	15·1	12·5	10·7	8·8	7·0
8×5¼	20	23·8	19·8	17·0	14·9	13·2	11·9	9·9	7·5	5·7	4·5
	17	19·7	16·4	14·1	12·3	11·0	9·8	8·2	6·1	4·7	3·7

Generally, tabular loads are based on a flexural stress of 10·5 tons/inch², assuming adequate lateral support.

Tabular loads to left of dotted zig-zag line exceed the load buckling capacity of the unstiffened web without allowance for actual length of bearing. The load bearing capacity should also be checked; see page 58.

UNIVERSAL BEAMS

BASED ON B.S. 449 1959

Safe Loads

SAFE DISTRIBUTED LOADS IN TONS FOR SPANS IN FEET										Serial Size	Weight per foot
20	22	24	26	28	30	32	34	36	40	ins	lbs
41·7	37·9	34·8	32·1	29·8	26·0	22·8	20·2	18·1	14·6	18×7½	66
37·7	34·3	31·4	29·0	26·8	23·3	20·5	18·2	16·2	13·1		60
34·4	31·2	28·6	26·4	24·2	21·1	18·5	16·4	14·6	11·9		55
31·2	28·3	26·0	24·0	21·8	19·0	16·7	14·8	13·2	10·7		50
28·2	25·7	23·5	20·7	17·8	15·5	13·6	12·1	10·8		16×7	50
25·3	23·0	21·1	18·4	15·9	13·8	12·1	10·8	9·6			45
22·5	20·5	18·8	16·3	14·0	12·2	10·7	9·5	8·4			40
19·7	17·9	16·4	14·1	12·1	10·6	9·2	8·2	7·3			36
22·9	20·6	17·3	14·8	12·7	11·1	9·7				14×6¾	45
19·1	17·0	14·3	12·2	10·5	9·1	8·0					38
17·0	15·0	12·6	10·7	9·2	8·0	7·0					34
14·6	12·8	10·7	9·1	7·8	6·8	6·0					30
15·0	12·4	10·4	8·8	7·6						12×6½	36
12·7	10·5	8·8	7·5	6·4							31
10·9	9·0	7·5	6·4	5·5							27
8·3	6·9	5·8								10×5¾	29
7·1	5·8	4·9									25
5·6	4·6	3·9									21
3·6										8×5¼	20
3·0											17

Tabular loads to right of full zig-zag line are reduced so that the deflection will equal 1/325th of the span.

For explanation of tables see notes on pages 56 to 59 inclusive.

Beams with limited, or without adequate lateral support should be designed to reduced stresses in accordance with clause 19a, B.S. 449: 1959.

UNIVERSAL COLUMNS

Safe Loads

BASED ON B.S. 449 1959

Serial Size inches	Weight per foot in lbs.	SAFE CONCENTRIC LOADS IN TONS FOR EFFECTIVE LENGTHS IN FEET													
		10	12	14	16	20	24	28	32	36	40	44	48	52	56
14 × 16	426	1008	972	935	899	826	754	681	607	534	467	407	356	313	276
	264	619	596	572	548	501	454	407	359	312	271	235	205	179	158
	202	472	454	435	417	380	343	306	269	233	201	174	152	133	117
	158	368	354	339	324	295	266	236	207	179	154	133	116	101	88·9
Column Core	320	752	724	695	667	610	553	496	438	382	332	288	251	220	194
14 × 14½	136	313	300	286	273	246	219	192	166	142	121	104	90·1	78·5	68·9
	119	274	262	250	238	215	191	168	144	123	105	90·4	78·2	68·1	59·7
	103	236	226	216	205	185	164	144	123	105	89·9	77·2	66·7	58·0	
	87	199	191	182	173	156	138	121	104	88·3	75·3	64·6	55·8	48·6	
12 × 12	190	422	401	379	357	314	270	227	190	158	133	113	97·2		
	161	357	338	320	301	264	226	189	157	131	110	93·5	80·2		
	133	294	278	262	247	216	184	154	127	106	89·0	75·5			
	106	233	220	208	195	170	144	120	99·2	82·4	69·1	58·6			
	92	202	191	180	169	146	124	103	84·8	70·4	59·0	50·0			
	79	173	163	153	144	125	105	87·0	71·7	59·4	49·8	42·1			
	65	142	134	126	118	102	85·7	70·6	58·1	48·1	40·3	34·1			

The above safe loads are tabulated for slenderness ratios up to, but not exceeding, 180.

Safe loads are calculated for the "effective length" of the stanchion by the formulae in B.S. 449 : 1959.

BASED ON B.S. 449 1959

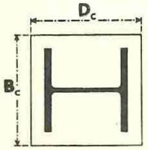
UNIVERSAL COLUMNS

Safe Loads

Serial Size inches	Weight per foot in lbs.	SAFE CONCENTRIC LOADS IN TONS FOR EFFECTIVE LENGTHS IN FEET													
		4	6	8	10	12	14	16	18	20	22	24	28	32	36
10 × 10	112	282	266	251	235	220	204	188	173	157	142	127	102	82·1	67·2
	89	224	211	199	186	174	161	148	136	123	111	98·9	79·0	63·7	52·1
	72	181	170	160	150	139	129	119	108	98·0	87·8	78·4	62·4	50·2	41·0
	60	150	142	133	124	116	107	98·5	89·8	81·0	72·5	64·6	51·4	41·3	33·7
	49	123	115	108	101	93·9	86·8	79·7	72·5	65·2	58·2	51·8	41·1	33·0	27·0
8 × 8	48	117	108	99·9	91·3	82·8	74·2	65·5	57·1	49·6	43·0	37·5	28·9		
	40	97·2	89·9	82·7	75·4	68·1	60·9	53·5	46·4	40·2	34·8	30·3	23·3		
	35	85·1	78·7	72·3	65·9	59·5	53·1	46·6	40·4	34·9	30·2	26·3	20·2		
	31	75·2	69·5	63·8	58·1	52·3	46·6	40·8	35·3	30·5	26·4	22·9	17·6		
6 × 6	25	57·6	51·5	45·5	39·4	33·2	27·4	22·6	18·7	15·7	13·3				
	20	46·4	41·4	36·4	31·4	26·4	21·7	17·8	14·8	12·3	10·4				
	15·7	35·9	31·8	27·8	23·8	19·8	16·2	13·2	10·9	9·0					

Each weight per foot is for the shaft only. Weight of base, etc., to be added.

For explanation of tables, see notes on pages 59 and 60.



UNIVERSAL COLUMNS CASED

Safe Loads

BASED ON B.S. 449 1959

Minimum Size $D_c \times B_c$ inches	Core Weight per foot in lbs	SAFE CONCENTRIC LOADS IN TONS FOR EFFECTIVE LENGTHS IN FEET												
		8	12	16	20	24	28	32	36	40	45	50	55	60
22¾ × 20¾	426	1176	1094	1012	930	848	766	683	602	526	444	376	321	276
20½ × 20¼	264	758	702	646	591	535	479	423	369	320	267	226	192	165
19¾ × 19¾	202	598	553	508	463	418	373	328	285	246	205	173	147	126
19 × 19¾	158	486	449	412	375	337	300	263	227	196	164	137	117	99·8
21 × 20¾	320	901	835	770	704	638	572	506	442	384	321	272	231	198
18¾ × 18¾	136	422	387	353	318	284	249	215	184	157	130	109	92·1	
18½ × 18¾	119	380	348	317	286	255	223	192	164	140	116	97·0	82·2	
18¼ × 18¾	103	339	311	283	255	226	198	170	145	124	103	85·6	72·5	
18 × 18½	87	298	273	248	223	198	173	149	127	108	89·5	74·7	63·1	
18½ × 16¾	190	529	479	429	379	328	278	234	195	165	135	112		
18 × 16¾	161	458	414	370	327	282	239	200	167	141	115			
17½ × 16½	133	388	350	313	275	238	200	167	140	118	96·4			
17 × 16¼	106	321	290	258	227	195	164	137	115	96·4	78·8			
16¾ × 16¼	92	287	259	231	202	174	146	122	102	85·5	69·8			
16½ × 16¼	79	255	230	205	179	154	129	108	89·9	75·4	61·6			
16¼ × 16	65	220	198	176	155	132	111	92·2	77·0	64·6	52·8			
15½ × 14½	112	313	278	243	207	172	140	114	94·2	78·7				
15 × 14½	89	259	229	200	170	140	114	93·3	76·7	63·9				
14½ × 14¼	72	217	192	167	142	117	94·9	77·3	63·6	53·0				
14¼ × 14¼	60	188	166	145	123	101	81·7	66·6	54·7	45·6				
14 × 14	49	161	142	124	105	85·9	69·5	56·6	46·5	38·7				
12½ × 12¼	48	143	123	103	82·5	64·7	51·0	40·7	33·1					
12¼ × 12¼	40	124	107	89·3	71·7	56·2	44·2	35·3	28·7					
12¼ × 12¼	35	113	97·3	81·2	65·1	50·9	40·1	*31·9*	*25·8*					
12 × 12	31	103	88·4	73·8	59·0	*45·9*	*35·3*	*27·8*	*22·4*					
10½ × 10¼	25	76·6	62·9	*45·2*	*31·4*	*22·7*	*17·1*							
10¼ × 10¼	20	65·9	*52·8*	*35·7*	*24·7*	*17·9*	*13·5*							
10 × 10	15·7	55·5	*39·5*	*26·4*	*18·2*	*13·1*	*9·8*							

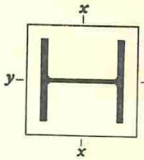
The above safe loads are tabulated for effective lengths of stanchions up to, but not exceeding, that giving the slenderness ratio of 180 for the cased section. If the end conditions require an effective length factor other than 1.0 for the cased section, the maximum permissible length should be checked in accordance with clause 30b of B.S. 449 : 1959.

Tabular loads printed in italics are based on loads restricted to 100% in excess of those permitted on the uncased section.

BASED ON B.S. 449 1959

UNIVERSAL COLUMNS CASED

Dimensions and Properties



Core Composed of One Universal Column		Core Area in square inches	Cased Section Area in square inches	Radius of Gyration			Elastic Modulus	
				Axis *y-y*		Axis *x-x* Core only	Axis *y-y*	Axis *x-x*
				Cased Section	Core only			
14 × 16 @	**426**	125·25	472·06	4·34	4·34	7·26	282·7	707·4
	264	77·63	415·13	4·14	4·14	6·74	166·1	427·4
	202	59·39	390·06	4·06	4·06	6·54	124·4	324·9
	158	46·47	375·25	4·00	4·00	6·40	95·8	253·4
Column Core @	**320**	94·12	435·75	4·17	4·17	6·63	195·7	492·8
14 × 14½ @	**136**	39·98	351·56	3·77	3·77	6·31	77·0	216·0
	119	34·99	346·88	3·75	3·75	6·26	67·1	189·4
	103	30·26	342·19	3·72	3·72	6·21	57·6	163·6
	87	25·56	333·00	3·70	3·70	6·15	48·2	138·1
12 × 12 @	**190**	55·86	309·88	3·33	3·25	5·82	93·1	263·2
	161	47·38	301·50	3·30	3·20	5·70	77·7	222·2
	133	39·11	288·75	3·27	3·16	5·59	63·1	182·5
	106	31·19	276·25	3·25	3·11	5·46	49·2	144·5
	92	27·06	272·19	3·23	3·08	5·40	42·2	125·0
	79	23·22	268·13	3·22	3·05	5·34	35·8	107·1
	65	19·11	260·00	3·20	3·02	5·28	29·1	88·0
10 × 10 @	**112**	32·92	224·75	2·88	2·67	4·67	45·2	126·3
	89	26·19	217·50	2·86	2·63	4·55	35·2	99·7
	72	21·18	206·63	2·83	2·59	4·46	27·9	80·1
	60	17·66	203·06	2·82	2·57	4·41	23·1	67·1
	49	14·40	196·00	2·80	2·54	4·35	18·6	54·6
8 × 8 @	**48**	14·11	153·13	2·42	2·08	3·61	15·0	43·2
	40	11·76	150·06	2·42	2·04	3·53	12·14	35·5
	35	10·30	150·06	2·41	2·03	3·50	10·60	31·1
	31	9·12	144·00	2·40	2·01	3·47	9·24	27·4
6 × 6 @	**25**	7·35	107·63	2·02	1·52	2·69	5·60	16·7
	20	5·93	105·06	2·00	1·50	2·66	4·46	13·5
	15·7	4·62	100·00	2·00	1·45	2·56	3·23	10·1

Each weight per foot is for the main steel shaft only. Weight of base etc. to be added and suitable allowances made where necessary for casing and reinforcement.

Stanchions must be constructed to comply with the casing requirements given in clause 30*b*, B.S. 449 : 1959.

For explanation of tables, see notes on pages 60 to 62 inclusive.

EXPLANATORY NOTES

General

SECTIONS The beams and columns are included in B.S. 4B : 1959. T-bars produced from universal sections are listed in Supplement No. 1 : 1959 to B.S. 4A : 1934.

WEIGHTS The weights per foot are calculated on the basis that a cubic foot of steel weighs 489·6 pounds, i.e. a piece of steel 1 inch square by 1 foot long weighs 3·4 pounds. A rolling margin of $2\frac{1}{2}\%$ over or under must be allowed on the weights listed.

AREAS The areas tabulated are the gross areas of the sections in square inches.

MOMENTS OF INERTIA The gross moments of inertia about both principal axes are tabulated in inch units for each section. The net moment of inertia relative to the *x-x* axis is tabulated for each beam and column section. In evaluating the net moments of inertia, holes have been deducted from each flange in accordance with the following table:

SERIAL FLANGE BREADTH	NUMBER OF HOLES PER FLANGE	DIAMETER OF HOLE
12″ and over	2	$\frac{15}{16}$″
$6\frac{1}{2}$″ to $11\frac{1}{2}$″	1	$\frac{15}{16}$″
under $6\frac{1}{2}$″	1	$\frac{13}{16}$″

$\frac{D}{T}$ RATIO The depth of section (D) to mean thickness of flange (T) ratio is tabulated for each beam and column section for use in the design of members subject to bending and having only intermittent, or no adequate lateral restraint. (Designers are referred to clause 19 of B.S. 449 : 1959.)

WORKING STRESSES The tabulated values are based on the stresses for mild steel to B.S. 15 : 1948 (amended April, 1959) and as given in B.S. 449 : 1959 for the Use of Structural Steel in Building.

The permissible working stresses are:

	Tons/inch²
Bending, web thickness up to and including $\frac{3}{4}$″	10·5
do. over $\frac{3}{4}$″	10·0
Shear, webs	6·0
Bearing, webs	12·0

Axial Compression, in accordance with Table 17 of B.S. 449 : 1959. The values have been reduced where necessary to comply with deflection and other limitations.

Universal Beams

WEB BUCKLING The buckling values for the unstiffened webs have been calculated in accordance with the formulæ in clause 28*a*(i) of B.S. 449 : 1959, namely:

$W = p_c . t . B$

where W = permissible reaction or concentrated load in tons on the unstiffened web

p_c = axial stress in tons/inch² for struts, as given in clause 30*a* of B.S. 449 : 1959 for a slenderness ratio of $(d\sqrt{3})/t$

d = clear depth of web between root fillets

t = web thickness

B = $\frac{1}{2}D+t_p+lb$ for end bearings of simply supported beams, or

= $D+2t_p+lb$ for intermediate bearings

in which,

D = depth in inches of the beam

t_p = thickness in inches of the bearing and/or flange plate (if any)

lb = length in inches of the stiff portion of the bearing; lb shall not be taken as greater than half the depth of beam for simply supported beams and the full depth of beam for an intermediate bearing over which the beam is continuous, unless the web is stiffened.

Where bearing, bending and shear stresses are co-existent the beam should be checked in accordance with clause 14*d* of B.S. 449 : 1959.

WEB CRUSHING To prevent local crushing of the web, the direct bearing stress delivered to the root of the web should not exceed 12 tons/inch² when the load is assumed to be dispersed at an angle of 30° through the flange and bearing and/or flange plate (if any). The tables give separately the loads that may be dispersed to the web through the flange and through the plates (if any) and also the load for each inch of stiff bearing.

WEB BUCKLING AND CRUSHING *Example* Required the maximum permissible reaction and uniformly distributed load, in terms of the web capacity, for a universal beam 24″×9″ @ 94 lbs./ft. having no bearing plates and supported on bearings each having a stiff length of 3″.

Web Buckling Value $= Cj + tp.\ Cp + lb.\ Cb$

$= 35{\cdot}93 + 0 + 3{\cdot}0 \times 2{\cdot}96$

$= 35{\cdot}93 + 0 + 8{\cdot}88 = \underline{44{\cdot}81 \text{ tons.}}$

Direct Bearing Value $= Cj + tp.\ Cp + lb.\ Cb$

$= 15{\cdot}60 + 0 + 3{\cdot}0 \times 6{\cdot}19$

$= 15{\cdot}60 + 0 + 18{\cdot}57 = \underline{34{\cdot}17 \text{ tons.}}$

The lesser of these two values is 34·17 tons which is thus the limiting reaction for the unstiffened web for this case. The corresponding uniformly distributed load is 2×34·17 = 68·34 tons.

SAFE LOADS The tabular loads are calculated as uniformly distributed loads on simply supported beams and include the weight of the beams.

For spans where the tabular load is not reduced to comply with the deflection limit, p_{bc} is 10·5 tons/inch² for beams having a web thickness up to and including ¾″ and 10·0 tons/inch² for beams having web thickness over ¾″, i.e. tabular loads are based on the assumption that the compression flange is adequately restrained laterally throughout its length or at intervals sufficiently frequent to comply with clause 19*a* and Table 3 of B.S. 449 : 1959.

For spans where the tabulated load is reduced to limit the deflection, $p_{bc} = 16D/L$ in which D is the depth of the beam in inches and L is the length of the span in feet.

DEFLECTION AND FULL ZIGZAG LINE The deflection of beams has been limited to 1/325th of the span. This corresponds to a span/depth ratio of 18·3/1 for beams stressed to 10·5 tons/inch² and 19·2/1 for beams stressed to 10·0 tons/inch².

These limits are shown by the full zigzag line. Tabular loads to the right of the full zigzag line are reduced so that the deflection will equal 1/325th of the span.

DOTTED ZIGZAG LINE Safe loads to the left of the dotted zigzag line are greater than the web buckling capacity provided by the beam alone and therefore web stiffeners may be necessary if sufficient additional capacity is not provided by the stiff bearing and any flange and/or bearing plates.

As indicated in the example on page 58, the web should be checked also for the direct bearing stress at the root and if this is excessive, means should be taken to relieve the stress at the root.

Universal Columns Uncased

SAFE LOADS The tabular loads are calculated in accordance with the permissible stresses in Table 17 of B.S. 449 : 1959 for effective slenderness ratios not exceeding 180. (See clause 33 of B.S. 449 : 1959.)

EFFECTIVE LENGTHS The effective length to be used in calculating the slenderness ratio of the column is governed by clause 31 of B.S. 449 : 1959 and several examples giving guidance for typical cases are given in Appendix D of that document.

ECCENTRIC LOADING When columns are subjected to eccentric loading, then the tabulated safe loads are generally inappropriate and the column must be designed so that the quantity

$$\frac{f_c}{p_c} + \frac{f_{bc}}{p_{bc}} \not> 1.$$

where f_c = the axial compressive stress

p_c = the permissible compressive stress in axially loaded struts as specified in clause 30*a* of B.S. 449 : 1959.

f_{bc} = the resultant compressive stresses due to bending about both rectangular axes and

p_{bc} = the appropriate allowable compressive stress for members subject to bending as given in clause 19*a* of the same specification.

In effectively jointed and continuous stanchions calculated in accordance with the "simple design" methods the bending moments due to eccentricities of loading at any one floor may be considered to be ineffective at the floor or frame levels above and below that floor and these bending moments may be divided equally between the upper and lower stanchion lengths unless the moment of inertia of either stanchion section divided by its actual length is greater than 1½ times the corresponding value for the other length. If this ratio is exceeded the bending moments shall be divided in proportion to the moments of inertia of the stanchion sections, divided by their respective actual lengths.

Universal Columns Cased

CASING The tables for cased columns are based on the assumption that the concrete casing and reinforcement comply with clause 30*b* of B.S. 449 : 1959. This clause stipulates that:

(i) The steel strut is unpainted and solidly encased in ordinary dense concrete, with ⅜″ aggregate (unless solidity can be obtained with a larger aggregate) and of a works strength not less than 3000 lb./ins.² at 28 days when tested in accordance with B.S. 1881, 'Methods for testing concrete,' Part 7, 'Making and curing compression test cubes in the field,' and Part 8, 'Test for compressive strength of moulded cubes'.

(ii) The minimum width of solid casing is equal to $b+4$ in., where b is the width overall of the steel flange or flanges in inches.

(iii) The surface and edges of the steel strut have a concrete cover of not less than 2 in.

(iv) The casing is effectively reinforced with wire to B.S. 785, 'Rolled steel bars and hard drawn steel wire for concrete reinforcement.' The wire shall be at least $\frac{3}{16}$ in. diameter and the reinforcement shall be in the form of stirrups or binding at not more than 6 in. pitch, so arranged as to pass through the centre of the covering of the edges and outer faces of the flanges and supported by and attached to longitudinal spacing bars not less than 4 in number.

AREAS The tabular core areas are the gross areas of the steel section forming the core of the stanchion. The tabular cased section areas are the gross areas of the composite member and represent the sum of the steel core area and area of encasing concrete, i.e., the area $B_c \times D_c$.

RADII OF GYRATION Radii of gyration are tabulated for each section relative to the principal axes. The radius of gyration about the x-x axis is not considered to be altered by the casing and is identical with that for the uncased section. Two radii of gyration are tabulated for each section relative to the y-y axis. That for the core only makes no allowance for the casing and is derived from the gross moment of inertia of the steel shaft. That for the cased section is taken as $0{\cdot}2(B+4)$ inches, or the radius of gyration relative to the y-y axis of the steel core, whichever is the greater.

SAFE LOADS The tabular loads are calculated on the basis of the concrete casing assisting in carrying the load in accordance with clause 30*b* of B.S. 449 : 1959, namely:

$$W = p_c . a_s + \frac{p_c}{30} . a_c$$

where W = safe axial load in tons on the cased column, which in no case shall exceed twice that which would be permitted on the uncased section

p_c = permissible axial stress for the encased core section as given by Table 17, B.S. 449 : 1959

a_s = area in square inches of the steel core section

a_c = gross area in square inches of the composite member.

The size of casings used in calculating the tabular loads are based on the surface or edge of the steel core receiving not less than 2 in. and not more than $2\frac{1}{8}$ in. concrete cover. (Overall dimensions of concrete to nearest $\frac{1}{4}$-inch.) When the designer is required to compute safe loads for greater cover thicknesses, it is permissible to use the concrete casing as assisting the steel core up to a limit of 3 in. cover; all concrete outside this limit to be ignored.

The tabular loads are calculated for effective slenderness ratios not exceeding 180 for the cased section.

For cased struts, the slenderness ratio of the uncased section, measured over its full length centre to centre of connections, should in no case exceed 250.

ECCENTRIC LOADING No provision is made in B.S. 449 : 1959 for the possibility of the concrete casing assisting the steel core in resisting bending moments caused by eccentric loading. Bending moments due to eccentric loading or other causes must therefore be deemed to be taken by the steel core alone.

Cased struts must be designed so that the quantity

$$\frac{F}{W} + \frac{f_{bc}}{p_{bc}} \ngtr 1.$$

where F = the axial load in tons on the cased member

W = the permissible safe load in tons on the cased member

f_{bc} = the sum of the compressive stresses in the steel section due to bending about both rectangular axes and

p_{bc} = the minimum permissible compressive stress for members subject to bending as given in clause 19*a* of B.S. 449 : 1959.

Plastic Properties of Universal Beams and Columns

The full plastic moduli and reduced plastic moduli are tabulated for all sections to facilitate the plastic design of members subject to bending only or to a combination of bending and axial load.

When an I section is loaded to full plasticity by a combination of axial thrust and bending about the major axis, the neutral axis may lie either in the web or in the flange whose outer fibres are in tension, dependent upon the relative values of thrust and bending. Different formulæ giving the reduced plastic moduli under combined loading have, therefore, to be used. The formula for lower values of n is to be used for values of n below the change value and indicates that the neutral axis is in the web. The formula for higher values of n is to be used for values of n above the change value and indicates that the neutral axis is in the tension flange.

The same principles apply to an I section loaded axially and bent about the minor axis, lower values of n again indicating that the neutral axis lies in the web and higher values indicating that it lies in the tension flange.

The value n is given by:

$$n = \frac{p}{y_s}$$

where p = the mean axial stress

y_s = the minimum yield stress

(to be taken as

16·0 tons/in.^{2} for material up to and including $\frac{3}{4}''$;

15·0 tons/in.^{2} for material over $\frac{3}{4}''$ and including $1\frac{1}{2}''$).

When the full plastic moment of a section is being used in design, as in the following example, adequate lateral restraint must be provided at suitable intervals.

Example Find the full plastic moment M_p of a $14'' \times 6\frac{3}{4}'' \times 45$ lb./ft. *U.B.* bent about its major axis under (*a*) no axial load (*b*) 20 tons axial load (*c*) 80 tons axial load.

(*a*) No axial load

Plastic Modulus axis x-x = 73·9 in.^{3}

$M_p = 73{\cdot}9 \times 16{\cdot}0 = 1182$ tons. ins.

(*b*) Axial load 20 tons

Area = 13·23 in.^{2}

$$n = \frac{20}{13{\cdot}23 \times 16{\cdot}0} = {\cdot}094 \text{ (less than } 0{\cdot}353)$$

Reduced Plastic Modulus

$$= 73{\cdot}9 - 122{\cdot}6 \times {\cdot}094^2 = 72{\cdot}8 \text{ in.}^3$$

$$M_p = 72{\cdot}8 \times 16{\cdot}0 = 1165 \text{ tons. ins.}$$

(*c*) Axial load 80 tons

$$n = \frac{80}{13{\cdot}23 \times 16{\cdot}0} = {\cdot}378 \text{ (greater than } 0{\cdot}353)$$

Reduced Plastic Modulus

$$= 6{\cdot}461\,(1 - {\cdot}378)\,(13{\cdot}67 + {\cdot}378) = 56{\cdot}5 \text{ in.}^3$$

$$M_p = 56{\cdot}5 \times 16{\cdot}0 = 904 \text{ tons. ins.}$$

PERMISSIBLE FLANGE WIDTH TO THICKNESS RATIO FOR FULL PLASTICITY It is recommended that *I* sections in which the ratio of width to thickness of flanges exceeds 18 shall not be assumed to be capable of attaining a state of full plasticity owing to the possibility of excessive local deformation. The following sections should therefore not be used on the basis of full plasticity unless suitably stiffened:

14″ × 14½″ × 87 lb./ft. U.C.

12″ × 12 ″ × 65 lb./ft. U.C.

8″ × 8 ″ × 31 lb./ft. U.C.

6″ × 6 ″ × 15·7 lb./ft. U.C.

PERMISSIBLE WEB DEPTH-TO-THICKNESS RATIO FOR FULL PLASTICITY When designing a member subject to a combination of bending and axial compression it is recommended that *I* sections shall not have a web depth-to-thickness ratio greater than 53. Accordingly, the following sections should not be used on the basis of full plasticity when subject to a combination of bending and axial thrust:

36″ × 12″ × 150 lb./ft. U.B.

33″ × 11½″ × 130 lb./ft. U.B.

For further information on the use of Universal and other sections in plastic design, designers are referred to *Plastic Properties of Rolled Sections*, British Welding Research Association.

DIMENSIONS AND PROPERTIES

(IN METRIC UNITS)

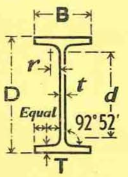
of

UNIVERSAL BEAMS AND COLUMNS

UNIVERSAL BEARING PILES

AND TEES CUT FROM

UNIVERSAL SECTIONS



UNIVERSAL BEAMS

TAPER FLANGES

Dimensions and Properties

METRIC

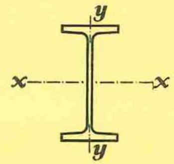
Serial Size	Weight per foot	Weight per metre	Depth of Section D	Width of Section B	Thickness Web t	Thickness Flange T	Root Radius r	Depth between Fillets d	Area of Section
ins	lbs	Kg	mm	mm	mm	mm	mm	mm	cm2
21×8¼	82	122	545	212	12·8	21·3	12·7	473	155·6
	73	109	539	211	11·6	18·8	12·7	473	138·4
	68	101	537	210	10·9	17·4	12·7	473	129·1
	62	92	533	209	10·2	15·6	12·7	473	117·6
18×7½	66	98	467	193	11·4	19·6	10·2	404	125·2
	60	89	464	192	10·6	17·7	10·2	404	113·8
	55	82	460	191	9·9	16·0	10·2	404	104·4
	50	74	457	190·5	9·1	14·5	10·2	404	94·9
16×7	50	74	413	180	9·7	16·0	10·2	357	94·9
	45	67	409	179	8·8	14·3	10·2	357	85·4
	40	60	406	178	7·8	12·8	10·2	357	75·9
	36	54	403	178	7·6	10·9	10·2	357	68·3
14×6¾	45	67	364	173	9·1	15·7	10·2	309	85·3
	38	57	359	172	8·0	13·0	10·2	309	72·1
	34	51	356	171·5	7·3	11·5	10·2	309	64·5
	30	45	352	171	6·9	9·7	10·2	309	56·9
12×6½	36	54	311	167	7·7	13·7	8·9	263	68·3
	31	46	307	166	6·7	11·8	8·9	263	58·8
	27	40	304	165	6·1	10·2	8·9	263	51·4
10×5¾	29	43	260	147	7·3	12·7	7·6	216	55·0
	25	37	256	146·4	6·4	10·9	7·6	216	47·4
	21	31	251	146	6·1	8·6	7·6	216	39·9
8×5¼	20	30	207	134	6·3	9·6	7·6	170	38·0
	17	25	203	133	5·8	7·8	7·6	170	32·3

UNIVERSAL BEAMS

TAPER FLANGES

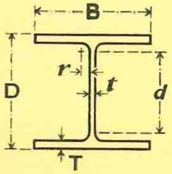
Dimensions and Properties

METRIC



Moment of Inertia Axis x-x Gross	Moment of Inertia Axis x-x Net	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Plastic Modulus Axis x-x	Plastic Modulus Axis y-y
cm4	cm4	cm4	cm	cm	cm3	cm3	cm3	cm3
76078	69119	3208	22·1	4·54	2794	303	3198	484
66610	60541	2755	21·9	4·46	2469	262	2820	419
61531	55942	2512	21·8	4·41	2293	239	2616	383
55225	50243	2212	21·7	4·34	2072	211	2362	340
45653	40978	2216	19·1	4·21	1954	230	2229	366
40957	36774	1960	19·0	4·15	1767	204	2012	325
37039	33278	1746	18·8	4·09	1610	183	1830	292
33324	29944	1547	18·7	4·04	1458	162	1654	260
27279	24287	1448	17·0	3·91	1322	161	1502	257
24279	21619	1269	16·9	3·86	1186	142	1343	226
21458	19101	1104	16·8	3·81	1056	124	1191	198
18576	16591	922	16·5	3·67	923	104	1046	167
19483	17215	1278	15·1	3·87	1071	148	1210	234
16038	14185	1026	14·9	3·78	894	119	1007	190
14118	12495	885	14·8	3·71	794	103	893	165
12052	10697	730	14·6	3·58	685	85·4	772	137
11686	10243	988	13·1	3·81	752	119	843	187
9924	8695	825	13·0	3·73	646	99·5	721	157
8500	7455	691	12·9	3·66	560	83·7	623	133
6546	5748	633	10·9	3·40	504	86·0	567	135
5544	4866	528	10·8	3·33	433	72·1	484	114
4427	3900	406	10·5	3·18	352	55·5	395	88·8
2880	2493	354	8·71	3·05	279	52·9	313	83·7
2348	2040	280	8·53	2·95	231	41·9	259	67·0

In calculating the Net Moment of Inertia about *x-x*, holes have been deducted from each flange in accordance with the table on page 56.



UNIVERSAL COLUMNS

PARALLEL FLANGES

Dimensions and Properties

METRIC

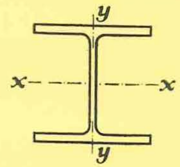
Serial Size	Weight per foot	Weight per metre	Depth of Section D	Width of Section B	Thickness Web t	Thickness Flange T	Root Radius r	Depth between Fillets d	Area of Section
ins	lbs	Kg	mm	mm	mm	mm	mm	mm	cm2
14×16	426	634	475	424	47·6	77·0	15·2	290	808·1
	264	393	419	407	30·6	49·2	15·2	290	500·9
	202	301	397	400	23·6	38·2	15·2	290	383·2
	158	235	381	395	18·5	30·2	15·2	290	299·8
Column Core	320	476	427	424	48·0	53·2	15·2	290	607·2
14×14½	136	202	375	374	16·8	27·0	15·2	290	257·9
	119	177	368	372	14·5	23·8	15·2	290	225·7
	103	153	362	370	12·6	20·7	15·2	290	195·2
	87	129	356	368	10·7	17·5	15·2	290	164·9
12×12	190	283	365	322	26·9	44·1	15·2	247	360·4
	161	240	353	318	23·0	37·7	15·2	247	305·6
	133	198	340	314	19·2	31·4	15·2	247	252·3
	106	158	327	311	15·7	25·0	15·2	247	201·2
	92	137	321	309	13·8	21·7	15·2	247	174·6
	79	117	314	307	11·9	18·7	15·2	247	149·8
	65	97	308	305	9·9	15·4	15·2	247	123·3
10×10	112	167	289	265	19·2	31·7	12·7	200	212·4
	89	133	276	261	15·6	25·3	12·7	200	168·9
	72	107	267	258	13·0	20·5	12·7	200	136·6
	60	89	260	256	10·5	17·3	12·7	200	114·0
	49	73	254	254	8·6	14·2	12·7	200	92·9
8 × 8	48	71	216	206	10·3	17·3	10·2	161	91·1
	40	59	210	205	9·3	14·2	10·2	161	75·8
	35	52	206	204	8·0	12·5	10·2	161	66·4
	31	46	203	203	7·3	11·0	10·2	161	58·8
6 × 6	25	37	162	154	8·1	11·5	7·6	123·5	47·4
	20	30	157	153	6·6	9·4	7·6	123·5	38·2
	15·7	23	152	152	6·1	6·8	7·6	123·5	29·8

UNIVERSAL COLUMNS

PARALLEL FLANGES

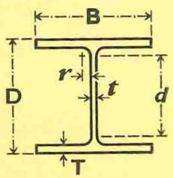
Dimensions and Properties

METRIC



Moment of Inertia Axis x-x Gross	Moment of Inertia Axis x-x Net	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Plastic Modulus Axis x-x	Plastic Modulus Axis y-y
cm4	cm4	cm4	cm	cm	cm3	cm3	cm3	cm3
275140	245764	98211	18·4	11·0	11592	4632	14247	7114
146765	130634	55410	17·1	10·5	7004	2723	8229	4157
105672	93923	40777	16·6	10·3	5324	2039	6119	3103
79110	70243	31008	16·3	10·2	4153	1570	4689	2384
172391	154580	68057	16·8	10·6	8075	3207	9700	4979
66307	58518	23632	16·0	9·58	3540	1262	3976	1917
57153	50410	20470	15·9	9·53	3104	1100	3457	1668
48525	42789	17470	15·8	9·45	2681	944	2964	1430
40246	35484	14555	15·6	9·40	2264	790	2482	1196
78777	67879	24545	14·8	8·26	4314	1525	5101	2337
64177	55230	20239	14·5	8·13	3641	1273	4245	1947
50832	43696	16230	14·2	8·03	2991	1034	3436	1576
38740	33282	12524	13·9	7·90	2368	806	2680	1228
32838	28204	10673	13·7	7·82	2049	691	2298	1052
27601	23700	9006	13·6	7·75	1756	587	1953	892
22202	19063	7268	13·4	7·67	1442	477	1589	723
29914	27401	9796	11·9	6·78	2070	741	2417	1132
22575	20670	7519	11·6	6·68	1634	576	1875	879
17510	16025	5901	11·3	6·58	1313	457	1485	695
14307	13082	4849	11·2	6·53	1099	379	1228	575
11360	10389	3873	11·05	6·45	895	305	989	462
7647	6830	2536	9·17	5·28	708	246	802	374
6088	5444	2041	8·97	5·18	581	199	652	303
5263	4703	1770	8·89	5·16	510	174	568	264
4564	4083	1539	8·81	5·11	449	151	497	230
2218	1948	709	6·83	3·86	274	91·8	310	140
1742	1532	558	6·76	3·81	221	73·1	247	111
1263	1113	403	6·50	3·68	166	52·9	184	80·9

In calculating the Net Moment of Inertia about x-x, holes have been deducted from each flange in accordance with the table on page 56.



UNIVERSAL BEARING PILES

PARALLEL FLANGES

Dimensions and Properties

METRIC

Serial Size	Weight per foot	Weight per metre	Depth of Section D	Width of Section B	Thickness Web t	Thickness Flange T	Root Radius r	Depth between Fillets d
ins	*lbs*	*Kg*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
14×14½	117	174	362	378	20·4	20·4	15·2	290
	102	152	356	376	17·9	17·9	15·2	290
	89	133	352	373	15·6	15·6	15·2	290
	73	109	346	370	12·9	12·9	15·2	290
12×12	74	110	308	310	15·4	15·[illegible]	15·2	247
	53	79	299	306	11·1	11·1	15·2	247
10×10	57	85	254	260	14·3	14·3	12·7	200
	42	63	247	256	10·6	10·6	12·7	200
8 × 8	36	54	204	207	11·3	11·3	10·2	161

THE SECTIONS listed above are known all over the world and have been used in many varied types of structures; as foundations for bridges, buildings and heavy machinery; for wharves, steamship piers and mooring dolphins; and in numerous other situations.

Briefly, their advantages arise from the ability to withstand extremely hard driving and to develop a high bearing value.

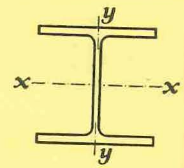
The cost of driving is low, because no secondary operations are required and extremely

UNIVERSAL BEARING PILES

PARALLEL FLANGES

Dimensions and Properties

METRIC

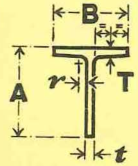


Area of Section	Moment of Inertia Axis x-x	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Serial Size
cm²	*cm⁴*	*cm⁴*	*cm*	*cm*	*cm³*	*cm³*	*ins*
222·2	51134	18444	15·2	9·11	2829	976	14×14½
193·6	43916	15799	15·1	9·03	2464	841	
169·0	37840	13576	15·0	8·96	2150	727	
138·4	30515	10901	14·8	8·87	1762	588	
140·4	23580	7689	13·0	7·40	1532	496	12×12
100·4	16400	5292	12·8	7·26	1096	346	
108·1	12264	4188	10·7	6·22	965	323	10×10
79·7	8775	2971	10·5	6·11	711	232	
68·4	4987	1683	8·54	4·96	489	162	8 × 8

long lengths can be pitched and driven as single pieces. Lengths up to 90 ft. are available from the mill, which reduces the number of splices required. Splicing by welding is quickly and easily carried out and develops the full strength of the section.

In special circumstances where minimum soil displacement is desirable, these sections are admirable and in normal conditions the life far exceeds requirements.

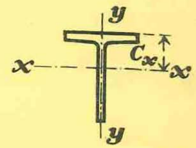
Standard tolerances and size extras as for Universal Beams and Columns are applicable.



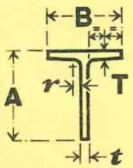
STRUCTURAL TEES
CUT FROM UNIVERSAL BEAMS
Dimensions and Properties
METRIC

Serial Size	Weight per foot	Weight per metre	Width of Section B	Depth of Section A	Thickness Web t	Thickness Flange T	Root Radius r	Slope Inside Flange
ins	lbs	Kg	mm	mm	mm	mm	mm	per cent
12×18	85	126	305	459	17·3	27·9	19·1	5·0
	75	112	304	455	15·9	23·9	19·1	5·0
11½×16½	76	113	294	425	16·1	26·8	17·8	5·0
	65	97	292	420	14·7	21·7	17·8	5·0
10½×15	66	98	268	385	15·6	25·4	16·5	5·0
	58	86	267	381	14·3	21·6	16·5	5·0
10×13½	57	85	256	346	14·5	23·7	15·2	5·0
	51	76	254	344	13·2	21·0	15·2	5·0
	47	70	254	342	12·4	19·0	15·2	5·0
12×12	80	119	312	316	18·6	31·4	16·5	5·0
	60	89	307	309	14·1	23·6	16·5	5·0
	50	74	305	305	11·9	19·7	16·5	5·0
9×12	47	70	230	308	13·1	22·1	12·7	5·0
	42	63	229	306	11·9	19·6	12·7	5·0
	38	57	228	304	11·2	17·3	12·7	5·0
13×10½	71	106	334	273	16·7	27·8	16·5	5·0
	63·5	95	332	270	14·9	25·0	16·5	5·0
	56	83	330	267	13·4	22·0	16·5	5·0
8¼×10½	41	61	212	272	12·8	21·3	12·7	5·0
	36·5	54	211	270	11·6	18·8	12·7	5·0
	34	51	210	269	10·9	17·4	12·7	5·0
	31	46	209	267	10·2	15·6	12·7	5·0

STRUCTURAL TEES
CUT FROM UNIVERSAL BEAMS
Dimensions and Properties
METRIC



Area of Section	Gravity Centre Distance C_x	Moment of Inertia Axis x-x	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Cut From Universal Beam
cm^2	cm	cm^4	cm^4	cm	cm	cm^3	cm^3	ins × ins × lbs
161·2	12·0	32665	6256	14·2	6·23	964	410	36×12 ×170
142·5	12·2	29000	5212	14·3	6·05	869	343	150
144·2	10·8	24635	5331	13·1	6·08	777	363	33×11½×152
123·4	11·1	21351	4193	13·2	5·83	690	287	130
125·3	9·91	17510	3850	11·8	5·54	613	288	30×10½×132
110·1	10·0	15477	3189	11·9	5·38	551	239	116
108·2	8·69	12025	3113	10·5	5·36	463	243	27×10 ×114
96·8	8·61	10727	2695	10·5	5·28	416	212	102
89·2	8·66	9926	2395	10·5	5·18	389	188	94
151·8	7·12	12283	7487	9·00	7·02	501	481	24×12 ×160
113·8	6·66	8939	5286	8·86	6·81	369	344	120
94·9	6·45	7355	4237	8·80	6·68	306	278	100
89·1	7·62	7739	2127	9·32	4·88	333	185	24× 9 × 94
79·7	7·56	6905	1838	9·31	4·80	300	161	84
72·2	7·62	6288	1592	9·33	4·70	276	139	76
134·8	5·56	7381	8032	7·40	7·72	340	482	21×13 ×142
120·6	5·36	6484	7046	7·33	7·64	300	425	127
106·4	5·23	5678	6029	7·31	7·53	265	365	112
77·8	6·68	5178	1604	8·16	4·54	252	151	21× 8¼× 82
69·2	6·61	4589	1377	8·14	4·46	225	131	73
64·6	6·58	4278	1256	8·14	4·41	211	120	68
58·8	6·58	3900	1106	8·14	4·34	194	106	62



STRUCTURAL TEES

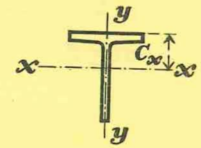
CUT FROM UNIVERSAL BEAMS

Dimensions and Properties

METRIC

Serial Size	Weight per foot	Weight per metre	Width of Section B	Depth of Section A	Thickness Web t	Thickness Flange T	Root Radius r	Slope Inside Flange
ins	lbs	Kg	mm	mm	mm	mm	mm	per cent
7½×9	33	49	193	234	11.4	19.6	10.2	5.0
	30	45	192	232	10.6	17.7	10.2	5.0
	27.5	41	191	230	9.9	16.0	10.2	5.0
	25	37	190	229	9.1	14.5	10.2	5.0
7 × 8	25	37	180	207	9.7	16.0	10.2	5.0
	22.5	33	179	205	8.8	14.3	10.2	5.0
	20	30	178	203	7.8	12.8	10.2	5.0
	18	27	178	201	7.6	10.9	10.2	5.0
6¾×7	22.5	33	173	182	9.1	15.7	10.2	5.0
	19	28	172	180	8.0	13.0	10.2	5.0
	17	25	171	178	7.3	11.5	10.2	5.0
	15	22	171	176	6.9	9.7	10.2	5.0
6½×6	18	27	167	156	7.7	13.7	8.9	5.0
	15.5	23	166	154	6.7	11.8	8.9	5.0
	13.5	20	165	152	6.1	10.2	8.9	5.0
5¾×5	14.5	22	147	130	7.3	12.7	7.6	5.0
	12.5	19	146	128	6.4	10.9	7.6	5.0
	10.5	16	146	126	6.1	8.6	7.6	5.0
5¼×4	10	15	134	104	6.3	9.6	7.6	5.0
	8.5	13	133	102	5.8	7.8	7.6	5.0

STRUCTURAL TEES

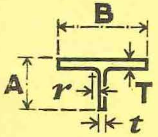


CUT FROM UNIVERSAL BEAMS

Dimensions and Properties

METRIC

Area of Section	Gravity Centre Distance Cx	Moment of Inertia Axis x-x	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Cut From Universal Beam
cm2	cm	cm4	cm4	cm	cm	cm3	cm3	ins × ins × lbs
62.6	5.56	2976	1108	6.90	4.21	167	115	18 × 7½ × 66
56.9	5.50	2699	980	6.89	4.15	153	102	60
52.2	5.49	2479	873	6.89	4.09	141	91.3	55
47.5	5.43	2244	774	6.88	4.04	129	81.2	50
47.5	4.81	1756	724	6.09	3.91	111	80.6	16 × 7 × 50
42.7	4.74	1572	634	6.07	3.86	99.9	71.0	45
38.0	4.63	1381	552	6.03	3.81	88.0	62.1	40
34.2	4.82	1280	461	6.12	3.67	83.6	51.9	36
42.7	4.01	1157	639	5.21	3.87	81.6	73.8	14 × 6¾ × 45
36.1	3.96	978	513	5.21	3.78	70.0	59.6	38
32.3	3.93	877	443	5.21	3.71	63.3	51.7	34
28.5	4.03	790	365	5.27	3.58	58.2	42.7	30
34.2	3.20	636	494	4.32	3.81	51.5	59.3	12 × 6½ × 36
29.4	3.09	540	412	4.28	3.73	44.1	49.8	31
25.7	3.07	475	346	4.30	3.66	39.2	41.9	27
27.5	2.67	349	317	3.56	3.40	33.8	43.0	10 × 5¾ × 29
23.7	2.58	296	264	3.54	3.33	29.0	36.1	25
20.0	2.69	263	203	3.63	3.18	26.6	27.8	21
19.0	2.10	152	177	2.83	3.05	18.5	26.5	8 × 5¼ × 20
16.2	2.13	133	140	2.88	2.95	16.6	21.0	17



STRUCTURAL TEES

CUT FROM UNIVERSAL COLUMNS

Dimensions and Properties

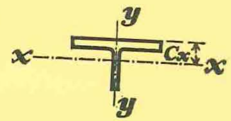
METRIC

Serial Size	Weight per foot	Weight per metre	Width of Section B	Depth of Section A	Thickness Web t	Thickness Flange T	Root Radius r	Slope Inside Flange
ins	lbs	Kg	mm	mm	mm	mm	mm	per cent
16×7	79	118	395	191	18·5	30·2	15·2	0
14½×7	68	101	374	187	16·8	27·0	15·2	0
	59·5	89	372	184	14·5	23·8	15·2	0
	51·5	77	370	181	12·6	20·7	15·2	0
	43·5	65	368	178	10·7	17·5	15·2	0
12×6	53	79	311	164	15·7	25·0	15·2	0
	46	68	309	160	13·8	21·7	15·2	0
	39·5	59	307	157	11·9	18·7	15·2	0
	32·5	48	305	154	9·9	15·4	15·2	0
10×5	44·5	66	261	138	15·6	25·3	12·7	0
	36	54	258	133	13·0	20·5	12·7	0
	30	45	256	130	10·5	17·3	12·7	0
	24·5	36	254	127	8·6	14·2	12·7	0
8×4	24	36	206	108	10·3	17·3	10·2	0
	20	30	205	105	9·3	14·2	10·2	0
	17·5	26	204	103	8·0	12·5	10·2	0
	15·5	23	203	102	7·3	11·0	10·2	0
6×3	12·5	19	154	81	8·1	11·5	7·6	0
	10	15	153	79	6·6	9·4	7·6	0
	7·85	12	152	76	6·1	6·8	7·6	0

STRUCTURAL TEES

CUT FROM UNIVERSAL COLUMNS

Dimensions and Properties



METRIC

Area of Section	Gravity Centre Distance Cx	Moment of Inertia Axis x-x	Moment of Inertia Axis y-y	Radius of Gyration Axis x-x	Radius of Gyration Axis y-y	Elastic Modulus Axis x-x	Elastic Modulus Axis y-y	Cut From Universal Column
cm2	cm	cm4	cm4	cm	cm	cm3	cm3	ins × ins × lbs
149·9	3·41	2886	15504	4·39	10·2	185	785	14×16 ×158
129·0	3·32	2500	11816	4·40	9·58	162	631	14×14½×136
112·9	3·10	2099	10235	4·31	9·53	137	550	119
97·6	2·92	1765	8735	4·25	9·45	116	472	103
82·5	2·73	1451	7278	4·19	9·40	96·4	395	87
100·6	3·04	1529	6262	3·90	7·90	115	403	12×12 ×106
87·3	2·86	1291	5336	3·85	7·82	98·1	346	92
74·9	2·69	1075	4503	3·79	7·75	82·5	294	79
61·6	2·50	858	3634	3·73	7·67	66·6	238	65
84·5	2·72	887	3760	3·24	6·68	79·9	288	10×10 × 89
68·3	2·47	683	2951	3·16	6·58	62·8	228	72
57·0	2·24	535	2424	3·06	6·53	49·6	189	60
46·4	2·05	416	1936	2·99	6·45	39·0	152	49
45·5	1·98	288	1268	2·52	5·28	32·7	123	8× 8 × 48
37·9	1·88	241	1021	2·52	5·18	28·1	99·5	40
33·2	1·76	203	885	2·47	5·16	23·7	86·8	35
29·4	1·71	180	769	2·47	5·11	21·2	75·7	31
23·7	1·55	95	354	2·00	3·86	14·5	45·9	6 ×6 × 25
19·1	1·41	73	279	1·95	3·81	11·3	36·5	20
14·9	1·43	61	202	2·03	3·68	9·9	26·5	15·7

DL